ARCHAEOLOGICAL INVESTIGATIONS AT TOSAWIHI, A GREAT BASIN QUARRY

Part 1: The Periphery

Volume 1

Robert G. Elston and Christopher Raven
Editors

Contributors

Kathryn Ataman
William W. Bloomer
Steve Botkin
Elizabeth E. Budy
Kristopher Carambelas
Michael P. Drews
Daniel P. Dugas
Robert G. Elston
Eric E. Ingbar
Melinda Leach
Mark W. Moore
Christopher Raven
Dave N. Schmitt

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Contributors

Kathryn Ataman
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Daniel P. Dugas
Robert G. Elston
Eric E. Ingbar
Melinda Leach
Mark W. Moore
Christopher Raven
Dave N. Schmitt

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prepared for
Bureau of Land Management
Elko Resource Area
3900 E. Idaho St.
Elko, Nevada 89801

on behalf of
Ivanhoe Gold Company
P.O. Box 2667
Winnemucca, Nevada 89445

prepared by
Intermountain Research
P.O. Drawer A
Silver City, Nevada 89428

CULTURAL RESOURCES MANAGEMENT SUMMARY

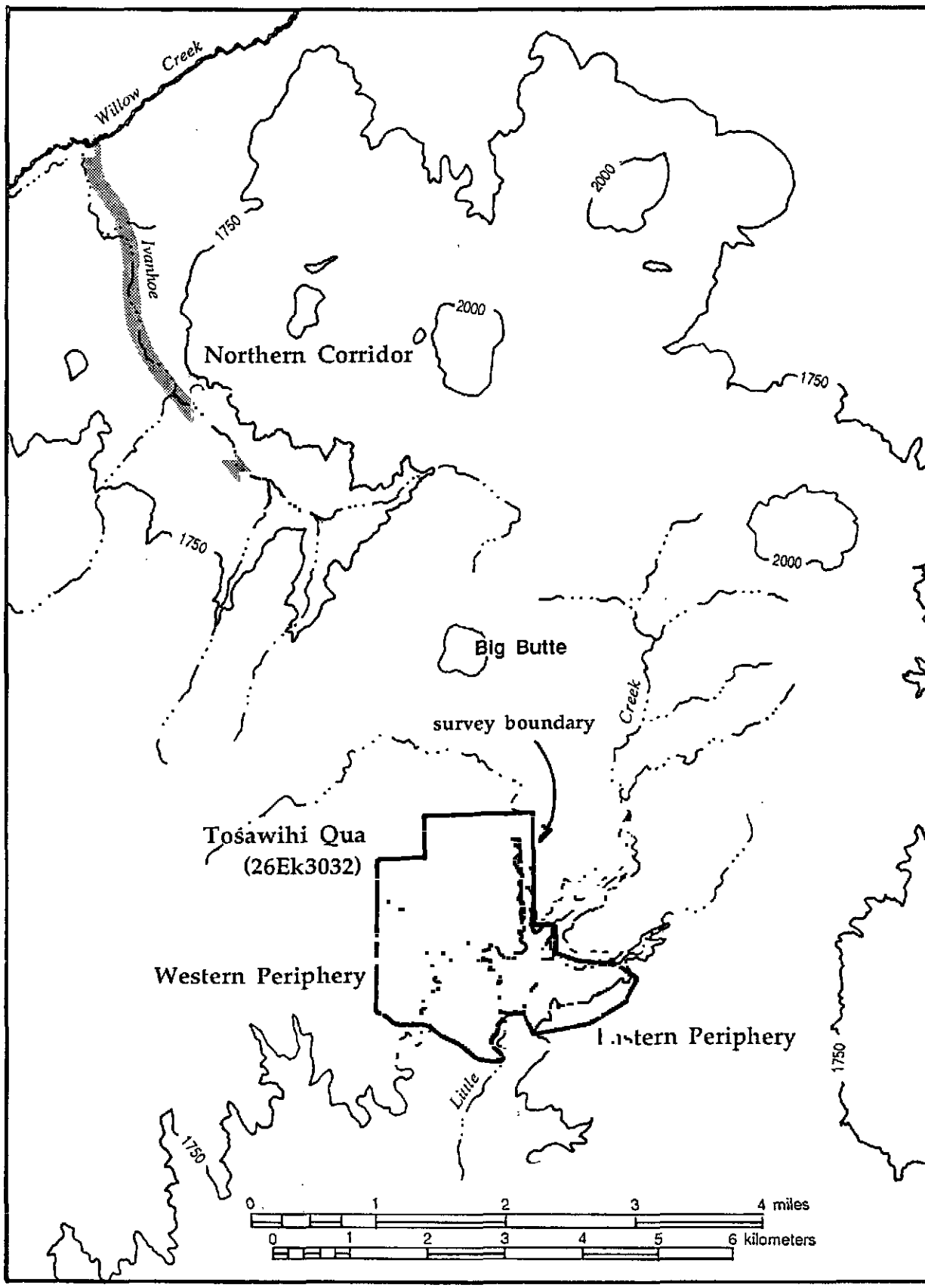
Minerals exploration, extraction, processing, and transport comprise the Ivanhoe Project, a gold development in the Ivanhoe Mining District, Elko County, Nevada. The Ivanhoe Project is located entirely on public lands administered by the Elko Resource Area of the Bureau of Land Management. An archaeological district, not yet formally defined but known regionally as the Tosawihi Quarries, is areally coincidental with the Ivanhoe Project.

A program of archaeological survey, testing, and mitigation has been in progress since 1987, prompted by the Ivanhoe Project. Funded by Ivanhoe Gold Company, the program addresses BLM obligations to Section 106 of the National Historic Preservation Act of 1966, in light of Ivanhoe Project development (Elston, Raven, and Budy 1987; Intermountain Research 1987, 1988a-d; Zeier 1987; Budy 1988; Drews 1988; Elston 1988a-b, 1989; Raven 1988). The work to which this summary refers, *Archaeological Investigations at Tosawihi, a Great Basin Quarry, Part 1: The Periphery* (Elston and Raven, eds. 1991), reports data recovery at twenty-five sites and localities determined eligible for nomination to the National Register of Historic Places (Elston, ed. 1989) and subject to impacts by elements of the Ivanhoe Project.

Data recovery plans for the twenty-five sites (Intermountain Research 1988a-d) were drafted and approved in 1988-89; field work began May 1, 1989 and continued through August 16, 1989, utilizing a crew that fluctuated in size between 16 and 32, augmented by supervisory personnel, camp staff, experimental lithics workshop personnel, and the occasional volunteer. The crew worked a ten-day on, four-day off schedule devoting, ultimately, 1771 person days to the field campaign. In the process, the crew profiled more than 350 meters of mechanically excavated trench and 12 meters of hand-excavated trench, shovel-skimmed 435 square meters of site area, and hand-excavated in excess of 110 cubic meters of fill, collecting along the way 973,000 artifacts, artifact lots, and cultural and noncultural samples. Post-field efforts—collections processing, sorting and cataloging, laboratory data collection and analysis, analysis of stratigraphic data, technical report development, project management and administration, and collections management and curation preparation—have consumed about 4000 person days. Commencing in November, 1989, analysis and draft final report preparation were completed in July, 1991; the final report, revised in light of comments received from the Bureau of Land Management, was produced in January, 1992. Seventeen of the twenty-five sites had been tested in 1988 (Elston, ed. 1989), and test data and assemblages were incorporated into post-field data recovery analysis and reporting. Selected assemblages (e.g., bifaces) and data from other previously studied sites have been incorporated into technological analyses undertaken for the present mitigation program.

The following discussion compares field procedures proposed (Intermountain Research 1988a-d) for each site with those actually executed; where discrepancies occur, details of alternative actions are offered. In all cases, the goals and objectives of data recovery plans were met by the field and post-field procedures selected and executed.

For reporting purposes, the study area is divided into three subareas known as the Eastern Periphery, the Western Periphery, and the Northern Corridor (cf. map). All refer to elements of the Ivanhoe Project which comprise the USX Mine: the Northern Corridor follows the alignment of an overland route accessing the mine from State Route 18 to the north; the Eastern Periphery encompasses ore processing facilities and a causeway; the Western Periphery encompasses USX mine pits, dumps, soil stockpiles, office compound, and the like. Table A lists mitigated sites and their Ivanhoe Project associations.



Principal study areas of the Tosawihi vicinity.

Table A. Investigated Sites and Localities.

Site/Locality	Elevation (ft. amsl)	Site Area (sq. m)	East	West	North
26Ek3170	5,620	31,000	x		
26Ek3171	5,670	7,540	x		
26Ek3184	5,640	11,309	x		
26Ek3192	5,660	3,190	x		
26Ek3195	5,700	9,425	x		
26Ek3198	5,740	12,724	x		
26Ek3200	5,760	242	x		
26Ek3204	5,680	60	x		
26Ek3032					
Loc 19	5,600	10	x		
Loc 20	5,630	200	x		
Loc 21	5,600	100	x		
Loc 22	5,580	5	x		
Loc 23	5,640	30	x		
Loc 25	5,700	2,250	x		
Loc 93	5,600		x		
Loc 98	5,600	900	x		
26Ek3084	5,775	300		x	
26Ek3085/3208	5,740-5,750	13,316		x	
26Ek3092	5,625	4,800		x	
26Ek3095	5,750	1,875		x	
26Ek3160	5,575	46,000		x	
26Ek3165	5,670	4,500		x	
26Ek3237	5,560	42,000			x
26Ek3251	5,215	15,000			x

Data were recovered from sixteen sites and localities in the Eastern Periphery. Table B summarizes selected procedures proposed and executed at each. Note that procedures were executed as proposed, or in excess of propositions, at half the sites, but that alternative actions resulting in modified efforts were undertaken at the other half.

26Ek3192 data recovery plans called for 100 soil probes. Only 88 probes were undertaken absent any need to probe those areas of the site which had been trenched.

26Ek3200 data recovery plans called for one 1 x 1 meter excavation unit to be placed in Feature 1, but the plan was abandoned due to the instability of quarry pit deposits. (Previously excavation had been attempted in similar deposits as a methodological experiment at site 26Ek3171, Feature 2, without success.)

26Ek3032, Locality 19 data recovery plans called for one 1 x 1 meter unit which was not excavated because surface scrapes demonstrated that cultural remains are confined to the upper 2 cm of the deposit.

26Ek3032, Locality 20 data recovery plans called for a backhoe trench of unspecified length to transect the quarry pit that was thought (during survey in 1987) to comprise the locality. However, 1989 review of the site could identify no quarry pit.

26Ek3032, Localities 21 and 22 data recovery plans called for "about 20" surface scrapes at each locality. Two were skimmed at the former and six at the latter because close interval reconnaissance during data recovery revealed the density of cultural remains outside the confines of features to be very sparse and because low bedrock outcrops and stream boulders occupy most of the ground surface within site precincts, making surface scraping virtually impossible.

Table B. Selected Data Recovery Procedures Executed in the Eastern Periphery.
(Proposed procedures are given in italics.)

Site No. (26Ek-)	Mechanical Trenching (no. m)	Hand Trenching (no. m)	Total Excavation Units (m^2)	Total Reserve Excavation Units (m^2)	Total Fill Excavated (m^3)	Total Surface Scrapes (m^2)	Mapping/ Description		Total Debitage Recovered (no. items)	Total Formed Artifacts Recovered Recovered (no. items)
3170	*1x8* / 1x8		*42* / 42	*4* / 2	6.77	*30-50* / 33	√	√	42,014	300
3171	*(2)1x8* / (2)1x8	½ x 5	*15* / 15	*4* / 0	5.91		√	√	30,870	151
3184		½ x 7		*10* / 5	.58	*80.5* / 189	√	√	56,011	397
3192*	*1x20* / 1x20		*26* /26	*10* / 19.5	11.13		√	√	39,246	444
3195	*(5)1x8* / (1)1x19.5 (2)1x12.5					5	√	√	44,888	56
3198	*1x15* / 1x15		*10* / 10	*4* / 30	5.57	*15* / 3	√	√	8,230	135
3200	*1x10* / 1x10		*1* / 0				√	√	240	15
3204	*1x9* / 1x9		*3* / 3		.4		√	√	123,915	140
3032										
Loc 19			*1* / 0			*30* / 32	√	√	14,673	96
Loc 20	*1x?* / 0					3	√	√	9,587	32
Loc 21			*1* / 1		.3	*ca. 20* / 2	√	√	1,794	21
Loc 22			*1* / 1		.2	*ca. 20* / 6	√	√	2,067	10
Loc 23	*1x?* / 1x8					7	√	√	38,487	119
Loc 25							√	√	25,716	129
Loc 93 (isolate)							√	√		1
Loc 98		*possible* / not done				10	√	√	1,287	11

*Soil Probes, site 3192: *100* / 88

26Ek3032, Locality 25 data recovery plans called for mapping and description of "30 discrete features," features that were apparent to 1987 surveyors but not to 1989 data recovery crews, who observed only seven features on the site. The discrepancy is attributable to inter-observer error—differences in the way individual field workers define features (lumpers versus splitters), and to differences between how reduction features are seen today as opposed to how they were seen four years ago.

26Ek3032, Locality 98 data recovery plans called for the possibility of hand trenching, but none was undertaken because surface scrapes demonstrated that cultural remains are confined to the upper 2 cm of the deposit.

Table C summarizes selected proposed and executed field procedures at seven sites in the Western Periphery. Work went as planned at five and in accordance with revised plans at two, as described below. Note that 26Ek3085 and 26Ek3208 are treated as a single site.

26Ek3084 data recovery plans called for two hand excavated 1 x 5 meter trenches and excavation of one 1 x 1 meter unit (with an additional unit held in reserve). One trench, to extend a test trench in Feature 1, was excavated mechanically rather than by hand because hand excavation was found too time consuming and too detailed simply to remove overburden and expose stratigraphy. The other trench, intended for Feature 2, was not excavated because it became apparent that the Feature 2 debris consisted only of colluvium from Feature 1, with no subsurface cultural component. The 1 x 1 m excavation unit to have been placed off Trench 1 could not be undertaken due to unstable side walls; instead, strata-based lithic samples were obtained from the trench walls.

In the Northern Corridor, data recovery was undertaken at two sites; procedures are summarized in Table D.

Table C. Selected Data Recovery Procedures Executed in the Western Periphery.
(Proposed procedures are given in italics.)

Site No. (26Ek-)	Mechanical Trenching (no. m)	Hand Trenching (no. m)	Total Excavation Units (m^2)	Total Reserve Excavation Units (m^2)	Total Fill Excavated (m^3)	Total Surface Scrapes (m^2)	Mapping/ Description		Total Debitage Recovered (no. items)	Total Formed Artifacts Recovered Recovered (no. items)
3084	(1)1x4	*(2)1x5*	*1* / 0	*1* / 0		.5	√	√	8,476	10
3085/ 3208	*(2)1x?* / (2)1x6 *(1)1x5* / 1x11 *(1)1x10* / (1)1x10	2 / 4					√	√	175,455	15
3092	*4 ext.* / 4 ext. 4 new trenches		*41* / 42		24.26		√	√	132,194	858
3095			*67* / 67	*10* / .5	11.23		√	√	82,493	646
3160			*36* / 36	*8* / 12	11.46	*66* / 57	√	√	47,034	1,047
3165			*33* / 33	*15* / 2	4.34	*40* / 40	√	√	13,067	96

ext. = extensions

Table D. Selected Data Recovery Procedures Executed in the Northern Corridor.
(Proposed procedures are given in italics.)

Site No. (26Ek-)	Mechanical Trenching (no. m)	Hand Trenching (no. m)	Total Excavation Units (m^2)	Total Reserve Excavation Units (m^2)	Total Fill Excavated (m^3)	Total Surface Scrapes (m^2)	Mapping/ Description		Total Debitage Recovered (no. items)	Total Formed Artifacts Recovered Recovered (no. items)
3237	*(8-10)(100m max)* / 8 (1x100m)		*35* / 35	*20* / 2	17.38	*25* / 25	√	√	12,509	328
3251	*(6)(60m max)* / 6 (1x60m)		*30* / 20	*15* / 0	10.5	*12* / 22	√	√	23,270	339

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Never forget this when the talk is clever:
Wisdom must be born in the flesh or wither,
And sacred order has been always won
From chaos by some burning faithful one
Whose human bones have ached as if with fever
To bring you to these high triumphant places.

—May Sarton

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We mention Mary Rusco first because she saw Tosawihi first, archaeologically speaking, and because she gave us lunch and access to her field notes. A consequence of Rusco's work at Tosawihi, BLM has concerned itself with continuing study of the place: Pat Barker of the Nevada State Office, and Stanley Jaynes of the Elko District Office, encouraged the work, and so did Alice Baldrica, Deputy State Historic Preservation Officer. Frank Dietz of the BLM Elko District Office commented on parts of the draft report.

Penny McPherson, of Ivanhoe Gold Company, proved a knowledgeable coordinator whose efforts gainsaid administrative disarray more than once. Her associate, Don Hruska, of Touchstone Resources Company, and his staff, assisted us in the field phase of the endeavor.

Robert Elston, with the help of Christopher Raven and Melinda Leach, designed and directed the Tosawihi study. Field Supervisors Steve Botkin and Dave Schmitt, Stratigrapher Dan Dugas, Laboratory Manager Lynn Rogers, and Lithics Supervisor Kathy Ataman, together with the principals, took a team approach to development and execution of field and laboratory strategies, with frequent assists by one or another of the field and laboratory staff. Those who served in the trenches and in the laboratory include Bill Bloomer, Bob Bratcher, Mel Brewster, Liz Budy, Meg Burns, Kris Carambelas, Andy Carey, Holly Carrera, Caitlin Carroll, Michael Clerico, David Coupe, Fred Crisson, Steve Erven, Ellen Glassmeyer, Dennis Gray, Teresa Hamby, Margaret Hangan, Heidi Hill, Eric Ingbar, Cari Inoway, Jana Jared, Bruce Jones, Pete Kiigemagi, Karen Lupo, Susan McCabe, Cathleen Mital, Mark Moore, Ken Moslak, Mitch Neilsen, Conrad Praetzel, Shelly Raven, Tom Ross, Joann Shea, Susan Stornetta, Wendy Stotts, Trish Webb, Bruce Wilson, Mary Works, Annabelle Younger, and David Zeanah. Alan McCabe, Mary Garsky, and Pat Garsky volunteered in the field. In camp, Cleo Ross managed and Hill Ross assisted. Supporting the effort were Mike Drews, who designed field camp systems and the graphic presentations appearing herein; Cari Inoway, who made artifact drawings, and Bill Germino, who made photographic plates; Kathy Nickerson, who processed words and edited and proofed and did report production layout; Roz Works, Greg Wimmer, and Denise Bisiaux-Lopez, who saw to our administrative needs; and Cashion Callaway, who managed the project.

Technical services were provided by Patricia Dean (ceramics), Jonathan Davis (tephra), Dave DeVries (photogrammetry), Michael Glasscock (neutron activation), Richard Hughes (obsidian sourcing), Tom Origer (obsidian hydration), and Beta Analytic (radiocarbon assay). Nevada Department of Transportation and Nevada Department of Wildlife helped with our replication experiments.

Flintknappers Peter Ainsworth, John Fagan, Jeffrey Flenniken, Terry Ozbun, Jo Reese, Gene Titmus, and Jim Woods joined us in the field, contributing enormously to our experimental replication program. We are grateful for their abiding interest in the Tosawihi research.

Richard Gould, Duncan Metcalf, and James O'Connell offered commentary from which this report benefitted and for which we thank them. And we thank Stanley Ahler, who provided us with his Knife River Flint Quarry database; our debt of gratitude is considerable.

It has been said of Jimmy Olsen that he did not suffer fools: that he suffered us either proves our competency or comments on his perceptions. No matter—Mr. Olsen sustained us.

Part I. RESEARCH CONTEXT

Chapter 1

INTRODUCTION TO THE TOSAWIHI QUARRIES

Robert G. Elston

...a shattered, overlapping, sometimes shallow, nondiagnostic, undatable, unattractive, redundant, and at times voluminous material record.
—Ericson (1984:2) on quarries

Tosawihi is the only toolstone quarry in the Great Basin for which there is unambiguous ethnographic reference. Although he apparently never visited the quarries, Steward (1938:162) wrote that Tosawihi ("White Knife") Shoshone groups living along the middle reach of the Humboldt River in the vicinity of Battle Mountain "procured a high quality of white flint for knives in the mountains to the north." That all other Shoshone groups identified themselves by food names testifies to the importance of this resource for the Tosawihi.

Ethnographers continued to mention the quarries in connection with the Tosawihi Shoshone (Harris 1940; Steward 1941) and the Tosawihi Shoshone retain knowledge of them (Richard Clemmer, personal communication), but the quarries did not become a subject of research until archaeologists began to work in the Humboldt Valley in the late 1960s. Heizer et al. (1968:23) speculated that the large number of white chert bifaces from South Fork Shelter resulted from use of the site by White Knife Shoshone. The existence of the Tosawihi Quarries was noted by Stephenson and Wilkinson (1969:50-51), citing a personal communication from knapping experimentalist, Don Crabtree, regarding the "Battle Mountain Quarries." Nevertheless, Mary Rusco properly is regarded the person who discovered the Tosawihi Quarries for archaeology. Rusco was first to map and describe the quarries in detail (Rusco 1976a, 1976b, 1979). She prepared a nomination to the National Register of Historic Places (Rusco 1983), and she was first to recognize the important role of Tosawihi toolstone in prehistoric economies of the Humboldt River Basin (Davis et al. 1976; Rusco 1978, 1982; Rusco and Davis 1979, 1987; Rusco and Seelinger 1974; Rusco et al. 1979, 1982). Although much of her work remains unpublished, Rusco was first to apply economic and geographic models to analysis of the distribution of Tosawihi chert.

Tosawihi is the largest known chert quarry in the Great Basin, and diagnostic projectile points suggest considerable time depth for its use. Tosawihi chert is distributed widely over a large region north of the Humboldt River, coinciding with the ethnographic territory of the Western Shoshone (Rusco 1979:2). White chert artifacts tend to dominate prehistoric assemblages between the Osgood Mountains and Elko in the Humboldt River Basin (Stephenson and Wilkenson 1969; Rusco 1976, 1979, 1982), as well as in uplands north of the river (Crittenden and Elston 1981; Elston et al. 1981; Clay and Hemphill 1986). The archaeological occurrence of Tosawihi-like white chert has been observed as much as 150 km from the quarries on the Snake River Plain (Rusco 1979, citing personal communication from Don Crabtree), and as far south as Gatecliff Shelter in the Monitor Range (Novick 1987). Even so, the proportion of Tosawihi chert decreases with distance until, at about 60 km, its dominance is replaced by other, more local materials (Rusco 1978; Tim Murphy, personal communication).

The distributional boundary at the Osgood Mountains is abrupt; west of the mountains, white chert is replaced by obsidian (Rusco 1979:2). For instance, Bard et al. (1979:86) report only a single white chert biface from Ezra's Retreat, a rockshelter site 65 km northwest of the quarries. This pattern, which coincides with the boundary between Northern Paiute and Western Shoshone, was noticed first by Stephenson and Wilkenson (1969:50-51), who observed that it appeared to be several thousand years older than the glotto-chronological estimate for the age of the cultural boundary.

Quarries in Archaeological Research

Interest in toolstone quarries began early in North American archaeology (cf. Holmes 1919; Honea 1983 and references; Ahler 1986:1), yet quarries only now are emerging from a long period of neglect that owed in large part to perceived methodological and technical problems inherent in their study (Ericson 1984:2; Purdy 1984:119-120; Torrence 1984:50). In the past decade or so, increased attention to adaptive cultural processes has subsumed the procurement and use of toolstone in subsistence systems and in trade (cf. Butler and May 1984; D. Davis, ed. 1978; Ellis and Lathrop 1989; Ericson and Earle 1982; Ericson and Purdy 1984; Johnson and Morrow 1987; Plew et al. 1985; Renfrew 1977; Vehik 1985; Wright 1977).

Microeconomics and geography provide theoretical approaches for most contemporary studies focused on quarry production and trade (Ericson 1977, 1984; Renfrew 1977; Torrence 1984, 1986; Luedtke 1984; Findlow and Bolognese 1984), while investigations of large scale lithic production and distribution systems, of which quarries are seen as one component, often incorporate aspects of Binford's (cf. 1983a) middle range theory regarding technological organization and mobility strategy (Goodyear 1979; Kelly 1985, 1988; Parry and Kelly 1987; Kelly and Todd 1988; Shott 1989). The organization of production at the toolstone source is seen as a crucial link between production technology and artifact distribution (Bradley and Edmonds 1988:181-183). Efforts to integrate ethnographic and ethnoarchaeological studies of lithic procurement (Binford and O'Connell 1984; Gallagher 1977; Gould 1977, 1980; Jones and White 1988) into archaeological investigations of lithic production (Leudtke 1984; Torrence 1986) are being made, and attention to site formation processes (Binford 1978a, 1978b, 1979, 1982; Schiffer 1987; Ahler 1986a) operating at quarries is apparent. With new theoretical approaches and methodological advances, the attributes of quarries that once dismayed archaeologists now are seen to offer enormous research potential.

Treatment of quarries in the Great Basin has paralleled that in the larger archaeological arena: for a long time they merely were noted (cf. Botti 1976; Davis 1964; Elston and Turner 1968; Grosscup 1956; Harrington 1951; Meighan 1955; Pippin 1980), but, with increasing frequency, they are being studied and described at various levels of detail (Elston and Zeier 1984; Elston et al. 1987; Elston and Budy 1990; Livingston and Pierce 1988; Pedrick 1985; Ragier and Lancaster 1966; Raymond 1984; Rusco 1976a, 1979; Singer and Ericson 1977; Thomas and Larsen 1988; Toney 1972; Tuohy 1970b). The present investigation of the Tosawihi Quarries, however, constitutes the first comprehensive investigation of a Great Basin chert quarry.

Lithic Resource Procurement in the Archaeological Record

Procurement of most biotic resources by hunters and gatherers usually leaves few residues and artifacts scattered widely across the landscape. Because non-lithic artifacts and procurement residues rarely survive long enough to enter the archaeological record, the archaeological visibility of places where biotic resources are procured (*locations*; cf. Binford 1980:9) is generally low. Artifacts accumulate only at locations where resources are encountered consistently and sufficient artifacts are discarded. Procurement *facilities* (hunting blinds, drive fences, weirs, etc.) are likely to occur solely at locations where resources are sufficiently abundant to balance the cost of construction (Thomas 1983a:84). Tools and facilities afford indirect evidence of resource procurement, but residues providing more direct documentation are rare in Great Basin archaeology.

The remains of facilities used for processing and storage (hearths, roasting pits, cache pits, etc.), and fossil evidence of resource processing and consumption (charred seeds, pollen, phytoliths, bones, coprolites, etc.), are more common in field and base camps. Nevertheless,

the interpretation of procurement behavior from these data is not straightforward; such sites usually are removed from the procurement location, so that it is difficult to know what resources were available in the camp catchment compared to those actually taken. Moreover, as productivity and locations of biotic resources vary over the long run, human groups may modify their annual ranges (Binford 1983a:46-47), making it difficult or impossible to estimate important factors such as site catchment and transportation costs for various resources. In any case, preservation of procurement and processing residues is accidental, and their proportions in the archaeological record rarely reflect the proportions in which they were deposited originally (Schiffer 1987).

In contrast, quarries often preserve a chronicle of prehistoric human economic behavior unique in its completeness. A toolstone quarry such as Tosawihi offers a static resource to which people return again and again. The creation of extraction facilities (quarry pits and adits), along with toolstone processing, generate vast amounts of non-perishable quarry and manufacturing debris that unambiguously mark localities of toolstone acquisition. The assemblages of adjacent workshop and camp sites are dominated by debitage from processing and manufacturing, along with smaller quantities of tools and waste from support activities. There is little doubt of the association between workshop-residential sites and toolstone quarry locations, even when separated by some distance.

Cultural and natural processes work to form and transform the archaeological record, and organic artifacts used to extract, process, and transport toolstone (digging sticks, antler wedges and percussors, baskets, etc.), along with subsistence residues, are no more likely to be preserved at quarries than they are at other kinds of open sites. But because toolstone is resistant to chemical and biological processes that degrade organic artifacts and residues, all the products and by-products of lithic procurement and processing at quarries that were not carried away by humans, or (in a few cases) transported or destroyed by violent geological processes (floods, volcanic eruptions, etc.), remain in the same proportions they were discarded (Schiffer 1987:27-28).

Consequently, the Tosawihi Quarries and surrounding archaeological sites contain a vast, relatively intact record of prehistoric toolstone procurement, along with a much smaller and less complete record of other activities. Over something like 11,000 years, the location of the toolstone resource remained constant; other factors affecting the costs and benefits of toolstone procurement, including social boundaries, settlement-subsistence strategies, trade and exchange systems, and technology are likely to have varied.

Research Potential of the Tosawihi Quarries

Tosawihi thus is an unusual place in the prehistoric landscape of the Great Basin, with enormous potential for investigation of the economics and organization of toolstone procurement; we consequently identified a number of research topics relevant to the quarries and their vicinity during the initial stages of our investigations (Elston 1988a). In broad categories, they include chronology, paleoenvironments, technological organization, subsistence strategies, the economics of lithic production, transportation, site structure and distribution, assemblage diversity, and site function. This list has been refined continually as we have gained information about particular areas and sites through testing (Elston 1989) and through the data recovery program reported here. It is important to note, however, that plans for intensive exploration and development of gold properties coincident with the Tosawihi Quarries vicinity, a matter of Federal oversight and regulation, prompted our Tosawihi research, *with investigations responding to the geography and schedule of minerals development.*

Most of the discussions contained herein are framed with reference to four subareas of the Tosawihi vicinity that we have investigated at various times and with various strategies

(Figure 1). Beginning work in 1987, we first surveyed the Tosawihi Quarries (26Ek3032; cf. Elston, Raven, and Budy 1987) in response to minerals exploration plans and surveyed the Western Periphery (Budy 1988), still in 1987, in response to a mine plan of operations. The Eastern Periphery (Raven 1988), corresponding to ancillary mine facilities, was surveyed early in the 1988 field season. The Northern Corridor, corresponding to a route that would permit the mine to be accessed from the north, was surveyed variously in 1988 (Drews 1988), 1989, and 1990. The 1988 field season saw a testing program underway that examined more than six score sites to be affected by mine development (Elston 1989). Testing assessed the significance and data potential of the sites so that formal data recovery plans (Intermountain Research 1988a-d) could be developed for those to be excavated. The twenty-five sites selected for data recovery, comprising the subjects of the present report, were investigated in the 1989 field season. The reader will discover that, while we observe Tosawihi from the perspective offered by these 25 sites, we broaden the perspective by drawing upon data developed during inventory of 238 sites and 225 localities*, and upon data and assemblages recovered by tests of 67 of them.

Without apology we observe that geographic constraints prevent the full study of numerous research questions in the present phase of investigation. At any point in time, toolstone procurement at Tosawihi was but one aspect of a cultural and economic system operating over a large area. Ideally, we would include the Tosawihi Quarries in a large scale, regional study (cf. Thomas 1983a, 1983b, 1988; Bettinger 1975, 1989; O'Connell 1975; Beck 1984), making sure to obtain an unbiased sample of sites from the entire area in which Tosawihi toolstone was processed and used, but presently this is not possible. Moreover, the location and shape of areas of minerals development strongly influence the sample of places so far investigated toward residential/workshop sites adjacent, but peripheral to, the main quarries. In comparison, we have studied relatively few quarry pits, or more distant, less quarry-related, sites. This effects our ability to address certain aspects of production, transportation, site distribution, technological organization, and assemblage diversity, while shallow soils and poor preservation of plant and animal remains in most sites limit studies of subsistence and paleoenvironmental reconstruction. Nevertheless, we have a full plate with regard to archaeological research at Tosawihi. The economics and organization of toolstone procurement are the major foci of our research, guided by the model outlined in Chapter 3 and developed more fully in subsequent chapters. In the process, we establish a theoretical and methodological framework that will facilitate future regional and local studies of the Tosawihi Quarries.

* The Tosawihi Quarries are known administratively as site 26Ek3032, a designation referring to a piece of the Tosawihi landscape encompassing discrete cultural localities that, for the most part, appear against a variable density background of opalite debitage.

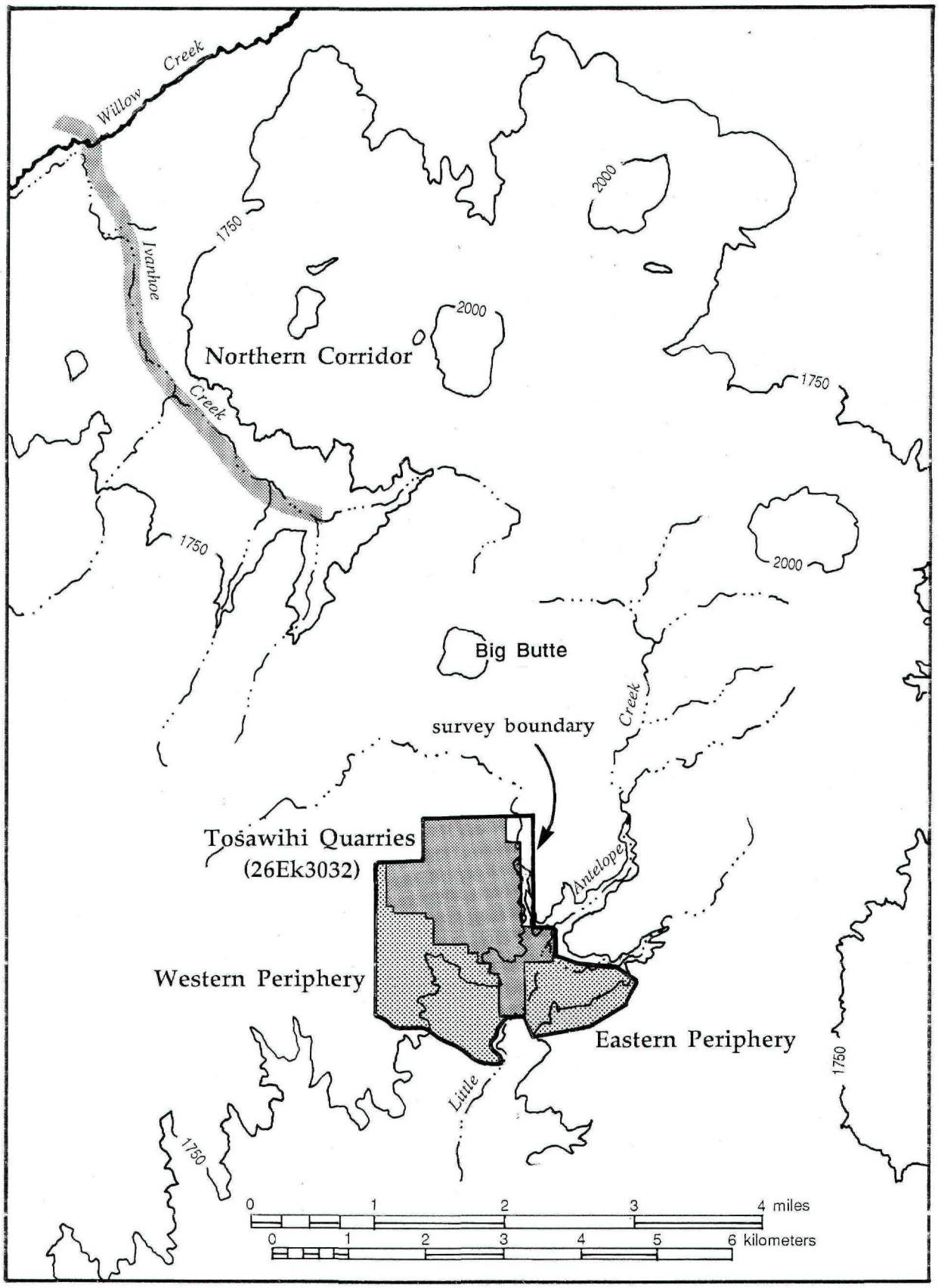

Figure 1. Principal study areas of the Tosawihi vicinity.

Chapter 2

THE NATURAL AND CULTURAL LANDSCAPE

Christopher Raven

The quarry lies like a jewel on the breast of the mountains, quiet, white, brittle, permanent, valuable. For ten millennia visitors carried its fragments away, sometimes far. Inexhaustible, it always offered measurable worth, while the lure of other landscapes fluctuated with the fortunes of warmth and water and plants and animals.

— Field Notes, 1989

To Aristotle's observation that four maps can be drawn of any landscape without repeating information, we are inclined to respond that that is not enough. Anthropologists have come to value information on the distribution of things in space, believing that spatial structures affect workable economies importantly and dictate a very great part of human behavior. To understand spatial aspects of behavior, then, or to anticipate their plausible alternatives, we need to map the multifactorial landscapes in which they are enacted, since the geography of opportunities substantially conditions the geography of events.

The landscape of central northern Nevada is subtly diverse in ways that always influenced how its various parts were used. Opportunities are scattered in space, and some of them in time, and efficient exploitation of the more valuable resources of the high desert province certainly always has required that foragers strategize their movements judiciously. The ricegrass comes to seed-ripe only for a brilliant, brief episode of every year, and Basin wildrye follows some months later, often in the same places. Deer observe seasonal agendas, and antelope congregate on the kidding grounds only episodically, and only in early spring. Most water fails by mid-summer under the current regime, and there is nothing to drink for the rest of the year throughout patches as large as 400 sq. km. Clearly, strategies of timing and placement, and the careful timing *of* placement, determined for many centuries where successful foragers should go, why and when they should go there, and what they should do at their destination.

The Countryside

Central northern Nevada lies on the poleward rim of the Great Basin (Figure 2). As elsewhere in the province, xerophytic plants and animals swarm sparsely across an arid landscape of basins and sometimes craggy ranges. Surface waters settle in sinks and evaporate, or they run off down the tilts of the landscape to settle and evaporate in lower, more distant sinks. The short summers are hot and the much too long winters cold (mean monthly temperatures range from a January low of -5° C to a pleasant high of 21° C in July), and the annual precipitation of 10 - 40 cm is realized chiefly as snowfall (Houghton, Sakamoto, and Gifford 1975; Brown 1960). Elevation (ranging from 1340 m to 2950 m amsl) dictates an acute spatial zonation of climate in any season. The Tosawihi Quarries occupy an intermediate upland (ca. 1600 m to 2100 m amsl) that experiences neither of the region's climatic extremes, although field crews have been heard to complain in the same month of debilitating afternoon heat and bone-numbing chill after dark.

While virtually all attributes of the landscape mosaic influenced to some degree how its various places were used by prehistoric human groups, we are concerned here particularly with details of geology, hydrology, flora, and fauna, since those configurations defined the principal opportunities, as well as the principal limiting factors, confronting foragers in the past.

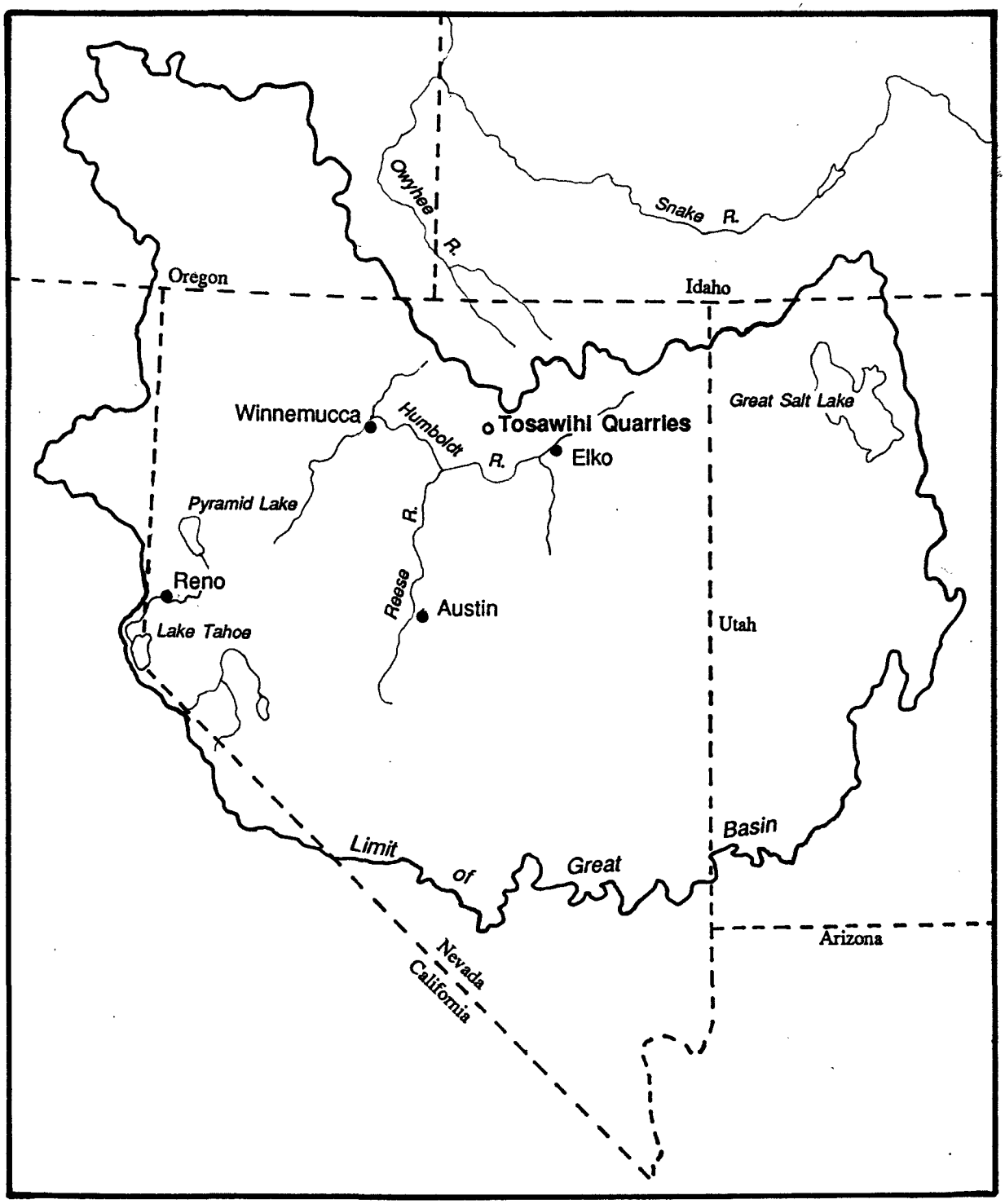

Figure 2. The Tosawihi Quarries in the Great Basin.

Landforms and Rocks

A long and complex geomorphic history has been played out in central northern Nevada, but the effects of most of its older events have been obscured from the contemporary landscape; the consequences of early episodes of mountain building largely have eroded away, and early sea beds lie buried by the sediments of later regimes. Geologically detectable only at depth, or in rare, more recently uplifted exposures, few pre-Cenozoic events left traces that could have been of much import to prehistoric foragers. Thus the dramatic upheavals of the Antler orogeny, a Devonian episode during which a wandering volcanic arc collided with what then was the western littoral of the continent and thrust upward a great shoreline highland, 90 km wide and meandering across our area of interest, are little evident on today's surface; most consequences of the event simply were washed out to sea or became buried by subsequent deposition (Coats 1987:85-87; Fiero 1986:86-90; Stewart 1980:36-41). Likewise, the Triassic arrival and continental accretion of the Sonomian land mass, although it altered substantially the relative configurations of land and sea, left surfaces largely eroded during the Jurassic and buried by the volcanism of later periods (Fiero 1986:95).

Even the turbulence attending the breakup of the Pangean protocontinent made less impact on the *effective* Holocene landscape than did the great volcanic storms of the mid-Cenozoic (especially, the Miocene), when massive ashes, ash-flow tuffs, and rhyolites spilled over the countryside (Fiero 1986:117-120). Coats (1987:68) plots the distribution of Miocene rhyolitic domes in southwestern Elko County, embracing the Tosawihi vicinity in what may be an enormous volcano-tectonic depression (Figure 3; cf. Coats 1987:67-69). Another wave of volcanism, coincident with Miocene extensional faulting that produced the principal overt topography of today's basin and range province, introduced basaltic and andesitic flows that now dominate much of the surface geology of central northern Nevada (Fiero 1986:134).

In the immediate vicinity of the Tosawihi Quarries, late Miocene or early Pliocene alteration of Tertiary volcanics modified the lithic terrane of the countryside in a way that was to have important economic consequences for both prehistoric and historic visitors. Hydrothermally-induced silicification of the rhyolitic ashes and tuffs left vast beds of a milky, internally homogenous opalite (Figure 4; cf. Bailey and Phoenix 1944:17-21) that evolved, over millennia of dehydration and crystallization, into a workable toolstone of remarkable durability. The chert-like cryptocrystallines of the Tosawihi Member (a name we propose here because the group has not been named geologically, although its incidence has had enormous long-term impact on prehistoric and historic land-use patterns) became the preeminent lithic raw material favored locally over the past several millennia for the production of stone tools. That its upper components trapped lodes of cinnabar rendered it attractive as well to mercury miners in the earlier decades of the present century, and prompted the initial historic exploitation of the Ivanhoe Mining District (Bailey and Phoenix 1944; Benson 1956; Hollister 1986:4; Smith 1976; Zeier 1987:4-8). Thus virtually the entire archaeological record of the vicinity, both prehistoric and historic, is likely to have been related intimately to the value and utility of the stones of the Tosawihi Member.

Water

Despite the inundations of the Pleistocene, the Tosawihi vicinity never retained a pluvial lake of any magnitude (Mifflin and Wheat 1979); the slope of the countryside was sufficient, and runoff corridors sufficiently available, that central northern Nevada missed the lacustrine episodes that punctuated the Holocene history of most of the rest of the state. The Tosawihi Quarries and their hinterlands lie entirely within the higher, eastern reaches of the Lahontan hydrographic basin (Mifflin and Wheat 1979:Pl. 1), from which surface waters drain west down the Humboldt River system to their terminal basin in the Humboldt and Carson Sinks. The

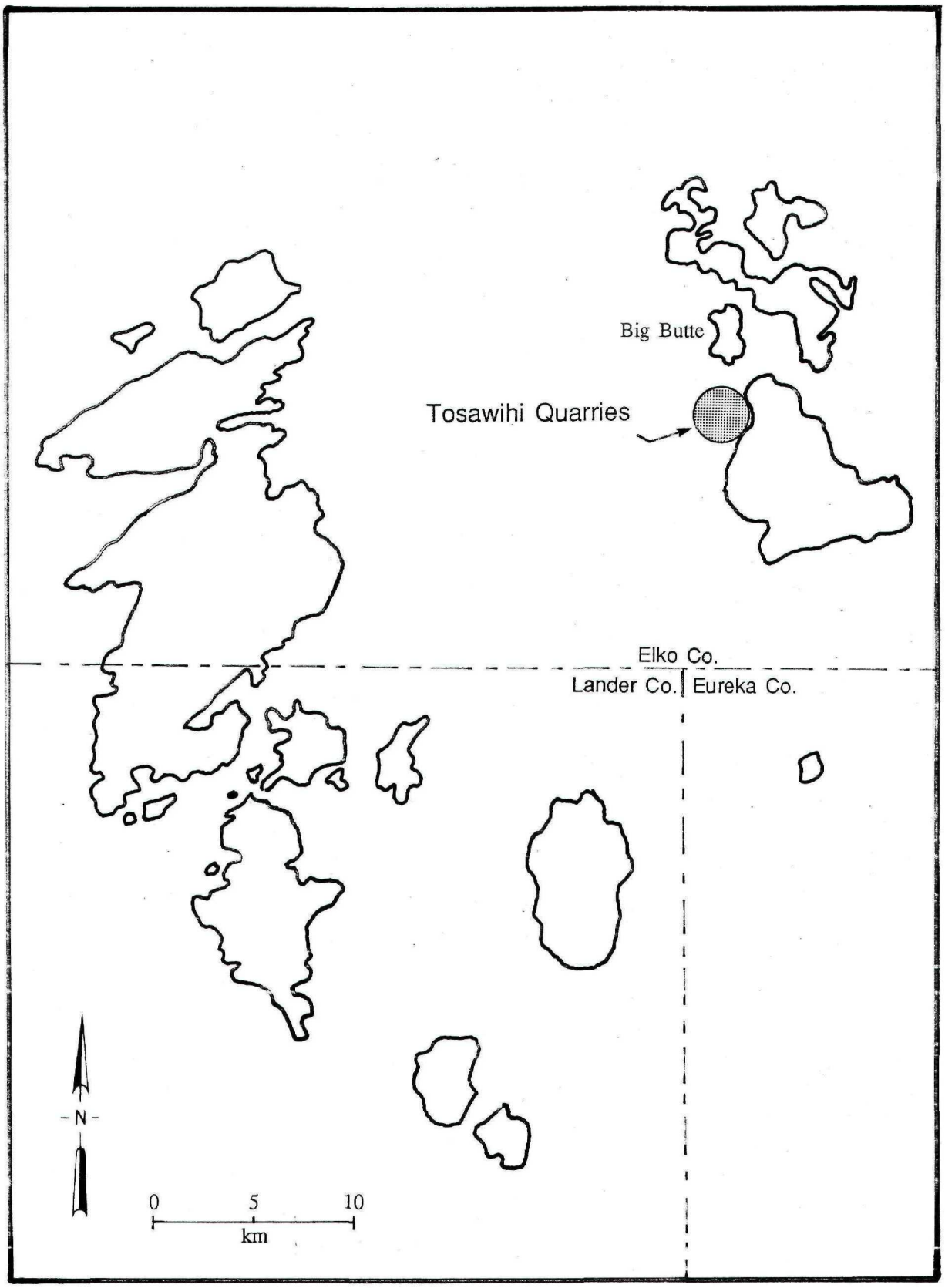

Figure 3. Miocene rhyolitic domes in Southeastern Elko County (after Coates 1987:68).

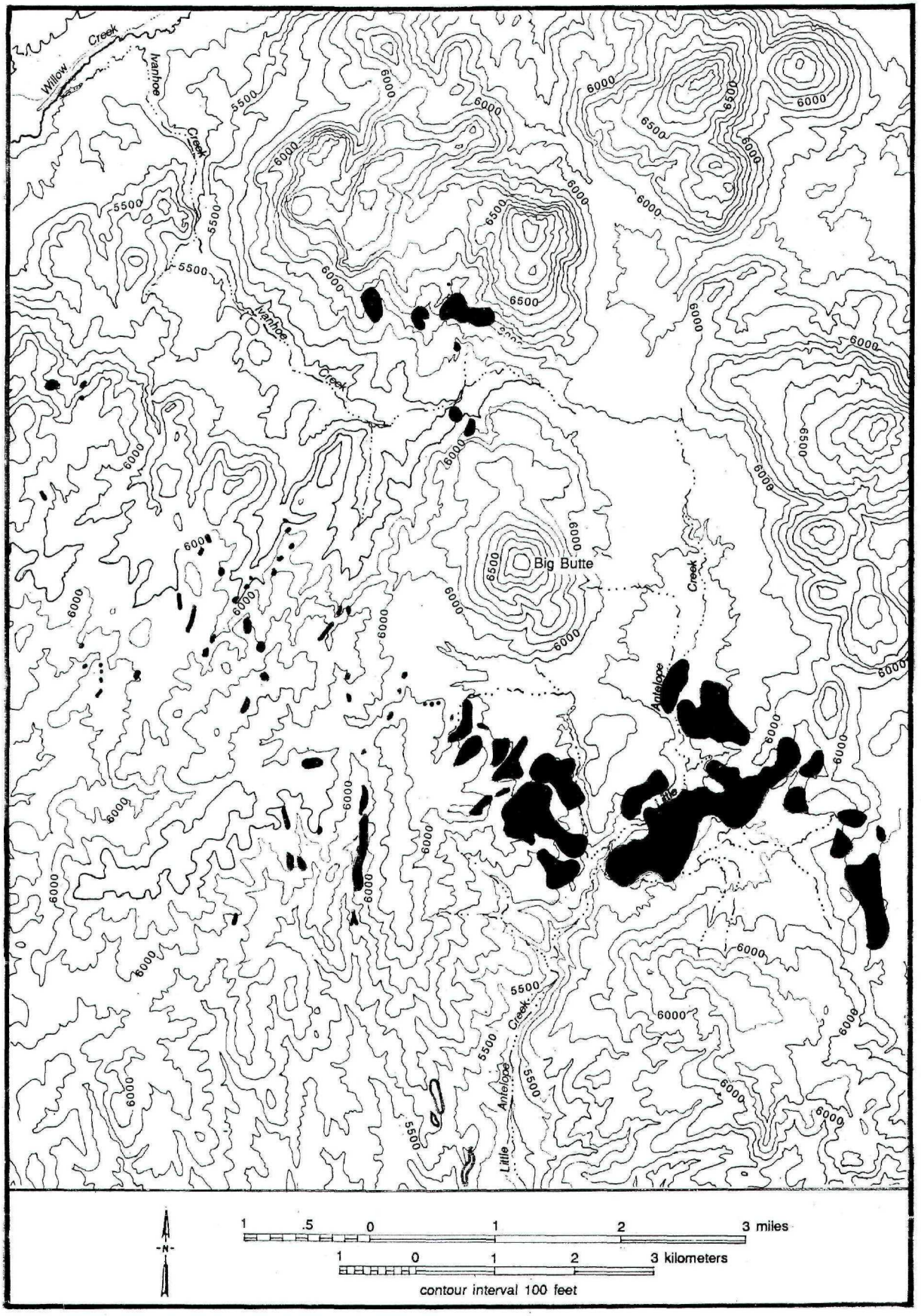

Figure 4. Silicification of the Tosawihi vicinity (after Q. Deng and R. Gosse 1990).

nearest Late Quaternary pluvial lakes stood in Buffalo Valley and Paradise Valley (the easternmost embayment of pluvial Lake Lahontan), about 75-80 km west and southwest of Tosawihi, and in Grass Valley, Diamond Valley, Ruby Valley, and Clover Valley, about 115-130 km to the south and southeast (Figure 5). We should not expect, then, to find in the local archaeological record much reflection, except indirectly, of the "Western Pluvial Lakes Tradition," a pervasive lake-margin orientation dominating much of the prehistory of the western Great Basin during the period 9000-6000 B.C. (Bedwell 1969, 1973).

The quarries lie well up the minor tributaries of the Humboldt River (Willow Creek and Rock Creek, both perennial, and the seasonal flow of Little Antelope Creek), only some 20 km from the hydrographic divide separating the Great Basin from the drainage of the Columbia River Basin (Figure 6). Waters falling north of the divide run down the branches of the Owyhee into the great westward-draining system of the Snake, thence into the Columbia, to empty finally into the Pacific Ocean. We do not think that there have occurred any very important changes in these drainage patterns during the entire time that people have inhabited the region. The issue merits note because the hydrologic location of the Tosawihi vicinity *may* have affected the economic orientations of prehistoric foragers importantly by bringing within the compass of a single day's walk access to a valuable riverine resource (salmon) generally not available to most other Great Basin groups. Some implications of this geography are discussed later in this chapter, and will be explored further in Chapter 20.

Water is scarce at Tosawihi under the current climatic regime; while perennial streams flank the vicinity, only ephemeral drainages transect it, fed chiefly by direct runoff from a watershed of modest size (Figure 7). The deeply-carved gorges of Little Antelope Creek and its immediate tributaries testify to a history of more substantial flows in the past, or to very long past episodes of gradual incremental scouring, but today (based on field observations from 1987 to 1990) their transport is minimal and they go dry by August every year. Too, the shallow aquifer generates few springs (Tosawihi Springs and Antelope Spring in the main body of the quarries, greater upwellings at Ivanhoe and Buttercup Springs near the Northern Corridor, and single minor seeps in the Eastern and Western Peripheries; cf. Figure 7). Of these, only the northern pair has continued to yield water past August in recent years, maintaining a modest, late-summer flow in Ivanhoe Creek; we infer that from time to time over much of the Holocene access to water must have imposed severe constraints on human exploitation of the quarries. On the other hand, various relict spring mounds (chiefly in Big Butte Valley) attest to more generous hydrologic regimes in the past, and the coincidence of archaeological habitations at the same locales argues that these defunct springs were productive during various periods of prehistoric human occupancy.

In part, the present dryness of the region may owe to a general recent decline in the local water budget, but it unquestionably has been affected as well by modern practices of intensive livestock grazing that have encouraged the proliferation of tap-rooted plants, sapping the aquifer and consequently lowering the water table. It is not unlikely that curtailment of the current grazing regime would result in measurable increases in spring productivity through all seasons, and a florescence of spring-associated vegetation.

Plants

Central northern Nevada occupies the heart of the Artemisian biotic province, a high desert countryside in which soils, landforms, temperature, and moisture conspire to sustain a shrubby upland dominated by big sage (*Artemisia tridentata*) and low sage (*Artemisia arbuscula*), perennial bunchgrasses including Great Basin wildrye (*Elymus cinereus*), bluebunch wheatgrass (*Agropyron spicatum*), fescues (*Festuca* spp.), and squirreltail (*Sytanion Hystrix*), and a host of spring-maturing forbs. The landscape is virtually treeless save where, at higher elevations, it is interspersed with fingers of the Montane Zonal Series (Billings 1951:113-119;

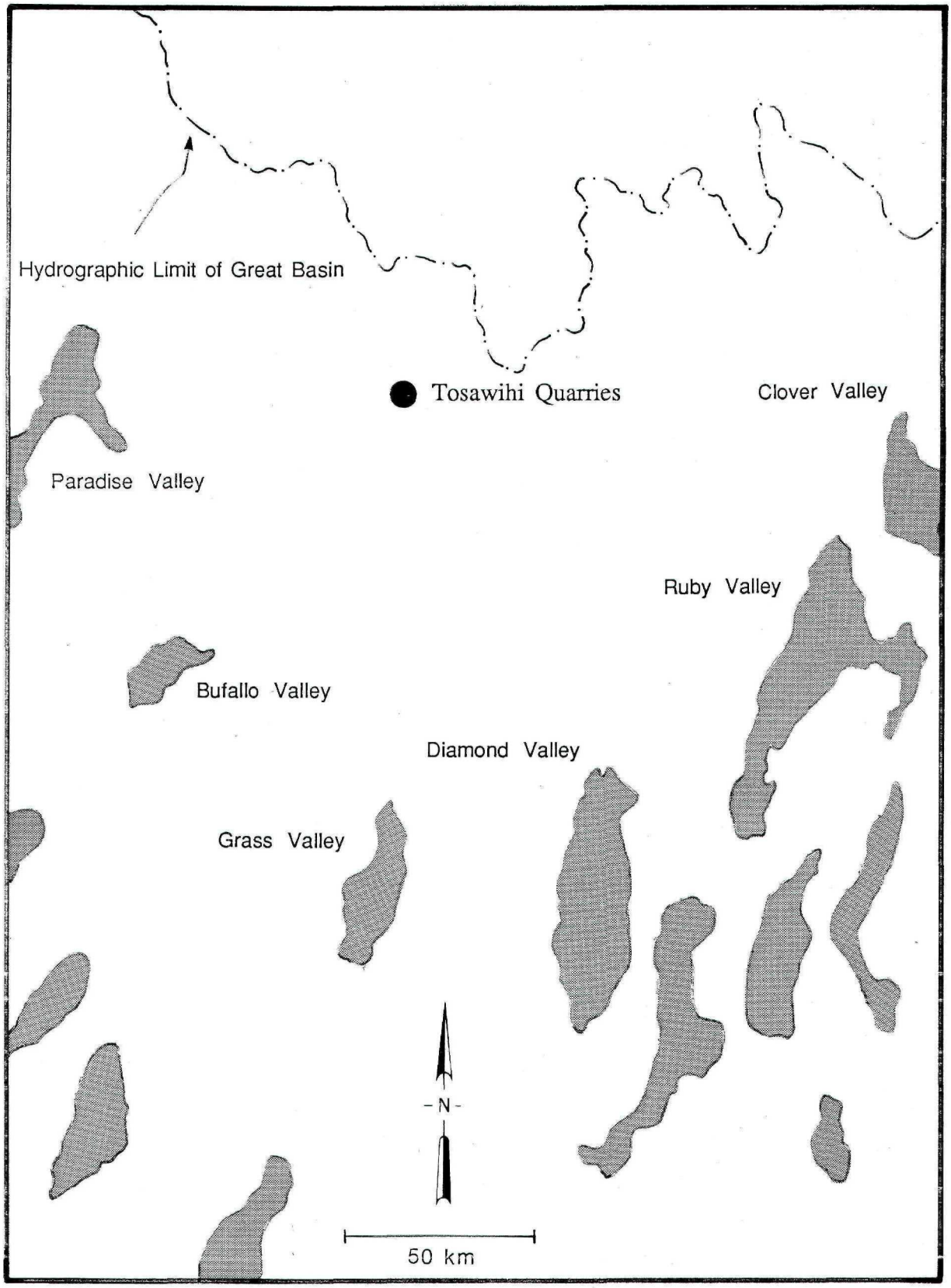

Figure 5. Late Quaternary pluvial lakes in Central Northern Nevada, Tosawihi vicinity (after Mifflin and Wheat 1979).

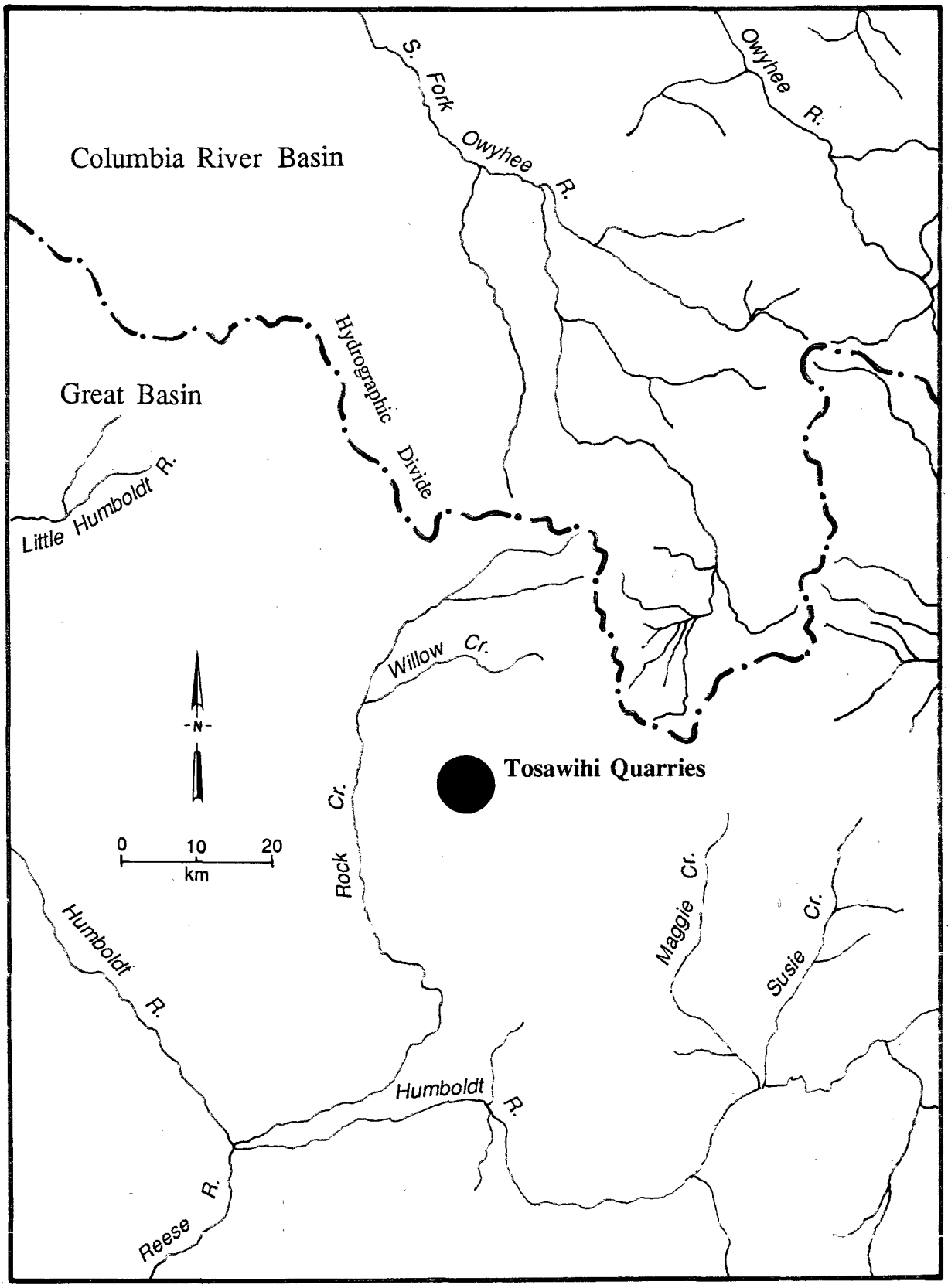

Figure 6. Principal perennial streams of Central Northern Nevada, Tosawihi vicinity (after U.S. Fish and Wildlife Service 1978).

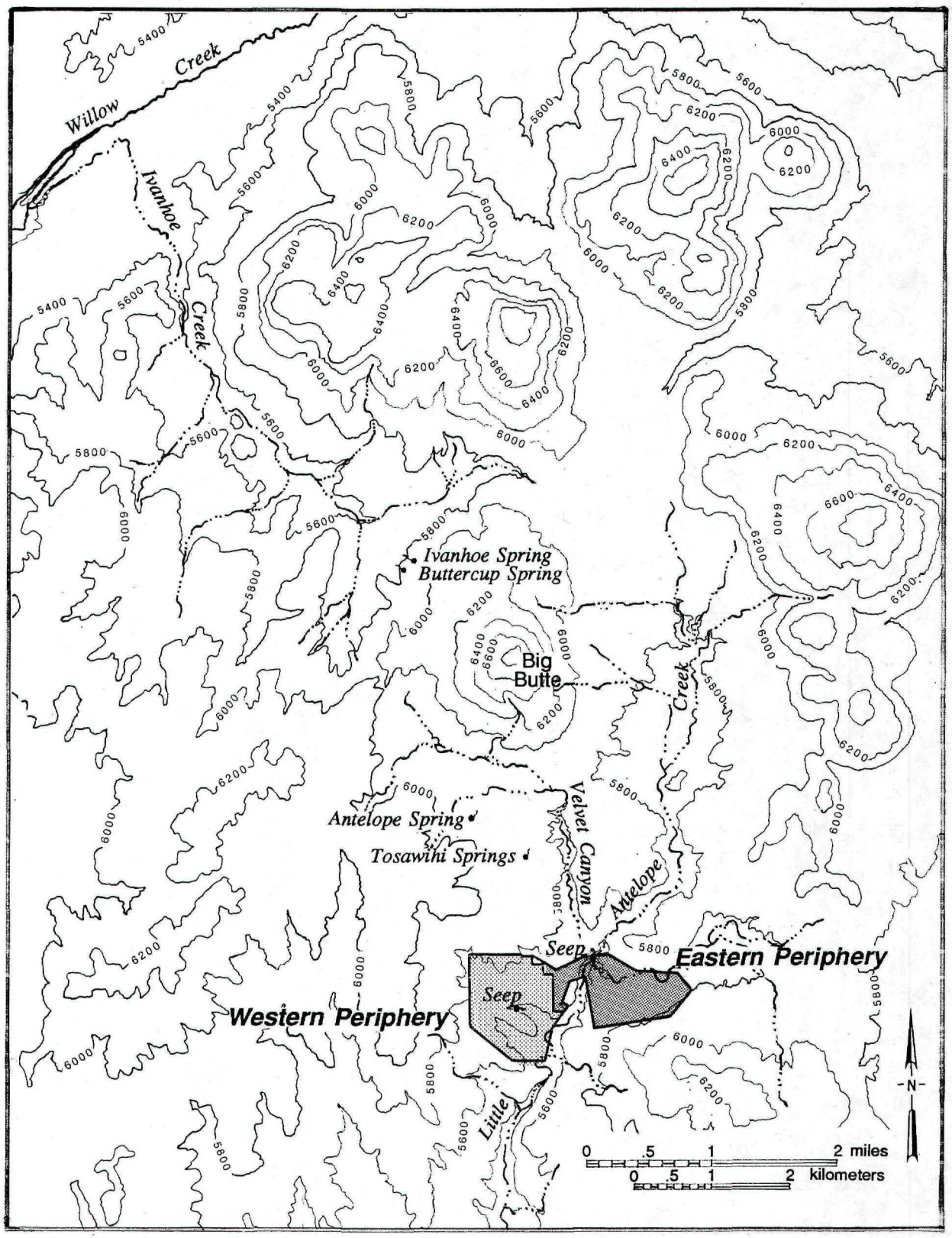

Figure 7. Water sources in the Tosawihi vicinity.

cf. Figure 8), in which stands of juniper (*Juniperus utahensis*) and pinyon (*Pinus monophylla*) are fringed by a mountain shrub association that includes bitterbrush (*Purshia tridentata*), mountain mahogany (*Cercocarpus ledifolius*), snowberry (*Symphoricarpos* spp.), and serviceberry (*Amelanchier alnifolia*). The distribution of pinyon, a major mid-to-high altitude subsistence resource in many other Great Basin settings, is latitudinally constrained; generally, the species does not occur north of the Humboldt River, and is absent from the Tosawihi vicinity.

Tosawihi lies in the rolling, mid-elevation sage grassland. There are no trees, and the largest shrubs we have seen are a few very widely-spaced serviceberry on the upper slopes. Big sage and low sage communities are interdigitated intricately on every hillside and crest, interspersed with phlox (*Leptodactylon* sp.) on the shallower, rockier soils and rabbitbrush (*Chrysothamnus* sp.) on the siltier flats and floodplains. In much more limited arenas (canyon bottoms and heavily shaded northern exposures, comprising less than 5% of the study area) relatively lush stands of wild rose (*Rosa* spp.) cluster with gooseberry (*Ribes aureum*), chokecherry (*Prunus virginiana*), serviceberry, and willow (*Salix* sp.), and the sandy floors of some of the gorges are laced with intermittent patches of *Artemisia ludoviciana*, an annual sage. A few otherwise barren exposures in the eastern periphery host unexpected clumps of *Coryphantha vivipara*, a small cushion cactus.

While all parts of the area currently are subject to intensive livestock grazing, and thereby express ecologies dependent on forces not at play in prehistoric times, native perennial grasses remain abundant in some settings; especially rich stands of Great Basin wildrye and bluebunch wheatgrass occur just north of the quarries, and virtually no patch is devoid of at least a sparse grassy understory (chiefly squirreltail, fescue, and bluebunch wheatgrass). Cheatgrass (*Bromus tectorum*, an alien annual) has encroached most disturbed zones, and in Big Butte Valley cheat grass, mustard (*Brassica* sp.), and thistle (*Cirsium* sp.) have rushed to occupy a large tract (more than 100 acres) recently burned. Too, grasses (both alien annuals and native perennials) are especially abundant on the berms of recent (historic) disturbances.

Scattered throughout the shrub communities are numerous forbs, among them various species that, prehistorically, may have held economic importance as food plants. In several settings, but never in great abundance, we have found various buckwheats (*Eriogonum* spp.), globe mallow (*Sphaeralca* sp.), *Mentzelia*, lupine (*Lupinus* sp.), larkspur (*Delphinium nuttallianum*), and bitterroot (*Lewisia rediviva*). Sedge (*Carex* sp.) and curly dock (*Rumex crispus*, an alien introduced during the past century) are found in a few wet meadows.

None of these plants is so abundant under the current ecological regime, so densely clustered, or so nutritionally valuable that it is likely to have formed a basis for prehistoric subsistence strategies. The grasses (and, by extrapolation, most of the edible forbs and shrubs; cf. Simms 1987) are low-ranked food resources, costly to procure or process when measured against their caloric returns. Too, their seasonal availability defines a fairly narrow window of time (roughly, May through July) during which foragers realistically might expect to harvest plants at Tosawihi. Even absent domestic livestock grazing there would be little plant food around the quarries, suggesting that, unless major climatic fluctuations have altered the biosphere substantially (and we have no data directly informative of this at present; cf. Drews et. al 1989:397-398), most currently observable plants played only marginal, incremental roles in the diet breadth of prehistoric quarriers. Some implications of our scant archaeological evidence reflecting the use of plants at Tosawihi are discussed further in Chapter 20.

Animals

Central northern Nevada falls within the Upper Sonoran and Pinyon-Juniper subdivisions of the Upper Sonoran life zone as defined by Merriam (1889), the largest and most diverse life zone of the state. Hall (1946:34-41) reports 83 mammalian species occurring

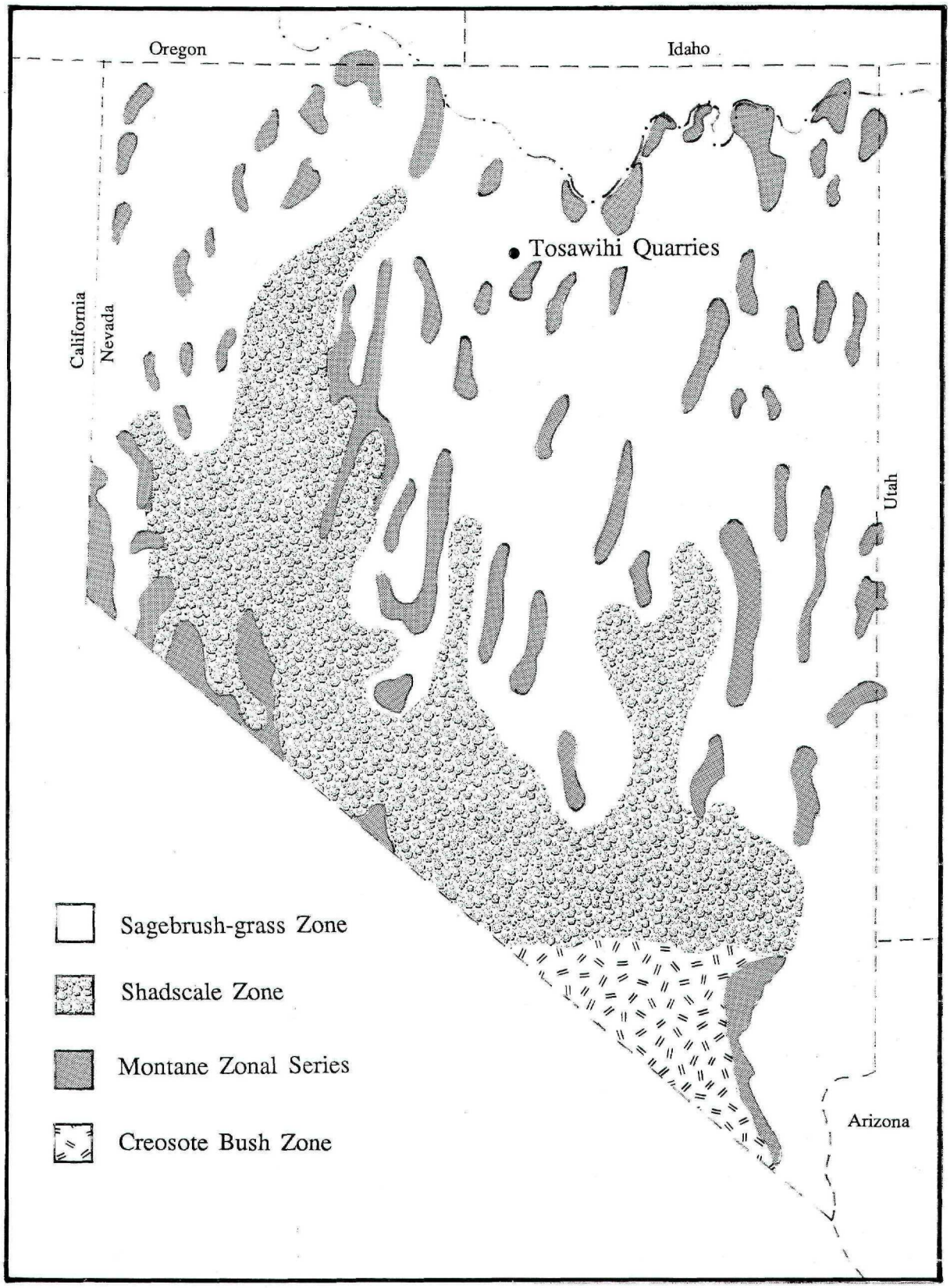

Figure 8. Principal Nevadan vegetation zones (after Billings 1951).

within it; of these, the populations of 35 species are exclusive to the Upper Sonoran or are denser there than within any other life zone. Characteristic species range from insectivores to artiodactyls, of the latter of which antelope (*Antilocapra americana*) and bighorn sheep (*Ovis canadensis*) find the Upper Sonoran their favorite Nevadan habitat. A cross-cutting zonation based on species distributions and centers of differentiation places our area of interest in the Elko center of the Central Rocky Mountain faunal area (Hall 1946:44-47), marked particularly by the exclusive occurrence of the Wyoming (Richardson) groundsquirrel (*Spermophilus elegans* [=*richardsonii*]) and subspecies of vagrant shrew (*Sorex vagrans amœnus*) and western jumping mouse (*Zapus princeps nevadensis*).

Because water is scarce and seasonal and the plant cover neither diverse nor particularly productive, there are not many animals around Tosawihi. Of larger mammals, only antelope and mule deer (*Odocoileus hemionus*) still come into the region, antelope on the open, rolling sage expanses and deer in the more sheltered gorges and upland crevices where tall shrubs and browse species cluster. Bighorn sheep currently reside no nearer than the Snowstorm Range, ca. 20 km northeast of the quarries (K. Gray, Nevada Department of Wildlife, personal communication 1989), but the recovery in 1988 of an immature sheep horn from the surface of a locality of archaeological site 26Ek3032 suggests that their residency in the Tosawihi vicinity lapsed only recently (i.e., within the present century?). Moreover, the unverified sighting of putative elk (*Cervus canadensis*) in Big Butte Valley in fall, 1987 (reported by C. Raven), and the observation (but *not* the collection) of an apparent elk antler on the slopes of Big Butte in 1989 (reported by S. Botkin), provocatively suggest that these rare but highly mobile artiodactyls still may traverse the region sporadically. Of course, the archaeological recovery of bison (*Bison bison*) bones from various contexts (cf. Chapter 14, this volume) implies prehistoric access to an even richer base of large game, irrespective of whether the species resided locally.

Smaller mammals are far more abundant, and include species of insectivores, bats, carnivores, rodents, and lagomorphs. While no formal species census has been compiled for the study area as a whole, we have, during the course of four seasons of archaeological survey and excavation, observed pocket gopher (*Thomomys* sp.), wood rat (*Neotoma cinerea*), chipmunk (*Tamias* spp.), various ground squirrels (*Spermophilus* spp.), marmot (*Marmota flaviventris*), cottontail rabbit (*Sylvilagus nutallii*), pygmy rabbit (*Sylvilagus idahoensis*), jackrabbit (*Lepus townsendii* and *L. californicus*), bats (order CHIROPTERA), badger (*Taxidea taxus*), kit fox (*Vulpes macrotis*), and coyote (*Canis latrans*). We suspect that most of the species identified by Hall (1946) as characteristic of the high valley/foothill biomes of central northern Nevada also may occur in the area, or may have done so in protohistoric times before livestock grazing induced a measurable attrition of habitat. Almost certainly, at least, our casual observations have under-represented the diversity of resident rodents, insectivores, and probably carnivores.

The very complex distributions of birds believed to inhabit the Tosawihi vicinity are discussed by Linsdale (1936; also cf. Ryser 1985); our far from exhaustive observations have logged sightings of golden eagle (*Aquila chrysætos*), red-tailed hawk (*Buteo jamaicensis*), kestrel (*Falco sparverius*), great horned owl (*Bubo virginianus*), common raven (*Corvus corax*), turkey vulture (*Cathartes aura*), sage grouse (*Centrocercus urophasianus*), and chukar partridge (*Alectoris chukar*), an introduced species. Numerous unidentified smaller birds inhabit each of the varied settings.

La Rivers (1962:101-104) discusses the fisheries of the Lahontan river system, wherein he counts ten original species still present during the historic period (also cf. Coffin 1984 and Sigler and Sigler 1987 for more general discussions of Nevada and Great Basin fishes). Most likely to have been important in prehistoric economies along the upper Humboldt and its tributaries are Lahontan cutthroat trout (*Salmo clarki henshawi*), Lahontan mountain sucker (*Pantosteus lahontan*), Lahontan tui chub (*Siphateles bicolor*), and perhaps the Tahoe sucker (*Catostomus tahoensis*). At Tosawihi we have observed only a few dace (*Rhinichthys* sp.) in spring-head ponds and some pools along Little Antelope Creek, suggesting that bigger fishes probably came no closer to the quarries than Rock Creek, ca. 10 km to the west, or its tributary Willow Creek, ca. 8 km north.

Of particular interest, however, is that neighboring our area of interest, just over the northern rim of the Great Basin, king salmon (*Oncorychus tshawytscha*) ran some 1800 miles upstream from the Pacific to spawn in the headwaters of the Owyhee River as recently as 1895 (La Rivers 1962:249-250; Gilbert and Everman 1985). Tremewan (1964) provides a vivid, first-person, past-century recollection:

> The salmon used to run up the South Fork of the Owyhee every spring. The ranchers in the Independence Valley and the people in Tuscarora would take them with pitch forks and spears...I remember the run of 1887. Those fish even went up that little stream that runs down through Tuscarora. It dried up completely in the latter part of July, but when it was high in the spring, the salmon could go up. Old Jess Snyder went out with a pitch fork one day and right under the bridge, he saw one spawning. He just put the pitch fork under it and heaved it on the bank. The fish weighed about 30 pounds.
>
> The Indians used to get them too. They would work the country near the reservation and bring them to Tuscarora in wagon loads.

Tremewan further recalls an abundant spring run of spawning cutthroat trout in the Humboldt.

Reptiles, whose regional distributions are described by Stebbins (1966), occur widely throughout the study area, although seldom in abundance. At virtually every site we observed one or two lizards, chiefly western whiptail (*Cnemidophorus tigris*), horned lizard ("horny toad;" *Phrynosoma* sp.), and side-blotched lizard (*Uta stansburiana*). In most settings snakes are scarcer or more furtive, but field crews have noted a few garter snakes (*Thamnophis elegans*) and gopher snakes (*Pituophis melanoleucus*) in all subareas, and just enough western rattlesnakes (*Crotalus viridis*) to inspire lingering caution.

Some Implications of the Coincidence of Resources

Why should prehistoric foragers have gone to Tosawihi? How are their activities likely to have been distributed over the landscape? And what sort of archaeological record are they likely to have left? Each of these questions, we believe, can be informed by referring to the geography of resources in the vicinity of the quarries, and by paying particular attention to spatial patterns of resource co-occurrence.

In the preceding pages we have sketched some general resource configurations characterizing central northern Nevada, and have related them to more specific constellations that occur in the immediate Tosawihi vicinity. We have not, however, dealt much with how these resources are likely to have generated specific *opportunities* for the prehistoric foragers who used the countryside, since effective opportunities usually are products of the complex interplay of sometimes unrelated factors. The costs, for instance, of procuring non-biotic resources escalate sharply in regions where the biomass is so little productive that subsistence during the act of procurement must be supported by transported stores; likewise, biotic subsistence resources are more costly where the distribution of water imposes lengthy travel between camp and the foraging patch. In *any* real-world circumstance, the costs and consequent benefits of engaging in *any* foraging enterprise at *any* level of technological or social complexity are situational, responding to the spatial coincidence of target resources and support resources.

At Tosawihi, the resources whose abundances and distributions appear most likely to have conditioned prehistoric land-use patterns are knappable toolstone, large and small game, plant foods (particularly, seeds and roots), and reliable sources of water. Of these, water

doubtless constituted throughout the Holocene the most stringent limiting factor; most springs (excepting Buttercup and Ivanhoe Springs, near the Northern Corridor) often fail by mid-year, when streams have gone dry and rainfall happens no more frequently than once a month. Quite simply, past August it is a long walk to the nearest drink of water from most places in and around the quarries, and foragers intent on plying other resources of the landscape would be hard-pressed to stay long without carrying water with them.

Biotic resources impose different kinds of constraints but they, too, fluctuate seasonally in distribution and abundance. Large gregarious animals (calorically, the most profitable subsistence resources available in almost any landscape) are not likely to have been plentiful locally save under dramatically altered (i.e., moister or cooler) ecological regimes, although some antelope doubtless could be taken by hard-working hunters throughout spring and summer under current climatic conditions, and deer well into the fall. We doubt, however, that their biomass bulks so high that foragers interested chiefly in large game would be prudent to abandon other patches or patch clusters (such as the Humboldt River corridor, Rock Creek, the Willow Creek floodplain, or the Snowstorm Mountains) to come to Tosawihi. On the other hand, occasional, fortuitous captures of big game probably could be counted on in almost any year to supplement a more predictable lower-ranked diet for foragers whose visits were motivated by other quests.

The relative abundance of small game, however, particularly lagomorphs and rodents, tends to be high enough around springs and along watercourses, as well as in a few upland settings with deep, friable soils away from water sources (e.g., Rodent Valley) that even under today's arid regime they might effectively, though briefly, support modest foraging populations. The attractiveness of water sources with resident colonies of small game as camping spots or foraging patches, however, probably would decline rapidly were they exploited continuously, owing to the depletability of localized animal concentrations. We have noted, for instance, a fairly boisterous colony of marmots (which *should* be quite high-ranked small game, although formal estimates of their caloric foraging return rates have not been calculated; cf. Simms 1987) inhabiting the meadows around Buttercup and Ivanhoe Springs, but their numbers could be decimated quite quickly through effective snaring techniques, requiring that small game foraging move further afield from the camp.

Of currently available plant foods, the most profitable to collect are bitterroot, best taken in spring (Simms 1987:118), and the various summer and fall-maturing berries. The distribution of bitterroot now is limited to a small but fairly abundant patch in the southern portion of the Western Periphery and to extremely meager occurrences elsewhere; berries, found only in a few microenvironmental enclaves (e.g., certain canyon-bottom and rim-base settings) and as isolated specimens, simply could not constitute under the present regime an economically important fraction of a human subsistence base, although they probably always would be collected by foragers already in the area during the appropriate season. Other plant foods, such as grass seeds, are more nearly ubiquitous and usually occur in larger, denser stands, but collecting them and processing them as food require, on the whole, significantly greater investments of effort for significantly lower caloric returns (Simms 1987). They are, then, "costlier" resources to exploit, and reliance on them necessarily inflates the cost of other activities (such as toolstone procurement) dependent upon them.

Toolstone, of course, always was present where it is now (at least throughout the period of human visits to the area), and it constitutes the single invariable on our map of the useful resources at Tosawihi; it does not move across the landscape (except by human agency), and its abundance is unaffected by seasons. This does not mean, however, that quarriers always should have concentrated their efforts at the same places, yielding them only in response to the depletion of the highest quality material. Rather, the likelihood that any particular toolstone source would be exploited doubtless was a function *both* of its intrinsic material quality as well as of the costs of exploiting it and, as we have observed above, those costs were affected in part by the locations of critical support resources (water, animals, and plants) upon which the quarry party had to subsist.

Although we do not control sufficiently fine-grained data on resource distributions within the Tosawihi study area to sketch except in broad strokes where foragers most profitably could pursue their interests, we note that the landscape can be subdivided on the basis of a number of cross-cutting resource opportunities. Even at a rudimentary level of modelling, in which the landscape is characterized only by the presence or absence of four proximate resource categories, we can define sixteen possible resource *profiles* each of which may occur in our area of interest, and each of which would offer a different suite of resource opportunities. These conceptual profiles are listed in Table 1, wherein any point on the landscape can be characterized by the presence or absence of a nearby, economically exploitable abundance of opalite toolstone, animals (big *or* small game), edible plants, and water. Seasonality is not considered in the scheme, since the profile of any individual tract changes seasonally (and does not necessarily repeat the same cycle of profiles in any sequent pair of years); too, the scheme does not address the almost certain probability of major environmental change throughout the Holocene, which doubtless induced changes in the resource profiles of places but *not* in the relevant resource categories by which their attractiveness is likely to have been measured.

Table 1. Conceptual Resource Opportunity Profiles.

Toolstone	Animals	Plants	Water
1	0	0	0
1	0	0	1
1	0	1	0
1	0	1	1
1	1	1	0
1	1	1	1
1	1	0	0
1	1	0	1
0	1	0	0
0	1	0	1
0	1	1	0
0	1	1	1
0	0	1	0
0	0	1	1
0	0	0	0
0	0	0	1

1: Presence of Exploitable Resource
0: Absence of Exploitable Resource

Complex as the array appears, it is, of course, merely an abstraction of alternatives, than which the decisions confronted by real-world foragers are vastly more complex. On the one hand, various other lower order resource distributions and landscape attributes also come into play; the availability of suitable hammerstones, for instance, affects the economics of quarrying and reduction, and topography affects the selection of campsites. On the other hand, our simple presence/absence dichotomy no more than symbolizes a suite of resource values the actual quantification of which complicates enormously the profile of each place, and renders the assessment of resource tradeoffs a labyrinthine exercise in cost/benefit decision making. In other terms, each instance where we recognize the *presence* of a resource actually represents a *value* measurable in various currencies (e.g., abundance, accessibility, and quality of toolstone, caloric return rates of foraging for available biotic species, abundance and reliability of water), and each value influences how a particular place will be used.

If we assume, as the archaeological record seems to suggest, that acquisition of toolstone and its reduction for transport were the principal prehistoric enterprises pursued at Tosawihi, then the geography of most activities should be tethered to the distribution of opalite (cf. Figure 4). To minimize transport costs, campsites should be located near toolstone sources, but they

also should correspond to the distribution of water (cf. Figure 7); Tosawihi Spring and the unnamed seeps in Little Antelope Canyon and Basalt Canyon appear to offer the most favorable coincidences of these resources. And assuming that quarrying parties should minimize foraging time, the most efficiently located campsites should give easy access to plant and animal resources; the ideal campsite for quarriers should exhibit resource profile 1111 (as in Table 1). Tosawihi Spring and the seep in Little Antelope Canyon are favorably located with respect to animals (rodents, and, at Tosawihi Spring, antelope), but plant foods in their vicinity (chiefly, grass seeds) are costly to exploit; these locations appear to reflect profile 1101, and should exhibit habitation residues dominated by early stage lithic reduction debris and hunting gear, with little plant processing equipment. The Basalt Canyon seep, owing to its proximity to bitterroot patches, more closely approximates the ideal camp location, although it is somewhat further removed from toolstone sources; we should expect habitation there to include early stage lithic reduction detritus as well as hunting *and* milling tool kits.

Of course, other resource profiles could characterize campsites not directly associated with quarrying; Buttercup Spring, Ivanhoe Spring, and the banks of Willow Creek and Ivanhoe Creek probably represent profiles 0111 or 0101, where foraging parties may have camped while exploiting local plant or animal abundances in the context of a general foraging round, perhaps on their way to or from the quarries, or during more favorable ecological regimes when biotic resources provided, in and of themselves, sufficient incentive for visiting the Tosawihi vicinity. Additional to hunting and/or plant processing paraphernalia, we should expect such campsites to contain only later stage reduction debitage. Places exhibiting unwatered resource profiles should contain a wide variety of task-specific sites with appropriately specialized tool-kits, but no habitations, while those exhibiting profile 0000 should have accumulated no *predictable* archaeological record whatsoever.

People in the Countryside

Human advantage was taken of the resource opportunities of central northern Nevada for at least 10,000 years, and of the Tosawihi vicinity for an apparently comparable period (cf. Chapter 19). We are interested at this point in the interplay of landscape and behavior, in the distribution of resources and how they were used, in the logic of making a living in a known and measured countryside, and in the archaeological record resulting from all that human activity. The strategies employed at Tosawihi can be reconstructed from two sources of data: from historical and ethnographic testimony on the lifeways of peoples inhabiting the region at the dawn of Euroamerican contact, and from the archaeological record. Both are informative of the role that the Tosawihi Quarries played in prehistory, and we discuss aspects of both of them here.

Native Peoples Observed: The Western Shoshone and the White Knives

When the upper drainage of the Humboldt River was visited for the first time by Euroamerican trappers and explorers (Peter Skene Ogden in 1825, John Work in 1831, and the Walker-Bonneville party in 1833), the countryside was found to be inhabited by "naked wretches" living, by all accounts, an impoverished existence, perpetually close to starvation (Ogden 1910; Irving 1837:259-261; Quaife 1934; Work 1913). These first reports of the Western Shoshone of central northern Nevada emphasize the mobility of their lifeway and the sparseness of their material culture, both, probably, concessions to the demands of making a living in a depauperate environment. Unknown at that time was the enormous extent of Western Shoshone territory, blanketing about half the state of Nevada and extending into portions of California, Utah, and Idaho (Figure 9), an approbation of the efficacy of Shoshone strategies for living in the desert.

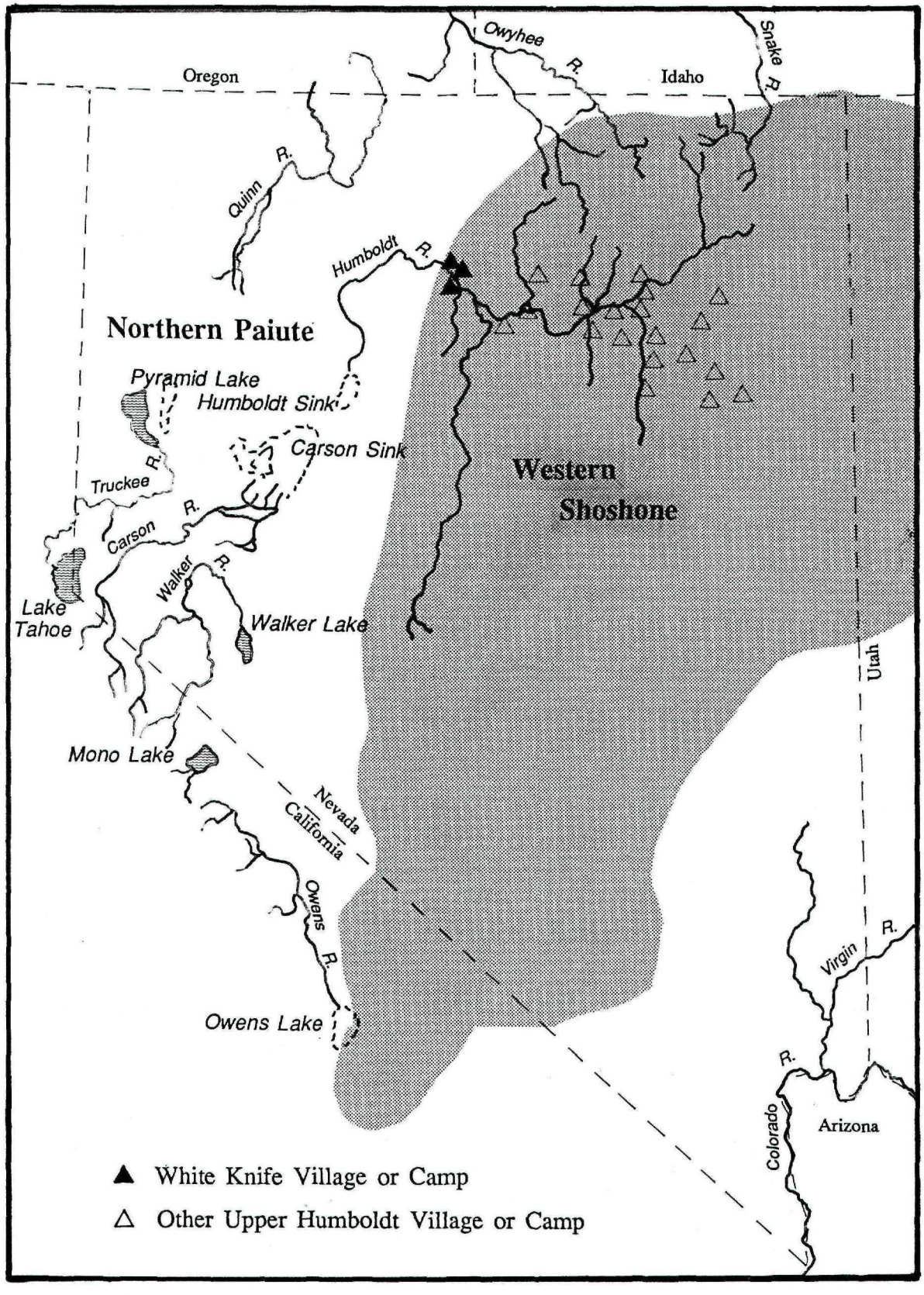

Figure 9. Western Shoshone Territory (after Steward 1937, 1938).

The Shoshone apparently expanded from a southern hearthland ten to fifteen centuries ago, when other speakers of Numic languages also spread north and east; the origin and timing of the expansion are inferred from linguistic evidence (Miller 1966, 1986). If such a movement actually occurred, it must have resulted in the displacement of earlier, now ethnically anonymous resident populations, since the archaeological record of the region clearly implies several millennia of prior human habitation. By the mid-nineteenth century the Western Shoshone had diverged into several smaller subgroups of which one, calling themselves *Tosawihi* ("White Knives"), occupied that stretch of the Humboldt River in the immediate vicinity of Battle Mountain and the adjacent hilly countryside.

Steward (1937, 1938, 1939, 1941) regarded the name *Tosawihi* to apply properly only to those Western Shoshonean groups who wintered around Battle Mountain and whose principal foraging radius encompassed the mountains flanking Rock Creek, but it was used variously to identify virtually all local groups in the region (Harris 1940:39; Powell and Ingalls 1874). Thomas et al. (1986:283) discuss the synonymy of the name, of interest here because it refers to the use of a high quality toolstone found in the mountains north of Battle Mountain, almost certainly the family of opalites outcropping at the Tosawihi Quarries. The name may have been applied to more distant groups who received the material through exchange or, since white cherts occur naturally for some distance along the upper Humboldt, those "Tosawihi" living further to the east may have earned rights to the name through the exploitation of local toolstone.

The White Knives shared a boundary to the west with the Northern Paiute (Stewart 1939, 1941), with whom they enjoyed generally amiable relationships including intermarriage and cooperation in hunting (Steward 1938:162); to the north, east, and south they met other Shoshonean groups. In the absence of land tenure, defense of territory, and exclusive rights in resources, the White Knives and their neighbors were able to benefit mutually from the natural occurrence of scarce but valuable attributes of the landscape. Harris (1940:55), particularly, emphasizes the egalitarian access to the countryside:

> There were no important property rights, no wars, no land-owning groups with bitterly defended boundaries, not even a marked ethnocentrism to separate one group from the rest and keep it intact.

This implies, of course, that control of a static resource such as Tosawihi opalite was not necessarily vested in a single ethnic group, and that wide archaeological distribution of the material *might* be the product of direct procurement by geographically diverse bands as much as the product of extensive exchange networks. Archaeologically, in fact, evidence of the two mechanisms could be indistinguishable unless readable ethnic "signatures" regularly were encoded in assemblage compositions, technologies, or support strategies.

While estimates of nineteenth century White Knife population range from an almost certainly too low 194 (Powell and Ingalls 1874) to 800 - 1000 (Harris 1940:42), most sources report the Indians to have been numerous and their territory, or at least that portion of it transected by the corridor of the Humboldt River, densely populated. Steward (1938:628) conjures that the more favorable localities (i.e., those downriver from Battle Mountain) may have supported one person per two square miles, a density exceptionally high compared to most other parts of the Great Basin outside Owens Valley. Harris (1940:42) contests that this figure applies beyond the lush riparian corridor of the Humboldt, and estimates that, area-wide, the White Knives occupied about fifteen to twenty miles per person.

People clustered along the banks of the Humboldt River in winter, during which season the population exhibited its least scattered distribution. Nonetheless, Steward (1938:161-162) remarks that these winter camps, composed of three to five related families, were smaller and less permanent than those characteristic of other Shoshonean groups. Harris (1940:44) further emphasizes the relative isolation of even the winter congregation by noting that each camp

group (family band) settled from one-eighth to one-quarter mile away from the next, composing large but very diffuse clusters of two to ten families. The consequent archaeological record should lack the large residential nucleations typical of most of the Great Basin, being the product of atypical behavior. Indeed, various observers of White Knife culture have remarked on this idiosyncratic pattern; Steward (1938:161) ponders:

> Why they did not deliberately concentrate in larger winter villages, which local economy certainly would have permitted, is not clear. Apparently they had no great urge, innate or learned, to associate with large numbers of people.

and Harris (1940:71), noting the independence, individuality, and autonomy of the residential group, but ascribing them more than Steward to environmental constraints, observes:

> Circumstances of food supply and poor transportation facilities prevented the occurrence of large or frequent group gatherings over an extended period of time, and true band organization was impossible. The camp group, therefore, was practically a complete ethnic unit, a microcosm of almost the total White Knives culture.

If the pattern described by Steward and Harris had protohistoric or late prehistoric precedent, its archaeological consequences should include small, lowland riverine habitations in greater abundance than occur in surrounding regions, and a concomitant dearth of large, semi-permanent residential nucleations. If, however, as seems possible, the pattern was an artifact of the historic era, emerging in response to early incursions of trappers and the subsequent floodtide of emigrants along the Humboldt River corridor during the gold rush, then protohistoric winter settlement in the area might be expected to exhibit the more typical Great Basin pattern of large winter villages.

Summer saw the fragmentation of winter clusters into individual, family-based foraging bands. Harris (1940:44-45) suggests that the seasonal foraging radius of individual camp groups ranged 25 - 100 miles from the winter camp, and that the same seasonal round was not necessarily reiterated in successive years. Steward (1938:162) reports the White Knives who wintered around Battle Mountain to have foraged particularly in the mountains above Rock Creek, which range would have brought them frequently within the vicinity of the Tosawihi Quarries. Farther travels were not uncommon, however, and both Steward and Harris report instances in which the summer subsistence quest carried foraging groups into the territories of neighbors; likewise, incursions by outsiders were expected.

Few ethnographic data have been collected regarding the structure of summer foraging patterns. Neither pine nuts nor salmon (among the most highly profitable target resources of the province) were available locally, but forays south to the vicinity of Austin were made to procure the former, and north to the tributaries of the Snake River for the latter (Steward 1938:162). Rabbits, antelope, deer, and mountain sheep (all available at or around Tosawihi) were the species most frequently hunted, and White Knife women engaged in the perpetual, ubiquitous Great Basin collection of plant foods. Antelope and rabbits often were taken in communal drives, sometimes involving the temporary amalgamation of camp groups; activities were directed by rabbit chiefs and antelope shamans, although these roles led to no other categories of social status (Harris 1940:154; Steward 1938:163). Most other subsistence quests were performed individually.

Large convocations were uncommon, although a few occurred in the context of seasonal festivals. Harris (1940:53) reports that as many as 300 people might congregate from nearby camps in the spring and fall for dancing and games; Steward (1938:163) notes that Iron Point and Battle Mountain were especially popular festival sites. Leadership of festivals, like that of communal hunts, was ad hoc, and vested authority did not extend beyond the duration of the festival (Harris 1940:53-54). Since authority was so little emphasized in White Knife society,

opportunities for the accumulation of prestige and wealth are likely to have been limited to economic success in the procurement and distribution of material goods.

White Knife technology was simple, characterized by a suite of classic Great Basin tools and processes. Material culture, consequently, was modest (Harris 1940). The distinctive archaeological signatures of White Knife culture, then, probably consist only of their isolating winter settlement pattern and their exploitation of Tosawihi opalite. To the extent that the former may reflect a prehistoric precedent and the latter an exclusive attribute, the White Knives should be visible as distinct *personae* in the regional archaeological record.

Prehistory

Aside from the immediate antecedents of the present work, little research in the upper Humboldt River drainage has focused specifically on the archaeology of the White Knives or on the exploitation of the Tosawihi Quarries. Broad syntheses, however, pitched at various levels of abstraction, provide a framework within which data collected at Tosawihi can be viewed from the larger perspectives of the western Great Basin (Elston 1986a), northern Nevada (James 1981; Smith et al. 1983), and the Humboldt River Basin (Elston and Budy 1990; Rusco 1982). These overviews, together with specific data from surrounding regions, allow us to develop expectations about the duration, nature, and intensity of prehistoric human use of the Tosawihi vicinity.

The distribution of archaeological sites in central northern Nevada was addressed first in the context of an extensive regional reconnaissance carried out by the Nevada Archaeological Survey (Stephenson and Wilkinson 1969); largely intuitive, the effort resulted in the recording of 91 prehistoric sites in a large area defined by Paradise, Eden, Kelley Creek, Evans, and Squaw Valleys. A time depth of about four thousand years was inferred. While little problem orientation guided the inquiry, Stephenson and Wilkinson made some observations of lingering interest. In the first place, they noted a predominance of hunting gear over plant preparation equipment, a pattern they attributed (1969:50), probably correctly, to the valley-margin and upland settings of most of the sites they found. In the second place, and of particular interest to the present investigations, they report a heterogenous distribution of utilized lithic material; west of the Osgood Mountains, local cultural assemblages are dominated by obsidian, while various cherts, evidently including Tosawihi opalite, tend to be favored to the east. This chert/obsidian cline closely approximates the reported ethnographic boundary separating Western Shoshone peoples from the Northern Paiute in the nineteenth century; Stephenson and Wilkinson (1969:50-51) suggest that it may reflect a cultural boundary of fairly long tenure.

The archaeological occurrence of Tosawihi opalites and similar white cryptocrystallines has been addressed in the context of other, usually site-specific, research in central northern Nevada, but the regional distribution of the material never has been examined methodically. At South Fork Shelter, for example, over 80 km from Tosawihi (cf. Figure 10), Heizer, Baumhoff, and Clewlow 1968) assumed that the large number of white chert knives recovered from excavations reflected prehistoric precedent for the ethnographically reported exploitation of the quarries. In the studies discussed below, more or less explicit attention has been paid to identifying the presence, relative abundance, and, in some cases, the functional role of Tosawihi opalites in diverse archaeological assemblages.

Prior to the inception of the present investigations, the vicinity of the Valmy power plant site (Figure 10) was the most thoroughly scrutinized archaeological zone in the region. Lying some 50 km southwest of Tosawihi, portions of the Valmy area were given intensive survey in the interests of cultural resource management (Bard 1980; Busby and Bard 1979; Rusco and Seelinger 1974); numerous sites were recorded, and three campaigns of data recovery ensued.

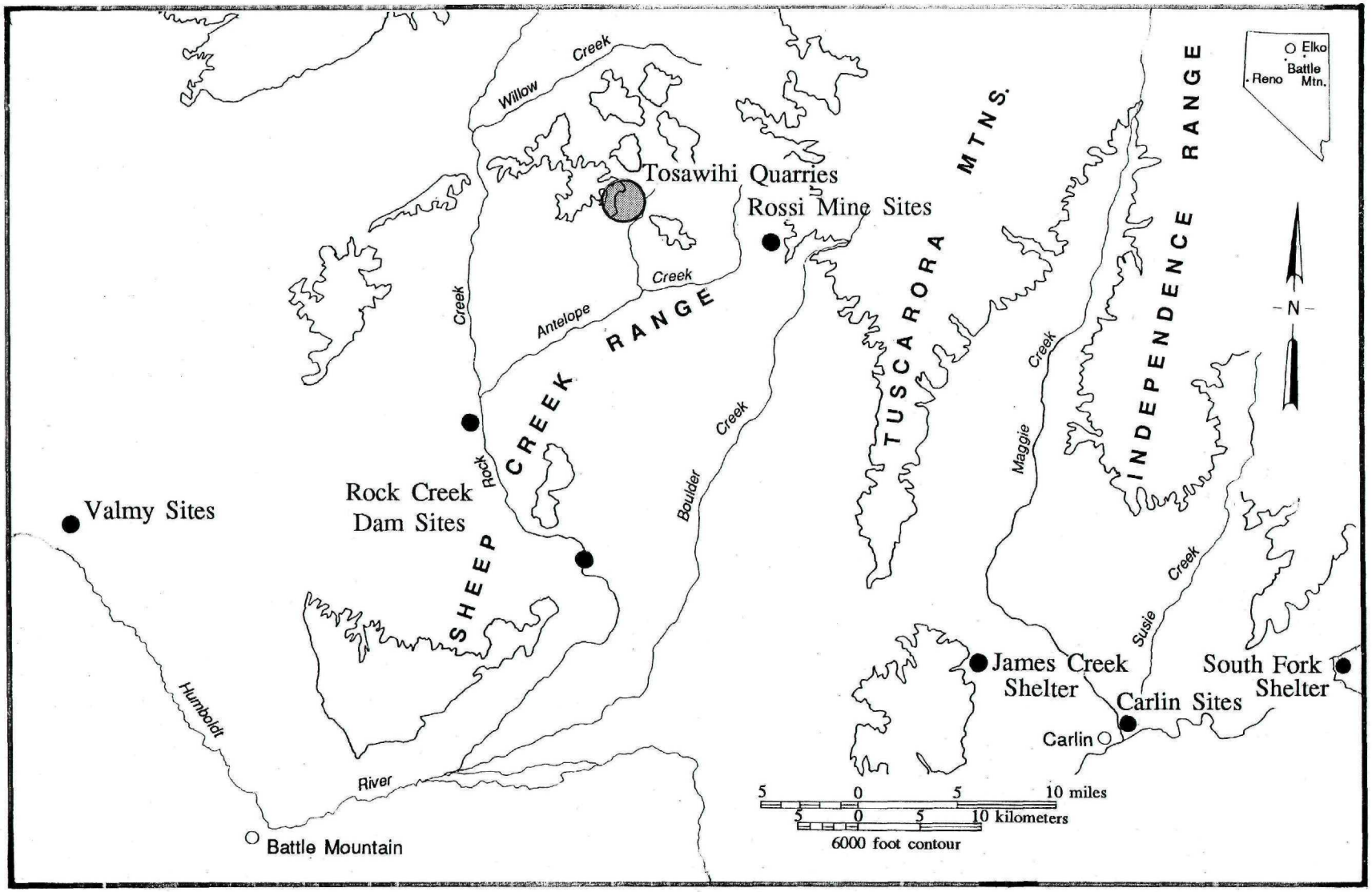

Figure 10. Locations of previous archaeological research in the Tosawihi vicinity.

First, surface collection and sample excavations at three sites near Treaty Hill led Davis, Fowler, and Rusco (1976) to conclude that human use of the area may have spanned the past 7000 years. Assemblage diversity suggested that two of the sites functioned as base camps, exhibiting modest plant processing equipment and projectile points ranging from the Northern Side-notched to Desert series. About 82.5% of the total lithic assemblage appears to consist of Tosawihi opalite, a fraction commensurate with expectations derived from ethnographic patterns. Moreover, the tool:debitage ratio of Tosawihi-like material is 2.2:100, while that for obsidian is 6.3:100; this implies that, despite the nearby occurrence of useable obsidian (Davis, Fowler, and Rusco 1976:51 refer to obsidian cobble sources only 15 -20 miles to the north and northeast), Tosawihi opalite was a cheaper commodity, available in more wastable quantities. These proportions vary little through time, suggesting a relatively long tenure of exploitation of the quarries. Lithic analysis indicates that most of the Tosawihi material was heat-treated prior to further reduction at Valmy, although a smaller fraction apparently was heat-treated on site.

Subsequently, Rusco and Davis (1979) made intensive surface collections in the Treaty Hill vicinity and tested two additional sites. As in the previous research, a 7000-year human chronology was inferred, and assemblage diversity suggested that five sites had functioned as base camps. Again, Tosawihi opalite dominates the local assemblage; 92.9% of the debitage and 69% of the projectile points are apparently of Tosawihi origin. Heat-treatment is common, being observed on 95% of the tools and 84% of the debitage. Low retrieval of cultural materials (0 - <3 specimens/m^3 of deposit excavated, opposed to the ca. 100 specimens/m^3 recovered in 1976) clearly indicates a lower intensity of use. The projectile point assemblage is weighted toward early and middle archaic forms (Great Basin Stemmed through Elko series), with an apparent *floruit* of hunting activity coincident with the production of Humboldt Concave Base points (which comprise 65% of the assemblage). Of all classes of flaked stone artifacts, only Great Basin Stemmed points tend to be manufactured of materials other than Tosawihi opalite.

The latest work at Valmy was undertaken by Elston et al. (1981), who made intensive surface collections and conducted test excavations and backhoe trenching at three major sites and several lesser localities near Treaty Hill. In part, the work was designed to inquire into the function of sites previously identified as base camps; assemblage compositions and site structure, however, indicated that the sites had been inhabited transiently by parties focusing on hunting and more limited plant food collection. Tosawihi opalite again dominates the local assemblages (constituting 92.8% of the lithic assemblage at NV-Hu-634, the richest site investigated). Principal occupation of the sites ranged from 6000 - 3000 B.P., with an earlier component (marked by Great Basin Stemmed projectile points) possibly relating to the period 11,500 - 8000 B.P.

About 29 km southwest of Tosawihi, sites along the Rock Creek drainage were reported by Botti (1985) and further examined by Clay and Hemphill (1986). Investigations at one open site and four rockshelters disclosed an intensive concentration on the reduction of bifaces of Tosawihi opalite (99% of the debitage, much of it tertiary, is apparently of Tosawihi origin, save at one rockshelter where Tosawihi material accounts for only 58% of the debitage); late prehistoric components are especially well-developed, with faunal assemblages dominated by small mammals. Further exploration of archaeological patterns along Rock Creek should be particularly illuminating, since the region is known to have been visited regularly by the White Knives.

Tosawihi opalite also dominates lithic assemblages occurring east of the quarries. In the western foothills of the Tuscarora Mountains, for instance, Rusco (1982) found Tosawihi material to comprise 90% of the tools and 99% of the debitage at seven sites in the vicinity of the Rossi mines. More strikingly, tool:debitage ratios in opalite at these sites were observed to be 1:46.7, but only 1:3.2 for all other materials, indicating that foreign material tended to be imported in the form of finished tools. Broadening the scope of inquiry, Rusco incorporated her Rossi mine data with figures from the Valmy sites as well as two sites near Carlin (Rusco 1979) to investigate the effects of distance from Tosawihi on local lithic assemblages; she

observed that the proportion of later stage biface and core reduction increases with distance from the quarries, supporting a generalized gravity model of lithic procurement and transport. The Carlin sites, however, although furthest from Tosawihi, exhibit the highest incidence of cortical flakes, suggesting that material sources may have been misidentified. Smaller sources of white chert occur variously along the upper Humboldt and doubtless were exploited locally; one such has been reported from the vicinity of Rusco's Carlin sites (Elston and Budy 1990).

More recently, several other mining-related projects in the western foothills of the Tuscarora Mountains have resulted in the archaeological survey of several thousand acres, the recording of hundreds of sites and isolates, and very limited testing of a few sites (Hicks 1989; Rafferty and Blair 1988; Russell, Tratebas, and Schroedl 1986; Schroedl 1986; Tipps 1989). These various investigations uniformly have found the principal lithic material used in the hilly country east of Tosawihi to consist of cherts, of which white chert predominates overwhelmingly, and to which all investigators are inclined to ascribe a Tosawihi origin. Assemblages in this region are composed chiefly of biface reduction debitage, bifaces, and projectile points (Early Archaic to Protohistoric types, with some indications of a Late Archaic intensification coincident with the use of Rosegate points); other formal flake tools, cortical flakes, and core reduction debitage are less frequent, and ground stone occurs sparsely only at a few habitations. Biface reduction is the principal activity identified at most sites.

Before Intermountain Research undertook investigations at Tosawihi, the only research directly concerned with the quarries had been that conducted by Mary Rusco and her associates over a period of more than a decade. Several unpublished papers (Rusco 1976a, 1976b, 1978, 1979, 1983) addressed the nature and composition of Tosawihi assemblages, the distribution of archaeologically transported Tosawihi opalite across the northern Nevada countryside, and the chemical "fingerprinting" of the material in order to objectify its recognition in non-local assemblages. Duffé (1976a, 1976b) attempted such characterization utilizing X-ray fluorescence techniques, but the results were not conclusive. Given the frequent occurrence of visually similar white cryptocrystallines in the upper Humboldt River basin, the issue of the correct identification of Tosawihi material becomes critical for resolving questions of ethnicity, resource transport, and trade; further research along these lines clearly is warranted.

Since 1987, Intermountain Research has conducted ongoing investigations at Tosawihi to identify the surface manifestations of activity areas, test the contents of many of them, order research agendas, and, as reported here, recover data from sites vulnerable to development. Survey of the main body of the quarries was reported by Elston, Raven, and Budy (1987), of the Western Periphery by Budy (1988), of the Eastern Periphery by Raven (1988), and of the Northern Corridor by Drews (1988); historic sites in the Tosawihi vicinity were reported by Zeier (1987). Concurrent with or following closely upon these studies came Elston's (1988a) initial iteration of research issues to guide all subsequent inquiry at Tosawihi (an evolved reconsideration of which appears here as Chapter 3) and a proposed plan for the cultural resource management of the quarries (Intermountain Research 1987). The testing of sites in the Eastern and Western Peripheries resulted in an anthology of new data (Elston, ed. 1989), generating along the way a detailed data recovery program (Intermountain Research 1988a-d) upon which the work reported here was based.

Although the focus of the present volume is on data newly acquired from the Eastern and Western Peripheries and the Northern Corridor, the findings of earlier investigations are synthesized and incorporated in both our analyses and conclusions. Our current understanding of local and regional chronology is summarized in Chapter 19.

Outside of recent work at Tosawihi, we really control very little regional data on the role of the quarries in prehistoric adaptive strategies. Although white "cherts" are known to be widespread in archaeological assemblages in central northern Nevada, it remains to be demonstrated that Tosawihi actually was the source of most of this material; troublesome local occurrences of visually similar natural deposits complicate our understanding of how Tosawihi opalites moved over the landscape. Resolution of the origin of these various lithic materials, and

definition of the chemical, physical, and visual signatures by which they can be identified reliably in the archaeological record, are achievements upon which an accurate human geography of the Tosawihi vicinity ultimately will depend.

Too, almost none of the research performed so far in the region has confronted the subsistence and settlement strategies by which foragers made a living over the past millennium. It is not sufficient merely to observe that they were hunters and gatherers, nor sufficient even to observe that sometimes (even if we can specify the times when they did so) they relied more on hunting or more on gathering; the resource structure of the countryside unquestionably dictated specific survival strategies, at times constraining and at times enabling enterprises such as the acquisition of toolstone. Until we can model how Tosawihi quarriers made a living across the changing environmental theater of the Holocene, we cannot begin to understand the economic exigencies of toolstone procurement, or to discern the logic of those quarrying strategies actually observed in the archaeological record.

In the following chapter we attempt to pose some answerable questions about how toolstone quarries tend to be used, and about how past use is likely to be recognizable archaeologically at places like Tosawihi. Some of our concern is to identify how toolstone procurement articulates with other ways that foragers use the landscape, and to learn how the economics of making a living in central northern Nevada affected, and was affected by, the costs and opportunities presented by Tosawihi opalites. In subsequent chapters we will explore how what we have learned of the archaeological record at Tosawihi informs us of what happened there in the past, and of how that instructs us to think about relationships between toolstone and the people who exploit it.

Chapter 3

MODELING THE ECONOMICS AND ORGANIZATION OF LITHIC PROCUREMENT

Robert G. Elston

The underlying principle is that, all else equal, more efficient strategies—those that produce the greatest return in energy relative to time or effort expended—will be favored over those that are less efficient.
—O'Connell, Jones, and Simms (1982:233)

Although several archaeological studies have focused on economic aspects of toolstone procurement and distribution (cf. Chapter 1), few have employed formal models and none has hazarded a comprehensive view of toolstone economics. The present chapter explicates a more formal approach developed over several previous archaeological investigations (Budy and Elston 1986; Zeier and Elston 1986), in particular, that of James Creek Shelter (Elston and Budy 1990).

The model of lithic variability applied to James Creek Shelter was informed by recent ethnographic and archaeological applications of microeconomics, including optimal foraging theory (cf. Earle 1980; Smith and Winterhalder 1981; Smith 1981, 1983; Keene 1981); it explored relationships between mobility, risk, and toolstone cost. James Creek Shelter is a small rockshelter that was used as a short term base by foraging parties between about 1250 B.C. and A.D. 1800. The site is adjacent a mediocre lithic source (Maggie Creek Chert), but more distant from sources of other, higher quality materials such as Susie Creek chalcedony (10 km), Elko hills chert (31 km), and Tosawihi chert (51 km). The model suggested that, in this situation, the longer the duration of occupation, the greater the risk of expending high quality tools, and the more advantageous the husbanding of supplies of high quality exotic material (through conservative design and maintenance techniques) while increasing use of local, lower quality toolstone. Tradeoffs between mobility and cost should be visible archaeologically in relative proportions of local versus exotic lithic materials in debitage, as well as in artifact staging and curation. These expectations largely were supported by the archaeological record of the site, where independent evidence of occupational duration was present.

The James Creek Shelter model addressed a special case; the site was a place where people processed locally procured toolstone, but toolstone procurement was not the reason for its occupation. Rather, the procurement and processing of local Maggie Creek chert was performed in support of other tasks involved with acquisition of food resources. The Tosawihi Quarries lie at the other extreme: at least during certain periods, the place was visited to procure toolstone, an activity supported by the procurement of food resources. While mobility and risk affected the costs and benefits of toolstone procurement at Tosawihi, we can expect them to have played out there very differently than at James Creek Shelter. Moreover, the organization and techniques of lithic procurement were archaeologically irrelevant and unknowable at James Creek Shelter, but they are critical to understanding the Tosawihi Quarries.

Toolstone is heavy, and its utility is realized only in its ability to increase the return of other resources. Optimization models are well suited to analysis of toolstone procurement. Data regarding the costs and returns of bedrock extraction and processing are crucial for such models, and the quarrying and processing experiments reported herein provide such data for the first time. We do not assume that our experimental rates are identical to return rates achieved by prehistoric quarriers and knappers, but they probably are within an order of magnitude, and they allow comparison with experimental and ethnographic data on the costs and benefits of food procurement and transportation (Simms 1987; Jones and Madsen 1989;

Metcalfe 1989; Metcalfe and Barlow 1991; Rhode 1990). Consequently, the following lithic procurement model is more informed by optimal foraging theory (Orians and Pearson 1979; Belovsky 1987; Stephens and Krebs 1986) than the model developed for James Creek Shelter, is more formal and comprehensive in its consideration of mobility patterns, and specifically addresses labor organization and procurement technology.

Lithic Procurement Strategies

Hunter-gatherers can respond to environmental variability by calling on technological and organizational skills and knowledge, the whole range of which could be carried by no single individual nor implemented at any one time or place. We assume that ancient people understood the properties and modes of occurrence of toolstones as well as they did plants and animals, and that they judged the costs and benefits of lithic procurement well enough to recognize risks, payoffs, and losses in order to make informed decisions most of the time. For purposes of analysis, we artificially isolate the body of skills, knowledge, activities, and locations that have to do with lithic procurement and refer to them in the aggregate as a *lithic production system* (Ericson 1984:3; Elston 1986c:138), without suggesting that anyone but an archaeologist ever relied on such a conception. Lithic production systems are further abstracted into several components, including patterns of mobility employed to bring people and toolstone together, organizations of labor involved in procuring and transporting toolstone, and techniques of extraction and processing. These are employed in various combinations as *lithic procurement strategies* to deal with the nature of toolstone and its distribution in the landscape, the location and distribution of food resources, seasonality, and other environmental variables that affect costs and risks of procurement. Since hunter-gathers apply a repertoire of organizational and technological options in response to a variable environment, different lithic procurement strategies are expected in different circumstances.

Minimizing Cost, Maximizing Return

Foragers may sometimes seem to be faced with the choice of minimizing costs or maximizing returns in procurement strategies, but these goals are two sides of the same coin to the extent that maximizing returns results in obtaining more product for time and energy invested. Any minimization problem can thus be restated as a maximization problem (Stephens and Krebs 1986:7); indeed, optimality models in evolutionary ecology usually assume maximizing goals in order to facilitate the definition of currency, constraints, and decision variables. This approach, however, is feasible only if the all variables in the problem can be well defined.

Unfortunately, we presently do not know how to define most variables of prehistoric lithic procurement strategies in ways that will permit construction of maximization models. Each of the several components (eg. mobility patterns, scheduling, labor organization, technology, procurement techniques, etc.) of a particular lithic procurement strategy may have a different currency, set of constraints, and decision variables. Although we believe that much of the archaeological record is the result of individuals arriving at similar economic decisions in similar circumstances, we are confronting (and attempting to explain) an archaeological record resulting from *myriad* behaviors and individual acts over long periods of time. Confronting the consequences of individual decisions is possible (but usually trivial) at the level of the discrete artifact; we are more often interested in explaining trends in archaeological variability at a larger scale: why sites at Tosawihi have particular spatial distributions; why the assemblages of some sites contain lots of bifaces while others do not; why some sites were occupied continually over long periods of time while others were visited infrequently.

Much of this kind of variability can be modeled as the result of scheduling, labor organization, positioning, and activity segmentation. We *can* assume that foragers manipulate these variables in order to maximize some rate such as time available for quarrying and processing, but in most archaeological situations, we will find it impossible to quantify and sum the different contributions toward that goal. A more productive strategy is to assume that foragers seek to increase the benefit/cost ratio of resource procurement by minimizing indirect costs of forays such as food, water, travel time and lost opportunity. We may also assume that minimizing indirect costs of lithic procurement decreases risk. Consider that while nutritional benefits are immediately accrue on the procurement of food resources, inedible toolstone confers no *direct* energetic return. The benefit of toolstone procurement is, through tool use, to *eventually* increase efficiency in procurement and processing of food and materials from which clothing, shelter, and non-lithic tools are made. The deferred benefits of investing in toolstone procurement are thus analogous to the deferred benefits of food storage, and both involve risk: the possibility of loosing the energetic stake in procuring and processing as well as the deferred benefits. Thus, we might reasonably expect foragers to avoid as many indirect costs as they can in food storage and lithic procurement.

Minimization of indirect costs in toolstone procurement should result in patterns of archaeological variation observable in site placement, activity segmentation and assemblage content. As modeled subsequently in this report, our expectations are framed in qualitative or relative expressions that can be tested by statistical pattern recognition: certain kinds of sites will tend to be located *nearer or further* to water, plant or toolstone resources; certain artifact or feature types are expected to occur with *greater or lesser* frequency in different functional site classes. The few *quantifiable* proxies of rate maximizing behavior that we can define for the archaeological record reflect the direct costs and returns of lithic procurement (time and energy for extraction and processing); it is in this domain that we develop rate maximizing models of lithic procurement behavior.

Managing Risk

Risk is the probability of loss or of a bad outcome (Wiessner 1977:5), a consequence to be avoided. Risk is not quantified here, but is part of the warranting argument for cost minimization and serves the heuristic purpose of visualizing the object of various procurement strategies. Given the basic premise of cost minimization in lithic tool procurement and maintenance strategies, increased cost looms as the greatest risk. Both procurement and use of toolstone are costly, but each involves different kinds of risk operating at different time scales. Acquiring toolstone involves *venture risk*, the probability that procurement and opportunity costs will exceed the benefits of any lithic resources gained (Elston 1990). Venture risk is borne for the duration of a procurement foray, ranging from minutes to several days (Figure 11). Venture risk increases during a toolstone foray in proportion to time, energy, and opportunity costs, each of which varies in different phases of the work. We assume that venture risk rises rapidly to unity during extraction and stays there until processing begins; with sufficient return, venture risk then decreases rapidly during processing and falls to zero when processed toolstone is in hand. Together, search, handling, and opportunity costs (defined below) determine whether a toolstone venture pays off or not, so the prudent quarrier will strive to minimize them.

The consumption of toolstone increases *contingency risk*, the probability of having insufficient toolstone to meet subsistence needs (Elston 1990). Such inability is lost opportunity, but unlike choosing to take a particular resource and giving up the opportunity to do better (or differently), the cost of insufficiency is not balanced by any kind of return. Contingency risk is borne for the time it takes to consume a supply of toolstone. In the model graphed in Figure 12, lithic procurement cost is held constant for simplicity. As an initial supply of toolstone is

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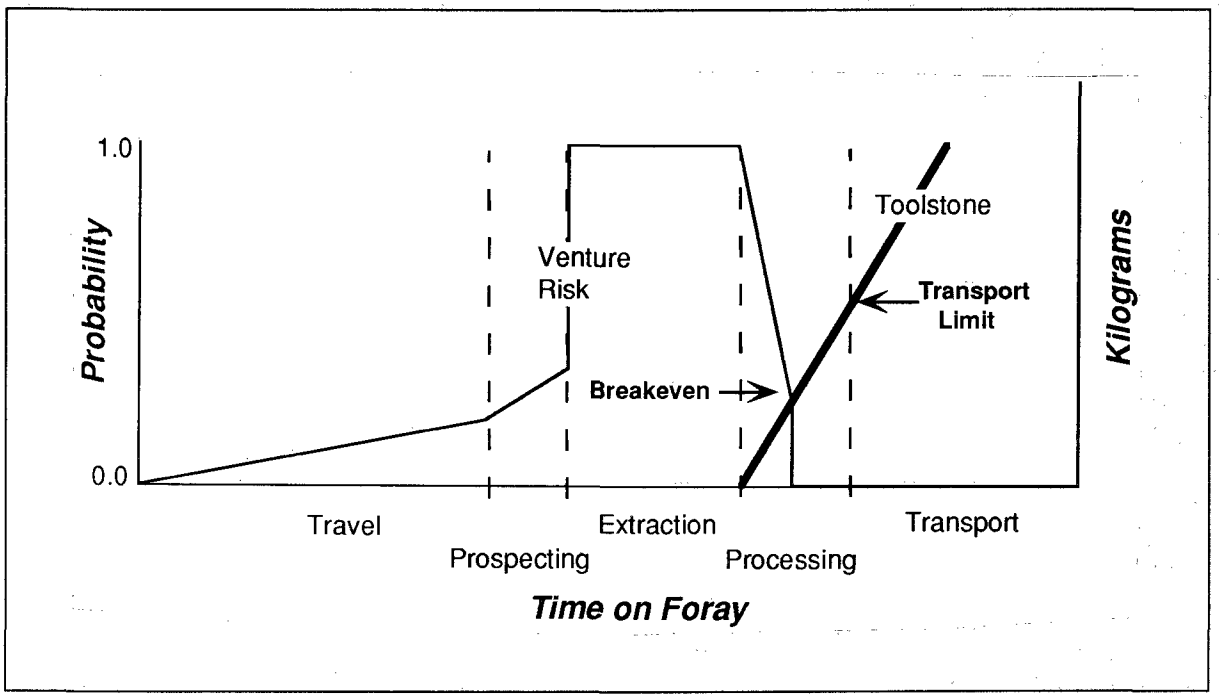


Figure 11. Venture Risk Model.

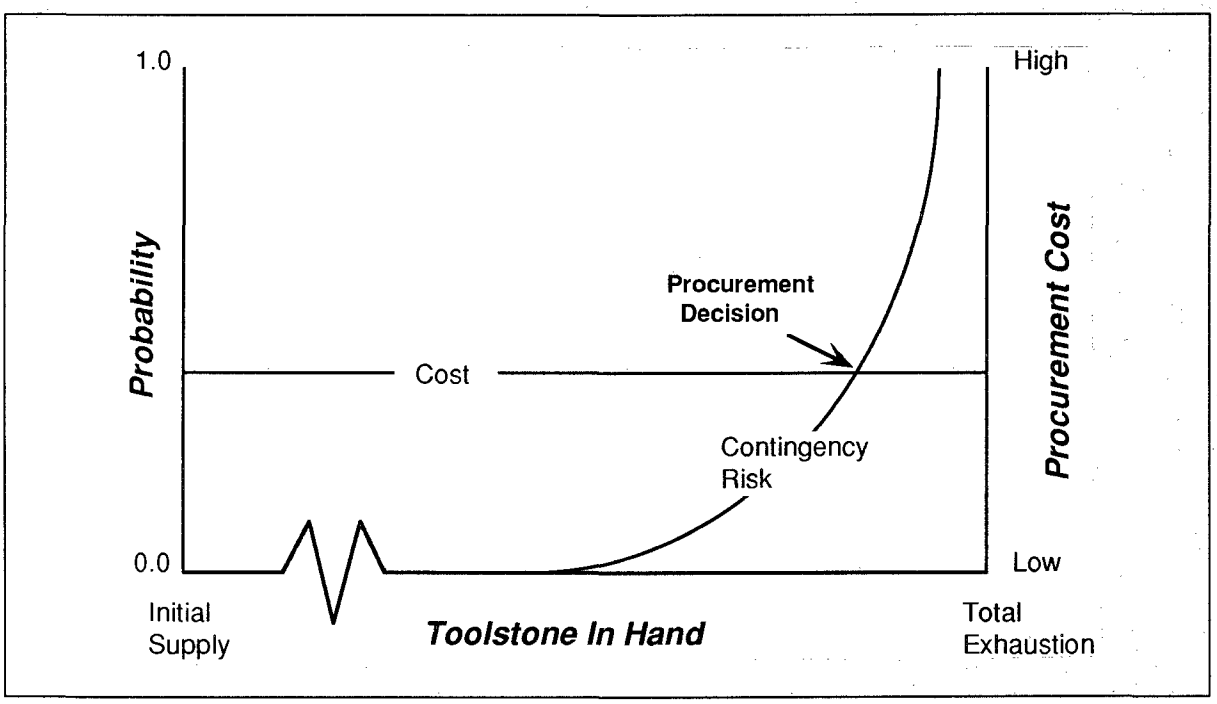


Figure 12. Contingency Risk Model.

consumed, the ability to meet subsistence demands becomes more and more at risk. The decision to procure toolstone is triggered when toolstone supplies fall low enough that potential costs of insufficiency (contingency risk) begin to approach the costs of procurement, but before supplies are totally exhausted. Since contingency risk increases (albeit slowly at first) from the moment of toolstone acquisition, it seems reasonable to assume the desirability of monitoring and managing lithic consumption to avoid insufficiency.

Extrinsic Cost Factors

Some costs of lithic procurement among hunter-gatherers are controlled by extrinsic factors governing the nature of toolstone, while other costs are controlled by choice among components of lithic production strategies (e,g., mobility, organization, technology). Extrinsic factors include the quality, abundance, distribution, and mode of occurrence of lithic raw material in the landscape.

Toolstone Quality

In the Great Basin, most piercing, cutting, and scraping tools were made by flaking or knapping stone. Knapping is most controlled and efficient when applied to a brittle, isotropic medium (Cotterell and Kamminga 1987) such as obsidian (volcanic glass) or cryptocrystalline or microcrystalline silicate stone (flint, chert, jasper, chalcedony, opalite). Fine-grained basalt and andesite also will serve, as will a host of less vitreous rocks, but they offer impaired control in reduction as well as reduced efficiency and durability of the resultant tool. Isotropy, sharpness, durability, and *compliance* (a word substituted for "workability" or the oxymoron "plasticity," *sensu* Goodyear 1979) in reduction are desirable qualities, but difficult to find strongly expressed in the same toolstone. The use of high quality toolstone is a parameter in tool design that seeks to prolong tool use-life (Goodyear 1979; Kelly 1988; Parry and Kelly 1987; Kelly and Todd 1988).

The Lithic Terrane and Absolute Toolstone Availability

Gould (1980:123) refers to the distribution of toolstone in a particular area as a lithic landscape. A more formal term is the geological *terrane*, "the area or surface over which a particular rock or group of rocks is prevalent," or "an area or region considered in relation to its fitness or suitability for some specific purpose" (American Geological Institute 1976:429). In most lithic terranes, high quality raw materials are quite rare compared to low quality stone. Nevertheless, some lithic terranes are richer than others, depending on the mode of toolstone occurrence, abundance, and distribution (Gould 1980:123). One can characterize lithic terranes at different scales ranging from the entire territory used by a group to the foraging radius around a base camp. As we shall see, lithic procurement strategies are sensitive to scale, because scale affects various costs of procurement.

The *absolute availability* of toolstone in a lithic terrane is given by its physical presence and distribution in the landscape. Absolute availability is resource specific and beyond human control. If the lithic terrane contains no obsidian, obsidian is simply not available in that terrane. At the scale of annual range, the absolute availability of toolstone is high in a lithic terrane where there is a good quality lithic source within the foraging radius of most residential camps (for instance, Figure 13a), and such a lithic terrane would be ranked as rich indeed. In

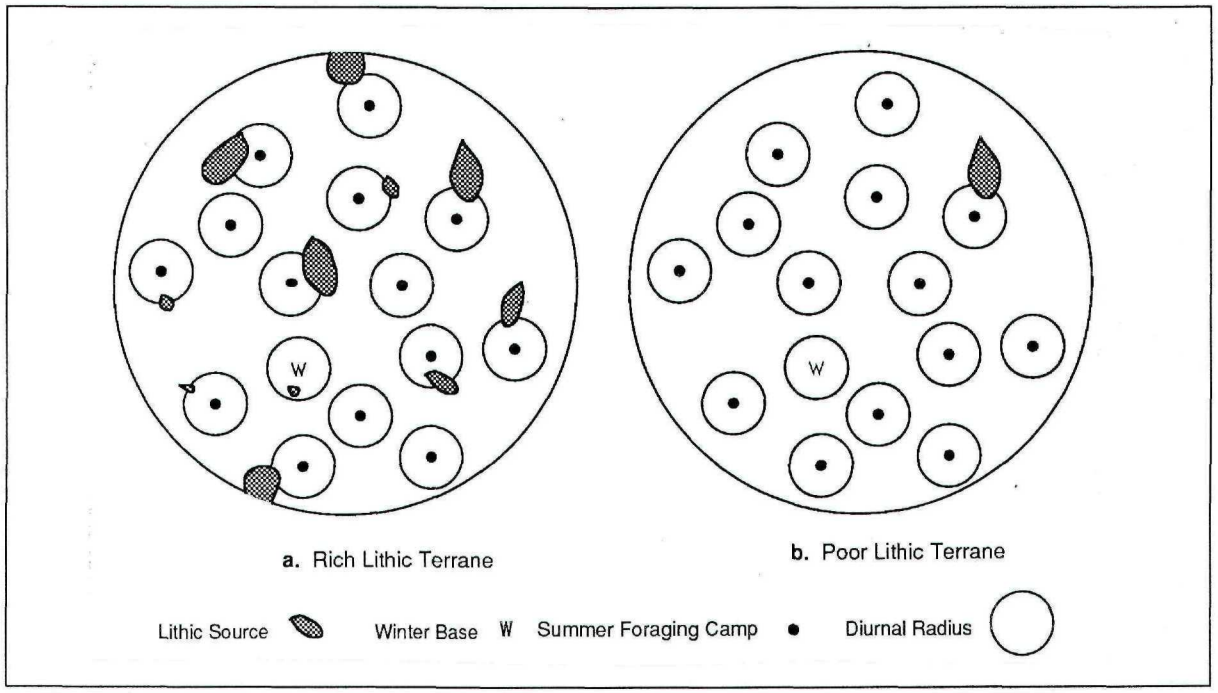


Figure 13. Lithic terranes.

contrast, an annual range of equal size in which there is only one lithic source of middling quality (Figure 13b) constitutes an extremely poor lithic terrane where the absolute availability of toolstone is low. Lithic procurement and maintenance in these two terranes call for different strategies. In the first case, people could move through the annual range with relatively little attention to the scheduling of lithic procurement or tool maintenance; lithic procurement and toolstone utility costs would be about the same everywhere. In the second case, lithic procurement over much of the annual range would have to be planned carefully to ensure sufficient toolstone to support subsistence tasks throughout most of the year. If we varied the quality of the lithic sources in our examples, so that all the sources in Figure 13a were mediocre to poor, and the quality of the single source in Figure 13b very high, we might rank the terranes differently and expect to see other sets of procurement and maintenance strategies.

Variable Cost Factors of Lithic Procurement

The foregoing suggests that choice of toolstone procurement strategies influences the cost in time and effort that must be spent to acquire lithic tools. Strategic variables (mobility pattern, labor organization, and procurement techniques) can be manipulated to vary access, effective availability, search and handling time, and opportunity costs.

Effective Toolstone Availability

While the absolute availability of toolstone is given by nature, its *effective availability* can be manipulated by modifying procurement strategies. Increasing or decreasing residential mobility, altering the shape or size of the annual range to exclude or add sources, or contriving

to be in the vicinity of sources at times when need for toolstone is highest (or opportunity costs least) can affect toolstone availability significantly and result in differences in the intensity of exploitation at various sources (Goodyear 1979; Elston 1990). Another option is to employ more intensive extraction techniques; for instance, Great Basin hunter-gatherers influenced the effective availability of toolstone at sources such as Tosawihi by making subsurface material available through intensive quarrying.

Toolstone Access

Access is the ability of one group to exploit a given resource vis-à-vis competition with other groups (Ericson 1984:3), and thus is dependent on social boundaries. Hunter-gatherers may be restricted to a poor lithic terrane because better ones are occupied by other groups. In such a situation, access to extraneous lithic sources usually requires the expenditure of time and energy for the maintenance of social networks and the accumulation of surplus goods for trade. This *social overhead* can be a significant factor in lithic procurement costs, and may lead to reduced procurement or abandonment of a source by a particular group.

Procurement and Opportunity Costs

As for any other resource, the procurement of toolstone involves search and handling time (Stephens and Krebs 1986:13-14). *Search time* entails time spent traveling to the toolstone source or patch, finding toolstone items in the patch (*prospecting*), and visual inspection and assaying of likely toolstone items (Figure 11). *Handling time* includes time spent in extraction, processing (or manufacturing), transport, and maintenance. *Extraction* of lithic resources occurs after the decision to go for an item of toolstone has been made; it can be as simple as plucking an item from the surface, but may necessitate excavation of soil to recover toolstone clasts or excavation of toolstone in beds and outcrops. *Processing* includes those tasks (decortication, contouring, bifacial reduction, heat-treatment) necessary to render the toolstone usable. Search time can be varied through changes in mobility pattern and prospecting techniques, while extraction and processing time are functions of quarrying and processing technology and tool design. Transport costs vary directly with distance and weight of the load (Jones and Madsen 1989); they can be mitigated by putting the manufactured object into use as soon as possible (ideally, before it leaves the quarry).

Search and handling can be thought of as *direct costs*. The decision to acquire toolstone entails *indirect costs* as well, perhaps the most important of which consists of the loss of other resources not taken, or *opportunity cost* (Stephens and Krebs 1986:11). There is a direct relationship between the direct costs of procurement and opportunity costs, because the amount of time an individual spends in lithic procurement is equal to the amount of time lost to other opportunities. One might expect, therefore, that, whenever the direct costs of lithic procurement rise as a result of intensification, for example, steps will be taken to reduce opportunity costs, probably through manipulation of mobility pattern and labor organization.

Procurement Techniques

Four basic techniques are used to procure toolstone: encounter, surface collection, quarrying, and retrieval. All could have been employed at Tosawihi.

Encounter Procurement

The *encounter* technique involves opportunistic procurement of lithic resources. As people move across the landscape, any suitable raw material encountered may be collected from the surface and incorporated into toolkits. Processing and tool expedience can vary situationally. This technique has the lowest procurement costs; it can be embedded seamlessly in hunting, gathering, and traveling from one place to another (Binford 1979), search and opportunity costs are well amortized, and it incurs the least venture risk. Handling costs are low because the amounts of raw materials are small (Figure 14), and it also serves to monitor the distribution of toolstone in the lithic terrane, reducing future opportunity costs. On the other hand, surface material often is so dispersed that time between encounters is significant. In addition, surface items generally occur within a narrow size range constrained by local geology. Surface toolstone is usually weathered (checked, dehydrated), and most pieces have to be *assayed* (tested for quality); many will be rejected because of stresses and flaws that would increase processing time and decrease use-life. Moreover, of surface items retained for processing, waste to toolstone ratios are likely to be relatively high. By definition, this technique never affords the opportunity to procure large amounts of high quality material, but, in combination with a pattern of high mobility in a rich lithic terrane, might yield a significant proportion of the annual toolstone requirement. Ethnographic accounts (Gould 1977, 1980; Hayden 1979a; MacCalman and Grobbelaar 1965) suggest that surface collection of toolstone often is employed on an encounter basis to obtain for expedient tasks tools which then are discarded on the spot.

Surface Collection

Encounter procurement grades into *surface collection,* but the latter implies a more intensive process, requiring greater time investments, opportunity costs, and venture risks. Surface collection is likely to occur in places where toolstone clasts are sufficiently abundant

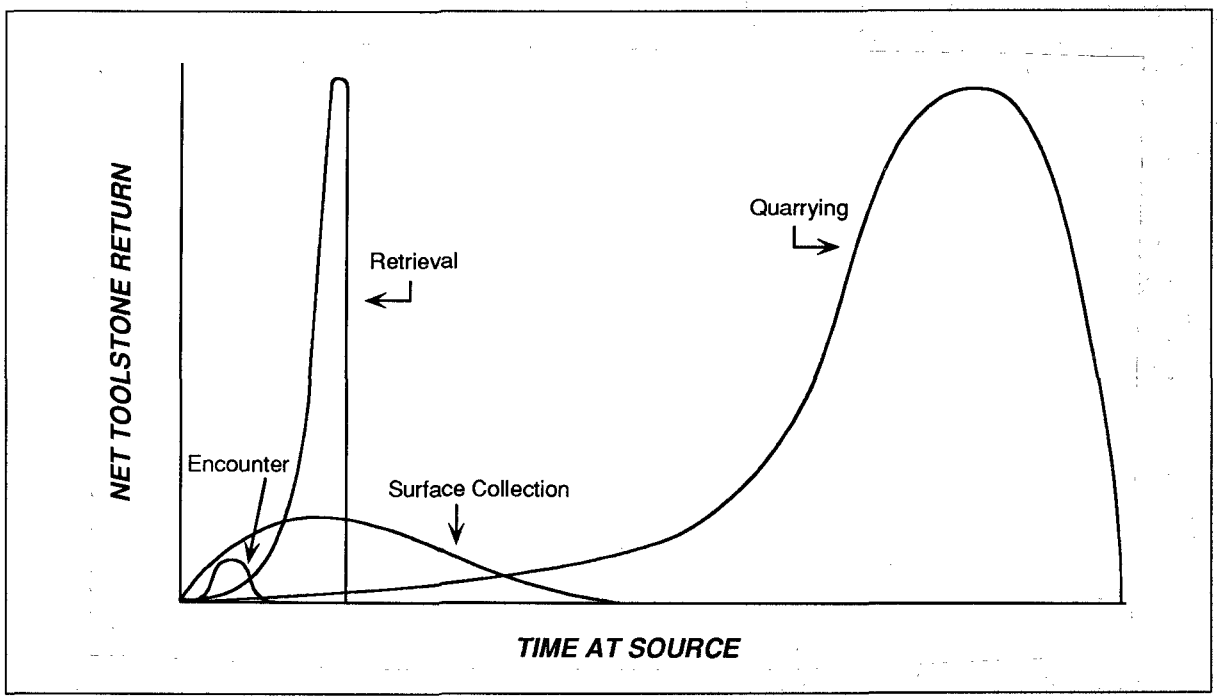


Figure 14. Hypothetical return curves for different lithic procurement techniques.

and concentrated to provide a positive return for the investment in search and handling time, which is much higher than in encounter procurement. It is more difficult, then, or impossible to embed surface collection in other tasks, because more material is assayed and processed. The quality of surface material is likely to be low for the reasons stated above. In most surface patches, the dispersion of items, high ratio of unsuitable material, and constrained size range will keep average post-processing return rates relatively low (Figure 14). Moreover, surface patches eventually may be depleted.

Quarrying

Procurement of toolstone through *quarrying,* or extracting lithic raw material from clasts in soil or from bedrock, extracts by far the greatest search, handling, and opportunity costs, and entails the greatest venture risks; it also can pay off in the acquisition of large amounts of high quality toolstone (Figure 14). Quarrying search time often involves looking for new sources of buried toolstone with a visual search of the ground surface, assaying likely pieces, and removal of overburden from toolstone deposits, usually by excavating a pit (Binford and O'Connell 1984; Jones and White 1988). Prospecting is risky because it can prove fruitless; a strategy of working in or adjacent a pit of known productivity may decrease search time and variance in returns. Handling costs include the isolation and extraction of toolstone masses, along with excavation of waste rock in which toolstone is embedded. If bedrock is to be quarried, it must be broken up into manageable pieces with hammers and wedges, and possibly with fire (Binford and O'Connell 1984).

Quarrying buried toolstone has several advantages, including higher quality and greater size of clasts than usually is available in surface material. Quarries often can produce vast amounts of material before they are exhausted, and are capable of yielding the highest volume of material per foray; sometimes more toolstone is processed than can be transported. Buried toolstone is less subject to weathering and thermal stress; moreover, its moisture content increases its compliance, thereby decreasing waste and contingency risk. Localities can be selected to ensure uniformity of quality, thus maximizing the ratio of toolstone to waste rock. With exploitation of bedrock, the size of cores and flake blanks theoretically is limited only by technology and human physique.

Retrieval

The technique of *retrieval* procurement (Figure 14) depends on overproduction, where more toolstone is processed at the source than is transported (Figure 11). The surplus may be cached at or near the source and retrieved at some later time. Retrieval is likely to be associated with quarrying because of the scale of production. Caching trades the energetic cost of overproduction for reduction of transportation costs and minimization of future labor and opportunity costs, since retrieval of a cache requires only the costs of travel and transport. Uncertainty in returns and associated venture risk are minimized absolutely. Overproduction and consequent caching are likely to occur where excess time or energy are available to produce more artifacts; residential occupations are favorable settings, since longer stays in an area may generate surpluses of time or energy.

Extending Tool Use Life

At first glance, extension of tool use life appears beyond the realm of lithic procurement, but in fact, strategies for getting the most from tools are integral to procurement cost minimization, guide the basic decisions of what toolstone to procure, and prescribe procurement and processing techniques. Techniques for extending tool life include use of high quality

toolstone, large tool size (demanding large blanks), symmetry of design, simultaneous use of bifaces as both tools and cores, and standard techniques for maintenance and rejuvenation (Goodyear 1979; Kelly 1988). Heat-treatment is used to improve sharpness and compliance (although at some expense of durability and increased risk of failure in manufacture). That many of these techniques require costlier forms of lithic procurement suggests that people are willing to bear increased venture risk in return for decreased contingency risk. Tool life extension employed elsewhere in the technological system theoretically can be gauged through such measures as the ratio of flake tools to biface tools, of resharpened edges to total used edges, of bipolar reduced tools to total number of tools, and many others (Zeier and Elston 1986; Elston and Budy 1990, Elston 1990; Kelly 1985).

Toolstone Utility and Returns

Paraphrasing Stephens and Krebs (1986:104-105), *utility* is the benefit a consumer derives from a particular package of goods. Under this broad definition, toolstone in various forms may confer benefits other than utilitarian value, e.g., medicinal and spiritual power, prestige, or ethnic identity, among others. Nevertheless, at this juncture, we choose to focus on utilitarian benefits.

Toolstone Utility

Since people do not derive energy directly from toolstone, and stone tools generate utilitarian benefits only when they are used, one measure of toolstone utility can be expressed as actual benefit in service time per unit weight. Hence, toolstone that produces tools with the longest average service life per unit weight (Saggers 1984; Gould and Saggers 1985) has the greatest utility. But because adequate ethnographic and experimental data regarding bifacial tool use lives are lacking, we must assume further that, for a given lithic material, *use life utility* (ulU) is directly related to mass where objects under consideration have a similar range of function and morphology and were made under roughly the same technological constraints, user skills, and work conditions.

Tool mass gives us an easily measured quantity, but one that admittedly is several times removed from fitness:

$$\text{fitness} \Rightarrow \text{efficiency} \Rightarrow \text{tool use} \Rightarrow \text{tool mass}$$

Nevertheless, for a given lithic material, we assume:

$$\text{ulU(10,000 gm of Stage 3 bifaces)} > \text{ulU(1,000 gm Stage 3 bifaces)}$$

That different functional types of tools confer different kinds and amounts of benefit in use is a potential complication of any scheme to evaluate lithic utility. We avoid this problem by assuming that the *functional utility* (fU) of a tool is 1.0 when it is able to perform adequately the task set for which it was designed, and less than 1.0 during manufacture or after failure. Variability in tool utility is expressed in use life, which, we have assumed previously, is directly related to tool mass. For example, a simple flake tool can have an fU at or near 1.0 the moment it is struck from a core, while the fU of a biface increases as it is processed from blank to early stage biface, to later stage biface, to heat-treated biface. The difference between the two is that the use life utility of the flake tool is soon expended, while

the biface is used in a long series of tasks with routine edge maintenance and repair of minor failures. As its morphology changes through maintenance and repair, it may be applied to a variety of tasks, or may change function altogether, but its functional utility remains at 1.0 through most of its use life.

Proportional utility, frequently appearing in optimal foraging models, was employed recently by Metcalfe (1989; Metcalfe and Barlow 1991) to model transportation costs and by Elston (1990) to compare utility of bifaces and flake tools. Proportional utility avoids the problem of comparing utility among different types of resources or different tool types by scaling the utility of each resource unit from zero to one. Applied to lithics, this model assumes that the utility of unprocessed toolstone is related to the proportion of waste to usable tool; waste has a utility approaching zero (ignoring the potential utility of flakes), while usable tools have a utility at or near one. Proportional utility is used to estimate the optimal amount of processing before transportation of toolstone from the quarries.

The quality of a particular toolstone is important, but does not determine toolstone utility totally. Both functional and use-life utility can be extended through technology and design, and decreased by procurement costs (service time minus time consumed by travel, search, extraction, and processing). Consequently, the net utility of the highest quality toolstone can fall below the net utility of mediocre material simply as a function of distance to source or difficulty of extraction (Figure 15).

Returns

The average return *rate* is the amount of toolstone obtained per unit of search and handling time, and depends in large part on the waste (mass of items rejected, minus mass of discarded processing debris) to toolstone ratio. *Gross returns* are simply the mass of material

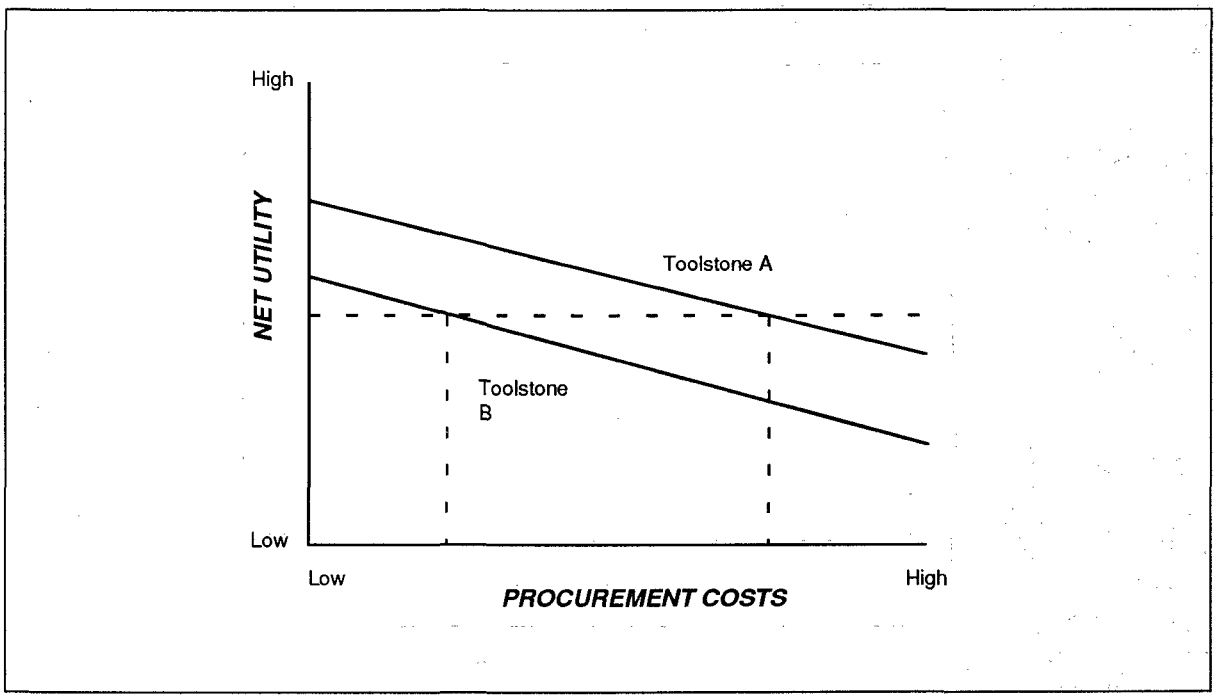


Figure 15. Net utility as a function of procurement costs.

(in grams) extracted (geR) or processed (gpR), while *net returns* (neR; npR) are gross returns divided by mass of material culled or failed. Gross or net return rates (geRr; neRr; gpRr; npRr) are gross or net returns divided by *extraction cost* (Ce) or *processing cost* (Cp), or both (in minutes or kilocalories):

$$npRr = npR/(Ce + Cp)$$

For example, the npRr of a 1000 gm biface that took 60 minutes to extract and process is 16.67 gm per minute, while the npRr of a 1000 gm biface that took 120 minutes to procure is 8.33 gm per minute. If the fU of both bifaces is 1.0 and their ulU's are similar, the prudent forager should prefer the quarrying situation where npRr is greatest.

Material handled but left at the quarry, even if partially reduced into bifaces and intended for later recovery, is not counted in returns for that quarrying foray. Toolstone caches may have utility in the reduction of opportunity costs and handling time on future trips to the quarry, but they may never be recovered. Thus, the net return of any particular foray (nfR) is limited by human load-carrying capacity (HLC):

$$nfR = (npR <= HLC)$$

Figure 14 compares hypothetical net return rates for encounter procurement, exploitation of surface patches, quarrying, and retrieval. Encounter procurement takes very little time, but generates little return. While surface collecting in a good patch, net returns rise quickly to a value set by the average encounter rate for the patch and are either maintained there for the time the patch is occupied or gradually begin to fall off as potential toolstone in the patch is sampled. In contrast, initial search at the quarry produces very little until a "strike" is made. Post-processing returns then rise steeply to values far beyond those that can be obtained in surface exploitation, and, just as rapidly, fall off when the material exposed in the pit is "worked out." These high returns balance the greater handling costs involved in quarrying. The return rate for retrieval is highest of all; it takes very little time, but has a very large net return.

Manipulating Costs through Mobility, Organization, and Scheduling

The preceding discussions identified costs of lithic procurement. Still assuming a basic goal of cost and risk minimization, we now turn to the ways costs can be manipulated.

Mobility Patterns

Mobility refers to the strategies employed by people to position themselves vis-à-vis resources, particularly to food, water, and shelter (Binford 1980, 1982; Kelly 1983; Thomas 1983a, 1988). Mobility patterns are designed to deal with variable temporal and spatial availability of subsistence resources. Binford (1980) has characterized hunter-gatherer mobility as a continuum with foraging and collecting at the antipodes. Since ethnographic Great Basin hunter-gatherers commonly practiced a seasonally mixed-mode residential strategy (Thomas 1983a), we are less interested in contrasting foragers and collectors than we are in exploring the consequences of different mobility patterns of lithic procurement at Tosawihi. The value of mobility pattern and economic zone models is that they provide means of relating variability in the exploitation of the quarry to regional settlement and subsistence patterns known ethnographically and inferred archaeologically.

Imagine that resources occur in a series of economic zones (foraging radius, logistical radius, annual range, and extended range, described below), delineated by constraints on human mobility and load-carrying ability. Mobility patterns include foraging in the vicinity of the residential base, residential moves to new resource areas, logistical moves from residential bases, or combinations of these. Mobility affects toolstone supply and demand because it is linked to boundaries imposed by social constraints and the distribution of biotic resources not necessarily congruent with lithic sources. Toolstone can be abundant in places devoid of game or food plants, but scarce in places where lithic tools are needed to capture or process biotic resources. The annual range of one's neighbors may constitute a rich lithic terrane, while one's own is a lithic desert. Accordingly, mobility patterns influence access, effective availability, and utility of toolstone.

Organization of Labor and Activities

Varying the organization of labor and activities should affect procurement costs profoundly. Optimal task group size is likely to be related to mobility pattern and mode of procurement. We should not expect large groups to be involved in logistically organized retrieval procurement, nor intensive quarrying to be carried out by an individual. Division of labor by sex, age, or skill might increase procurement efficiency, particularly on longer forays where quarrying has to be supported by local foraging to reduce opportunity costs. In this case, we might also observe the greatest spatial segmentation of tasks and variation in site function.

In a given year, Great Basin hunter-gatherers tended to operate over a relatively large area with frequent residential moves during the spring, summer, and fall. This *annual range*, a subset of a larger *extended range,* can shift from year to year. From each residential base camp, food and other resources are exploited in a relatively small area within the *foraging radius*, or *diurnal range* (the distance one can walk, do business, and return in a day [Thomas 1983a]). When return rates fall off (a matter of days to a few weeks) and foraging in the vicinity of the residential base no longer is profitable, the camp is moved to a new area with access to a new set of resources. The foraging strategy is best adapted to environments in which target resources are distributed evenly across the landscape, or are available sequentially over an extended period. In the Great Basin, foraging typically was practiced during the period of greatest productivity in spring and summer.

High mobility through a large annual range often makes a greater number of toolstone sources available. Choices can be made among the highest quality sources, but groups may not be able to predict accurately when they will be in the vicinity of any particular source, and are limited in the amount of toolstone they can transport between sources. Since considerable time may elapse between visits to the best sources, contingency risk is an important consideration. Highly mobile groups tend to "gear up" (Binford 1979) with new tools when a high quality lithic source is encountered, leaving their old tools behind. Consequently, the lithic tools of mobile foraging groups are likely to be highly symmetrical in form (for efficiency and ease of maintenance) and large in size (mobile storage of toolstone); Paleoindian tools are a case in point (Goodyear 1979; Kelly and Todd 1988). That biface technology, particularly well adapted for use by highly mobile hunter-gathers (Kelly 1988), has been the focus of lithic production in the Great Basin throughout prehistory perhaps is indicative of the overall importance of mobility in the region.

Low residential mobility with logistical movement is a pattern adapted to more heterogeneous environments in which resources are distributed unevenly or are seasonally unavailable. This pattern was typical of Great Basin groups in the fall and winter. Long term residential base camps are established; resources in the foraging radius are exploited from them, but a much larger area (the logistical radius) also is exploited by means of special task groups formed to procure a specific resource or restricted range of resources (i.e., pine nuts or

mountain sheep). Such groups travel a long distance from base camp, establish one or more temporary field camps, procure and process the target resource(s), then return to base camp with the goods. Logistical field camps are occupied for a relatively short period of time, perhaps a few days (but cf. Binford 1982:7; Downs 1966:30). Because human load carrying capacity is strictly limited (Jones and Madsen 1989), resources usually are processed at or near their source to reduce bulk and weight. Storage is an integral part of the collector strategy, designed to deal with seasonal shortages and transport limits. Goods can be cached at the field camp for later retrieval, at the main base camp, or at points between the two. Logistically based hunter-gatherers, or those practicing a seasonally mixed mode strategy, may operate within a smaller annual range than more mobile foragers. When this limits access to toolstone sources, use of high quality sources within the annual range probably will increase.

Scheduling

Scheduling lithic procurement is important in order to minimize opportunity costs of food resources. Scheduling conflicts and time limitations with regard to key food resources can increase toolstone demands sharply for limited periods (Torrence 1983). For instance, time is available to pursue intensive methods of quarrying and ensure the acquisition of the highest quality toolstone only in the absence of acute toolstone demand and when opportunity costs are low. Duncan Metcalfe (personal communication) has suggested that intensive methods of lithic procurement are most likely at times when variance in food patch return rates are lowest (Figure 16), so that the added potential lithic utility of toolstone balances some food resource opportunity costs and makes it more attractive to be at the quarry than at other places. In the model of lithic procurement diagramed in Figure 17, procurement costs vary through time with changes in seasonal mobility and climatic conditions. Episodes of lithic procurement are timed to coincide with the lowest points in procurement cost, but might respond also to toolstone demand, time constraints, or other factors. Note that the curves suggest different rates of toolstone consumption and contingency risk in various seasons.

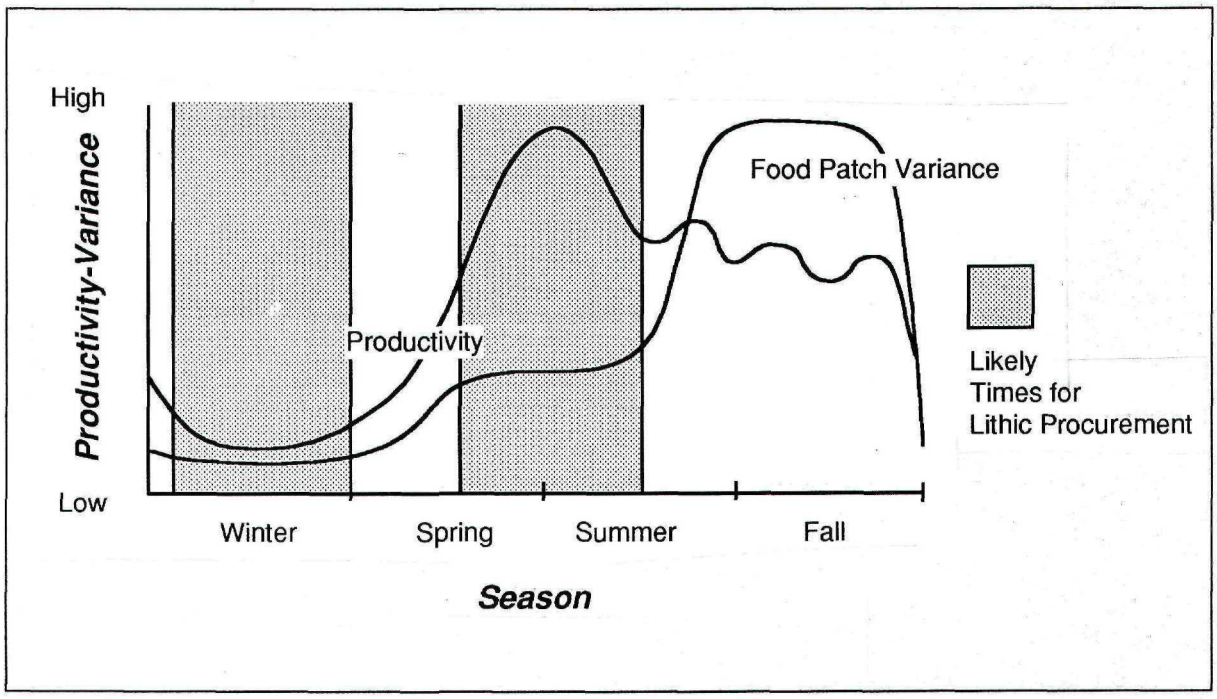


Figure 16. Seasonal variation in food patch returns and overall productivity.

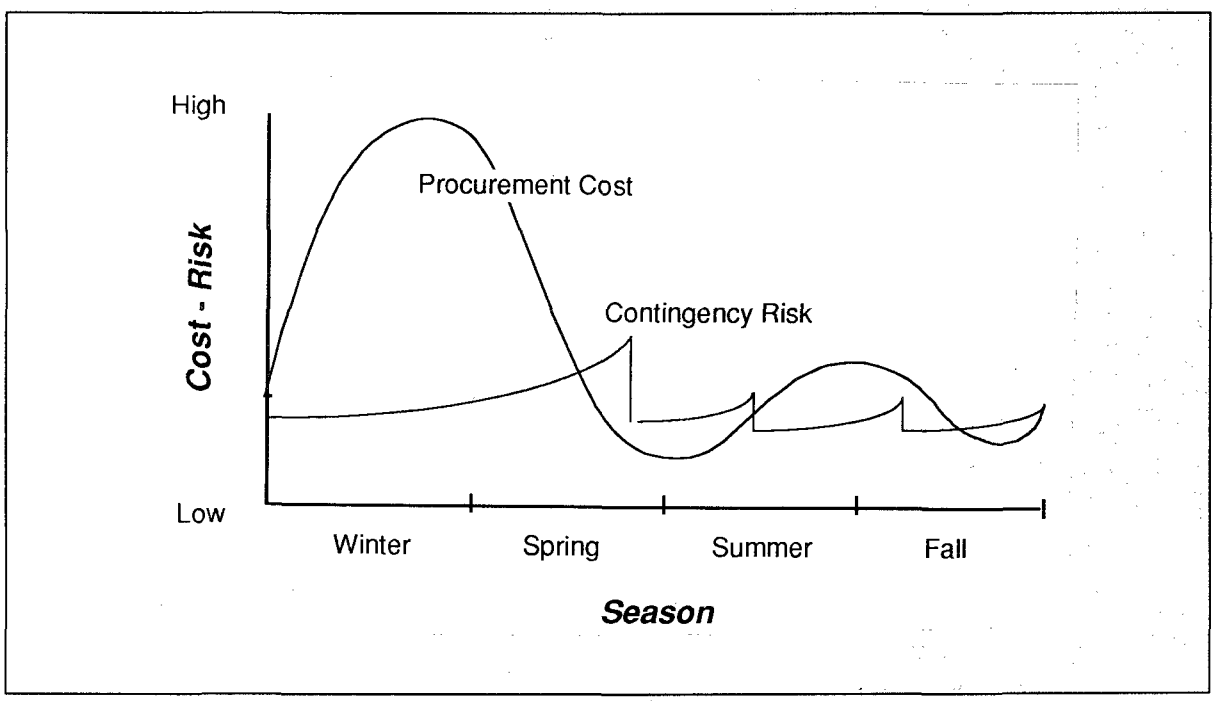


Figure 17. Seasonal variation in toolstone procurement cost and contingency risk.

Toolstone Demand and Output

It is reasonable to expect lithic procurement strategies to respond to different costs and levels of demand for toolstone by changes in *output*, or amounts of toolstone produced in a given period. There is, however, no simple relationship between cost, demand, and output. The following section is more of a cautionary tale than a model, but serves an heuristic purpose.

Demand can refer to a *particular* commodity (Campbell's Vegetarian Vegetable Soup; Tosawihi chert) or for a *generic class* of commodities (canned soup; obsidian, regardless of source). *Individual demand* is the total amount of some resource that a consumer wants per unit of time. In classic economics, individual demand for a commodity is summed to produce *market demand* (A. Smith 1982:1-2), and this too can be particular or generic. In the absence of markets, individual demand can be summed at various scales, for instance *household demand* or *regional demand*. Luedtke (1984:65) defines demand as "the amount of lithic material necessary per fixed unit of population over a fixed period of time."

In free market economies, demand theoretically is linked to supply through price. Prices rise and fall inversely with supply, and demand usually is related inversely to price. In the market economy, supply and price (cost) are set by producers and sellers; the buyer-consumer responds to cost by demanding more or less of the commodity. Demand feeds back into the system and stimulates more or less production, resulting in higher or lower prices. In a non-market, hunting and gathering economy, the consumer usually is the producer whose perceived survival needs originate demand. If a producer-consumer experiences a rise in toolstone cost due, for instance, to reduced access to a source, he or she, or an entire group, can elect to acquire toolstone from some other source. This decision lowers individual and group demand for material from the first source, but has no effect on its cost, which remains high as long as access is restricted. In this case, demand responds to cost, but cost does not respond to demand; rather, a lower cost resource is substituted for the higher cost resource through a change in lithic procurement strategy. This, however, does not necessarily have any effect on *overall* toolstone demand at the scale of the individual or group.

Among hunters and gatherers in temperate environments, individual or household toolstone demand probably rises and falls within a relatively small range in a yearly cycle tied to the frequency of activities that consume toolstone (Figure 17). For groups with limited winter residential mobility, it is likely that the most acute demand for toolstone will be felt toward the end of winter encampment when supplies are low and contingency risk high in the face of the coming foraging season. Other acute peaks may occur from time to time, but these are more likely to be situational and not usually visible in the archaeological record. Major, long term fluctuations in toolstone demand on the regional scale may be responses to changes in food procurement that increase toolstone consumption, or, more likely, population growth with attendant declines in mobility and range, along with competition for lithic resources; trade is a possible outcome. Such large scale, long term changes in mobility and range can show up in the archaeological record as variation in output at particular sources.

The more mobile the group, the more lithic sources potentially available to it; less production need occur at any one source to satisfy demand. Less mobile groups, or groups with otherwise decreased access to toolstone sources, who are unwilling to relax toolstone quality and tool design standards, may need to focus on the relatively few high quality sources available within their range. Neither group nor regional demand may have increased, but now all demand must be satisfied at a few sources. This may involve more intensive (and costly) methods of lithic procurement, using the time and energy formerly spent in travel through a larger territory, spread out over exploitation of several lithic sources. If adopted over long enough periods, intensification may be extremely visible, as it is at the Tosawihi Quarries.

Another alternative is to relax tool design parameters and step down to use of lower quality material that is cheaper to procure within the limited range (Figure 15). Overall demand for and consumption of toolstone may increase in this situation because it now takes 50 kg of poorer quality toolstone to fill the same needs once satisfied by 30 kg of higher quality material. This scenario may play out in the archaeological record, however, as a decrease in output at formerly favored high quality sources and lack of visibility elsewhere because the abundance of poorer material is so high that no single source need be exploited very much.

Thus, increased output at a particular lithic source can be a response to many factors, which may or may not include increased demand at a particular scale. We suspect that archaeologically visible variability in the intensity of exploitation of a source *most likely* signals a decrease in effective availability and access vis-à-vis other sources in the annual range; confirmation of this requires a regional study of toolstone procurement.

Implications of the Model

The preceding discussions present a model that identifies costs of lithic procurement and suggests how they can be manipulated, assuming a basic strategy of cost minimization and risk avoidance. As we will develop further in the following chapter, there are two basic strategies for minimizing costs of toolstone: cheap procurement and prudent use. The use of either or both, and the particular ways in which they are likely to be realized, are conditioned by situational demands.

The model suggests that the economics of toolstone procurement can be an important aspect of hunter-gatherer adaptation. Further, it suggests that situations in which toolstone procurement costs "essentially nothing" because it is embedded in the acquisition of food resources, occupies slack time, or is pursued when primary food target resources fail to materialize (Binford 1979:260), may not be common. While embedding toolstone procurement in subsistence activities can amortize many procurement costs (thus reducing venture risk), opportunity costs are not necessarily canceled. Because toolstone consumption confers no direct energetic benefit to the consumer, opportunity costs vis-à-vis food resources are attendant on

each decision to acquire toolstone. Binford (Binford and Stone 1985:152) cautions that his 1979 description of Nunamiut toolstone acquisition is not intended as a general model of lithic procurement. Nevertheless, it is worth observing that encounter and surface collection procurement of the kind Binford describes for the Nunamiut Eskimo, *if the only procurement strategy used*, would exacerbate contingency risk in any but very rich lithic terranes or technological systems wherein maximizing toolstone utility is not an important concern.

We expect that the Tosawihi Shoshone (and other prehistoric Great Basin hunter-gatherers with mixed mode mobility patterns) employed different strategies of lithic procurement depending on position, season of the year, and scheduling demands in the procurement of other resources. Furthermore, the mix of lithic procurement strategies is likely to have varied through prehistory, along with changes in overall mobility and settlement/subsistence systems. Our model suggests several possible lithic procurement strategies that could have been employed at Tosawihi. We examine the likely archaeological consequences of these in Chapter 4.

Chapter 4

RESEARCH DESIGN

Robert G. Elston, Eric Ingbar, Melinda Leach, Christopher Raven, Kristopher Carambelas, and Kathryn Ataman

Models are undeniably beautiful, and a man may justly be proud to be seen in their company. But they may have their hidden vices. The question is, after all, not only whether they are good to look at, but whether we can live happily with them.

—Abraham Kaplan
The Conduct of Inquiry (1964)

Chapter 3 provides a theoretical structure for the study of the Tosawihi Quarries based on economics; relationships between costs and benefits of quarrying are framed in terms of abstract values such as time, energy, quality, and utility. Although we outline the archaeological consequences of different modes of lithic procurement, the scenarios are without dimension until adaptive variability in time and space, signaled by cultural, technological, and ecological change, are taken into account. Toward this end, we have collected a very large amount of data regarding chronology, paleoenvironment, technology of procurement and processing, and subsistence, as well as site formation, structure, function, and distribution.

In this chapter, we discuss the linkage between data and theory, and present the rationale for methods of data collection (the methods themselves are so diverse and numerous that they are more sensibly presented to the reader in later chapters when needed to explicate the particular phenomena or analyses described). Most of the present chapter is devoted to economic models and their archaeological consequences in site formation, site structure, site function, assemblage composition and diversity, and subsistence. At the end of the chapter we discuss briefly the economic geography of toolstone procurement and use, diachronic change and how it can be detected and interpreted in the archaeological record at Tosawihi, and paleoenvironments.

Economic Models and Prehistoric Use of the Tosawihi Quarries

In hunter-gatherer systems, lithic terrane and organizational patterns interact to affect toolstone cost. Factors affecting toolstone search and handling costs intrinsic to a given lithic terrane are toolstone abundance and distribution (including the relative accessibility of high quality toolstone and its ratio to lower quality material) and mode of toolstone occurrence. The time available for lithic procurement, and the opportunity costs it entails, are controlled by mobility patterns, subsistence strategies, and labor organization. Since there is much to suggest that hunter-gatherers attempt to minimize costs of food procurement (which results in direct energetic benefit) in order to maximize returns (Belovsky 1987), we assume that hunter-gatherers also should seek to minimize costs of stone tool manufacture and maintenance in most circumstances. Two strategies are available to realize these goals, minimizing procurement costs ("cheap procurement") and maximizing toolstone usefulness. The former strategy minimizes opportunity costs. The latter strategy lowers toolstone demand within an economy. Each strategy is discussed below and its archaeological implications considered.

Tosawihi as a Lithic Terrane

In order to put these propositions "on the ground" we must understand the lithic terrane of the Tosawihi Quarries, particularly with reference to opportunities and cost minimization strategies for lithic procurement. The nature of Tosawihi toolstone is the aspect of the resource least controlled by prehistoric miners and knappers; geological forces created the opalite and determined its accessibility. If, as we suspect, toolstone quality was a major factor guiding prehistoric choices among toolstone sources, it is important to understand the range of variation in toolstone quality *at* Tosawihi. The calculation of fall-off rates and the decrease in utility with time and distance require chemical and mineralogical identification of Tosawihi chert at sites far from the quarries. Thus, understanding the geology of Tosawihi opalite, its range of quality throughout the Quarries, and its chemical nature are essential to understanding the economics and strategy of prehistoric extraction-production. The lithic terrance of Tosawihi Quarries is explored in the following Chapter.

Models of Cheap Procurement: Minimizing Opportunity Costs

Because hunter-gatherers are rational decision-makers, they should attempt to minimize the loss of other potential benefits incurred by labor demands. As outlined in Chapter 3, collecting and processing raw materials necessarily entail a series of such opportunity costs, or lost chances to acquire, process, or consume resources. The efficient hunter-gatherer, however, can minimize opportunity costs by manipulating labor and mobility scheduling.

A Perspective on Organization and Mobility Patterns

The opportunity costs of toolstone procurement can be reduced in several ways. One is to position activities so that travel time and transport costs are minimized (Kelly 1990; Jones and Madsen 1989). A related option segments the organization of labor so that some, but not all, individuals risk opportunity costs. These strategies—activity positioning and labor organization—are not mutually exclusive; any set of activities may combine them.

Efficient workers organize their work spatially so that time spent in travel and transport are abbreviated, volumes of material needing to be handled separately are minimized, and energetic outlays are diminished. Two spatial strategies afford these desirable results; the location of tasks can be fitted to the geography of resources, or geography can be adjusted by transporting resources to more favorable locations. In the ensuing discussion, we refer to the former as reliance on *propinquity*, to the latter, as *convenience*.

Propinquity guides the location of activities in response to the natural distribution of things on the landscape; travel and transport costs can be minimized by staging activities near the resources on which they depend, and single-resource tasks (especially extractive ones) can be performed most efficiently where the relevant raw materials are immediately at hand. The archaeological expression of propinquity consists of site distributions highly correlated with the distributions of resources attracting their dominant activity, so we should expect quarrying sites to reflect the distribution of toolstone, hunting sites to reflect wildlife distributions, and milling sites to reflect the geography of food plants. Such patterns are *monistic*, that is, they are conditioned by consideration of a single resource (Figure 18a). Where multiple activities entail multiple, non-coincident resources (e.g., at residential sites), however, site location is likely to modify propinquity in favor of placement central to several target resources (Figure 18b); this *pluralistic* or "central place" solution to distance minimization has been a recurrent discovery

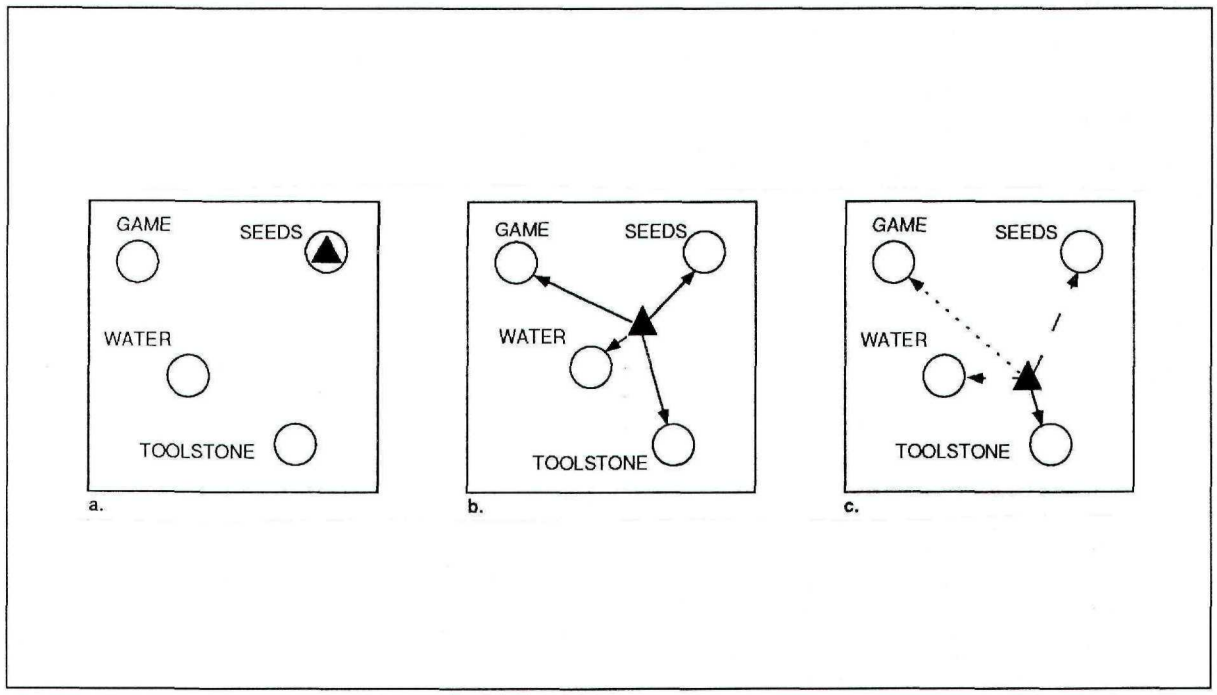


Figure 18. Site location strategies. a. Monistic location, emphasizing propinquity only to seeds; b. Pluralistic location, emphasizing equal propinquity to all resources; c. Pluralistic location, emphasizing ranked propinquity in the order toolstone-water-seeds-game.

of classical geography (Christaller 1933; Isard 1956; Losch 1954), and variants of the model have been applied analytically to help understand the spatial behavior of foraging populations (Orians and Pearson 1979; Stephens and Krebs 1986:53-60; Wilmsen 1973).

In practice, of course, some resources are more important than others, and their attraction is stronger; a dominant resource can exert displacement from central location (Figure 18c) because it must be exploited more frequently than others, because timing of its exploitation is critical, or because the costs of transporting it are disadvantageous. Water, for instance, often "tethers" the residence of otherwise mobile populations to the vicinities in which it occurs (Taylor 1964), and quarrying can be done only where suitable rocks are available. The habitations of quarriers, then, if they are to maximize efficient use of space, should be stationed at or immediately adjacent those water sources closest to sources of toolstone; the distribution of other pivotal resources (chiefly, subsistence materials) should fine-tune the optimal placement of residences.

Convenience, on the other hand, is an arranged circumstance; things are brought to a central location *(convened)* in the interest of making them easier to use, extending the time that can be spent in processing them, or bringing them within the ambit of other resources or toolkits with which they need to interact. Every act of transport constitutes an adjustment of resource distributions, yielding a temporary, expedient geography of useful things; most such acts, we assume, are undertaken to serve efficiency in the organization of work. Distance minimization remains the principal strategy by which time and effort spent in work are reduced and the handling of materials is diminished, but the strategy is consummated by moving *things* to *sites* rather than the reverse. Thus, basalt and quartzite hammerstones (as well, probably, as other specialized tools) are transported for use at quarrying locales, food and water are carried to work sites, task-specific tool kits are scattered across the landscape at places where their function is realized, foraging products such as meat, seeds, and roots are relocated to habitations for processing and consumption, and the products of quarrying and early stages of

lithic reduction sometimes are convened from raw material sources to locations more favorable for further reduction, heat-treatment, or tool manufacture.

Archaeological Expectations of Propinquity and Convenience

At Tosawihi, quarriers confronted an heterogeneous landscape in which target resources (especially, toolstone), as well as critical sustaining ones (water, animals, and plants), were distributed unevenly and *non-coincidentally*. We propose that locational decision-making was based on costs and benefits of access to each target resource. Foragers estimated the most advantageous mix of propinquity and convenience that minimized the time, energy, and distance required to obtain the target resource set. If true, the archaeological record should exhibit patterning in the distribution of functionally distinct activities, and that patterning should reflect a spatial logic minimizing the acquisition costs of four principal currencies (toolstone, water, animals, and plants). Leaving for later discussion the impact of seasonal fluctuation in some resources, we consider below how propinquity and convenience are likely to have affected the degree to which these currencies contributed to the location and composition of the principal site classes expected to occur at Tosawihi. We assume, for purposes of developing some specific expectations, that acquisition of toolstone was the principal motive for visiting the quarries and the principal factor contributing to the local archaeological record.

Residences

Residential sites should be positioned at locations maximizing access to all target resources; if all resources are of equal importance and demand the same procurement costs, the most economical solution should be to reside at that point from which the average distance to all of them is least (i.e., the central place solution; Figure 18a). But because of frequency of need, differential transport costs, or non-transportability, some resources exert *hierarchical* demands of propinquity in the placement of residences. We expect water to be chief among these, since it must be consumed frequently, is costly to transport, and its sources cannot be convened; all residential sites in the Tosawihi vicinity, then, should be found in immediate proximity to water, and, because its sources are scattered and infrequent, the distribution of water should be a relatively reliable predictor of residential locations.

Quarriers, however, should select from available water sources those that also maximize access to toolstone, and so should reside where water occurs nearest to stone sources. Archaeologically, the intensity of quarry-related activity, reflected by quarrying tools, facilities, and products (especially the earlier stages of lithic production), should be directly proportional to distance from toolstone, and should decline away from toolstone to a point from which it no longer is profitable to stage diurnal quarrying forays. Beyond 10 km from toolstone (an empirical daily travel radius; cf. Lee and DeVore 1968), we do not expect to find *any* evidence of diurnal quarrying (although later stages in the reduction of quarried products are likely).

The operation of propinquity with respect to subsistence resource distributions is likely to be more subtle in locating quarriers' residences than other classes of residential site, but its archaeological consequences remain potentially detectable. Once quarriers have segregated water sources appropriately close to desireable toolstone, they still are likely to face a choice among alternate residential locations. If we assume that the choice is made from site locations at which water reliability, toolstone quality and accessibility from surface, and distance between toolstone and water are equivalent, prudent foraging quarriers should locate residences at those places minimizing distance to the most favorable foraging patch or mix of patches. Such placement in large part should be a function of group composition and the organization of labor;

groups composed exclusively of males probably should do best by selecting campsites close to large game to enable off-hours hunting, while mixed parties should seek proximity to the highest-ranked resource patches (small game, roots, and, least desirably, seeds; cf. Chapter 20) exploitable by a non-quarrying labor force of women and children. In practice, of course, subsistence needs are likely to have been managed through a mixture of labor specialization and task scheduling, but in either case, the archaeological consequences of positioning quarriers' residences to accommodate foraging concerns should consist not only of relative propinquity to favorable resource patches, but also the convening at the residential base of subsistence gear, food processing facilities, and subsistence residues. Millingstones within residential precincts, for instance, probably reflect site placement successfully near food plant patches, while their absence may reflect either field processing of more distant plant resources or site selection biased in favor of hunting. Likewise, the proportion of high-utility to low-utility faunal residues in quarrying camps should reflect distance from big game habitats directly.

Quarries

Since primary toolstone extraction can occur *only* where suitable raw material is available, the role of propinquity in positioning quarrying activities would *seem* to be trivial; it is not. While toolstone quality is likely to be the prime selector of which stone source or group of sources will be exploited, other factors figure as well. If we assume toolstone quality and accessibility from surface to be equal at a number of sources, then quarriers should exploit that source closest to the residential base, *since the economic geography of toolstone sources already has been altered by the decision to camp at a certain place*. By invoking propinquity in the selection of quarrying sites, costs of travel and transport can be reduced to the benefit of quarriers.

The relationship between residential site location and toolstone procurement location, then, is reciprocal, but the logic of locational decision-making is not circular; at Tosawihi, usable toolstone is distributed far more widely than water, and more choices were available in selecting where to get stone than where to camp. Tradeoffs between toolstone quality and distance from camp should define a threshold beyond which it becomes less likely that quarriers will venture, and we expect that the Tosawihi vicinity harbors some sources of very high quality toolstone that went unexploited, or were exploited less intensively, simply because their location relative to water and potential campsites was unfavorable (i.e., more costly). Likewise, material quality should define a lower threshold beneath which stone should not be exploited however close to camp it might lie. Archaeologically, then, we should expect those sources of usable material lying closest to residential sites to have been quarried most intensively, with distance-dependent falloffs in intensity of use mitigated chiefly by variation in toolstone quality.

Upon the quarry are convened all the paraphernalia of extracting stone from a bedrock matrix: the toolkits of digging, wresting blocks from parent material, and breaking them into transportable packages. The Tosawihi landscape offers little raw material for these other than hammerstones, however, so we should expect the importation of exotics (wood, antler, robust bone) to serve as digging sticks, wedges, and pries; their archaeological detectability, of course, would be contingent upon preservation. Hammerstones offer a better opportunity to observe the operation of convenience; sources of basalt and quartzite occur erratically in the Tosawihi countryside, but rarely coincident with toolstone sources. While the transport of hammerstones inevitably entailed certain costs, their utility in quarrying is unlikely to have been ignored and the effort to get them and bring them to a quarry likely to have been repaid (within constraints imposed by distance). Their search and pursuit costs, however, would have contributed to the overall expense of toolstone procurement. And because their use inflates the cost of toolstone, hammerstones offer a potential opportunity to observe the interplay of convenience and propinquity; given two toolstone sources of equal quality equidistant from a residential base, the source closer to a supply of hammerstones should be the one more economically exploited.

Reduction Stations

The products of quarrying are convened for use away from their place of origin, but not in the form in which they emerge from the ground. Transport costs and the risk of failure can be diminished by initiating lithic reduction before transport, and we expect this to have been the case at Tosawihi. In fact, surface survey of the entire vicinity and preliminary testing in the Eastern and Western Peripheries found "reduction stations" to be the most numerous class of activity feature, outnumbering quarry features by a factor of 1.4:1 and residential sites by 6.6:1. Two issues of propinquity are likely to have affected their locations.

In the first place, elimination of substantial waste mass *before* significant transport has occurred reduces the cost of getting usable toolstone packages to their destination, so early stages of reduction (irrespective of technological trajectory) should be undertaken at or near the stone source. This means that the distribution of most archaeologically distinguishable early stage reduction stations should be *clustered* (rather than random or uniform; cf. Clark and Evans 1954), and that they should cluster in the vicinity of their parent quarry. Such clustering should allow prediction, in fact, of the general location of utilized but otherwise undiscerned stone sources (e.g., buried quarry pits, collapsed adits). Of course, some early stage reduction stations are likely to be coincident with primary quarry debris at the source, and thus are likely to be difficult to segregate archaeologically. Likewise, individual reduction episodes may be interwoven inextricably; even successful material sourcing should fail to tease them apart, since they are likely to derive from the same source. Palimpsests and high density of packing within a cluster of reduction stations, however, may serve as proxy indices of intensity or duration of use of the parent quarry.

In the second place, later stages of reduction entail the removal of less waste mass, so limited transport can precede their accomplishment without incurring excessive transport costs. Too, if later stages in the reigning reduction trajectory are enabled by heat-treatment (a time-intensive process), it actually may be advantageous to transport partially reduced material to a camp setting, where its processing can be tended in off-hours or by a non-quarrying labor force. In this case, late stage and post heat-treatment reduction stations should cluster around or be nested within the residential precinct.

The role of quarries and residential sites in centralizing the location of reduction stations does not imply that *all* reduction stations will be members of such clusters, but we expect that most will. Moreover, we do not expect most non-clustered reduction stations to occur in free spatial variation over the landscape. Rather, they are most likely to occur in transport corridors between quarries and residential sites, the consequence of stopovers at favorable foraging patches, minor water sources, or topographically inviting flats and benches where a little productive work could be done. That such locations still are partially governed by propinquity, and still technically share membership in clusters, may be difficult to distinguish archaeologically unless both origin and destination of their transport can be determined.

Minimizing Opportunity Costs of Toolstone Procurement through Mobility and Organization

Propinquity and convenience are relative terms; they describe the relationship of activities to the distribution of resource targets. Because labor organization mediates between task and task location, the larger pattern created by positioning and labor organization strategies is a *mobility pattern*. At one end of the continuum of mobility patterns is a *logistical pattern*, in which resources are moved to consumers. At the other end is a *residential pattern*, in which consumers move themselves to resources. Points lying between these two extremes are equally important, and represent different mixtures of these two "pure" patterns of mobility.

Labor organization effects these different tactics of locating activities within a landscape. Segmentation of tasks serves to minimize the costs associated with any given activity. For example, the use of a central place to gather non-coincident resources may be most efficient when each resource is exploited and transported by a different task group. As long as resource acquisitions are shared, each task group incurs an opportunity cost but the group as a whole does not. Another option is to vary how labor is deployed temporally; the scheduling of tasks and task groups also serves to minimize the net loss of other resource opportunities.

Various mobility and labor scheduling options are available to toolstone collectors, ranging from unplanned collection of raw material found in the course of travel and foraging (an encounter strategy), purposeful gathering of toolstone within the vicinity of the residential base (diurnal or residential strategies), dispatching special task groups to the toolstone source (a logistical strategy), and combinations of all strategies. Which strategy comes into play at any one time is influenced, of course, by a number of factors—seasonality of quarry use, scheduling decisions demanded by the procurement of other resources, regional population density, trade demands, and more. Thus, no one mobility pattern is inherently "better" than any other at cost minimization; rather, each has a range of cost minimization payoffs depending on the particular situation in which it is utilized (cf. Chapter 3).

Data relating to group composition and mobility strategy may be relatively abundant at Tosawihi, but teasing them from the roar of extraction and processing debris (e.g., distinguishing logistical from residentially organized forays) at the quarries is a thorny problem (Thomas 1983a, 1988; Elston and Budy 1990). In the following sections we illustrate several models reflecting points along the continuum of potential mobility and organization. We assume that prehistoric groups could schedule and organize their visits to Tosawihi as they wished, and could choose from a full range of technological options for exploiting toolstone observed there. The archaeological record thus need not fit any of these interpretive models isomorphically; instead, the models illustrate the range of variation expected in prehistoric use of the quarries and their vicinity.

Encounter Strategy

The simplest toolstone procurement strategy is to collect toolstone as it is encountered (Figure 19a). As residential or logistical movement brings foragers to toolstone sources, raw material is assayed, collected from the surface, and either used expediently and discarded (Hayden 1979b) or incorporated as personal gear into toolkits (upon which old gear may be discarded). This *encounter* strategy can be employed anywhere, and is most effective under conditions of mobility, as for instance, while people travel from one place to another. It is less a pattern of convenience or propinquity than it is of simple opportunism (cf. Binford 1979:258). We doubt that encounter procurement alone can meet all toolstone demands, particularly in technological systems where tool design constraints (size, form) are important.

The archaeological signature of encounter procurement of toolstone should be characterized by low debris densities. Lithic assemblages should be relatively small and dominated by processing debris (abundant primary flakes, core remnants, biface fragments, hammerstones), but also might contain a fair number of exhausted tools made of exotic materials. The visibility of this pattern is expected to be very low at Tosawihi, perhaps apparent only in the occurrence of isolated projectile points and isolated lithic reduction scatters.

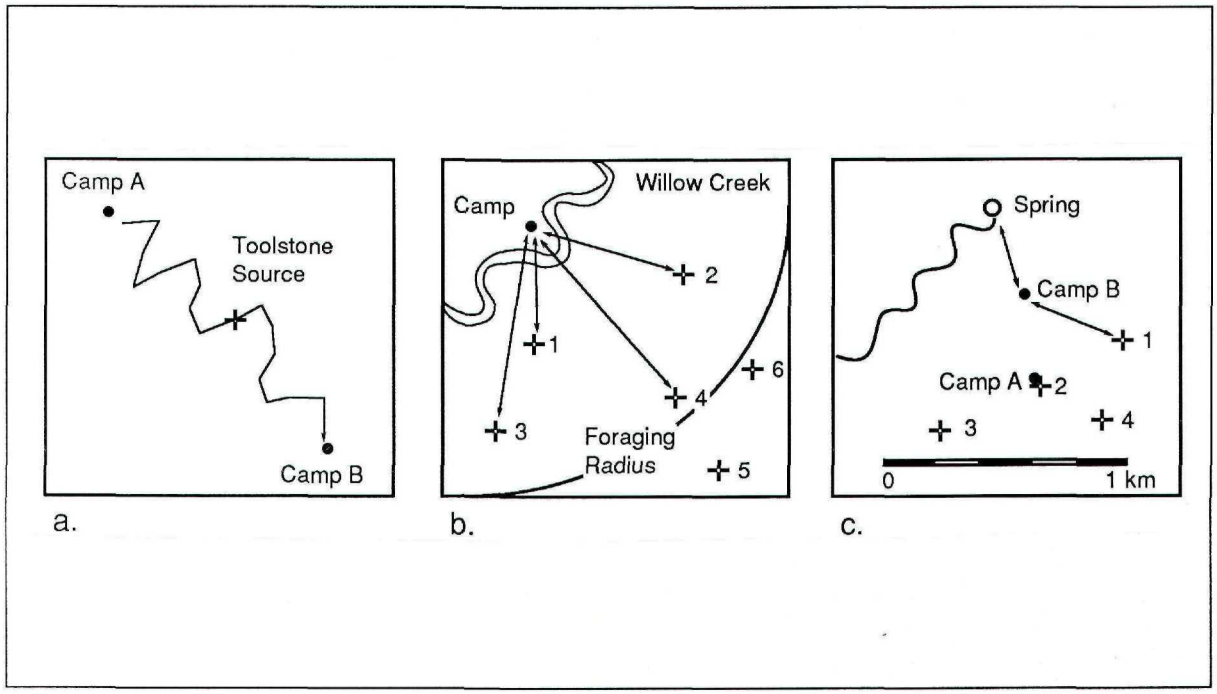


Figure 19. Mobility patterns and toolstone procurement strategies. a. Encounter procurement during travel on residential move. b. Diurnal procurement from camp on Willow Creek; because of travel costs, profitability of source **4** is least and that of source **1** is greatest. Sources **5** and **6** are beyond diurnal range. c. Residential camp **A** monistically located at toolstone source **2**; camp **B** is located pluralistically with reference both to toolstone source **1** and a spring.

Diurnal and Residential Strategies

If residential movement to the vicinity of a toolstone source forfeits other higher return resource options, there may be higher opportunity costs for the group as a whole, prompting this kind of residential mobility only under some conditions or in some seasons. In the case of moves to the Tosawihi Quarries, opportunity costs can be minimized by scheduling residential group moves to coincide with productive foraging seasons when variation in food patch returns are low (cf. Chapter 3). If such food gathering opportunities produce excess resources for storage and future consumption, then opportunity costs are further ameliorated.

Propinquity to food resource patches may be forfeited in the choice of residential base location to ensure that toolstone sources are placed within the daily foraging radius (Binford 1983b). The Tosawihi Quarries are within the 10 km diurnal range of camps on Willow Creek, Rock Creek, Little Antelope Creek, Antelope Creek, and Ivanhoe Creek; these settings probably provided attractive conjunctions of resource sets (cf. Chapter 2), and so were favored for residential bases of this sort.

Diurnal Strategy. Employing a *diurnal* lithic procurement strategy, one to a few people conduct a toolstone collection trip within the foraging radius of the residential base and return in the same day (Figure 19b). Opportunity costs are minimized, both by using normal foraging trips to gather toolstone (as in the encounter strategy described above) and/ or by using only a part of the work force for toolstone procurement while the rest of the group exploits other resources.

Although transport costs are lower than for longer distance logistical procurement, diurnal exploitation of toolstone is constrained by the time available for work, which decreases with distance from the residential base. Since the profitability of toolstone is the ratio of toolstone obtained during a particular foray to handling time (extraction and processing time; cf. Stephens and Krebs 1986:23, 54-55), distance affects the extraction techniques that can be employed at a toolstone source. Thus, resources in close proximity to the base camp (such as source 1, Figure 19b) can have lower profitability (be of lower quality or require more intensive methods of extraction and processing), while resources in the vicinity of the maximum diurnal range (such source 4, Figure 19b) must have very high profitability (be of high quality and require little processing) to achieve a payoff.

This suggests a continuum for lithic resource procurement within a given daily foraging radius. At the maximum diurnal range, it would pay only to procure very high quality, pre-processed lithic material—for example, to retrieve cached flake blanks and bifaces. With shorter distances or travel times, a likely target might be previously quarried, but relatively unprocessed, material available from the surface of quarry pit berms and dumps. Closer still to the base camp, it might pay to grub through quarry pit berms in hopes of encountering chunks of high quality material requiring minimal processing. Finally, when close enough to the base camp, it pays to employ full scale quarrying techniques.

The archaeological visibility of diurnal use in the quarries is expected to be low. Accidental tool loss, disturbed caches, and debitage from assaying and processing surface toolstone are indistinguishable from similar features generated by quarrying, processing quarried material, and supporting occupation of the quarries during logistical or diurnal use. Perhaps the best evidence for diurnal use consists of shallow pits excavated in quarry pit berms to glean previously quarried but discarded toolstone.

Residential Strategy. A *residential* strategy is in effect when propinquity to other resources has been sacrificed for propinquity to toolstone, and the residential base is positioned so close to the toolstone source that travel time is no longer a significant cost of lithic procurement. At its most extreme, this results in residence *on* the quarry, a *monistic* residential strategy (Camp A in Figure 19c). A *pluralistic* residential strategy results in location of the residential base with some consideration also for non-toolstone resources local to quarries (Camp B in Figure 19c). In the Tosawihi landscape, monistic, toolstone-based residence may rocket opportunity costs, since toolstone sources often are spatially disjunct from many other natural resources (cf. Chapter 2). This suggests that residence and quarry sites should coincide only when a) the quarry locality also coincides with the location of water and food resources, or b) occupation is of such short duration that the location of local non-toolstone resources is irrelevant. Nonetheless, this kind of mobility and organizational pattern should result in an archaeological record of quarrying debris associated with indicators of residential use of places (cf. Chapter 24).

The greater the duration of occupation in the vicinity of the quarries, the more foragers will have to depend on local resources for support, and the more likely they are to employ a pluralistic residential strategy, occupying sites near, but not on, quarries. This in turn is likely to result in greater segmentation of tool production, with early stage processing performed at the quarries and later stage processing (including heat-treatment) performed at the residential base or at intermediate stations (Elston, Raven, and Budy 1987; Elston 1989). Assemblages generated during such residence should contain few tools related to quarrying, and greater frequencies of tools reflecting procurement and processing of biotic resources (projectile points, partially consumed tools of local Tosawihi chert, grinding equipment, pottery), tool maintenance, and replacement (exhausted tools of exotic materials). Debris representing later stage lithic processing and heat-treatment should be abundant. Such relatively long-term camps should contain cooking and heat-treating hearths, and possibly evidence of differential use of space.

In contrast, monistic residences on, or immediately adjacent, quarry locales should be dominated by debris and features related to quarrying and early stage processing (flakes, core

remnants, biface fragments, hammerstones), but perhaps with the addition of small assemblages of equipment related to short term residence such as pottery, grinding equipment, and weapons.

Logistical Strategy

At the opposite end of the mobility continuum is a logistical pattern of exploitation. Small, logistically organized task-groups conduct short-term, toolstone-targeted collection forays requiring overnight or longer trips away from the residential base. In the example depicted in Figure 19b, sources 5 and 6 are located beyond the diurnal range of the Willow Creek camp; their exploitation from that camp would require a logistical trip. There may be many reasons for such logistical use of the Tosawihi Quarries, including specialized procurement for exchange, critical functional requirements necessitating high quality toolstone, or religious and social incentives (Gould 1980, 1985; Gould and Saggers 1985; Hughes and Bettinger 1984). Whatever the motivation for logistical use of a toolstone source, opportunity cost is minimized by labor organization, since only a few group members are removed from the residential labor pool. Yet, transport of quarried products may be costly. Transport costs in part may be ameliorated by other functions of logistical forays such as resource monitoring (in which case the logistical party maximizes its opportunity yields), or embedding procurement of other resources in the trip; game was taken during ethnographic logistical quarrying trips observed by Jones and White (1988) and Binford and O'Connell (1984).

Scheduling of logistical forays also may help minimize opportunity costs, depending on seasonal labor needs. For example, logistical forays may have been mounted from either a winter residence base or a summer foraging camp, and each may have exacted different opportunity costs. Summer forays may have been "cheap" in terms of provisioning the foray party, but expensive in terms of the opportunities lost to the group as the labor force was reduced. Winter forays may have been costly to provision, but if labor productivity was low in the winter they may have entailed lower opportunity costs.

Given the small group size characteristic of logistical forays, the quantity of toolstone transported back to the residential base may be low; the energetics of toolstone transport require that the return of "useful" stone be maximized. As in diurnal exploitation, the highest payoff would accrue from retrieval of a cache; this, in fact, might be the only payoff sufficient to justify a winter trip to the quarries. Certainly, one would not expect a logistical foray to focus on mediocre material from the surface or in quarry pit berms, because toolstone of similar quality is likely to be available at much less cost closer to home. Intensive methods of extraction (excavation of quarry pits or adits) and attendant large scale processing are expected only when people could remain at the quarries long enough, so seasonality may be important in this regard, as well.

Logistical camps for direct procurement are likely to be located near the source since less time need be spent in foraging. Little segmentation is expected in direct, logistical procurement—processing and residential activities are expected to occur at or near the place of extraction with little caching. The assemblages of logistical field camps are expected to be relatively small, to exhibit little diversity, and to be dominated by processing debris (flakes, core remnants, biface fragments, hammerstones) and weapons. This assemblage composition is so similar to that expected from monistic residential occupation that it may not be possible to differentiate the two. Time constraints will prevent the production of large surpluses of toolstone, so the creation of caches is not expected during logistical use of the quarries, and heat-treatment may be deferred until return to the home base. Hearths are expected to be minimal in construction, and other features absent, in summer logistical camps. Winter logistical camps should require the construction of shelters and more elaborate hearths, or the occupation of rockshelters.

Caching Strategy

Caching artifacts near their source is another strategy to minimize opportunity costs. Artifact caching trades the energetic cost of overproduction for future minimization of opportunity costs, since retrieval of caches requires only the opportunity and labor costs of travel and transport; neither procurement nor production costs are incurred. Caches also minimize future procurement costs (cf. below). Because caching depends on overproduction—excess time or energy to produce more artifacts—it should occur most often in settings where excess time or energy were available. The best candidates for such settings are residential sites.

Mobility and Organization in the Archaeological Record

In the preceding discussions, several simple archaeological expectations were presented. These are essentially ethnographic in scale, and are not necessarily visible in the archaeological record. Many different combinations of mobility scheduling and labor organization may have contributed to the archaeology of the Tosawihi vicinity—over millennia, decades, or even seasons of the same year. A primary attribute of the complex archaeological record resulting from so complex a history of use is its spatial structure.

Since strategies of economizing rely so heavily on how space is used, we assume their archeological consequences to be overt, detectable, and interpretable. Particularly, we expect spatial relationships in the archeological record to comment on the macroscopic role of environmental influences in locating prehistoric activities (Binford 1978a, 1983a:109-143, 1983b; Losch 1954; O'Connell and Hawkes 1984; Wagner 1960), as well as on the more microscopic details of how group size, work structure, and duration of occupation affected the relocation of resources and the use of space within activity areas (Binford 1983a:144-192; O'Connell 1987; O'Connell, Hawkes, and Blurton Jones 1991; Simms 1988).

At Tosawihi, we expect most observable spatial patterns to be referable to the organization of toolstone procurement, and we expect to be able to segregate specific patterns relating to the extraction of lithic raw material, the conduct of subsequent stone reduction and processing, and the feeding and sheltering of quarriers. Artifact size and stage with regard to distance from source, and functional type of site in which artifacts are found, also should reflect organizational patterns of lithic processing. The principle of least effort suggests that, from a given residential base, the most intense exploitation should occur at the nearest available source, other things (such as stone quality) being equal (Chapter 25). In future research, the actual distribution of raw materials in residential bases from different sources (assuming these can be identified), will test the model and suggest where other things are *not* equal.

Identification of these patterns and interpretation of their meaning necessarily will rely on other categories of inquiry; particularly, our reading of the spatial component of the record will depend on judgments of site function informed by analyses of landscape geography, site formation and transformation, assemblage composition and diversity, feature composition and distribution, and the nature and distribution of subsistence residues.

Recognition of site formation processes—understanding how the archaeological record of Tosawihi formed—is an important precursor to interpretation of the archaeological record at Tosawihi. Site formation processes govern how archaeological sites form initially and are transformed subsequently (Binford 1979, 1980; Schiffer 1976), and their study involves both anthropological study of how sites form due to human action and how they are modified by natural processes (cf. Chapter 22).

People create archaeological sites by living and working in them. Use of space is differentiated as people sleep in one place, work in another, and dispose of refuse in yet another. Several models of site formation processes derived from ethnographic data (Binford 1977, 1978a, 1986; Binford and O'Connell 1984; Yellen 1977a; Gould 1977; 1980) are applicable at Tosawihi. Activities at residential sites also can be expected to create cultural features and transform archaeological sites; examples include the excavation and cleaning of hearths and heat-treating features, creation of debitage scatters, disposal of lithic and other waste, clearing of work spaces, and shelter construction. In caves and rockshelters, the latter may effect massive transformations of archaeological deposits (Elston and Budy 1990).

Geological and biological processes begin to transform archaeological sites as soon as they are created. At Tosawihi, the notable agencies of non-cultural site transformation are slope movement, eolian and alluvial deposition, and bioturbation by burrowing animals. Pack rats (*Neotoma* sp.), mammalian predators, and raptors all contribute to the faunal content of caves and rock shelters; the former two may cause extensive disturbance of archaeological deposits through burrowing (Elston and Budy 1990).

Investigation of site formation processes requires careful analysis of sediments in context, and understanding site-transforming cultural and natural features. An integrated interpretation of site formation can be derived from feature mapping, trench profiling, and geomorphic studies (as in Chapters 16, 17, 18 and 22). Where applicable, analysis of faunal remains can reveal proportions of naturally and culturally introduced bone (cf. Chapter 14; Schmitt 1990).

Data on spatial relationships at Tosawihi were gathered at several scales. Intrinsic attributes of site location were monitored by recording topographic, hydrologic, floral, and faunal details of site settings, and by comparing site distributions to the distribution of available deposits of toolstone. Intrasite locations and distributions of functionally classifiable features were mapped. Intrafeature and interfeature patterns of artifact distribution were discovered by intensive surface scrutiny and mapping, various case-specific strategies of systematic collection (chiefly, patterned surface scrapes and limited excavations), and subsequent analyses (size grading and functional characterization) of collected assemblages. These data are employed in Chapters 21 and 25 to test the degree to which our assumptions about distance minimization account for spatial configurations in Tosawihi archaeology.

The spatial structure of a site often suggests the size, social structure, and duration of occupation of groups occupying it (Binford 1978a; 1983a; O'Connell 1987; Zeier and Elston 1986; Novick 1987; Thomas 1983b, 1988; Elston and Budy 1990). Obviously, quarry localities, workshops, rockshelters, and open habitation sites all may exhibit different structures because each presented a different set of spatial constraints and each may have been occupied by groups of different size for different sets of activities over different periods of time. The ethnoarchaeological literature, particularly that of Australia, provides some insight into what we might expect of the site structure of lithic quarries and workshops (Jones and White 1988; Binford and O'Connell 1984; Binford 1986; Gould 1977, 1980: 124-125; Hayden 1979a:51; O'Connell 1974, n.d.; Tindale 1965:140); this is explored in Chapter 22.

Whether or not the organization of field camps is highly structured probably has a great deal to do with length of occupation. If archaeologically visible, sites occupied for a very short duration usually have a correspondingly simple structure (or none at all). Conversely, the structure of sites occupied over longer periods, and those consistently reoccupied, may be highly structured as occupants clear certain space and keep it clean, empty hearths, and otherwise organize and reorganize work areas and places of debris disposal. These relationships are investigated in the analysis of feature aggregation in Chapter 25.

The functions of archaeological sites at Tosawihi have been classified tentatively on the basis of limited evidence from surface collection and testing (Budy 1988; Raven 1988; Elston 1989), but these distinctions remain to be demonstrated. For instance, what *really* were the functions of "reduction stations," small, discrete lithic scatters usually found on ridges or in

small rockshelters? Do they represent hunting stations, procurement of lithic material by groups passing through on their way elsewhere, or places where specialized reduction tasks were carried out? Do sites provisionally named "residential" on the basis of the presence of ground stone and "finished" tools contain additional evidence to support this classification? We have observed considerable structural complexity in several open sites; are more complex sites functionally different from less complex ones?

Site function is addressed in Chapters 23 and 24 by assessment of variability in the content of individual localities and comparison of assemblage composition and diversity (Thomas 1988; Elston and Juell 1987; Elston and Budy 1990). Functional tool classes and use wear evidence signal ranges of activities; the presence or absence of distinct feature classes (eg. hearths, storage pits, and house pits or other structures) reflect both the duration of occupation and functional range of a site.

Models of Cheap Procurement: Production Efficiency

Manipulation of labor organization and mobility scheduling is one option available to hunter-gatherers to minimize the cost of lithic procurement; another is to maximize the amount of "useful" toolstone procured with a given amount of energy. Because the opportunity cost of quarrying is a comparative measure (actual gain minus forfeited gain), increasing the amount of toolstone garnered with a given amount of energy necessarily lowers opportunity cost (cf. Chapter 3). As in mobility and labor scheduling, an overall strategy of efficient procurement can be accomplished through a variety of options.

In general (and at Tosawihi), different kinds of toolstone occurrence (e.g., bedrock, outcrops, cobbles) have varying costs and benefits associated with extraction. Given constraints on time or energy, it is likely that prehistoric quarriers focused on those occurrences with the lowest cost-to-benefit ratios, ignoring those less profitable (cf. Chapter 3). At Tosawihi specifically, bedrock deposits provided toolstone of the highest quality, but, in terms of time and effort, it was the most costly to extract. Quarrying techniques, quarrying tools, and the organization of human work were the means by which the costs of subsurface toolstone extraction could be minimized.

Techniques and Tools

Subsurface quarrying always requires more time than surface collection, regardless of technique. Some quarrying methods, however, are less costly than others. Excavations forming pits and adits allow quarriers the opportunity to focus most of their efforts on extracting toolstone, with maintenance restricted mostly to periodic cleaning and disposal of quarry waste. Other methods, such as the excavation of shafts, galleries, or drift tunnels, almost always demand investments of time and effort in the design and maintenance of the mining feature (cf. Shepherd 1980:12-18).

Subsurface quarrying requires removal of overburden prior to toolstone extraction. Ethnographers have documented the use of modern steel tools in toolstone extraction, (Binford and O'Connell 1984:412; Gallagher 1977; Jones and White 1988:62; James O'Connell, personal communication), but most prehistoric quarriers were limited to tools fashioned from stone and organic materials. Bone and antler picks, rakes, points, and levers used to loosen overlying soils and rock have been recovered from a number of quarries (H. Lech and J. Lech 1984:193; McBryde 1984:273; Mercer 1987:160-163; Rudebeck 1987:151, 153; Schild 1987:142; Shepherd 1980:19-20, 28-33). Removing loosened sediments from the work area can be accomplished by

pushing materials aside by hand (cf. Binford and O'Connell 1984: 412), but shovels and containers are more efficient. Scapulae from large mammals were recovered from quarry features at Tosawihi (cf. Chapter 14) and other quarries (Ahler 1986:75-76; Rudebeck 1987:153; Shepherd 1980:32-33), and are efficient when used as shovels to scrape loosened sediment away from the work area (Shepherd 1980:32-33). For hauling spoil greater distances, a container would have been appropriate. Burton (1984:241, cf. Figure 2) notes that the Tuman axe makers' *grenj kon*, or quarrymen's basket, solves the problem of moving large amounts of rock quickly.

Once a sufficient work space is cleared, quarriers can extract toolstone in the form of clasts, cobbles, or boulders from a soil matrix, or chunks and flakes from primary bedrock. Hammerstones are perhaps the most important tool for extracting stone from large boulders or bedrock. Large, two-handed hammerstones are effective for loosening lithic material that surrounds toolstone, or for pounding against the weak planes of a rock surface in order to free pieces (cf. Burton 1984:242). Small, one-handed hammerstones are useful for removing large flake or core blanks from parent material. A liability of hammerstone use, however, is that internal fractures are introduced which ultimately inhibit flake propagation and make the stone useless for tool fabrication. Wooden, bone, and antler wedges (cf. Burton 1984:241; Rudebeck 1987:153; Shepherd 1980:82) are effective for skirting this problem; driven into cracks or joints by hammerstones or billets, wedges force chunks from their parent material without destroying the stone or producing internal flaws.

With the exception of hammerstones, most quarrying tools used at the Tosawihi Quarries should have been kept as personal gear (cf. Binford 1979:262-263), either cached at the quarries or stored as passive gear at a base camp, since their availability in the vicinity was not reliable. An additional reason to keep them as personal gear, versus trying to locate them situationally (Binford 1979:264-266), is that their manufacture at the quarries would have occupied time that could have been spent quarrying. Hammerstones, on the other hand, are readily available around Tosawihi in the form of quartzite and basalt boulders; they easily could have been procured situationally, and left as site furniture.

Charcoal concentrations in many quarry features at Tosawihi suggest that fire may have been used in toolstone procurement. The use of fire (and water) in toolstone extraction relies on differential thermal expansion and contraction of the constituent minerals of a lithic material, and it is most successful on heterogeneous rocks (Shepherd 1980:19) or large, isolated pieces (Binford and O'Connell 1984); its application, then, is contingent on the geology of the toolstone being extracted. The Tuman axe makers, for instance, never used fire because it was unsuitable for the conditions (Burton 1984:260). Binford and O'Connell (1984:418), however, observed fire being used to break a large quartzite boulder into smaller chunks, and informants told Jones and White (1988:62) that fire sometimes was used to crack large rocks. Akerman (1979:144) reports that fire was used throughout the Kimberleys for extracting toolstone from bedrock.

Labor Availability

Given limited time, quarriers can maximize the amount of quality toolstone procured by intensifying the amount of work completed per unit of time. Organizing human labor for toolstone procurement is the principal way in which this could have been accomplished. For instance, Yolngu quarriers were observed working at various toolstone procurement tasks simultaneously (Jones and White 1988:74); while one man extracted cobbles from a pit, others flaked stone or searched for new sources. Putting more men to work at the Tuman ax quarries increased the overall output significantly and, consequently, more men could claim axe stone (Burton 1984:242). Actualistic quarrying experiments at Tosawihi (Carambelas and Raven 1991) have shown increases in the rate of overburden removal with two quarriers either working as a team or relieving one another at quarrying.

Organizing human work by age, sex, or ability is another means of minimizing the costs of quarrying. Binford and O'Connell (1984:409) note that the ability to procure toolstone was expected of all Alyawara men, and Yolngu quarriers emphasized that it was the work of men to flake stone, that of women, to haul it away (Jones and White 1988:61). Moreover, older Yolngu men were responsible for core reduction and production of primary flakes (tasks considered more demanding and requiring greater skill), while younger men excavated quarry pits and completed secondary thinning of flakes (Jones and White 1988:62, 71). The relatively skilled task of removing axe stone from an outcrop was completed by only a few Tuman axe makers, while unskilled labor was put to work removing waste stone from the work area (Burton 1984:242).

When contemplating how human work may have been organized at the Tosawihi Quarries, an important issue to consider is the composition of the group from which quarriers were drawn. Task-specific work groups that made short but work-intensive forays most likely would have been organized from a permanent base camp composed of multiple families. Supported by others at a temporary field camp, quarriers could have extracted and processed quality toolstone without having to focus on other subsistence activities. Jones and White (1988:76) estimate that between 50 and 100 finished *ngambi* points could have been produced by 3 or 4 Yolngu quarriers in a single day, when supported by individuals at a base camp. On the other hand, opportunistic quarrying seems most likely when residential mobility was greater and groups were composed of fewer individuals, perhaps only an extended family. Less time could have been devoted to quarrying, since personnel would have had to participate in other subsistence related activities.

Archaeological Consequences

Subsurface toolstone extraction creates pits and adits surrounded by berms composed of soils and lithic debris. These features are subsequently filled in by quarriers who expand or excavate adjacent; erosion also fills in quarry features (cf. Chapter 22). Broken or rejected cores and large quantities of raw (not heat-treated) lithic material make up the cultural fill (Wilke and Schroth 1989:170).

Complete and fragmented hammerstones of various shapes and sizes also should be present within and around quarry features. Lithic material suitable for hammerstones is abundant in the Tosawihi vicinity, and probably allowed quarriers to procure hammerstones situationally and leave them as site furniture (Binford 1979:263-266). Using a gravity model, hammerstone size already has been shown to be an inverse function of distance from basalt or quartzite source (Elston, Raven, and Budy 1987). Organic materials from which other tools were fabricated were not present or predictable in the Tosawihi vicinity; when quarrying was not underway, these tools (personal gear; cf. Binford 1979:262-263) probably were cached in the vicinity or at a base camp. Therefore, organic tools should be present only in fragmented or exhausted form, and only when conditions permit them to be preserved (cf. Chapter 14).

Social groups visiting the quarries may be manifest in the types of sites they created, as discussed above. For example, short-term, task-specific groups should be represented by quarrying and reduction locations and, at a short distance from these, field camps (Binford 1980:9-10). More heterogenous social groups, on the other hand, probably conducted a number of activities additional to toolstone procurement, reflected in base camps and locations (Binford 1980:9). Consequently, detection of social groups requires determination of site function and structure, as discussed above.

Extending the Utility of Toolstone

The foregoing outlines ways in which hunter-gatherer groups could lower the relative costs of toolstone through labor or scheduling strategies and procurement tactics. These tactical options pertain largely to the exploitation of particular lithic sources. Another option to reduce toolstone costs is to extend the period of its utility within a toolkit. Extending utility reduces the overall demand for toolstone within an adaptive system, and consequently reduces the systemic cost of its procurement. This section discusses how such a cost reduction strategy may be played out.

Necessarily, we approach variation in the extension of toolstone utility from the perspective of technological organization. Technological organization derives from the fit between the tool using activities in an adaptive system and the tools used to perform them. Insofar as tool using activities can be anticipated, technology itself can be organized (cf. Kelly 1988:717). Many factors affect technological organization among lithic economies; these include activity planning, labor organization, nature of the lithic terrane, and available resources. We limit our discussion here to those aspects of technological organization most determinant of toolstone costs, specifically, initial tool design and manufacture tactics, and tool maintenance and recycling tactics.

Tool Design and Maintenance Tactics

The design and initial production of tools unquestionably is a complex process (Bleed 1986:738-739), and one not particularly amenable to retrodictive analysis since diverse design criteria may result in similar tool forms. For example, Kelly (1988:718) argues that a biface may result from three different design decisions: to create a useful core providing flakes for use as tools, to serve as a tool in its own right, and as the byproduct of shaping a core for some other purpose (for flakes of appropriate sizes and shapes, hafting, etc.). Thus, tool form alone cannot be taken as homologous with design decisions. Nonetheless, initial tool design strategies amongst mobile foragers must minimize the costs of pre-manufacture and post-manufacture transportation, the cost of initial manufacture, and the costs of maintenance. The benefit against which these costs must be measured is the energy gained through use of the tool. The calories derived from killing a deer with an arrow, for example, must offset the energy expended in pursuit of the prey as well as the energy spent on producing the weapon to take the prey.

One trade-off that design decisions must confront lies in the range of tasks for which a tool is suitable. Tool forms that have many useful edges, but are not particularly suited to one specific task, can be considered highly *flexible* (Goodyear 1979). On the other end of the spectrum lie tool forms that are good only for a single task, yet perform it very efficiently. Because transport and production cost are important factors, most tools incorporate some degree of flexibility.

Another trade-off dictated by the economics of tool manufacture is the degree to which a tool is modifiable, that is, its potential to be changed into another form as needed. Since chipped stone production is a reductive process, the ability to modify a tool is often (although not always) related to how much stone is contained in a given form. This aspect of tool design can be summarized as *recyclability*.

Mobile technologies face two simultaneous problems created by disjuncture between spatial locations of toolstone and resources upon which tools are employed. First, a mobile technology must be *portable* (Goodyear 1979), since excessive tool transport is costly; the caloric return of a resource may be canceled by the caloric cost of carrying too-heavy tools. Second, tool *availability* (Bleed 1986:739)—the readiness of an implement at the time it is needed—must be

ensured to avoid contingency risk (cf. Chapter 3); to arrive at a resource unable to derive benefits from it for want of appropriate tools also is costly. The simultaneous requirements of portability and availability of tools virtually dictate that mobile technologies incorporate flexibility and recyclability in tool design strategies.

Because the energy gained by using tools must offset the cost of toolstone procurement, production, and transport, it is possible to model some general but simple relationships among tool form flexibility, recyclability, and activity structures. Activity structure in this highly simplified model consists of the predictability by foraging groups of two factors: action and location of action. Either can be known or unknown.

Activity scheduling is an important component of hunter-gatherer mobility systems (Binford 1980, 1982). Mobility systems in which, in the long term, both location and actions are known in advance can be considered *specialized foraging*. When actions are known, but location is not (again in the long term) such a system can be called *targeted foraging*. When the actions to be undertaken are not known, but the location is known, one can consider the system to be one of *generalized foraging*. When both task and location are unknown, the system can be considered *aimless foraging*. No single mobility system need fit perfectly into one of these categories; probably, in fact, none does (Thomas 1988). The point is simply that activity scheduling is an important component of adaptation and it underlies much of what is meant by the term "mobility system."

Activity scheduling is closely related to the costs and risks of stone tool use (Chapter 3). Under the terms of this model, whenever an action can be anticipated, tool needs are known and contingency risks are low. Consequently, tool design can be determined in advance, permitting the costs of tool design and use to be minimized. Likewise, knowing where an action will occur determines whether transport cost can be predicted, decreasing venture risks. When both the action and its location are known, foragers can predict all aspects of technological costs, lowering both venture and contingency risk. Conversely, when action and location are unknown, no aspect of technological cost is predictable; venture and contingency risks are both high. Bleed (1986) argues that because tool availability is the most important aspect of a technology, flexibility and recyclability should characterize tool forms associated with unpredictable activity structure (high contingency risk situations). Similarly, under predictable activity structures, tool form flexibility and recyclability may be less important than the efficiency of the tool in processing a specific resource in a given amount of time.

Bleed (1986) combines the dimensions of flexibility and recyclability, preferring instead "maintainability" and "reliability" to describe the two dimensions, respectively. Since tool form flexibility and recyclability are determined through different sets of observations on archaeological specimens, they are held separate here.

Initial design decisions limit the potential future uses of tools. The argument sketched above suggests that flexibility and recyclability, as starting properties of different tool forms, are related to (anticipated) activity structures and risk avoidance, and, by extension, to mobility strategies, which are long-term aggregates of activity structures. The potential utility of different tool designs is played out in the actual use, maintenance, and recycling of the tools themselves. Maintenance tactics involve refurbishing tools for use in the same task, and reshaping or reworking tools for use in other tasks. The former category includes resharpening and repair of tool edges and shape, the latter, modification of tool edges and shape. Resharpening and repair of tools is cost effective when future actions and the tools to be used in them are expected to be similar to those at present, since tool maintenance without subsequent use is simply wasted energy. Recycling differs fundamentally from resharpening, in that it indicates anticipation of need for a different tool form at the expense of the current one. In a sense, resharpening indicates a steady state and recycling indicates fluctuation in activity structure.

Archaeological Implications of Extending Toolstone Use

The arguments made above link variation in initial tool design, use, maintenance, and recycling strategies to broad characterizations of mobility patterns. Tool design strategies suggest the degree to which future activities can be forecast within the mobility system. Tool maintenance and discard strategies reflect the outcome of that forecast— whether similar or different activities are anticipated.

Initial tool design strategies are evident in the archaeological record, revealed by analysis of specimens broken during manufacture (cf. Chapters 6, 7, 8 and 9). Such analysis also delineates tool production sequences, indicating the energy expended to produce a particular tool form (e.g., heat-treatment may require a considerable effort in gathering firewood, tending a fire, etc., to facilitate continued reduction). Manufacture breakage analysis also allows the discovery of standardized tool forms, which in turn suggest how routinely those forms followed a particular cycle of use, re-use, and recycling. Another important attribute observed in manufacture breakage analysis is tool size and shape, since these limit the potential flexibility of a tool form and its recyclability into different forms.

Tool use histories, evident in archaeological specimens as use wear traces, edge damage patterns, resharpening, refurbishing, and recycling, are another important source of information (cf. Chapter 7). Different tool forms may sustain different rates of resharpening, refurbishing, and recycling, depending on anticipated uses, availability of raw material, and suitability for particular tasks. If tool function and form are related closely (as in a tool form with low flexibility), then we expect use wear and edge damage to be similar across all tools of the same form. On the other hand, heterogeneous wear patterns on tools of the same formal class suggest flexibility for that tool form. How tools break in use also informs on the mechanics of tool use as well as on the "lifespan" of stone tools relative to edge attrition and potential recyclability.

A summary way of examining these patterns is through the definition of *trajectories*, regular patterns in the production, use, reuse, recycling, and discard of tools (Elston 1986c). Trajectories of opalite toolstone use at Tosawihi should be conditioned strongly by opalite abundance. Under conditions of raw material abundance, tools needed for local use may be subject to few design restrictions since they need not be transported. Thus, we can expect an expedient strategy of local toolstone use among tools intended for use at the quarries. Manufacture of tools for use elsewhere should be subject to a different set of design restrictions. Specifically, we expect that tool production and use should follow two distinct trajectories, one of local expedient tool production and use, and one for production of tools intended to be used elsewhere (cf. Bamforth 1986). In Chapter 21 we summarize our observations on trajectories after discussing the manufacture, use, reuse, breakage, and discard patterns of each opalite tool class. Trajectory delineation provides a concise description of overall technological strategies, and it is perhaps at this level that the linkage to general patterns of mobility can be made best.

The Economic Geography of Tosawihi Toolstone

Economic geography studies the distribution and movement of resources, exploring transportation costs, rates of consumption, fall-off rates, the interaction of resources, and the role of commodities in trade and exchange, usually over large areas (cf. Ericson and Earle 1982). There are many suggestions in the existing literature that geographic factors influenced the use of toolstone in north-central Nevada; these include the sharp boundary between use of white chert and obsidian to the west of Tosawihi (Stephenson and Wilkenson 1969), the preference for cherts of mediocre quality around local source areas in the Upper Humboldt Valley (Armentrout and Hanes 1987; Elston and Budy 1990), and ethnographic references to long distance trade in Tosawihi chert among the Western Shoshone (Steward 1938, 1941).

Although we do not address such problems directly here, most of the models concerning strategies of lithic procurement and maintenance developed in Chapter 3 and in the present chapter either refer specifically to a regional scale or easily can be expanded to do so in future investigations. In the meantime, the present study explicitly sets up the necessary baseline data for larger scale investigations.

Toolstone distribution can reveal much about trade, toolstone economics, resource access, settlement, and subsistence throughout large portions of the north-central Great Basin and southern Columbia Plateau. If Tosawihi cherts are as widely distributed in the archaeological record as suspected, then the probability that they were acquired by trade increases with distance, and this must influence any cost/benefit model applied to primary procurement.

The ability to identify Tosawihi chert in sites outside the quarries is thus prerequisite to determining how far and in what volumes it travelled. Likewise, the identification at the quarries of toolstone exotic to them informs as to distance and direction of travel and/or trade. In addition, the ability to distinguish different chert sources within the quarries would make it possible to monitor the distance toolstone was transported from source to workshop/field camp, to investigate whether particular sources and/or camp sites were favored, and to determine how many sources were exploited during a given visit to the quarries. By identifying specific sources among samples of debitage from winter base camps on the Humboldt River, one might come to know if different groups traditionally exploited different parts of the quarries.

Color variation of formed opalite artifacts was recorded along with other descriptive data (cf. Chapter 5), but color crosscuts source to such a degree that it is a reliable means of source identification in only a few instances. Samples taken from selected toolstone sources, together with samples of non-Tosawihi toolstones, form the basis of a small pilot study of source identification through neutron activation analysis (cf. Appendix J). Finally, identification of artifacts at Tosawihi made of cryptocrystalline toolstones, such as Maggie Creek Chert or Elko Hills Chert (Elston and Budy 1990), also would be of great interest. The recent realization by archaeologists (Hofman, et al. 1991) that certain cryptocrystalline rocks fluoresce in distinctive colors under ultraviolet light affords a quick and inexpensive means of identifying rocks from different sources that was applied to samples of debitage from several different sources in the quarries as well as to all cryptocrystalline bifaces and projectile points collected to date. The results of neutron activation and ultraviolet florescence studies are summarized in the following chapter.

Obsidian remains the best toolstone for sourcing studies because many sources have been identified throughout western North America, and chemical source identification is now routine and relatively inexpensive. Consequently, all obsidian artifacts and samples of obsidian debitage were subjected to source identification by means of X-ray florescence (cf. Appendix G; Hughes 1983, 1984).

Chronological Change at Tosawihi Quarries

Virtually all archaeological research is concerned with chronology, and temporal variation certainly is a critical element in the present investigation. Three lines of chronological inquiry (cultural chronology, temporal variation in quarry use, and temporal variation in knapping technology) are especially pertinent to research in the Tosawihi Quarries.

Cultural Chronology

Chapter 18 reviews regional chronologies to provide a framework for discussion of known temporal variation in technology, subsistence, mobility strategy, and stylistic change. Temporal data from the Tosawihi Quarries are used to construct a local chronology of archaeological sites and cultural features in sites, as well as geological surfaces and strata. Sources of temporal information at Tosawihi include stratigraphy, radiocarbon assay, tephrochronology, obsidian hydration, and diagnostic artifact types.

As we discovered during testing, well-stratified deposits containing charcoal exist in the fill and berms of quarry pits (Elston 1989). On the other hand, most residential sites are shallow and unstratified, and hearth and oven features uncommon. Accordingly, radiocarbon dates from residential sites are relatively few, and most dates document episodes of quarrying. Obsidian hydration dating lacks the precision of the radiocarbon method, but the large number of hydration readings is informative, nevertheless. From the obsidian assemblage, all temporally diagnostic projectile points, bifaces, and cores, a sample of flake tools and preforms, and debitage from several proveniences of interest were submitted for hydration dating. Temporally diagnostic artifacts such as projectile points (Thomas 1981) and pottery (Madsen 1986) help constrain the age of the deposits in which they are found within certain limits (between several hundred and several thousand years, depending on the artifact class).

Tephrochronology provides another precise dating method (Bradley 1985:110-112). Chemically distinct tephra (volcanic ash) from the explosive eruption of Mt. Mazama (now Crater Lake, Oregon) was widely deposited over western North America about 7,000 years ago (Davis, J.O. 1978a). Mazama ash is present in deposits exposed in Willow Creek at site 26Ek3251, and on Ivanhoe Creek just upstream of 26Ek3237 (Elston 1989), but not in any sites of the Eastern and Western Peripheries reported here. The chances are, therefore, that all sites described in this report are younger than 7,000 B.P., since Mazama ash, if present, lies far below cultural deposits, or is absent altogether. The presence of Mazama ash in the Tosawihi uplands allows correlations with other Mazama localities in the Great Basin.

Temporal Variation in Intensity of Quarry Use

The intensity of quarry use refers to the amount of time and energy spent in toolstone procurement at the quarry; various factors might influence quarrying intensity. One is exhaustion of the most accessible toolstone. The earliest visitors to Tosawihi may have found high quality toolstone as surface clasts that could be collected at minimal cost. Even if surface material could furnish all toolstone needs (an unlikely proposition), the abundance and quality of such material inevitably would decline. Increasing search costs eventually could make subsurface exploitation profitable without changing output requirements. Other factors involve increasing output requirements for Tosawihi material as functions of reduced accessibility to other sources, change in the overall position of Tosawihi in the annual range, and others previously discussed. As task groups are required to remain at the quarries longer to accommodate more intensive methods of toolstone extraction, they may require an attendant residential group to conduct coincident food gathering and processing in support of the quarriers.

Although surface exploitation may lack archaeological visibility in places subsequently quarried, we assume that intensification will be signaled by increases per unit time in the number of quarry localities, of quarry features within localities, and of quarrying episodes within quarry features. Quarry pit size and depth are likely to grow. The number of camp and workshop sites occupied per unit time should vary directly with intensity of quarry use, and assemblages of such sites should reflect the greater time spent in the vicinity of the quarries by higher frequencies of tools not related to quarrying or lithic processing.

Temporal Variation in Knapping Technology

Technological changes in stone tool manufacture were expected to be difficult to monitor because the basic approach to lithic reduction in the Great Basin has focused on biface production from the earliest times (Elston 1986a). The size and final forms of tools differ, but intermediate stages are similar (Elston and Budy 1990; Novick 1987). Consequently, the most technologically diagnostic elements are likely to be debitage produced during specialized and/or terminal reduction procedures such as fluting (channel flakes), final thinning and shaping (parallel diagonal or collateral thinning flakes), or creation of hafting elements (notch flakes). We mention this important research domain only to say that no temporal variation in knapping technology was evident in technological analysis of assemblages from distinct stratigraphic components at habitation sites or in technological comparisons between quarry and reduction localities.

Paleoenvironmental Reconstruction

Considerable climatic and environmental variation has occurred in the Great Basin since the end of the Pleistocene (Wells 1983; Mehringer 1986). Whether or not these changes were of sufficient magnitude to effect the availability of non-lithic resources at Tosawihi and vicinity adds another dimension to questions regarding prehistoric economy, but one that is difficult to address at this juncture.

Paleoenvironmental data are not well preserved in the shallow, open sites so far investigated at the Tosawihi Quarries. Most sites have failed to preserve plant macrofossils, and pollen weathers badly in unprotected eolian, colluvial, and alluvial sediments. Faunal remains from stratified alluvial deposits provide some clues to paleoenvironmental circumstances. For instance, bison scapulae recovered from quarry pits at 26Ek3208 and 26Ek3200, as well as bison bones at 26Ek3092, help document the distribution of a species poorly known in the western Great Basin (Elston and Budy 1990; Bradley 1985).

As previously mentioned, stratigraphy is often problematic in the shallow deposits of open sites at the Tosawihi Quarries. Of course, deposits filling quarry pits are very well stratified, but such sediments are almost entirely cultural in origin, having little to do with paleoenvironments. Eolian silts and colluvium usually are churned by slope movement and bioturbation. Nevertheless, natural stratigraphy is present in alluvial terrace deposits of sites in the Western Periphery (26Ek3092) and Northern Corridor (26Ek3237 and 26Ek3251).

Discussion

In this chapter we have proposed a series of expectations for the archaeological record of Tosawihi. Beginning with the tenet that hunter-gatherers will attempt to minimize the cost of toolstone procurement, we examined ways in which they might do so: by spatial positioning to minimize transport costs, by labor organization to decrease opportunity costs, by toolstone procurement tactics that maximize the rate of toolstone return within a given unit of time, and by tool design and use strategies which minimize the systemic need for inputs of fresh toolstone. The prehistoric human actions associated with these strategies and tactics should, we suggest, have created the archaeological record at Tosawihi quarries.

Whether such behaviors are discernible in the archaeological record is another question with which we have attempted to grapple. Our hypotheses may outstrip our abilities to test

them. For example, we have outlined above differences between the archaeological record of logistical forays vs. residential encampments. Yet, teasing these differences out of the actual materials themselves is not straightforward. Highly diverse tool assemblages could indeed indicate a residential encampment. They could also equally indicate a site surface with a long history of use. To the best of our abilities, we have attempted to phrase our expectations for the archaeology of Tosawihi in realistic, hence somewhat uncertain, terms. We remain completely unabashed about the tenuous nature of such predictions, for Tosawihi presents a challenge to archaeology. Aside from the sheer volume of archaeological material is a problem of method: how to extract information from a complex archaeological record.

Ensuing chapters show how we have chosen to do so. We first discuss Tosawihi as a lithic terrane—a topic of great importance in our expectations but also necessary for the unfamiliar reader to envision the Tosawihi landscape. The work then turns to analyses of artifactual material, followed by descriptions of the archaeological sites examined. Lastly, we turn to interpreting the archaeology of Tosawihi through a series of synthetic archaeological studies that link the behavioral expectations made in this chapter, their potential archaeological consequences, and the archaeological record of Tosawihi.

Part II. ANALYTICAL DATA CLASSES

Chapter 5

THE LITHIC TERRANE OF TOSAWIHI

Robert G. Elston

Geological forces create toolstone and determine where it is exposed and accessible for extraction. Given a particular technology, the range of search and handling costs for toolstone procurement is controlled by the overall occurrence of lithic raw material, including the relative accessibility of high-quality toolstone and its ratio to lower-quality material. Chapter 3 suggests that hunter-gatherers deal with lithic variability by manipulating mobility and subsistence patterns to insure toolstone procurement with minimal cost.

Lithic terranes can be characterized at various scales, ranging from the immediate foraging radius around a base camp to the entire annual range. We have few hard facts concerning the lithic terrane at the regional scale of people wintering on the Middle Humboldt River, but we assume that the alluvial deposits of the Humboldt River Valley itself are poor in toolstone, if not lacking in it altogether. Toolstone doubtless is available in volcanic hills and mountain ranges to the north, but aside from the Tosawihi Quarries and other opalite sources in the Tosawihi uplands, no other major lithic sources presently are known in the region. The fact that Archaic lithic assemblages in the Middle Humboldt are dominated by Tosawihi opalite suggests dependence on, if not a single toolstone source, then on a group of sources in a small area in a remote part of the region over several thousand years. On a regional scale, such a situation superficially resembles the hypothetical poor lithic terrane previously diagramed in Chapter 3 (cf. Figure 13b).

But the high quality of Tosawihi opalite as toolstone may compensate its relatively high cost. Too, the Tosawihi Quarries lie in the center of the annual range exploited by ethnographic people living on the Middle Humboldt River (Steward 1938). Assuming winter occupation along the Humboldt throughout the Archaic, foragers could have minimized procurement costs with proper scheduling by arranging visits to the quarries at the most propitious times. In any case, the presence of so much Tosawihi opalite in sites remote from the source indicates that prehistoric people found it better to procure much (if not most) of their toolstone from Tosawihi than to exploit other, perhaps inferior materials, or to do much trading for obsidian, major sources of which lie far beyond the range of the Tosawihi Shoshone. We will not know if this is true or why it might be so until we can characterize the lithic terrane of the Upper Humboldt Region more fully. We make a start in this direction by describing the toolstone available at Tosawihi, its geology, mode of occurrence, and attributes that distinguish it from other toolstone.

Bedrock Stratigraphy

Raven has summarized the bedrock geology of central northern Nevada in Chapter 2, describing the emplacement of 50 to 150 m thick massive ash-flow tuffs and other volcanic rocks during the Miocene that now dip 10 to 15 degrees to the southeast. As described, the existence of Tosawihi chert or opalite is due to the hydrothermal alteration of tuff that extended over an area of about 130 km^2 (Figure 4).

Most of the following discussion is based on geological reports of the Ivanhoe Mining District concerned with its past mercury production (Bailey and Phoenix 1944) and its potential as a gold property (Bartlett et al. 1991), and on recent detailed geological mapping of the current Ivanhoe Project (Cornucopia Resources 1987). Slight differences between the names and

map symbols of the geological units used by Bartlett et al. (1991) and Cornucopia Resources (1987) are reconciled. These data have been augmented by our observations of bedrock at quarry localities where backhoe and hand-dug trenches sampled quarry pits. In the following discussion, we ignore most information regarding the distribution and quality of mercury or gold ore which presumably were irrelevant to prehistoric peoples who exploited Tosawihi toolstone. Nor do we dwell on alteration processes such as argillization and propyltilization that, unlike silicification, did not contribute to the formation of toolstone; prehistoric use of bedrock units as toolstone is noted.

The bedrock stratigraphy at Tosawihi, depicted in Figure 20, includes the following units discussed from oldest to youngest:

1) Massive (no recognizable bedding), medium to dark gray, fine to medium-grained orthoquartzite (Ovq) of the Ordovician Valmy Formation in thin interbeds to 2m thick. The upper portion of the quartzite usually is fractured, brecciated, and resilicified, grading upwards to the overlying Tertiary/Ordovician fragmental unit (TOf). This unit is not exposed at the surface, but cobble sized clasts of similar rock are common in alluvial deposits of Velvet Canyon and often were used as hammerstones. Flaked stone artifacts made of quartzite are much less common; most notable is the base of a stemmed point found on the surface at Locality 72 in 26Ek3032.

2) Tertiary/Ordovician fragmental unit (TOf) up to 30 m thick, an angular quartzite breccia comprised of angular to subrounded clasts of quartzite in a matrix of tuff and small quartzite fragments. This unit marks the Ordovician-Tertiary disconformity, and is thought to derive from adjacent quartzite highlands. It is bedded indistinctly, and contains sand grains, clay, and iron oxides in addition to angular quartzite clasts, suggesting that it formed while exposed at the surface before deposition of the overlying volcanic rocks, when it may have undergone some pedogenisis. It does not outcrop at Tosawihi.

3) Lower Tuff (Tt1) a tufaceous unit up to 30 m thick, probably deposited as ash-flow; it does not outcrop at Tosawihi. The Lower Tuff is overlain by andesite or basaltic andesite (Tb).

4) Basaltic andesite (Tb) is apparently a local flow unit, outcropping on the southern slopes of Twin Buttes and Red Hill along Basalt Canyon, and forming the hills and ridges west of the Tosawihi Quarries. It consists of massive black rock (weathering to red), sparsely porphyritic to aphyric with rare phenocrysts of plagioclase feldspar. It tends to form platy outcrops at the present surface, but is more massive below. The platy basalt was used frequently for grinding stones and edging tools, while massive, rounded pieces were favored as quarrying hammerstones and occasional flaked stone items. A paleosol on the basalt is marked by red montmorillinite clay (giving Red Hill its name), grading upward to the overlying Upper Tuff (Ttu). Silicification of the paleosol and immediately overlying tuff produced brightly colored, jasper-like rock that was exploited as toolstone. The basalt pinches out to the northeast and does not outcrop in Velvet Canyon or elsewhere at Tosawihi north of the southern slopes of Twin Buttes and Red Hill.

5) Upper Tuff (Ttu) ranges from massive crystalline tuff to laminated and bioturbated tufaceous siltstone, both white to light pink in color, probably deposited in streams and shallow lakes. The Upper Tuff frequently has been altered completely to clays and contains beds of reworked tufaceous sediments, mudflow or ashflow deposits of quartzite conglomerate or breccia, and sandstone (Tts) that are generally silicified; it may be the source of quartzite clasts in fluvial deposits in Velvet Canyon. The origin of the quartzite is unknown, although size-sorting suggests a source to the east. The Upper Tuff is up to 40 m thick and contains sinter deposits and a near-surface cap (or caps) of massive replacement-type silica (both mapped as Ss), as well as localized contact silicification zones. This silicification created the predominantly opal and chalcedony Tosawihi "chert" or opalite, and formed the principal sources of toolstone. Imperfectly silicified tufaceous sandstones were used for small abrading tools such as shaft smoothers.

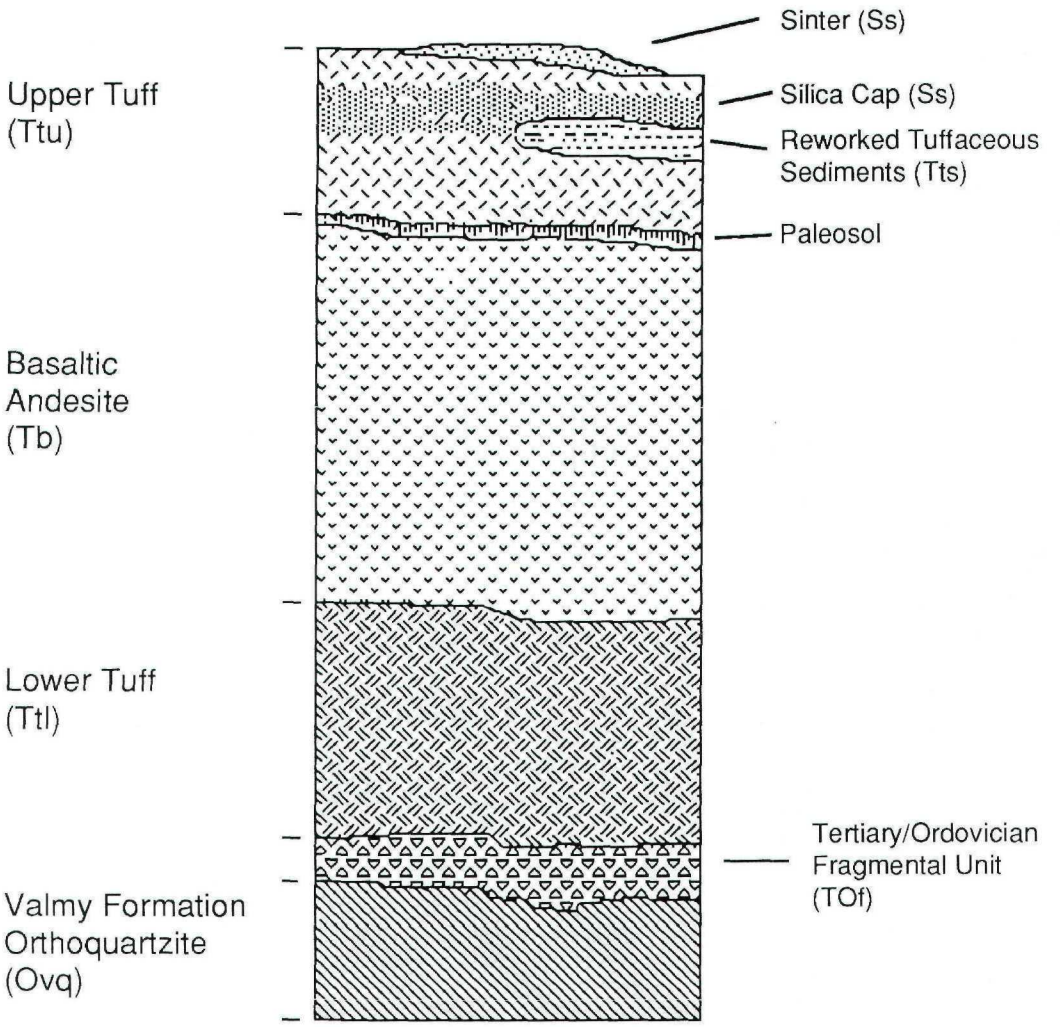


Figure 20. Tosawihi bedrock stratigraphy.

6) Flow banded rhyolite (TRb) overlies the Upper Tuff east of the Tosawihi Quarries, forming Owl Ridge. A similar unit, the Craig Rhyolite (Trc), constitutes the highland to the southeast of Tosawihi. Rhyolite was used for hammerstones and grinding implements.

Formation of Sinter and Opalite Toolstone at Tosawihi Quarries

Silicification occurs in all units of the Upper Tuff, including massive tuff, tufaceous siltstone, and reworked tufaceous sediments. The resulting cherty rocks, or opalite, occur mainly as large sinter deposits associated with vents and as stratified masses of replacement silica in tuff deposits (silica caps). Bartlett et al. (1991:21) suggest that sinter always occurs at or near the surface and that the silica caps always are found below the sinter near the lower tuff/basalt or lower tuff/upper tuff contact; recent geological mapping by Cornucopia Resources (1987), however, discloses a more complex situation. Sinter and replacement silica, both mapped as Ss, are shown as a more or less continuous band in cross sections, in most places a few meters below the surface. The description of a typical section on the map notes that surface sinter deposits are mostly eroded and relatively thin. Layers of tufaceous sediment (Tts), described as "generally silicified," are shown in various positions in the upper half of the Upper Tuff, both above and below sinter/replacement silica units.

Massive sinter deposits are up to several meters thick and are described as "finely laminated chalcedony with lesser amounts of opal, sparse to abundant interlayer cavities, layers of silicified sand and sediment with some mudcracks, and vuggy and brecciated chalcedony which contains clasts of laminated silica...[ranging in color]...from mostly white and light gray to tan, brown, red, blue and purple" (Bartlett et al. 1991:21). Although sinter often grades downward to the underlying silica cap, it also may overlie massive unsilicified crystalline or argillicized tuff abruptly, and frequently contains layers or stringers of this much softer material or of more brittle opal (cf. description of bedrock at 26Ek3208).

The emplacement of sinter often is a complex process. At Steamboat Hot Springs near Reno, Nevada, chalcedonic sinter similar to that from Tosawihi was formed in two stages (White et al. 1964:31-33). In the first stage, opaline sinter was deposited by precipitation of opal directly out of cooling thermal waters on the surface of broad discharge aprons. Opaline sinter typically is very friable when dry, but was preserved because of rapid burial by additional opaline sinter. In some cases, percolating thermal water then deposits additional opal and decreases porosity in the buried sinter to the extent that it is transformed into massive opal. At Steamboat Hot Springs, however, chalcedonic sinter was formed when percolating thermal water deposited chalcedony and quartz instead of opal, replacing opal already formed. At Tosawihi, the association of opal with chalcedony strongly suggests a similar process.

Massive layers of replacement silica, or opalite, at Tosawihi range in thickness from 3 to 35 m. Opalite is a term used by quicksilver miners and mineral collectors to refer to amorphous, cryptocrystalline rock that often hosts cinnabar, but otherwise is not more rigorously defined (Bailey and Phoenix 1944:17). Bartlett et al. (1991:21) describe this material at Tosawihi as "almost entirely composed of chalcedony with some veinlets and vug linings of drusy quartz...[its texture ranges from]...massive to extremely vuggy and brecciated; it typically shows well developed replacement features in the enclosing tuff." The association of opal with chalcedony observed frequently in these beds also implies a two-stage process, or perhaps thermal or chemical zones where different processes dominated.

According to Bartlett et al. (1991:21), the distribution and blanket-like structure of the replacement silica strongly suggest formation near the water table. Bailey and Phoenix (1944:20) believe that "blankets" of opalite replacement silica were formed when thermal waters percolated laterally through layers of porous tuff and replaced the pyroclastic glass with chalcedony. Some

support for the lateral circulation hypothesis is found in the general silicification of tufaceous sediments (Tts), even though they occur at various depths. These units must have been highly porous and therefore conducive to circulating thermal waters.

In practice, it is difficult to distinguish sinter from opalite, and we use the latter term throughout this report to refer to any of the massive chalcedonic rocks that occur at Tosawihi. All appear to have a similar range of quality, as well as similar knapping and heat-treatment properties; this is true even of the silicified tufaceous sediments with quartzite clasts.

Toolstone Occurrence

Erosion has removed overlying unaltered volcanic strata and cut into the beds of sinter and opalite. The silicified bedrock now lies near the surface, thinly mantled with colluvium or fully exposed in stream cuts and outcrops. Potential sources of toolstone include bedrock outcrops, thinly mantled bedrock, opalite talus deposits, and opalite clasts in colluvium and streambeds. Large (up to refrigerator size) relict opalite clasts deposited as Pliocene alluvium are found perched on the landscape as much as 30 meters above the present stream beds, and terraces of probable Pleistocene age containing large opalite boulders are found along Little Antelope Creek several kilometers south of Tosawihi. Bedrock was the preferred source of toolstone; colluvial and alluvial stone appears to have been procured only intermittently, with low-cost, expedient techniques. Presumably, quality of clast material is low enough that it was not worthwhile to exploit it in the vicinity of the quarries, except casually. We suspect, however, that use of streambed opalite increased with distance from the quarry.

Accessibility of bedrock opalite depended greatly on whether the bed was intersected by the surface. The three situations schematically depicted in Figure 21 are the most common, and quarriers were confronted with different sets of problems in each case (cf. Chapter 23).

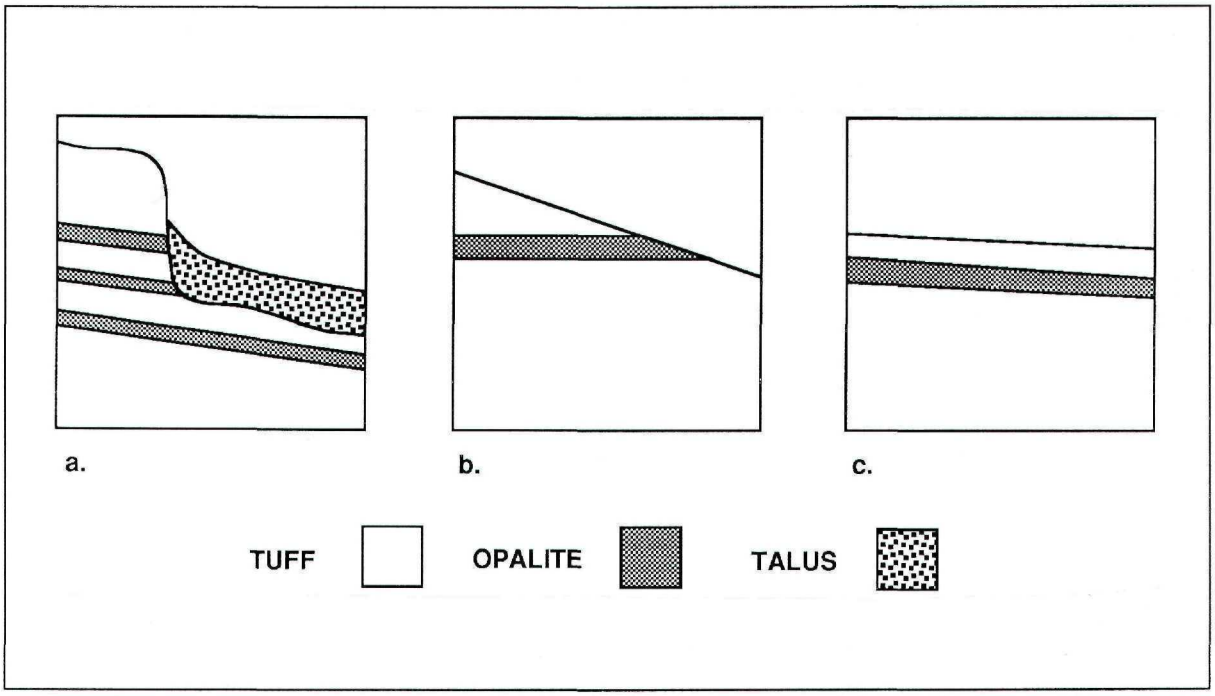


Figure 21. Opalite occurrence. a. surface outcrop; b. intersected by surface slope; c. parallel to surface.

Opalite exposed at the surface is exposed constantly to chemical weathering, winter freezing and thawing, summer heating and cooling, and wildfire. Material in outcrops is thus flawed by extensive cracks and spalls that can extend several centimeters into the stone from the surface. When struck with a hammerstone, such weathered opalite tends to break into small, angular, irregular pieces ("cuboids") and is useless as toolstone. Quarrying surface bedrock requires removal of the cracked and stressed outer material to expose less weathered stone. Only then can quarrying begin, entailing the breakup of the tough, massive inner rock.

One might expect intensive bedrock quarrying only under certain conditions that make the effort worthwhile: toolstone quality must be high, and it is helpful if geologic processes work fast enough to remove weathered rock as it is formed, or if the rock is somewhat protected from weathering on slightly overhanging faces or buried by colluvium. As our experiments show (cf. Chapter 26), quarrying massive opalite bedrock is difficult and costly. Large cracks in the rock provide means of ingress with hammerstones and wedges. Situations in which tuff and opal are interbedded with opalite are favorable as well, since the more easily excavated materials can be removed to isolate masses of opalite that then can be detached with percussion and fire (cf. Chapters 23 and 26).

The most intensive quarrying at Tosawihi occurred where erosion has exposed opalite bedrock in vertical or near vertical outcrops (such as Localities 82 and 30 in Velvet Canyon and its western tributaries), or in places (such as Locality 44) where knobs of opalite bedrock have been isolated by erosion and now are mantled thinly by colluvium and eolian accumulations. The extensive quarries on Butterscotch Ridge were excavated into a smooth slope lacking any protruding outcrops. The presence of opalite talus stripes, however, suggest that bedrock lies close to the surface; perhaps the slope of the ridge intersects several opalite beds in the manner of Figure 20b.

The zones of silicification noted in Chapter 3 (cf. Figure 13) merely reflect the *potential* occurrence of toolstone. Recent areal survey of the region surrounding Tosawihi Quarries (Leach and Botkin 1991) has shown that many of these zones contain opal or other material that is not toolstone quality. On the other hand, not all silicified rock has been mapped geologically, and our recent survey turned up several unmapped zones of silicification, including prehistoric opalite sources with quarry features or other evidence of exploitation.

Toolstone Types: Quality and Variation

The quality of opalite as toolstone varies on two axes: frequency of flaws (vugs and cracks) and degree of chalcedonic silicification. Among the least usable material at Tosawihi is opalite containing myriad tiny open and quartz crystal-filled vugs; it is impossible to flake, although it makes a good hard hammerstone. As previously described, weathered opalite frequently is too cracked and stressed to knap properly; other material contains hidden or partially healed cracks that cause failures during processing.

Although most opalite is "white," it exhibits a wide variety of colors, including opaque salmon pink (typical of the "Pink Pits" Localities 38, 39, and 48 in 26Ek3032), opaque to translucent yellows and tans (as on Butterscotch Ridge), and purple to red and white candy-striped material (as at Locality 159). Varieties of opalite appear to have similar flaking characteristics, however, and no special effort appears to have been made to procure toolstone of any particular color. High quality, fresh toolstone from 26Ek3208 is opaque white to slightly translucent, very pale (ice-like) blue or green, but the subtle colors change to more opaque gray in weathered material found in archaeological deposits. Light opalite exposed on the surface for a long period often acquires a light tan, biscuit-colored patina. Some opalite containing mercury is photosensitive and turns dark gray upon exposure to a few days of sunlight.

The toolstone we call *jasper* in this report was formed by silicification of a paleosol developed on basalt. At Locality 78 in 26Ek3032 and at 26Ek3084, this material exhibits a variety of earth colors (red, yellow, brown), purple, and, where the overlying tuff also was involved, brighter pink, red, and yellow with stripes or spots (as at Locality 19). This material requires a somewhat higher heat-treatment temperature than opalite, is more brittle, and does not produce as sharp an edge.

Opal typically is opaque but shiny, and is quite brittle, tending to fracture into cuboids when struck. Opal often can be flaked by gentler methods, but it contains water and sooner or later dehydrates and falls apart.

Patches of green to brown, subangular chert pebbles and small cobbles occur here and there throughout Tosawihi Quarries and Big Butte Valley. Their origin is unknown, but perhaps they are a lag derived from erosion of once overlying rhyolite bedrock. We have observed prehistoric use of this material only for hammerstones. Small (pea to tennis ball sized), chalcedony-filled geodes are also found in Big Butte Valley. No evidence for prehistoric use of this material except for hammerstones presently is known. Jade-green chert of good quality associated with a large rhyolite outcrop near the confluence of Ivanhoe and Willow Creeks occurs in angular chunks up to five centimeters maximum dimension, but we have seen no evidence for its use; ultraviolet fluorescence suggests that this is not the source of jade-green chert debitage observed in a few samples from 26Ek3170.

Distinguishing Tosawihi Opalite From Other Toolstones

Tosawihi opalite shares many gross physical characteristics with chert and chalcedonic toolstones from other sources, yet study of the economic geography of Tosawihi opalite (cf. Chapter 4) depends on the ability to distinguish it from other toolstones. The following sections summarize findings of ultraviolet fluorescence and neutron activation analyses.

Ultraviolet Fluorescence

Geologists and mineralogists have long known that certain minerals fluoresce when stimulated by ultraviolet light (Raytech Industries 1965). Not visible to humans, ultraviolet (UV) light interacts with atoms in the fluorescent material, changing the energy in the electron shells of atoms and causing them to emit photons in the visible spectrum. The color of the fluorescence depends on the chemical composition of the mineral, and, to a lesser degree, on the wave length of the UV radiation. Compared to daylight or ambient artificial light, the stimulated fluorescent light is faint, and must be viewed in darkness.

Distinguishing toolstones from different sources by their behavior under UV light was recently pioneered by Hofman et al. (1991), who were able to distinguish Knife River Flint, Edwards Plateau Chert, and toolstone from the Alibates source in Paleoindian lithic assemblages from the Great Plains. We applied the same methods to analysis of all "cherty" bifaces and projectile points recovered from testing and data recovery at Tosawihi, as well as to rock specimens from 62 quarry localities well-distributed throughout Tosawihi Quarries. In addition, we examined control samples of chalcedonic toolstones from Susie Creek and Elko Hills between Carlin and Elko, Nevada (Elston and Budy 1990), a sample from Sulphur on the southern margin of the Black Rock Desert (Elston 1986d), and several other less well-provenienced specimens from various Nevada locations.

A Raytech Model LS-88CB UV lamp that can be switched between long (3500 angstrom units) and short (2600 angstrom units) wavelength light, or can provide both simultaneously,

was used as an ultraviolet light source. Uniform viewing conditions were provided by use of a Raytech Viewbox in a darkened room. The specimens were placed in the box, illuminated by the UV lamp through an aperture, and viewed through a separate port.

Our findings from UV screening are simple: all *opalite* samples from Tosawihi localities fluoresce green no matter what their color in visible light. Freshly-broken Tosawihi opalite fluoresces green under shortwave UV, probably due to its uranium content (Raytech Industries 1965:47-48). Under long wavelength UV, Tosawihi opalite is a dark, velvety purple. The value and chroma of the green fluorescence fades over time in specimens exposed on the surface, probably as a reaction to sunlight and perhaps other weathering processes. In weathering on the surface, objects develop peach colored to purplish blotches, eventually achieving a strange, dull rosy purple (DRP). Many specimens thus fluoresce bright green on one face, DRP on the other. The purplish patches seen in UV are often biscuit color in visible light. In other specimens, DRP prevails except for spots or lines of green in chalcedony-filled vugs and veins. Some specimens, DRP in the bottom of the viewing box about 10 cm from the UV source, glow green when held closer to the light. Jaspers from Locality 78 and 26Ek3084 do not fluoresce, but chalcedony-filled veins or vugs glow green. Generally opaque materials either do not fluoresce or do so less brightly than translucent varieties of opalite. Graying under visible light due to mercury photosensitivity, however, has no effect on fluorescence, nor does heat-treatment, with the exception noted below.

No non-Tosawihi control specimens fluoresce green. The specimen from Sulphur, a translucent white chalcedony, is bluish white under shortwave UV, and retains an afterglow for a few seconds. All other controls either are non-fluorescent (including the jade-green chert from Ivanhoe Creek) or fluoresce in the gold-yellow-orange range. Using the criterion of green fluorescence, all archaeological bifaces recovered are made of Tosawihi opalite, but (as we might expect) many projectile points are not.

In examining archaeological specimens from Tosawihi under shortwave UV, I noticed one specimen fluorescing bright orange on the surface with a green core or interior visible through a break. Under long wavelength UV, the exterior remained orange, but the core turned dark purple. Eventually, I discovered several other specimens that fluoresced green with orange patches under shortwave UV and purple with orange patches under long wavelength UV. I noticed that on these specimens, the orange patch was associated with a relict pre-heat-treated surface or a surface created by post heat-treatment flaking. In all cases, the relict heat-treated surface is slightly grayer than post heat-treatment surfaces.

In the specimen with a green core, the orange material forms a rind between 0.5 and 1.0 mm thick, suggesting that some chemical process changed the UV fluorescence characteristics of the material penetrated from the surface inward; this seemed a possible *result* of heat-treatment.

A sample of Tosawihi opalite deliberately over-cooked in heat-treatment experiments acquired a dark gray surface resembling "smoke stain." Under short wavelength UV this dark exterior surface is dull orange, while the interior is dull green with bright green spots. Under long wave length UV the exterior is brighter orange and the interior dark purple. The alteration producing the orange color has penetrated to a depth of about 1 mm. The dark gray surfaces of the experimental and archaeological specimens suggest the deposition of carbon in a reducing atmosphere, a common environment in a heat-treating hearth. Perhaps carbon has diffused inward from the surface, or perhaps oxygen has been removed. Chemical analysis will be required to identify the actual process.

UV screening offers a fast, inexpensive means of identifying Tosawihi opalite in samples of lithic artifacts. Continuing efforts should be made to collect documented toolstone samples from other sources and subject them to UV for comparison. So long as the green-orange distinction between Tosawihi opalite and other toolstones holds up, UV analysis can be applied to address source material fall-off rates and other problems of economic geography.

Neutron Activation

Neutron activation is a technique of trace element analysis (Tite 1972). A specimen is irradiated with neutrons, exciting atomic nuclei of elements that are transformed into unstable radioactive isotopes which then decay, emitting gamma rays. Gamma ray energy and intensity provide identification of constituent elements and their concentration in the specimen to parts per billion. Because of its great sensitivity and accuracy, neutron activation is the preferred technique for trace element analysis of cryptocrystalline toolstone (Luedtke 1978; Luedtke and Meyers 1984).

The basic problem of any chemical analysis striving to distinguish toolstone sources is that variation within a single source may be greater than variation between sources. Our hope was that since Tosawihi opalite had been created by localized hydrothermal activity, its chemistry would reflect constituents of the local heat source and local bedrock mineralogy. We also hoped, though more faintly, that local toolstone sources *within* the Tosawihi Quarries could be distinguished on the basis of trace element chemistry.

As a pilot study, a suite of twenty-one samples was analyzed by Michael D. Glascock of the University of Missouri Research Reactor Facility. The samples were divided into seven groups of three (Table 2). Each of six groups were from different sources within the Tosawihi Quarries and peripheral areas studied in this report. Five were typical white to pink opalite; the sixth group was jasper. The seventh group contained samples from Steamboat Hot Springs (near Reno), Sulphur (southern Black Rock Desert), and Elko Hills (southwest of Elko).

Table 2. Toolstone Samples Submitted for Neutron Activation Analysis.

Sample Group	Sample No.	Locality	Tosawihi Neighborhood or Other Provenience
1	IMRNA 1	26Ek3032, Locality 38	Pink Pits
1	IMRNA 2	26Ek3032, Locality 39	Pink Pits
1	IMRNA 3	26Ek3032, Locality 38	Pink Pits
2	IMRNA 4	26Ek3032, Locality 188	Butterscotch Ridge
2	IMRNA 5	26Ek3032, Locality 188	Butterscotch Ridge
2	IMRNA 6	26Ek3032, Locality 188	Butterscotch Ridge
3	IMRNA 7	26Ek3208, Jasper Quarry	Red Hill
3	IMRNA 8	26Ek3208, Jasper Quarry	Red Hill
3	IMRNA 9	26Ek3208, Jasper Quarry	Red Hill
4	IMRNA 7	26Ek3084	Red Hill
4	IMRNA 8	26Ek3084	Red Hill
4	IMRNA 9	26Ek3084	Red Hill
5	IMRNA 10	26EK3200	Corral Fan
5	IMRNA 11	26EK3200	Corral Fan
5	IMRNA 12	26EK3200	Corral Fan
6	IMRNA 13	26EK3196	Undine Gorge
6	IMRNA 14	26EK3196	Undine Gorge
6	IMRNA 15	26EK3196	Undine Gorge
7	IMRNA 16		Sulphur, Nevada
7	IMRNA 17		Elko Hills, Nevada
7	IMRNA 18		Steamboat Hot Springs, Nevada

Details of the neutron activation analysis are given in Appendix A. Statistical analyses performed by Glascock and his associates used log-transformed values for the eight most discriminating of 30 elements measured (Eu, Cs, Fe, Hf, Sb, Sc, Ta, and Tb). Analyses included bivariate plots, canonical discriminant analysis, and cluster analysis. Discriminant analysis failed to provide much separation of the samples, but cluster analysis (using log-transformed values and average linkage) correctly linked all sample sets except those from Butterscotch Ridge. The greatest distances are observed among three groups of groups: all non-Tosawihi samples, the non-opalite samples from 26Ek3208, and all other Tosawihi samples.

These results seem promising, and warrant further study with larger samples. The possibility of discriminating even a few Tosawihi localities offers the possibility of linking exploitation of particular quarry localities with particular workshop and residential sites.

Chapter 6

BIFACES

William W. Bloomer, Kathryn Ataman, and Eric E. Ingbar,
with a contribution by Mark W. Moore

Biface production is the major lithic reduction activity evident at the Tosawihi Quarries, and the focus of most prehistoric human activity in the Tosawihi vicinity. The following analysis attempts to identify the kinds of bifaces produced at Tosawihi and to understand how their production was organized. The analytical database consists of 4,388 whole, incomplete, and fragmentary bifaces collected during survey, testing, and data recovery exercises.

From a general consideration of bifaces, we move to discussion of the research questions, methods, and interpretive models employed in the Tosawihi study. Results of the analysis follow, looking first to the technology of biface production at Tosawihi, then to spatial variation in biface production and biface caches. We conclude with a synopsis of analytical results as they relate to research issues.

Biface Analysis

Bifaces are a major tool class in North American chipped stone assemblages, and their forms and functions, and the technologies that produced them, have received considerable research attention. Paleoindian biface production has been studied extensively (Callahan 1979; Crabtree 1966; Flenniken 1978; Frison 1978; Frison and Bradley 1980; Frison and Stanford 1982), and a century-long inquiry into biface production technology began with Holmes' (1897, 1919) research at the Piney Branch Quarries. Biface analyses have been used to replicate technology (Callahan 1979; Crabtree 1966; Johnson 1981), to determine site function (Pippin and Hattori 1980; Thomas 1983a; Zerga and Elston 1990), to indicate reduction trajectories (Muto 1971a, 1971b; Sampson 1985; Flenniken and Ozbun 1988), to delineate mobility patterns (Goodyear 1985; Sassaman, Hanson and Charles 1988), and to define adaptive strategies (Kelly 1988).

In general, biface studies variously investigate form, technology, function, and context. Analysis of form can reveal spatial or temporal variability in technology, but some forms, especially those representing unfinished pieces, are produced within generalized technologies that persist over large areas and through long periods of time.

Analysis of technology examines the process whereby bifaces are produced, and can characterize production stages at particular loci. Such characterization then can be used to examine the organization of production. Moreover, detailed analyses of particular production techniques can aid identification of local groups of craft specialists, or, in unusual cases, of individual knappers. Investigation of the incidence and nature of technological failures can be used to examine limitations of raw material or the presence of specialist knappers. Estimates of levels of production effort and of heat-treatment contribute to evaluation of biface technology.

Biface functions can be examined at a variety of levels. Bifaces may function as cores or as bifacial tools, or as a combination of the two, in any particular assemblage. Finished artifacts can be examined for traces of use. In combination with estimates of breakage rates among stages of manufacture, the proportions of production stages can inform questions of site function and export form.

Because biface production is a reductive process, it is not possible to reconstruct production sequences in detail unless pieces rejected during manufacture are present in an assemblage. Fragmentary bifaces, however, often are common in archaeological assemblages; numerous studies have focused on analytical methods for interpreting fragments within the contexts of production techniques (e.g., Johnson 1981) and reduction stage (e.g., Amick 1985). Although fragmentary specimens lack the full set of attributes desirable for analytical purposes, they usually retain flake scar patterns and morphological clues as well as at least partial dimensional attributes. These are useful for calculating thinning indices, inferring reduction stage, placing specimens within production sequences, and determining the place of heat-treatment within the reduction sequence. However, one problem with using biface fragments as indicators of production technique is that they most often are the pieces that failed or were rejected for other reasons. In the latter case, reconstruction of intended form through analysis of fragments is susceptible to spurious conclusions; in most assemblages, however, breakage is the most common reason for rejection.

The nature of archaeological deposition inhibits biface analysis to some extent. In most cases, material enters the archaeological record as discarded items, but the locations of manufacture, use, and discard need not correspond. So, determination of production technology, use history, or discard behavior in any given archaeological context (a site, a feature, an excavation level) is subject to interpretive bias.

For these reasons, most biface analyses are undertaken in conjunction with other studies. Debitage, for example, provides a useful adjunct data class; since debitage assemblages often contain flakes from bifaces that left the archaeological locus (Frison 1967; Yerkes 1987). Thus, the biface studies discussed here have been undertaken in concert with analyses of other chipped stone artifact classes from Tosawihi.

Since biface technology is reductive, biface production occurs on a continuum of endeavor and results in a continuum of form. Biface production proceeds from an initial unaltered blank form, whether flake, cobble, or block, to formed artifact. Some researchers invoke continuous variables to document the place of a biface along the continuum, such as width to thickness ratios or mass to area ratios (Johnson 1981; Sassaman 1988; Amick 1985). Such techniques have the advantage of being objective and thus replicable, but they can suffer from dependence on maximum (not overall) dimensions, from inability to account for variation in original blank form, and from arbitrary division of the production continuum. Experimental flintknapping has shown that the reduction continuum can be divided into analytical units. Sometimes such divisions are arbitrary, but they often correspond to changes in knapping techniques or to approaches to strategic knapping problems (Young and Bonnichsen 1984; Callahan 1979; Crabtree 1972; Patten 1980). Attributes unique to these segments on the production continuum allow bifaces to be assigned to technological production categories or stages. Combinations of attributes generally include width to thickness indices, shape of cross-section, and extent of reduction (as suggested by flake scar patterning). The subjectivity of such schemes has been criticized, but they offer the flexibility to assign varying weights to attributes; we adopt them here precisely for these reasons.

Research Questions

A fundamental question asks what biface forms were produced at Tosawihi. Although it is obvious immediately to the Tosawihi visitor that bifaces were a product of quarrying, it is necessary to examine their forms in order to determine their production and transport costs and to address their potential uses as tools and cores. A related topic focuses on consistency of biface size and shape. Were bifaces produced at Tosawihi standardized in size or shape? Did standards change through time? Standardization of size or shape during a particular period of time suggests relatively regular, predictable uses for bifaces in the mobility system (Kelly 1988;

Parry and Kelly 1987). Perhaps specialized production for exchange or for a regular pattern of tool use by the quarriers themselves is indicated (cf. Chapter 4).

The techniques and knapping options employed by Tosawihi knappers engaged in biface production demand understanding, as does their use in any particular time period. Bifaces serve as cores or as tools; understanding how Tosawihi bifaces were produced should clarify the reasons for their production. If they functioned as tools *at* Tosawihi, some specimens should show traces of use wear. If they functioned primarily as tools *away from the quarry area*, then reduction techniques should show purposeful shaping of the core to regularize its shape. On other hand, if Tosawihi bifaces are an incidental result of successive flake removals from cores (so that they are byproducts and flakes products), then the reduction sequence should reflect opportunistic flake removals and the size of exported bifaces should be large enough to provide blanks for tool manufacture. Thus, our analyses seek to determine the technology and sequence of biface production.

Biface production requires an estimable labor investment. Prehistoric flintknappers may have selected production techniques to minimize labor costs. Costs may differ, for example, depending on the nature of the toolstone: tabular cobbles may require little reduction to produce bifaces when compared to large blocky cores. By examining where different production techniques were used (e.g., near or away from toolstone sources), we may begin to assess whether variation in production is related to transport costs, to toolstone occurrence, and to other activities. We also wish to know if bifaces were produced for local use and, if so, to identify those uses.

In sum, the research questions addressed through the Tosawihi biface study are intended to elucidate toolstone procurement patterns. As discussed earlier (cf. Chapter 4), these patterns can be linked to forager mobility strategies. Our ability to discern procurement patterns depends on data the availability of which is a function of the analytical methods we employed.

Methods, Models, and Techniques

The Tosawihi biface analysis began with consideration of methods and techniques. Although general trends of biface production were evident from examination of the collections, we wondered how best to determine systematically the ways bifaces were produced. It was clear from the outset that replication experiments could provide insight into appropriate analytical techniques, as well as providing a controlled database from which to develop and test such techniques. Thus, our analyses began with replications of Tosawihi bifaces.

The replication program began informally during fieldwork. There is no lack of raw material at Tosawihi, so the pastime of flintknapping became a favorite after-shift activity. Some of the products were saved, and, as they frequently became reference sources for discussion of the archaeological bifaces, a more formal replication program was initiated. The replications were used primarily for interpreting debitage recovered in the course of the project, but also provided data for use in biface analysis. Causes of manufacturing failure, recognition of mode of production, and variation in blank type were investigated.

The high incidence and wide distribution of heat-treated bifaces and other tools, as well as heat-treated debitage, indicated that heat-treatment of toolstone was a common practice at Tosawihi. Heat-treated toolstone is relatively common in North America (e.g., Holmes 1919), and its study suggests that each toolstone source requires unique treatment procedures to achieve the benefits of increased compliance and predictability. In order to recognize heat-treated Tosawihi opalite better, understand the effects of heat-treatment on the flaking qualities of the opalite, and infer the level of effort involved in heat-treatment, we initiated the heat-treatment experiments discussed in Chapter 26.

Experimental flintknapping and heat-treatment continued over the course of biface analysis. Archaeological biface data collection occurred during two separate periods of laboratory work, associated first with testing and then data recovery phases of the project. Results of the first biface analysis, and the experimental program, led to refinement of subsequent archaeological data collection. Thus, some attributes recorded for second phase analysis were not observed on first phase bifaces. Limitations of this sort are noted in the following discussions when they are germane. The following description of attributes recorded refers to the most evolved attribute set.

How (and even *if*) bifaces were used at Tosawihi is an issue central to this study. Because bifaces generally are regarded as multipurpose cutting and occasionally scraping tools, limited experiments using hafted and unhafted bifaces replicated wear traces caused by cutting and scraping meat, hide, and bone. Wear traces on experimental bifaces then were compared to traces on the archaeological specimens most likely to have been used. Procedures for this work follow those for the functional analysis of flake tools described in Chapter 7.

Biface Attributes

Recorded biface attributes are described below and the data recording form we used appears as Figure 22.

Provenience

Site, locality, reference, and specimen numbers constitute provenience data in the artifact database. Refitted fragments were recorded as single pieces and were given special specimen numbers.

Metric information

Dimensions were recorded in millimeters for maximum length (along the axis of the blank when this could be determined), maximum width perpendicular to the axis, and maximum thickness. Weight was recorded to the nearest tenth of a gram.

Raw Material

Tosawihi opalite occurs in a variety of textures, qualities, and colors. Most specimens were designated non-specific "opalite," but we distinguished three specific combinations of attributes, designating them "chalcedony," "jasper," and "opal." Opalite most often is opaque, colored cream, white, or grey; most other colors occur less frequently. It is quite hard and flakes very well. It is worked most easily when heat-treated, when it has the characteristic waxy look and feel of other heat-treated silicious materials. Chalcedony is semi-translucent and amorphous, has excellent flaking characteristics, and usually is white, occasionally with a pink, yellow, or green tint. Jasper is brittler and softer, in dark, dull shades of red, purple, yellow, and brown, often mottled. This material resembles opalite, but it seems to heat-treat at

BIFACE ANALYSIS RECORDING FORM (638-1989) CLASS=7 TYPE=____(SEE VAR. #14)

1. SITE NO _____ 2. LOCALITY NO ___ 3. REFERENCE NO _____ 4. SPECIMEN NO ___

AREA _____ UNIT _____ FEATURE _____ LEVEL _____

5. LENGTH _____
6. WIDTH _____
7. THICKNESS _____
8. WEIGHT_____

9. MATERIAL COLOR

1. White	5. Black	9. Blue/Pink
2. Beige	6. Grey	10. Pink
3. Yellow	7. Purple	11. Red
4. Brown	8. Blue	12. Green

10. MATERIAL TYPE

1. Opalite	5. Jasper
2. Obsidian	6. "Opal"
3. Basalt	7. Other
4. "Chalcedony"	

11. MATERIAL QUALITY
1. Excellent
2. Good
3. Poor

12. CORTEX
1. Present
2. Minimal
3. Absent

13. BLANK TYPE
1. Flake
2. Cobble
3. Indeterminate

14. TRAJECTORY

1. Quarry	4. Indeterminate
3. Small Biface	5. Possible Biface Trajectory

15. SMALL BIFACE OUTLINE

1. N/A	5. Sq.-Based
2. Lanceolate	6. Elongate
3. Oval	7. Irregular
4. Triangular	8. Indeterminate

16. SMALL BIFACE HAFTING ELEMENT

1. N/A	5. Edge Grinding
2. Notch(es)	6. Absent
3. Sq. Base	7. Multiple
4. Cont. End	8. Possible

17. REDUCTION STAGE

10. Blank	35. Mid 3
2. Indet 2	39. Late 3
20. Early 2	4. Indet 4
25. Late 2	40. Early 4
3. Indet 3	45. Late 4
30. Early 3	50. 5
	60. Indet Stage

18. FRAGMENT TYPE

1. Complete	7. Prox. missing
2. Proximal	8. Dist missing
3. Distal	9. End missing
4. End	10. Edge Collapse
5. Medial	11. Outrepassé flake
6. Lateral	12. Other
	13. Indeterminate

19. MANUFACTURE FAILURE

1. None	8. Cone
2. Lat hinge	9. Edge Collapse
3. Long hng.	10. Perverse
4. Out., end	11. Bending
5. Out., lat	12. Thermal
6. Frac plane	13. Multiple
7. Mat. flaw	14. Indeterminate

20. THERMAL ALTERATION
1. Blank from HT Core
2. HT Blank
3. HT during Reduction
4. Therm. altered post-manuf.
5. Possibly Altered
6. Not Thermally Altered
7. HT Stage Indeterminate

Figure 22. Biface recording form.

a slightly higher temperature. Opal often is quite shiny, less dense, and softer than other opalites. Obsidian, basalt, and a few other unusual materials also are present in the assemblage in small proportions.

Twelve material colors were recorded based on field and laboratory observations. The color of Tosawihi toolstone varies from source to source and often within source. We recorded only very general color categories. During analysis, color designations were combined to form an index of color diversity, contrasting white and non-white groups of artifacts. The frequencies of white, beige, and grey specimens were divided by the total in order to yield a relative measure of color diversity.

Similarly, material quality was recorded only in general terms. Obsidian and chalcedony quality usually was designated "excellent" while other materials seldom received that designation. Very little material was considered to be "poor."

Cortex is uncommon on pieces of Tosawihi raw material because weathered cortical surfaces are rare in the bedrock quarry sources. Stream-rolled cobbles account for almost all cortex recorded on opalite pieces. More common on basalt and obsidian, cortex was recorded as present, minimal, or absent.

Blank Type

Blank type describes the general morphology of the specimen on which biface reduction was initiated. *Flake Blanks* exhibit the traditional attributes of lithic reduction flakes, i.e., points and cones of percussion, compression rings, and often feathered terminations. Flake blanks are exclusive of primary or secondary flakes with cobble cortex. *Cobble Blanks* are alluvial or colluvial cobbles, or primary or secondary flakes derived therefrom, with weathered or incipient cone cortex. Cobble cortex is the key defining attribute. *Indeterminate Blanks* are specimens reduced beyond the point where original surfaces are visible.

Trajectory

Discrimination of trajectory responded to an observed dichotomy between large bifaces produced from relatively large quarried flake blanks and small bifaces made on small flake blanks. The latter may have been produced during the reduction of large bifaces; if so, large bifaces may have functioned as cores for the production of small bifaces. Trajectory was recorded to test this dichotomy; the determination was largely subjective, without standardized dimensional measures, but we observed four discriminations:

Large ("Quarry") Trajectory: larger-than-palm-sized specimens with proportionately large widths and thicknesses.

Small Trajectory: smaller-than-palm-sized specimens with proportionately small widths and thicknesses.

Indeterminate Trajectory: overall size intermediate between large and small trajectories; also fragmentary specimens.

Possible Biface Trajectory (recorded only during second phase biface study, so pertaining only to approximately half the assemblage): specimens exhibiting bifacial modification, but so minimally that a definite biface classification is not justified. Morphologically, most are intermediate between cores (or modified chunks) and bifaces, but more closely resemble bifaces.

Small Biface Outline

Outline planar shape was recorded for small bifaces. Outline variants include *Lanceolate, Oval, Triangular, Square Based, Elongate, Irregular, Indeterminate, and Not applicable (NA).*

Small Biface Hafting Element

Hafting modifications at the proximal/hafted end of the biface were described. Variants include *Notches, Square Base, Contracting End, Edge Grinding, Absent, Multiple, Possible, and Not applicable (NA).*

Reduction Stage

Experimental flintknapping and examination of the archaeological assemblage indicated that a stage model could classify Tosawihi bifaces reliably. Biface stages employed here generally follow Callahan's (1979) definitions for Stages 1 through 5 and are applied to all specimens. Where attributes indicated that a reduction stage had been initiated, the specimen in question was classified to that stage. Callahan's scheme is defined primarily by flake scar pattern, so became the most important observation in determining stage (Figure 23). Generally, flake scar patterns indicate whether primary or secondary thinning has been initiated. Flake scar pattern also is observable on fragmentary specimens, so they, too, can be assigned to stage. Width to thickness ratio and shape of cross-section were secondary considerations, affecting stage determination when specimens that were reduced less than most Stage 3 bifaces, but had been made on thin flake blanks, were assigned to Stage 3. Another secondary observation was the regularity of edge morphology and proportional symmetry of specimens. In spite of the numerous variables defining biface stages, there is considerable variation among specimens within each stage; Figure 24 illustrates the range of sizes and flaking patterns among Stage 3 bifaces. For this reason, we have subdivided Callahan's Stages 2, 3, and 4.

Blanks are Stage 1 bifaces, flakes removed from bedrock outcrops, cores, or bifaces which show no reduction modification. Our ability to recognize them as biface blanks is constrained by our ability to recognize them as having been "selected." That observation follows only from context and is limited to large flake blanks. Thus, large non-reduced flakes recovered away from quarry and core reduction activity, away from the reduction of very large bifaces, essentially out of contexts within which they could have been produced, are considered to have been selected and transported for the purpose of biface production.

Edge Prepared bifaces are Stage 2 bifaces. In this stage, biface blanks are reduced to produce a scalloped bifacial edge. Most of the reduction occurs near the edge, with no attempt to begin the thinning process. Edge preparation creates an edge suitable for platform preparation during primary thinning, and begins to shape the blank into a generally ovate form. A large amount of toolstone mass and irregularities often are removed during this process. This stage has been sub-divided into early and late.

Primary Thinning is Stage 3 biface reduction. This reduction thins the specimen by removing flakes to or slightly across its longitudinal center. Symmetrical shaping and edge straightening is begun as well. Stage 3 reduction results in a symmetrically shaped and lenticular biface, ready for further thinning or immediate use. This stage has been divided into early, middle and late.

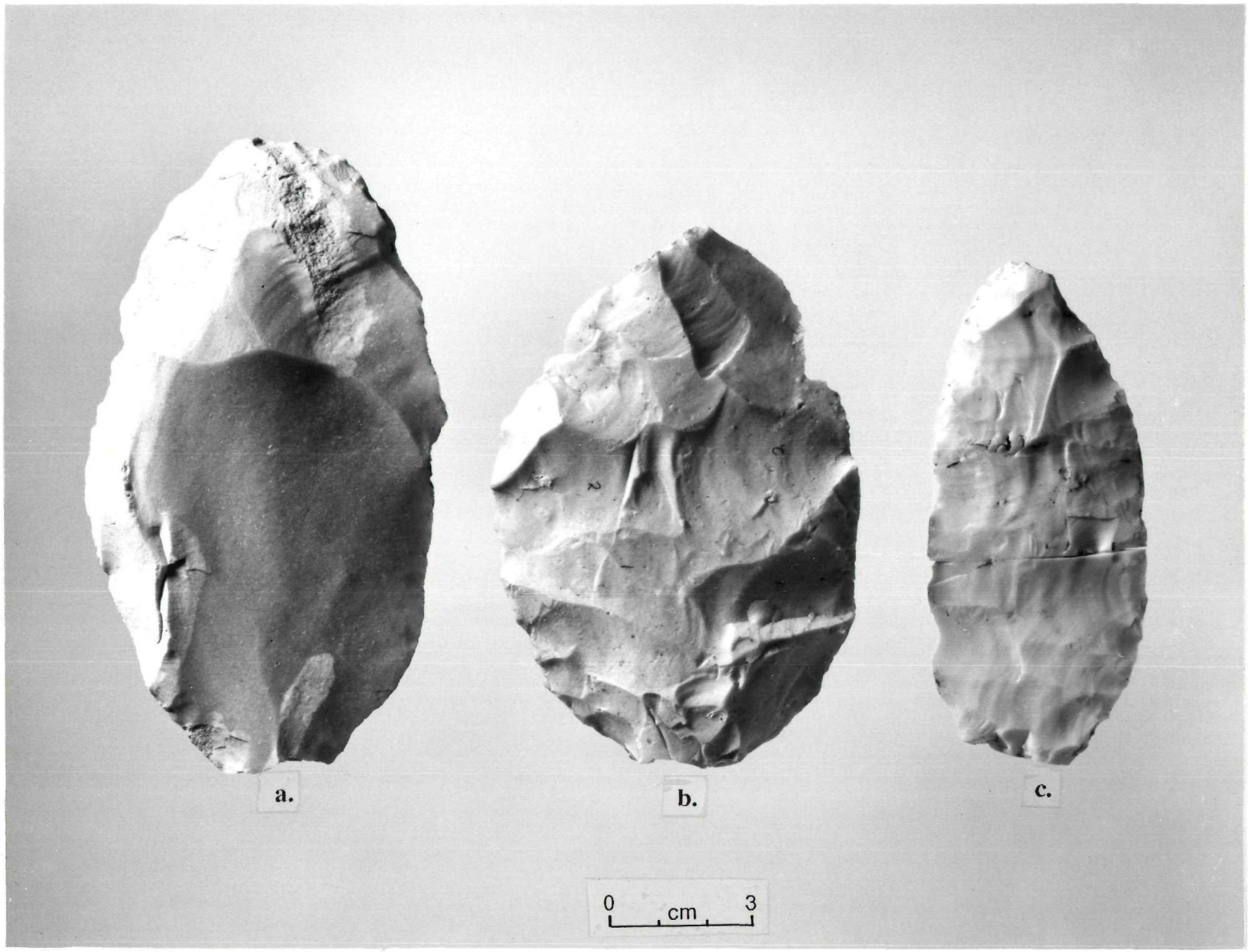


Figure 23. Biface stages according to Callahan's Staging Scheme. a. Stage 2 biface; b. Stage 3 biface; c. Stage 4 biface.

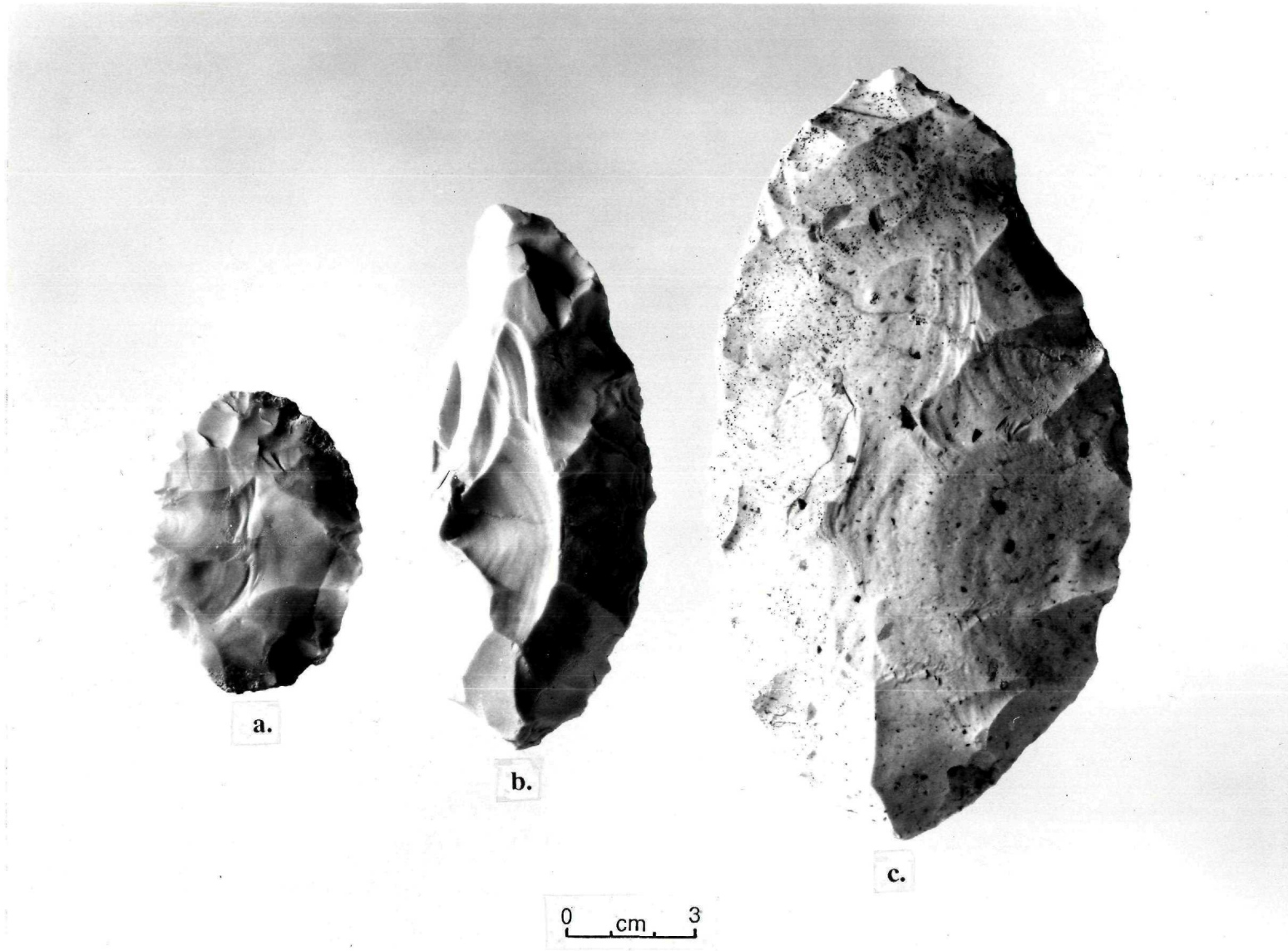


Figure 24. Variation among Stage 3 bifaces.

Secondary Thinning is Stage 4 reduction; it serves to flatten the lenticular cross-section of the biface, further straighten the edge, and improve symmetry. Stage 4 negative flake scars often cross the longitudinal center of the specimen to flatten the central ridge. This stage has been divided into early and late.

Shaping refers to a Stage 5 biface. A Stage 5 biface is essentially at the end of the biface production trajectory, but at a point where it is not modified in any way that allows specific functional classification. Final shaping may be executed by pressure or percussion, but may only refine the symmetry of the pointed ovate.

Indeterminate stage indicates that the reduction stage cannot be classified with confidence; bifaces in this class are primarily small fragments.

Fragment Type

We recorded fragment types as reflections of the completeness of specimens and as guides to the morphology of breakage. Analytically, *Proximal Missing*, *Distal Missing*, and *End Missing* are considered nearly complete specimens, while all other designators, save *Complete*, refer to fragments. The latter include *Proximal End*, *Distal End*, *End* (when orientation is not possible), *Medial*, *Lateral*, *Other* (designates a type not listed), and *Indeterminate* (usually a small fragment without recognizable orientation or form).

Manufacture Failure Type

Manufacture failure attributes describe manufacturing breaks (cf. Crabtree 1972; Flenniken 1978; Cotterell and Kamminga 1979, 1987). We recorded such failures as *None, Lateral Hinge, Longitudinal Hinge, End Struck Outrepassé, Lateral Struck Outrepassé, Fracture Plane*, (natural or cultural), *Material Flaw* (usually vugs or nonsilicified areas), *Cone*, *Edge Collapse* (a large expanded crescent shaped notch similar to an outrepassé failure), *Perverse Fracture* (truncating the biface), *Bending Fracture* (also usually truncating the biface and including evidence of end shock, lateral snap, and transverse shock; cf. Crabtree 1972; Johnson 1979, 1981; Rondeau 1981), *Thermal Fracture* (including that caused by intentional heat-treatment and unintentional thermal alteration), *Multiple*, *Other*, and *Indeterminate*. Hinge fractures that might prompt biface discard are often large and deep, cutting into the mass of the biface. Multiple hinges also obstruct further thinning (Figure 25c). Outrepassé removals cause failures if they plunge through the greatest mass of the biface edge (Figure 25b), often leaving a large, expanded, crescent-shaped notch at the edge. Large cones that contribute to failure result from heavy, often repeated, hard hammer percussion in association with quarry activity and the reduction of large cores. Cones act as fracture planes to halt or redirect energy during reduction, thereby causing repeated inadequate flake removals.

Thermal Alteration

Thermal alteration improves flaking quality and alters the appearance and texture of opalite, rendering the surface of flake scars produced after heat-treatment glassy and lustrous (Figure 26). The detection of luster resulting from heat-treatment and, more importantly, the detection of *differential* luster, allows determination of the stage in biface reduction at which a specimen was heat-treated.

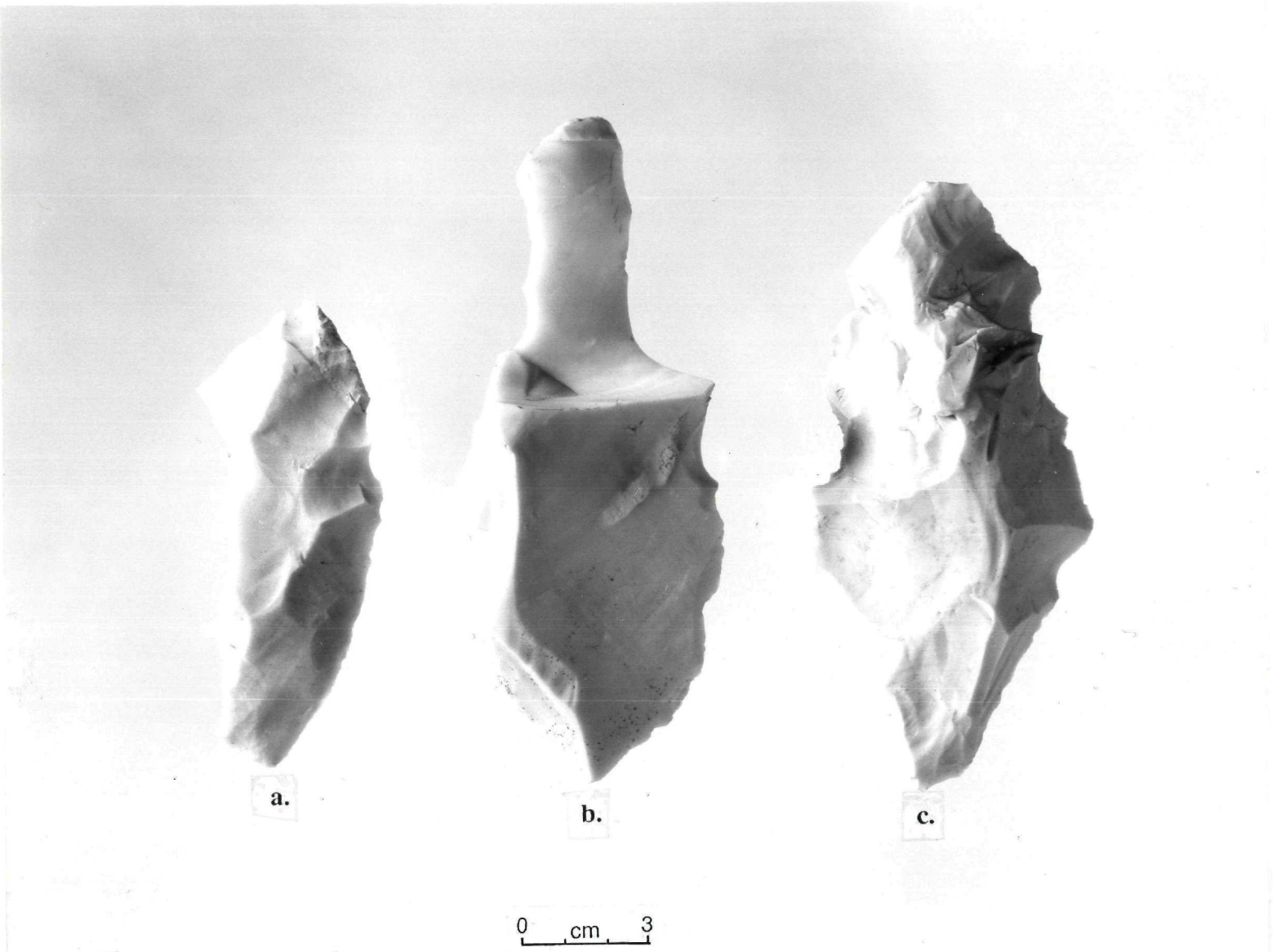


Figure 25. Biface failure types. a. edge collapse due to thermal failure; b. failure in longitudinal thinning (end struck outrepassé); c. complete biface exhibiting stacked step fractures resulting in discard.

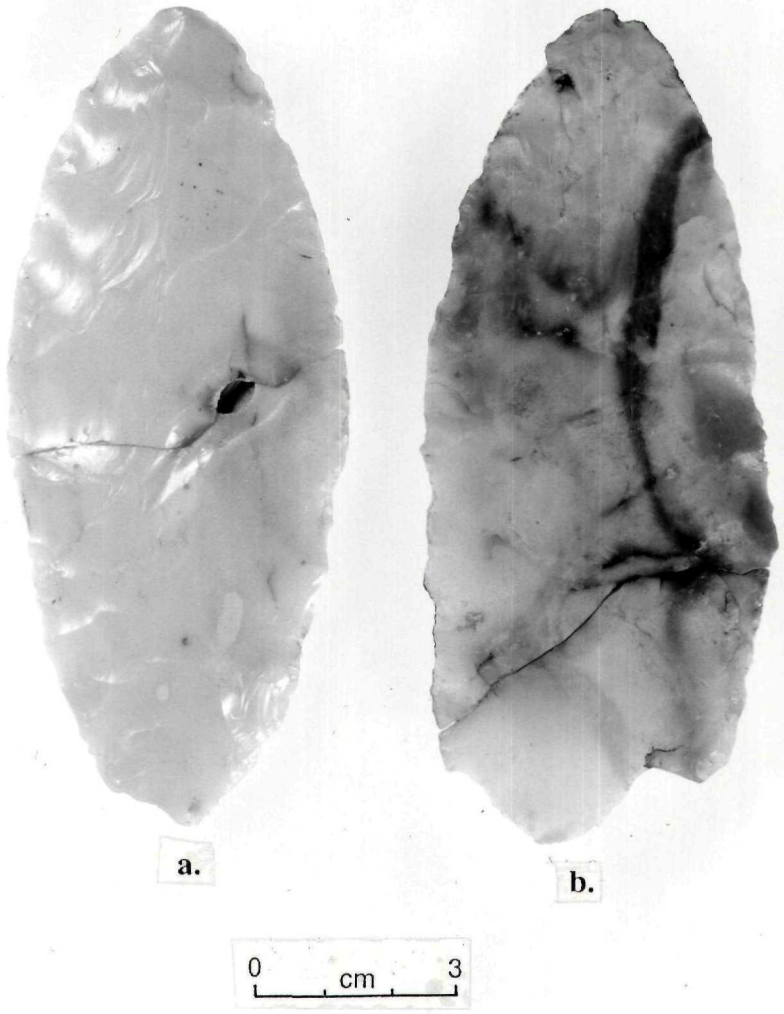


Figure 26. Heat-treatment of opalite. a. lustrous, heat-treated biface; b. non-lustrous biface.

A *blank from a Heat-Treated Core* is usually recognized only among Stage 1 or Stage 2 bifaces because the observation requires the original ventral surface of the flake blank to be visible; a small number of Stage 3 and Stage 4 bifaces *may* retain remnant ventral surfaces. For example, an otherwise unreduced blank from a heat-treated core will exhibit a lustrous ventral surface and a dull or less lustrous dorsal surface.

A *Heat-Treated Blank* is heat-treated after removal from a raw (non-heat-treated) core. A heat-treated blank should have non-lustrous original dorsal and ventral surfaces. A Stage 2 or early Stage 3 biface heat-treated as a blank should exhibit differential luster between the non-lustrous original dorsal and ventral surfaces and the lustrous reduction scars.

A biface *Heat-Treated During Reduction* is recognized by differential luster of reduction scars. Lustrous scars produced during Stage 3 reduction, overlapping dull (non-lustrous) ones produced during Stage 2 edge preparation indicate the specimen was heat-treated at the end of Stage 2 reduction.

Bifaces that were *Thermally Altered Post-Manufacture* have been unintentionally exposed to heat (often direct flame) through human and/or nonhuman processes. Evidence of unintentional thermal alteration is not always obviously different from the results of intentional heat-treatment, but is often recognized by the presence of angularly patterned surface crazing or potlids resulting from direct exposure to flame. Heavily discolored surfaces (black and brown discoloration) also indicate exposure to flame or intense heat without the benefit of heat buffering sediments.

Bifaces of *Indeterminate Heat-Treatment Stage* were heat-treated intentionally, but the point along the reduction continuum at which treatment was undertaken cannot be identified. This category usually is confined to later stage bifaces which have been considerably reduced.

Possibly Heat-Treated bifaces have a somewhat lustrous appearance, but classification is inconclusive. Analytically, they are not considered to have been heat-treated, but comprise a separate analytical data set for comparison with heat-treated bifaces.

Not Thermally Altered bifaces show no evidence of thermal alteration.

Redirection and/or Reworking

This variable records attempts to rework truncations or hinges that otherwise would have rendered the reduction effort a failure. Biface forms which appear to have resulted from successful reworking or redirection were recorded as such. The attributes include *None*, *Attempt to Repair Truncation*, *Attempt to Repair Hinge*, *Reworked to New Form*, and *Other*.

Use Wear Analysis

The attributes recorded for use wear analysis of bifaces are the same as for flake tools, as described in detail in Chapter 7.

Analytical Results

The Tosawihi biface collection is considered first as one assemblage, regardless of specimen provenience. From this vantage we observe raw material use and selection, formal

characteristics, production technology, and use of bifaces. Distribution in the Tosawihi vicinity is examined by geographic subarea. Finally, we consider bifaces made from non-local materials. Biface caches are discussed as a special case.

General Assemblage Results: Toolstone Sources and Color Diversity

Most bifaces are made of opalite; other materials, present in very low proportions, include jasper, opal, obsidian, chalcedony, and basalt in decreasing frequency (Table 3).

Table 3. Toolstone Material, Proportional Composition, All Bifaces (n=4388).

General Toolstone Type	% of Assemblage
Opalite	**96.8**
Jasper	1.3
Opal	0.6
Obsidian	0.5
Chalcedony	0.4
Basalt	0.3
Other	0.1
Non-opalite total	**3.2**

In principle, toolstone color can be used as a measure of the diversity of toolstone sources exploited. The most common colors of Tosawihi opalite are white, grey, and beige, grouped here as a generally "white" category. Toolstone color diversity in the general biface assemblage is relatively uninformative (Table 4).

Table 4. Toolstone Proportional Color, All Materials (n=4388).

Color	% of Opalite Biface Assemblage
White	63.1
Beige	12.9
Gray	11.8
Total: white, beige, gray	**87.7**
Pink	3.2
Brown	2.5
Yellow	1.7
Purple	1.3
Red	1.2
Green	0.8
Black	0.8
Blue	0.5
Blue/Pink	0.2
Total non-"white"	**12.2**

General Assemblage Results: Reduction Stages

Reduction stage is the single most salient attribute of the assemblage. The biface collection contains the entire range of reduction stages (Table 5). Middle Stage 3 bifaces are most common, comprising 27% of the assemblage, with 22% of the bifaces being of stages earlier than mid Stage 3 and 36% being later. Approximately 10% of the assemblage was classed as indeterminate. It is likely that many of the indeterminate specimens would be assigned to Stages 4 or 5, since bifaces are most likely to break during later stage manufacture (Amick 1985; Johnson 1981). The reduction stage at which they were exported from Tosawihi probably varied from early Stage 3 to Late Stage 4, with most pertaining to middle and late Stage 3 (cf. Chapter 21).

Table 5. Biface Reduction Stage and Heat-Treatment.

Stage	Heat-Treated n	Heat-Treated % of stage	Non-Heat-Treated n	Non-Heat-Treated % of stage	Indeterminate or Accidental Heat-Treatment n	Indeterminate or Accidental Heat-Treatment % of stage	TOTAL n	TOTAL % of assemblage
Stage 1	0	0.00	17	100	0	0	17	0.39
Early 2	4	11.43	28	80	3	8.57	35	0.80
Late 2	31	25.83	75	62.5	14	11.67	120	2.76
Indeterminate 2	0	0.00	3	75	1	25	4	0.09
Subtotal 2	35	22.00	106	66.67	18	11.32	159	3.65
Early 3	133	17.16	574	74.07	68	8.77	775	17.81
Mid 3	385	33.28	643	55.58	129	11.15	1157	26.59
Late 3	312	49.13	252	39.69	71	11.18	635	14.59
Indeterminate 3	241	48.49	199	40.04	57	11.47	497	11.42
Subtotal 3	1071	34.95	1668	54.44	325	10.61	3064	70.42
Early 4	239	54.69	155	35.47	43	9.84	437	10.04
Late 4	61	63.54	26	27.08	9	9.38	96	2.21
Indeterminate 4	91	70.54	22	17.05	16	12.40	129	2.96
Subtotal 4	391	59.06	203	30.67	68	10.27	662	15.21
Stage 5	6	54.55	3	27.27	2	18.18	11	0.25
INDETERMINATE	225	51.37	155	35.39	58	13.24	438	10.07
TOTAL	1728	39.72	2152	49.46	471	10.83	4351	100.00

Many other attributes of bifaces are systematically related to reduction stage. As a consequence, many analytical results for single variables are sensible only when reduction stage is used as a controlling variable in analysis. Thus, many of the following results are presented in crosstabulation with reduction stage.

General Assemblage Results: Biface Dimensions

Initial qualitative examination of the Tosawihi biface collection indicated there might be two sizes of bifaces present, perhaps due to different production technologies or goals of biface production. During data collection, each biface was classified "small" or "large." The

production trajectory validity of the size distinction was examined with metric data collected during analysis. The frequency distributions of length, width, and thickness approximate a continuous normal distribution, so the distinction between small and large trajectories is artificial and was not carried further.

However, the two biface size classes are not distributed randomly across reduction stages (Table 6). Early stages of reduction and large sizes are always associated (chi-square = 162.38; df=2, p<.001). Analysis of variance was used to examine how dependent biface dimensions are upon stage. Only pieces assigned to a reduction stage and having complete dimensions (i.e., complete and laterally fragmented pieces for length and weight, complete and proximal or distal missing pieces for width and thickness) and reduction stage data were employed in this analysis. Results showed that dimensions are significantly (p<0.000) dependent upon stage, when stages are considered as early (Stages 1 and 2), middle (Stage 3), and Late (Stages 4 and 5). Average dimensions and standard deviations for length, width, and thickness, as well as weight, are presented for each production stage in Table 7 Dimensional patterning by area is discussed later.

Table 6. Cross-Tabulation of Large and Small Biface Trajectories Against General Reduction Stages.

Parentheses enclose significant (P<.05) adjusted standardized chi-square residues (cf. Everitt 1977).

	Stages 1 and 2	Stage 3	Stages 4 and 5	Total
Quarry	122 (2.1)	2131 (14.9)	253 (-17.3)	2506 71.9%
Small	32 (-2.1)	607 (14.9)	339 (17.3)	978 28.1%
Total %	154 4.4%	2738 78.6%	592 17.0%	3484 100.0%

Table 7. Dimensional Data for Complete Opalite Bifaces.

Length and Weight are for complete bifaces.
Width and Thickness are for pieces with complete w/th dimensions.

Stage	n Length/ Weight	Weight Mean	Weight sd	Length Mean	Length sd	n Width/ Thickness	Width Mean	Width sd	Thickness Mean	Thickness sd
1	010	188.5	88.8	114.1	16.4	12	70.9	9.7	24.9	8.7
Early 2	22	236.3	148.9	107	26.8	23	73.3	13.4	29.9	11.5
Late 2	39	258	218.5	110.6	28.7	56	69.2	17.8	28.2	12
Indeterminate 2	1	63.6	-	60	-	1	49.2	-	21.5	-
Early 3	250	231.9	165.1	107	25.3	347	67.7	16.6	29.5	10.6
Mid 3	203	182.6	137.1	106.8	29.8	369	60	18	21.9	9
Late 3	35	128.2	88.4	108	36	126	50.7	17.8	14	5.7
Indeterminate 3	6	85.1	78.2	74.8	34.5	14	45.8	14.1	16.3	7.7
Early 4	15	140.7	92.6	125.7	39.1	93	45.3	15.1	10.5	3.9
Late 4	1	18.9	-	71.9	-	36	42.5	14.7	8.1	2.4
Indeterminate 4	1	13.7	-	41.9	-	5	30.3	7.8	6.9	1.7
5	4	41.5	20.1	107.2	13.8	8	37.1	11	7.4	2.9
Total	587					1090				

* all measurements are in mm

Some bifaces recorded in the small trajectory group are formally different from the bulk of the specimens (Figure 27); they generally are of late stage, and have a variety of intentionally shaped bases. They may have been intended as small knives, but many probably were preforms for large projectile points which sustained a percussion flaking stage before final pressure flaking (cf. Chapter 9). Few are complete, however, so evaluation of size with respect to possible point type is not feasible. We have included them in the discussion here because, although they could have been either knives or projectile point preforms, they cannot be differentiated reliably from generic bifaces.

Although a range of flake blank sizes was employed in the manufacture of bifaces, size patterning is not marked in the assemblage. For instance, length does not change substantially throughout the reduction sequence, while other dimensions, as well as weight, exhibit a general decrease from early to late stages (Table 7). As might be expected when intended products are of similar size but blank sizes vary, the greatest variation in size occurs in the earliest stages. Small numbers of complete bifaces in some stage classes precluded statistical examination of the differences between individual stages, prompting us to combine bifaces into two groups, early and late stage. The early stage group is composed of Stage 1, Stage 2 and early Stage 3, while the late stage group is composed of middle and late Stage 3 and Stage 4.

T-tests confirm the general observation that only length does not differ significantly across reduction classes. Weight, width, and thickness all differ significantly and in the expected fashion (early stages are larger than later stages).

General Assemblage Results: Heat-Treatment

The compliance of Tosawihi opalite increases greatly with heat-treatment. Although late stage biface production can be accomplished without heat-treatment, the increased compliance resulting from heat-treatment makes it far easier. Heat-treatment also tends to decrease manufacture breakage rates, because it permits increased control with decreased force. On the other hand, heat-treatment of opalite can be too much of a good thing since lower force has greater potential to remove flakes or to break the biface, and, after heat-treatment, the material is more brittle. Hence, heat-treatment permits less force in flaking but requires greater precision in work.

Clearly, heat-treatment and reduction stage are related (Table 5). While some Stage 2 bifaces are heat-treated, the proportional frequency of heat-treatment increases dramatically between middle and late Stage 3, suggesting that it regularly occurred at this point in the reduction sequence. Sixty-three percent of the late Stage 4 bifaces were heat-treated, suggesting that thermal alteration was an integral part of biface production (Ataman and Bloomer 1990). Bifaces of indeterminate stage (mostly fragmentary) frequently are heat-treated; this suggests that most are from late Stage 3 or later biface reduction.

General Assemblage Results: Manufacture Failures and Fragment Types

Manufacturing failure reflects several details of biface production (Table 8). More than 90% of the Tosawihi bifaces are fragmentary. Most are items broken during manufacture and discarded (Sassaman 1988). Analysis of breakage patterns reveal the most common failure points in the reduction sequence. This, in turn, provides insight into specific knapping techniques.

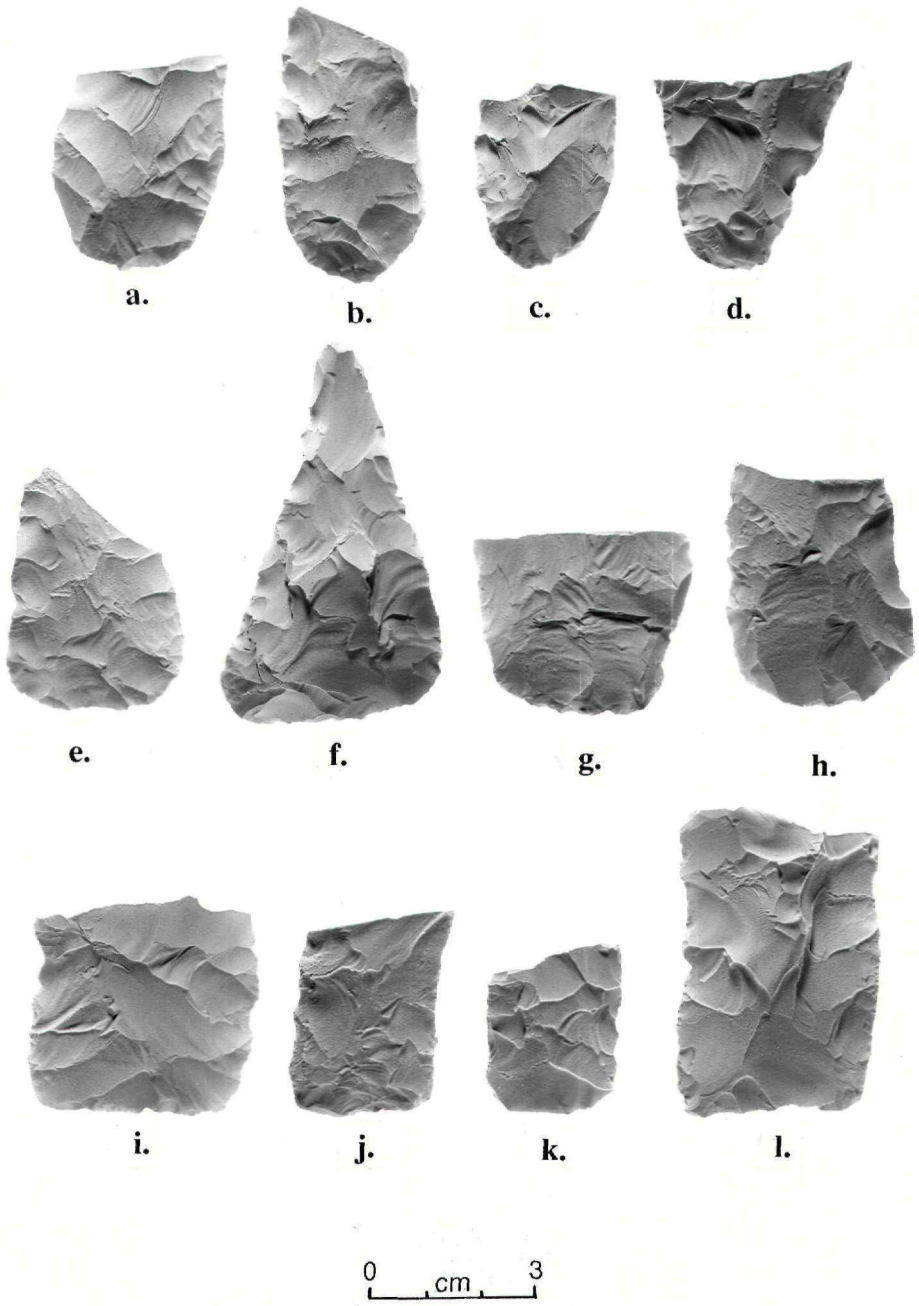


Figure 27. Selected small bifaces which may have served as large point preforms or small knives.

Table 8. Biface Manufacturing Failure Types.

Failure Type	Indeterminate	BIFACE STAGE 1	2	3	4	5	Total
None	4	11	41	291	15	3	365
Lateral hinge	2	1	2	54	0	0	59
Longitudinal hinge	0	0	1	19	0	0	20
Outrepassé end	0	0	0	18	0	0	18
Outrepassé lateral	3	0	1	16	2	1	23
Fracture plane	2	0	2	19	1	0	24
Material flaw	7	0	16	104	7	0	134
Cone	0	0	0	2	0	0	2
Edge collapse	15	0	3	41	2	0	61
Perverse fracture	7	0	1	49	17	0	74
Bend break	198	4	49	1206	404	4	1865
Thermal fracture	40	0	1	93	12	1	147
Multiple causes	116	0	38	971	181	1	1307
Indeterminate	3	1	2	33	2	0	41
Other	41	0	2	148	19	1	211
Total	438	17	159	3064	662	11	4351

The proportion of complete bifaces in each stage decreases through the reduction sequence. Stage 1 bifaces (blanks) are the least frequently broken (less than 40%). Bending fractures account for most of the observed breakage.

More than 75% of the Stage 2 bifaces are fragmentary. Most breakage types were observed on Stage 2 bifaces; material flaws, bending fractures, and multiple fracture types appear fairly often. Multiple fracture types are of particular interest, since they often result from general failure of the specimen during knapping. For example, a material flaw may set up a series of other weakness zones, causing bending breaks, edge collapses, and other kinds of breaks to coincide.

Stage 3 bifaces have the greatest variety of breakage types, perhaps due to the size of the sample. Bending breakage is common, as are multiple breakages. In general, the proportion of fractures due to material failure (e.g, fracture planes, material flaws) diminishes in Stage 3; the biface already has withstood initial shaping, so raw material flaws generally have been discovered. Breakage due to flintknapper error (e.g., misapplied force) becomes much more common in Stage 3 reduction, as shown by increasing proportions of perverse fractures, bending fractures, and outrepassé removals. Breakage from thermal stress also increases, reflecting a greater incidence of heat-treatment in this stage.

These trends continue into Stage 4, where relatively little breakage can be attributed to inherent material flaws and much more is due to knapper error. However, outrepassé and hinge fractures are rare on Stage 4 bifaces, probably since facial thinning was well controlled by the time this stage was reached. Stage 5 breakage is limited primarily to bending fractures.

Overall, there is a pattern of decreasing breakage from material flaws and a corresponding increase in the occurrence of non-specific breakage and breakage attributable to knapper error or misapplied force. Pieces with multiple breakage patterns also increase. Many of the bifaces having multiple fragmentation types broke because of thermal stress. Thermal stress weakens a biface by making it more brittle and creating internal fracture planes. Subsequent attempts to continue working a thermally stressed biface causes multiple failures: fracture planes break, edges collapse, and previously unseen material flaws create uncontrollable fractures. A common effect of thermal failure is a curved plane of weakness which becomes a bending break when the biface fractures. When thermal failure is the primary cause of a bending break, the break surface is often a twisting fracture surface similar to a perverse fracture plane.

Although bending breaks can be due to misapplied force or thermal failure, they also can be caused by trampling (Frison and Bradley 1980:43-44). Later stage bifaces are especially prone to this kind of breakage since they generally are thinner (cf. Amick 1985:143-144). Overall, bending breakage increases through Stage 4, and then decreases in Stage 5. The causes of the bending breaks in each stage may differ; in Stages 1 and 2 they can be due to misapplied force, in Stages 3 and 4, to misapplied force and failed heat-treatment, and in Stage 5, to misapplied force and accidental breakage by trampling.

Breakage patterns are useful indicators of reduction techniques (Amick 1985; Johnson 1981). In the Tosawihi biface collection, breakage patterns indicate the procurement and initial testing (and often rejection due to failure) of opalite. Testing does not end with the successful procurement of a blank, or even with its initial edging during Stage 2; rather, it apparently is most crucial (if perhaps unintentional) during Stage 3 reduction. In Stage 3 reduction, flaking shifts from edge shaping to facial thinning, so the influence of different kinds of material flaws which may not have appeared in edge flaking determines the success of the reduction. At the same time, bifaces become thinner during Stage 3 and often are heat-treated; both create additional opportunities for catastrophic breakage. In Stage 4, the incidence of heat-treatment is higher and the average biface thinner than in earlier stages, both of which can increase breakage. In addition, it is likely that much Stage 4 reduction was accomplished with a soft hammer, which also has been linked to higher breakage rates (Amick 1985). The increase in unbroken Stage 5 bifaces, on the other hand, may be due to discard of superfluous finished tools, but our sample (n=11) is small.

General Assemblage Results: Use Wear Analysis

A sample of 44 bifaces was selected for use wear analysis, chosen from later stage specimens having characteristics of finished tools (regularized edges, pressure flaked lateral margins, and dulled edges). The high incidence of heat-treatment in the sample made analysis more difficult, since heat-treatment on opalite tends to obscure use wear polishes or to mimic them. As a result, edge abrasion and striations were our primary criteria for determining use.

Seventeen of the 44 specimens exhibited use wear traces. The motion of use on 14 of these reflected cutting, 1 had been used for scraping, and 2 were indeterminate. Use, or lack of it, could not be determined for 27 items. The hardness of the material manipulated was identified for nine specimens (Table 9).

Table 9. Determinable Function of Stage 4 and Stage 5 Bifaces.

Hardness	Scraping n	Cutting n	Indeter-minate (n)	Total
Soft	0	0	0	0
Soft/Medium	0	2	0	2
Medium	0	0	0	0
Medium/Hard	1	6	0	7
Hard	0	0	0	0
Indeterminate	0	6	2	8
Total	1	14	2	17

Use wear analysis suggests that late stage Tosawihi bifaces with characteristics of finished tools were used occasionally as cutting tools. No traces of wear from hafting nor fragments of hafting material were visible on the Tosawihi bifaces examined. Hafting traces

are observable only rarely because they are obscured by various post-depositional processes (cf. Beyries 1988). There are ethnographic and archaeological examples of hafted bifaces from the Great Basin and other areas which appear to be knives for skinning and butchering (Fowler and Liljeblad 1986; Hester and Follett 1976; Hester 1974) and ethnographic accounts document their use (Goddard 1903). In spite of these reports, some researchers suggest that bifaces do not function well for butchering (e.g., Hester et al. 1976). Experiments carried out in the course of this project, however, demonstrate that they work extremely well for skinning, if somewhat less well for initial incisions and deboning.

Although these data suggest that some bifaces may have been used as knives, probably very few were finished or used as knives at the quarries (Figure 28). The use of bifaces as cores for the production of flakes is another explanation for the intended function of bifaces leaving Tosawihi. These hypotheses are discussed in Chapter 21.

General Assemblage Results: Summary

The Tosawihi biface collection is dominated by local opalite, jasper, chalcedony, and opal. Basalt occurs locally, but only a small number of basalt bifaces (n=11) are present in the assemblage. Nonlocal cryptocrystalline raw material is also rare (n=26), and consists primarily of exotic obsidian. In any case, the general assemblage results are strongly conditioned by the local availability of toolstone, and regularities in how it was used.

The single most important feature of the biface assemblage is its strong patterning. The pattern is created by the selected techniques of biface reduction. Almost all attributes are associated positively with biface reduction stage. Heat-treatment, fragmentation and manufacture failure, biface dimensions, and reduction stage are interrelated. Heat-treatment occurs within and increases in proportion by stage from reduction Stage 2 through Stages 3 and 4. Fragmentation due to material flaws decreases in proportion through Stages 2, 3, and 4; that due to poorly controlled application of force during knapping and to heat-treatment occurs during Stages 3 and 4. Not surprisingly, biface dimensions diminish with increased reduction stage. Thus, reduction stage is probably the single most important variable in the Tosawihi biface assemblage.

Areal Comparisons

The general assemblage results discussed above indicate that biface production was an important focus of prehistoric use of the Tosawihi vicinity. For a variety of reasons, probably including transport costs and procurement maximization (cf. Chapters 3, 4), stage/ size variation in the biface assemblage is a function of distance from toolstone sources. Stage/size variation may also correspond with other resource opportunities presented by the Tosawihi landscape (cf. Chapters 2, 5, 20).

Each area is discussed in terms of biface reduction techniques and the overall organization of biface production, transport, and use in the Tosawihi vicinity.

26Ek3032 contains over 200 distinct cultural localities. Most toolstone sources in the Tosawihi study area lie within the site; eight which were investigated contain bifaces and form the subject of later discussion.

The Eastern Periphery also contains several toolstone sources. The quality of surface toolstone varies from poor to good, but the average material quality of bifaces is good to excellent.

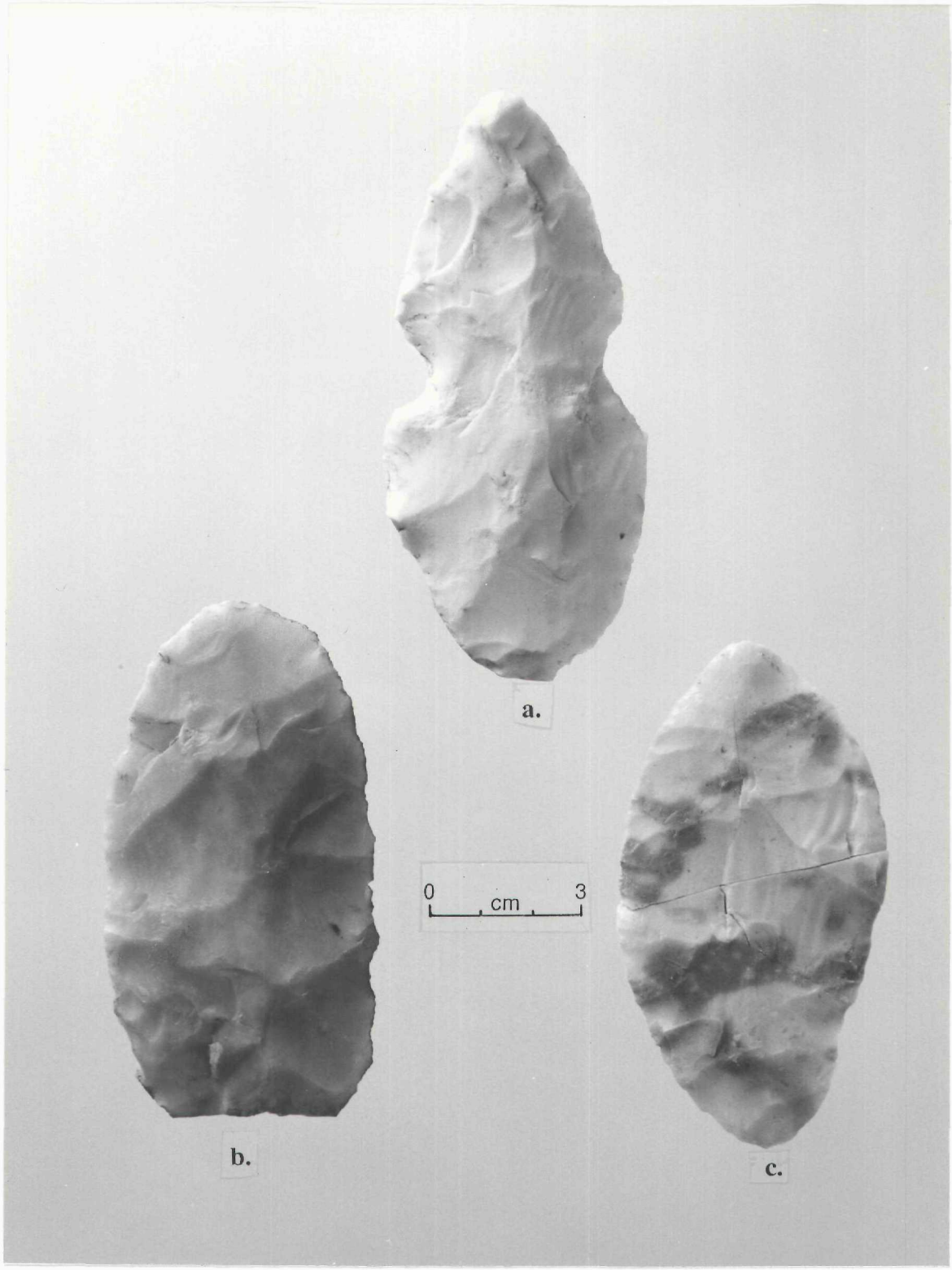


Figure 28. Examples of possible finished bifacial tools.

This suggests that some bifaces from this area may have been quarried elsewhere (probably in 26Ek3032) or that local, higher quality toolstone (probably from subsurface deposits) was exploited selectively.

The Western Periphery contains few toolstone sources, yet the biface sample is larger than from other subareas. Most bifaces appear to have been transported as partially reduced pieces, then reduced further and processed here.

The Northern Corridor contains no toolstone sources; cryptocrystalline bifaces within it most likely were transported at least 6 km. About 80% of the bifaces recovered were collected from two sites, 26Ek3237 and 26Ek3251. The latter lies at the northern edge of the subarea near the confluence of Ivanhoe and Willow Creeks, approximately 12 km from 26Ek3032, adjacent water and other riparian resources.

Areal Comparisons: Material Sources and Color Diversity

All four subarea biface assemblages are dominated by local cryptocrystalline material (opalite, jasper, chalcedony, and opal). Basalt, locally available, is rare in the assemblages (Table 3), as are other non-local materials; no assemblage contains more than 2% non-local raw material. The number of material types within each area (source richness) is highly correlated with assemblage size, precluding interareal comparison of variety on the basis of material type variety (Jones et al. 1989).

The number of toolstone colors represented in each assemblage also correlates with logarithmically transformed values of subarea assemblage size, so that no interpretation based on color variety is possible. However, when colors are considered as "white" (the most common opalite color, including the material color values of white, grey, and beige) vs. "other", differences emerge (Table 10). 26Ek3032 has a significantly ($p=0.05$) higher proportion of non-"white" bifaces than expected under a chi-square model of independence between color and subarea. The Northern Corridor also has a substantial proportion of non-"white" bifaces, but does not differ significantly from the expected value under a chi-square model of independence. The Eastern Periphery has a significantly higher than expected proportion of "white" opalite bifaces. The Western Periphery does not deviate significantly from expected chi-square values.

Table 10. "White" vs. Other Material Colors,
Locally Available Cryptocrystalline Materials Only, by Subarea.
Significant ($p<0.05$) adjusted standardized residuals marked with asterisks.

Color		26Ek3032	East	West	North	**Total**
"White"	n	191	1180	2090	383	3844
	%	74.9	91.8	88.4	85.7	88.4
	adj. std. resid.	-6.9*	4.6*	0.1	-1.9	
Other	n	64	105	274	64	507
	%	25.1	8.2	11.6	14.3	11.6
	adj. std. resid.	6.9*	-4.6*	-0.1	1.9	

The proportion of "white" to non-"white" material in each subarea in part may reflect the toolstone sources represented in each area's biface collection. 26Ek3032, (the Quarry area) contains numerous "non-white" toolstone sources. Not surprisingly, the biface assemblage appears to have a greater proportion of these materials when compared to the other subareas. Toolstone sources in the Eastern Periphery are predominantly white; consequently, the biface

assemblage is dominated by "white" toolstone. Sites in the Western Periphery have few toolstone sources nearby, and bifaces recovered in this subarea probably were derived from sources in the Quarry area. In contrast to the general pattern of color proportions reflecting local toolstone availability, assemblages from the Northern Corridor exhibit a slightly greater proportion of white toolstone than do sites in the West; bifaces probably derived from sources in the Quarry area as well as a wider range of other sources outside of Ek3032. Northern Corridor sites may also include bifaces made on the multi-colored stream cobbles found along Ivanhoe and Willow Creeks.

Areal Comparisons: Reduction Stages

The reduction stages of local cryptocrystalline bifaces are not distributed randomly across the four subareas. There is a strong positive association between early reduction stages and proximity to toolstone sources (chi-square=70.97, df=12, $p<0.001$). A dot plot (Figure 29; Cleveland 1985) and examination of adjusted standardized residuals (Figure 30; Everitt 1977) to determine significant ($p=0.05$) deviations from chi-square expected values are useful in elucidating additional patterns.

In the main quarry area, 26Ek3032, there are significantly more Stage 1, Stage 2, and early Stage 3 bifaces than late Stage 3 and Stage 4 bifaces. In the Eastern Periphery, which is adjacent the toolstone sources of 26Ek3032 and contains some sources of its own, there are significantly more Stage 2 and early and middle Stage 3, and fewer late Stage 3 and Stage 4 bifaces, than expected under a chi-square model of independence. The Western Periphery, which is further removed from sources in 26Ek3032, contains fewer Stage 1, 2, and early Stage 3 bifaces and more late Stage 3 and Stage 4 bifaces than expected. The Northern Corridor has fewer early Stage 3 bifaces and more Stage 4 and Stage 5 bifaces than expected. A rough seriation of the four areas, based upon reduction stage, follows the order of presentation above, from earliest to latest biface reduction: 26Ek3032, Eastern Periphery, Western Periphery, and Northern Corridor.

Areal Comparisons: Biface Dimensions

Variation in biface sizes between and within subareas was examined. Comparison of size variation is complicated by the interrelationship between reduction stage and biface size, discussed above, so reduction stage was a necessary controlling variable in these analyses. As discussed above, with increasing distance from toolstone sources, the proportion of later stage bifaces increases at the expense of earlier reduction stage bifaces. If stage were *not* controlled in comparing biface sizes, biface dimensions would decrease in the same order as the proportion of late stage bifaces increases.

Examination of mean dimension values for bifaces in Stages 2, 3, and 4 for each subarea (Table 11) shows that even when reduction stage is held constant, the trend is one of diminution in size at greater distances from toolstone sources. For example, Northern Corridor stage 3 bifaces are smaller than Stage 3 bifaces from the Western Periphery. In turn, the latter are smaller than their counterparts from the Eastern Periphery. Stage 2 bifaces follow this trend, but are always larger than Stage 3 bifaces.

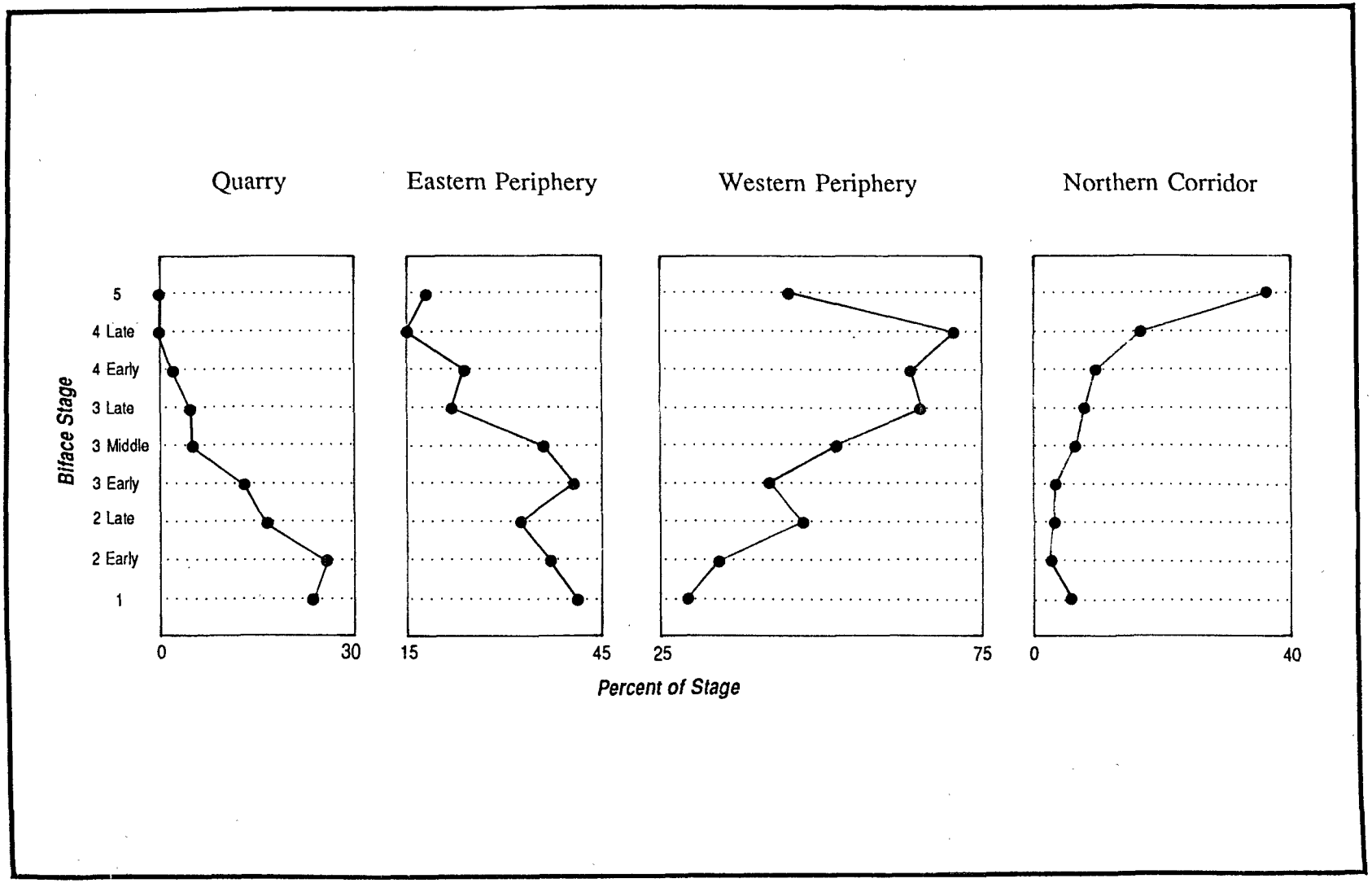


Figure 29. Proportions of each stage in subarea.

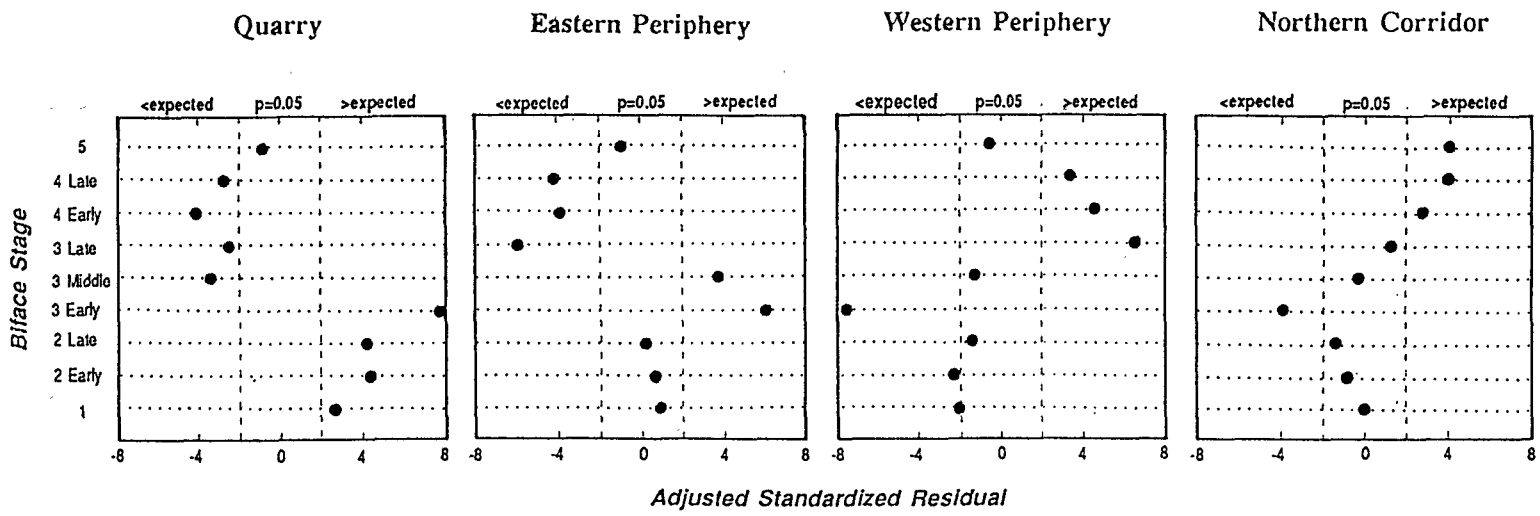


Figure 30. Adjusted residuals of stage by area.

Table 11. Size Variation in Bifaces of Local Cryptocrystalline Silicates, by Subarea and Reduction Stage.

Subarea	Reduction Stage		Length* (mm)	Width** (mm)	Thickness** (mm)	Weight* (g)	Width:Thickness Ratio
26Ek3032	2	mean	122	79	32	337	2.7
		sd	35	13	11	262	0.8
		n	13	20	20	13	20.0
	3	mean	114	67	28	234	2.6
		sd	21	13	10	141	0.8
		n	52	80	80	52	80.0
	4	mean	161	72	17	231	4.2
		sd	5	10	2	35	0.7
		n	5	6	6	5	6.0
East	2	mean	111	69	28	222	2.8
		sd	24	12	12	117	1.1
		n	27	31	31	27	31.0
	3	mean	113	68	26	230	2.9
		sd	24	17	11	142	0.9
		n	250	372	372	250	372.0
	4	mean	106	53	11	105	5.0
		sd	34	14	4	86	1.0
		n	7	35	35	7	35.0
West	2	mean	97	66	26	228	2.7
		sd	26	21	12	229	0.8
		n	20	27	27	20	27.0
	3	mean	98	55	21	162	2.9
		sd	32	18	10	161	1.0
		n	181	376	376	181	376.0
	4	mean	91	40	9	51	4.6
		sd	48	12	3	55	1.2
		n	5	81	81	5	81.0
North	2	mean	98	59	33	201	2.0
		sd	25	8	18	112	0.8
		n	2	2	2	2	2.0
	3	mean	69	38	15	99	3.0
		sd	23	17	11	123	0.9
		n	11	28	28	11	28.0
	4	mean	-	32	7	-	4.7
		sd	-	9	2	-	1.0
		n	0	12	12	0	12.0

*Complete specimens only
**Complete specimens and specimens missing ends

Statistical separation of the dimensions of bifaces within the same stage reduction but in different subareas is possible, yet it is not very enlightening. We performed t-tests at a predetermined significance level of p=0.05 to contrast the dimensional variates between subareas. For most dimensional variables, there were no significant differences between a

subarea and its adjacent neighbors. For example, t-tests showed no significant difference in most mean dimensions when Eastern Periphery Stage 3 bifaces were contrasted with Western Periphery Stage 3 bifaces. Yet, there is a significant difference between the Western Periphery Stage 3 bifaces and Stage 3 bifaces from the Quarry (26Ek3032) area. Significant t-test contrasts were found only when such nearest neighbors were skipped, and even these are not wholly consistent across all size measures. Northern Corridor bifaces, however, are consistently (and significantly) smaller than those from the Eastern Periphery and the Quarry areas.

A second statistical analysis was performed to examine whether variation in the overall mean dimensions of bifaces is explained best by subarea, reduction stage, or both. A multiple analysis of variance was performed contrasting subarea and reduction as factors, and using biface dimensions as response variates. The results of this analysis (not presented here) showed that both reduction stage proportions and subarea were influential factors, so size variation cannot be ascribed to either factor singly.

Outside 26Ek3032, most bifaces were found away from toolstone sources, indicating large-scale transport of bifaces around the Tosawihi landscape. As discussed above, both placement relative to toolstone sources and reduction stage determine (in a statistical sense) the diminution of biface sizes from Quarry to East to West to North. This pattern is wholly sensible given the costs of transport (cf. Chapter 4, Chapter 26): the mass of material transported should be reduced to the greatest possible extent to minimize energetic costs. Thus, one expects increasing standardization of transported bifaces at greater distances from toolstone sources. We now turn to examining whether standardization of biface sizes is evident in the assemblage. A shift in focus is required, since now we are comparing the sizes of bifaces at different stages within each subarea, rather than sizes in the same reduction stages from different subareas. If standardizing of size (and not form, since form has no direct relationship to transport cost) occurred, then we expect the sizes of stages to become increasingly similar at greater distances from toolstone sources.

Since weight ultimately determines transport cost, we examined its variation between stages from the same subarea, again using t-tests at a predetermined significance level of *0.05*. The mean values for adjacent stages (2 vs. 3, 3 vs. 4) were contrasted. Stage 4 bifaces from the Northern Corridor are a null set, and thus could not be contrasted.

No significant differences were found between Stage 2 and Stage 3 bifaces. Significant differences were found between Stage 3 and Stage 4 bifaces in the Eastern and Western Peripheries.

The lack of difference in Stage 2 and Stage 3 bifaces suggests that within each subarea, both stages are a "standard transport weight." The standard transport weight should vary with distance from source, because the costs of transport increase in linear fashion. For example, one might be willing to transport 10kg for 1km, but not for 10km, since it is 9 times as costly to travel the additional distance. The decrease in biface size with distance from toolstone sources, therefore must be more a function of distance than of stage proportions.

The differences between mean weights of Stage 3 and Stage 4 suggest that Stage 4 biface transport operated under different constraints. We can only surmise what these may have been, but one likely possibility is that Stage 4 bifaces were more important as potentially useful tools than as commodities for transport away from Tosawihi.

In any case, insofar as weight is indicative of standardization and our most distant subarea from toolstone sources was still within a transport-production radius for Stage 3 bifaces, the mean weight of Stage 2 and Stage 3 bifaces from the Northern Corridor reflect maximum sizes of bifaces removed from Tosawihi. The grand mean for both stages is 115g, although there is considerable variation around this (standard deviation = 123g). This provides a very rough estimate of biface sizes removed from the Tosawihi vicinity.

Areal Comparisons: Heat-Treatment

The incidence of heat-treatment varies considerably in the four subareas (Table 12) and the proportion of heat-treated bifaces generally increases through the reduction sequence. Using counts of definitely heat-treated bifaces against all other categories (including possibly heat-treated), general reduction stages 2, 3, and 4, and the four major subareas, chi square values indicate that all these relationships are non-random, that the incidence of heat-treatment, biface reduction stage, and subarea are interrelated and interdependent:

stage/ht	$\chi 2 = 158.39$, df = 2, $p<.001$
subarea/ht	$\chi 2 = 369.14$, df = 3, $p<.001$
subarea/stage	$\chi 2 = 139.65$, df = 6, $p<.001$

The greatest incidence of heat-treatment and the highest proportion of later stage reduction were found at the greatest distance from toolstone sources. The least amount of heat-treatment and the highest proportion of early reduction stages were found nearest to toolstone sources.

Within each subarea, the incidence of heat-treatment was compared with chi-square tests to general reduction stages 2, 3, and 4:

Quarry	$\chi 2 = 2.23$, df = 2, $p <.328$
East	$\chi 2 = 34.12$, df = 2, $p <.001$
West	$\chi 2 = 58.50$, df = 2, $p <.001$
North	$\chi 2 = 5.25$, df = 2, $p <.073$

Table 12. Proportions of Heat-Treated Bifaces by Stage in the Four Subareas.
(Possible heat-treated specimens not considered heat-treated.)

	SUBAREA			
Stage	Quarry	East	West	North
1	0	14.29	0	0
2	6.90	11.50	28.90	40.00
Early 3	3.88	12.30	24.09	29.63
Mid 3	8.62	21.29	43.16	54.05
Late 3	13.33	27.86	59.62	61.22
Early 4	20.00	35.24	63.21	64.29
Late 4	0	75.00	58.82	50.00
5	0	50.00	60.00	100.00

The results from the East and the West indicate that in these two areas, stage and heat-treatment are associated, while in the Quarry and the north they are not. Figure 31 illustrates heat-treatment proportions by stage in each subarea. The proportion of heat-treated bifaces in the Eastern Periphery is lower than in the West and the North, especially in the earliest stages of manufacture. All three of these areas are very different from the Quarry subarea, where there is little heat-treatment at any stage of reduction. Overall, heat-treatment is most common in the North, where it is more common in earlier stages.

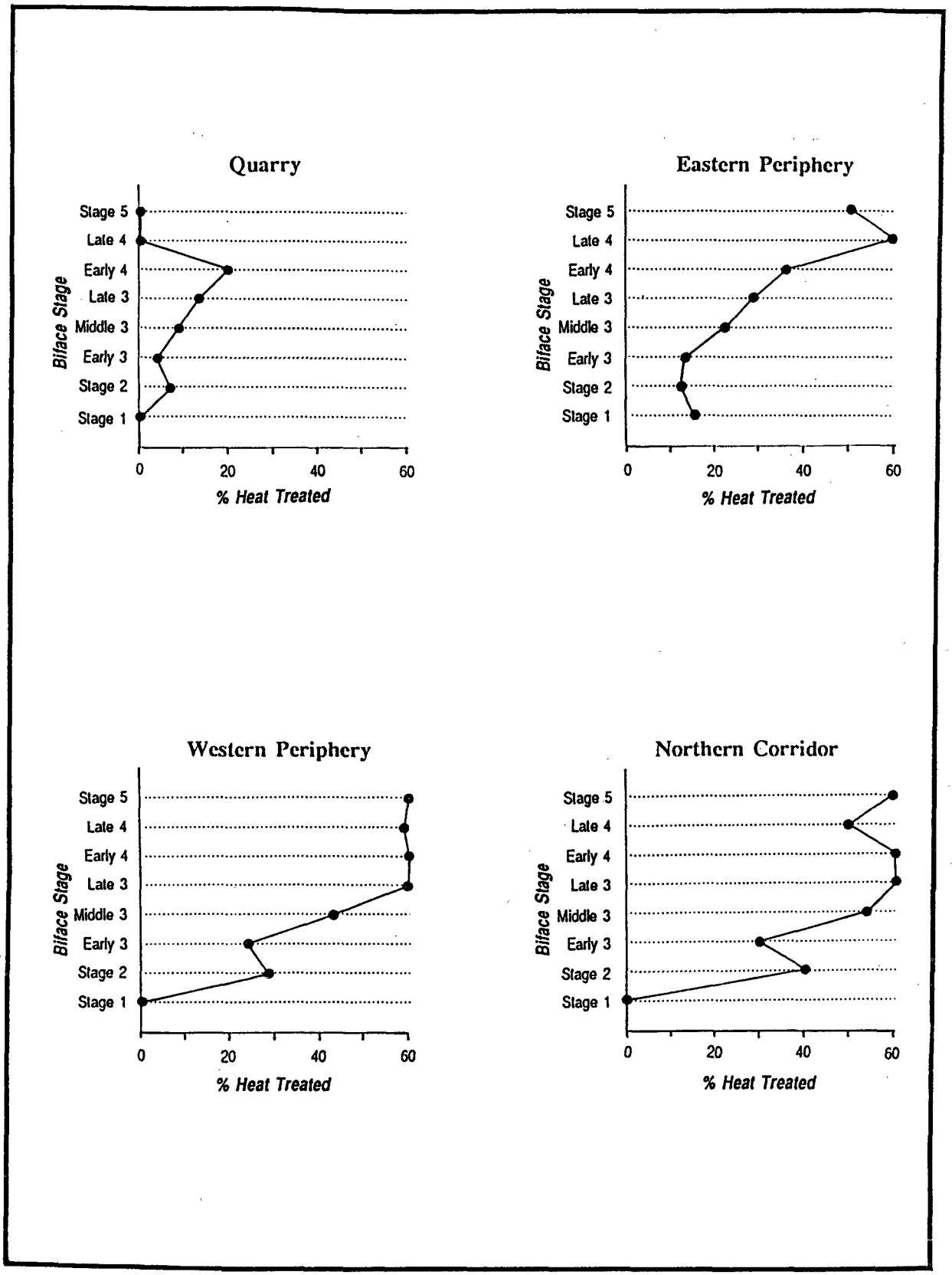


Figure 31. Dot plots of the proportions of heat-treated opalite bifaces of each stage in the four subareas.

Overall, heat-treatment was undertaken most often between middle and late Stage 3 (cf. Chapter 21). Heat-treatment was carried out only infrequently where toolstone was extracted; generally, early stage bifaces were moved to residential sites for further reduction and (often) heat-treatment, but in the West and North, bifaces often were heat-treated as early as Stage 2 or early Stage 3. Thus, the Eastern Periphery has a much higher proportion of heat-treated bifaces and late stage reduction than the Quarry, but fewer than either the West or North, from which it also differs in other details, probably because it contains toolstone sources. In the West and North, further removed from toolstone sources, heat-treated bifaces are more common. The higher proportion of heat-treated Stage 2 bifaces in these assemblages is not expected and suggests that, although bifaces sometimes were transported before processing through Stage 3, the greater risk attending this decision often was mitigated by heat-treating the artifacts before the move.

Areal Comparisons: Biface Breakage and Failure

Biface breakage rates and types are dependent on stage, as discussed above. The probability of any single biface breaking during production increases with its continued reduction. The Quarry subarea has the highest proportion (30%) of unbroken bifaces. However, many of these are very early stage bifaces probably rejected for their material quality or initial proportions. The broken 70% are dominated by early stage fracture types.

Breakage from misdirected blows, typical of later stage reduction, is more common in the Eastern Periphery than in the Quarry. Outrepassé removals, edge collapses, perverse fractures, and thermal failures are much more frequent in the east. This parallels the greater proportions of later stage bifaces in the Eastern Periphery than in the Quarry.

Similarly, the Western Periphery is dominated by manufacture failures, a function of the even later reduction of bifaces. Bifaces probably were transported more often into the Western Periphery already reduced to late Stage 2 or early Stage 3. This is supported by the lower proportion of hinge failures, common in the early reduction of large blanks, in the West. However, the proportion of other early fracture plane and material flaw related failures is fairly constant across the Quarries, the Eastern Periphery, and the Western Periphery. By this token, the reduction of early stage bifaces occurs in all three subareas, even though fewer large flake blanks are reduced in the West.

Biface breakage and failure in Northern Corridor assemblage are quite different. Northern Corridor bifaces have fewer hinge fractures, while outrepassé failures associated with later reduction are correspondingly higher. The proportions of bifaces broken solely by thermal failure also are lower in the Northern Corridor, but the association of heat-treatment with some other breakage type (e.g., breakage due to the creation of internal fractures by heating) is higher. Once again, the Northern Corridor biface assemblage, more distant from toolstone sources, represents later stage reduction than do the other subareas.

Basalt and Obsidian Bifaces

The Tosawihi assemblage also contains 11 bifaces made of basalt and 25 of obsidian. Little basalt or obsidian was recovered from the Quarry (Table 13), but both materials are found in the other subareas; most obsidian bifaces were recovered from the East.

Table 13. Frequencies of Basalt and Obsidian Bifaces from the Four Subareas.

	Quarry	East	West	North	**Total**
Basalt	0	3	3	5	11
Obsidian	1	12	7	5	25
Total	1	15	10	10	36

The basalt bifaces are made on flakes detached from local raw material; cobbles and angular chunks of tabular and massive basalt are common in the Western Periphery and Northern Corridor. Manufacturing techniques similar to those used in opalite biface reduction produced the small assemblage.

Tosawihi basalt is relatively fine-grained and flakes well, although edges produced on basalt flakes are neither as durable nor as sharp as those produced on opalite. This affects the tasks for which basalt tools are most suited. Intended forms of basalt bifaces probably varied. In at least one case, a basalt biface seems to have been used as a quarrying tool; in another, a biface probably served as a large projectile point preform. It is unlikely that basalt bifaces served as cutting tools when so much sharper, more durable material was readily available.

In contrast, the obsidian bifaces are quite different from their opalite counterparts. They are made from small nodules that result in tools much smaller than the average Tosawihi biface (Figure 32). Their fragmentary nature makes their intended forms difficult to infer, but rather than serving as preforms for large bifacial knives or as cores for the production of flake blanks, most probably were large projectile point preforms. Few are complete, but they manifest manufacturing techniques different from those used to produce opalite bifaces.

Examination of other tool categories (points, preforms, flake tools) indicates that obsidian was preferred over opalite for the manufacture of projectile points. Obsidian is particularly well suited to point manufacture because it pressure flakes easily without heat-treatment. Evidence for the *in situ* manufacture of obsidian projectile points was found at a number of sites, and, in fact, little of the obsidian debitage collected reflects biface manufacture. At Tosawihi, as elsewhere in the Great Basin (cf. Chapter 8), Rosegate and Desert Series points are pressure flaked directly on unworked flake blanks, while varying proportions of points of earlier (and larger) point types may exhibit evidence of an intervening percussion flaking phase. In those cases, points broken in manufacture usually would be indistinguishable from small bifaces.

Comparison of the sizes of obsidian bifaces and the target points for which they may have been intended is difficult because most obsidian bifaces in our sample are broken. However, hydration rinds are available for most the obsidian bifaces in the assemblage (cf. Chapter 19; Appendix M); few are as thin as those recorded for Rosegate and Desert Series points. The majority of sources determined by X-ray fluorescence (Appendix N) are from Brown's Bench, the source from which the only two sourceable stemmed points were derived.

One small, apparently reworked, obsidian biface tip from an unknown source resembles examples of fluted point fragments from the Dietz site (John Fagan personal communication; Willig 1988:Figure 11a-d). Three hydration rim measurements (6.1, 6.4, 3.6) place the piece within the range recorded for many of the Early Archaic and Stemmed Series obsidian points in the assemblage. This biface has an impact fracture on the ventral surface and the distal portion of a negative scar originates from its proximal end (Figure 32a; Figure 33); it may be a Western Clovis point (Willig and Aikens 1988). Thus, we suggest that the obsidian bifaces from Tosawihi represent primarily percussion flaking stage preforms for the production of large, Early Archaic (or earlier) projectile points.

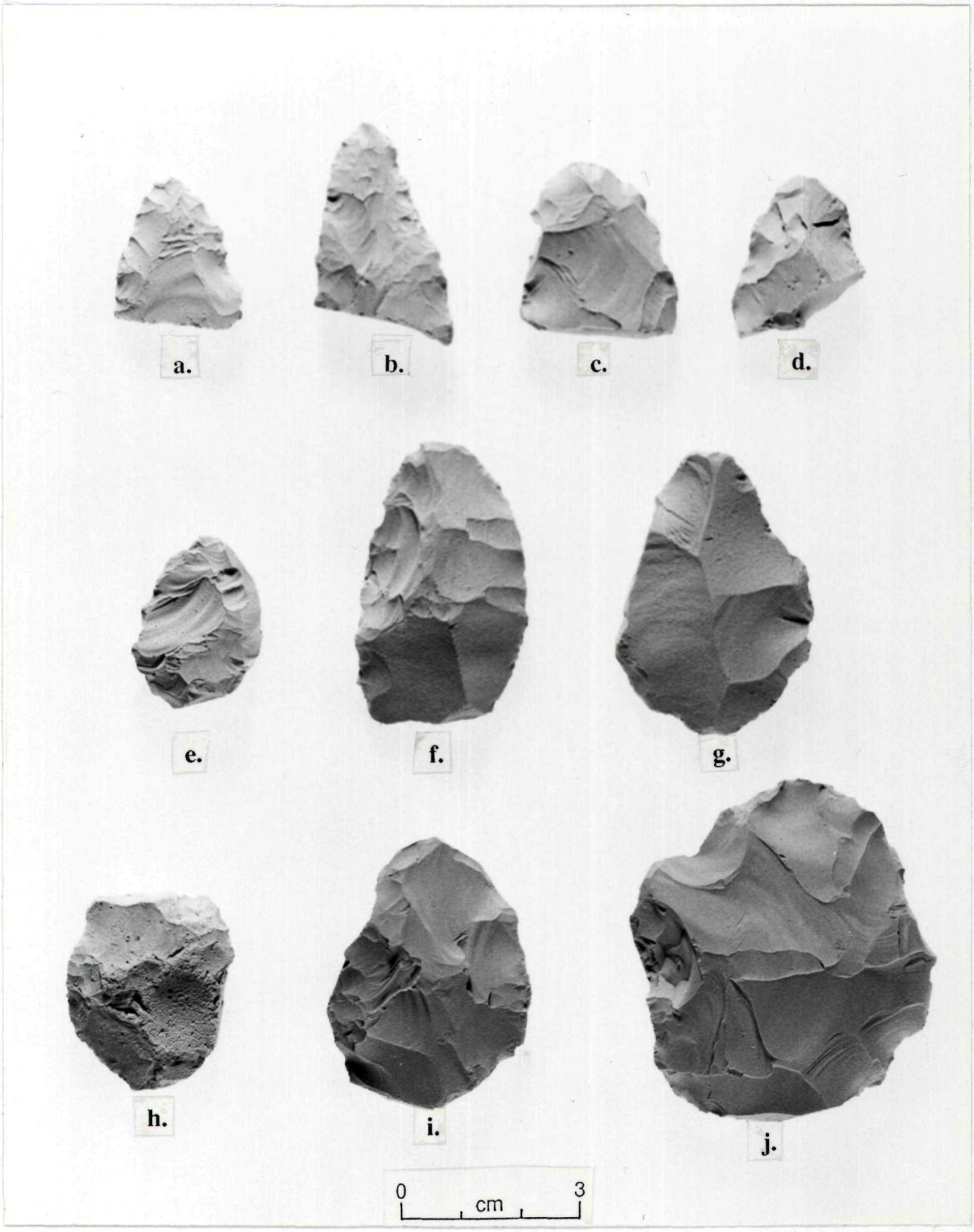


Figure 32. Selected obsidian bifaces.

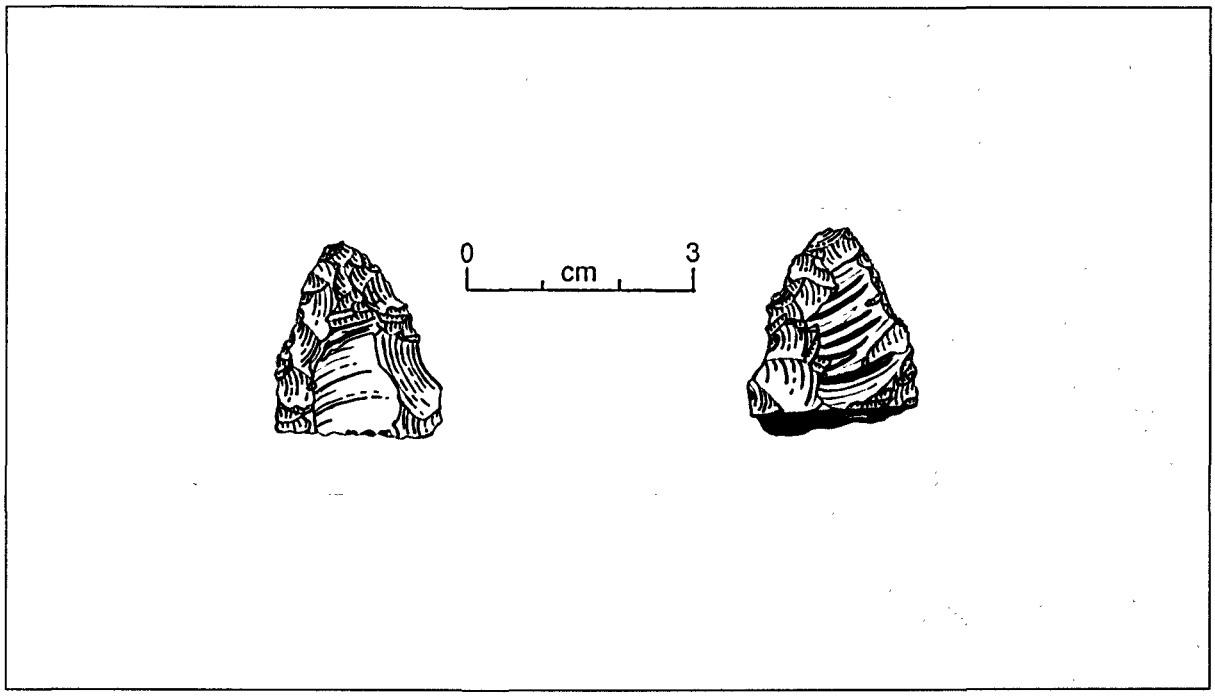


Figure 33. Possible fluted point from 26Ek3237.

Caches

During her initial Tosawihi investigations in 1977, Mary Rusco discovered a cache of six large bifaces lying on the surface in 26Ek3032. During the course of our more recent work, we have recovered four additional caches, bringing the total number of cache finds to 84 bifaces.

Cached goods are not uncommon in the Great Basin. Ethnographic accounts of caches refer primarily to foodstuffs (Fowler and Fowler 1971), but dry cave finds indicate that a wide variety of objects and commodities were cached (Heizer and Kreiger 1956; Thomas 1985; Ingbar 1985), including snare kits, fishing kits, duck decoy manufacture and repair equipment, sewing kits, basket-making kits, stone tool making kits, etc.

Caches of unfinished lithic tools most often contain point preforms (Pavesic 1985; Scott et al. 1986; Hester 1974), sometimes mixed with finished points. Caches of large unfinished bifaces are less frequent, but are reported from the Northern and Southern Plains (Miller et al. 1991; Tunnell 1977) as well as from the Great Basin (Janetski et al. 1988). These biface caches differ from those at Tosawihi in that they occur at considerable distances (up to 200 km) from raw material sources.

At Tosawihi, cache bifaces were found in the Quarry, East, and West in a variety of depositional circumstances ranging from surface finds (probably exposed through erosion) to storage in a crack at a small rockshelter, as described in later chapters. Biface caching at Tosawihi may have been a function of over-production, or of purposeful storage for a return foray; or, they may contain special trade objects, or merely the less successful products of a quarrying episode (cf. Chapter 4). The general quality (Figures 34, 35) of cache bifaces, and their careful storage, suggests that the latter possibility is unlikely. Cache bifaces probably were produced and stored for retrieval during times less suitable for quarrying.

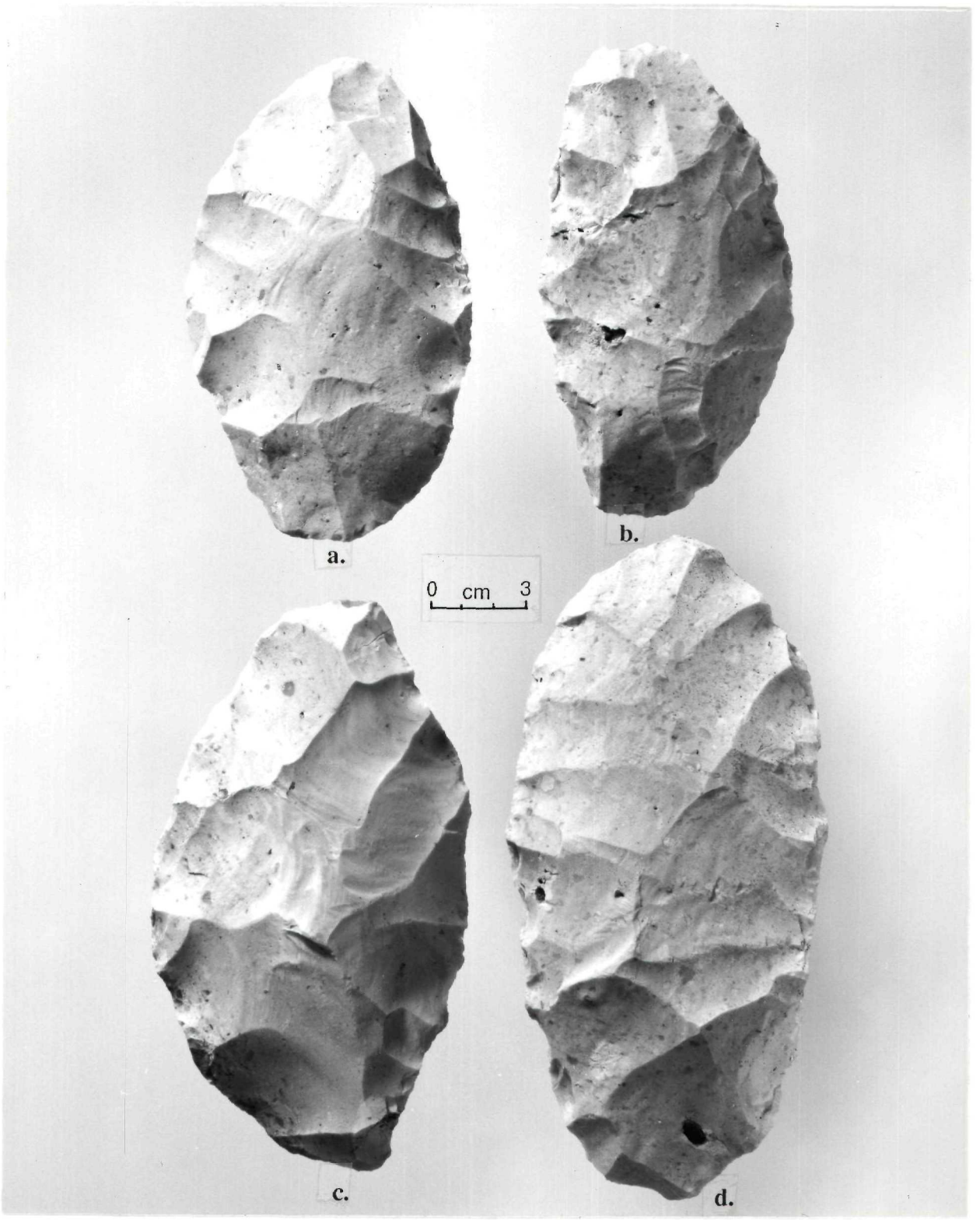


Figure 34. Cache bifaces from 26Ek3095.

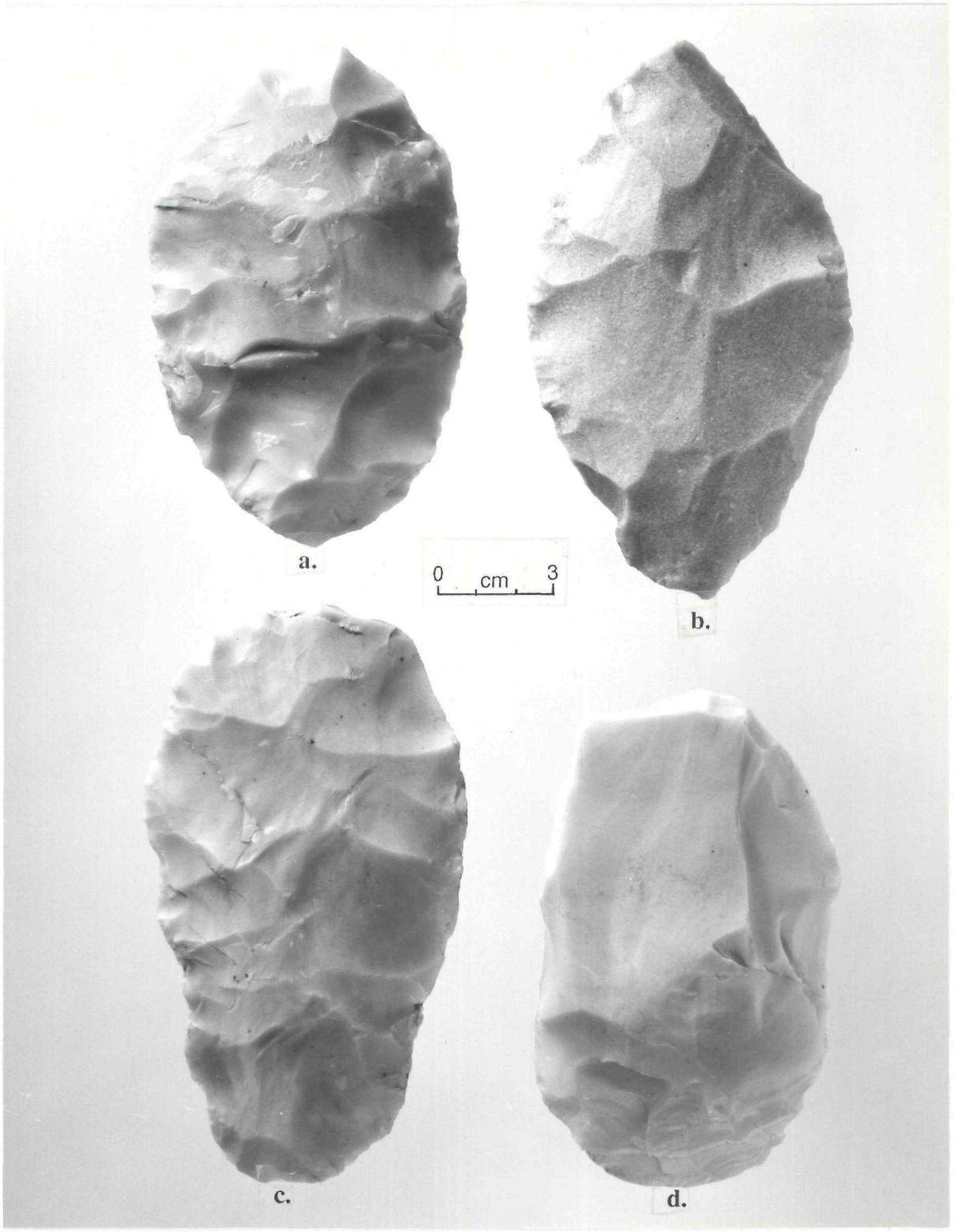


Figure 35. Selected cache bifaces from 26Ek3170.

Almost all the cache bifaces are complete; only one has been heat-treated. Neither within caches nor between them do the bifaces conform to standardized sizes (Table 14a). A cache from the Western Periphery contains the largest bifaces, and exhibits the greatest variation in size. The mean sizes of cache bifaces are larger than for the Tosawihi assemblage as a whole, perhaps because they represent successful production rather than discard of production failures.

Table 14. Attributes of Cache Bifaces.

a. Mean Sizes of Complete Cache Bifaces (in mm)

Site	n	Mean Length	sd	Mean Width	sd	Mean Thickness	sd	Mean Weight	sd
26Ek3032	6	159.8	6.7	72.5	9.9	17.9	1.2	221	43.9
26Ek3095	7	170.7	33.7	87.3	19.8	28.7	9.7	465.1	280.1
26Ek3170	10	135.7	16.3	82.6	13.8	21.5	3.8	277.1	134.7
26Ek3192	38	126.9	16.2	79.4	8.6	23.3	4.1	245	89.7
26Ek3197	14	135.1	7.6	75.4	4.9	30	5	284.7	26.1
Total	75	136.3	21.7	79.3	10.8	24.4	5.9	275.3	130.3

b. Stages of Cache Bifaces.

Site	Stage 1	Late 2	Early 3	Middle 3	Late 3	Indet. 3	Early 4	Total
26EK3032	0	0	0	0	2	0	4	6
26EK3095	0	0	1	6	0	1	2	10
26EK3170	1	0	0	8	1	0	0	10
26EK3192	1	0	15	21	4	0	0	41
26EK3197	0	3	9	5	0	0	0	17
Total	2	3	25	40	7	1	6	84
%	2.38	3.57	29.76	47.62	8.33	1.19	7.14	100.00

Four cache bifaces are made from materials other than opalite (Table 15). The diversity of material color in the cache assemblage is very low; 96.5% are "white". Three caches contain large proportions of pieces made on a distinctive grey brecciated opalite which could be from a single source.

Table 15. Raw Material Types Represented in Caches.

Site	Opalite	Grey Breccia	"Quartzite"	Jasper	Total
26Ek3197	0	17	0	0	17
26Ek3192	24	17	0	0	41
26Ek3032	4	0	2	0	6
26Ek3095	3	6	0	0	9
26Ek3170	9	0	1	1	11
Total	40	40	3	1	84

Most cache bifaces (77%) are reduced to early or middle Stage 3, although the Rusco cache are all late Stage 3 or early Stage 4 bifaces. Since that cache also included a raw

material type uncommon in the other caches, it is possible that it was made by a different group at a different time. It contains two unworked flake blanks, three late Stage 2 bifaces, seven late Stage 3 bifaces, and six early Stage 4 bifaces (Table 14b); this stage distribution is earlier than for the assemblage as a whole, where 23% are early Stage 3 and 34% middle Stage 3.

As noted above, the biface caches were recovered from three of the four project subareas. The distributional pattern of these caches in terms of dimensions and stages does not fit the patterns observed for the bulk of Tosawihi bifaces. We might expect to see the highest proportion of larger, earlier stage bifaces in the Quarry area and smaller, later stage bifaces in the West, but the reverse seems to be true. Bifaces in the one cache from the West, located farther from toolstone sources than the other caches, are the largest of all (although not with the earliest stage profile); the cache from the Quarry (where toolstone sources are most common) has the latest stage profile.

Technological Characteristics

Contributed by Mark W. Moore

The caches provide insight into biface production at Tosawihi quite distinct from that provided by the general biface assemblage. For the most part, cache bifaces are complete and probably are internally contemporaneous. The nature of the caches allows us to see the results of successful reduction strategies and to identify possible time-sensitive specialized reduction techniques.

Technological characteristics of the five caches were examined in order to address two questions: What distinctive knapping techniques produced the bifaces found in the caches? How much technological variability is present among caches? Our cache analysis employed replication experiments and negative flake scar analysis.

Knapping techniques used in manufacture were replicated and the experimental and prehistoric products compared. This allowed a high degree of confidence in reconstructing prehistoric knapping techniques from negative flake scars, and generated insights into why such techniques may have been employed.

A biface can be seen as a stratified knapping product on which most recent flake scars overlap previous flake scars. By identifying which scars overlap others, the analyst can reconstruct the order of flake removal. Once data on the order of flake removal are combined with data on flake scar patterning and orientation, fabricator type, and morphology of experimental products produced using specific knapping techniques, reconstruction of knapping techniques can be made. Methods used to determine the order of flake removal are as described by Moore (1990).

Bifaces with Stage 1 remnant surfaces bearing any one of the following traits are manufactured from flake blanks: contact point (point of percussion), cone of force, pronounced and unidirectional compression rings, hinge termination, feathered edges/termination, or curved ventral surface (profile). If a Stage 1 remnant surface is not obscured and none of these traits is present, the blank is assumed to have been a block. A block that once contacted the bedrock along a stress plane can bear compression-like rings, but they usually are diffuse rather than strongly directional. Nevertheless, the appearance of a ventral surface of a flake blank and a bedrock contact surface can be similar, and this may have resulted in misclassification in some cases. Moreover, when reduction has obscured the ventral surface of the flake blank, it often is not possible to distinguish the two types.

The type of fabricator responsible for a flake scar (soft hammer versus hard hammer) was determined by the presence or absence of prominent negative point and cone of percussion or of pronounced compression rings. These traits are associated with hard hammer percussion, but the appearance of hard and soft hammer scars can be so similar as to prompt misclassification in some cases. Distinguishing soft hammer percussion scars from hard hammer percussion scars is an issue discussed in more detail in Chapter 21. Although not quantified, examination of experimentally produced opalite bifaces showed that the two criteria noted above could be used successfully to distinguish hard and soft hammer percussion scars on biface surfaces.

Definition of Knapping Techniques

Serial, Selective.

Although opportunities for successful flake removal from an evolving biface are limited by surface morphology, such opportunities sometimes can be increased through the use of ordered percussion knapping techniques; ordered manipulation is not required for bifacial reduction, however. Following Huckell (1978:43) and Bradley (1974:193), non-ordered flaking is referred to in this study as "selective," rather than "random," and ordered flaking is referred to as "serial." We use "selective" flaking as a catch-all for percussion flaking techniques in which no consistent order of flake removal is noted. The presence of such patterning allows better assessment of the contemporaneity of caches and specialization of production.

Side-by-Side Percussion.

Side-by-side percussion involves removing a series of two or more flakes next to one another from the same face of a biface (Figure 36).

Skip Patterned Percussion.

Skip patterned percussion involves first removing at least two flakes from one edge of a biface spaced so that they fail to overlap or overlap very little (Figure 36). Subsequent percussion flakes are removed from the same edge, utilizing the area of high mass left between the previous flake scars for flake propagation.

Margin Contouring.

A biface margin is defined here as the portion of the biface extending approximately one-half the distance from the edge to the center line. Margin contouring refers to the process of topographically regularizing the biface margins (cf. Young and Bonnichsen 1984:65).

Alternate Percussion.

Alternate flaking involves removing flakes serially down an edge, alternating faces with each flake removal. The scar resulting from a flake removal from one face is used as the platform for flake removal from the alternate face, resulting in a characteristic wavy edge. Alternate flaking often is used as an edging technique (Callahan 1979:Table 11h).

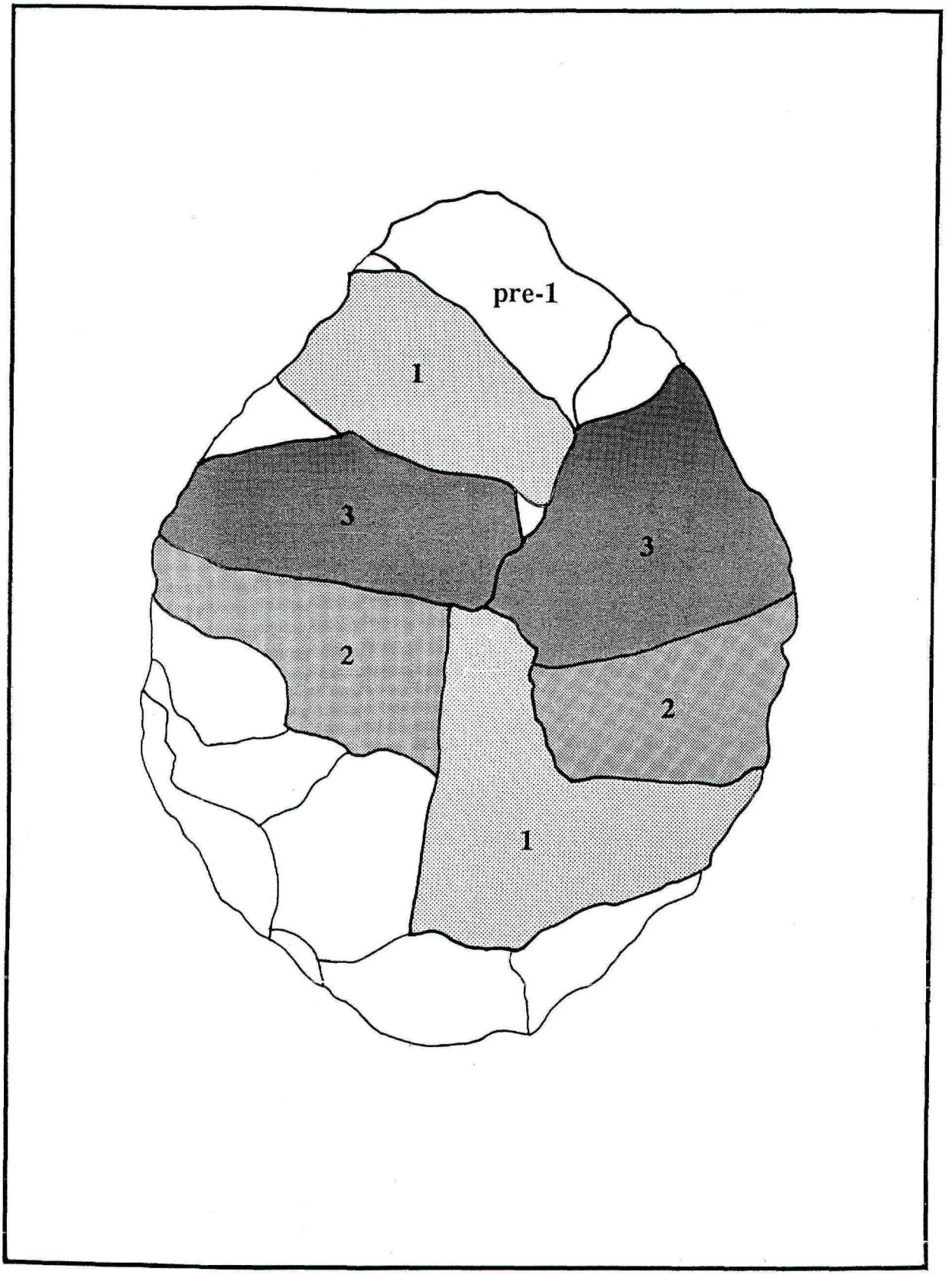


Figure 36. Cache biface from 26Ek3095 showing evidence of side-by-side (right margin) and skip-patterned (left margin) flaking series on a single biface.

Edge Run.

Edge running involves removing a flake down the edge of a biface, resulting in a tranchet-like scar (Shafer 1985:299, 302-303; Callahan 1979:Table 11h; Figure 37c). This scar is used as a platform for additional flake removals. An edge run flake always is removed using an end of the biface as the platform.

Flat Facet Flake Removals.

Flat facet platforms are squared or nearly squared edges used as platforms in percussion thinning or contouring (Figure 38). A flat facet may be a naturally occurring squared edge, an extremely steep negative scar remnant from earlier reduction, or an edge-running negative scar (e.g., Callahan 1979:Table 11h).

Percussion Flattening Scars.

Percussion flattening involves removing flakes in such a way that the biface is thinned radically, providing a flat—not lenticular—cross section. Percussion flattening may be accomplished by only one or two major removals from each face; flakes removed in percussion flattening always travel past the center line, and often terminate near the opposite margin (cf. Callahan 1979:Figures 19c, 89, 39). Scars from percussion flattening normally are partially obscured by later stage contouring and thinning scars.

General Results

Cache 3197.

Cache 3197 consists of early stage bifaces from what appears to be a single discrete source of grey brecciated opalite. Most of the cache was produced from blocks of opalite, with the remainder made on flake blanks (Table 16). The morphologies of the dorsal surfaces of flake blank bifaces suggest the flakes were produced in extraction or in percussion flattening rather than from prepared cores.

Many flake blanks are wider than long ("side struck;" Crabtree 1972:15) and often end in a hinged termination (Figure 37a, b). Such hinged termination negative scars have been observed on bedrock within quarry pits and it appears that some flake blanks were obtained in this way. Following extraction, blocks normally were flattened by percussion flaking from flat facet platforms, sometimes using side-by-side percussion (Table 17). No attempt was made to edge the bifaces completely prior to caching. An edge running technique, to produce flat facet platforms, is common (Figure 37c). Bifaces in cache 3197 were reduced exclusively by hard hammer percussion (Table 19).

Cache 3192.

Cache 3192 consists of early and middle stage bifaces from at least four discrete opalite sources. Most of the bifaces were produced from flake blanks; however, dorsal morphologies suggest the flakes were produced in extraction or from percussion flattening, rather than from prepared cores (Table 16). Most of the flake blanks are wider than they are long ("side struck;" cf. Figure 37a, b). Following procurement, most flakes and bifaces were flattened, sometimes by using flat facet platform. A side-by-side removal technique was frequent, and a skip-patterned technique occasional (Table 17). Many of the bifaces were edged prior to caching. Edge

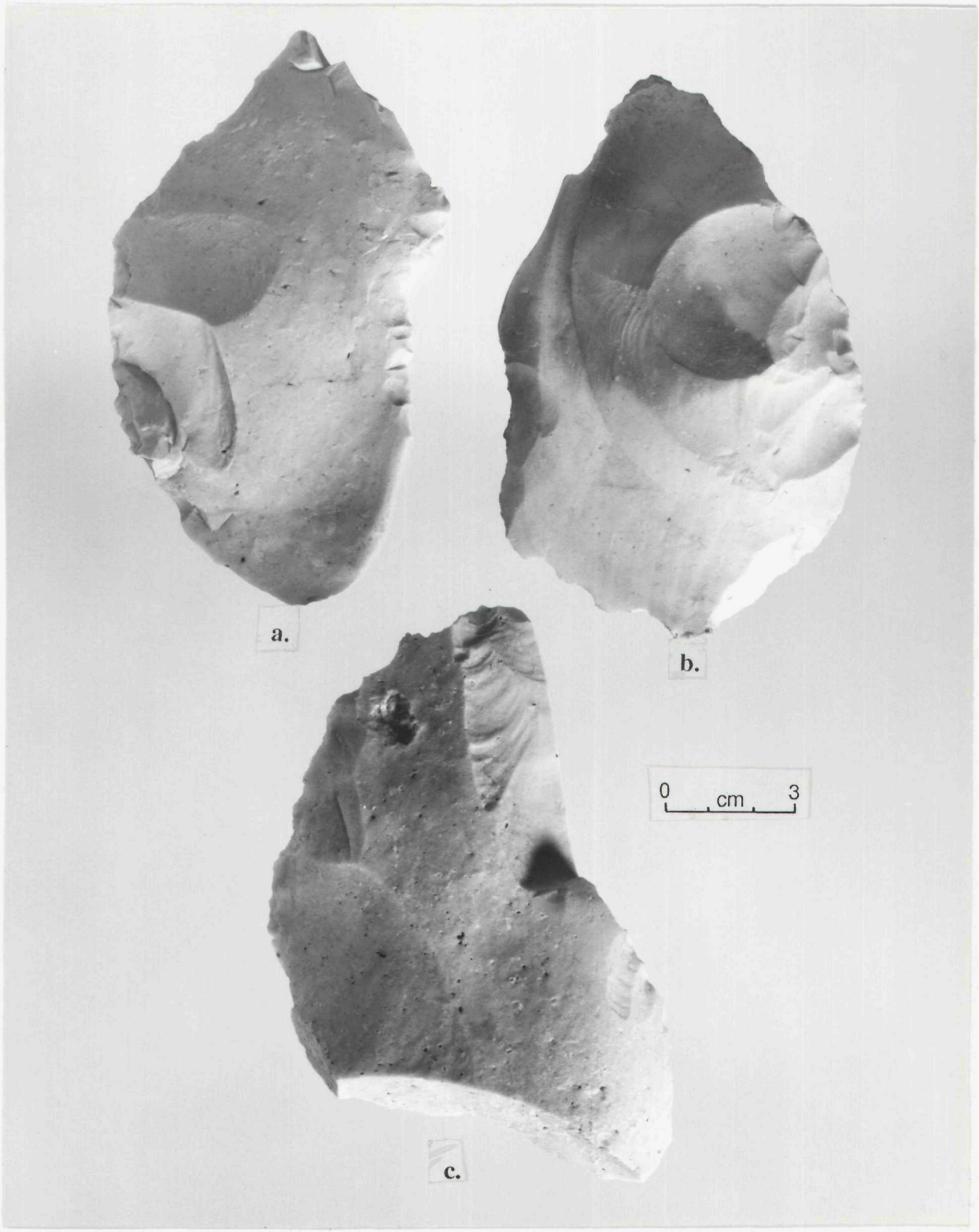


Figure 37. a, b. Bifaces on "side struck" flake blanks; c. biface exhibiting edge run flake scar.

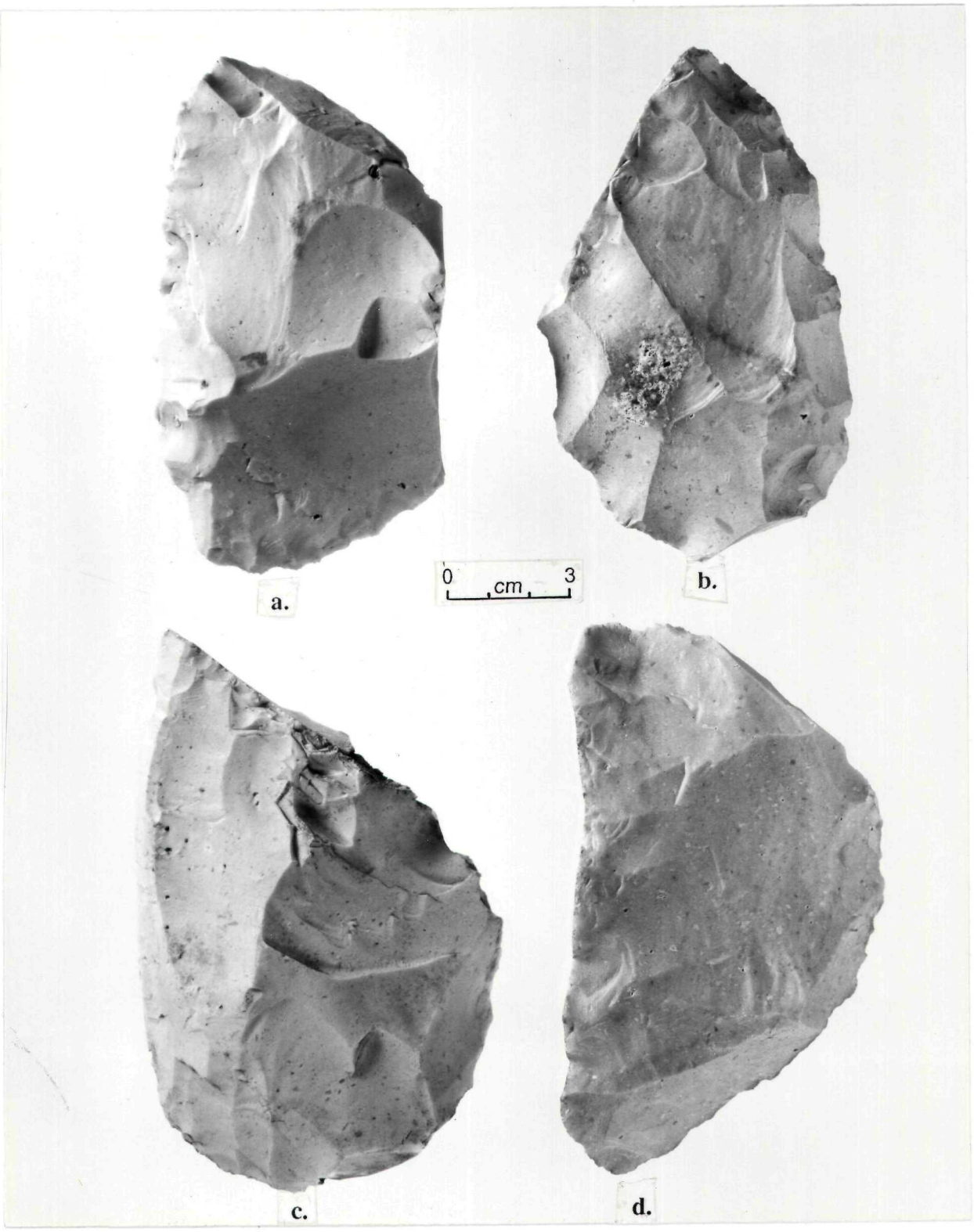


Figure 38. Bifaces exhibiting flat facet flake removals.

running was practiced occasionally to produce flat facet platforms. Bifaces in Cache 3192 were reduced by hard hammer percussion, soft hammer percussion, and a mixture of the two (Table 19).

Cache 3032 (Rusco Cache).

Cache 3032 consists of later stage bifaces from at least two discrete raw material types, one of which appears to be a fine grained quartzite. Blank types could not be determined. All the cache 3032 bifaces have signs of percussion flattening. Serial techniques were commonly utilized in thinning, with skip-patterned thinning more common than side-by-side (Table 17). All the bifaces are completely edged or nearly so. None shows signs of flat facet platform thinning, although one has an unutilized flat facet platform in the form of edge run scar. Bifaces in Cache 3032 were reduced by soft hammer percussion, hard hammer percussion, and a mixture of the two (Table 19).

Cache 3095.

Cache 3095 consists of later stage bifaces from at least two discrete opalite sources. Most of the cache was produced from blocks of opalite, with the remainder made on flake blanks (Table 16). A few bifaces were percussion flattened. Percussion flaking was common, using a patterned technique, most frequently side-by-side, occasionally, skip-patterned (Table 17). A few bifaces show flake removals from a flat facet platform; none derives from edge running. All are edged entirely or nearly so. Bifaces in Cache 3095 were reduced by soft hammer and by a mixture of hard and soft hammer (Table 19).

Cache 3170.

Cache 3170 consists of predominately later stage bifaces from at least three discrete opalite sources. Most of the cache was produced from blocks of opalite, with the remainder made on flake blanks (Table 16). One flake blank may have been struck from a prepared core, or may have been recycled from earlier reduction. The latter flake blank is longer than it is wide. About half the bifaces were percussion flattened. Percussion flaking was common, using a patterned technique, most frequently side-by-side, with some skip-patterned flaking (Table 17). A few bifaces show flake removals from a flat facet platform, some of which derive from edge running. All the bifaces are edged entirely or nearly so. Bifaces in Cache 3095 were reduced by hard hammer, soft hammer, and a mixture of the two (Table 19).

Inter-Cache Comparisons

Block Blanks, Flake Blanks.

Differentiation between block blanks and flake blanks becomes more difficult as biface stage increases because initial morphologies become obscured. Hence, the earliest stage caches perhaps comprise more accurate indicators of blank type employed in biface production. The reduction technology responsible for the 3197 and 3192 caches utilized both block and flake reduction (Table 16).

Table 16. Proportions of Blank Types Present in Caches.

Site	% Flake Blank	% Block	% Indeterminate
26Ek3197	31	56	13
26Ek3192	46	37	17
26Ek3032	0	0	100
26Ek3095	14	29	57
26Ek3170	20	30	50

Flake blanks in both of these caches are thick and usually are wider than long. Typical dorsal morphology is simple, consisting of one or more bedrock contact surfaces. Hence, it appears that these large flakes were removed directly from bedrock, or derived from initial contouring of large blocks. They do *not* appear to derive from flake core reduction. Replication experiments suggest that a "side struck" flake results from an attempt to remove a large flake without the benefit of a constricted area of high mass for propagation. As a result, the propagating flake fans out rather than continuing straight along an area of high mass. Flakes struck under these conditions frequently end in hinge terminations, a characteristic noted on many flake blanks from Caches 3197 and 3192 and on several flake scars in bedrock observed in Tosawihi quarry localities.

One flake blank in Cache 3170 is relatively thin and has a multifaceted platform; it may have been struck from a prepared core. It is too small, however, to have been used to produce a biface typical of the cache.

Serial-Selective.

All the caches are dominated by selective percussion flaking techniques; however, serial flake removal techniques are present to varying degrees in all the caches. Generally, the earlier the stage of the bifaces, the fewer the number of episodes of serial flaking. Consequently, caches 3197 and 3192—the earliest stage caches—show the lowest numbers of serial removals; and caches 3032, 3095, and 3170—the latest stage caches—have the highest numbers of serial removals.

Side-by-Side.

The side-by-side percussion technique is the most commonly utilized serial technique used to produce the biface caches (Table 17).

Table 17. Proportions of Side-by-Side and Skip-Patterned Flake Removals on Cache Bifaces.

Site	% Side-by-Side	% Skip-Patterned
26Ek3197	100	0
26Ek3192	93	7
26Ek3032	43	57
26Ek3095	78	22
26Ek3170	83	17

Side-by-side percussion occurs most frequently in earlier reduction. Whereas Caches 3197 and 3192—the earliest stage caches—have the lowest absolute amount of serial flaking (Table 17),

they also have the highest incidence of side-by-side thinning: serial flaking at Cache 3197 is entirely side-by-side, 97% at Cache 3192. The presence of skip-patterned flaking in Cache 3192 may owe to the presence of later stage bifaces within the same cache. Nevertheless, side-by-side thinning is the most common serial thinning technique utilized in all caches save 3032.

Skip Patterned.

The skip patterned percussion technique is the least applied serial technique used to produce cache bifaces. It is most frequent in later reduction, but, with the exception of Cache 3032, is used infrequently (Table 17). Cache 3032 has the most Stage 4 bifaces, and the high incidence of skip patterned flaking within it probably is a function of the high number of Stage 4 bifaces. The skip/patterned thinning technique may in fact be a characteristic of late stage Tosawihi bifaces, and the incidence of skip/patterned flaking may increase dramatically in later reduction stages not represented in the caches.

Margin Contouring.

All the bifaces from the Tosawihi caches have margin contouring scars. Margin contouring scars derive from edging, platform preparation, and removal of margin irregularities. While scars of these types normally are present in all kinds of bifacial reduction, Young and Bonnichsen (1984:65-66) imply that different knappers may use margin contouring techniques differently; thus, variation in the types of margin contouring scars may reflect variations in reduction technology. No attempt was made in the present study to define variation in margin contouring.

Alternate.

Alternate flaking, commonly thought of as an edging technique (e.g., Flenniken and Ozbun 1988:232), should have occurred most frequently in the earlier stage caches. Cache 3095, however, a later stage cache, showed the greatest amount of alternate flaking. This may be due to post-stage 2 edging. Alternate flaking was not common in any case (Table 18).

Table 18. Proportions of Specialized Knapping Techniques Present on Biface Caches.

Site No.	% Patterned	% Flat	% Sq. Edges	% Alternate	% Edge Run	% Overstrike
26Ek3197	38	56	75	6	44	6
26Ek3192	54	66	39	10	17	10
26Ek3032	67	100	-	-	17	33
26Ek3095	71	29	14	29	-	30
26Ek3170	80	50	20	10	30	-

Flat Facet Platforms.

Removing flakes from flat facet platforms is a common knapping technique in the Tosawihi caches, particularly in the earlier stage caches (3197 and 3192). Several bifaces in Cache 3197 have many contouring and thinning scars. However, these bifaces are not edged; instead, all the flakes were removed from flat facet platforms (Table 18). This is somewhat contrary to Callahan's (1979:67) stage classification in that, facially, Stage 3 bifaces are produced prior to satisfying the Stage 2 edging criteria.

Replication experiments suggest that hard hammer percussion is best conducted from flat facet platforms. Non-heat-treated opalite falls at about 4.3 on Callahan's (1979:16) lithic

grade scale, and consequently is quite hard and unelastic. When attempting to remove a large flake with a hammerstone (local Tosawihi hammerstones are rather hard, consisting primarily of basalt, quartzite, opalite, or rhyolite), the edge consequently must be "thick" and the blow applied at some distance from the edge; applying a hard hammerstone blow to the thin edge of a raw opalite biface often results in platform collapse. Flat facet platforms are desirable, then, because they allow the application of non-marginal hammerstone blows. Complete edging, therefore, may remain undesirable as long as a hard hammer fabricator is being used. Switching to soft hammer percussion allows for the application of marginal blows and marks a switch in reduction technique, particularly in terms of platform (and edge) morphology.

Edge Run.

The edge running technique is most common in early stage Cache 3197, but also is present on later stage bifaces in Caches 3192, 3032, and 3170. The high use frequency of the edge running technique in Cache 3192 probably is the result of an attempt to set up flat facet platforms for further flake removals, and is therefore an extension of the flat facet platform technique.

Edge running is present in the later stage caches, where it appears to prepare platforms for soft hammer rather than hard hammer percussion. The edge running facets on these later stage bifaces rarely are as steep as the flat facets commonly used as platforms in earlier reduction.

Percussion Flattening.

Percussion flattening was practiced to varying degrees in all the biface caches. Replication experiments suggest the degree of percussion flattening necessary depends on the morphology of the object reduced; generally, flake blanks require less flattening than blocks. There appears to be no relationship between general stage of the cache and amount of flattening.

Hard Hammer, Soft Hammer.

The degree of hard hammer percussion appears dependent on reduction stage; the earlier the stage, the more hard hammer percussion was employed. Consequently, all the flake scars on Cache 3197 bifaces were produced by hard hammer percussion (Table 19). Cache 3192, containing a mix of early and late stages, also has a high proportion of hard hammer percussion scars. Since a shift to soft hammer percussion appears to occur near the end of Stage 2, all hard hammer scars may be eliminated by the middle of Stage 3. Consequently, late stage caches—particularly 3170—have a high percentage of soft hammer scars. Both hard hammer and soft hammer scars can be observed on the same biface if the earlier hard hammer scars have not been eliminated by soft hammer percussion. Cache 3095 may have been reduced entirely by soft hammer, but it seems more likely early stage hard hammer scars were eliminated by later stage reduction.

Table 19. Proportions of Cache Bifaces Produced using Hard and Soft Hammer Percussion.

Site	% Hard Hammer only	% Soft Hammer only	% Hard and Soft
26Ek3197	100	0	0
26Ek3192	44	7	49
26Ek3032	17	17	67
26Ek3095	0	14	86
26Ek3170	10	50	40

Summary

Caches provide multiple examples of the end product of a single knapping technology. Chronological ambiguity is not a problem when assessing knapping strategies exemplified by cached objects produced at a discrete time by individual knappers working within the constraints of the same technology (Young and Bonnichsen 1984:136). Theoretically, differences in thinning techniques observed among caches can permit differentiation among technologies, and therefore among chronologically distinct or culturally distinct assemblages. In order to make the latter case, however, the caches must be comparable in terms of stage, and there must be no overlap in at least some manufacturing techniques among the caches. The Tosawihi caches do tend to overlap by stage, and nearly every knapping technique is present in every cache. Consequently, while some differences among caches may be due to chronological and cultural technological differences, this cannot be demonstrated; in fact, the overlap in discrete techniques between caches is more remarkable than the differences, and most caches appear technologically similar.

Three techniques repeated in most of the biface caches may be peculiar to Tosawihi reduction technology. The first of these, skip/patterned percussion thinning, seems to have been practiced in middle to late Stage 3 and beyond, and increases in frequency as biface thinning continues. The second, percussion thinning from flat facets, was common in early bifacial contouring and thinning, and is associated strongly with hard hammer percussion. Flake removal from flat facets may be a technique at least partially dictated by the nature of the opalite. The third technique, edge running to provide a flat facet platform, represents an extension of flat facet flake thinning into Stage 3 reduction.

Thus, with the exception of the Rusco cache, the cache bifaces recovered at Tosawihi are quite similar. In terms of raw material, three caches contain high proportions of grey brecciated opalite, rare in the assemblage as a whole, and the remainder is almost exclusively good quality white opalite with no distinctive characteristics. It is not possible to determine if the raw material was derived from common sources; Tosawihi opalite is quite variable, however, and biface assemblages recovered from most sites demonstrate more material variety than do any of the caches.

Technological characteristics are quite similar among all but the Rusco cache, and distinctive knapping techniques were used in each. It is possible that the bifaces were produced by a single technological tradition, perhaps within a limited range of time. The early nature of reduction stages and the lack of heat-treatment suggest that the bifaces cached at Tosawihi were stored in a form not yet prepared for export from the quarries (cf. Chapter 21) or, conversely, that they represent a special export form (perhaps for long-distance trade).

Bifaces in the Rusco cache, on the other hand, are made from material different from those in the other caches and have been reduced more extensively. It is unlikely that this cache is related to the others; perhaps these bifaces were stored for quick retrieval during a short visit to the quarry.

Conclusions

Biface Technology and Reduction Trajectory

The production of opalite bifaces at Tosawihi followed a nearly technologically homogenous reduction trajectory. Although idiosyncratic variability in reduction techniques can be observed from biface to biface, the consistent technical pattern within particular reduction

stages, the similarity in size and morphology of bifaces, and the recurrent use of heat-treatment in a particular range of reduction stages underscore this homogeneity.

Evidence from complete Stage 1 and Stage 2 bifaces indicate that biface reduction often was initiated on large flake blanks produced through large block core reduction or direct quarrying. The reduction of colluvial and stream rolled cobbles is minimal in the assemblage as a whole, but more common near cobble sources such as drainages. The reduction of opalite blocks into bifaces is represented, but can be distinguished reliably only among early stage bifaces and debitage.

Reduction passed from Stage 1 blank procurement through Stage 2 edge preparation for the initiation of primary thinning. Edge preparation techniques vary with the morphology of Stage 1 blanks. Thick, square edges necessitate extensive reduction, while thin edges require minimal preparation prior to primary thinning. At Tosawihi thick edges often were thinned by the removal of large interior flakes from almost 90 degree platforms, probably with hard hammer percussion. This technique can be contrasted with that of alternate flaking for the production of a scalloped edge. Reduction experiments show that removing large interior flakes with large platforms and bulbs serves to remove a large amount of toolstone mass from the biface edge with relatively few blows and to begin creation of a lenticular cross-section. With reduction in edge mass, alternate flakes then can produce the desired edge morphology more effectively. Many of the cache bifaces discussed above were not made using this technique because their thin edges and symmetrical shapes required very little edge preparation before primary thinning.

Primary thinning (Stage 3) followed the initial reduction and edge preparation of biface blanks. During this stage, bifaces were shaped to ovoid form and thinned to produce a lenticular cross-section. Much early phase primary thinning may have been done with hard hammerstones. Although we did not quantify either the instances of negative flake scars or the frequency of debitage produced with soft hammers, the overall morphology of many bifaces and biface thinning flakes indicate that soft hammer billets probably were used during the later stages of reduction and possibly to some extent in earlier phases of primary thinning. Antler billets found at quarrying locations where primarily early stage reduction was practiced support this contention. The high proportions of heat-treated Stage 3 and Stage 4 bifaces in the assemblage indicate that heat-treating occurred most often during Stage 3 reduction (Table 5) and was an integral part of the reduction trajectory; that heat-treated Stage 3 bifaces are significantly smaller than non-heat-treated Stage 3 bifaces supports this.

Secondary thinning occurs in Stage 4. Approximately 60% of Stage 4 bifaces were heat-treated. Since the remainder of the Stage 4 bifaces are raw, it is clear that heat-treatment was beneficial, but not essential, to secondary thinning. Experimental reduction of heat-treated opalite increased compliance, allowed better controlled reduction, and required less impact force. The reduction of raw opalite with elk antler and moose antler billets rapidly wore down billets, indicating their potentially short uselife. Increased compliance and the concomitant decrease in required force undoubtedly would serve to prolong the uselife of antler billets. The reduction of billet wear might have been a benefit of heat-treatment, depending on the relative value of billets and their ease of procurement.

Stage 5 is represented by only 11 specimens. These pieces are thin, well shaped, and symmetrical, and nine examples have edges finished by pressure flaking. We consider them to be finished tools. Pressure flaking also is apparent on 44 of the 673 Stage 4 and Stage 5 bifaces, indicating that some of them also may be finished tools.

Results of biface and debitage analyses indicate that lithic production in the vicinity of the Tosawihi Quarries was directed primarily towards the export of a range of biface forms (cf. Chapter 21). But from the relatively frequent occurrence of heat-treated bifaces and the presence of Stage 4 and 5 bifaces, it seems that middle Stage 3 bifaces represent probably only 50% of the intended export products. Some biface reduction would have continued away from

Tosawihi. Reduction experiments indicate that the greatest reduction in mass occurs during initial edging (Stage 2) and primary thinning (Stage 3). So, the reduction of opalite bifaces to early or middle Stage 3 near the quarries was probably to minimize transport costs and maximize usable toolstone transported (Elston 1988b; 1990).

Heat-treatment occurred most often in the Western Periphery and the Northern Corridor; the incidence of activities unrelated to lithic reduction was high there, indicating a relationship between heat-treatment and diversified activity. Heat-treatment of bifaces before the last stages of reduction is apparent, and perhaps was undertaken near the quarries when time allowed. Debitage analysis indicates that in the Western Periphery no more than 25% of the debitage in any assemblage resulted from the reduction of heat-treated bifaces. Although our detailed analysis of debitage involved a limited number of samples, we can assume that a portion of the bifaces produced in the West were heat-treated before they left the area where the toolstone was quarried. The study of reduction assemblages collected from sites farther from the Quarries could yield ratios of raw to heat-treated debitage and provide some indications of proportions of raw versus heat-treated biface reduction. If the quantity of raw debitage is minimal at most reduction locations more distant from the Quarries, probably many more bifaces and flake blanks were heat-treated at the Quarries than was apparent from examined reduction debris.

Our examination of Rossi Mine (Rusco 1982) and Rock Creek (Clay and Hemphill 1986) collections indicated that as much as 95% of Tosawihi opalite debitage assemblages from those sites was heat-treated. Tosawihi bifaces reduced at those locations were either heat-treated in the Tosawihi vicinity, at the Rossi Mine or Rock Creek locations before reduction, or somewhere in between. Evidence from Tosawihi biface caches indicates that cached bifaces are usually large, early and middle Stage 3, non-heat-treated items. The function of caches remains uncertain. If cached bifaces represent standard toolstone storage for quick retrieval and transport, then they differ somewhat from the predominant postulated export forms (cf. Chapter 21), since they are earlier in stage and less often heat-treated than bifaces leaving the Tosawihi vicinity. Cache bifaces may have had a different intended purpose (e.g., as long-distance trade items). If, on the other hand, a cache might be retrieved and its contents further processed (including heat-treatment) on the spot, then caches indicate production beyond immediate need. Caching may have been intended to meet more than one contingency and probably was predicated on the bases of restricted stays in the quarry area, transportability, and target use of the procured material.

The foregoing discussion has presented the results of the biface analysis absent temporal context. Our chronological data give a general idea about the periods during which sites were occupied, but distinct reduction episodes over time cannot be compared. We realize that some variability in biface production may be the result of temporal variation in technology. Still, the patterns of biface production technology at Tosawihi are remarkably clear and consistent, and appear to have been relatively homogenous for a long period.

Spatial Variability in Biface Production

The spatial organization of biface production is evident in variability among biface assemblages of the Quarry, East, and West subareas. Tosawihi bifaces range from large raw Stage 1 and Stage 2 bifaces to small heat-treated Stage 5 bifaces. The distribution of staging and heat-treatment reflects the spatial variability in reduction activities occurring in and around the Quarries. This variability is patterned, indicating patterns in the organization of production across the southern margin of the Quarries; it also may be representative of the reduction variability over the entire (to date unsampled and unanalyzed) expanse of the Tosawihi Quarries.

The Quarry subarea is not well sampled, but is distinct in hosting reduction of the largest raw bifaces. Most of that reduction continued through Stage 2 to produce edge prepared

(Stage 2) and some early Stage 3 bifaces. Heat-treatment and late stage reduction occurred only rarely within the Quarry. The Eastern Periphery includes some quarrying activity, but primarily was an area of early stage biface reduction. Reduction loci usually are discrete, with relatively low frequencies of material and technological diversity. Biface production usually was initiated on blanks, Stage 2, and early Stage 3 bifaces. Reduction generally was carried further than at the Quarry, but still resulted in a high proportion of raw Stage 3 bifaces. Heat-treatment was infrequent compared to the Western Periphery.

The West incorporates a number of large residential/reduction loci and a few quarry locations. The West is no farther from Quarry locations than some sites in the East, but biface production in the West often began at later stages, continued farther into the trajectory, and more frequently incorporated heat-treatment. Too, the diversity of reduced materials was greater, indicating wider ranging sources of toolstone procurement.

The Organization of Biface Production

Several lines of evidence reflect how lithic production at Tosawihi was organized. Transport costs appear important because the vast majority of bifaces are greatly reduced in mass at or near toolstone sources. Even within a few hundred meters of sources there is a consistent pattern of later stage reduction with increasing distance. Over a larger landscape, this is apparent in inter-area comparisons. Package size for transport may be approximated as that of a middle to late Stage 3 or Stage 4 biface (mean weight 128.2-182.6 g). The early stage bifaces found at sites farthest from the Quarry are significantly smaller than the same stage bifaces recovered immediately adjacent toolstone sources.

Even sites on Willow Creek, at the north end of the Northern Corridor, still are within the sphere of biface production rather than of use. Early stage biface fragments, production debris (a significant proportion of it raw, rather than heat-treated), and absence of extensive biface use attest to this. In contrast, primarily late stage bifaces and heat-treated debitage are encountered at sites along Rock Creek and at Rossi Mine.

Standardization of biface form reflects consistent demand. The forms exported from Tosawihi appear to be middle Stage 3 to Stage 4 heat-treated bifaces (cf. Chapter 21). However, we cannot assess this issue adequately in the Tosawihi vicinity, where we remain in the sphere of production. How morphological and spatial patterns of biface manufacture relate to chronology, resource distribution, strategies of toolstone procurement, organization of production, and site location and residentiality are discussed in Chapters 19, 20, 24, 25 and 26.

Chapter 7

FLAKE TOOLS

Kathryn Ataman

Chipped stone tools other than bifaces and projectile points often comprise an important component of prehistoric assemblages. When their function is considered, they can provide information about the diversity and intensity of prehistoric activities, especially where they comprise a large fraction of an archaeological assemblage. Flake tools may have formal shapes, in which an edge is modified to a specific form, or they may be minimally altered. The Tosawihi assemblage includes both formal tools and tools with little edge modification.

Minimally altered flake tools often are referred to as "expedient tools" or "utilized flakes," implying that they were prepared with little effort and were intended for short-term use. This is not necessarily true. Tool utility depends on the relationship between morphology and planned function. An unretouched flake may require no manipulation after selection, but its production, as well as its selection for appropriateness, may require as much strategy as the production of more formal tools. Too, flake tool utility may equal that of the formal tool (Jones 1981; Frison 1979; Lewenstein 1987; Walker 1978; Hester et al. 1976).

Hunting and gathering technologies often employ simple flake tools (MacCalman and Grobbelaar 1965; Jones and White 1988; Callaway, Janetski and Stewart 1986; Powers 1976; Miller 1979; Gould et al. 1971; White and Thomas 1972; O'Connell 1977); such tools probably were used throughout prehistory and in almost every kind of economy (Wendorf 1968). They exhibit a wide range of shapes; some had specific, limited functions, while others were used for a variety of tasks. Variation in form owes in part to mechanical limitations of the size and shape of individual flakes and to efficient patterns of use, and in part to cultural preference (Close 1979).

It often is impossible to distinguish deliberate or use-induced retouch from post-depositional retouch (Howes 1980; Young and Bamforth 1990), so we have included in our sample only pieces on which retouch is unequivocally deliberate. The great abundance of flaked stone debris at Tosawihi, its largely surface context, and the likelihood that it has withstood several millennia of post-depositional damage, have led us to be quite conservative in identifying flake tools. Trampling, for instance, can produce macroscopic and microscopic edge damage mimicking deliberate and use-induced retouch (Knudson 1979; Tringham et al. 1974; Flenniken and Haggarty 1979); we have tried to avoid including such pieces in our analysis, predictably biasing our favor of more heavily retouched pieces. Use wear analysis was conducted on samples of debitage to serve as partial control for this problem.

Flake tools were classified according to overall morphology and outline of working edge. While sharing some morphological attributes, pieces assigned to the same class may or may not have shared a common function. Establishing functional typologies is thorny; not only are such typologies difficult to compare to more traditional (morphological) regional typologies, but degrees of stylistic variation and standardization are observed. In addition, functional analysis based on use wear traces is conclusive only for a portion of any analytical assemblage, owing to variation in post-depositional modification; this inhibits interpretive accuracy and precision. Nonetheless, functional terms (e.g., "scrapers") are useful because they describe morphological classes; although we use such terms expediently in the present discussion (e.g., "end-scraper" instead of "convex-edged flake with continuous, abrupt to semi-abrupt retouch"), we disavow the implied functional assessments.

Use wear analysis was conducted on somewhat more than half the flake tools recovered from the quarries, but, as noted above, the results have not affected the classification used here.

In the pages following, consideration of the functions of pieces in a tool class is embedded in the class description, and correspondences between form and function are discussed. A sample of unretouched flakes also was examined for use wear traces to identify the use-frequency of unmodified flakes.

Research Aims

The intent of the analysis reported here was to examine the morphological and functional variability, as well as the intensity of use, of the recovered tool assemblage. More diverse and more intense activities, and diverse raw materials, generally are expected at sites occupied for relatively long periods by larger groups. Fewer activities, whether intensive or ephemeral, indicate more limited occupation; such sites may represent short term camps or special purpose sites. Brief visits by small groups of quarriers unaccompanied by their families should not have produced assemblages as large or diverse as those produced by a number of families over a season of quarrying. Degree of tool curation, too, characterizes the nature of the occupation; exotic raw materials and highly formalized, hafted, or intensively used tools probably indicate longer term occupations.

Tool production technology is also part of our analysis. Whether flake tools are produced on selected by-products of biface manufacture rather than on blanks from flake cores indicates whether flake tool production was independent of biface production or was an opportunistic strategy. Variation in production strategies among tool types and from site to site is used to examine the standardization and organization of lithic technology. Variability within morphological types and among subareas is examined in this chapter; locationally specific variability is discussed later.

Investigation Techniques

Analytical Definitions and Data Collection Structure

Our flake tool sample includes 864 pieces from 52 sites and localities (including 3 non-site, discretionary surface collections). Forty variables (provenience, metrics, raw material type, blank characteristics, tool and edge morphology, and macroscopic and microscopic edge damage characteristics) were recorded. Recording of provenience, metrics, and raw material variation common to several artifact categories is described in Chapter 6; categories specific to the flake tool data class are discussed below.

Blank Morphology

Five variables describe tool blanks (selected flakes); they include extent of retouch, blank type, blank shape, fragment type, and nature of thermal alteration. The latter observation was intended to record the reduction stage at which heat-treatment was carried out. This stage is difficult to assess where reduction has removed most of the original surface of blanks, but *general* stages frequently can be recognized. We segregated tools made on blanks produced from heat-treated cores, tools heat-treated as flakes, and tools heat-treated after initial blank reduction; we also recorded post-manufacture alteration, *possible* instances of heat-treatment, and evidence of heat-treatment carried out at an indeterminate production stage.

Retouch

Retouch observations recorded five variables: retouch type (percussion or pressure), direction (direct, inverse, or bifacial), extent of retouch along the worked edge (continuous, localized, or intermittent), degree of invasiveness, and number of edges retouched.

Tool Morphology

Four variables describe morphology: plan (concave, convex, straight, irregular, convergent, or multiple) and profile (straight, sinuous, alternating, or irregular) of the main retouched edge, edge angle, and morphological type. Edge angle was recorded only as acute (<35°), medium (>35°<55°), or obtuse (>55°). Twenty-two morphological types were identified, and they can be grouped into more general tool classes (cf. below).

Three categories of scraper (flakes with continuous abrupt or semi-abrupt retouch serving to strengthen or regularize a usually convex edge) are included. Side-scrapers and end-scrapers were segregated by the orientation of the retouched edge on the blank; and a category of miscellaneous and fragmentary specimens also was established.

Four categories of pointed tools were defined; the class subsumes specimens commonly called perforators, awls, drills, and gravers. To evade functional ascriptions, morphologically descriptive terms were used; we recognized elongate and short symmetrically pointed tools, asymmetrically pointed tools, and trihedral tools.

Pieces exhibiting notches have been assigned to a single tool class, irrespective of whether notching is singular or multiple. Too, three categories of flake tools exhibit bifacially worked edges; we sorted them on the basis of edge profile (straight, slightly sinuous, and coarsely sinuous). They are distinguished from bifaces in that the flaking often is not invasive, the plan often is circular, and the edge frequently is regularized; none of these attributes commonly characterizes bifaces.

Modified flakes ("retouched flakes," "edge-damaged flakes," or "expedient tools") have been segregated by the extent and location of retouch. We recognized five categories: flakes with continuous retouch on one edge, those with continuous retouch on multiple edges, those with localized retouch, crudely retouched flakes or chunks, and flakes with variable retouch patterns on multiple edges.

Microdenticulates are small tools with a fine-toothed edge; we separated them from notches and other denticulates because of their distinctive, fine, and regular denticulation. Discoids are large, shaped, and often battered pieces flaked around their entire perimeter. Flaked/battered tools are large, irregular tools with both flaked and battered edges which appear distinct in technology (and perhaps in function) from the hammers and choppers discussed elsewhere. Pressure flaked tool fragments may be pieces of flake tools, bifaces, preforms, or projectile points, but they are too fragmentary to classify. "Other" tools include unique, distinctively-shaped specimens.

Edge Damage and Microscopic Wear Traces

Macroscopic and microscopic wear patterns also were observed and recorded. Macroscopic wear was sought on all flake tools, while microscopic characteristics were recorded for 578 pieces (66.9% of the assemblage). Based on these observations, tool-use was inferred for all the pieces examined microscopically. The techniques used to assess tool function are described in detail in the following section.

The sample of flake tools considered in this analysis includes tool classes examined in entirety and some classes from which only a few pieces were selected; some classes were not examined at all. We concentrated on scrapers, pointed tools, notched items, and miscellaneous retouched flakes, because most specimens fall into one or another of these classes. Many broken pieces were excluded from study, as were tools too large for microscopic scrutiny and tools of especially coarse raw material which conceals wear traces.

Microwear studies rely on comparison of macroscopic and microscopic wear traces on prehistorically used edges to those on experimental tools used to simulate prehistoric tasks. Accordingly, experiments were undertaken to observe how opalite tools function and wear when used to accomplish a variety of tasks and to provide a comparative wear-pattern collection. We undertook limited experiments using Tosawihi opalite, and extrapolated our results to other flint and chert materials to infer direction of motion, intensity of use, and hardness of the worked material. The experiments were conducted with facsimiles of tools in the Tosawihi assemblage, including bifaces, scrapers, pointed tools, and miscellaneous retouched and unretouched flakes. The experimental tools were made from a variety of Tosawihi opalites; they were manufactured utilizing techniques similar to those which produced the tools in the archaeological assemblage, and both raw and heat-treated blanks were employed. Fifteen tools skinned, butchered, filleted, and removed sinew for intervals of ten minutes to 2.5 hours; seven tools cut, scraped, and perforated fresh hide for 15 minutes to 3 hours; and, six tools sawed and grooved soaked antler for 15 minutes to one hour.

The results indicate that raw opalite yields durable, sharp edges that develop use wear polish more slowly when working soft materials than do other, more fine-grained or amorphous flints or cherts. For example, an opalite tool used to butcher deer meat for 2.5 hours exhibited very little polish visible at 100x magnification, while my own experience indicates that similar activities using finer-grained materials produce polish after shorter periods of use. Work on harder materials, however, develops polish at a faster rate; macroscopically visible gloss was produced on opalite tools after 1.5 hours of scraping soaked deer hide.

Heat-treated materials are slightly more brittle and have less durable edges than untreated stone. No advantage was noted in the use of heat-treated opalite tools, although in manufacture they are easier to flake. Heat-treatment does, however, affect the appearance of the tool surface under the microscope and often limits identification of function to general levels of interpretation.

The approach to function analysis we used represents an adaptation (Grace et al. 1988) of Keeley's (1980) method of microwear analysis whereby we assume that the distribution and level of development of microwear polish produced by use reflect tool function, but that *the appearance of the polish itself* is not diagnostic of function; edge damage and tool morphology also are incorporated into inferences of tool function. The chief variables considered by this approach include edge shape, edge angle, degree of edge rounding, distribution of polish and striations (in the case of obsidian, striations only), and degree of polish. Such an approach has been tested using tools made of English chalk flint (Grace et al. 1988), and then modified and tested on obsidian tools (Ataman 1989) with results that compare favorably to other blind tests; motion of use was interpreted successfully in 90% of the cases.

Microwear studies can characterize tool function in a number of ways; from general to specific, these include initial identification of use, identification of use-edges, motion of use, hardness of material worked, intensity of use, and the nature of the worked material. Longitudinal or transverse use, for example, in combination with edge form and the location of edge damage reflects motion of use, type and degree of edge damage reflects hardness of the contact material, and polish and edge rounding reflect intensity of use.

Function inferences commented on intensity of use when wear traces were sufficiently interpretable; tools with less interpretable traces were characterized only as used, unused, or indeterminate. Many tools were classed as indeterminate but very few as unused, probably because our segregation of flake tools from debitage was biased towards more heavily used tools.

Post-depositional surface modification also can preclude functional determination. Mechanical damage caused by trampling, weathering, and excavation and post-excavation procedures can make wear traces uninterpretable (Levi-Sala 1986; Plisson and Mauger 1988; Keeley 1980). Post-depositional traces on opalite can be detected by the presence of polish on high spots and interior surfaces. On obsidian, the random orientation and distribution of striations are indicators of post-depositional mechanical damage. Our suite of analytical techniques sometimes permitted low level interpretations (e.g., whether or not a tool had been used) on post-depositionally altered pieces, but more specific inferences could not be made with confidence.

A Type "S" trinocular Nikon metallurgical microscope with light incident attachment was used for microscopic analysis. Most tools were scanned at 50x and 100x magnification, and 200x and 400x magnifications were used to inspect specific features. Before examination, specimens were cleaned with alcohol using cotton swabs; when necessary, previously applied catalog numbers were removed with acetone.

Type Descriptions

Scrapers

Three types of scraper were defined by orientation of the working edge on the tool blank: side-scrapers (n=39), end-scrapers (n=97), and miscellaneous and fragmentary scrapers (n=52) (Figures 39-41). Apparent functional variability within type is discussed later in the chapter.

Side scrapers are longer (mean length=69.8 mm) than end-scrapers (mean length=58.6 mm) but similar in width and thickness (Table 20). None differs much from the average size of all flake tools. Most (83%) are made of opalite; jasper and obsidian comprise much smaller fractions, and other materials form about one to three percent of the total (Table 21). The material diversity of scrapers, measured by color, is similar to that of all flake tools (Table 22).

Table 20. Mean Dimensions of Complete Flake Tools.

		Length (cm)		Width (cm)		Thickness (cm)		Weight (gm)	
Tool Type	Total	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Side Scraper	22	69.8	24.5	43.1	16.8	12.4	4.8	52.2	48.1
End Scraper	67	58.6	21.1	44.2	15.0	6.3	5.5	38.9	49.5
Misc. Scraper/Frag.	24	67.2	27.2	51.3	19.0	2.3	6.5	55.1	45.6
Sym. Pointed Tool (elong)	13	3.5	13.5	22.9	12.7	7.1	2.3	6.3	4.9
Sym. Pointed Tool (short)	6	1.4	11.4	30.9	6.3	8.5	2.7	10.1	9.0
Assym. Pointed Tool	15	43.4	13.0	32.5	13.0	7.9	3.5	11.6	8.8
Trihedral Pointed Tool	5	85.6	14.2	30.8	12.0	20.1	5.8	52.3	33.7
Notch/Denticulate	25	68.4	21.1	52.4	17.7	15.6	9.0	60.0	63.0
Bif. w/slightly sinuous prof	6	54.3	15.5	43.3	11.4	11.3	3.3	30.8	16.3
Bif. w/coarse sinuous prof	2	80.7	8.6	59.3	4.4	19.3	3.6	79.0	32.0
Flake w/cont. retouch (one edge)	36	48.1	19.9	41.2	16.9	9.7	5.9	26.7	66.0
Flake w/cont. retouch (multiple edges)	14	68.1	24.1	51.2	20.8	12.0	6.7	46.1	59.1
Flake w/localized retouch	50	58.8	22.3	44.7	16.3	11.0	5.6	33.8	35.5
Crudely retouched flake/chunk	6	70.1	31.2	49.7	10.8	15.0	9.5	73.9	68.6
Flake w/var. retouch pattern (multiple edges)	26	56.7	22.4	42.7	19.7	10.2	5.3	30.1	36.4
Microdenticulate	4	41.0	6.7	19.1	6.5	4.0	1.9	3.8	1.8
Discoidal tool	8	102.6	33.4	93.9	29.0	24.6	16.3	382.3	366.8
Chopping Tool/Hammer	5	116.2	49.5	71.4	16.6	31.5	11.3	324.9	288.7
Other	3	81.8	19.6	39.6	11.1	22.4	9.6	71.9	67.3
	337								

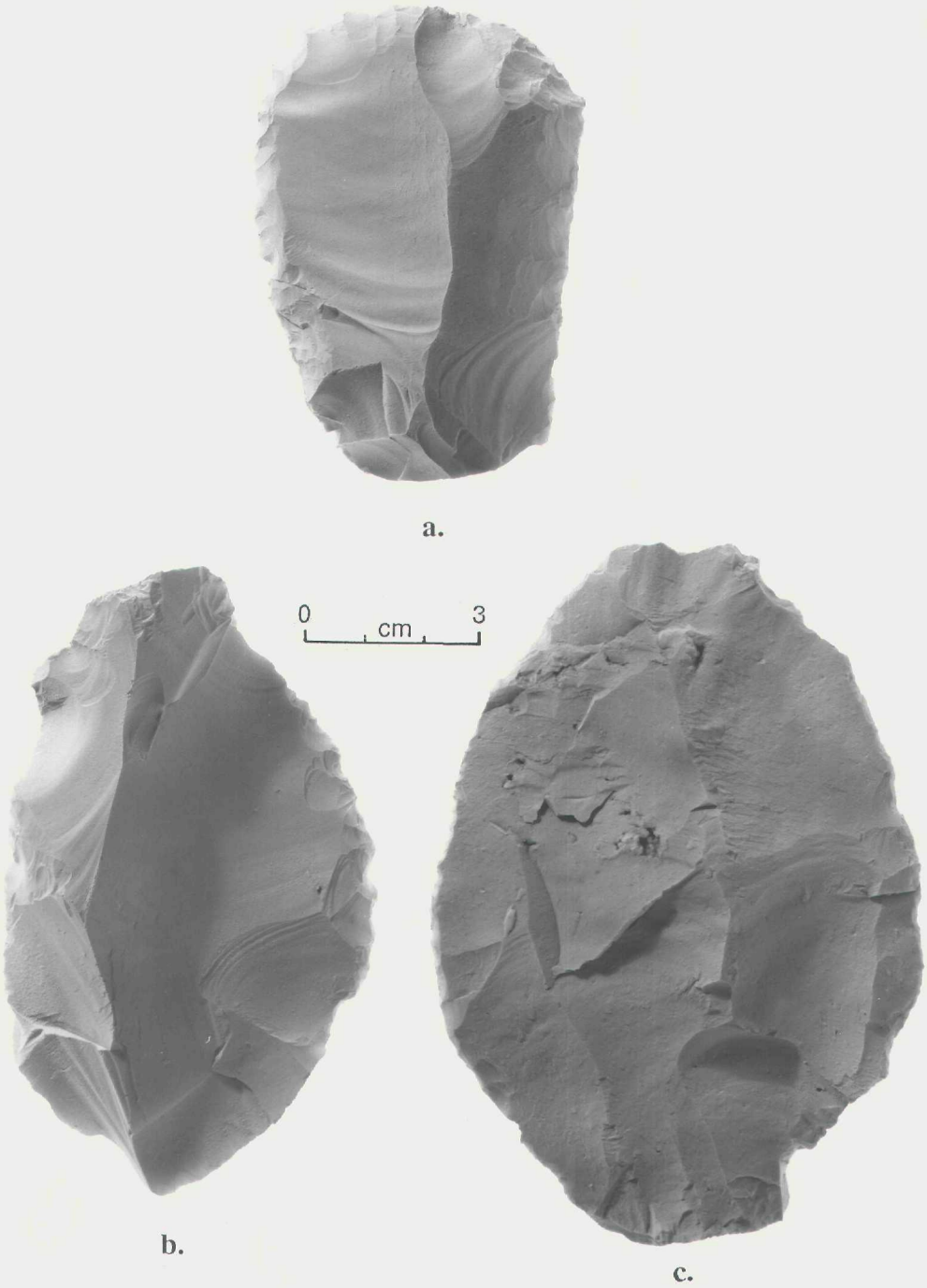


Figure 39. Selected side scrapers.

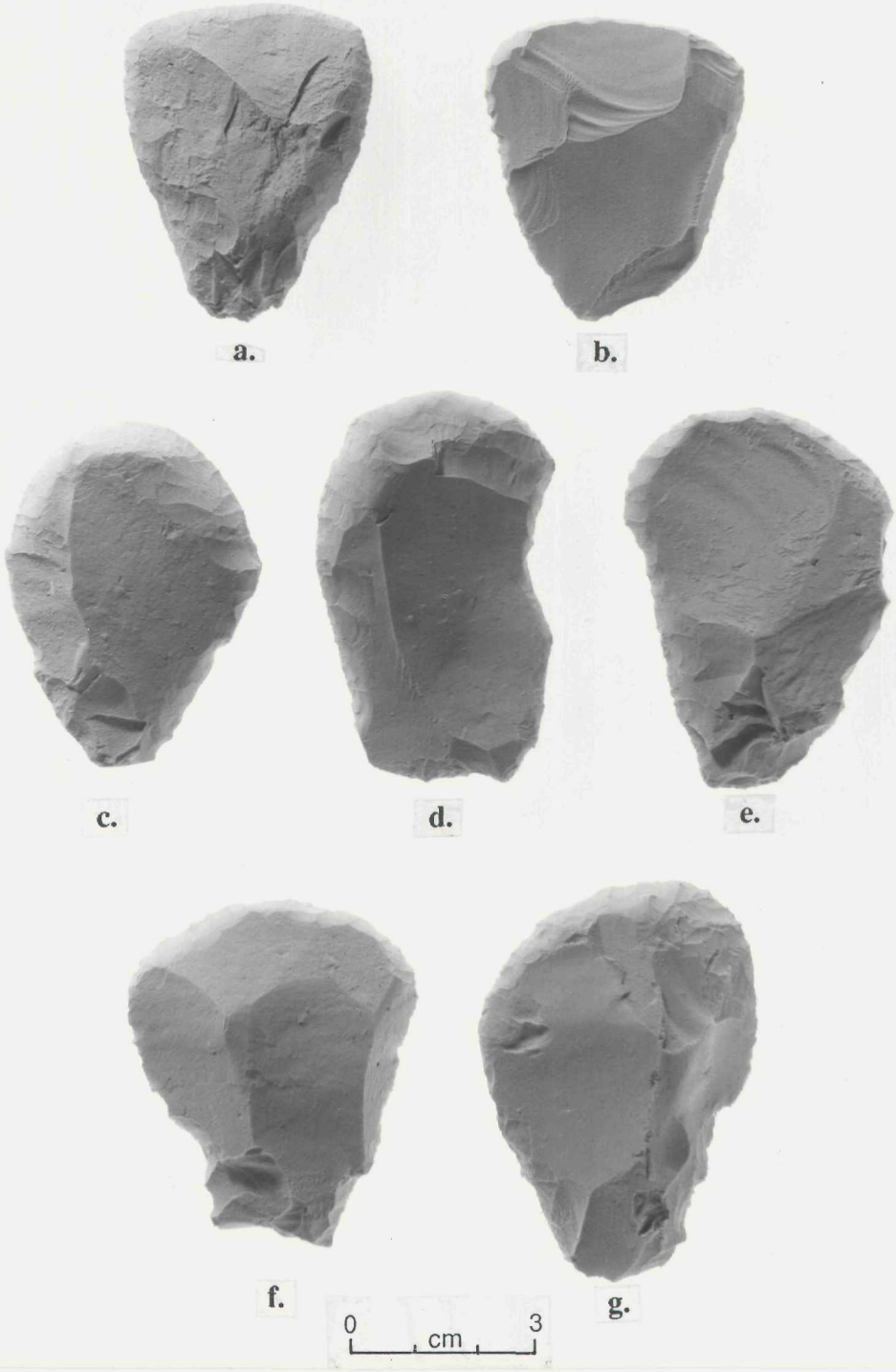


Figure 40. Selected end scrapers.

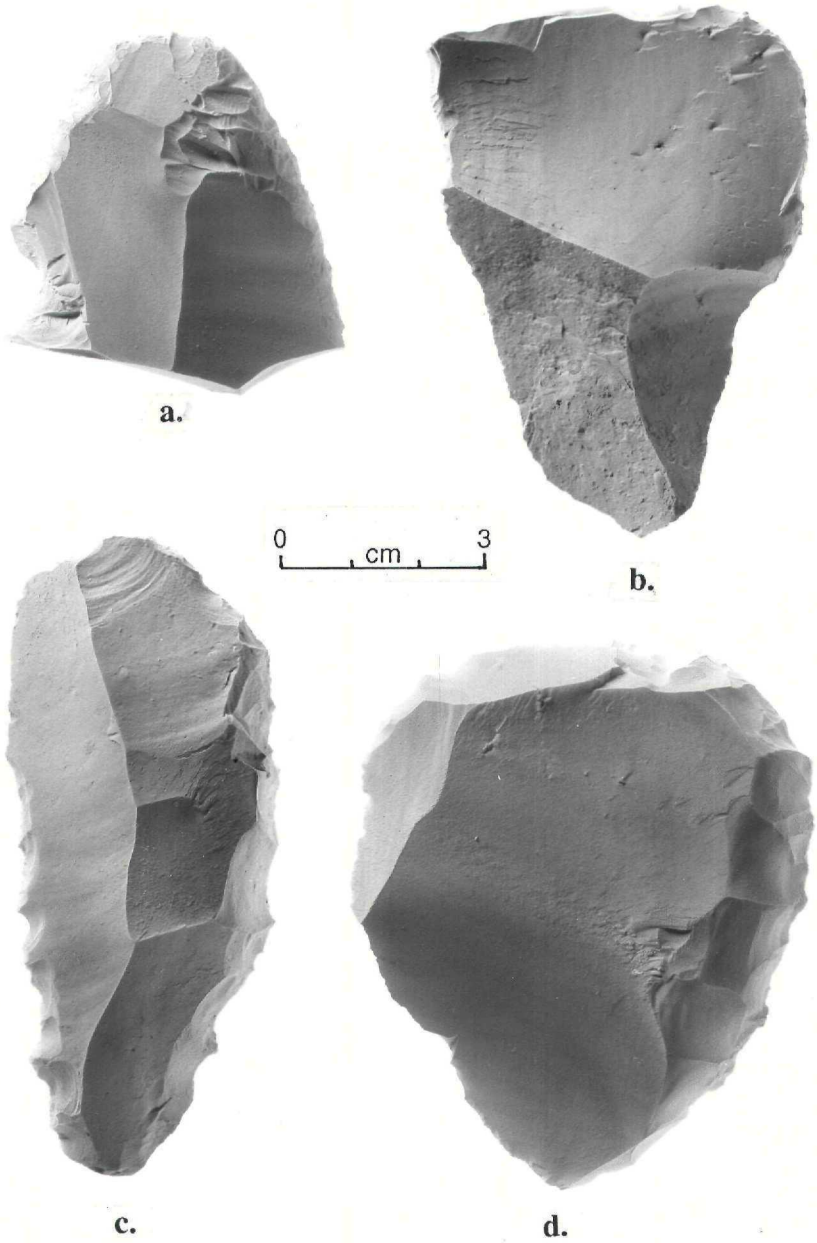


Figure 41. Selected miscellaneous scrapers.

Table 21. Flake Tool Types by Material Type.

Tool Type	Opalite	Obs	Bas	Chal	Jas	Opal	Other	Total	%
				Material					
Side Scraper	32	1	-	1	4	1	-	39	4.51
End Scraper	75	3	1	-	6	6	6	97	11.23
Misc. Scraper/Frag	43	-	-	-	3	4	2	52	6.02
Sym. Pointed Tool (elong)	48	3	1	1	2	1	-	56	6.48
Sym. Pointed Tool (short)	16	4	-	-	1	-	1	22	2.55
Assym. Pointed Tool	24	2	-	1	-	-	1	28	3.24
Trihedral Pointed Tool	5	-	-	-	-	-	-	5	0.58
Notch/Denticulate	58	-	-	-	3	5	-	66	7.64
Bif. w/straight profile	6	-	-	-	-	-	-	6	0.69
Bif. w/slightly sinuous prof	12	2	-	-	-	-	-	14	1.62
Bif. w/coarse sinuous prof	3	1	-	-	-	-	-	4	0.46
Flake w/cont. retouch (one edge)	89	4	1	3	11	1	-	109	12.62
Flake w/cont. retouch (multiple edges)	29	-	-	-	1	-	-	30	3.47
Flake w/localized retouch	92	4	-	-	8	1	1	106	12.27
Crudely retouched flake/chunk	12	-	-	-	-	2	-	14	1.62
Flake w/var. retouch pattern (multiple edges)	46	5	-	6	3	-	1	61	7.06
Microdenticulate	6	1	-	-	-	-	-	7	0.81
Discoidal tool	6	-	1	-	-	-	3	10	1.16
Pressure flaked tool fragment	20	3	-	3	2	-	-	28	3.24
Fragmentary Indeterminate	80	6	-	-	5	2	-	93	10.76
Chopping Tool/Hammer	9	-	3	-	-	-	-	12	1.39
Other	4	-	1	-	-	-	-	5	0.58
Total	715	39	8	15	49	23	15	864	
%	82.75	4.51	0.92	1.74	5.67	2.66	1.74		

Key: Obs = Obsidian Chal = Chalcedony
Bas = Basalt Jas = Jasper

Table 22. Material Diversity by Tool Type.

Flake Tool Type	"White"	Total	%
Side Scraper	27	39	69.23
End Scraper	66	97	68.04
Misc. Scraper/Fragment	36	52	69.23
Sym. Pointed Tool (elongated)	42	56	75.00
Sym. Pointed Tool (short)	9	22	40.91
Assym. Pointed Tool	24	28	85.71
Trihedral Pointed Tool	4	5	80.00
Notch/Denticulate	50	66	75.76
Bif. w/straight profile	6	6	100.00
Bif. w/slightly sinuous profile	7	14	50.00
Bif. w/ coarse sinuous profile	2	4	50.00
Flake w/ cont. retouch (one edge)	86	109	78.90
Flake w/ cont. retouch (mult. edges)	24	30	80.00
Flake w/localized retouch	75	106	70.75
Crudely retouched flake/chunk	8	14	57.14
Flake w/ var. ret. pat. (mult. edges)	39	61	63.93
Microdenticulate	5	7	71.43
Discoidal tool	8	10	80.00
Pressure flaked tool fragment	13	28	46.43
Fragmentary Indeterminate	67	93	72.04
Flaked/Battered Tools	8	12	66.67
Other	3	5	60.00
Total	609	864	70.49

Scrapers (69%) are made on biface thinning flakes more often than other tool types (54% for all flake tools; cf. Table 23), and are less often broken. This probably owes to their morphology (which includes a high edge angle; cf. Table 24) as well to their use pattern. Scrapers generally are manufactured by direct percussion; most especially, side-scrapers exhibit exclusively unifacial-direct retouch (retouch initiated from the ventral surface), and several exhibit more than one working edge (Table 25).

Table 23. Flake Tools Sorted by Blank Type.

Tool Types	Biface Frags.	BTF	BTF %	Other/ Ind. Flake	Ang. Frag. Chunk	Indet.	Total	%
Side Scraper	-	26	67.0	11	1	1	39	4.51
End Scraper	2	67	69.0	24	2	2	97	11.23
Misc. Scraper	-	27	52.0	17	4	4	52	6.02
Sym. Pointed Tool (elong)	11	19	34.0	22	-	4	56	6.48
Sym. Pointed Tool (short)	3	12	55.0	7	-	-	22	2.54
Assym. Pointed Tool	-	18	64.0	10	-	-	28	3.24
Trihedral Pointed Tool	-	-	-	3	2	-	5	0.57
Notch/Denticulate	1	35	53.0	22	7	1	66	7.63
Biface w/straight profile	1	4	67.0	1	-	-	6	0.69
Biface w/slightly sinuous profile	4	4	29.0	6	-	-	14	1.62
Biface w/coarse sinuous profile	1	2	50.0	-	-	1	4	0.46
Flake w/cont. retouch (one edge)	1	58	53.0	39	5	6	109	12.61
Flake w/cont. retouch (mult. edges)	-	25	83.0	4	-	1	30	3.47
Flake w/localized retouch	-	79	75.0	22	1	4	106	12.27
Crudely retouched flake/chunk	-	5	36.0	6	1	2	14	1.62
Flake w/variable ret. pattern (mult. edges)	-	44	72.0	16	-	1	61	7.06
Microdenticulate	-	5	71.0	2	-	-	7	0.81
Discoidal Tool	2	-	-	5	2	1	10	1.16
Pressure flaked tool fragment	3	6	21.0	16	1	2	28	3.24
Fragmentary Indeterminate	-	29	31.0	44	1	19	93	10.76
Chopping Tool/Hammer	-	3	25.0	6	3	-	12	1.39
Other	-	1	20.0	2	1	1	5	0.58
Total	29	469	54.0	285	31	50	864	
%	3.36	54.28	0.54	32.99	3.59	5.79		

Table 24. Edge Angles of Flake Tools.

Flake Tool Type	Acute n	Medium n	Obtuse n	Total	%
Side Scraper	11	17	11	39	4.51
End Scraper	10	36	51	97	11.23
Misc. Scraper	7	20	25	52	6.02
Sym. Pointed Tool (elong)	13	31	12	56	6.48
Sym. Pointed Tool (short)	9	11	2	22	2.55
Asymmetrical Pointed Tool	7	13	8	28	3.24
Trihedral Pointed Tool	0	0	5	5	0.58
Notch/Denticulate	13	29	24	66	7.64
Bif. w/straight profile	2	4	0	6	0.69
Bif. w/slightly sinuous profile	3	11	0	14	1.62
Bif. w/coarse sinuous profile	0	4	0	4	0.46
Flake w/cont. ret. (one edge)	42	49	18	109	12.62
Flake w/cont. retouch (mult. edges)	14	13	3	30	3.47
Flake w/localized retouch	52	36	18	106	12.27
Crudely ret. flake/chunk	0	8	6	14	1.62
Flake w/var. ret. pat. (mult. edges)	27	24	10	61	7.06
Microdenticulate	7	0	0	7	0.81
Discoidal tool	0	6	4	10	1.16
Pressure flaked tool fragment	8	17	3	28	3.24
Fragmentary Indeterminate	39	39	15	93	10.76
Chopping Tool/Hammer	0	3	9	12	1.39
Other	2	1	2	5	0.58
Total	266	372	226	864	
%	30.79	43.06	26.16		

Table 25. Proportion of Flake Tools Exhibiting Pressure Flaking.

Flake Tool Type	Pressure Flaked	Total	%
Side Scraper	1	39	2.56
End Scraper	5	97	5.15
Misc. Scraper/Frag	1	52	1.92
Sym.Pointed Tool (elongated)	26	56	46.43
Sym.Pointed Tool (short)	11	22	50.00
Assym.Pointed Tool	6	28	21.43
Trihedral Pointed Tool	0	5	0.00
Notch/Denticulate	1	66	1.52
Bif. w/straight profile	0	6	0.00
Bif. w/slightly sinuous profile	3	14	21.43
Bif. w/ coarse sinuous profile	0	4	0.00
Flake w/ cont. retouch one edge	5	109	4.59
Flake w/ cont. ret. (mult. edges)	1	30	3.33
Flake w/localized retouch	6	106	5.66
Crudely retouched flake/chunk	0	14	0.00
Flake w/ var. ret. patt.(mult. edges)	1	61	1.64
Microdenticulate	0	7	0.00
Discoidal tool	1	10	10.00
Pressure flaked tool fragment	28	28	100.00
Fragmentary Indeterminate	11	93	11.83
Chopping Tool/Hammer	0	12	0.00
Other	0	5	0.00
Total	107	864	12.38

Heat-treated scrapers are less frequent (16.5%) than all heat-treated flake tools (21.4%). Like most other tool classes, when heat-treated, scrapers are made on heat-treated flakes (Table 26). Of seven pressure flaked scrapers, only three were heat-treated.

Table 26. Thermal Alteration of Flake Tool Types.

Flake Tool Type	Blank H/T Core	H/T Blank	H/T During Reduction	Post. Dep. H/T	Poss. Dep. H/T	Not H/T	H/T-Stage Indet.	Total	H/T Total	H/T %
Side scraper	1	3	-	-	1	34	-	39	4	10.3
End scraper	4	9	-	2	1	78	3	97	16	16.5
Misc. scraper	-	8	-	1	3	37	3	52	11	21.2
Sym. pointed tool (elong)	5	5	-	3	1	36	6	56	16	28.6
Sym. pointed tool (short)	-	10	2	1	-	9	-	22	12	54.5
Assym. pointed tool	3	5	-	-	1	19	-	28	8	28.6
Trihedral pointed tool	-	2	-	-	-	3	-	5	2	40.0
Notched/denticulate	2	3	-	-	2	58	1	66	6	9.1
Bif. w/straight profile	2	2	-	-	-	2	-	6	4	66.7
Bif. w/slightly sinuous prof.	-	3	2	1	-	8	-	14	5	35.7
Bif. w/coarse sinuous prof.	-	-	1	-	-	3	-	4	1	25.0
Flake w/cont. ret. (one edge)	9	9	-	1	2	86	2	109	20	18.3
Flake w/cont. ret. (mult. edges)	-	7	-	-	-	22	1	30	8	26.7
Flake w/localized retouch	8	14	-	-	1	82	1	106	23	21.7
Crudely retouched flake/chunk	-	-	-	-	-	14	-	14	-	0
Flake w/var. ret. pat. (mult. edges)	3	7	-	1	-	48	2	61	12	19.7
Microdenticulate	1	-	-	-	-	6	-	7	1	14.3
Discoidal tool	1	-	-	-	-	8	1	10	2	20.0
Pressure flaked tool fragment	1	7	-	1	3	15	1	28	9	32.1
Fragment-indeterminate	5	19	-	3	-	65	1	93	25	26.9
Chopping tool/hammer	-	-	-	-	-	12	-	12	-	0
Other	-	-	-	-	-	5	-	5	-	0
Total	45	113	5	14	15	650	22	864	185	21.4

Most end-scrapers tend to have convex edges, while other types have almost equal proportions of straight and irregular edges (Table 27). Few scrapers (6 examples) have convergent working edges; straight profiles dominate in all types.

Table 27. Edge Shapes of Flake Tools.

Flake Tool Type	Convex n	Concave n	Straight n	Irregular n	Multiple n	Convergent n	Total	%
Side Scraper	13	2	12	11	1	-	39	4.51
End Scraper	64	2	11	9	6	5	97	11.23
Misc. Scraper	19	1	12	13	3	4	52	6.02
Symmetrical Pointed Tool (elong)	-	-	15	8	1	32	56	6.48
Symmetrical Pointed Tool (short)	1	-	6	8	-	7	22	2.55
Asymmetrical Pointed Tool	-	-	4	11	1	12	28	3.24
Trihedral Pointed Tool	-	-	1	2	1	1	5	0.58
Notch/Denticulate	1	44	3	17	-	1	66	7.64
Biface w/straight profile	1	-	3	2	-	-	6	0.69
Biface w/slightly sinuous profile	8	-	-	6	-	-	14	1.62
Biface w/coarse sinuous profile	1	-	-	3	-	-	4	0.46
Flake w/cont. retouch (one edge)	17	6	60	26	-	-	109	12.62
Flake w/cont. retouch (mult. edges)	5	-	6	15	2	2	30	3.47
Flake w/localized retouch	16	11	42	32	5	-	106	12.27
Crudely retouched flake/chunk	2	-	2	10	-	-	14	1.62
Flake w/variable ret. pattern (mult. edges)	12	4	23	18	3	1	61	7.06
Microdenticulate	2	-	3	2	-	-	7	0.81
Discoidal tool	2	-	-	4	-	4	10	1.16
Pressure flaked tool fragment	6	-	15	3	3	1	28	3.24
Fragmentary Indeterminate	19	5	54	14	-	1	93	10.76
Chopping Tool/Hammer	3	-	1	8	-	-	12	1.39
Other	1	-	1	2	1	-	5	0.58
Total	193	75	274	224	27	71	864	
%	22.34	8.68	31.71	25.93	3.13	8.22		

One hundred eighty-four pieces were examined for use wear traces. Fragments were included in the sample because at least a portion of the worked/used edge usually is retained on scrapers. Sixty-seven percent of the specimens had been utilized (Table 28); between 10% and 20% of end-scrapers and side-scrapers exhibit macroscopically visible rounding produced by intensive use on the working edge. As evidenced by greater incidence of macroscopically visible rounding and gloss, end-scrapers probably often were hafted (allowing more pressure to be applied in use; cf. Broadbent and Knutsson 1975), and consequently had a longer use life than other scraper types.

Striations, possible indicators of long use-life, are produced when a small flake is detached from a working edge and is dragged across its surface during use, or when an abrasive foreign particle intrudes between the tool and the worked material (Del Bene 1979; Fedje 1979). Striations are most frequent when hard material is worked, when the tool is used for long periods of time, or when an abrasive is present. Twenty-five percent of side-scrapers, 16.5% of end-scrapers, and 10% of miscellaneous scrapers exhibit striations.

Striations also reflect motion of use. Those observed on scraper edges most often exhibit perpendicular and angled orientations, indicating a scraping or planing motion (Hayden 1979b). Parallel striations indicating motions other than scraping, such as grooving or cutting, are present but rare. Most variation in motion of use is seen on end-scrapers, perhaps a function of the large sample size. Few motions other than scraping were identified (Table 29), although one tool exhibits wear from chopping, three reflect both scraping and cutting motions, and one specimen apparently was used for grooving, scraping, and cutting. The hardness of worked

material ranges from soft/medium to medium/hard (Table 30). Side-scrapers and miscellaneous scrapers were used on harder materials than were end-scrapers.

Table 28. Determination of Flake Tool Use by Type.

Flake Tool Types	Unexam.	Used	Indet.	Unused	Total
Side Scraper	4	26	8	1	39
End Scraper	0	71	25	1	97
Misc. Scraper	0	26	26	0	52
Symmetrical Pointed Tool (elong)	0	39	17	0	56
Symmetrical Pointed Tool (short)	0	12	9	1	22
Asymmetrical Pointed Tool	0	18	10	0	28
Trihedral Pointed Tool	5	0	0	0	5
Notch/Denticulate	0	33	27	6	66
Biface w/straight profile	0	5	1	0	6
Bifacial w/slightly sinuous profile	3	7	4	0	14
Bifacial w/coarse sinuous profile	3	1	0	0	4
Flakes w/cont. retouch (one edge)	39	36	31	3	109
Flakes w/cont. retouch (mult. edges)	8	16	6	0	30
Flakes w/localized retouch	48	29	29	0	106
Crudely retouched flake/chunks	14	0	0	0	14
Flake w/variable ret. pattern (mult. edges)	23	22	16	0	61
Microdenticulate	0	5	2	0	7
Discoidal Tools	10	0	0	0	10
Pressure flaked tool fragments	25	1	2	0	28
Fragmentary Indeterminate	87	3	3	0	93
Flaked/Battered Tools	12	0	0	0	12
Other	5	0	0	0	5
Total	286	350	216	12	864

Table 29. Motion of Use of Flake Tool Types.

	MULTIPLE USES									
Flake Tool Type	Scrape/ Cut n	Scrape/ Chop n	Scrape/ Perf. n	Cut/ Groove n	Drill/ Perf. n	Perf./ Bore n	Drill/ Groove n	Bore/ Drill n	Total	%
End Scraper	5	-	-	-	-	-	-	-	5	21.74
Misc. Scraper	2	-	-	-	-	-	-	-	2	8.70
Symmetrical Pointed Tool (elong)	-	-	1	-	2	3	1	1	8	34.78
Asymmetrical Pointed Tool	-	-	1	-	1	1	-	-	3	13.04
Trihedral Pointed Tool	-	-	-	-	-	-	-	-	-	0.00
Notch/Denticulate	-	1	-	-	-	-	-	-	1	4.35
Biface w/coarse sinuous profile	-	1	-	-	-	-	-	-	1	4.35
Flake w/cont. retouch (one edge)	1	-	-	-	-	-	-	-	1	4.35
Flake w/cont. retouch (mult. edges)	1	-	-	-	-	-	-	-	1	4.35
Flake w/variable ret. pattern (mult. edges)	-	-	-	1	-	-	-	-	1	4.35
Total	9	2	2	1	3	4	1	1	23	
%	39.13	8.70	8.70	4.35	13.04	17.39	4.35	4.35		

Table 29, continued.

Flake Tool Type	SINGLE USES Scrape n	Cut n	Groove n	Perf. n	Bore n	Drill n	Chop n	Total	%
Side Scraper	27	-	-	-	-	-	-	27	9.06
End Scraper	60	-	-	-	-	-	1	61	20.47
Misc. Scraper	21	-	-	-	-	-	-	21	7.05
Symmetrical Pointed Tool (elong)	2	-	3	9	2	5	-	21	7.05
Symmetrical Pointed Tool (short)	-	1	3	4	1	-	-	9	3.02
Asymmetrical Pointed Tool	4	-	1	6	-	-	-	11	3.69
Notch/Denticulate	25	5	-	-	-	-	-	30	10.07
Biface w/straight profile	-	5	-	-	-	-	-	5	1.68
Biface w/slightly sinuous profile	1	5	-	-	-	-	-	6	2.01
Flake w/cont. retouch (one edge)	15	19	-	-	-	-	1	35	11.74
Flake w/cont. retouch (mult. edges)	5	9	-	-	-	-	-	14	5.03
Flake w/localized retouch	13	16	-	-	-	-	-	29	9.73
Flake w/variable ret. pattern (mult. edges)	7	12	-	-	-	-	-	19	6.38
Microdenticulate	3	2	-	-	-	-	-	5	1.68
Pressure flaked tool fragment	-	1	-	-	-	-	-	1	0.34
Fragmentary Indeterminate	1	1	-	-	-	-	-	2	0.67
Total	184	76	7	19	3	5	2	296	
%	61.74	25.50	2.35	6.38	1.01	1.68	0.67		

Table 30. Flake Tools - Hardness of Worked Materials.

Flake Tool Type	N/A n	Unused n	Soft n	Soft/ Medium n	Medium n	Medium/ Hard n	Hard n	Ind n	Total	%
Side Scraper	-	1	-	3	9	11	-	15	39	4.51
End Scraper	-	1	1	23	14	13	-	45	97	11.23
Misc. Scraper	-	-	1	3	4	10	-	34	52	6.02
Symmetrical Pointed Tool (elong)	-	-	1	10	10	8	-	27	56	6.48
Symmetrical Pointed Tool (short)	-	1	-	3	6	1	-	11	22	2.55
Asymmetrical Pointed Tool	1	-	1	5	3	1	-	17	28	3.24
Trihedral Pointed Tool	5	-	-	-	-	-	-	-	5	0.58
Notch/Denticulate	-	6	-	1	8	9	3	39	66	7.64
Biface w/straight profile	-	-	-	1	1	3	-	1	6	0.69
Biface w/slightly sinuous profile	3	-	-	1	1	4	-	5	14	1.62
Biface w/coarse sinuous profile	3	-	-	-	1	-	-	-	4	0.46
Flake w/cont. retouch (one edge)	39	3	1	4	11	12	4	35	109	12.62
Flake w/cont. retouch (mult. edges)	8	-	-	-	7	6	2	7	30	3.47
Flake w/localized retouch	48	-	1	7	13	5	1	31	106	12.27
Crudely retouched flake/chunk	14	-	-	-	-	-	-	-	14	1.62
Flake w/var ret pat (mult. edges)	22	1	-	2	8	8	-	20	61	7.06
Microdenticulate	-	-	-	4	1	-	-	2	7	0.81
Discoidal tool	10	-	-	-	-	-	-	-	10	1.16
Pressure flaked tool fragment	25	-	-	-	-	-	-	3	28	3.24
Fragmentary Indeterminate	88	-	-	-	2	-	-	3	93	10.76
Chopping Tool/Hammer	12	-	-	-	-	-	-	-	12	1.39
Other	5	-	-	-	-	-	-	-	5	0.58
Total	283	13	6	67	99	91	10	295	864	
%	32.75	1.50	0.69	7.75	11.46	10.53	1.16	34.14		

Five side-scrapers exhibit traces of red staining (ochre?), while other scraper classes each contain only one specimen with such traces (Table 31). This staining may be post-depositional or may reflect the addition of an abrasive during use.

Table 31. Flake Tools with Red Staining.

Flake Tool Type	No. with staining	Total
Side Scraper	5	39
End Scraper	1	97
Misc. Scraper	1	52
Symmetrical Pointed Tool (elong)	1	56
Biface w/slightly sinuous profile	1	14
Flake w/cont. retouch (one edge)	1	109
Flake w/cont. retouch (mult. edges)	1	30
Flake w/localized retouch	1	106
Flake w/variable ret. pat. (mult. edges)	1	61
Total	13	

Tosawihi scrapers, while diverse in form, appear to have been used for similar functions, i.e., scraping medium-hard materials. While other materials also may have been scraped, fresh and dry hides are the materials most likely to have been processed. Antler and bone are too hard to have produced the observed traces, but scraping soft wood may have co-occurred with hide working. Minimal microscopic edge damage (other than rounding) limits the activity to light-duty tasks.

Pointed Tools

Pointed tools include symmetrical tools (55 with long bits and 22 with short bits), as well as 28 asymmetrical ones and 5 trihedrals. All are elongate; with the exception of trihedrals, they are relatively small, show little size variance, and were made on thin (average 7.2mm) blanks (Figures 42, 43; Table 20). The possibility that symmetrical short-bit tools were reworked and more highly curated than other pointed tools is suggested by bit size and the greater proportion of obsidian (exotic to the project area) material from which these tools are manufactured.

Somewhat fewer symmetrical-elongate tools are made on biface thinning flakes (Table 23), but surfaces tend to be obscured by pressure flaking and a large number of blank types remain indeterminate. Pressure flaking is more frequent than average for this group, as is the incidence of heat-treatment (Tables 25, 26). These two variables are not perfectly correlated but, unlike some other artifact classes, about half the pressure flaked tools are heat-treated. Most retouch is continuous and invasive, and frequently is bifacial.

More than half the pieces are complete or broken only at the tip. Symmetrical pointed pieces often are less complete, perhaps due to functions that resulted in more frequent breakage (Unger-Hamilton et al. 1987). The proportion of heat-treated pieces ranges from 28.5 to 54.5% (20% is average for the entire Tosawihi assemblage; cf. Table 25). Most specimens were heat-treated as flakes rather than as cores.

Seven pieces, most of them symmetrical with short bits, show macroscopic gloss, suggesting that some pieces in this sub-class were used more heavily than those in other classes. All pointed tools, with the exception of trihedrals, were examined for microscopic use wear traces. Trihedral pieces were excluded primarily because they are difficult to position under the microscope. Frequency of observed use wear ranges from 54% to 70% (Table 28), similar to that of scrapers but higher than the average for all flake tools.

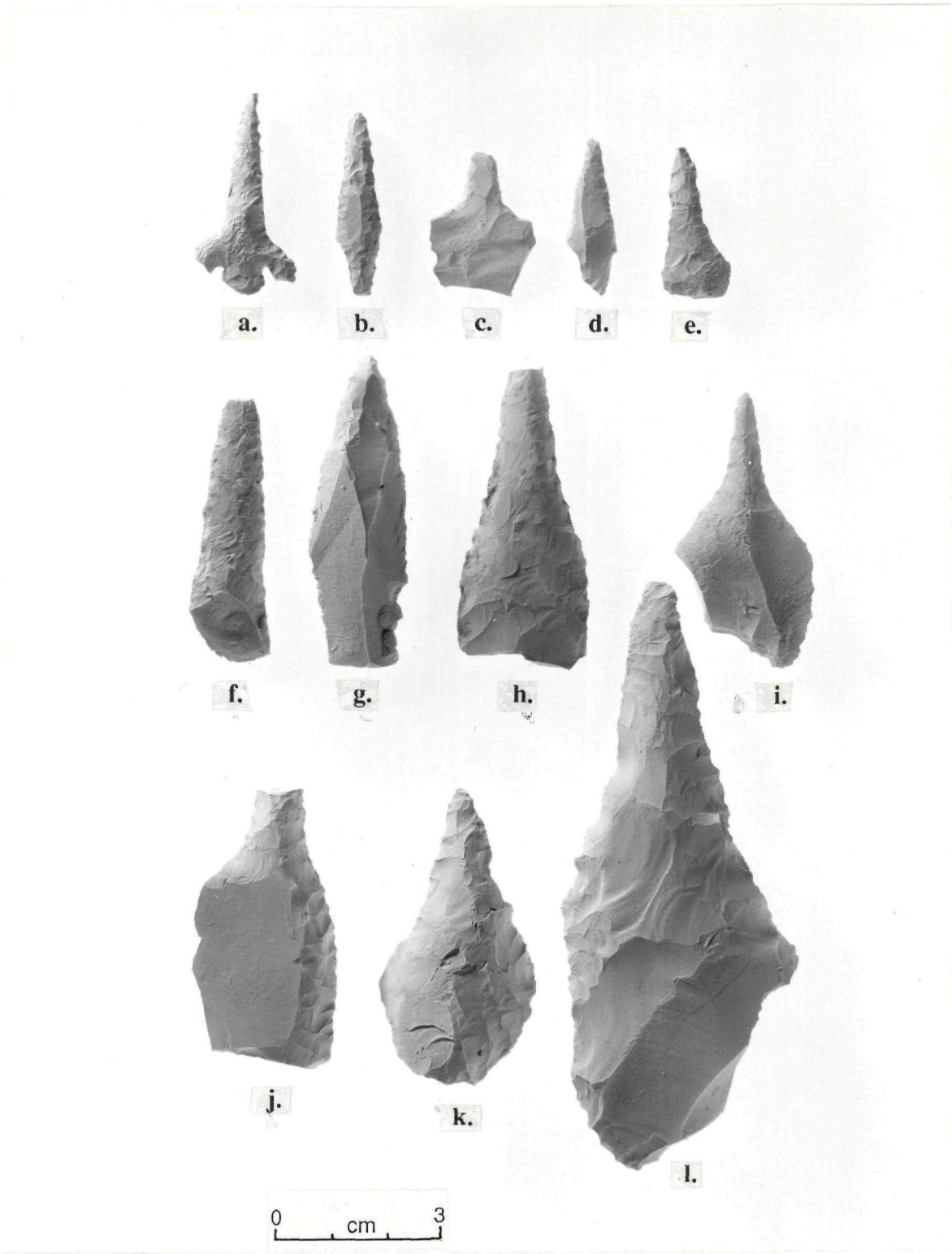


Figure 42. Selected symmetrically pointed tools.

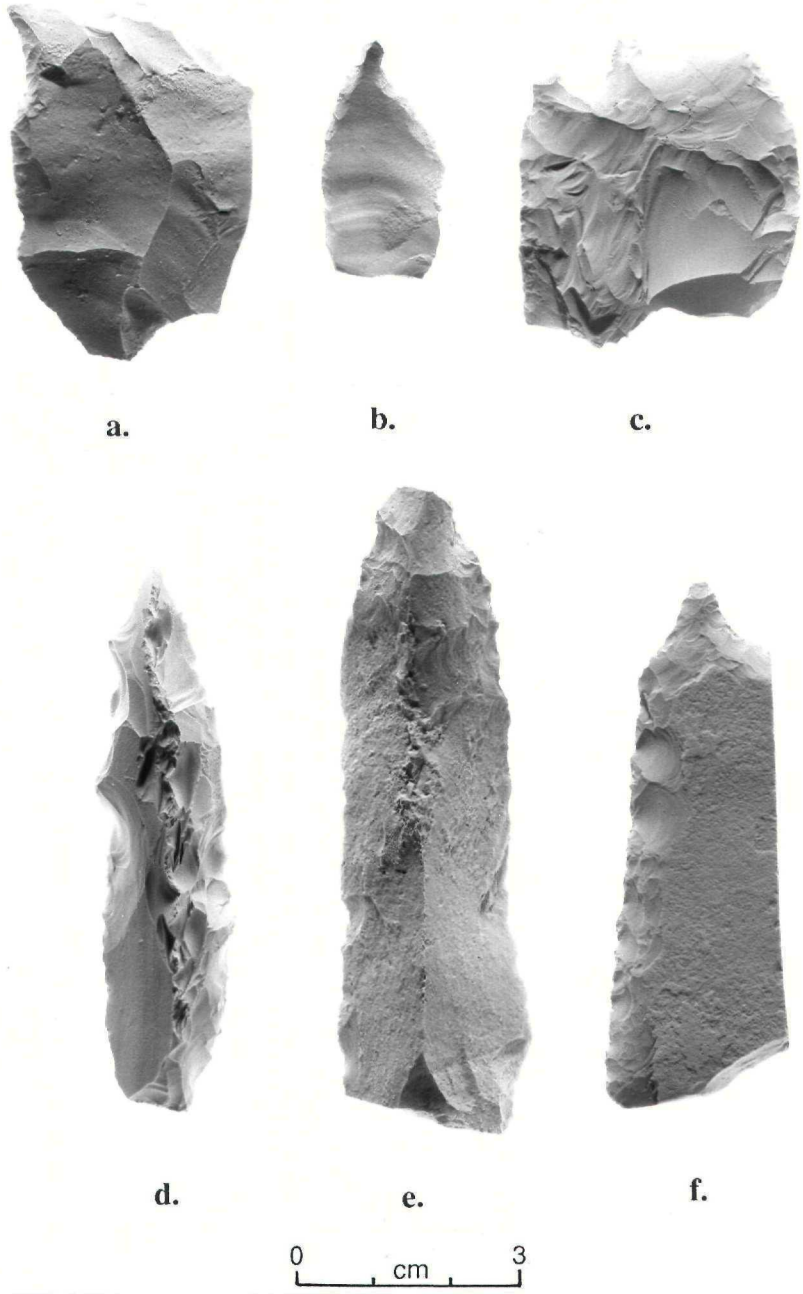


Figure 43. Selected asymmetrical and trihedral pointed tools.

Striations are more common on pointed tools than on many other types, probably owing to heavier use or use on harder materials. Perpendicular striations (indicating perforating, boring, scraping, or drilling motions) are most common, but parallel striations caused by cutting or incising also are present. A number of pointed tools have striations with more than one superimposed pattern, indicating multiple motions of use. Symmetrically pointed pieces, the largest group, exhibit the widest range of use motions (Table 29). Most specimens were used for perforating. A few pieces also exhibit drilling-wear (concentric patterns of striations and a symmetrically rounded tip), and others, wear from grooving or incising. Symmetrically pointed tools with short bits show wear chiefly from perforating and grooving and asymmetrically pointed tools, chiefly from scraping and perforating. Most inferred multiple motions include perforating. Perforating and grooving tools were used primarily on soft or soft/medium materials, and scraping, boring, and drilling tools on medium/hard materials (Table 30).

In contrast to scrapers, pointed tools exhibit less variation in size and form, but greater variation in apparent function. Perforating is common to all three sub-classes. Materials worked with perforating and grooving tools would include hide, wood, plants, and other materials of a yielding nature; scraping and drilling tools may have been used on materials such as wood, antler, or soft stone.

Notches/Denticulates

Sixty-six flake tools are classified as notches or denticulates. This tool type can be mimicked by trampling, so we were particularly conservative in classifying angular pieces as notches or denticulates, especially when recovered from quarry locations; even so, fully one third of the specimens in this class are from localities in the Tosawihi Quarry.

Of 66 tools, we consider 25 to be complete, that is, made on unbroken blanks. The pieces are quite variable in size (Table 20, Figure 44); the length of complete specimens ranges from 34.4 mm to 107.0 mm and the mean length is 68.4 mm, comparable to other flake tool classes.

Ninety percent of notches and denticulates are non-specific opalite, while 10% are jasper and opal (Table 21); none is basalt or obsidian. More than half the blanks for notches clearly are biface thinning flakes, most made on either expanding or irregular flakes (Table 23). The fragment types show no clear pattern; few (38%) are on complete flakes, but this tool type can be made effectively from flake fragments.

Ten percent of the tools have been thermally altered (Table 25); only one obviously was pressure flaked (Table 26). More than half the pieces exhibit localized retouch only in the area of the notch(es), but many are notched on edges with retouch along the entire margin. Most (80%) retouch is unifacial, and most is direct (initiated from the ventral surface and lying on the dorsal), although some is inverse (initiated from the dorsal surface). The retouch on most, but not all, specimens is quite invasive. Few (10%) pieces were used on more than one edge. Both medium and obtuse edge angles are about twice as frequent as acute ones (cf. Table 24).

All notches and denticulates were examined for use wear traces. About half the sample was considered indeterminate because polish produced by post-depositional surface modification has altered or covered use traces. Six pieces are unused, 25 were used for scraping/shaving, five for cutting, and one piece was used for scraping and chopping (Tables 28, 29). The invasiveness and distribution of polish produced by use is quite variable, but few examples exhibit highly developed polish. This, together with light or medium microscopic rounding of used edges, indicates moderate use intensity and little use on hard materials. Only four examples exhibit striations, all of them perpendicular to the edge (consistent with a scraping/shaving motion).

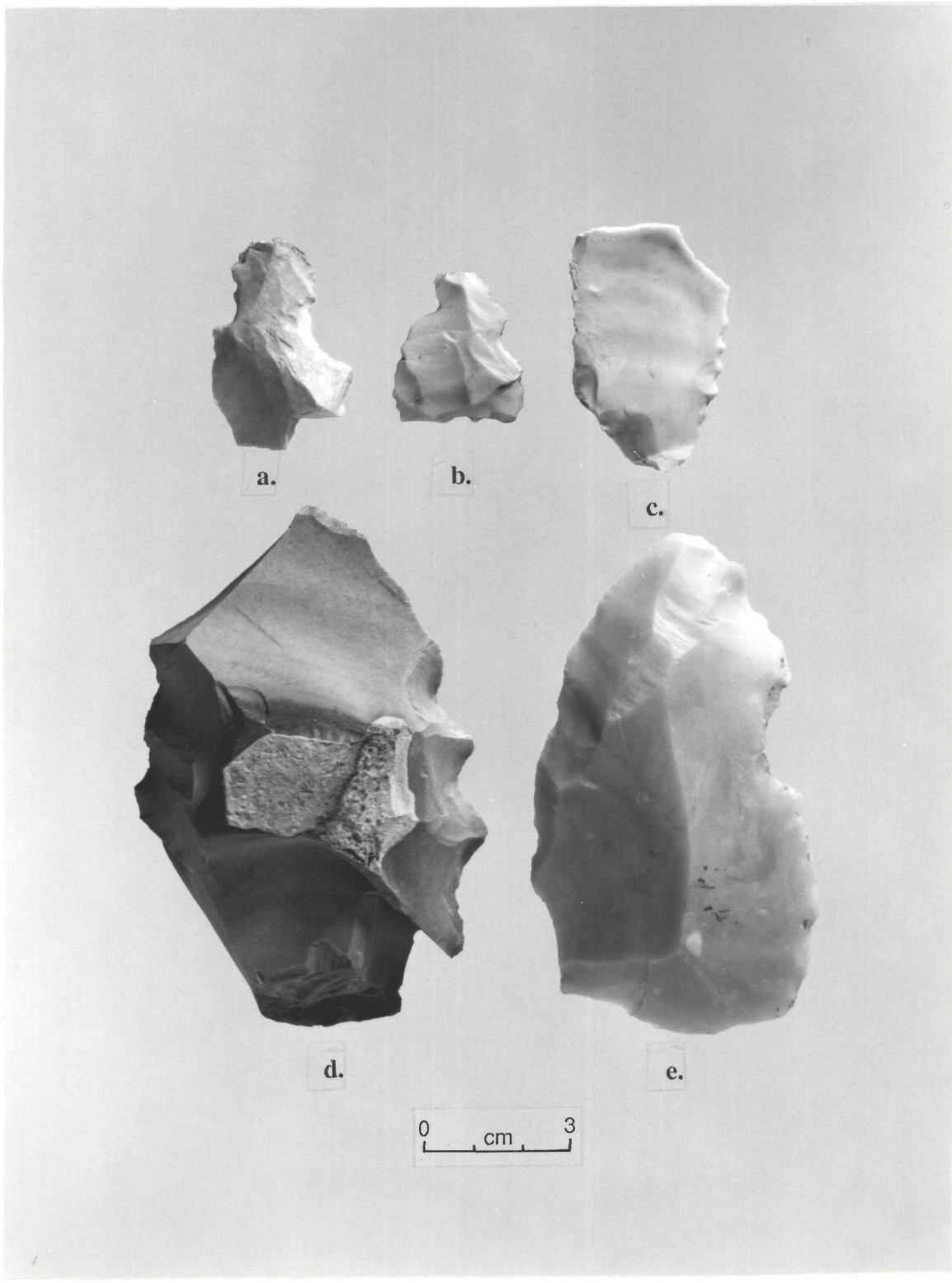


Figure 44. Selected notched and denticulate tools.

Most specimens were used on medium to medium/hard material at moderate intensity of use (Table 30). Thus, most were used for scraping medium to medium/hard contact materials. Hard plant material such as arrow cane, wood, or soaked antler could have been worked in the production or sharpening of tools such as arrows, atlatls, or digging and quarrying tools. The hardness of worked material could not be determined for 39 pieces.

Bifacial Flake Tools

This class includes bifacial tools with a straight profile (i.e., the shape of the edge in cross-section), those with a slightly sinuous profile, and those with a coarsely sinuous profile. Bifacial flake tools are distinguished from bifaces (although a few are made on bifaces) in that the former have regularized or straightened edges, and the flake scars on working edges often do not extend far onto interior surfaces (Figure 45). The class is represented by 24 specimens.

Six specimens with straight profiles have a mean length of 46.1 mm, slightly smaller than the other subtypes (Table 20). Fourteen specimens have slightly sinuous profiles and four, coarsely sinuous ones. The mean lengths of complete examples of these two types are 54.3 mm and 80.7 mm, respectively. The size variance among all types is smaller than for other tool classes, perhaps reflecting small sample sizes.

Three of these tools are obsidian and the rest are non-specific opalite (Table 21). Half the specimens are made on biface thinning flakes (Table 23), and several are made on biface fragments. One-half are heat-treated, a proportion higher than the average for all flake tools. Pressure flaking is not associated with heat-treatment (Table 25) or with tools of obsidian (Table 26).

Blank shapes for bifacial flake tools often are indeterminate because the pieces are highly reduced. No uniform fragment type is represented, but the shape of the worked edge is usually convex or irregular (Table 27). Edge angles are primarily medium but some are acute (Table 24). Flake, step, and snap fractures are found on the edges. There is very little macroscopic rounding.

Pieces were selected for use wear examination on the basis of completeness of working edge and straightness of profile; we assumed that traces on more complete pieces should be interpreted more easily and that tools with straighter edges are more likely to be broken in use than in manufacture. All specimens with straight profiles were examined, as were 11 with slightly sinuous edges and one with a coarsely sinuous edge. A wide range in the degree of polish indicates that tools in this class were used for various lengths of time on materials of various hardnesses. Thirteen pieces were used (Table 28); use of five could not be determined, and six pieces were not examined. One piece was used for scraping, ten for cutting, and one for chopping/whittling (Table 29). Most pieces were used relatively intensively for cutting medium/hard material (Table 30). In our experiments, such tools have proven useful in skinning and butchering large mammals; too, they can be resharpened easily. Wear traces observed on the worked edges of our archaeological examples are compatible with such use.

Miscellaneous Retouched Tools

Miscellaneous retouched tools (Figure 46) were defined by the presence of patterned retouch along one or more edges. These pieces, commonly referred to as "utilized flakes" or "expedient tools," often have more acute edges and straighter profiles than other tool types and may have served specific functions. We collected 306 of them, comprising more than a third of our entire flake tool assemblage.

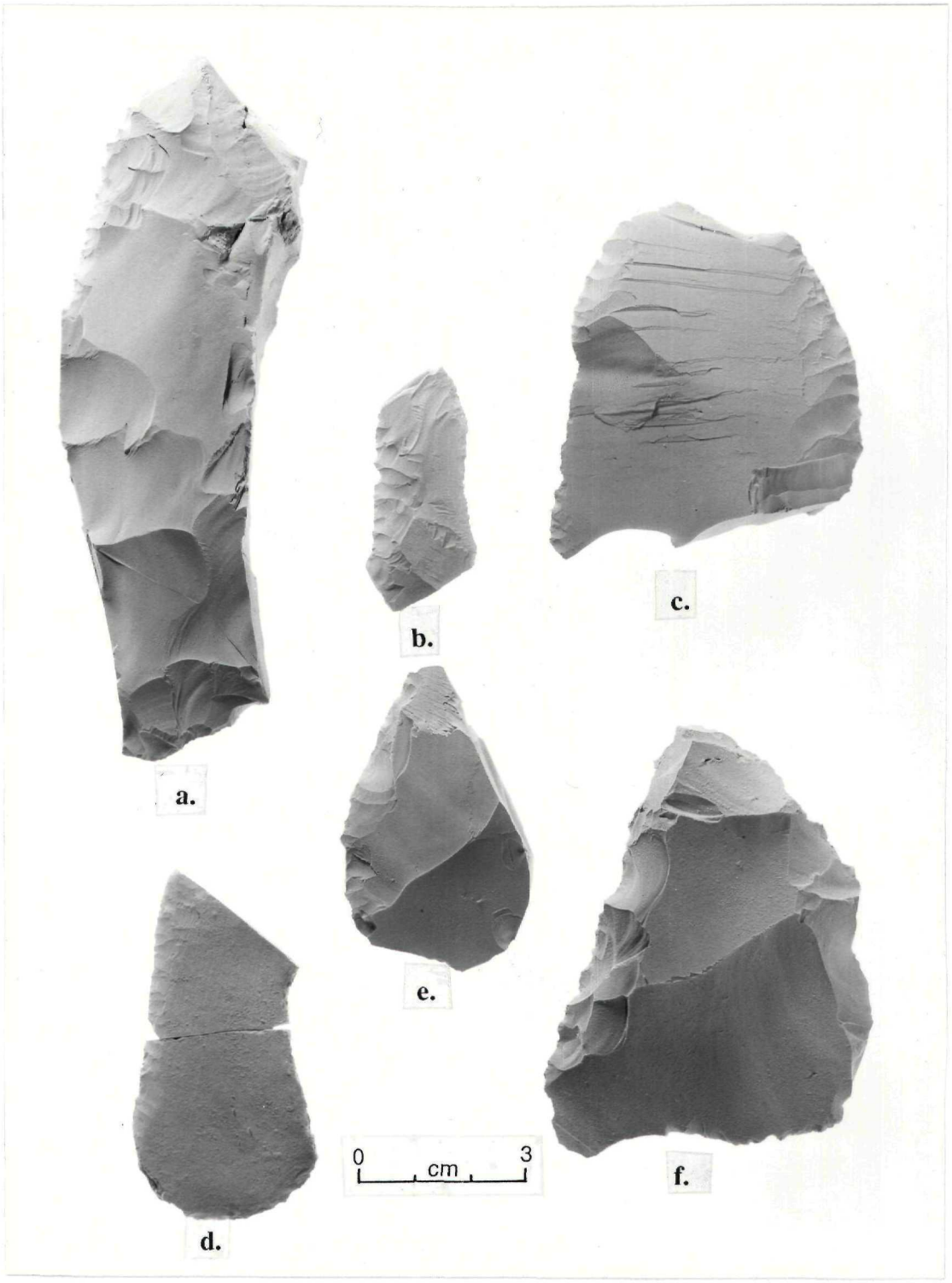


Figure 45. Selected bifacial flake tools.

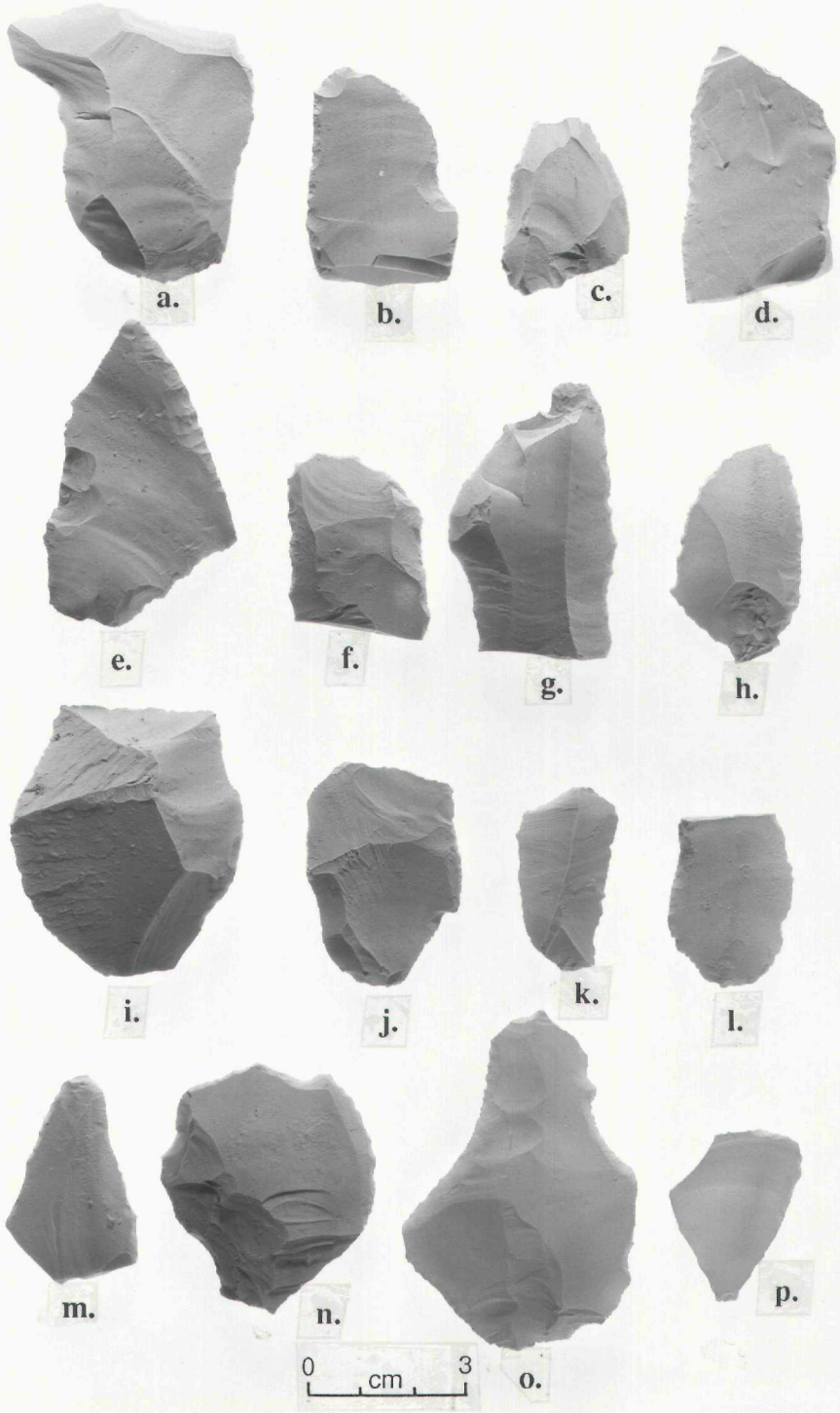


Figure 46. Selected examples of miscellaneous retouched tools.

Miscellaneous retouched tools include four morphological types defined by the number of retouched edges and the nature of retouch: flakes with continuous retouch on one edge (n=109), flakes with continuous retouch on multiple edges (n=30), flakes with localized retouch (n=106), and flakes with variable retouch on multiple edges (n=61); variance within each morphological group is high. The length of complete pieces ranges from 48.1 to 68.1 mm, the average being 48.7 mm (Table 20). Specimens tend to be somewhat more elongate than some other flake tool types.

Jasper and chalcedony were used in slightly higher proportions than among flake tools. Of the subtypes presently considered, the two categories with single retouched edges contain slightly more jasper; the proportion of non-white opalite is similar to that for all flake tools (Tables 21, 22). Specimens with continuous retouch on multiple edges have less material diversity, while those with variable retouch on multiple edges exhibit greater material diversity (obsidian is twice as frequent as the average, and chalcedony slightly more frequent than average). These may represent more highly curated tools.

A larger proportion of miscellaneous retouched tools is made on biface thinning flakes than most flake tools (Table 23). Those with continuous retouch on a single edge have the lowest proportion (53%) made on such flakes; those with continuous retouch on multiple edges have the highest (83%). About 47% of the total are made on expanding flakes, but this varies greatly from sub-type to sub-type; 37% of specimens with localized retouch and 80% of those with variable retouch on multiple edges exhibit the trait. Only pieces with continuous retouch on a single edge show it frequently (33%; cf. Table 23).

The proportion of heat-treated specimens is similar to that of all flake tools, and varies only slightly among sub-types. More than twice as many pieces were heat-treated as blanks than were made on flakes removed from heat-treated cores (Table 25).

Retouch is variable and unpatterned, containing high proportions of both invasive and non-invasive scars. Most invasive scars are found in the groups with continuous retouch on multiple edges and with localized retouch. Variable retouch on multiple edges occurs least. Pieces with continuous retouch on a single edge have the greatest frequency of straight edges, and pieces with localized retouch the least, suggesting that straighter edges may have been chosen for tasks requiring a long cutting edge (Table 27). Almost all pieces in every category have straight profiles, perhaps a factor in tool blank selection.

The edge angles of most pieces (84%) are acute or medium. They are less acute on tools with continuous retouch on a single edge; pieces with continuous retouch on multiple edges and with localized retouch have more acute edges, while those with variable retouch on multiple edges exhibit both acute and medium edge angles. A few pieces have light macroscopic rounding. Three exhibit visible gloss, and four, red staining (Table 31).

One hundred eighty-eight pieces were examined for use wear traces; most complete specimens were included. Of the total, 54.8% clearly were used; evidence of use wear could not be identified on the remainder (Table 28). Almost all use wear is referable to cutting and scraping. Cutting was somewhat more important in all categories, especially for tools with more than one used edge (Table 29). Cutting soft materials often leaves no visible trace, although straight, acute edges are ideal for cutting soft materials such as meat or soft plants (Keeley 1980; Symens 1986). In general, material worked with miscellaneous retouched tools was medium to hard. Tools with one continuous retouched edge appear to have been used on variable material hardness while those with localized retouch were used on soft materials (Table 30). Cutting tools seem to have been used on diverse materials while most scraping tools were used on medium/hard materials. A few pieces exhibit multiple use traces; these tools seem to be used more heavily than those with only one indicated motion.

Crudely Retouched Flake/Chunk

This tool class contains only 14 examples. They are modified intentionally, but the retouch is relatively coarse and less patterned than on other tools. These pieces are somewhat larger and much heavier than most other flake tools, and they vary in size (Table 20). There is little material diversity in this group; 12 specimens are opalite and two are opal. Only 57% are white, indicating greater material diversity (when measured by color) than other tool types (Tables 21, 22), suggesting these tools derive from multiple lithic sources.

Six specimens are made on complete flakes, of which five are biface thinning flakes (Table 23). In general, these blanks are much more robust than those of other types. Blanks are primarily irregular or expanding flakes with unifacial-direct or combination retouch. Half the pieces show use on multiple edges, with great variation in the extent of retouch; most (78.6%) exhibit invasive retouch, perhaps the result of deliberate production of a strong edge. Seventy-one percent have irregular edges exhibiting various types of edge profile. Almost all have medium or obtuse edge angles. No rounding or gloss was observed (Table 24), and no specimens were thermally altered.

Discoids

Pieces in this category have generally circular shapes and flat cross-sections. Some resemble circular bifaces, some discoidal hammerstones, and some are merely curious objects. Their distinctive shape occurs in no other tool type, and their variation in size, material, and modification makes it unlikely that they served similar functions (Figure 47). Highly variable in size (length 45.0-143.5 mm), these tools exhibit a mean length (102.6 mm) greater than other classes of flake tools (Table 20). Raw material is highly variable as well, and includes one tool of basalt, one of quartzite, one of schist, one of "bedded ash," and six of opalite (Table 21).

Although some discoids are made on flakes, all are too robust to be biface thinning flakes. Quartzite and basalt specimens are made from rounded cobbles, those of schist and bedded ash from tabular pieces, and three of the opalite specimens on flakes detached from cobbles. All are retouched (often bifacially) around the edges, some more extensively than others. Only two appear to be made on heat-treated pieces. None shows clear evidence of pressure flaking.

Five (including the largest pieces) are battered and three are rounded, both presumably by use. At least three of these pieces may have been used as hammerstones or for other heavy-duty tasks, but unlike other percussion tools, they have been flaked extensively to form the discoidal shape. Two are opalite and one is quartzite. The basalt specimen also may be a chopper or a hammer, but it exhibits much less edge damage and has some rounding of the retouched edges. It may have been used for heavy duty cutting rather than percussion, possibly in the dismemberment of large game or the production of wood or antler quarrying tools. These pieces are too large to examine microscopically.

Specimens of schist and bedded ash are more unusual. The schist piece is made from a thin sheet with parallel faces, of a material not local to the immediate quarry area. Three-quarters of its circumference is retouched, with two convex and two straight edges. It could have been used either for cutting or scraping, but it exhibits no macroscopic gloss. It was not used on very hard material, as it is of soft, brittle stone. The specimen of bedded ash has several, apparently natural, holes on interior surfaces. The material is soft and striations are visible to the naked eye on one interior surface. Whether they are products of manufacture, use, post-depositional alteration, or excavation and processing procedures is not clear. The striations run perpendicular to the edge in a localized area on one-half of one face. Despite their macroscopic

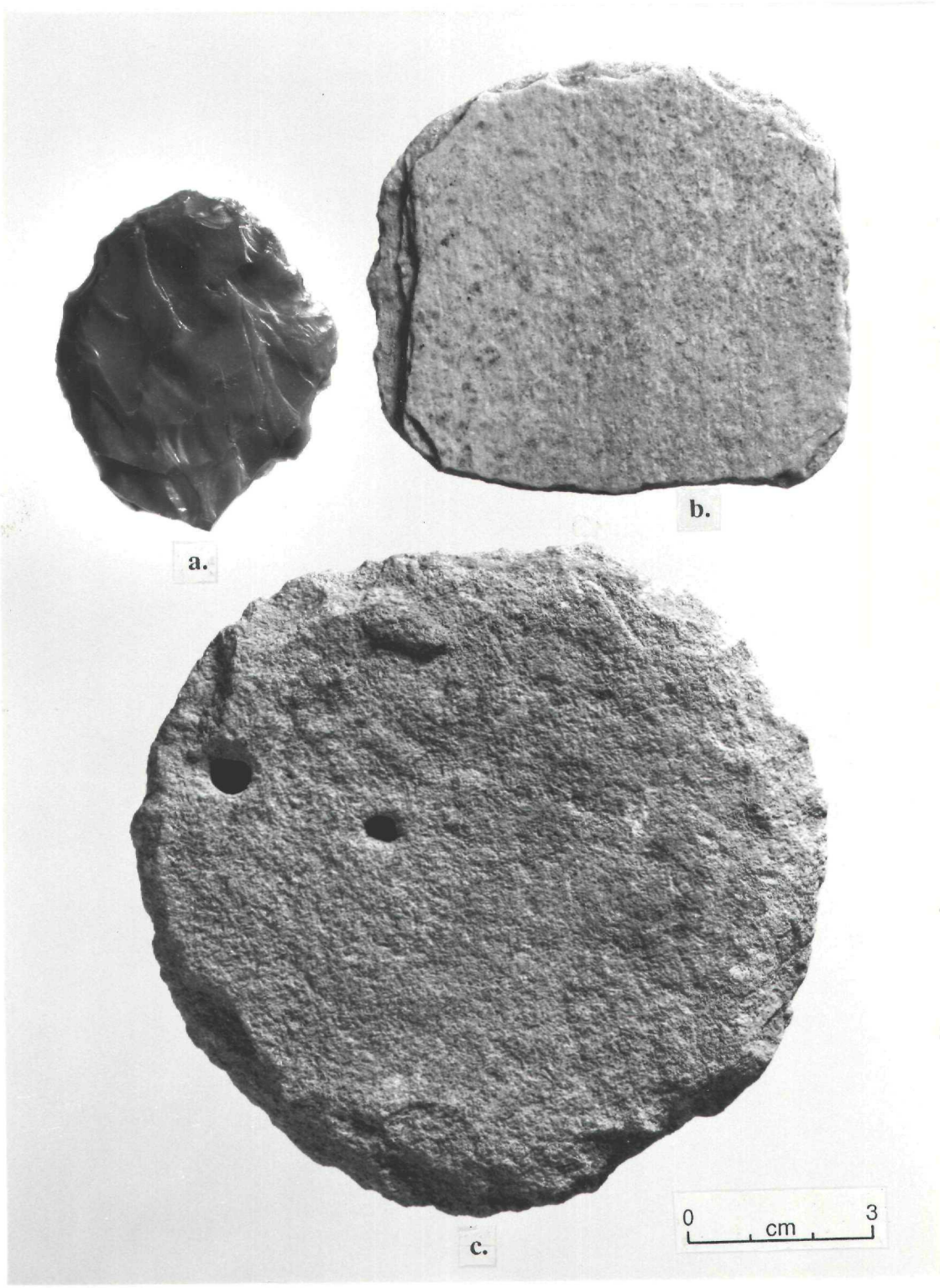


Figure 47. Selected discoidal tools.

visibility, they cannot be seen even at the lowest (50x) magnification available to us because of the coarseness of the material. These tools could have been used for scraping soft to medium materials such as hide, or for processing (shredding, grinding, scraping) soft or fibrous plant materials. Other tools of this class are flaked more extensively, have medium edge angles, and could have been employed in cutting, chopping (of soft/medium materials), or scraping.

Microdenticulates

This small tool group contains only seven specimens. Given small sample size and minimal retouch, we are not certain that these pieces have been retouched deliberately. Nevertheless, they are very similar in form to clearly documented European Mesolithic and Neolithic examples (Jensen 1988; Levi-Sala 1984-86; Barton 1981). Similar artifacts also have been reported from California (E.L. Davis 1978b), where they have been described as "flakes with micro-serrations" and "steak knives."

These tools are rather small compared to some other tool types (34-50 mm in length; cf. Table 20), and their size variance is low (Figure 48). Most are made on biface thinning flakes (Table 23), and only one is thermally altered (Table 21). There is little diversity in raw material; six are opalite and one is obsidian. Several are made on parallel-sided, blade-like flakes, but expanding and contracting flakes also are present. The precise and even retouch probably was produced by pressure.

Five specimens have retouch on more than one edge, but they are denticulated only on one edge. On three pieces, denticulation extends continuously along a single edge while on others it usually is more localized. Edge shape varies, but the profile of all edges is straight (Table 27). All pieces have acutely angled edges, none showing macroscopic rounding and only one piece showing a slight macroscopic gloss.

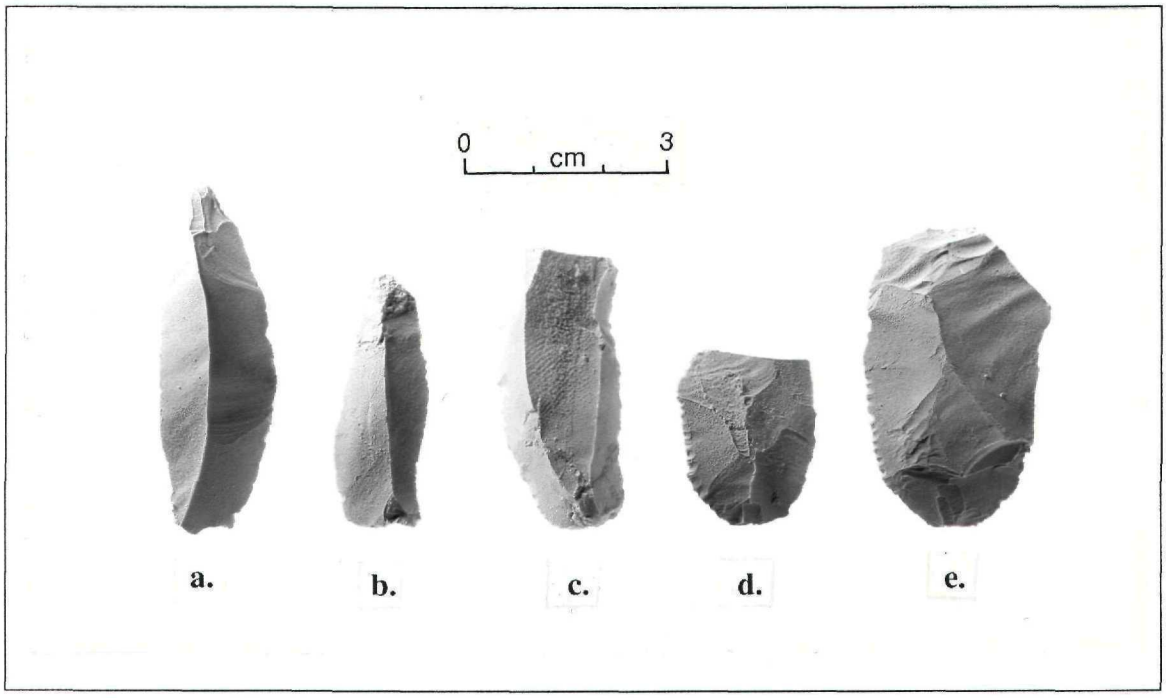


Figure 48. Microdenticulates.

Use wear examination was made of all specimens; five exhibit clear traces of use (Table 28). Three apparently were used for cutting soft/medium materials and two for scraping soft/medium and medium materials (Table 30). Similar tools occur in the European Mesolithic, where their use has been interpreted to entail both parallel and transverse motions for cutting or scraping plants or plant fibers (Levi-Sala 1984-86; Jensen 1988). A similar range of uses is possible here, but materials worked might also include wood.

Pressure Flaked Tool Fragments

Twenty-eight small pieces (mean length = 30.3 mm) consist of pressure flaked tool fragments whose intended form is unclear. Materials are diverse; three pieces are obsidian, three are chalcedony, and two are jasper. Among the remaining pieces, all opalite, a wide range of color, similar to that observed among points and preforms, is present. Nine pieces were heat-treated.

Use wear studies were not performed on these tools; they are assumed to have been broken in manufacture and in use. Most of the pressure flaked pieces in the Tosawihi assemblage are projectile points or preforms; many of the present specimens (at least seventeen of them) *could* be point or preform fragments.

Flaked/Battered Tools

These heavy-duty tools differ from the hammers and choppers described in Chapter 11 because their primary modification was by flaking rather than by battering (Figure 49). The 12 specimens of the class exhibit variable size (mean length = 111.8 mm). Nine are opalite and three are basalt (Table 21). Few (25%) are made on biface thinning flakes; most are on other flakes or chunks and only five are complete. None is heat-treated.

Flaking is primarily bifacial, producing medium to obtuse edge angles (Table 24). The edges include straight, slightly sinuous, and coarsely sinuous examples. Two basalt pieces and one opalite piece are similar in manufacture to Tosawihi bifaces exhibiting distinctive edge preparations and thinning techniques in which multiple flakes are removed contiguously from a single face using a flat, wide platform (cf. Chapter 6). These pieces were not completed as bifaces, however; they exhibit edges battered as a result of use, not of platform preparation. One large basalt piece retains tuff dust in its battered edges, and was likely used as a quarrying tool. The other basalt specimen has a long, straight edge with edge damage suggesting scraping or light chopping.

Two opalite pieces also were flaked bifacially but are domed, suggesting a scraper in form (except for the bifacial retouch); both, however, also have heavily battered edges. Another opalite piece is flaked on its entire circumference and exhibits little battering. Its function is unclear but, based on size, it may have been used as a hammerstone for removing flake blanks. Yet another opalite tool resembles a split hammerstone subsequently flaked and used for chopping or adzing. Two others are flakes with strong but somewhat pointed edges suggesting use as choppers.

Other Flake Tools

Five pieces are distinctive, but they do not fit in any other category; they vary in form and size. Three are complete; none is heat-treated; one is made on a biface thinning flake. One is basalt and the others are non-specific opalite.

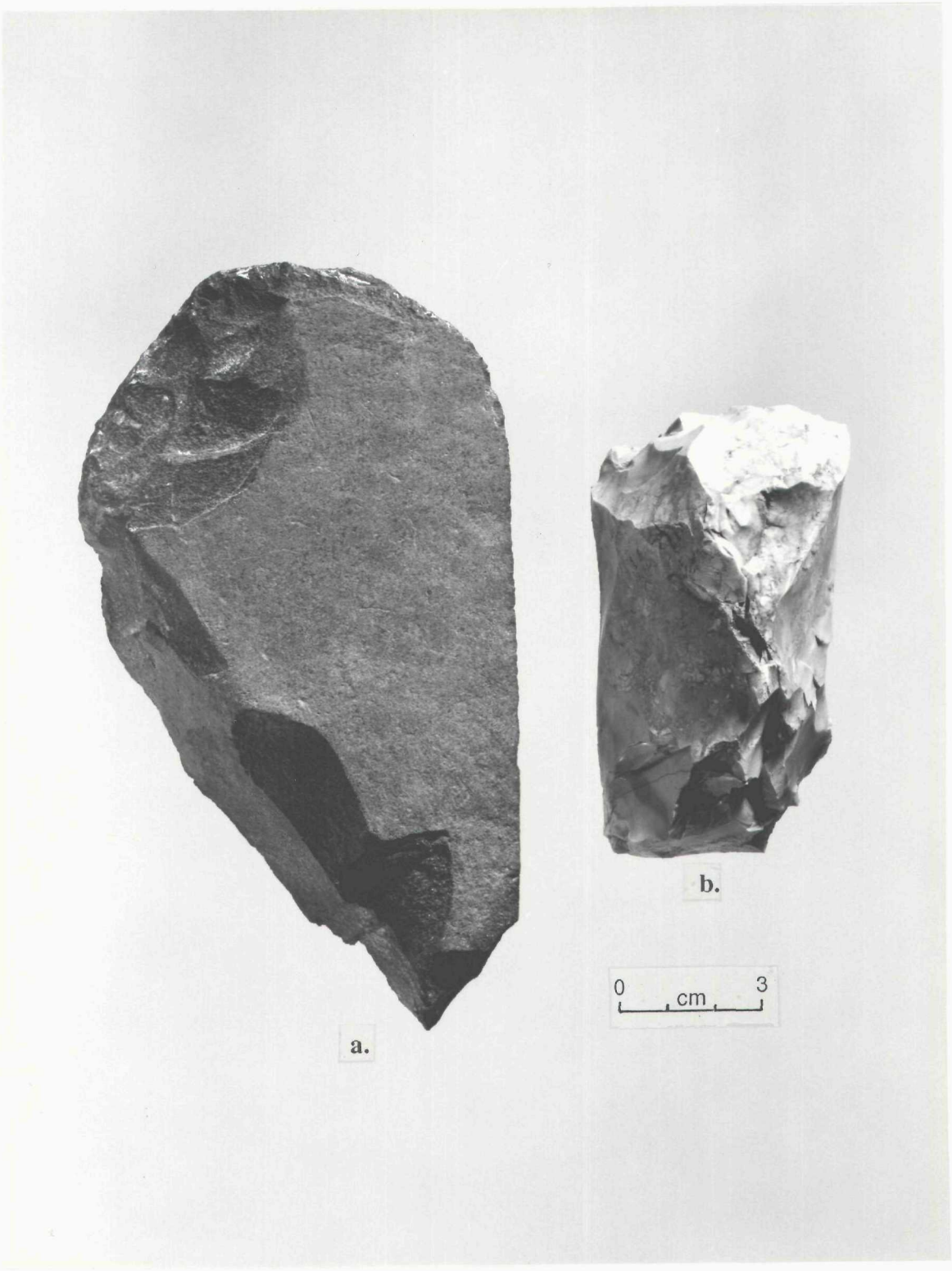


Figure 49. Selected flaked/battered tools.

One piece resembles the distal end of a backed bladelet. Another resembles a small unifacial biface, thick and narrow with several hinge fractures on its dorsal surface. Differing significantly from other Tosawihi bifaces, it was classified separately. Another piece is an opalite flake with a rounded protuberance flanked by two notches; a larger, similar piece is of basalt. Both are unifacially flaked and their probable function is ambiguous. One piece with a heavily worn (but not deliberately retouched) edge also has battering on the opposite end.

Flake Tool Fragments

This class consists only of retouched flake fragments, not pressure flaked, the original form of which cannot be determined. Ninety-three pieces form the group; they are generally small, with a mean length of 25.7 mm. Eighty-six percent of them are opalite, and a few are obsidian, jasper, and opal. Seventy-two percent are white, and 26% are heat-treated. About a third of them are made on biface thinning flakes.

Debitage

A sample of unretouched flakes was examined to determine how often such pieces were used as tools without creating patterned edge damage. This was intended to test our conservative assignment of flakes as flake tools. A sample of 76 pieces was selected largely on the basis of morphology, particularly the presence of long straight edges useful for tasks such as cutting, scraping, or whittling which can be accomplished with unretouched edges. We drew the sample from proveniences which seemed, from the presence of other tools and debitage, to be those hosting the widest variety of activities. We can suggest that, in most cases, the proportion of used debitage at any unexamined locus probably is not higher than in the sample.

The sample consists of 51 opalite, 20 obsidian, 1 basalt, 1 chalcedony, 1 jasper, and 2 opal pieces. The mean size of 50 complete pieces is smaller than scrapers and notches but larger than miscellaneous retouched tools. The proportion made on biface thinning flakes (49%) is similar to the average for all flake tools (54%). Blank shapes are variable; expanding and irregular shapes each account for approximately 33% of the sample, and blade-like flakes, 20%. Only 10 pieces (8 of them complete) were thermally altered. Edge shapes also are quite variable; most (91%) have straight profiles and acutely angled edges (60%).

Fifteen specimens clearly were used (Table 32). Edge shape, profile, and angle do not differ significantly between used and unused specimens. Approximately one-half of the used pieces have acutely angled edges; four probably were used for scraping and ten for cutting materials of various hardness. Cutting tools were used less often on hard materials; one specimen was used for scraping and cutting medium/hard materials. Additional to unequivocally used specimens, 21 clearly were not used, while the use of 40 could not be determined.

Table 32. Functional Analysis of Debitage Sample.

Hardness of Material Worked	Scraping n	Cutting n	Multiple n	Total
Soft		1		1
Soft/Medium	1	1		2
Medium	1	4		5
Medium/Hard	1	1	1	3
Indeterminate	1	3		4
Total	4	10	1	15

Summary and Discussion

Manufacturing

Material Preference

The choice of raw material for the production of particular tool types in an area where raw material is abundant is influenced by curation as well as by manufacturing and functional considerations. Tools made of exotic materials should be more highly curated, more intensively used, and of more formal design. The proportions of material types used in production of flake tools are listed in Table 21. Obsidian and basalt were used rarely, but they clearly were preferred for the production of some tool types.

Obsidian was used most often to produce pressure flaked tools. It also occasionally yielded miscellaneous retouched tools used in cutting, for which it is particularly well suited. The presence of several heavily used tools of obsidian and other exotic materials indicates that some flake tools probably were brought to Tosawihi in finished form.

Basalt is very rare in the flake tool assemblage, and its use is restricted almost exclusively to heavy duty tools (i.e., flaked/battered tools and discoids). It was used occasionally for other tools, one of which is a robust, symmetrically pointed piece made on a blank, originally perhaps a large projectile point. Relatively fine-grained basalt is common in some parts of the project area but it does not produce edges as sharp as opalite does and its flaking is more difficult to control. Thus, it is less suitable for many Tosawihi tool types.

Chalcedony, which of local lithic materials is easiest to pressure flake without heat-treating, was used primarily for pressure flaked tools. Jasper was used for a wide range of tool types without apparent preference by type, while opal was used primarily for scrapers.

Symmetrically pointed tools with short bits, bifacial flake tools, and pressure flaked tool fragments, were made of non-white material more often than were other types (Table 22). Within these types, some of the color variation is due to the presence of higher proportions of obsidian, but it also reflects the presence of curated tools made of opalite from diverse quarry locations.

Blank Production

A question central to understanding Tosawihi technology concerns whether or not flake tool blanks were struck from bifaces (either produced with specific intent or scavenged from debitage) or from flake cores. Most flake tools *could* have been detached from flake cores (cf. Table 77), but because flake cores are relatively rare and because approximately 50% of the flake tools were made on biface thinning flakes (Table 23), we assume the flake core/flake tool trajectory to have been of minor importance.

Consequent questions involve the stage in the biface trajectory at which flake tool blanks are produced, and whether this varies from type to type. Most flake tools are oriented on the detachment axis of the blank, so their lengths are functions of the widths of the bifaces from which they were detached; flake lengths, thus, can be used to index the widths (and probably the stage) of the original bifaces. Using the mean lengths of complete examples of each flake tool type and the mean widths of bifaces by stage, t-tests were run for the 14 tool types most frequently made on biface thinning flakes (Tables 33, 34).

All three types of scrapers are longer than could have been removed from average Stage 2, 3, or 4 bifaces. Symmetrically elongate and asymmetrically pointed tools probably were removed from Stage 2 or 3 bifaces, while symmetrically pointed tools with short bits, as well as microdenticulates, could have been removed from bifaces of any stage. Trihedrally pointed tools are too large to have been removed from Stage 2, 3, or 4. Notched and denticulate tools most likely were removed from Stage 2 or 3 bifaces, while miscellaneous retouched tools could have been removed only from Stage 2 bifaces.

Table 33. Comparison of Mean Sizes of Complete Flake Tools and Bifaces.

Flake Tool Type	Total n	LENGTH (cm) Mean	Range	S.D.
Side Scraper	22	69.8	28.1 - 117.3	24.5
End Scraper	67	58.6	20.8 - 110.4	21.1
Misc. Scraper	24	67.2	21.3 - 120.2	27.2
Symmetrical Pointed Tool (elong)	13	43.5	24.2 - 69.3	13.5
Symmetrical Pointed Tool (short)	6	41.4	31.9 - 63.3	11.4
Asymmetrical Pointed Tool	15	43.4	25.0 - 67.5	13.0
Trihedral Pointed Tool	5	85.6	71.1 - 104.2	14.2
Notch/Denticulate	25	68.4	34.4 - 107.4	21.1
Biface w/straight profile	0	-	-	-
Biface w/slightly sinuous profile	6	54.3	34.6 - 75.3	15.5
Biface w/coarse sinuous profile	2	80.7	744.6 - 86.8	8.6
Flake w/cont. retouch (one edge)	36	48.1	20.8 - 131.3	19.9
Flake w/cont. retouch (multiple edges)	14	68.1	34.0 - 112.9	24.1
Flake w/localized retouch	50	58.8	30.0 - 125.1	22.3
Crudely retouched flake/chunk	6	70.1	23.1 - 100.4	31.2
Flake w/variable retouch pattern (mult. edges)	26	56.7	32.5 - 122.3	22.4
Microdenticulate	4	41	34.4 - 50.3	6.7
Discoidal tool	8	102.6	45.0 - 1143.5	33.4
Pressure Flaked Tool Fragment	1	-	29.4 - 29.4	-
Fragmentary Indeterminate	2	40.6	15.2 - 66.0	35.9
Chopping Tool/Hammer	5	116.2	58.3 - 180.0	49.5
Other	3	81.8	61.1 - 100.0	49.5
Biface Stage			WIDTH	
Stage 1	24	72.7	54.0 - 87.1	9.3
Stage 2	191	69.2	28.9 - 116.2	16.5
Stage 3	380	62.4	21.4 - 118.5	17.9
Stage 4	6	59.6	35.2 - 84.4	21.6

Table 34. T-test Results Comparing Mean Flake Tool Lengths and Estimated Mean Biface Sizes.

Flake Tools Made on Biface Thinning Flakes	BIFACE MEASURE Stage 2	Stage 3	Stage 4
Side scraper	+	+	+
End scraper	+	+	+
Misc. scraper	+	+	+
Sym. pointed (elong)	-	0	+
Sym. pointed (short bit)	-	0	0
Assym. pointed tool	+	0	+
Trihedral pointed	+	+	+
Notched/denticulate	+	+	+
Misc. Retouch			
Cont. retouch-single edge	0	0	+
Localized	0	+	+
Variable ret.-mult. edges	0	0	0
Microdenticulate	0	0	0

Given P = .05:

+ = Flake tool (average size) significantly larger than biface measure
- = Flake tool (average size) significantly smaller than biface measure
0 = Flake tool and biface measure equal

These observations suggest that most flake tools were detached from early stage, "raw" (i.e., not heat-treated) bifaces. Most bifaces probably were exported from the quarries around middle Stage 3, and at least half probably were heat-treated. Therefore, it seems likely that most reduction (much of the biface debitage was detached from Stage 3 bifaces) is unrelated to flake tool manufacture. If bifaces removed from the quarries served as cores for the production of flake tool blanks, the resulting tools necessarily would be smaller than most of those recovered at Tosawihi.

Thermal Alteration

Heat-treatment is an important step in the manufacturing sequence for many Tosawihi artifact types. In the biface, projectile point, and preform classes it appears to precede thinning and pressure flaking. Among flake tools heat-treatment is less frequent (22%), and has little interpretable patterning (Table 25). Some flake tool types were heat-treated more frequently than others, including those with the greatest degree of pressure flaking (pointed tools and fragments; Table 35). There is not, however, perfect correspondence between pressure flaking and heat-treatment.

Table 35. Frequency of Heat-Treatment on Flake Tools.

Stage of	Tools w/Pressure Flaking		All Flake Tools	
Heat-Treatment	n	%	n	%
Blank From H/T Core	7	7.29	45	5.21
H/T as a Blank	22	22.92	113	13.08
H/T during Reduction	3	3.13	5	0.58
H/T Stage Indet.	8	8.33	22	2.55
Post-Dep. H/T	2	2.08	14	1.62
Possible H/T	4	4.17	15	1.74
Not H/T	50	52.08	650	75.23
Total	96		864	

Heat-treated flake tools more often were heat-treated as flakes than they were detached from heat-treated cores. However, 16% of them were made on flakes struck from heat-treated cores (usually bifaces), a proportion considerably greater than in other tool categories. Thus, the selection of blanks for tools drew from a mixture of variously heat-treated and non heat-treated flakes resulting from biface manufacture. This pattern suggests expediency in flake tool production.

Retouch

Most Tosawihi flake tools are not heavily modified; scrapers and pointed tools are the most formalized. Percussion techniques dominate; only about 10% of the tools exhibit clear evidence of pressure flaking (Table 26). Unretouched but utilized flakes were not examined systematically in this analysis since their macroscopic identification is equivocal (Young and Bamforth 1990). Obsidian tools are pressure flaked more often than tools of other materials, but the resulting forms do not appear to differ from those made of local materials. Obsidian debitage is distributed widely over the project area, indicating that at least some obsidian flake tools were manufactured at Tosawihi.

Hafting

Microscopic hafting traces caused by friction between tool and haft have been reported (Buller 1988; Plisson 1987; Anderson-Gerfaud and Helmer 1987; Winiarsk-Kabacinska 1988), but such identifications have been criticized strongly (Unger-Hamilton et al. 1987). Even proponents of the distinctiveness of microwear polishes note that the incidence of such traces is rare (Keeley 1982). The present analysis has not attempted such observations. No other direct evidence for the hafting of flake tools was found in the Tosawihi assemblage, that is, no breakage or use wear traces produced by use in a haft were noted, nor were any hafts recovered. Too, no residue of mastic adhering to the hafting elements was identified.

There is however, some indirect evidence for tool hafting. The symmetrically rounded tip with concentric striations occurring on drilling tools (Calley and Grace 1988; Keeley 1983) could have been produced only by incorporation in a mechanical drill (such as a bow drill or pump drill); therefore, they must have been hafted. Many scrapers, especially end-scrapers, probably were hafted as well. This is suggested by analogy with numerous ethnographic and archaeological examples of similar tools (Cauvin, Deraprahmian, and Helmer 1987; Julien, Vaughan, and Lavallée 1987; Asch 1981; Tohey 1981; Burch 1984); many are small, formally shaped, and probably resharpened (Semenov 1964; Keeley 1982) and would be much more efficient and easier to use when hafted (Broadbent and Knutsson 1975). Other tool forms also may have been hafted, but we have no evidence of it.

Standardization of Production

The question of standardization and specialization of lithic production has been approached in various ways (Torrence 1986; Sackett 1982; Miller 1987; Gibson 1982) and, though generally associated with complex economies, the existence of lithic specialists has been documented among hunter-gatherer groups (McBryde 1978). The apparently intense volume of production and the discovery of a number of biface caches, as well as the quality of products observed at Tosawihi, prompt examination of this question (cf. Chapter 6 for discussion of the issue as it applies to biface production).

Evidence for lithic specialists may be expressed variously in the archaeological record. Three principal indicators are 1) spatial segregation of production stages suggesting production by different individuals, 2) scales of production indicating manufacture for trade, and 3) standardization of products, including evidence of high degree of skill and low error rate as well as consistency of form. This information also bears on questions of contemporaneity, cultural similarity, and ethnicity which may cloud interpretation of the archaeological record.

Since there are few regionally distinctive tool types present at Tosawihi, our particular flake tool classes cannot inform the issue directly. Examination of evidence for the standardization of manufacturing techniques, however, may be more useful. As noted above, almost all Tosawihi flake tools are produced on early stage biface thinning flakes, retouch is produced primarily by percussion, and patterns of heat-treatment are extremely consistent. So, although flake tool manufacture was somewhat expedient (i.e., blanks were scavenged from biface production), it was also rather uniform. The pattern suggests that most Tosawihi knappers generally approached flake tool manufacture similarly.

Use

Flake tools at Tosawihi are diverse in function as well as in use intensity. Predictably, given the local abundance of toolstone, more than twice as many miscellaneous retouched tools,

often with more than one suitable working edge, exhibit use on only one edge. Some tool types were used for a single purpose (e.g., all scraper types were used almost exclusively for scraping), some were used for a few (e.g., miscellaneous retouched tools were used for both cutting and scraping), and others for several (e.g., pointed tools were used for scraping, grooving, perforating, boring, and drilling). As discussed above, 20% of a sample of debitage selected from contexts exhibiting great diversity in tool manufacture exhibit evidence of use, suggesting that unretouched flakes were used as tools fairly frequently, primarily for cutting and occasionally for scraping materials of varying hardness.

The following discussions examine function in terms of macroscopic characteristics, in the hope that these may help compare the Tosawihi assemblage to other published collections.

Tool Design and Function

Tool selection and design are related to function (Jones and White 1988), as well as to raw material availability, mechanical properties of available toolstone, and cultural preferences (Close 1979; Sackett 1982). Generally, the highly formalized flake tools at Tosawihi (primarily end-scrapers and symmetrically pointed tools) are very similar in form to those found across the Great Basin, and their form probably was dictated largely by function. Less formalized flake tools appear to have been selected for the suitability of their edges (e.g., straightness of profile, acuteness of angle) for performing specific tasks.

At Tosawihi, tools with convex and concave working edges were used primarily for scraping but also for cutting; straight working edges served equally for scraping and cutting as well as for other functions (Table 36). Tools with irregular working edges and those with more than one used edge were used primarily for scraping and diverse functions (including cutting), while convergent edges (such as those on pointed tools) were used chiefly for scraping and perforating.

Table 36. Edge Shape and Motion of Use of Flake Tools.

Motion of Use	Convex n	Concave n	Straight n	Irregular n	Convergent n	Multiple n	Total	%
Scraping	67	20	33	43	11	10	184	57.32
Cutting	17	5	31	18	2	3	76	23.68
Grooving	-	-	3	1	3	-	7	2.18
Perforating	-	-	4	3	12	-	19	5.92
Boring	-	-	1	1	1	-	3	0.93
Drilling	-	-	2	1	2	-	5	1.56
Chopping	-	-	-	2	-	-	2	0.62
Multiple								0.00
Scraping and Cutting	4	-	2	-	1	2	9	2.80
Scraping and Chopping	-	1	-	1	-	-	2	0.62
Scraping and Perforating	-	-	1	1	-	-	2	0.62
Scraping and Boring	-	-	-	-	1	-	1	0.31
Cutting and Grooving	-	-	-	1	-	-	1	0.31
Drilling and Perforating	-	-	-	-	3	-	3	0.93
Perforating and Boring	-	-	2	-	3	-	5	1.56
Drilling and Grooving	-	-	-	-	1	-	1	0.31
Boring and Drilling	-	-	-	-	1	-	1	0.31
Total	88	26	79	72	41	15	321	
%	27.41	8.10	24.61	22.43	12.77	4.67		

Straight edge profiles, produced by unifacial retouch, dominate all functional categories and may have formed criteria for blank selection; sinuous edges, produced by bifacial retouch,

were used most often for cutting, perforating, and drilling. Tools with different degrees of edge angle also were used differentially. Acute edges were used about equally for scraping and cutting, as well as for perforating, grooving, boring, drilling, and other functions (Table 37). Medium angled edges were used for scraping and, to a lesser degree, for cutting. Obtuse edges were used primarily for scraping, but also for perforating and drilling.

Table 37. Edge Angle and Motion of Use of Flake Tools.

Motion of Use	Acute n	Medium n	Obtuse n	Total
Single Motion				
Scraping	42	67	75	184
Cutting	37	34	5	76
Grooving	2	5	0	7
Perforating	9	5	5	19
Boring	1	2	0	3
Drilling	1	3	1	5
Chopping	1	1	0	2
Multiple motion				
Scraping/cutting	3	4	2	9
Scraping/chopping	0	2	0	2
Boring/perf.	2	1	2	5
Scraping/perf.	1	1	0	2
Perf./cutting/grooving	1	0	0	1
Cutting/grooving	0	1	0	1
Drilling/perf.	0	2	1	3
Grooving/scraping/cutting	0	1	0	1
Scraping/grooving	0	0	1	1
Scraping/boring	0	1	0	1
Drilling/grooving	0	1	0	1
Drilling/boring	0	1	0	1
Indeterminate	62	115	68	245
Unused	5	5	3	13
Unexamined	99	120	63	282
Total	266	372	226	864

Other macroscopic indications of use include the presence of gloss and edge rounding. Intensive use of opalite in certain circumstances creates a macroscopically visible gloss. We produced such gloss experimentally on three scrapers while scraping one deer hide, both in fresh and dry states, for 5 to 10 hours. Macroscopically visible gloss was observed on 13 Tosawihi flake tools, primarily scrapers and miscellaneous retouched tools (Tables 38, 39). Five were used for scraping, two for cutting, and one for multiple tasks.

Table 38. Presence of Gloss on Flake Tool Types.

Flake Tool Type	Presence of Gloss n	Total	%
Side Scraper	2	39	5.13
End Scraper	4	97	4.12
Notch/Denticulate	1	66	1.52
Biface w/straight profile	1	6	16.67
Flake w/cont. retouch (one edge)	1	109	0.92
Flake w/cont. retouch (mult. edges)	1	30	3.33
Flake w/variable ret. pattern (mult. edges)	1	61	1.64
Microdenticulate	1	7	14.29
Fragmentary Indeterminate	1	93	1.08
Total	13	508	2.56

Table 39. Presence of Microscopic Gloss Relative to Motion of Use on Flake Tools.

Motion	Presence of Gloss n
Unexamined	2
Scraping	5
Cutting	2
Grooving scraping/cutting	1
Indeterminate motion	3
Total	13

Nine specimens with gloss also exhibit macroscopic rounding, another indication of intensive use (Table 40). Rounding, recorded as light, moderate, or heavy, was observed more often than macroscopic gloss. Our own experiments demonstrate that rounding can be produced by both scraping and cutting. At Tosawihi, macroscopic edge rounding is found on a wider range of tool types than is gloss; they include scrapers, pointed tools, bifacial tools, and miscellaneous retouched tools. Most rounding is light, less is moderate, and on a small number of tools it is heavy. Thus, few Tosawihi flake tools evidence very intensive use.

Table 40. Edge Rounding on Flake Tool Types.

Flake Tool Type	Light n	Medium n	Heavy n	Absent n	Total	%
Side Scraper	7	1	-	31	39	4.51
End Scraper	7	4	1	85	97	11.23
Misc. Scraper	2	-	-	50	52	6.02
Symmetrical Pointed Tool (elong)	1	-	-	55	56	6.48
Symmetrical Pointed Tool (short)	4	-	-	18	22	2.55
Asymmetrical Pointed Tool	1	-	-	27	28	3.24
Trihedral Pointed Tool	-	-	-	5	5	0.58
Notch/Denticulate	3	-	-	63	66	7.64
Biface w/straight profile	2	-	-	4	6	0.69
Biface w/slightly sinuous profile	2	-	-	12	14	1.62
Biface w/coarse sinuous profile	-	-	-	4	4	0.46
Flake w/cont. retouch (one edge)	7	2	1	99	109	12.62
Flake w/cont. retouch (mult. edges)	1	-	-	29	30	3.47
Flake w/localized retouch	7	-	-	99	106	12.27
Crudely retouched flake/chunk	-	-	-	14	14	1.62
Flake w/variable ret. pattern (mult. edges)	9	-	-	52	61	7.06
Microdenticulate	-	-	-	7	7	0.81
Discoidal tool	-	1	1	8	10	1.16
Pressure flaked tool fragment	-	-	-	28	28	3.24
Fragmentary Indeterminate	2	-	-	91	93	10.76
Chopping Tool/Hammer	-	1	-	11	12	1.39
Other	1	-	-	4	5	0.58
Total	56	9	3	796	864	
%	6.48	1.04	0.35	92.13		

We also examined macroscopic red staining on flake tools, but it remains unclear if and how it relates to use. Such staining has been noted elsewhere in the Great Basin; at James Creek Shelter it is associated with scraping (Elston and Budy 1990), while at Gatecliff Shelter, various tools were stained with what was identified as red ochre (Thomas 1983b). Of the flake tools at Gatecliff, however, only a scraper plane and a perforator were stained. At Kramer Cave in Western Nevada, red ochre was found on the hafts of flaked obsidian objects used as pendants (Hughes and Bennyhoff 1986). At several sites in Idaho, red ochre staining has been noted on stone tools recovered from burials (Pavesic 1985).

Red ochre has been associated with hide-working in the Old World Paleolithic (Rosenfeld 1971; Leroi-Gourhan and Brézillon 1972; Audoin and Plisson 1982), but its purpose is debated; insecticidal, preservative, and aesthetic reasons all have been cited (Keeley 1980). An additional explanation for the occurrence of red ochre on the non-working surfaces of stone tools involves its possible use as a hafting temper (Buller 1988; Beyries 1983). At Tosawihi, red staining was noted primarily on the working edges of scrapers (54% of red stained pieces) and miscellaneous retouched tools (31% of red stained pieces; cf. Table 31, Figure 50). Six of seven stained scrapers were used for scraping, whereas only one of four miscellaneous retouched pieces definitely was used for cutting (Table 41). Unidentified stained retouched flakes are of indeterminate function, as is the single example of a stained pointed tool.

Table 41. Frequency of Red Staining by Motion of Use on Flake Tools.

Motion	Presence of Staining n
Unexamined	1
Scraping	6
Cutting	1
Indeterminate function	5
Total	13

Edge Maintenance

Only scrapers exhibit unequivocal evidence of edge maintenance; approximately one-third of them have short, stepped terminations around the working edge. This type of fracture can be produced by hafted scrapers, but it also can be caused by original retouching tool or by heavy use on rather hard materials (Broadbent and Knutsson 1975).

Curation and Expediency

Curated tools are transported from their location of manufacture with the expectation of future use, while *expedient* tools are produced, used, and discarded at the same locus. The possibility that some obsidian tools were brought to Tosawihi in finished form has been noted above; obsidian wears down quite quickly, however, so it is difficult to identify which tools may have been most highly curated. The issue is less ambiguous for opalite tools. Based on a number of macroscopic and microscopic variables reflecting intensity of use (including edge rounding and macroscopic gloss, number of used edges, and degree of polish development), analyzed tools were

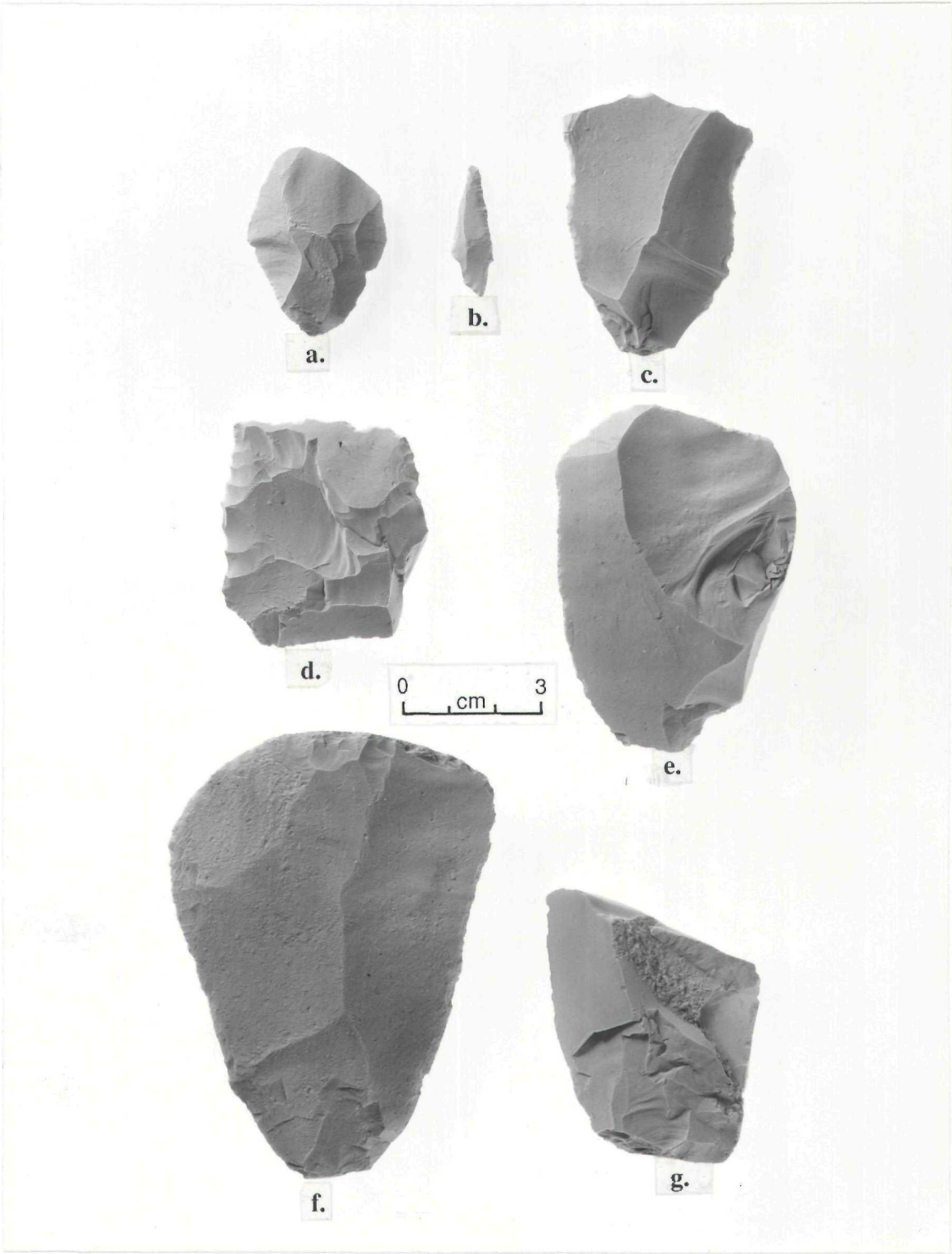


Figure 50. Tools with red staining. a,c. miscellaneous retouched tools; b. symmetrically pointed tool; d. bifacial tool; e,f,g. scrapers.

sorted into classes of light, moderate, or heavy use. The number of tools in each class was weighted, summed, and divided by the total, producing an index. An intensity-of-use-index was assigned each tool type (Table 42) and each site (Table 43); the higher the index, the more intensive the flake tool use at that site or of that tool type. This index measures only relative, not absolute, intensity. Types and sites exhibiting greatest intensity of use are those which contain the most highly curated tools and/or those used to work harder materials.

Table 42 reveals that microdenticulates and bifacial tools with straight and slightly sinuous edges exhibit greatest intensity of use, while retouched flakes with localized retouch, notches, and denticulates exhibit least. Most other tools fall between; scrapers, pointed tools, and most miscellaneous retouched types differ only subtly.

Table 42. Intensity of Use by Flake Tool Type.

Flake Tool Type	Weighted Score	n	Intensity Index
Side scraper	95	28	3.4
End scraper	240	69	3.5
Misc. scraper/fragment	94	25	3.8
Sym. pointed tool (elong.)	135	37	3.6
Sym. pointed tool (short)	37	11	3.7
Assym. pointed tool	60	17	3.5
Notched/denticulate	130	39	3.3
Bifacial w/straight profile	20	5	4.0
Bif. w/slightly sinuous profile	24	6	4.0
Flake w/cont. retouch/single edge	123	36	3.4
Flake w/cont. retouch mult. edge	55	15	3.6
Flake w/localized retouch	58	24	2.1
Flake w/var. ret. patt. (mult. edges)	70	19	3.7
Microdenticulate	20	5	4.0

Excluding sites with small samples of flake tools, quarries (such as Localities 19 and 20) score lower than more residential places (such as Locality 27). Taken together, tools at quarries exhibit a similar or slightly lower level of use intensity than at larger sites in the East, levels which are slightly lower than that of the largest sites in the West and North (Table 43). This suggests that certain tool-using activities of longer duration were undertaken more often at non-quarry sites removed from the quarry proper.

There is some evidence for the expedient *manufacture* of flake tools. Blanks frequently were selected from debitage produced in early stage biface manufacture rather than from flake cores. Selection of blanks, however, was not random; certain characteristics were favored and pieces exhibiting, for example, straight edges and straight profiles were chosen for making flake tools. There seems to be little correlation between tool type or function and heat-treatment, and only a weak correlation between heat-treatment and pressure flaking. On the other hand, we find little evidence reflecting the expedient use of most tools; rather, most tools in most tool classes exhibit moderate use intensity. With the exception of miscellaneous retouched tools with localized retouch, the intensity of use on most miscellaneous retouched tools is roughly equivalent to that on scrapers and pointed tools, despite a small number of scrapers and pointed tools that display a far greater use intensity than most. Unretouched pieces from the debitage sample exhibit a lower intensity of use, but this merely may reflect their suitability for short-term rather than "expedient" use.

Table 43. Intensity of Flake Tool Use by Site.

Subarea	Site/Locality	Weighted Score	n	Intensity Index
Quarry	26Ek3032/L19	43	13	3.3
	L20	10	3	3.3
	L21	0	0	0
	L22	0	0	0
	L23	35	10	3.5
	L25	17	5	3.4
	L26	0	0	0
	L27	47	13	3.6
	L98	0	0	0
East	230	0	0	0
	123	4	1	4
	26Ek3170	54	16	3.4
	26Ek3171	12	4	3
	26Ek3173	8	2	4
	26Ek3179	2	1	2
	26Ek3184	100	28	3.6
	26Ek3185	34	10	3.4
	26Ek3190	15	5	3
	26Ek3191	0	0	0
	26Ek3192	117	34	3.4
	26Ek3193	0	0	0
	26Ek3195	8	2	4
	26Ek3196	6	2	3
	26Ek3197	0	0	0
	26Ek3198	21	7	3
	26Ek3200	4	1	4
	26Ek3204	37	10	3.7
West	26Ek3084	4	1	4
	26Ek3086	8	2	4
	26Ek3088	4	1	4
	26Ek3090	4	1	4
	26Ek3092	172	49	3.5
	26Ek3093	6	2	3
	26Ek3095	88	26	3.4
	26Ek3101	4	1	4
	26Ek3102	0	0	0
	26Ek3106	4	1	4
	26Ek3114	4	1	4
	26Ek3115	12	3	4
	26Ek3116	22	6	3.7
	26Ek3149	8	2	4
	26Ek3160	121	33	3.7
	26Ek3165	12	3	4
	26Ek3208	0	0	0
	26Ek3271	78	20	3.9
North	26Ek3234	23	6	3.8
	26Ek3238	4	1	4
	26Ek3239	0	0	0
	26Ek3251	37	10	3.7

Distribution

The distribution of flake tools in the project area is essentially a reflection of discard practices, variously induced. Tools broken in manufacture, use, and resharpening, as well as those used expediently, probably were discarded in their area of final use in most cases. On the other hand, heavily curated tools and hafted tools may have been discarded in areas where they were repaired rather than where they were used. Only a small proportion of pieces from each tool type appear to have been broken in manufacture. Since only a minority of tools were hafted or heavily curated, most pieces in the assemblage probably were discarded near their area of final use. If we assume that most tools were discarded near where they were used, the co-occurrence of types at particular sites, the diversity of assemblages, and their contextual distribution may inform us of site-specific activities.

Co-occurrence of Types within Site Assemblages

When correlation coefficients are calculated for morphological types and functional types on a site by site basis, the general patterns of each (Table 44) suggest the following:

- Scrapers correlate strongly with the incidence of miscellaneous retouched tools. They are used for both cutting and scraping so we examined correlations between motions of use (functional types). Were cutting and scraping *not* highly correlated, we would have inferred an association between scrapers and only those miscellaneous retouched tools used for scraping (but not for cutting). However, when these actually are calculated, scraping and cutting are the only strongly correlated motions of use.

- Notched and denticulate tools, most often used for scraping, often are found at quarries, and are not statistically associated (Pearson's correlation coefficient) with other tool types. They may reflect maintenance of quarry-related tools such as antler wedges, digging sticks and such.

- Pointed tools are associated with unidentifiable pressure flaked tool fragments, suggesting that at least some of the latter may be pointed tool fragments broken in manufacture or use.

- Symmetrically pointed tools, used for a variety of functions, are found with end-scrapers and with asymmetrically pointed tools, but not with side-scrapers or miscellaneous scrapers.

- Scraper types correlate weakly with each other and miscellaneous retouched tool types correlate strongly with each other, while pointed tool types are less internally correlated than either group. Either the morphological distinctions between scrapers and miscellaneous retouched tools do not reflect functional differences, or each type was used in specialized but related tasks.

Table 44. Flake Tool Diversity by Site.

Subarea	Site/Locality	High	Moderate	Low	No. of Classes	No. of Tools
Quarry	Loc. 19		x		11	6
	Loc. 20			x	5	6
	Loc. 21			x	2	2
	Loc. 22			x	1	1
	Loc. 23			x	10	26
	Loc. 25	x			10	13
	Loc. 26			x	1	1
	Loc. 27	x			14	35
	Loc. 98			x	1	1
East	123 (DSC)		x		2	2
	230 (DSC)			x	1	1
	311 (DSC)		x		2	2
	26Ek3093		x		3	3
	26Ek3170	x			14	46
	26Ek3171	x			10	16
	26Ek3173		x		4	4
	26Ek3179		x		3	3
	26Ek3181			x	3	5
	26Ek3184		x		14	76
	26Ek3185			x	8	13
	26Ek3190	x			9	17
	26Ek3191			x	4	5
	26Ek3192		x		15	69
	26Ek3193			x	1	1
	26Ek3195			x	3	4
	26Ek3196			x	2	3
	26Ek3197			x	1	1
	26Ek3198			x	8	13
	26Ek3200			x	1	1
	26Ek3201			x	1	1
	26Ek3204	x			12	21
West	26Ek3084			x	2	3
	26Ek3086		x		2	2
	26Ek3088			x	1	1
	26Ek3090			x	1	1
	26Ek3092	x			20	147
	26Ek3095		x		13	59
	26Ek3101		x		3	3
	26Ek3102			x	1	1
	26Ek3106			x	2	3
	26Ek3114		x		2	2
	26Ek3115			x	3	4
	26Ek3116			x	6	8
	26Ek3149			x	3	4
	26Ek3160	x			18	83
	26Ek3165			x	6	10
	26Ek3208		x		3	3
	26Ek3271	x			16	44
North	26Ek3237	x			13	28
	26Ek3238			x	1	1
	26Ek3239		x		4	4
	26Ek3251			x	10	38

Assemblage Diversity

Assemblage diversity often has been shown to be a function of sample size (Jones, Beck, and Grayson 1989); that is, large assemblages almost always display larger numbers of artifact classes than small ones. For the sites at Tosawihi from which flake tools were recovered, the number of tool classes was plotted against the logged number of specimens and a regression line fit to the distribution; lines delimiting a confidence interval of 0.95 were plotted as well (Figure 51). Sites falling above the regression line have a high tool diversity relative to sample size; those below the line have less diversity, or exhibit more specialized activity. Table 44 classifies sites according to high, moderate, and low diversity. It appears that large residential sites were loci of diverse but perhaps not very intensive activities, while smaller sites (including many reduction stations) witnessed a narrow range of perhaps more intensive activities (Table 45).

The flake tool assemblage from a site (26Ek3251) in the Northern Corridor does not fit the pattern described above. It is a large site, with relatively large numbers of flake tools (38), points (45), and preforms (63). Its low flake tool diversity suggests that it may reflect an intensive but limited range of activities, thus differing from most other large sites in the project area.

Table 45. Sites Arrayed in Order of Decreasing Number of Flake Tool Classes.

Site	No. of Tool Classes Present	Site	No. of Tool Classes Present
26Ek3092	20	26Ek3093	3
26Ek3160	18	26Ek3101	3
26Ek3271	16	26Ek3115	3
26Ek3192	15	26Ek3149	3
26Ek3184	14	26Ek3179	3
26Ek3170	14	26Ek3181	3
26Ek3032 L27	14	26Ek3195	3
26Ek3095	13	26Ek3208	3
26Ek3237	13	123 (DSC)	2
26Ek3204	12	311 (DSC)	2
26Ek3032 L19	11	26Ek3032 L21	2
26Ek3032 L23	10	26Ek3086	2
26Ek3032 L25	10	26Ek3106	2
26Ek3171	10	26Ek3114	2
26Ek3251	10	26Ek3196	2
26Ek3190	9	26Ek3084	2
26Ek3198	8	230 (DSC)	1
26Ek3185	8	26Ek3032 L22	1
26Ek3165	6	26Ek3032 L26	1
26Ek3116	6	26Ek3032 L98	1
26Ek3032 L20	5	26Ek3088	1
26Ek3173	4	26Ek3090	1
26Ek3191	4	26Ek3102	1
26Ek3239	4	26Ek3193	1
		26Ek3197	1
		26Ek3200	1
		26Ek3201	1
		26Ek3238	1

Contextual Distribution of Flake Tools

Various contextual distributions (i.e., surface vs. sub-surface, feature vs. non feature, residential vs. non-residential) of major tool groups were compared; the data are presented in Tables 46-48. Adjusted standardized residuals (Everitt 1977) were calculated, and statistically statistically significant associations noted on the tables. Since surface materials were collected

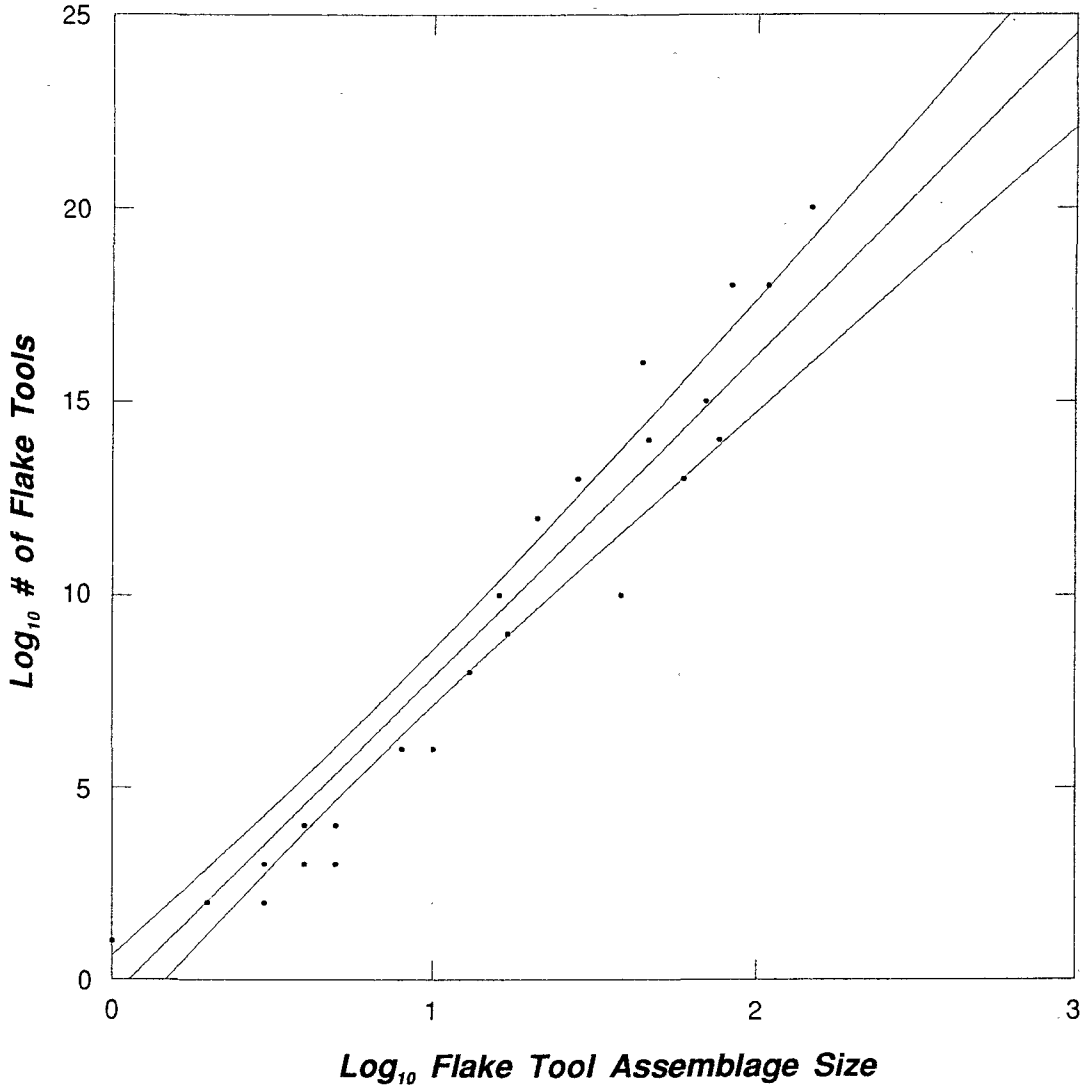


Figure 51. Flake tool assemblage diversity (logged).

from every site, and since formal tools and larger, more complete ones were recognized more easily and collected more often, surface samples contain high proportions of formed tools; subsurface samples contain a lower proportion of fragmentary tools.

Table 46. Incidence of Surface vs. Subsurface Flake Tools by Subarea.

	NORTH		EAST		WEST		QUARRY		TOTAL	
	n	%	n	%	n	%	n	%	n	%
SURFACE FLAKE TOOLS										
Scrapers	10	0.43	21	0.40	19	0.23	6	0.43	56	0.32*
Pointed	7	0.30	6	0.11	24	0.29	3	0.21	40	0.23*
Misc. Retouch	2	0.09	18	0.35	23	0.28	4	0.29	47	0.27*
Notch	1	0.04	4	0.08	5	0.06	1	0.07	11	0.06*
Fragment	2	0.09	1	0.02	8	0.10	0	0	11	0.06
Press	1	0.04	2	0.04	4	0.05	0	0	7	0.04
Total	23		52		83		14		172	
SUBSURFACE FLAKE TOOLS										
Scrapers	2	0.04	65	0.28	47	0.18	18	0.22	132	0.21*
Pointed	10	0.22	23	0.10	28	0.11	9	0.11	70	0.11*
Misc. Retouch	13	0.29	97	0.41	126	0.48	23	0.29	259	0.42*
Notch	2	0.04	15	0.07	18	0.07	20	0.25	55	0.09*
Fragment	15	0.33	27	0.12	32	0.12	8	0.10	82	0.13
Press	3	0.07	5	0.02	11	0.04	2	0.02	21	0.03
Total	45		232		262		80		619	

*Indicates types with statistically significant differences.

Table 47. Incidence of Feature vs. Non-feature Flake Tools by Subarea.

	NORTH		EAST		WEST		QUARRY		TOTAL	
	n	%	n	%	n	%	n	%	n	%
FEATURE FLAKE TOOLS										
Scrapers	3	0.08	69	0.29	33	0.20	15	0.23	120	0.24
Pointed	8	0.22	22	0.09	22	0.13	7	0.11	59	0.12*
Misc. Retouch	8	0.22	101	0.43	73	0.43	20	0.31	202	0.40
Notch	1	0.03	17	0.07	15	0.08	16	0.25	49	0.09
Fragment	14	0.39	24	0.10	21	0.12	5	0.08	64	0.13
Press	2	0.06	4	0.02	4	0.02	2	0.03	12	0.02*
Total	36		237		168		65		506	
NON-FEATURE FLAKE TOOLS										
Scrapers	8	0.26	17	0.36	33	0.19	9	0.30	67	0.23
Pointed	9	0.29	7	0.15	30	0.17	6	0.20	52	0.18*
Misc. Retouch	7	0.22	14	0.30	76	0.43	7	0.23	104	0.36
Notch	2	0.06	2	0.04	8	0.05	5	0.17	17	0.06
Fragment	3	0.10	4	0.08	19	0.11	3	0.10	29	0.10
Press	2	0.06	3	0.06	11	0.06	0	0	16	0.06*
Total	31		47		177		30		285	

*Indicates types with statistically significant differences.

Table 48. Incidence of Flake Tools in Residential and Non-residential Contexts by Subarea.

	NORTH		EAST		WEST		QUARRY		TOTAL	
	n	%	n	%	n	%	n	%	n	%
NON-RESIDENTIAL FLAKE TOOLS										
Scrapers	1	1	67	0.31	14	0.44	15	0.23	97	0.31
Pointed	0	0	17	0.08	6	0.19	7	0.11	30	0.10*
Misc. Retouch	0	0	90	0.43	10	0.31	20	0.31	120	0.40
Notch	0	0	10	0.05	1	0.03	16	0.25	27	0.09
Fragment	0	0	21	0.10	1	0.03	5	0.08	27	0.09*
Press	0	0	6	0.03	0	0	2	0.03	8	0.02
Total	1		211		32		65		309	
RESIDENTIAL FLAKE TOOLS										
Scrapers	11	0.16	19	0.26	52	0.18	9	0.31	91	0.19
Pointed	17	0.25	12	0.16	17	0.06	5	0.17	51	0.11*
Misc. Retouch	15	0.22	25	0.34	139	0.49	7	0.24	186	0.40
Notch	3	0.04	9	0.12	22	0.08	5	0.17	39	0.08
Fragment	17	0.25	7	0.09	39	0.14	3	0.1	66	0.14*
Press	4	0.06	1	0.01	15	0.05	0	0	20	0.04
Total	67		73		284		29		453	

*Indicates types with statistically significant differences.

Late projectile points were found more often in feature than in non-feature contexts, suggesting that earlier features have become dispersed while later ones are more intact and can be defined on the ground. This is supported by differences in hydration rind thicknesses on obsidian artifacts from feature and non-feature contexts (cf. Chapter 19), but here the difference might owe equally to varying patterns of site use and point discard. Among flake tools, pointed tools (one of the smaller and most frequently pressure flaked tool groups) and pressure flaked tool fragments are associated positively with non-feature contexts.

When apparently residential and non-residential sites are compared, differences among proportions of flake tools types are evident. Assemblages from "non-residential" sites (Elston and Budy 1990) exhibit a much larger proportion of scrapers (31% as opposed to 19%); fragmentary tools and pressure flaked tool fragments are more common at "residential" sites. Differences among other tool classes in the two contexts do not differ significantly. If several of the large sites with large flake tool inventories from the Eastern Periphery, originally thought to be primarily reduction stations, are considered residential, differences in assemblages become more pronounced; scrapers still dominate at non-residential sites, but we find an increased proportion of miscellaneous retouched tools at residential sites.

In sum, the Eastern Periphery dominates the non-residential sample and the Western Periphery dominates the residential sample, but it is clear that the East hosts proportionally a greater number of scrapers than the West. It is clear as well that notches and denticulates are most common in the Quarry sub-area, and fragmentary tools (as well as a high proportion of pointed tools) prevail in the North; miscellaneous retouched tools are found everywhere. Some implications of these patterns are discussed in subsequent chapters.

Chapter 8

PROJECTILE POINTS AND PREFORMS

Kathryn Ataman and Michael P. Drews

This chapter describes the chronological, morphological, technological, and functional characteristics of the projectile points and preforms recovered from Tosawihi. For the purposes of this study, preforms are defined as flakes discarded during the process of being made into smaller projectile points. Preforms for larger points often are indistinguishable from small knives or small knife preforms; for this reason, such pieces have been included under the more general grouping of small bifaces. The differences between large preforms and small knives are discussed in more detail in Chapter 21. Distinctions between preforms and points were made on the basis of degree of finishing and certain key morphological attributes. The research questions to be addressed by projectile points and preforms involve chronology, technology, and the characterization of feature-specific activity areas. All have implications concerning the nature of prehistoric exploitation of the quarries.

Research Questions

Chronology

Projectile points have proven useful temporal indicators in the western and central Great Basin (Heizer and Baumhoff 1961; Heizer and Hester 1978; O'Connell 1967; Clewlow 1967; Thomas 1971, 1981). As such, they help constrain the age of deposits in which they are found. The relative dating they provide can be used to construct local chronologies of sites and features as well as to date associated geological strata. They also provide frameworks in which to analyze temporal variation in technology, intensity of use, subsistence, mobility, and stylistic change. The chronological discussions here are descriptive, relating to specific point types and their suggested temporal ranges. A chronological synthesis is presented in Chapter 19.

Several researchers (Flenniken 1985; Flenniken and Raymond 1986; Titmus and Woods 1986; Flenniken and Wilke 1989) question the validity of the currently accepted Great Basin projectile point sequence, suggesting that breakage and subsequent modification produce morphological variation sufficient to render many types poor temporal indicators. A relatively large projectile point assemblage (402 specimens) allowed us to examine breakage patterns and instances of reworking in the interest of addressing this issue.

C14 dating and obsidian hydration readings are relatively accurate indicators of chronological age; together with patterns of post-production modification, they allow us to assess the general validity of the typological scheme. Preforms provide less specific chronological information, but, to a degree, relative size may prove a useful chronological index.

Technology

Projectile points and preforms enter the archaeological record variously, and evidence of their manufacture, use, reworking, retooling, and discard have implications concerning the logistical organization of prehistoric groups. Several levels of technological organization may be reflected in an assemblage; too, projectile points may elucidate variations in group and technological patterns from one period to another.

We should expect projectile point manufacture to have occurred at Tosawihi. Manufacture alone requires little more than incidental or diurnal visits to the quarry, and the projectile point assemblage should be dominated by pressure flakes, broken, discarded preforms, and unfinished points broken in manufacture. If field camps or more logistically organized forays were required to exploit the toolstone resource, then coincidental activities such as hunting and processing might be expected. Use wear analysis and breakage patterns should reflect this, with high incidences of macroscopic and microscopic impact damage.

Evidence of reworking or redirection of broken artifacts may indicate another level of logistical organization. Thomas (1983b) suggests that tool maintenance, redirection, and discard probably are associated with long term, seasonal occupation. Evidence of post-production modification, resharpening, edge repair, redirection, or discard may signal more intensive, well planned exploitation.

Since only scant faunal material helps reconstruct Tosawihi subsistence activities, distinctions between manufacture and use of points may contribute to our understanding of subsistence. In addition, manufacturing and use wear data provide insights into the organization of lithic production. We wanted to know at what types of site (quarries, kill sites/butchering localities, or residential bases) projectile points were produced, reworked, or discarded.

Characterization of Specific Activity Areas

Data on the manufacture and function of projectile points and preforms can be used to characterize specific activity areas. Specimens broken during manufacture are unlikely to have been transported around the landscape and probably were discarded at or near their place of production. Likewise, points lost or irreparably broken during hunting should be discarded near capture or processing locales. Thus, unlike other classes of broken tools which may have been produced in one place, used in another, and discarded in a third, preforms, broken points, and pressure flakes can be assumed to reflect *in situ* or nearly *in situ* activities.

Analytical Methods

Typology

Typological criteria and temporal constraints employed in this analysis follow those outlined by Thomas (1981). This system assigns projectile points to temporal series on the basis of morphological observations including length, width, thickness, weight, basal width, and notch angles. In this scheme, the "series is the time-bearing unit and the type is merely a morphological modifier" (Thomas 1981:160). Chronological and morphological attributes for the Great Basin Stemmed Series, not addressed by Thomas (1981), follow Layton (1979), Clewlow (1968) and Frison (1978). Elston and Budy (1990), using radiocarbon dated deposits at James Creek Shelter, have developed a regional chronology for the Upper Humboldt Valley; phase names and chronological sequences throughout this chapter refer to their chronology.

Technological and Functional Analysis

In recent years considerable research has focused on the manufacture and use of projectile points. These studies have taken a variety of forms, most using typological schemes

as a broad research framework. For example, some studies have used functional and technological analyses to distinguish points tipping thrusting spears, atlatls, and arrows (Thomas 1978; Holmer 1986). Our analysis employs a similar typological framework, but examines manufacturing techniques, as well as evidence of use, to address technological and functional variability within the assemblage.

Technological Variability

Manufacturing stages of various projectile points types are investigated by contrasting them with a variety of other artifact classes. Attributes of projectile points and preforms such as general morphology, flake scar patterns, and heat-treatment are compared to those of small bifaces, and reduction sequences then are proposed. This allows us to consider associations between these artifact classes and the debitage associated with point manufacture.

The presence of diagnostic manufacturing debris such as notching flakes (Titmus 1985), pressure flakes, and other characteristic debitage associated with broken point fragments should indicate whether the entire manufacturing sequence is represented. If no point fragments are present, production debris *may* suggest the possible range of point types manufactured.

Manufacturing failures, such as notching failure or (as in the case of our single Clovis preform) fluting failure, can be recognized as well. The presence of failed points, especially when associated with broken preforms and pressure debitage, provide evidence for on-site point manufacture. Stages of preform manufacture have been used to examine the organization and standardization of production. Other variables used to compare points and preforms include the orientation of tips on blanks, the types of blank used, the general shape of preforms as opposed to finished points, and the incidence and stage of heat-treatment.

Functional Analysis

Numerous studies have concentrated on distinguishing manufacture-induced breakage from use-related damage (Barton and Bergman 1982; Miller 1982; Bergman and Newcomer 1983; Fischer et al. 1984; Odell and Cowan 1986; Ataman 1986). Distinctive breakage types have been established through experimental replication and use of replicated pieces as atlatl darts, points for thrusting spears, and arrowpoints. Diagnostic and non-diagnostic breakage patterns have been produced in a variety of materials on a number of different point types. Although breakage, proportions of fracture types, and amount of fragmentation vary, these characteristic fractures reflect utilization of points as projectiles.

Several fracture types were observed at Tosawihi; they are illustrated in Figure 52. Snap fractures are bending fractures, produced during manufacture, in use, or post-depositionally. Fluting fractures are narrow, elongated impact fractures running parallel to the axis of the point; they initiate either at tip or base, or at snap fractures in the center of the point. Another fluting fracture is caused by rebound in the haft as a result of impact (usually contact with bone), and is signalled by the presence of extensive step-like fractures initiating from a snap fracture. Burin-like fractures also are diagnostic of impact; they remove a flake from the edge of a point resembling the facet on an angle burin. Burin-like fractures may be initiated from the tip, the base, or a break at the center of the point.

Several researchers have suggested alternative or multiple uses for artifacts classified as projectiles points (Ahler 1971; Greiser 1977; Zeir 1978; Wheat 1979; Woods 1986), including their use as knives. In order to identify wear associated with alternate use, projectile points were examined microscopically. This finer level of examination allowed us to observe polish and

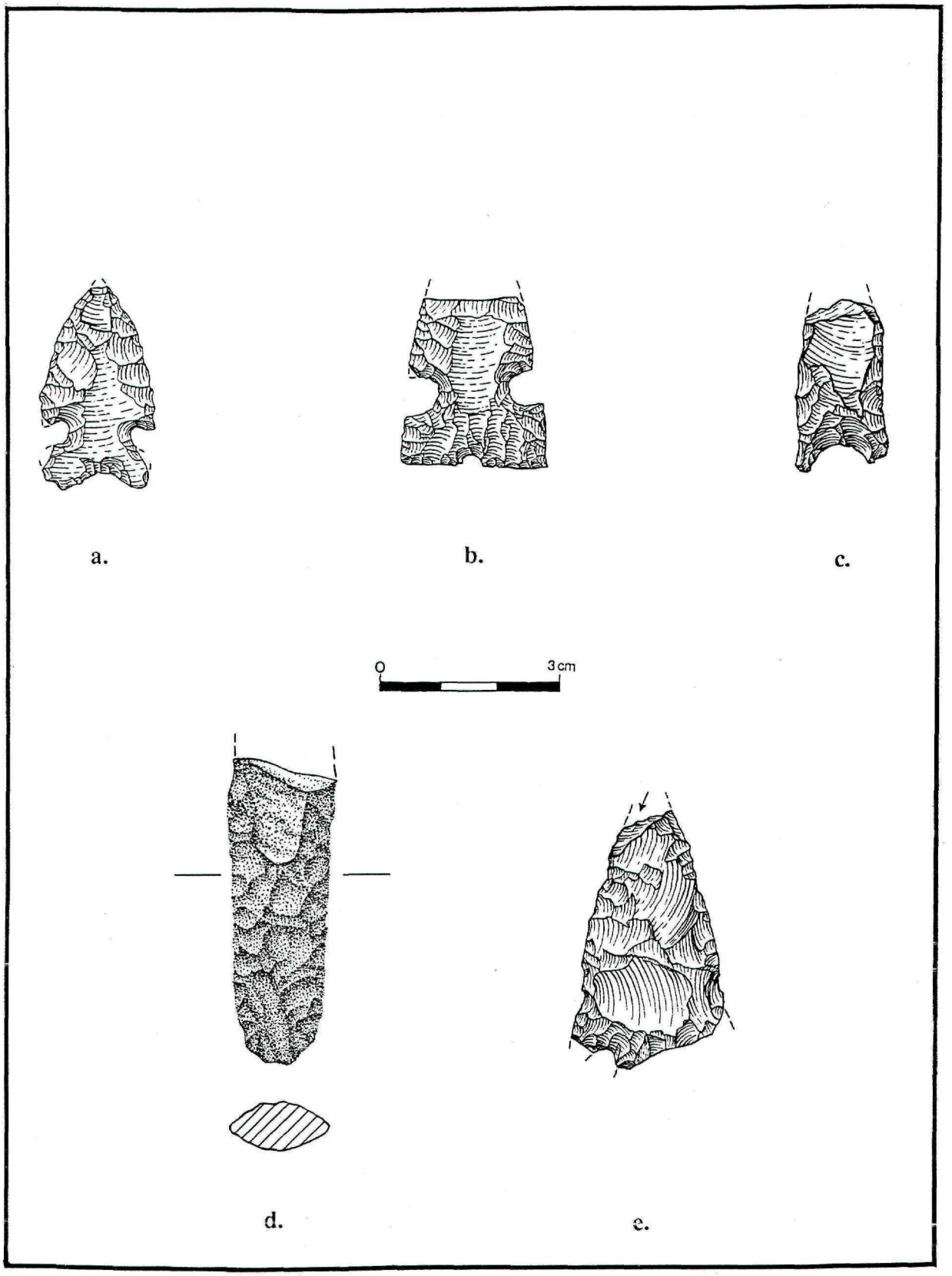


Figure 52. Fracture types on selected Tosawihi projectile points. a. fluting fracture; b. snap fracture; c,d. snap and fluting fracture; e. burin-like fracture.

striations on tool surfaces and correlate type of wear with a range of activities. The models used for identification of diagnostic features are based on experimental replication and simulated use (Nance 1971; Moss and Newcomer 1982; Fischer et al. 1984; Ataman 1986). A more detailed discussion of methods of microscopic analysis is presented in Chapter 7.

Additional to projectile points, a sample of preforms was examined for use wear traces to determine whether they might have served as finished tools. Forty-two specimens were selected, primarily complete or substantially complete pieces. Using methods similar to those described above, they were examined for the presence of macroscopic and microscopic fractures, polish, and striations indicative of use.

Data Collection Methods

Provenience, metric attributes, raw material, and thermal alteration of projectile points and preforms were recorded, and refitted pieces were logged as single specimens. Variables recorded during analysis included blank type, tip orientation, fragment type, breakage pattern, and stage of manufacture. Microscopic wear traces were recorded by the presence or absence of characteristic micro-fractures, micro-rounding, polish, and linear features or striations.

Blank types were sorted into biface thinning flakes, other blank types, or indeterminate specimens. Orientation of the point tip on the blank was attempted, but extensive pressure flaking often made this difficult. Fragment types were recorded as complete, tang or barb, stem or base, tip missing, midsection, tip, base missing, lateral fragment, barb or tang missing, or indeterminate. Breakage patterns were recorded as snap fractures, fluting fractures, burin-like fractures, haft rebounds, notch failures, other manufacturing failures, combination fractures, and indeterminate types. Stage of manufacture was recorded for preforms in a system paralleling that used for bifaces (i.e., edge preparation, primary thinning, secondary thinning, and finishing). Evidence of reworking was recognized by asymmetrical form, work on a break, non-standard form, or a localized flaking pattern not conforming to that on the rest of the point. The incidence of reworking probably is greater than indicated in our data since it is not always possible to recognize such modification on symmetrical forms.

Results

Projectile Points

The projectile point assemblage consists of 402 complete points and fragments from the Tosawihi vicinity. The assemblage exhibits a wide temporal range, providing evidence for an extremely long period of human exploitation of the quarry area. This section describes the assemblage by type, employing the typological criteria advanced by Thomas (1981), and discusses raw material preference, size, and breakage characteristics.

Clovis Preform

Our single Clovis preform consists of large basal fragment measuring 101.6 mm x 65.4 mm x 12.8 mm. It weighs 108.7 gms and approximates one-half of the intact length of the artifact (Figure 53). It was manufactured from moderate brown (5YR 4/4 Munsell Rock) to yellowish brown (10YR 5/4 Munsell Soil) local chert. Its lateral margins are percussion flaked;

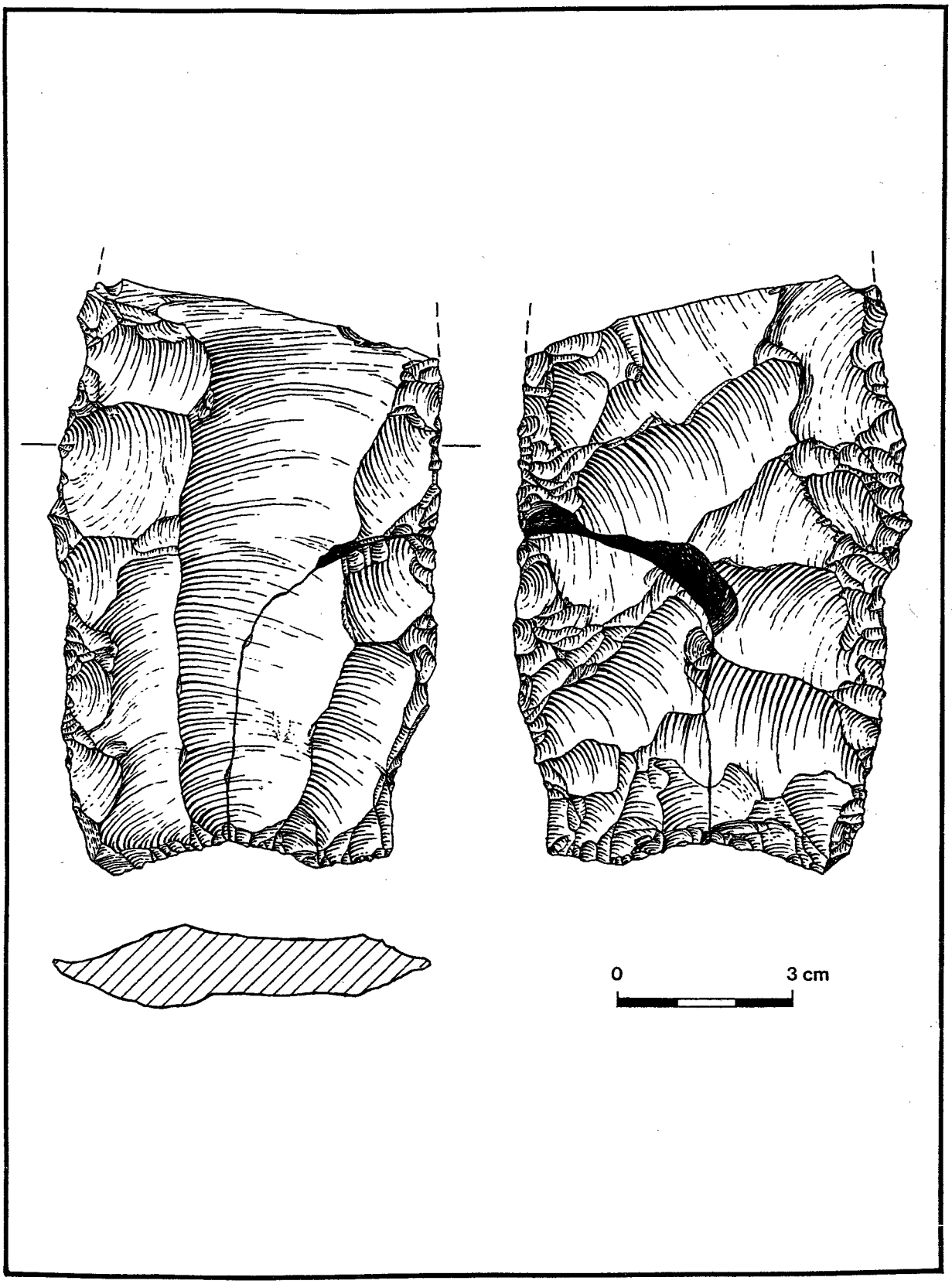


Figure 53. Clovis preform.

they exhibit very light grinding, probably related to platform preparation. The base is broadly concave. Three elongated thinning flakes were detached from the proximal end of one face. The two peripheral removals were intended to set up the preform for detachment of the central flute. The use of this sequence of flake removals, known as the "Enterline technique" (Witthoft 1952) has been noted in many Clovis industries and is often found when, as in the case of our example, successful biface thinning has resulted in a flattened rather than lenticular cross-section. The fluting attempt failed, plunging and resulting in a hinged termination. This proximal fragment, which measure 101.1 mm in length, represents 1/2 to 2/3 of the original preform. It is broken in two pieces, the fracture runs up from the center of the base, terminating in the center of a lateral edge, and could have been produced by the same blow which broke the preform.

Clovis points are widely distributed in North America, making their appearance, dispersal, and disappearance between 9500 and 9000 B.C. (Haynes 1964). Isolated Clovis and Clovis-like points are found throughout California and the Great Basin (Campbell and Campbell 1935; Shutler and Shutler 1959; Davis and Shutler 1969; Tuohy 1968, 1985). The Dietz Site, in the extreme northwestern portion of the Great Basin, has yielded the largest Clovis assemblage in the western United States (Fagan 1984). Clovis localities usually are associated with extinct low beach terraces or sluggish streams feeding pluvial lakes; ideal watering places for extinct big game species (Davis and Shutler 1969; Tuohy 1974).

The Tosawihi Clovis point was recovered from 26Ek3237 on Ivanhoe Creek. The site is stratigraphically superior to a Mazama ash layer exposed in stream cutbanks, suggesting a post-6800 B.P. date. It is uncertain whether the point represents a later manifestation of Clovis fluting technology or merely a highly curated form. Regardless, it is of local manufacture, and suggests that use of the Tosawihi opalite source may have considerable antiquity.

Great Basin Stemmed Series

Great Basin Stemmed points are long, shouldered forms, with square to contracting bases. Edge grinding along the stem and basal margins is a common and diagnostic trait. The series combines Cougar Mountain and Lake Parman variants into a contemporaneous type (Layton 1979). Usually associated with pluvial lakes in the Great Basin, they date between 8000 and 6000 B.C. (Bedwell 1973; Butler 1970; Clewlow 1968; Tuohy 1969, 1970a) and fall within the Dry Gulch Phase of the Upper Humboldt Valley sequence.

Twenty Stemmed points were recovered from Tosawihi. Eight are opalite, seven obsidian, four basalt, and one is chalcedony; only two are complete. All exhibit grinding along contracting to square basal margins. Most basal truncations occur at or below the shoulder (Figure 54). A wide range of sizes are represented by bases; basal lengths range from 65.1 to 21.1 mm (mean 35.59 mm), and widths from 32.2 to 15.9 mm (mean 16.88 mm).

Stemmed points were found throughout the Tosawihi vicinity (Table 49). Highest frequencies occur at 26Ek3170 (Eastern Periphery), 26Ek3237 and 26Ek3238 (Northern Corridor), and at Locality 23 of 26Ek3032.

Large Side-notched Points

Thomas (1981) combines several side-notched variants (Northern Side-notched, Bitterroot Side-notched, Madeline Dunes Side-notched, Elko Side-notched, and Rose Spring Side-notched; cf. Gruhn 1961; Swanson 1966; Riddell 1960; O'Connell 1975; Clewlow 1968; Heizer and Hester 1973) into a single, broadly defined series. The points are triangular in outline, with straight,

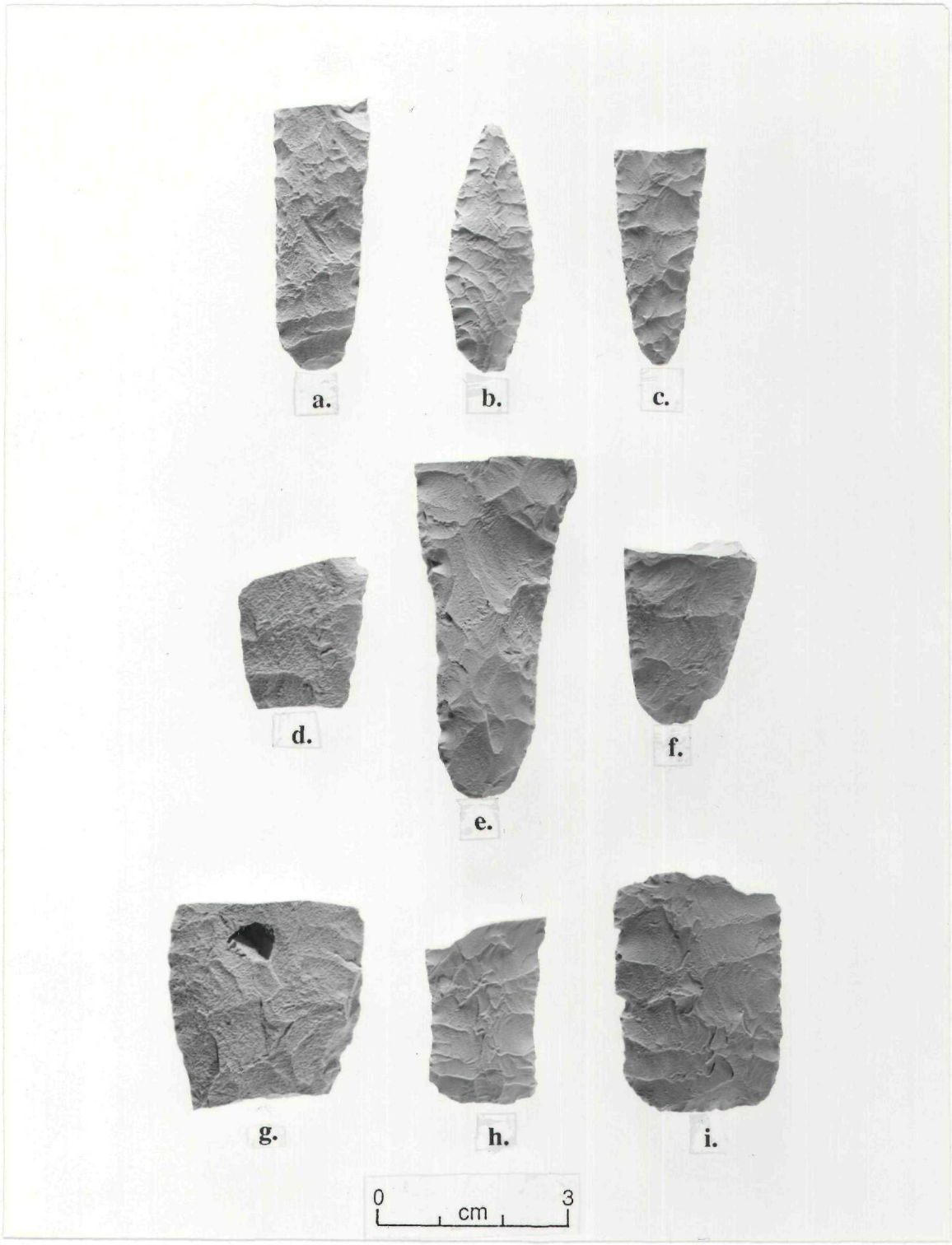


Figure 54. Great Basin Stemmed points.

concave, or notched bases (Figure 55a-c). Notches are removed from the sides rather than from corners of the blank. Temporally, the series pre-dates A.D. 1300, but extends as far back as the No Name Phase (5000 B.C.) of the Upper Humboldt Valley sequence.

Nine Large Side-notched points were identified (Table 50). Five are opalite and four are obsidian. No Large Side-notched points were recovered from localities within 26Ek3032, but they are present in the eastern, western, and northern subareas.

Table 49.
Distribution of Stemmed Points.

Site	(Locality)	Area	n
26Ek3170		Eastern Periphery	3
26Ek3192		Eastern Periphery	1
26Ek3092		Western Periphery	1
26Ek3101		Western Periphery	1
26Ek3107		Western Periphery	1
26Ek3160		Western Periphery	1
26Ek3208		Western Periphery	1
26Ek3237		Northern Corridor	2
26Ek3238		Northern Corridor	2
26Ek3032	(152)	Quarry	1
	(138)	Quarry	1
	(27)	Quarry	1
		Quarry	1
	(23)	Quarry	3
Total			20

Table 50. Distribution
of Large Side-Notched Points.

Site	Area	n
26Ek3184	Eastern Periphery	1
26Ek3204	Eastern Periphery	1
26Ek3093	Western Periphery	1
26Ek3160	Western Periphery	1
26Ek3271	Western Periphery	1
26Ek3237	Northern Corridor	3
26Ek3238	Northern Corridor	1
Total		9

Humboldt Series

The Humboldt Series was defined by a surface assemblage at the Humboldt Lakebed site (Heizer and Clewlow 1968). Humboldt points are lanceolate, of variable size, with slight to deeply concave bases (Figure 54d-h). Morphological variability and an extreme temporal range renders them relatively poor time markers in the Great Basin. Dating between 3000 B.C. and A.D. 700 (Thomas 1981), the series spans several chronological phases of the Upper Humboldt Valley sequence.

Thirteen Humboldt Series points were identified, five from two sites in the Northern Corridor, the remainder from Eastern and Western Peripheries (Table 51). Twelve points are opalite, one, basalt.

Gatecliff Series

A number of contracting stem and split stem forms are combined in the Gatecliff Series. On the basis of similar morphologies, Thomas (1981) reclassified Elko Contracting Stem (Heizer and Baumhoff 1961), and Gypsum Cave points (Harrington 1933; Fowler, Madsen, and Hattori 1973; Heizer and Berger 1970) as Gatecliff Contracting Stem variants, and Pinto Points (Clewlow 1967; Heizer and Hester 1978; Thomas 1971) as Gatecliff Split Stem. Gatecliff series

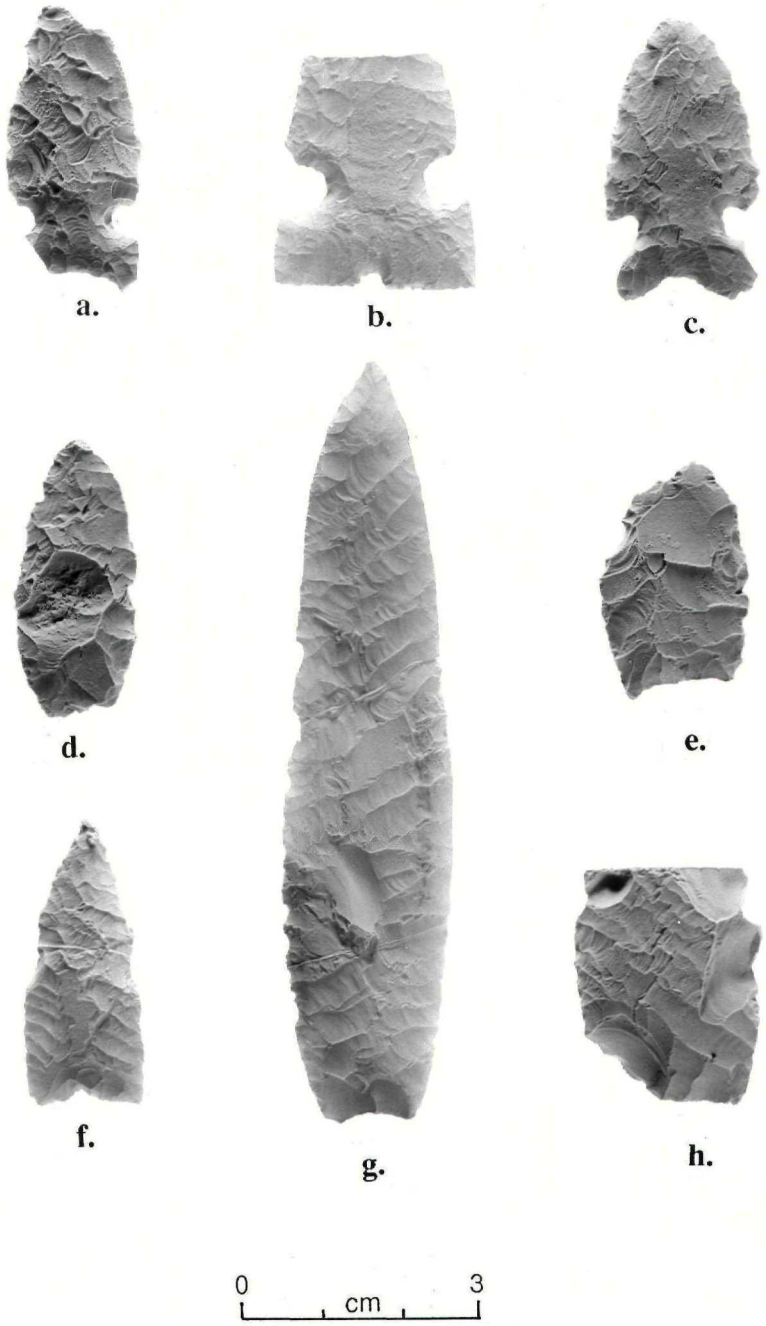


Figure 55. Large Side-notched (a-c) and Humboldt Series points (d-h).

points are relatively large triangular forms with sloping to deeply notched shoulders. Bases are parallel to contracting; split stem forms are basally notched (Figure 56a-i). Thomas (1981) dates the series between 3000 B.C. and 1300 B.C., within the latter part of the No Name Phase and most of the South Fork Phase of the Upper Humboldt Valley sequence.

Twenty Gatecliff Series points were identified. Highest frequencies occur in the Western Periphery and Northern Corridor (Table 52), with fewer numbers in the Eastern Periphery and Quarry localities. Seventeen Gatecliff points are opalite, three are obsidian. One specimen (3095-6941-1) is a contracting stem variant, the remainder are split stem.

Table 51.
Distribution of Humboldt Points.

Site	Area	n
26Ek3192	Eastern Periphery	1
26Ek3198	Eastern Periphery	2
26Ek3092	Western Periphery	2
26Ek3116	Western Periphery	1
26Ek3160	Western Periphery	1
26Ek3271	Western Periphery	1
26Ek3237	Northern Corridor	3
26Ek3251	Northern Corridor	2
Total		13

Table 52.
Distribution of Gatecliff Points.

Site	(Locality)	Area	n
26Ek3170		Eastern Periphery	1
26Ek3198		Eastern Periphery	1
26Ek3092		Western Periphery	3
26Ek3095		Western Periphery	4
26Ek3142		Western Periphery	1
26Ek3160		Western Periphery	2
26Ek3237		Northern Corridor	4
26Ek3238		Northern Corridor	1
26Ek3251		Northern Corridor	1
26Ek3032	(27)	Quarry	1
	(28)	Quarry	1
Total			20

Elko Series

The Elko Series is comprised of Elko Corner-notched and Elko Eared types (Heizer and Baumhoff 1961; Heizer, Baumhoff and Clewlow 1968; Lanning 1963). Elko points are relatively large, triangular in outline, with deep corner notches and relatively straight, expanding (Corner-notched) or deeply notched (Eared) bases (Figure 56j-r).

O'Connell (1967) demonstrated the utility of Elko points as time markers in the western Great Basin. Flenniken and Raymond (1986) warn, however that reworking of Elko points may obscure typological boundaries. The Series dates between 1300 B.C. and A.D. 700 (Thomas 1981); it occupies the latter portion of the South Fork Phase and the entirety of the James Creek Phase of the Upper Humboldt sequence.

Thirty one Elko points were identified. Nine are Elko Eared and twenty-two are Corner-notched variants. Most (n=22) are opalite, while seven are obsidian; one Corner-notched point is chalcedony and one Eared point is Basalt. Elko Series points were found in all subareas (Table 53). The highest frequencies occur in the Western Periphery, where eleven points were recovered from 26Ek3160. Relatively high frequencies also occur at 26Ek3237 in the Northern Corridor.

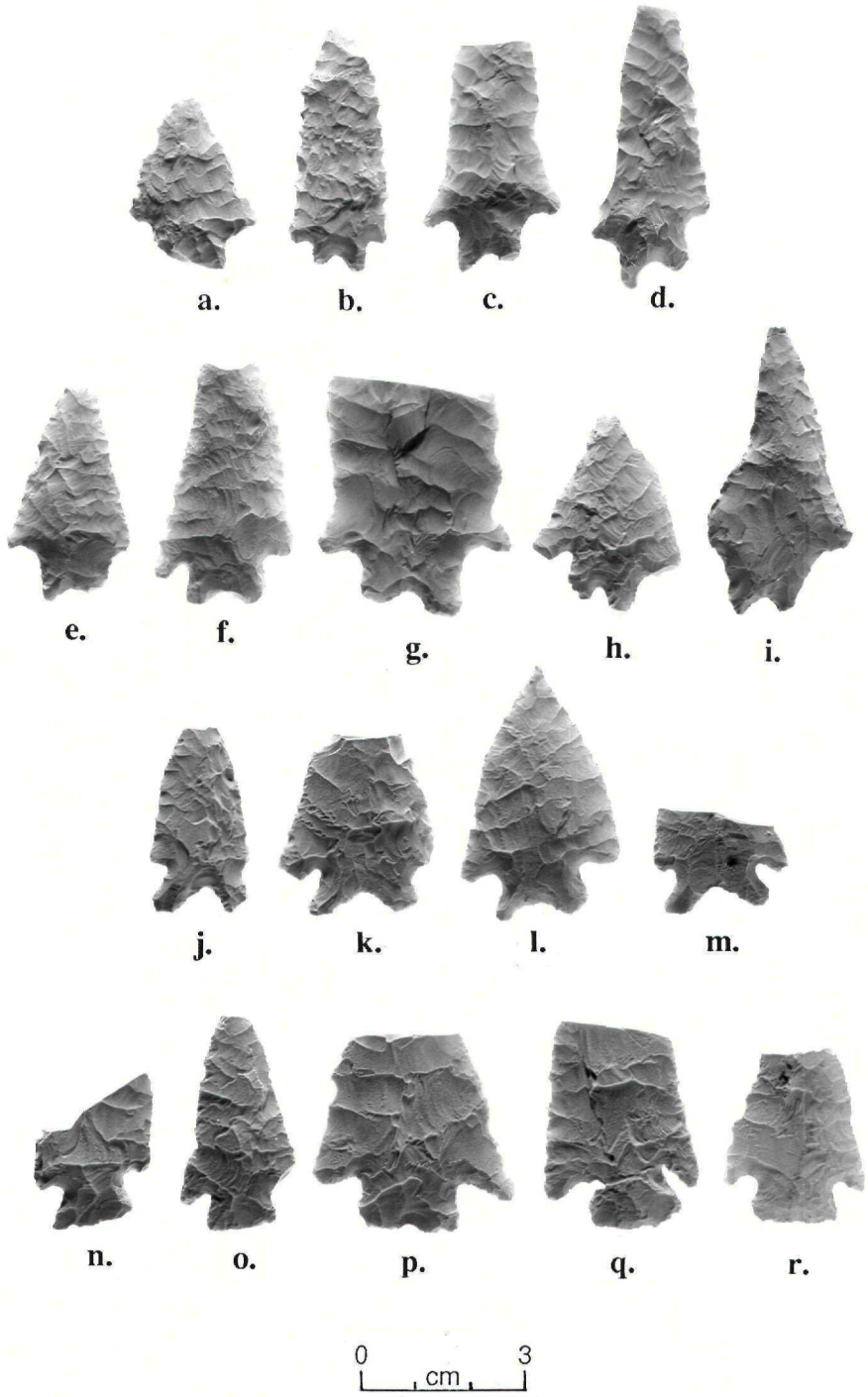


Figure 56. Gatecliff (a-i) and Elko Series points (j-r).

Rosegate Series

Rose Spring and Eastgate types have been combined into this single series (Thomas 1981). Rose Spring Corner-notched points were defined by Lanning (1963) and named for the Rose Spring Site in southern Owens Valley; Wagon Jack Shelter, near Eastgate, Nevada is the type locality for Eastgate points (Heizer and Baumhoff 1961). Both styles are relatively small and triangular with deep notches and small, expanding bases (Figure 57). Notching is generally finer, and bases are flatter and slightly more expanding among Eastgate variants.

Thomas recognizes that the two types may be regionally differentiated, but he regards them temporally indistinct. Rosegate Points are assignable to the Maggie Creek Phase of the Upper Humboldt Valley sequence; they occur within a relatively short time span, dating between A.D. 700 and A.D. 1300 (Thomas 1981).

Thirty-four Rosegate Series points were identified. Twenty-eight are opalite, five obsidian, and one chalcedony. Rosegate points were not recovered from 26Ek3032, but occur in the other three subareas (Table 54). Most were found in the Western Periphery, with relatively high frequencies at 26Ek3160 and 26Ek3271. High frequencies are present also at 26Ek3251 in the Northern Corridor.

Table 53.
Distribution of Elko Points.

Site	(Locality)	Area	n
26Ek3184		Eastern Periphery	2
26Ek3095		Western Periphery	2
26Ek3123		Western Periphery	1
26Ek3160		Western Periphery	11
26Ek3271		Western Periphery	1
26Ek3237		Northern Corridor	8
26Ek3239		Northern Corridor	1
26Ek3516		Northern Corridor	2
26Ek3032	(107)	Quarry	1
	(138)	Quarry	1
	(20)	Quarry	1
Total			31

Table 54.
Distribution of Rosegate Points.

Site	Area	n
26Ek3204	Eastern Periphery	2
26Ek3075	Western Periphery	1
26Ek3092	Western Periphery	2
26Ek3095	Western Periphery	3
26Ek3102	Western Periphery	1
26Ek3160	Western Periphery	6
26Ek3271	Western Periphery	8
26Ek3231	Northern Corridor	1
26Ek3237	Northern Corridor	3
26Ek3239	Northern Corridor	1
26Ek3251	Northern Corridor	6
Total		34

Desert Series

Three coeval types, Desert Side-notched (DSN), Cottonwood Triangular, and Cottonwood Leaf-shaped, comprise the Desert Series. Although morphologically dissimilar, all date from A.D. 1300 to the Historic Period (Thomas 1981), falling within the Eagle Rock Phase of the Upper Humboldt River Valley sequence.

Desert Side-notched points, originally defined by Baumhoff and Byrne (1959), are divided into General, Sierra, Delta, and Redding sub-types on the basis of basal treatment. They are distributed throughout southern and central California and the Great Basin. Cottonwood variants were defined originally by Riddell (1951) and Lanning (1963); they are named for the Cottonwood Site in Owens Valley, and their spatial distribution is similar to that of Desert Side-notched points.

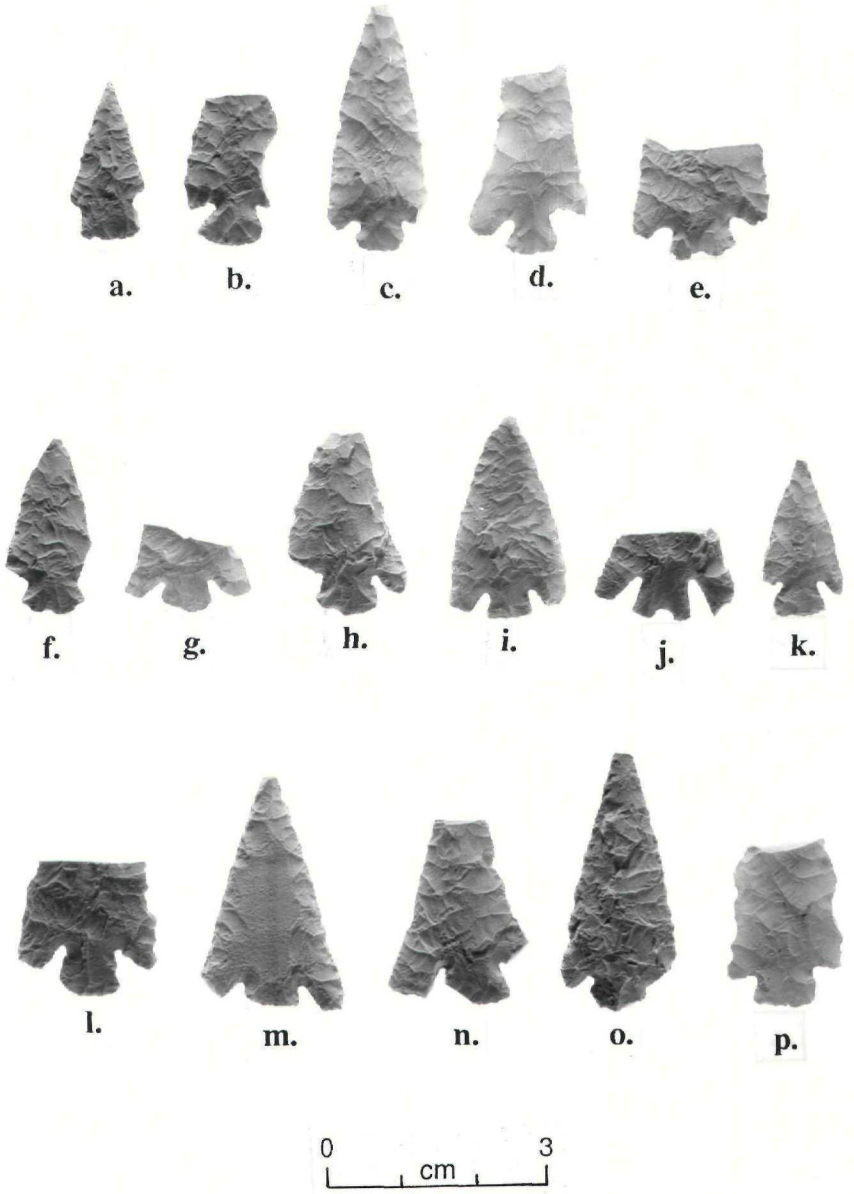


Figure 57. Rosegate Series points.

Desert Side-notched points are small, triangular in outline, with a shallow notch along the lateral margins and flat, concave, or notched bases (Figure 58a-r). Fifty-four specimens were identified; thirty-six are opalite, fifteen obsidian, and three chalcedony. DSN points are found in all subareas, with highest frequencies at 26Ek3092 in the Western Periphery (Table 55). One point (Figure 58b) is more appropriately a preform, but a notch along one margin suggests classification within the Desert Side-notched type. Five points from 26Ek3237 appear stylistically similar (Figure 58n-r); all are considerably smaller than other side-notched points, with very shallow notches located well down the lateral margins. This apparently idiosyncratic style may signal the work of a single knapper.

Cottonwood points are small (<30mm long and <4mm thick) and leaf-shaped or triangular in outline. Notching is absent. Bases of the Triangular variant are straight to slightly concave, while those of the Leaf-shaped variant are pointed to oval (Figure 58s-cc). The collection includes thirty-two Cottonwood points; four are Leaf-shaped and twenty-eight are Triangular. Cottonwood points were not found in the Quarry, the highest frequencies occurring in the Western Periphery (Table 55). Nineteen specimens are opalite, eleven are obsidian, and two are chalcedony. Only one Leaf-shaped point is opalite; the remaining three are obsidian.

Table 55. Distribution of Desert Series Points.

Site	(Locality)	Area	DSN	Cottonwood	Total
214		Eastern Periphery		1	1
26Ek3170		Eastern Periphery	3	1	4
26Ek3171		Eastern Periphery	1		1
26Ek3178		Eastern Periphery	2		2
26Ek3184		Eastern Periphery	1	1	2
26Ek3185		Eastern Periphery	3	2	5
26Ek3190		Eastern Periphery	2		2
26Ek3192		Eastern Periphery	4	1	5
26Ek3198		Eastern Periphery	4	4	8
26Ek3092		Western Periphery	8	6	14
26Ek3095		Western Periphery	4	5	9
26Ek3106		Western Periphery		1	1
26Ek3114		Western Periphery	1		1
26Ek3116		Western Periphery	2		2
26Ek3160		Western Periphery	7	8	15
26Ek3271		Western Periphery	2		2
26Ek3237		Northern Corridor	7	1	8
26Ek3251		Northern Corridor	2	1	3
26Ek3032	(4)	Quarry	1		1
Totals			54	32	86

Other Projectile Points

Twenty-eight points were modified or manufactured in such a way that their attributes do not meet type criteria proposed by Thomas (1981). Table 56 shows the probable affiliation of these remaining points. Seven would be classified as Desert Side-notched points if their proximal shoulder angles or basal width/maximum width ratios were larger. Six relatively small, thin, triangular forms are too long to be classified as Cottonwood Triangular points, and their bases are too straight for classification within the Humboldt Series. Likewise, seven concave base points evade the Humboldt Series due to their large, triangular form. Reworked margins

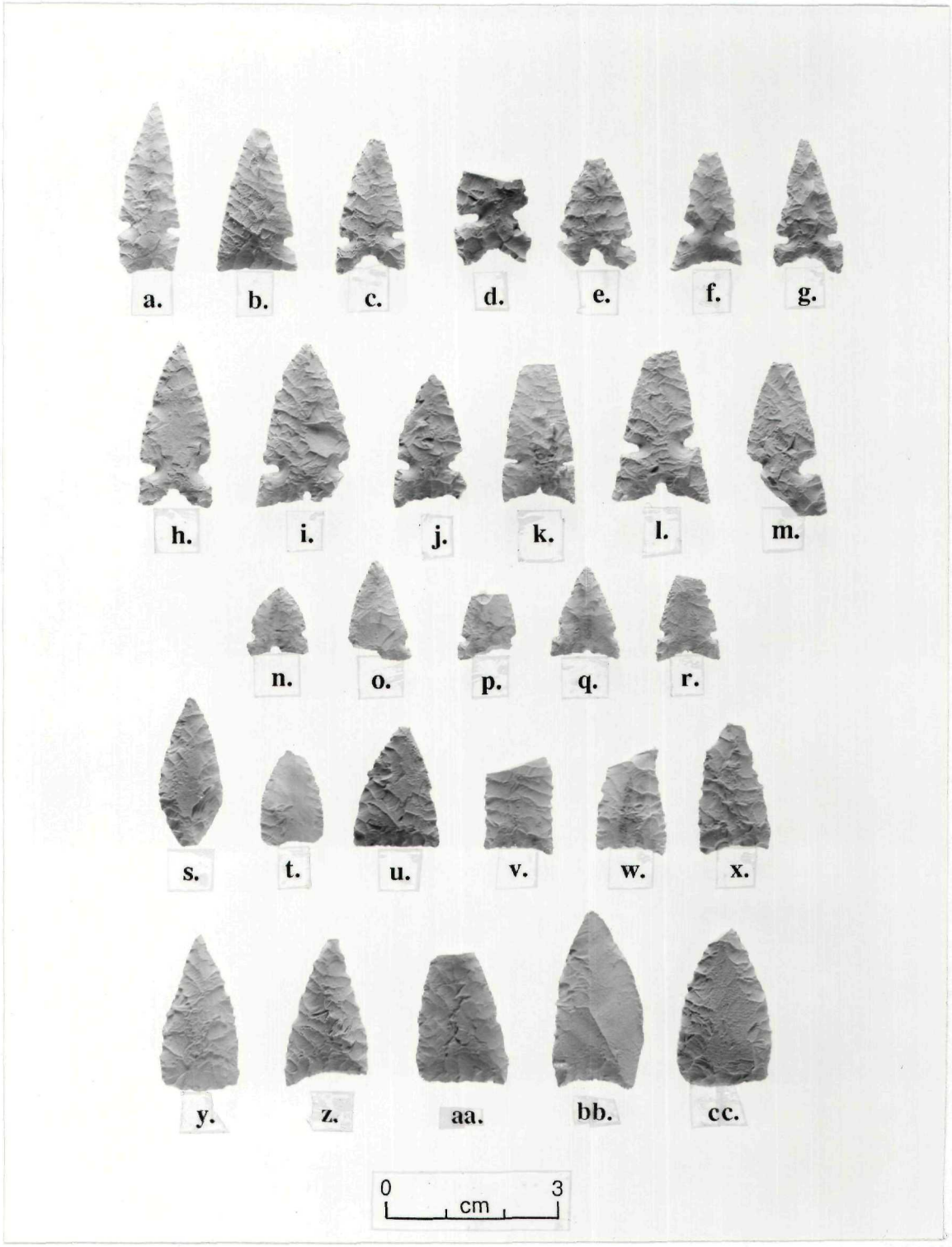


Figure 58. Desert Side-notched (a-r) and Cottonwood points (s-cc).

and excessively broad notches place four Elko points and one Rosegate point out of key, and an indeterminate proximal shoulder angle results in a similar classification for an Elko or Gatecliff point. Probable affiliations of two points could not be ascertained due to extensive reworking.

These "other" projectile points illustrate a wide range of stylistic variability within most point types. As discussed above, several researchers (Flenniken and Raymond 1986; Titmus and Woods 1986) suggest that rebasing of Pre-archaic and Archaic points may result in an apparent earlier or later type. The Tosawihi assemblage, however, while limited, indicates that rebasing of two Elko points resulted in broader proximal shoulder angles, placing the points outside Thomas's (1981) key rather than into new types.

Table 56. Probable Affiliation of Out-of-Key Projectile Points.

Site No.	(Locality)	Reference No.	Probable Type	Material	Remarks (cf. Thomas 1981)
3032	(158)	35-4	Desert Side-notch	Obsidian	Wb/Wm <.90
3032	(40)	56-3	Elko	Obsidian	Reworked, Wb < 10mm
3023	(23)	4002-21	Humboldt	Obsidian	BIR >.98
3032	(27)	6521-1	Desert Side-notch	Obsidian	PSA < 130
3092		2500-1	Cottonwood	Obsidian	reworked margin
3093		505-11	Cottonwood	Opalite	Length > 30mm
3095		510-44	Cottonwood	Opalite	Length > 30mm
3095		510-46	Rosegate	Obsidian	reworked margin
3095		510-49	Elko	Opalite	Indeterminate PSA
3095		519-12	Desert Side-notch	Obsidian	PSA < 130
3095		3011-1	Desert Side-notch	Obsidian	PSA < 130
3106		2002-1	Desert Side-notch	Basalt	PSA < 130
3148		103-1	Humboldt	Obsidian	Wb/Wm > .90
3154		109-1	?	Obsidian	Extensive rework
3160		500-2	Humboldt	Opalite	Wb/Wm > .90
3160		520-2	Humboldt	Opalite	Wb/Wm > .90
3170		4060-2	DSN/Cottonwood	Opalite	Unfinished
3171		504-7	Cottonwood	Obsidian	Length > 30mm
3177		2001-1	Elko	Opalite	Shallow notches
3177		2001-10	?	Opalite	Extensive rework
3184		4156-2	Humboldt	Obsidian	Wb/Wm> .90
3185		16-3	Humboldt	Opalite	Wb/Wm> .90
3190		1004-5	Cottonwood	Opalite	Length > 30mm
3237		1-127	Elko/Gatecliff	Opalite	PSA Indeterminate
3237		500-17	Elko	Opalite	PSA < 110
3251		1-1	Humboldt	Opalite	BIR > .98, rework
3251		3006-4	Desert Side-notch	Obsidian	PSA < 130
3251		6541-1	DSC/Cottonwood	Opalite	Extensive rework

Attributes

Raw Material

Like other flaked stone artifact classes from Tosawihi, projectile points are made primarily of opalite (Table 57). This material comprises 64.7% (n=260) of the assemblage, while 24.6% (n=99) are obsidian and the remaining 10.7% consist of chalcedony (n=24), jasper (n=7), basalt (n=5), opal (n=4), and other materials (n=3). The opalite chosen for the production of points however, is more variable than for other tool classes; it exhibits a wide range of colors, probably reflecting use of a variety of sources or outcrops. The proportion of points (especially Desert Series and Stemmed points) made from obsidian also is higher.

Table 57. Raw Materials Used for Projectile Points.

Point Type	Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other	Total
Cottonwood	15	11	-	3	2	1	-	32
DSN	32	15	-	6	-	1	-	54
Rosegate	25	5	-	2	-	1	1	34
Elko	21	7	1	2	-	-	-	31
Gatecliff	17	3	-	-	-	-	-	20
Humboldt	11	1	-	1	-	-	-	13
LSN	5	4	-	-	-	-	-	9
Stemmed	4	9	4	-	1	-	2	20
Clovis	1	-	-	-	-	-	-	1
Out of Key	14	13	-	1	-	-	-	28
Fragmentary	115	31	-	9	4	1	-	160
Total	260	99	5	24	7	4	3	402

The diversity of lithic material varies from one type to another (Figure 59). Stemmed points exhibit the greatest diversity of material, the highest incidence of obsidian, and significant proportions of opalite and basalt. Humboldt, Gatecliff, and Rosegate points exhibit little diversity; opalite dominates, basalt does not occur, and obsidian is infrequent.

Size

In the Great Basin, late points generally are smaller than earlier ones, a condition that has been linked to the transition from dart and spear to arrow. This pattern occurs at Tosawihi as well. When only complete points are considered, as arrayed in Figure 60, there appears to

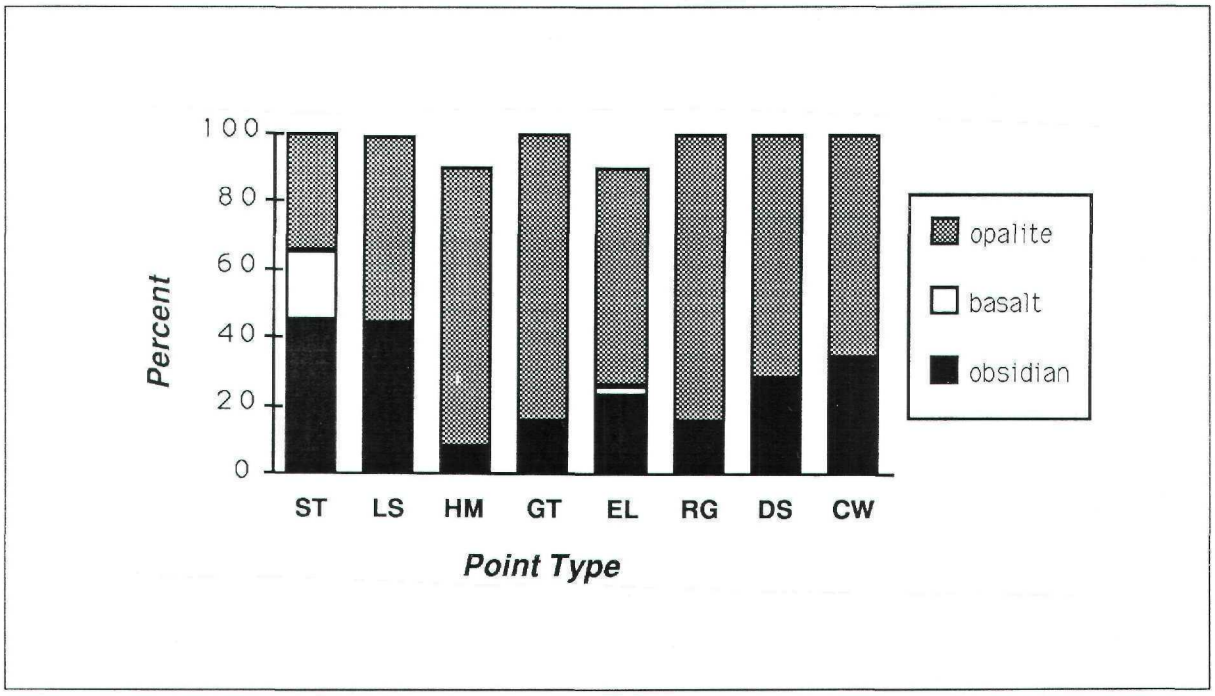


Figure 59. Frequencies of raw material by point type (opal and chert combined with opalite).

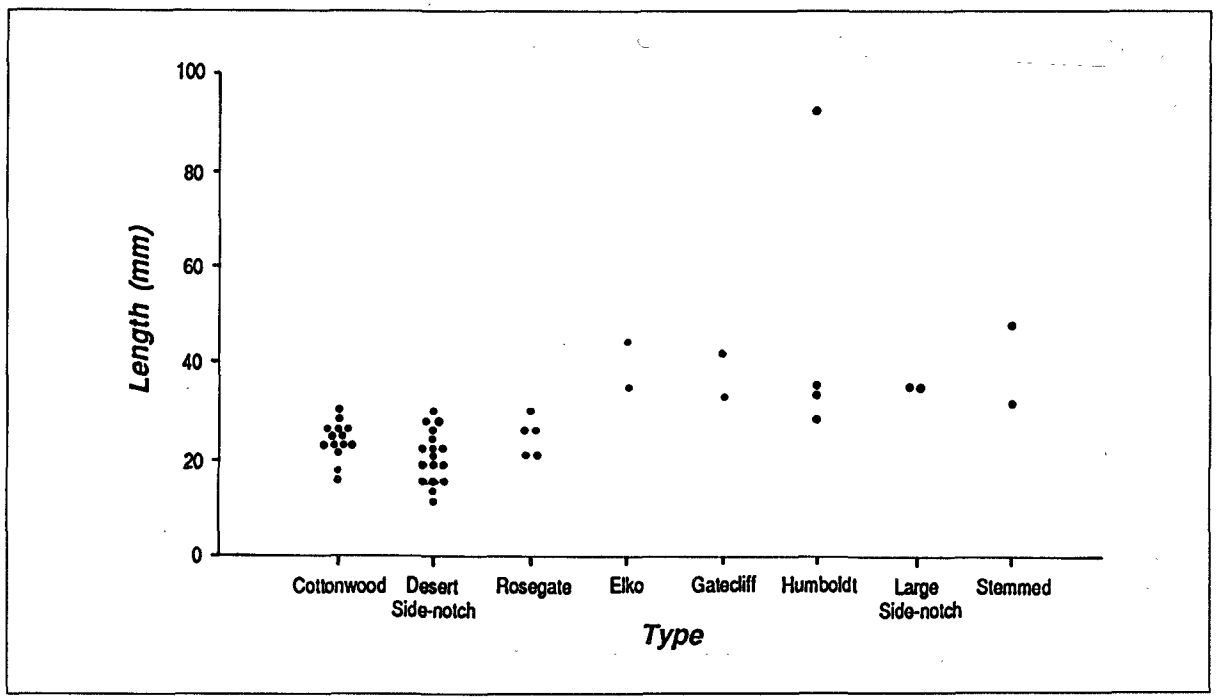


Figure 60. Lengths of complete projectile points by type.

be a break in length between Cottonwood, Desert Side-notched, and Rosegate points as opposed to earlier types, and their lengths are much more tightly clustered. This may be because earlier points, beginning larger, are more likely to have been reworked and thus to exhibit a greater size range; alternatively, their manufacture may have been less standardized. Projectile point size, in fact, may provide a means to examine production strategies. If lengths are tightly constrained, then production of a series may have been more standardized; conversely, greater size diversity may indicate more variable production strategies.

Table 58 presents mean lengths of Tosawihi projectile points, and calculates the coefficient of variability for each series. Both complete and fragmentary specimens with estimatable total lengths are included in the data set. No attempt was made to estimate lengths of Stemmed points, so measurements for that series (with the exception of two complete points) are for stems only. The table shows a gradual diminution from Gatecliff to Desert Series points, spanning the transition from atlatl to arrow. Points of the Stemmed and Humboldt exhibit the highest coefficients of variability, while Large Side-notched exhibit the least. Variability within the remaining series is relatively low, suggesting some degree of standardization within each.

Table 58. Mean Lengths and Coefficients of Variation of Projectile Point Series.

Type	Mean Length (mm)	SD	Maximum (mm)	Minimum (mm)	Coefficient of Variation
Desert	23.89	5.00	32.9	10.4	20.9
Rosegate	29.46	5.95	41.3	15.9	20.2
Elko	43.55	8.51	62.8	31.2	19.5
Gatecliff	48.31	11.22	79.5	32.1	23.2
Humboldt	46.04	18.09	94.9	21.6	39.3
Large Side-notched	38.67	5.32	49.3	31.4	13.8

Flenniken and Wilke (1989:153) suggest that Elko Corner-notched and Northern Side-notched points are archetypal forms of Thomas's (1981) Gatecliff and Humboldt Series. If that is true, the coefficient of variability within both Elko and Large Side-notched points should be high, and they should be larger than Gatecliff and Humboldt points. The data show them to be smaller, however, with a lower coefficient of variability than the Gatecliff and Humboldt Series. Given the tightly constrained, smaller size of Elko and Large Side-notched points, it seems unlikely that they could have been reworked into larger Gatecliff and Humboldt points.

Heat-Treatment

Over 85% of the opalite and chert projectile points were heat-treated during production (Table 59). Stemmed and Elko Series points exhibit the lowest frequency of heat-treatment, while frequencies for the remaining types fall near or above the mean. Since thermal alteration improves the flaking characteristics of opalite, it is not surprising that a large proportion of pressure flaked opalite points have been heat-treated.

Table 59. Heat-Treatment of Chert and Opalite Points.

	Heat-treated		Possible/ Not Heat-treated		TOTAL Chert & Opalite
Type	n	%	n	%	n
Desert	56	93.3	4	6.7	60
Rosegate	26	89.7	3	10.3	29
Elko	17	73.9	6	26.1	23
Gatecliff	17	100.0	0	0.0	17
Humboldt	10	83.3	2	16.7	12
Large Side-notched	5	100.0	0	0.0	5
Stemmed	1	14.3	6	85.7	7
Clovis Preform	1	100.0	0	0.0	1
Out of Key	11	73.3	4	26.7	15
Fragmentary	110	85.3	19	14.7	129
Total	254	85.2	44	14.8	298
Preforms	157	66.8	78	33.2	

Breakage Characteristics

Projectile points enter the archaeological record variously; they are broken in manufacture, broken in use, or lost. Patterns of breakage and microscopic wear reflect *how* particular pieces were broken, whether they were used as projectiles or for other functions, and something of the circumstances of their discard or loss.

Breakage in manufacture is often difficult to recognize. Titmus and Woods (1986) have suggested that fatal breaks tend to occur on obsidian Elko points, during notching, at the end of the manufacturing process. Distinctive breaks such as lateral and snap fractures of barbs, lateral fractures at the neck, and longitudinal fractures at the notch can be identified, but manufacturing breaks occurring earlier in production often are easy to repair and may not be observable in archaeological assemblages. Lateral snap fractures at the midsection are rare during manufacture, and cannot be separated reliably from fractures caused by use or post-depositional damage. Ten pieces in the Tosawihi assemblage show clear evidence of breakage in manufacture; additional to the Clovis preform, four are Desert Series points, one a Gatecliff, one is untypeable, and three are fragmentary.

Bases may enter the archaeological record when points are broken in manufacture or during use (Titmus and Woods 1986). Flenniken and Wilke (1989) even maintain that notched points were designed to break at the notches, concluding that notches not only served as aids to hafting, but also limited the location of bending fractures so that the largest, re-usable portion of the point remained in the prey for recovery and subsequent rejuvenation. Broken tips, then, may have been transported to base camps in meat, or left among the waste portions of carcasses abandoned at kill or butchering sites. Points broken above the notches could be resharpened into shorter, blunter variants retaining the original basal morphology, while broken bases or barbs would have required basal modification prior to rehafting. A projectile point assemblage, then, should be dominated by broken bases, small broken tips, and exhausted point nubbins of various basal morphologies.

This does not seem to be the case at Tosawihi. Table 60 indicates that 14% of the points in the Tosawihi assemblage consist of bases only. Twenty seven percent lack bases or tips, but exhibit no evidence of reworking, and 32% consist only of tips and midsections. The remaining barbs, tangs, and lateral fragments may be related to breakage during use or manufacture; none exhibits evidence of reworking.

Table 60. Projectile Point Fragment Types

Type	n	%
Complete	58	14.42
Base Only	57	14.18
Base Missing	17	4.23
Tip Missing	93	23.13
Tip	72	17.91
Midsection	56	13.93
Tang/Barb	5	1.24
Tang/Barb Missing	23	5.72
Lateral Fragment	12	2.99
Indeterminate	9	2.24
Total	402	100.0

Complete points are introduced into the archaeological record through loss as misses during hunting, discard in a carcass, or loss in a residential context. Less commonly, caches may go unretrieved. Nearly 15% of the Tosawihi point assemblage *are* complete specimens. They are found in a variety of settings, but most often at residential sites. Proportions of complete specimens vary greatly from type to type; the lowest are observed in the Elko, Stemmed, and Gatecliff Series, while about one-third of the Desert Series points are complete (Table 61).

Table 61. Proportion of Complete Points by Type.

	Complete n	Total n	%
Desert	31	86	36.0
Rosegate	4	34	11.7
Elko	2	31	6.5
Gatecliff	3	20	15.0
Humboldt	4	13	30.8
Large Side-Notched	3	9	33.0
Stemmed	2	20	10.0
Out of Key	9	29	31.0

Relative size, functional variability, and reworking may account for this disparity. Large points may break in the haft more frequently than smaller ones, and bigger targets and greater propulsion may further predispose large points to breakage. Resharpening and reworking extend the use life of larger points, making discard necessary only when a piece is broken beyond repair. Conversely, maintenance of the edges of smaller points is restricted by the small margins, and resharpening may be of limited utility. Consequently, small, complete points with worn or damaged edges may be discarded rather than repaired.

Thomas (1981) maintains that bases are the most diagnostic portions of points, changing little as broken tips and margins are reworked. On the other hand, Flenniken and Wilke (1989) argue that breakage at the notches is a function of design, that rebasing *often* affects basal morphology, and that basal attributes are poor typological indicators. The Tosawihi point assemblage seems to support Thomas's argument. Table 62 identifies the location of breakage on notched points; most are broken at the tip, and few at the notches. Of course, many of the types identified in the sample may have been reworked and now are indistinguishable from unbroken points. Size variability within types and breakage characteristics argue against this, however, and we conclude that it is unlikely that many points were reworked into types with basal morphologies diagnostically different from the original.

Table 62. Location of Breakage on Points with Notches.

	Opalite		Obsidian		Total	
	n	%	n	%	n	%
Complete	22	17.1	5	18.5	27	17.3
Broken at Notches	18	14.0	6	22.2	24	15.4
Broken at Tip	41	31.8	9	33.3	50	32.1
Broken Mid-section	16	12.4	2	7.4	18	11.5
Broken at Tip and Notch	29	22.4	5	18.5	34	21.8
Indeterminate	3	2.3	0	0.0	3	1.9
Total	129	82.8	27	17.2	156	100.0

Preforms

Our preform sample consists of 260 specimens. They are characterized by retouch around the entire perimeter in early manufacturing stages and by more invasive pressure flaking in later stages (Figure 61). Some of the preforms identified here may have served as blanks for small, pointed, pressure flaked tools such as perforators or drills; we assume, however, that preforms are an intermediate stage within the projectile point trajectory. The raw materials, size, and breakage characteristics of preforms are described below.

Raw Material

Almost 83% of the preforms are opalite, 10% are obsidian, 5% percent are chalcedony, and the remainder are jasper or opal. Frequencies of non-opalitic toolstone are higher than observed among flake tools and small bifaces, and resemble more those of projectile points (Figure 62). However, the proportional use of obsidian is higher among projectile points than preforms, suggesting that some obsidian points were brought to Tosawihi in finished form. This pattern is in distinct contrast to that at James Creek Shelter (Zerga and Elston 1990), where similar proportions of obsidian points and preforms were observed.

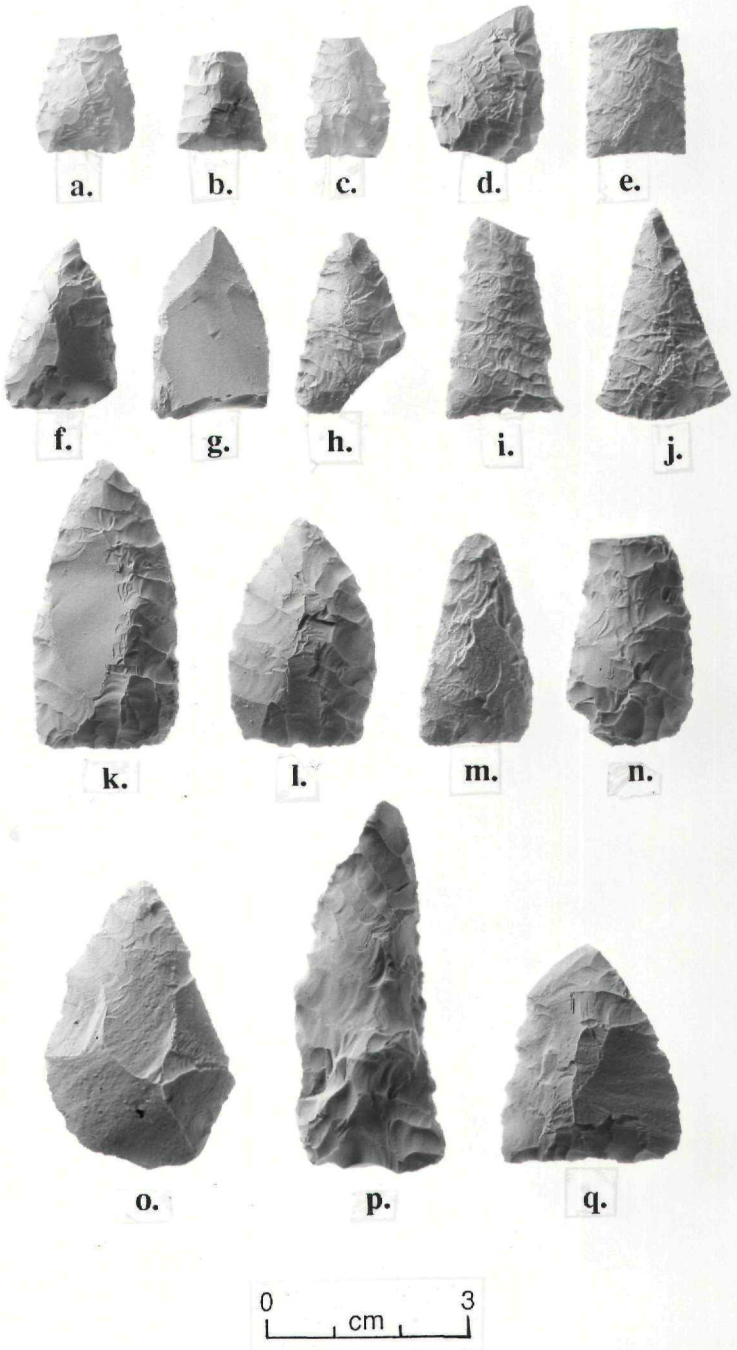


Figure 61. Selected preforms.

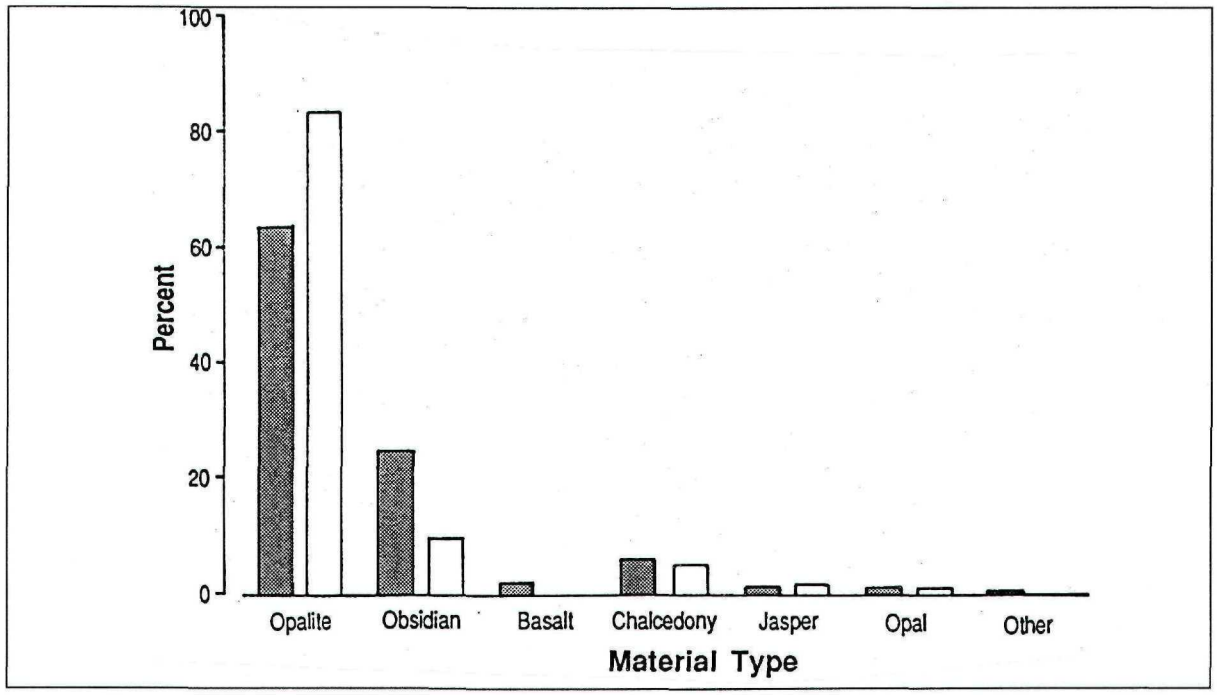


Figure 62. Raw material proportion for points and preforms.

Size

Thirty-eight preforms (14.6%) are complete; they are generally elongate to triangular. Lengths range from 13.3 to 53.3 mm, widths from 10.0 to 33.4 mm, and thicknesses from 1.7 to 7.9 mm. Since in some dimension preforms always are larger than the points produced from them, we should be able to correlate mean sizes of preforms to mean sizes of the projectile points they might have yielded. Mean dimensions for the various point types and preforms are shown in Table 63. Only Desert and Rosegate series points fall entirely within the mean size range of Tosawihi preforms. Size ranges of other, larger point types overlap with preforms when standard deviations are considered, but the means of each dimension as well as the weights of points always are higher than those of preforms.

Table 63. Mean Dimension of Points and Preforms.

Type	n	Mean Length (cm)	SD	Mean Width (cm)	SD	Mean Thickness (cm)	SD	Mean Weight (g)	SD
Desert	31	22.1	4.8	12.5	2.0	2.8	0.5	0.7	0.3
Rosegate	4	23.5	2.7	12.1	2.1	3.0	0.4	0.8	0.4
Preform	38	34.3	9.1	21.8	5.5	4.7	1.4	3.6	2.3
Elko	2	40.6	3.3	24.8	3.5	5.4	0.7	4.4	1.5
Gatecliff	3	39.4	3.8	22.7	4.0	4.4	0.6	3.6	0.8
Humboldt	4	47.9	27.3	17.4	2.6	4.3	1.5	4.5	4.2
Large Side-notched	3	36.3	3.8	18.7	2.4	3.8	0.5	3.4	1.6
Stemmed	2	39.8	7.7	16.6	0.7	5.0	0.8	3.5	1.5

To further test the correlation between small (arrow) points and preforms, Z-Scores were calculated from the mean dimensions of each point type and compared against the absolute dimensions of all complete preforms. As depicted in Figure 63, only four (10.5%) preforms are smaller than the mean of projectile point types, 5.3% (n=2) could have been made into Desert Series points, and 52.6% (n=20) could have served as preforms for points within either the Desert or Rosegate Series. The remaining 31.6% (n=12) could have been made into Desert or Rosegate Series points, but in some dimension also fit the mean of larger points.

Although a few larger, earlier point types could have been produced from our discovered preforms, we suspect that most were used to produce arrowpoints (Rosegate and Desert series) and post-date A.D. 500. Thus, preforms may be indicators of late occupation at Tosawihi.

Heat-Treatment

Like projectile points, preforms produced on heat-treated opalite blanks, or thermally altered during manufacture, would exhibit greater material compliance, better flakability, and reduced risk of breakage. One hundred eighty-four opalite preforms (78.3%) appear to have been heat-treated or manufactured on heat-treated flakes, a lower frequency (78.3%) than exhibited by projectile points. This probably is due to a higher incidence of failure and increased application of heat-treatment during preform production.

Shape and Breakage Characteristics

Outline can be determined for only 113 (43%) of the 260 preforms. Of these, 43% are oval, 35% are triangular, and about 10% each are lanceolate and elongate. Base shape, exclusive of overall shape, can be classified on 104 specimens. Among those, oval (n=55) and square bases (n=23) are most common; concave, flat, contracting, and other irregular bases account for

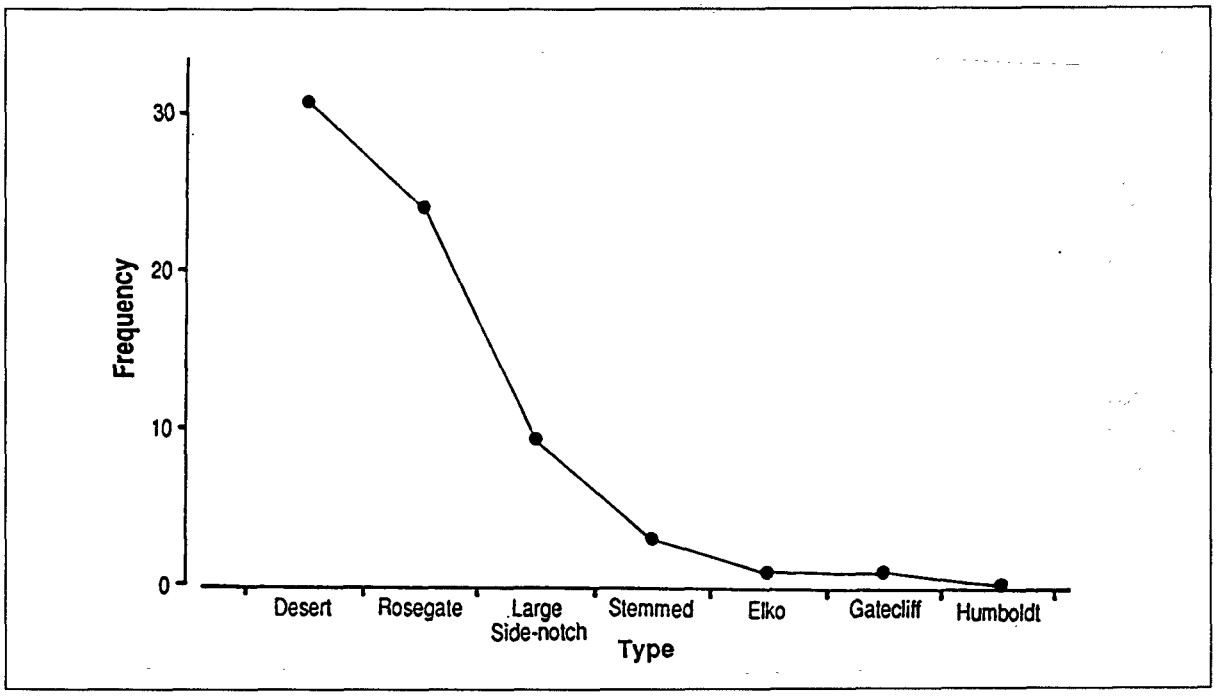


Figure 63. Preforms of sufficient dimensions to produce projectile points of different series.

relatively small proportions of the assemblage. Except for Humboldt and Stemmed points, most Great Basin point types are triangular or elongate-triangular in outline, and can be made from flat or concave based preforms.

Less than ten percent of the performs are complete, as would be expected if they did indeed represent unfinished tools. A wide range of manufacturing stages is represented, suggesting that preforms broke during all stages of reduction in roughly equal proportions.

Discussion

Chronology

The projectile point assemblage exhibits considerable typological and temporal variability (cf. Chapter 19). A Clovis point fragment suggests that utilization of the Tosawihi vicinity may have begun as early as 10,000 years ago; the range of point types present suggests that people visited the Tosawihi area without a break down to the present. Nearly all Great Basin projectile point styles are signal utilization at least to ethnographic times, but the highest frequencies are associated with later occupations.

Desert Series points dominate the total assemblage, with steadily declining frequencies of other types. A similar pattern is evident in the Eastern and Western peripheries; over one-half the points from the Eastern periphery pertain to the Desert Series. By contrast, the Northern Corridor assemblage exhibits a relatively even distribution of types. At the Quarries (26Ek3032), Stemmed points dominate and late types are rare.

With the exception of Localities 26 and 27, field work in 26Ek3032 consisted only of initial surface reconnaissance and subsequent documentation. The reversed proportions of projectile points from the Quarries might suggest more intensive use during earlier times, but field techniques and the small sample size may have resulted in a sampling bias toward the recovery of larger, more findable point types.

Materials used for projectile points also exhibit temporal diversity. The Stemmed, Large Side-notched, and Desert Series contain the highest proportions of obsidian, while lower frequencies are observed among all other types. Basalt occurs only in the Stemmed and Elko Series. The proportions suggest that during the earliest and latest phases of occupation, exotic materials were used more frequently, and that projectile points may have been manufactured elsewhere and transported into the area. This pattern is opposite that observed at James Creek Shelter, where local materials predominate during the Late Archaic (Elston and Budy 1990). The pattern may signal a temporally different logistical strategy involving increased trade and external economic influence. This is reinforced by obsidian sourcing data (cf. Chapter 5) showing that the Paradise Valley source (some 60 miles west of Tosawihi) is used almost exclusively for Rosegate, Elko, Gatecliff, Humboldt, and Large Side-notched points.

Technology

Blanks

The blank types on which projectile points and preforms are made often cannot be determined because platforms and dorsal surfaces so often are obscured by retouch; only about 10% of the preforms, for instance, unequivocally were made on biface thinning flakes. However, because so few cores occur in the industry or industries represented at Tosawihi, and because at least half the other types of flake tools are made on biface thinning flakes, it seems likely that the flakes on which preforms and projectile points are made were produced during biface reduction, whether or not the primary purpose of reduction was to produce flakes or bifacial tools.

The sizes of preforms suggest from which stage of biface they could have been detached. Flenniken and Ozbun (1988) studied bifaces from Newberry Crater, and have proposed that twice the length of a flake reflects the size of the biface from which it was detached. This assumes that most flake scars on a biface extend only to the midline. For Stage 1 and 2 Tosawihi bifaces, the 2 x length approximation is appropriate, but flake scars on Stage 3 and 4 bifaces carry across the midline, so we have estimated the size of Stage 3 and 4 bifaces by multiplying the length of complete preforms by 1.33.

Using a t-test, the length of each complete preform was compared to the computed average width of each biface stage. Table 64 shows that preform flake blanks probably were produced from Stage 3 bifaces, but could have been produced from any average size Tosawihi biface, regardless of stage. However, most bifaces were heat-treated by middle Stage 3, and many heat-treated preforms were made on flakes produced from raw bifaces. It seems likely, then, that preforms were made on flakes produced from late Stage 2 or early Stage 3 bifaces.

Table 64. Comparison of Preform Length and Estimated Biface Widths.
(ALL MEASUREMENTS IN CENTIMETERS)

	Using 2 x Length Estimate				Using 1.33 x Length Estimate	
Preform Length	Stage 1	Stage 2	Stage 3	Stage 4	Stage 3	Stage 4
13.3	+	+	+	+	+	+
16.8	+	+	+	+	+	+
23.5	+	+	+	0	+	+
24.4	+	+	+	0	+	+
24.9	+	+	+	0	+	+
25.1	+	+	+	0	+	+
28.1	+	+	+	0	+	+
28.4	+	+	+	0	+	+
28.4	+	+	+	0	+	+
28.9	+	+	+	0	+	+
29.4	+	+	+	0	+	+
29.4	+	+	+	0	+	+
30.3	+	+	+	-	+	+
30.4	+	+	+	-	+	+
30.8	+	+	+	-	+	+
30.8	+	+	+	-	+	+
31.3	+	+	+	-	+	+
31.4	+	+	+	-	+	+
31.5	+	+	0	-	+	+
33.2	+	+	0	-	+	+
33.3	+	+	0	-	+	0
34.1	+	+	0	-	+	0
35.1	+	0	0	-	+	0
35.8	+	0	0	-	+	0
36.0	+	0	0	-	+	0
39.2	0	0	0	-	+	0
40.0	0	0	0	-	+	0
41.0	0	0	-	-	+	0
41.3	-	0	-	-	+	0
41.4	-	0	-	-	+	0
41.6	-	0	-	-	+	0
41.8	-	0	-	-	+	0
42.1	-	0	-	-	+	0
43.1	-	0	-	-	+	0
49.2	-	-	-	-	0	-
50.8	-	-	-	-	0	-
52.2	-	-	-	-	0	-
53.3	-	-	-	-	0	-

+ = Preform producible from biface stage x
0 = Preform marginally producible from biface stage x
- = Preform not producible from biface stage x

Reduction

Reduction stages were assigned to preforms. Based on extent of retouch, preforms with greater proportions of retouched surface area were considered more finished. Stage 1 consists of the selection of a suitable blank; Stage 2, edge preparation; Stage 3, primary thinning; Stage 4, secondary thinning. Basal treatments and notching are applied during Stage 5. Stage 2 preforms are produced by pressure or abrasion of the edges, while Stages 3, 4, and 5 exhibit exclusively pressure retouch.

No Stage 1 preforms were identified, since preform blanks are indistinguishable from many flakes produced during biface reduction. Of the remaining stages, 28% are Stage 2, 26% Stage 3, 36% Stage 4 and 2.5% Stage 5. The remaining 7.5% could not be assigned to stages.

After initial edge preparation, the specific techniques used to produce points from flakes or preforms are quite varied. Some preforms are worked first on the dorsal and then on the ventral surface, but more often the reduction is less patterned. This contrasts with the practice at James Creek Shelter where Elko, Rosegate, and Desert Series points have a dorsal-to-ventral manufacturing sequence (Zerga and Elston 1990). Variation in these reduction strategies may be related to the cross-sections of preforms or flake blanks rather than to manufacturing traditions.

It has been assumed that Early and Mid-Archaic dart points in the Great Basin were made on small percussion flaked bifaces, while Late Archaic arrow points were made on thin flake blanks reduced directly by pressure flaking (O'Connell 1967; Lanning 1963; Zerga and Elston 1990). This scheme has been questioned by Novick (1987), who observed that Early Archaic Gatecliff and Middle-Archaic Elko points exhibit remnants of the ventral surface of the flake blank; she concludes that they were produced directly from flakes rather than from percussion flaked bifaces.

In order to discover whether there was temporal change in manufacturing techniques, remnant ventral flake scars and evidence of percussion flaking were recorded and tabulated for each point type (Table 65). In many cases, evidence of early stage reduction has been obscured by pressure flaking, making observation difficult; occasionally, however, surfaces are left unflaked or early stage percussion scars are visible.

Table 65. Proportion of Projectile Points with Ventral Detachment Scars and Visible Percussion Scars.

	Ventral Detachment Scars					Visible Percussion Scars					
	Present		Absent		TOTAL	Present		Indeterminate		Absent	
Type	n	%	n	%	n	n	%	n	%	n	%
Cottonwood	23	71.9	9	28.1	32	0	0.0	0	0.0	32	100.0
Desert Side-notched	28	51.9	26	48.2	54	0	0.0	0	0.0	54	100.0
Rosegate	13	38.2	21	61.8	34	0	0.0	2	5.9	32	94.1
Humboldt	4	30.8	9	69.2	13	0	0.0	3	23.0	10	77.0
Large Side-notched	5	55.5	4	44.4	9	0	0.0	3	33.3	6	66.7
Elko	7	22.6	24	77.4	31	4	12.9	8	25.8	19	61.3
Gatecliff	5	25.0	15	75.0	20	5	25.0	7	35.0	8	40.0
Stemmed	1	5.0	19	95.0	20	10	50.0	5	25.0	5	25.0

Table 65 shows that, unlike Early and Middle-Archaic points from Gatecliff Shelter, larger Tosawihi points were made more frequently on percussion flaked bifacial preforms while smaller ones were made on flakes requiring little thinning. Percussion scars are present or indeterminate on most larger points, and the lack of ventral detachment scars suggests that blanks were thinned fully and their margins reduced during production. Conversely, the lack of percussion scars and predominance of ventral detachment scars indicates that full reduction of the ventral surface was not always necessary to thin small blanks sufficiently.

Differences in manufacturing patterns may be related to availability of raw material or variation in material quality rather than to changes in technology. Some Early and Middle Archaic points were made on flake blanks produced without a percussion flaking stage, so the change from atlatl/dart to bow and arrow is not accompanied invariably by a complete replacement of manufacturing techniques.

Tip Orientation

Tip orientation serves as another indicator of manufacturing technique standardization. Projectile point tips may be produced on the proximal ends of point blanks, distal ends, or may be oriented transversely. Of the 51 points for which this variable could be observed (most of them Late Archaic types), 30% were made on the proximal ends of blanks and 57% on distal ends. Only 1.5% are oriented transversely. Tip orientation could be determined on 93 preforms. Of these, over 40% were made on proximal blank ends, slightly less than 40% on distal ends, and 20% are oriented transversely. Our results suggest that the orientation of tips on flake blanks is quite variable. The ventral surface of many specimens has been obscured by excessive pressure flaking, however, so observations were not always possible. Tip observations may, in fact, be limited to points with only partially reduced ventral surfaces, and blanks selected for those points may have had significantly different morphologies from fully reduced points and preforms.

Heat-treatment

A relatively high proportion of projectile points (93.3%) and preforms (78.3%) are heat-treated. Table 66 identifies the stage at which thermal alteration may have been applied to blanks within the preform/point trajectory. Most projectile points (55.7%) appear to have been made on blanks heat-treated during an indeterminate stage of production. This is true for all point types, and, since many points have fully reduced ventral surfaces, it is not surprising that stage of heat-treatment is difficult to discern. Preforms, on the other hand, especially early stage forms, should retain greater proportions of their ventral detachment surface and thus should reflect heat-treatment stage better.

Table 66. Production-Related Heat-Treatment of Points and Preforms.

	Core HT		Flake HT		Blank HT		Poss/Post		No HT		
	n	%	n	%	n	%	n	%	n	%	Total
Projectile Point											
Late Archaic	3	3.4	32	36.0	47	52.8	4	4.5	3	3.4	89
Early/Mid Archaic	3	4.6	12	18.5	36	55.4	7	10.8	7	10.8	65
Out of Key/Fragments	1	0.7	37	25.7	83	57.6	13	9.0	10	6.9	144
Total	7	2.4	81	27.2	166	55.7	24	8.1	20	6.7	298
Preform											
Stage 2	8	11.8	28	41.2	12	17.6	6	8.8	14	20.6	68
Stage 3	5	8.1	31	50.0	11	17.7	6	9.7	9	14.5	62
Stage 4	3	3.5	17	20.0	35	41.2	8	9.4	22	25.9	85
Stage 5	1	14.3	1	14.3	1	14.3	2	28.6	2	28.6	7
Indeterminate	1	7.7	0	0.0	3	23.0	5	38.5	4	30.8	13
Total	18	7.7	77	32.8	62	26.4	27	11.5	51	21.7	235

93.3% Points Heat-treated
(most at indeterminate stage - extent of reduction obscures flake and core)
78.3% Preforms Heat-treated
(Most on H.T. flakes. Stage 4 reduced enough to obscure flake/core. Higher incidence of No H.T. probably related to mfg. failure during all stages.)

Table 66 indicates that Stage 2 and 3 preforms commonly were made on heat-treated flakes (41.2% and 50% respectively), and that, as with points, thinning of progressively later stage preforms allows assignment of heat-treatment only to an indeterminate level. Few preforms or points were made on flakes removed from heat-treated cores, and we assume that most were made on blanks heat-treated as flakes.

When compared to projectile points, higher frequencies of non-heat-treated preforms are observed. By stage however, slightly *lower* frequencies of non-heat-treated, early stage preforms suggest that thermal alteration may have been undertaken during the initial stages of shaping and thinning. The higher proportion of non-heat-treated preforms then, may reflect manufacturing failures of marginally reduced flakes prior to heat-treatment.

Use Wear

Use wear and breakage patterns on points and preforms can be segregated into products of use, manufacture, and taphonomy. Of 42 preforms examined, only one clearly appears to have been used. This supports the assumption that preforms are, indeed, unfinished pieces.

All projectile points and preforms were examined macroscopically and types of breakage recorded. Generally, fluting fractures, burin-like fractures, and haft rebound fractures are associated with damage from use, while notching failures occur during manufacture. Snap fractures may occur during manufacture, during use, or post depositionally. Table 67 indicates that two-thirds of the Tosawihi points exhibit snap fractures, 12.2% exhibit breakage characteristic of use, and only 2.5% were broken during manufacture. Most breakage appears to be related to post depositional processes rather than to use or manufacture; on points without snap fractures, however, most failures appear to have occurred during manufacture.

Table 67. Fragment Types of Broken Points.

	Manufacturing Failure			
Area	Notch	Other Mfg.	Total	
	n	n	n	%
North	2	3	5	5.1
East	2	1	3	3.2
West	2	-	2	1.1
Quarry	-	-	-	0.0
Total	6	4	10	2.5

	Use Failure					
Area	Flute	Burin	Haft	Combination	Total	
	n	n	n	n	n	%
North	9	-	1	1	11	11.2
East	2	-	-	3	5	5.3
West	23	2	1	3	29	15.6
Quarry	3	-	-	1	4	17.4
Total	37	2	2	8	49	12.2

	Other				
Area	Snap		Indeterminate/NA		Total
	n	%	n	%	n
North	68	69.4	14	14.3	98
East	64	67.4	23	24.2	95
West	120	64.5	35	18.8	186
Quarry	16	69.7	3	13.0	23
Total	268	66.7	75	18.7	402

In order to identify the proportion of points that may have been utilized as arrow or atlatl tips, a sample of points and fragments was examined microscopically for use wear patterns. Damage resulting from piercing soft materials or impact with bone or similar dense material includes striae oriented parallel to the long axis, small step fractures, micro-rounding, and micro-polish. Since microscopic use wear is most easily recognized on obsidian, all obsidian points and fragments were examined. We also looked at opalite points retaining enough original form to reflect use wear.

Table 68 shows that over 40% of the selected sample exhibit evidence of use. This suggests that many points were brought back to camps embedded in carcasses; hunting probably was carried out nearby. Highest frequencies occur at sites in the Northern Corridor and the Western Periphery, reflecting the more residential use of those areas. Extensive retooling and discard also may have occurred there.

Table 68. Frequency of Use Wear Observed on a Sample of Projectile Points.

	Micro-Use Present		Indeterminate		Not Used		Total Sample
Area	n	%	n	%	n	%	n
North	24	47.1	27	52.9	-		51
East	19	35.9	34	64.1	-		53
West	43	40.6	62	58.5	1	.9	106
Quarry	5	38.5	8	61.5	-		13
Total	91	40.8	131	58.7	1	.4	223

Little evidence suggests that Tosawihi points often had alternative or multiple functions. Three obsidian specimens have wear traces consistent with being shot into soil, perhaps results of a missed shot; these traces consist of multiple parallel striations along the long axis of the point distributed across the entire surface. One point either was shot into soil or used as a knife, and another was used as a drill or perforator. One large, parallel flaked Humboldt point, broken in three pieces, was examined carefully for wear traces indicating use in cutting, but no use wear was observed.

Reworking

Forty-three projectile points (10.7%) exhibit reworking (Table 69). Most observable modification occurs along lateral margins or on the tips of broken points, and is revealed by asymmetrical forms (Figure 64). The Desert Series comprises nearly 36% of the classifiable assemblage, but few points (8.1% of the Series) appear to have been reworked. The highest incidence of reworking is observed in the Gatecliff (35%) and Elko Series (25.8%). Since Early and Middle-Archaic points are relatively large, their size may have invited higher incidence reworking.

Higher frequencies of reworking of Early to Middle-Archaic points might support the thesis that, owing to repair, projectile points are poor chronological indicators. In most cases observed, however, reworking is confined to lateral margins or to tips, and does not affect basal morphology. Basal modification is apparent on four specimens, all Late Archaic types. Reworking is confined only to the broken portion of the base (Figure 64a, b), and does not affect intact basal morphology significantly.

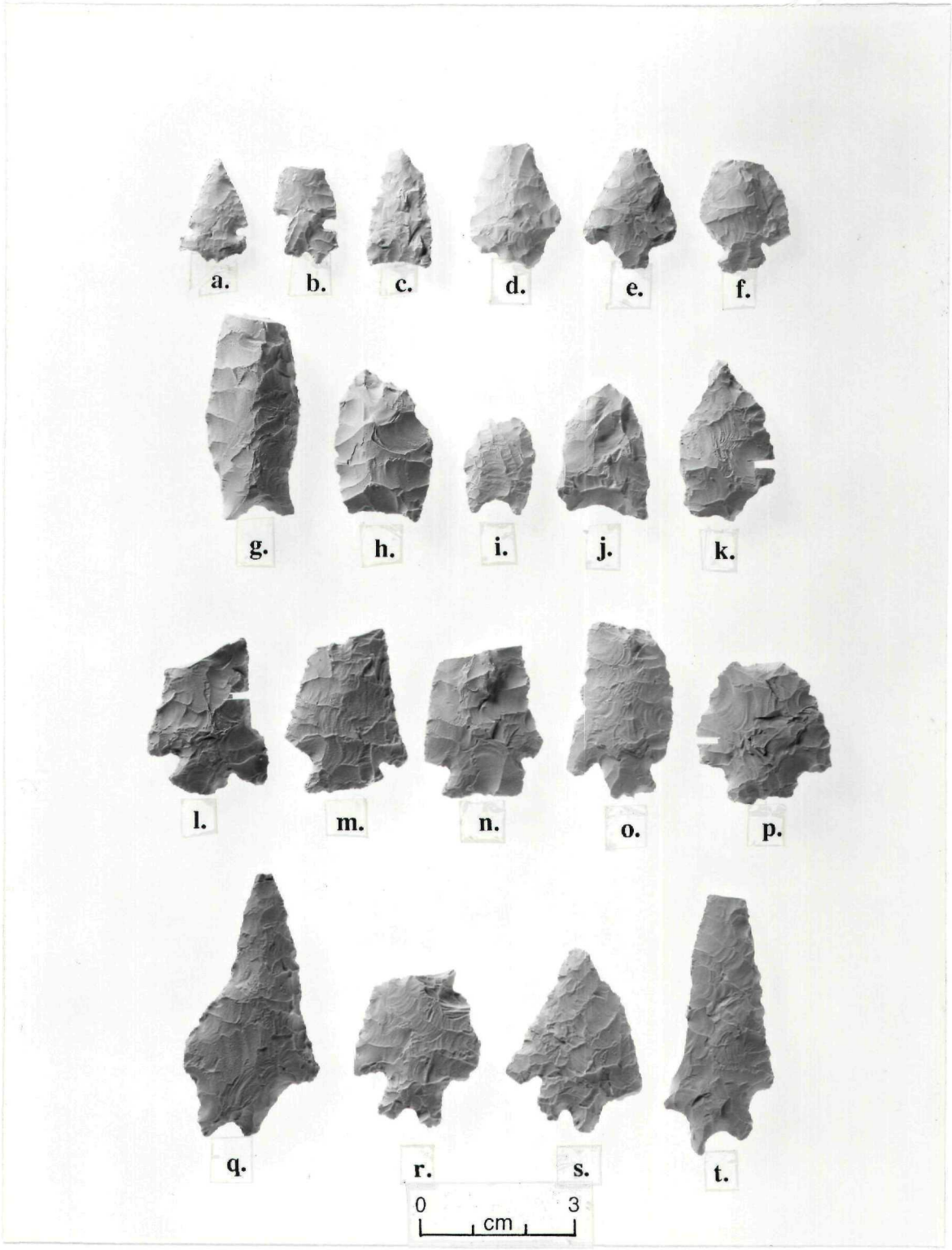


Figure 64. Reworked projectile points.

Table 69. Incidence and Type of Reworking Observed on Projectile Points.

Site Number	Reference/ Specimen No.	Type	Evidence of Reworking: Assym.	Work on Break	Non-Standard Form	Location of Reworking: Lateral	Tip	Base
26Ek3185	1015-1	DSN		X				X
26Ek3116	1007-1	DSN		X				X
3271	522-1	DSN	X				X	
3092	6362-1	DSN			X			X
3095	514-1	Cottonwood	X			X		
3106	2001-4	Cottonwood	X			X		
3160	6541-5	Cottonwood	x				X	
3102	500-10	Rosegate	X			X		
3160	500-103	Rosegate	X					X
	4032-1	Rosegate	X			X		
3271	500-138	Rosegate		X		X		
3251	1-10	Rosegate		X		X		
30327/20	4002-9	Elko	X			X		
3092	8302-1	Elko	X			X		
3123	78-1	Elko	X			X		
3160	1-190	Elko	X			X		
	4053-1	Elko	X			X		
3516	1-9	Elko	X			X		
3237	6744-1	Elko	X			X		
	6762-1	Elko	X			X		
3032/27	6062-2	Gatecliff	X			X		
3032/28	81-1a	Gatecliff	X			X		
3170	1-44	Gatecliff		X			X	
3095	5000-8	Gatecliff	X			X		
3237	6704-2	Gatecliff		X		X		
3238	500-1	Gatecliff	X			X		
3251	8001-1	Gatecliff	X			X		
	1-4	Humboldt	X				X	
3192	2203-2	Humboldt	X				X	
3237	6902-1	LSN	X			X		
3072/40	56-3	Unclassifiable		X		X		
3170	4060-2	Unclassifiable	X			X		
3177	2001-1	Unclassifiable	X			X		
3154	109-1	Unclassifiable	X			X		
3160	520-2	Unclassifiable	X			X		
3251	1-1	Unclassifiable			X	X		
3032/27	1-130	Fragment	X			X		
3032/72	66-9	Fragment		X		X		
3192	1055-1	Fragment	X			X		
3198	1018-3	Fragment			X			X
3160	6362-3	Fragment		X				X
3271	500-309	Fragment	X			X		
	1045-2	Fragment			X	X		

Characterization of Specific Activity Areas

Almost twice as many points were recovered from the Western Periphery as from any other sub-area (Table 70). This uneven distribution may owe partly to differential intensities of surface collection in the various subareas, but many points were recovered from the Northern Corridor, in which a much smaller area was sampled. The Northern Corridor and the Western Periphery exhibit the greatest degree of residential activity and the longest chronological sequences; the Quarries, the least and shortest.

Table 70. Point and Preform Frequencies by Subarea.

	Quarry		East		West		North		Total
	n	%	n	%	n	%	n	%	n
Points	23	5.7	95	23.6	186	46.3	98	24.4	402
Preforms	7	2.7	48	18.5	120	46.1	85	32.7	260
Total	30	4.5	143	21.6	306	46.2	183	27.6	662

The distribution of preforms largely reflects that of projectile points; few were recovered from the Quarries and the Eastern Periphery, while the highest relative proportions were found in the Northern Corridor and the Western Periphery. These differences in distribution may be related to different activity patterns or to variation in the temporal exploitation of sub-areas. Intensive exploitation of the East began fairly late in the Tosawihi sequence and probably accounts for the relatively low proportion of points and preforms recovered there.

Obsidian points and preforms occur in greater proportions in the Eastern Periphery and the Quarries, where points in general are least common (Table 71). Use of obsidian seems to intensify toward the end of the temporal sequence (Desert Series times), and may account for obsidian's greater relative frequency in the East the exploitation of which intensified then. Basalt and jasper points are more abundant in the Western Periphery and in the Quarry, where they occur naturally. Points made of chalcedony, a material favorable for its flaking properties, are found in the North, the East, and the West.

Table 71. Projectile Point-Preform Raw Material Types by Area.

	Opalite		Obsidian		Basalt		Chalcedony		Jasper		Opal		Other	
Area	n	%	n	%	n	%	n	%	n	%	n	%	n	%
North														
Points	76	77.5	15	15.3	-	-	5	5.1	-	-	1	1.0	1	1.0
Preforms	76	89.4	5	5.9	-	-	2	2.3	1	1.2	1	1.2	-	-
East														
Points	53	55.8	33	34.7	1	1.1	7	7.4	1	1.1	-	-	-	-
Preforms	32	66.6	14	29.2	-	-	2	4.2	-	-	-	-	-	-
West														
Points	123	66.1	40	21.5	2	1.1	12	6.5	4	2.2	3	1.6	2	1.1
Preforms	101	84.2	5	4.2	-	-	9	7.5	4	3.3	1	0.8	-	-
Quarry														
Points	8	34.8	11	47.8	2	8.7	-	-	2	8.7	-	-	-	-
Preforms	6	85.7	1	14.3	-	-	-	-	-	-	-	-	-	-
TOTAL														
Points	260	64.7	99	24.6	5	1.2	24	6.0	7	1.7	4	1.0	3	0.7
Preforms	215	82.7	25	9.6	-	-	13	5.0	5	1.9	2	0.8	-	-

Generally, points in the Quarry are heat-treated less frequently than those from other subareas. Lower apparent frequencies probably are due the relative abundance of stemmed points, which rarely are heat-treated. While the remaining three sub-areas all exhibit a relatively high proportion of heat-treatment, the Northern Corridor exhibits a slightly lower frequency (Table 72). Lower proportions in the North are influenced by a higher frequency of post-depositionally burned and possibly heat-treated specimens. As well, the Northern Corridor

exhibits a slightly higher proportion of points made on flakes removed from heat-treated cores. This may owe to the frequency of heat-treated biface reduction and the concurrent detachment of flakes suitable for point production.

Table 72. Heat-Treated Projectile Points and Preforms by Site Area.

Area	Core	HT	Flake	HT	Blank	HT	Poss/Post		No	HT
North										
Points	3	3.6	17	20.5	45	54.2	14	16.9	4	4.8
Preforms	8	10.0	28	35.0	30	37.5	7	8.7	7	8.7
East										
Points	2	3.3	24	39.3	30	49.2	2	3.3	3	4.9
Preforms	3	8.8	10	29.4	6	17.6	4	11.7	11	32.3
West										
Points	2	1.4	39	27.1	87	60.4	7	4.9	9	6.3
Preforms	7	6.1	38	33.0	25	21.7	14	12.1	31	27.0
Quarry										
Points	0	0	1	10.0	4	40.0	1	10.0	4	40.0
Preforms	0	0	1	16.7	1	16.7	2	33.3	2	33.3
TOTAL										
Points	7	2.3	81	27.2	166	55.2	24	8.0	20	6.7
Preforms	18	7.7	77	32.8	62	26.4	27	11.4	51	21.7

The pattern of thermal alteration of preforms is similar to that of bifaces. Proportions of preforms and projectile points made on blanks detached from heat-treated cores is slightly higher in the Northern Corridor, but heat-treatment of blanks is the predominant pattern in all subareas.

Tip orientation on preforms varies between subareas. In the North and West, the pattern is similar: tips tend to be located on the proximal ends of flakes. They comprise about one-half of the classifiable sample. The remaining half is divided equally between distal and transverse orientations. In the East, a distal tip orientation is most common (ca. 50% of the classifiable sample), while 30% of the tips are oriented proximally. Arrowpoints (Rosegate and Desert Series points) frequently have unflaked areas on their ventral surfaces, facilitating identification of tip orientation. They are most often made on distal ends of blanks. When ventral surfaces are observable, earlier points exhibit a variety of orientations.

The proportion of preforms made on biface thinning flakes does not vary much between subareas. The sample of projectile points for which blank form can be determined is too small to reflect areal differences.

The frequency of points broken during manufacture is highest in the Northern Corridor. If we also consider preforms and pressure flakes to be indicators of projectile point manufacture, some sites display concentrations of this activity (Table 73). Outside the Quarry, some sites in each of the other three subareas exhibit substantial point manufacture. Technological analysis was conducted on only a small sample of the debitage, and screening with 1/8 inch mesh (without the use of which pressure flakes rarely are recovered) was employed only on portions of sampled features; pressure flake quantities listed in Table 73, therefore, cannot be considered particularly representative. Many of the assemblages with the highest frequency of pressure flakes also contain other indicators of residential activity, but a few sites (e.g., 26Ek3251 and 26Ek3198) which have high frequencies of artifacts and evidence of point manufacture have little groundstone, and few flake tools. They may have served limited functions.

Table 73. Distribution of Artifacts Related to Projectile Point Manufacture.

Area	Points Broken During Manufacture	Preforms	Pressure Flakes
North	5	85	144
East	3	43	239
West	2	125	49
Quarry	-	7	1
Total	10	260	433

Greater frequencies of points broken in use were recovered in the Western Periphery, a subarea characterized by sites with a long temporal span and a wide range of activities (Table 74). Reworked points are found in all areas, with highest proportions in the Quarries, where the oldest types are common, and lowest frequencies in the Eastern Periphery, dominated by Late Archaic point types. The ratio between points broken in use and those broken in manufacture is highest in the Western Periphery.

Table 74. Projectile Point Breakage by Area.

	Quarry		East		West		North		Total	
	n	%	n	%	n	%	n	%	n	%
Broken in Use	4	17.4	5	5.3	29	15.6	11	11.2	49	12.2
Broken in Manufacture	0	0.0	3	3.2	2	1.1	5	5.1	10	2.5
Indeterminate	19	82.6	87	91.6	155	83.3	82	83.7	343	85.3
Total	23	100.0	95	100.0	186	100.0	98	100.0	402	100.0
Reworked	6	26.1	7	7.4	21	11.3	9	9.2	43	10.7
Points Broken in Use : Points Broken in Manufacture	4.0		1.7		14.5		2.2		4.9	

Preforms, pressure flakes, and projectile points with manufacturing failures indicate that a good deal of point manufacture was carried out in all sub-areas. Incidence of *use* is lowest in the Eastern Periphery, then increases westward through the Quarries, Western Periphery, and Northern Corridor.

The proportion of later points is greater in feature contexts and the proportion of earlier points greater in non-feature contexts. Obsidian hydration data from a variety of artifact classes also reflects differences in the age of feature and non-feature associated material (cf. Chapter 19). This pattern suggests that older materials have been dispersed over the landscape, while the later material is more tightly clustered (Table 75). As a result of dispersal, older activity areas may no longer be recognizable. The distribution of points and preforms at the site and feature level will be discussed and their co-occurrence with other artifact classes examined in Chapters 24-26.

Table 75. Point Types from Feature and Non-feature Contexts.

Point Type	Feature Contexts n	Feature Contexts %	Non-Feature Contexts n	Non-Feature Contexts %	Total
Desert Series	55	64.0	31	36.0	86
Rosegate	15	44.1	19	55.9	34
Elko	7	22.6	24	77.4	31
Gatecliff	4	20.0	16	80.0	20
Humboldt	5	38.5	8	61.5	13
Large Side-notched	4	44.4	5	55.6	9
Stemmed	5	25.0	15	75.0	20
Clovis	0	0	1	100.0	1
Unclassifiable	18	64.3	10	35.7	28
Fragmentary	106	66.3	54	33.7	160
Total	219	54.5	183	45.5	402

Summary

The projectile points in the Tosawihi assemblage include types that range from Clovis to the Desert Series. The Clovis preform, broken during manufacture, was found at a large, intensively occupied site. It is made from material available locally, but it may have been imported and served a broader function. Close to half the dateable points recovered are of Late Archaic age. Despite the pattern of late, intensive exploitation of the quarries (supported by carbon dates, pottery, and obsidian hydration) the presence of Stemmed points made of Tosawihi opalite indicates that the quarries were used as raw material sources in the Pre-Archaic.

Seventy percent of preforms are too small to have been made into points dating earlier than Rosegate times, and it is probable that some portion of the remaining preforms also were made into Late Archaic types. This allows us to use preforms as relative indicators of Late Archaic occupation.

The predominance of opalite points notwithstanding, obsidian clearly was favored as a raw material the projectile point production. Obsidian points compose a far greater proportion of the point assemblage than do obsidian specimens in other flaked tool categories. This probably is because obsidian is easier to pressure flake than the other available materials. Chalcedony, which also is easier to pressure flake than other non-heat-treated materials also comprises a greater proportion of the point assemblage than it does of other artifact categories. When the proportions of obsidian points and preforms are compared to all points and preforms, it is clear that some obsidian points were brought to Tosawihi in finished form.

The presence of pressure flakes and broken preforms indicates *in situ* manufacture of both opalite and some obsidian points. Tip orientations of points and preforms are not very similar, but preforms and Late Archaic points reflect a tendency to produce tips on the distal ends of flake blanks. This, and the more tightly clustered lengths of these point types, suggest a more standardized approach to point production during the Late Archaic.

To facilitate pressure flaking, the majority of opalite points were heat-treated. Heat-treatment of points and preforms is much more common than of other artifact classes. Except for stemmed examples, almost all opalite points were heat-treated.

Manufacturing techniques changed, but were not completely replaced, with introduction of the bow and arrow. Arrowpoints almost always were made from flake blanks, first slightly pressure flaked or abraded around the edges, then pressure flaked. Retouch usually covers all of the dorsal surface, but a portion of the ventral surface frequently remains unflaked. Dart points appear to have been made in two ways, i.e., with and without a percussion flaking stage before pressure flake finishing. The manufacturing stages of dart points are more difficult to document; their preforms probably resemble small bifaces, and we have not been able to distinguish them from failed or exhausted bifacial tools.

Although original blank form often is obscured by subsequent reduction, we assume that many points and preforms (with the exception of Stemmed points) are made on flakes detached from bifaces. Larger point types are derived from early stage biface manufacture, while smaller types could have been removed during any stage of reduction. Because they are heat-treated as flakes and not struck from heat-treated bifaces, however, flakes for smaller points probably were detached before middle Stage 3.

The proportion of complete points differs among types. Elko and Gatecliff Series points tend to be more fragmentary, perhaps indicating a greater degree of reworking, or reflecting changes in targets or velocities. Their larger size also may have facilitated reworking and repair. Breakage and use-wear patterns reflect a variety of activities. Failures during manufacture rarely are identifiable in the point assemblage, but broken preforms and pressure flakes signal loci where point manufacture took place. Points exhibiting breakage during use are more

common; they identify kill or butchery sites, sites where carcasses were processed or consumed, or places where points were reworked. While manufacture and reworking of points occurred in all areas, the evidence for point *use* is lower in the Quarries and the East, reflecting the non-residential character of these sub-areas.

Projectile point frequencies and distributions suggest a change in toolstone exploitation over time. The Western Periphery and Northern Corridor exhibit higher incidences of point use, and also exhibit the broadest temporal diversity. Points from the Quarries reveal an early focus; utilization of the Eastern Periphery is late. The high frequency of late points in the East may reflect an intensification of production and a concurrent restructuring of logistical organization.

Chapter 9

CORES AND MODIFIED CHUNKS

Kathryn Ataman and William W. Bloomer

Cores consist of blocks of raw lithic material from which pieces intended for use or for further modification have been detached. In biface industries, however, cores often cannot be distinguished from bifaces, since many bifaces may have functioned at times in their use cycles both as cores and as bifacial tools. Only cores *not* exhibiting biface morphology are considered here; relatively few pieces in the Tosawihi assemblage fit this narrow definition.

Modified chunks are angular pieces of debitage, as large as cores or bifaces, deliberately modified, but not exhibiting the morphology or patterned flake removals characteristic of *either* core or biface reduction. They may represent assayed pieces, expedient cores, failed bifaces, or unique products of quarry-related reduction. We consider modified chunks and cores in the same analytical framework, since both appear related to raw material procurement and early stage reduction.

Most cores and modified chunks included in this analysis were recovered from areas peripheral to the Tosawihi Quarries. While we expect that most were used and discarded at quarries, the presence of cores made on stream and colluvial cobbles indicates that some may have other origins and distributions. The small sample from the Quarries limits our ability to observe variation in cores and other quarry-related artifacts. Consequently, conclusions concerning the place of core reduction in the Tosawihi technological system are provisional.

Research Aims

The study was designed to examine whether a core reduction trajectory, separate from the clearly discernible biface reduction trajectory, can be observed at Tosawihi. Secondarily, if such a trajectory exists, we must know what was produced from core reduction flakes and how the production of such flakes varied temporally, spatially, and in relation to other artifact production.

Morphology and Technology of Cores and Modified Chunks

Tosawihi cores vary morphologically, but two predominant forms, irregularly shaped, blocky or spheroidal cores and well-shaped, often conical pieces exhibiting regular flake scar patterns, reflect distinct modes of production. Blocky or spheroidal cores may be by-products of core reduction used to produce large flake blanks in a biface reduction trajectory. They might, in fact, represent exhausted cores that initially yielded large flake blanks for the production of large bifaces; when no longer yielding sufficiently large flakes, they may have fallen out of the biface trajectory into a core reduction trajectory for the production of blanks for flake tools, projectile point preforms, or small bifaces. Alternatively, they may have entered the core reduction trajectory as relatively small, minimally reduced blocks for the production of small flake blanks. Since, for reasons outlined in more detail below, well shaped conical cores are less likely to be by-products of a biface trajectory, they constitute our strongest argument for the co-occurrence of an independent core reduction trajectory.

Core Reduction Technology

Our investigation of core reduction technology focuses on the dimensional and morphological parameters of flake blank production. Flake blanks used to produce flake tools, preforms, and bifaces are compared with data from core analysis to yield inferences on the types of artifacts produced from various core types. This information informs us if the reduction of cores proceeded along a distinct trajectory, and allows us to assess to what extent and in which cases biface and core reduction trajectories may have overlapped (e.g., as in the production of small bifaces).

Spatial and Chronological Variability in Core Reduction Strategies

Two distinct core production modes directed our attention to the possibility that each might vary spatially and/or chronologically, and might reflect variation in mobility strategies. If, for example, the earliest visitors understood the expedient use of stream cobbles as cores during hunting forays, and later visitors quarried toolstone from outcrops or quarry pits, we might expect to find cobble cores in earlier associations. Hence, we focused research on the spatial distribution of cores and their association with reduction and residential activities. These associations are discussed in subsequent chapters.

Data Collection Methods

Provenience, metric data, and raw material characteristics were recorded for cores and modified chunks. Cores were segregated into seven classes, consisting of assayed pieces, block cores, spheroidal cores, split nodules, fragments, possible cores, and other types (primarily conical cores).

Assayed Pieces consist of pieces discarded after the removal of one or more flakes had revealed undesirable features or proportions; they often are of inferior raw material and have flaws rendering them unsuitable as cores. *Block cores* are angular, with flat working faces and one or more platforms, while *spheroidal* cores are worked from multiple platforms, resulting in roughly spherical pieces. *Split nodules* most often are made from stream cobbles and exhibit cortex or weathered surfaces. *Possible cores* have less distinctly patterned flake removals than other types; they do not appear to be bifaces, however, and are more similar to cores than to modified chunks. *Other types* consist primarily of conical cores, the most patterned pieces in the core assemblage, usually with a single platform. Opalite, basalt, and obsidian cores are illustrated in Figures 65-68.

Only one core was found unquestionably to have been heat-treated. The paucity of heat-treated cores at Tosawihi may indicate that prehistoric tool makers found it difficult to heat a large chunk evenly or to cause it to reach the critical temperature.

Modified chunks were recorded in terms of flake tool attributes since the place of such pieces in Tosawihi lithic trajectories was unclear, and core attribute lists were less informative. Neither cores nor modified chunks were examined for traces of use.

The Core Assemblage

The analytical sample is composed of 136 cores. The sample is small because few quarry areas (where core reduction is expected to have occurred most often) have been examined in great detail.

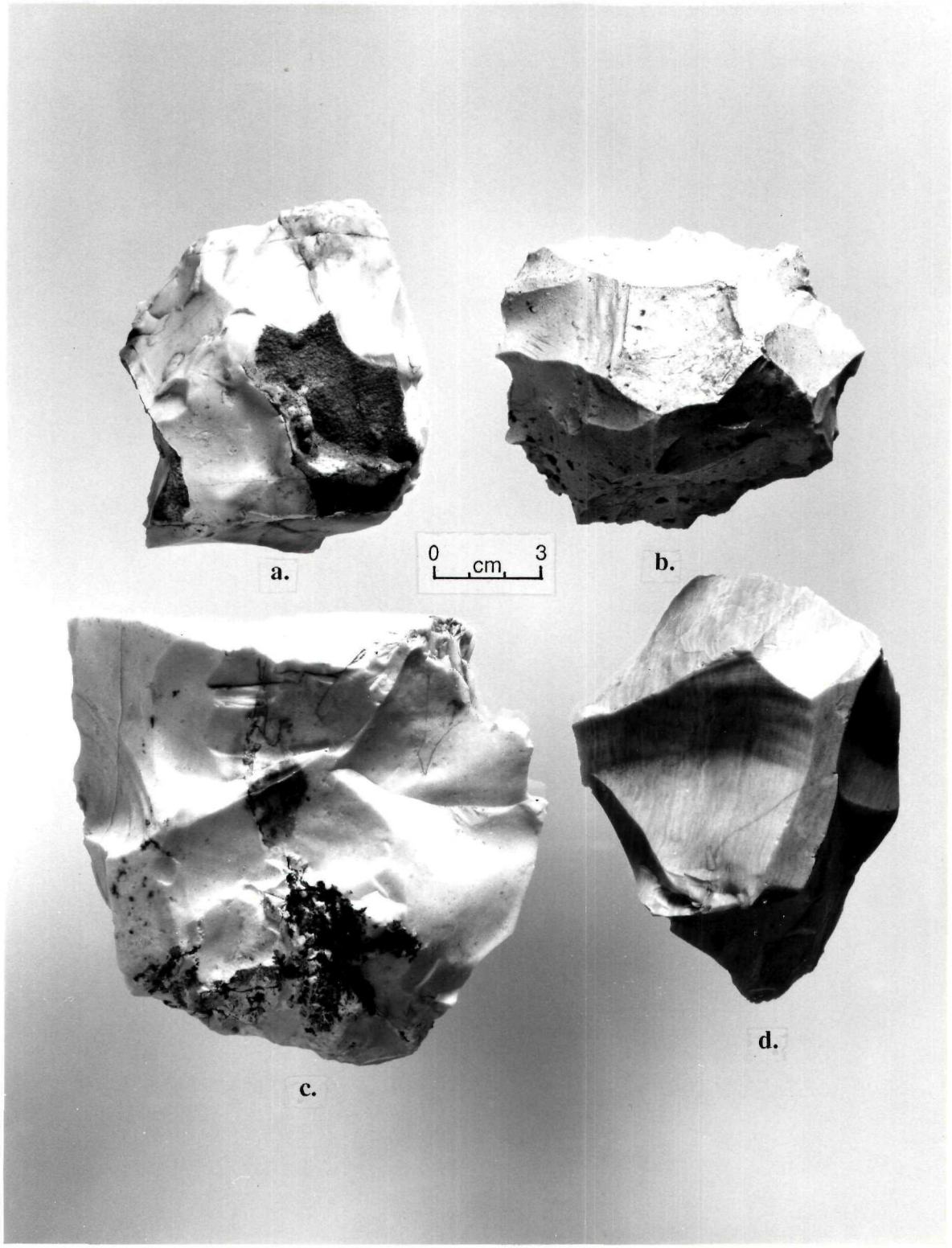


Figure 65. Selected opalite core types.

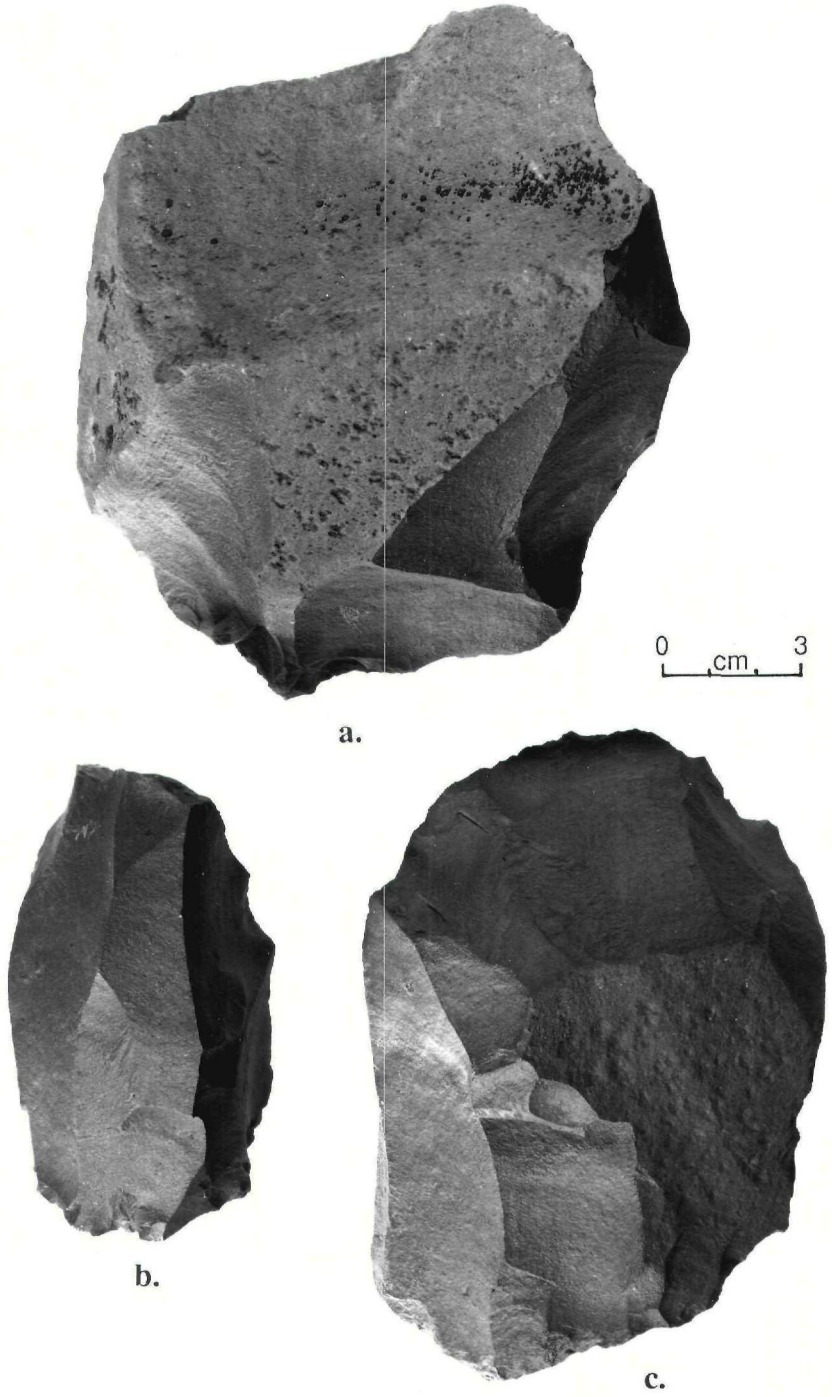


Figure 66. Basalt core types.

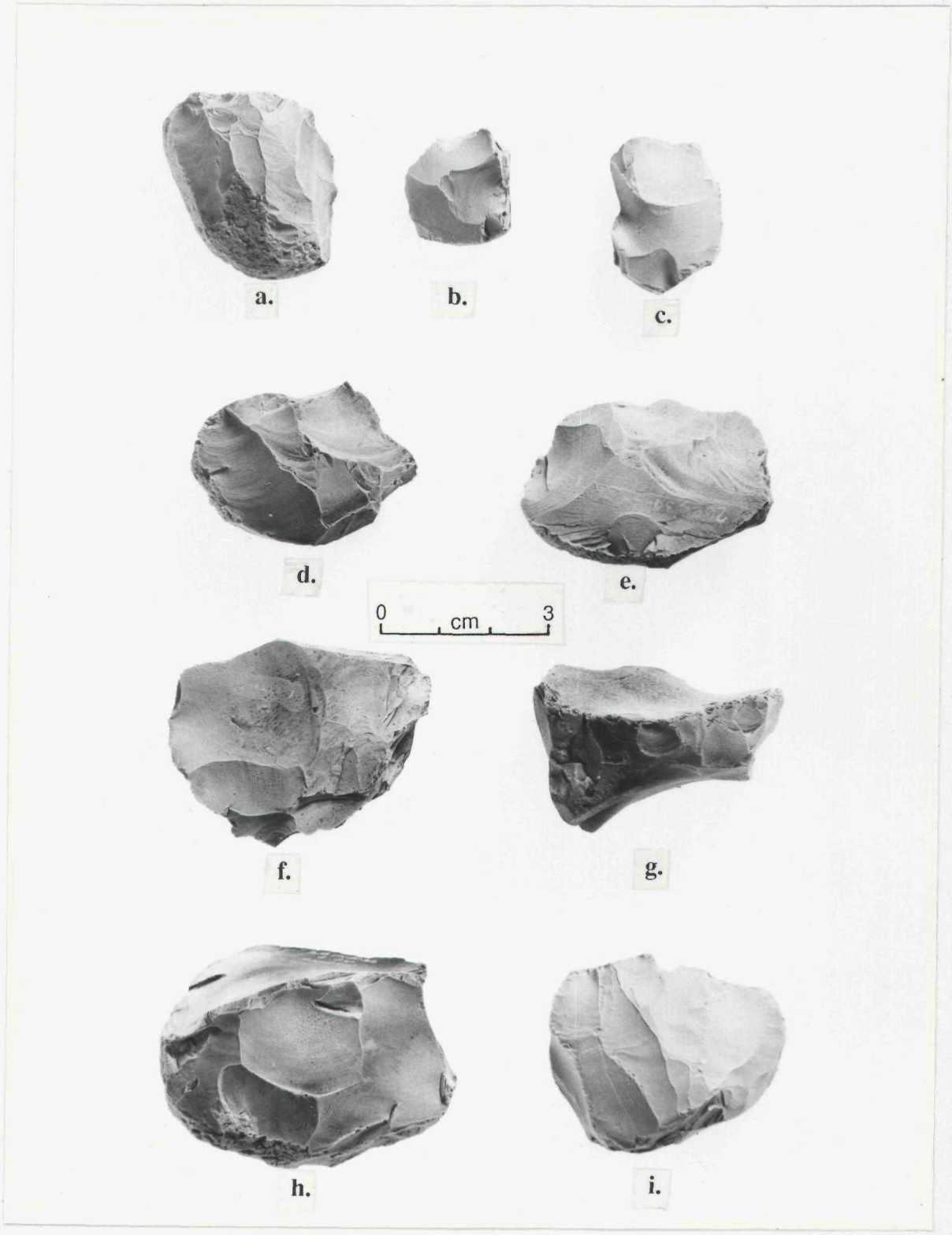


Figure 67. Obsidian cores.

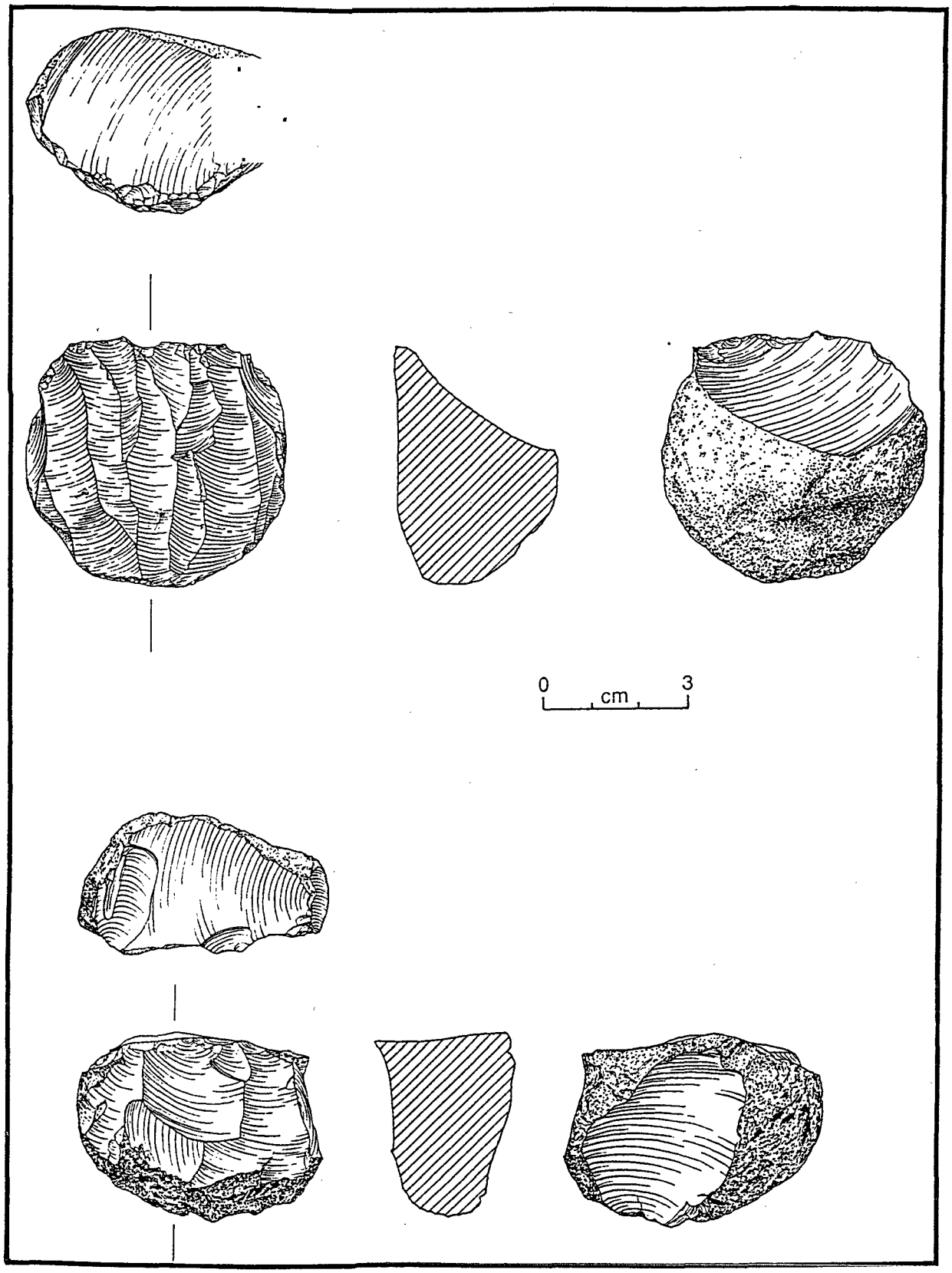


Figure 68. Obsidian cores.

The average weight of cores is 686 g, and the average longest dimension about 100 mm. The mean lengths of each core type do not differ greatly, save that assayed pieces are about 50% longer than most cores. Core dimensions were examined to suggest the probable dimensions of detached flakes. The maximum length and width of each core limits the size of flakes that could have been detached from it. Comparison with dimensions of flake blanks for other chipped stone artifacts indicates that most projectile points and preforms in the analytical sample were produced on flake blanks that could have come from *any* of the cores (Table 76); only some stemmed points and a Clovis preform appear too large.

Flake tool mean lengths are smaller than those of all core types, but the ranges overlap in several categories; almost all flake tools in our sample could have been detached from these cores independent of material type. Obsidian stemmed point blanks, however, probably were detached from cores larger than those in the obsidian core sample.

Table 76. Mean Lengths of Cores and Complete Flake Tools By Type.

Tool Type	n	LENGTH (in mm) Mean	Min/Max	SD
Side Scraper	22	69.8	28.1-117.3	24.5
End Scraper	67	58.6	20.8-110.4	21.1
Misc. Scraper/Frag.	24	67.2	21.3-120.2	27.2
Sym.Pointed Tool (elongate)	13	43.5	24.2- 69.3	13.5
Sym.Pointed Tool (short bit)	6	1.4	31.9- 63.3	11.4
Assym. Pointed Tool	15	3.4	25.0- 67.5	13.0
Trihedral Pointed Tool	5	85.6	71.1-104.2	14.2
Notch/Denticulate	25	68.4	34.4-107.4	21.1
Biface w/slightly sinuous profile	6	54.3	34.6- 75.3	15.5
Biface w/coarse sinuous profile	2	80.7	74.6- 86.8	8.6
Flake w/ cont. retouch -- one edge	36	48.1	20.8-131.3	19.9
Flake w/ cont. retouch -- multiple edges	14	68.1	34.0-112.9	24.1
Flake w/localized retouch	50	58.8	30.0-126.1	22.3
Crudely retouched flake/chunk	6	70.1	23.1-100.4	31.2
Flake w/ var. ret. pattern -- multiple edges	26	56.7	32.5-122.3	22.4
Microdenticulate	4	41	34.4- 50.3	6.7
Discoidal tool	8	102.6	45.0-143.5	33.4
Chopping Tool/Hammer	5	116.2	58.3-180.0	49.5
Other	3	81.8	61.1-100.0	19.6

Core Type	n	LENGTH (in mm) Mean	Min/Max	SD
Assayed Piece	11	148.1	41.0-230.0	50.8
Block	47	99.0	20.0-193.0	42.6
Spheroid	17	89.9	27.5-160.0	43.1
Split Nodule	4	93.1	32.2-167.0	63.8
Fragment	23	80.4	20.2-136.0	31.2
Other	28	98.1	30.1-200.0	35.8
Possible Core	7	100.3	40.3-185.0	50.5

Most cores probably are exhausted forms and were somewhat larger in earlier stages of reduction; their present sizes represent lower limits for comparison with other artifact classes. Core morphology, however, the paucity of flake scars, and that approximately one-third of the specimens were made on cobbles of estimable size suggest that they probably were not much larger at any previous stage.

Only the smallest biface flake blanks in the collection could have been detached from observed cores, but we collected a few Stage 1 bifaces (unreduced biface blanks) larger (mean length = 109.1 mm) than could have been detached from cores in our sample. Size distribution among bifaces is not bimodal (cf. Chapter 7:Figures 20 and 21), suggesting it is unlikely that a separate trajectory for small bifaces made on flake blanks struck from small, prepared cores was significant. A few small bifaces *could* have been produced from such flakes, however (cf. Chapter 21).

Most cores (82%) are made of opalite, but nine (6%) are of obsidian and eight (5.8%) of basalt (Figures 65-68). Cores of jasper and other varieties of opalite (chalcedony and opal) are infrequent. All assayed cores and possible cores are of opalite (Table 77). Obsidian cores are primarily spheroidal forms or split cobbles, while those of basalt are mostly blocky and conical. Obsidian and basalt cores are more regular and patterned than those of opalite, and are not likely to have been produced during biface manufacture; they reflect a flake/core trajectory for the production of blanks for flake tools, points, and even bifaces.

Table 77. Core Type by Material.

	MATERIAL					
Core Type	Opalite n	Obsidian n	Basalt n	Jasper n	Other n	Total
Assayed Piece	11	0	0	0	0	11
Block	36	3	5	1	2	47
Spheroid	14	3	0	0	0	17
Split Nodule	3	2	0	0	0	5
Fragment	19	1	1	2	0	23
Other	23	1	2	2	0	28
Possible Core	7	0	0	0	0	7
Total	113	10	8	5	2	138

Spatial Distribution

Cores were recovered most frequently from 26Ek3032, although surface collections are small and excavated volume is low (Table 78). The Northern subarea exhibits the lowest proportion of cores, probably because it is farthest from raw material sources. The Western and Eastern Peripheries both exhibit similar proportions of cores, indicating association with early stage reduction of tools and/or small bifaces. Assayed pieces and possible bifaces are most common in the East, while spheroids and split nodules are found most often in the Quarry. Blocky and conical cores (the most patterned types) as well as fragments occur in all areas.

Table 78. Core Type by Subarea.

Core Type	East n	West n	North n	Quarry n	Total
Assayed Piece	7	3	0	1	11
Block	10	15	3	19	47
Spheroid	3	3	0	11	17
Split Nodule	1	0	0	3	4
Fragment	4	9	1	9	23
Other	8	7	2	11	28
Possible Core	4	1	0	2	7
Total	37	38	6	56	137

Obsidian cores were found in all subareas (Table 79); the greatest proportion was recovered from the East. Basalt cores (excepting one example from the North) were found only in the West, where basalt is common both in drainages and on slopes. Site 26Ek3092 (in the Western Periphery) exhibits the widest range of material and types, although Localities 23 and 27 of 26Ek3032 also have high incidences of cores (all opalite). The North and West exhibit the widest range of materials, the East, only opalite and obsidian, and the Quarry, opalite only.

Table 79. Core Material by Subarea.

Material	East n	West n	North n	Quarry n	Total
Opalite	32	26	1	54	113
Obsidian	4	2	1	2	9
Basalt	0	7	1	0	8
Jasper	1	2	2	0	5
Other	0	1	1	0	2
Total	37	38	6	56	137

Core Procurement

Many core blanks (36%) are of indeterminate origin; of the remainder, we have sorted those made on flakes or blocks from those made on cobbles (Table 80). Most *probably* were made on chunks of opalite extracted from the quarry but, once reduced, this is difficult to recognize. Some cores (and some bifaces as well) were made on cobbles collected from stream beds or colluvial deposits. Cobbles infrequently provided raw material for bifaces, but close to one-third (28%) of the cores were made on cobbles of opalite, basalt, and obsidian; most frequently, they are assayed pieces, blocky cores, or split nodules. Opalite cobble cores are distributed widely, not restricted (as are opalite cobble bifaces) to sites along the middle reaches of Little Antelope Creek. The proportion of opalite cores made on cobbles increases with distance from the quarries.

Table 80. Core Blank Types By Subarea.

	SUBAREAS				
Blank Type	East	West	North	Quarry	Total
ALL CORES					
Flake	15	12	1	21	49
Cobble	8	17	4	9	38
Indeterminate	14	9	1	26	50
Total	37	38	6	56	137
OBSIDIAN CORES					
Flake	0	0	0	0	0
Cobble	1	1	1	0	3
Indeterminate	3	1	1	1	6
Total	4	2	2	1	9
BASALT CORES					
Flake	0	1	0	0	1
Cobble	0	6	1	0	7
Indeterminate	0	0	0	0	0
Total	0	7	1	0	8
OPALITE CORES					
Flake	15	11	1	21	48
Cobble	7	10	3	8	28
Indeterminate	11	8	0	25	44
Total	33	29	4	54	120

The Modified Chunk Assemblage

Sixty-seven modified chunks were recovered. They are of opalite almost exclusively and are slightly smaller than most cores, averaging 88.3 mm in length and weighing an average of 233.4 g. Twenty-two percent of them exhibit some cortex; they probably were made on cobbles (Table 81).

Table 81. Presence/Absence of Cortex on Modified Chunks by Subarea.

	East		West		North		Quarry		
Cortex	n	%	n	%	n	%	n	%	Total
Presence	7	22.6	5	20.8	1	33.3	2	22.2	15
Absence	24	77.4	19	79.2	2	66.7	7	77.8	52
Total	31	100.0	24	100.0	3	100.0	9	100.0	67

This proportion is slightly less than that for cores, and (also in contrast to cores, which almost *never* are heat-treated) 12% of the modified chunks were thermally altered (Table 82). Most were worked on more than one edge, and worked edges are generally irregular.

Table 82. Heat-Treatment of Modified Chunks by Subarea.

	East		West		North		Quarry		
Thermal Alteration	n	%	n	%	n	%	n	%	Total
Blank from Heat-Treated Core	2	6.5	-	-	-	-	-	-	2
Heat-Treated as a blank	1	3.2	3	12.5	-	-	-	-	4
Heat-Treated during reduction	-	-	1	4.2	-	-	-	-	1
Post-Depositional thermal alteration	1	3.2	-	-	-	-	-	-	1
Not Heat-Treated	27	87.1	20	83.3	2	66.7	9	100.0	58
H/t but Stage Indication	-	-	-	-	1	33.3	-	-	1
Total	31	100.0	24	100.0	3	100.0	9	100.0	67

Modified chunks are distributed somewhat differently from cores. While cores are found in the East, West, and Quarry areas, modified chunks are found primarily in the East and West. However, the distribution of modified chunks exhibiting cortex is more evenly distributed; suitable alluvial and colluvial material occurs in many areas, and probably was exploited opportunistically.

The incidence of thermal alteration of modified chunks resembles that of bifaces more than cores; most thermally-altered modified chunks were found in the Western and Northern subareas.

The morphology of modified chunks, their spatial distributions and frequency of heat-treatment indicate that they probably were by-products of early stage biface reduction. Fewer examples are found in the Quarry than in other subareas, owing to smaller samples collected there; fewer examples were recovered from the North because less early stage reduction was conducted there.

Discussion

We do not believe that most cores in our sample represent exhausted cores used for the production of large bifaces. Several observations support this conclusion. First, the number

of bifaces greatly exceeds the number of cores; it seems that cores, at least in the forms we recognize, were not common by-products of biface blank production. Second, observed cores probably were not much bigger than they are now, and thus were not large enough to have yielded the blanks on which most bifaces were made. Third, recent observations of material from a Tosawihi quarry location not reported herein indicate that bifaces were made not only on flake blanks *detached from* blocks of material extracted from bedrock but also *directly* on the blocks without an intervening flake stage. It is possible, however, that cores used for the production of small bifaces commonly were reduced to unrecognizable form, or that they were worked into bifaces subsequent to detaching large flake blanks; modified chunks, then, (but not cores) might be by-products of either process.

If Tosawihi cores represent a separate trajectory for the production of small blanks for opalite flake tools, preforms, and even small bifaces, it was a distinctly minor trajectory. It seems likely that most pieces classified as cores were used to produce flake blanks for flake tools, points, or small bifaces. Over half the flake tools were made on flakes clearly detached from bifaces, reinforcing our view of the relative unimportance of a core/flake trajectory. This is less clear for preforms and points (although 10% of the preforms were made on biface thinning flakes), of which the origin of the majority of blanks is indeterminate.

Obsidian and basalt trajectories differ from that of opalite. Obsidian flakes used for the production of flake tools, points, or bifaces apparently were produced from small obsidian cobble cores. We found few obsidian bifaces and few obsidian biface thinning flakes, so it seems particularly unlikely that obsidian tool blanks were detached from bifaces. Basalt flakes for the production of tools and bifaces were produced from cobbles and tabular pieces in the West and North. Obsidian and basalt cores are much more patterned than those of opalite, and a core trajectory is clear for both (Figures 66-68; cf. Chapter 21).

Modified chunks are reduction by-products that *probably* resulted more from early stage biface reduction than from core reduction; they might, however, represent the fragmentary remains of exhausted cores. The distributions of cores and modified chunks differ sufficiently, however, to suggest that if modified chunks are flake core fragments, cores were reduced differently in the East and West than in the Quarry. The infrequent occurrence of cores in Tosawihi assemblages indicates the intentional production of small blanks for tools or bifaces; modified chunks reflect early stage reduction, whether of bifaces, biface blanks, or blanks for other classes of tools. The distribution of these two artifact types in specific feature and non-feature loci is examined in later chapters.

Chapter 10

DEBITAGE ANALYSES

William W. Bloomer and Eric E. Ingbar

Debitage has been perceived both as an ideal artifact class ands a millstone around the necks of archaeologists. It is common, generally has a short use-life (Schiffer 1975), and endures most depositional settings. It should be an ideal venue for the study of chipped stone reduction and stone tool use and, in fact, debitage analyses have contributed to the study of a broad range of topics, ranging from style (Close 1989) to site function and technological organization (Camilli 1989). There is ongoing debate about the degree to which debitage analyses contribute useful information to all of these topics, but the data class undoubtedly offers important evidence concerning the production, use, and modification of stone tools. The ubiquity of flakes, however, also can be a liability. Sheer frequencies and masses of debitage sometimes are overwhelming, especially at quarry and workshop localities, and the time necessary to analyze debitage collections, even at a gross level, can be so great that such analysis often is deferred in favor of investigation of less common artifacts. At Tosawihi, debitage is undoubtedly the most common artifact class; billions of flakes occur in and around the quarries. The present analyses address more than 900,000 specimens.

Two approaches have been used in most debitage studies. One processes the materials in "bulk" (e.g., by size grading), and the other collects information on individual flakes through classification or attribute data. The latter has the disadvantage of requiring much time to record even a moderate assemblage. Bulk techniques of analysis are quicker, but they sacrifice the documentation of variation provided in piece by piece analysis.

Given the immense numbers of flakes present in the Tosawihi samples, our analytical techniques focus more on assemblage characteristics than on detailed characterizations of chipped stone production. We employ two complementary approaches: mass analysis (Ahler 1989b) and technological analysis (Flenniken 1987; Flenniken and Ozbun 1988). Controls for both techniques are provided by documented replications produced by colleagues using Tosawihi opalite, as well as by replicative exercises conducted by Ahler (1989b).

Research Goals

Quarries are important sources of information about the technological organization (as well as higher levels of organization) of prehistoric peoples (Ericson and Purdy 1984); they divulge the "starting point" of stone tools. Toolstone reduced at quarries ultimately was used for tools within other parts of the settlement and subsistence system (Binford 1979; Gould and Saggers 1985). Size, shape, numbers, and variability among stone tools all contribute information to models of lithic economies (cf. Chapter 3). One goal of our analysis of debitage from Tosawihi, therefore, has been to determine the sizes, shapes, and numbers of tools and other products (such as cores) produced for "consumers" in the regional settlement and subsistence system. These are rough measures of the prehistoric importance of Tosawihi. In turn, the importance of lithic sources may have determined which raw materials were used and the tool forms they yielded (Kelly 1988).

Debitage analysis is one way to discover the forms and numbers of products that left the quarries prehistorically. Core forms are indicated by distinctive kinds of debitage and characteristic size and mass profiles. The frequencies of distinctive flake types also suggest how many different cores or bifaces were reduced. The mass of debitage in an assemblage is a minimal estimate of the mass of material reduced; compared to experimental ratios of debitage

to core weights, it can be used to estimate the original numbers of cores. The organization of reduction activities also is measured indirectly by the occurrence of heat-treatment; since debitage reflects these values only equivocally, our results are considered here in concert with the results of analyses of other artifact classes. Debitage, however, rarely is transported away from its place of creation (especially in bulk), and it therefore reflects the full range of lithic reduction activity occurring at a place without the bias of differential transport costs (Frison 1967; Yerkes 1987).

A second goal of our study was the delineation of temporal change in the use of the quarries. If present, and detectable, temporal variation in Tosawihi debitage may reflect changes in reduction strategies and variation in the intensity with which the quarries were used.

A third goal has been to examine how visits to the quarries were scheduled and organized. Visits to Tosawihi required some degree of mobility on the part of prehistoric peoples, but what strategies enabled such forays? On opposing ends of a continuum we can envision use of the quarries by logistical forays and by long-term residential forays (cf. Chapter 4). Logistical forays should have involved few people visiting for short times only to procure and process toolstone for transport. In contrast, long-term residential forays should have involved large, diverse groups moving to the quarries and procuring toolstone as one activity among many routine domestic ones.

Distinctly different debitage assemblages should characterize these strategies. Because logistical forays would have entailed visits to the quarries for short periods to procure toolstone, primary reduction debitage (generally large in size) should be their predominant trace. Archaeologically, prehistoric processing of opalite for transport from the quarries seems to have been done by reducing bifaces to approximately early Stage 3 (cf. Chapter 6). Domestic activities, which often include tool maintenance, should produce debitage assemblages characterized by high frequencies of small retouch flakes, flakes from later stages of reduction (e.g., biface production beyond early Stage 3), and (if primary reduction of quarry blocks was undertaken) the same kinds and sizes of flakes as logistical forays. Thus, domestic foray assemblages should be distinguished by a greater diversity of flake types and sizes, and perhaps a greater diversity of raw material sources. Debitage distinctive of different tool and core reduction techniques can be used roughly to monitor these activities, as can debitage assemblage size profiles.

Methods

Two techniques were employed to analyze debitage samples. Mass analysis (Ahler 1989a), in which weights and counts of samples retained in nested sieves are recorded, was our primary approach. We also employed technological analysis, classifying individual flakes into types without measurement of distinct attributes, inferring reduction activities from relative proportions of flake types. Because the procedures are distinct, we discuss their rationales and techniques separately; we also describe replicative experiments which we used as a control for both approaches.

Mass Analysis

Mass analysis, based on proportional frequencies and weights of size-graded samples, was pioneered by Ahler (1986, 1989a, 1989b; Ahler and Christensen 1983); we have followed the analytical procedures he prescribes.

The approach is based on the commonly observed phenomenon of diminution of flake size through the lithic reduction process. In general, reduction debris shrinks throughout the course of formal tool production. In fact, the presence of larger debris is the factor most useful for differentiating different core reduction strategies from biface reduction, since small flakes are produced throughout the reduction sequence. The procedure is simple; flake assemblages are shaken through nested sieves, and counts and weights are tallied for each size-grade and converted to proportional frequencies across size-grades. The data can be used to assess similarities to experimentally derived values through Kolmogorv-Smirnov tests of cumulative proportional differences, discriminant analysis, and linear regression.

Mass analysis reliably distinguishes three modes of flaking when tested on experimentally produced debitage assemblages: unifacial-bifacial reduction, core reduction, and bipolar reduction. Finer divisions also may be distinguished with slightly less statistical reliability. Ahler (1986, 1989a, 1989b) used discriminant analysis to classify unknown (archaeological) cases with linear discriminant functions derived from controlled experiments; his database included debitage from core reduction/flake production, biface production, tool production and maintenance, and bipolar reduction. Inclusion of other variables, such as counts of cortex-bearing flakes in each size-grade and ratios of flake shatter to platform remnant-bearing flakes were found to enhance classificatory accuracy (Ahler 1989b).

Similarly, Stahle and Dunn (1982, 1984) examined size distributions of debitage from various stages of biface production. Sieving debitage through nested, size-graded screens, they transformed the resulting data into an approximately straight linear function using a Wiebull transformation and then applied discriminant analysis, finding fairly good separation of experimental assemblages from different stages. Another study (Stahle and Dunn 1984) attempted to control for mixing of assemblages resulting from the inclusion of more than one stage of reduction in a sample; a constrained least squares regression analysis separated the components in mixed samples moderately well.

Mass analysis is relatively quick and requires little training of laboratory personnel, but it is not a panacea for the flake-ridden. An important requirement of the approach is that a statistically valid sample size must be available; this has been no problem at Tosawihi. A grave problem, however, has been separating samples that reflect mixtures of different core reduction strategies from mixtures of stages from the same reduction strategy. Such mixtures do not "fit" the experimental data very well, because experimental assemblages are not mixed, and the usual measure of analytical success is how well controlled assemblages can be classified (Ingbar et al. 1989). Stahle and Dunn (1984) examined this problem in detail, but were only moderately successful in developing a technique to circumvent it. Nonetheless, it probably is more often the case that archaeological assemblages are mixtures of different kinds of reduction.

Data Collection Methods

All Tosawihi debitage samples were subjected to mass analysis. Samples were processed according to Ahler's (1989a:99-100) procedures; first they were sorted by material type (Table 83), and particularly large samples were split using a standard geological sample splitter into 1/2, 1/4, 1/8, or 1/16 samples. Samples were passed through a column of U.S. Standard sieves, topped by meshes of one inch (testing phase assemblages), or two inch (data recovery phase assemblages) with smaller screens beneath (Table 84). The sieve column was then shaken mechanically for 30 seconds. Counts, weights of flakes were recorded for each size-grade, and cortical flakes were counted separately. The counts of cortex-bearing flakes are not reliable, since Tosawihi opalite contains unsilicified chalky veins identical to cortex; cortex counts are reliable for other materials.

Table 83. Variables Recorded During Mass Analysis of Debitage.

Material Type: 1. Opalite 2. Jasper 3. Obsidian 4. Basalt 5. Other

Split Type: N, split is 1/n, where n = 1, 2, 4, 8, 16, 32

Size Grade:
G0 -- >2 in.+
G1 -- 1 in. to 2 in.
G2 -- .5 to 1 in.
G3 -- .25 to .5 in.
G4 -- .125 to .25"

Weight: Weight of debitage in size grade.

Count: No. of pieces of debitage in size grade.

Count w/Cortex: No. of pieces w/cortex in size grade.

Table 84. Size-grades, Nominal Sizes, and Actual Sizes of Sieves Used in Mass Analysis.

Size-Grade	Nominal Opening	Actual Opening (inches) Square	Diagonal	U.S. Standard Sieve Size
G0*	2 in.	2	2.82	2 in.
G1	1 in.	1	1.41	1 in.
G2	1/2 in.	0.5	0.71	1/2 in.
G3	1/4 in.	0.22	0.32	No. 3 1/2
G4	1/8 in.	0.10	0.07	No. 7

*Size grade 0 was used only on samples recovered during Data Recovery.

To evaluate the bias introduced by splitting samples we conducted a series of experiments in which whole samples first were counted and weighed by size-grade, then split into 1/2 and 1/4 segments for counting and weighing. Predictions for the total frequencies and weights within each size-grade were compared to the known counts and weights, as were cumulative percentages of weight and count by size-grade. In general, weight was found to be somewhat more sensitive to skewing than count, especially in quarter samples. The largest size-grade was always the most variable, since no upper size limits were imposed. The conversion of split sample extrapolations to proportions by size-grade largely eliminate statistical differences between split samples and total debitage counts and weights.

Analytical Models and Interpretive Methods

The models and techniques used to interpret debitage relied on controlled or known cases. Experimental data used to build our models came from two sources: Ahler's (1989a) analytical database, which he graciously made available to us, and replications of core and biface reduction made by colleagues and IMR staff using Tosawihi opalite (described below). Ahler's (1989a) database does not include the largest of our size-grades (G0 -- 2 inch nominal mesh). Too, assemblages recovered and analyzed during the testing phase of investigations do not include the smallest size-grade (G4 -- 1/8 in. nominal mesh) because we used mostly 1/4 in. screens in the field. So, in building discriminant models with the experimental data, all G0 data were summed with G1 data for each sample, and G4 weights and frequencies were excluded. The raw data are too voluminous to tabulate, but the variables used are shown in Table 85.

Table 85. Variables Used in the Creation of Discriminant Models.

REDTYPE: 1. Core 2. Biface production 3. Tool edge maintenance

GENSTAGE: (bifaces only) 1. Early (stage 1-3.5) 2. Mixed (Early and Late 3. Late (stage 3.5+)

NOG0	Count of flakes in 2"+ size grade
NOG1	Count of flakes in G1 size grade
NOG2	Count of flakes in G2 size grade
NOG3	Count of flakes in G3 size grade
NOG4	Count of flakes in G4 size grade
WTG1	Weight of flakes in 2"+ size grade
WTG1	Weight of flakes in G1 size grade
WTG2	Weight of flakes in G2 size grade
WTG3	Weight of flakes in G3 size grade
WTG4	Weight of flakes in G4 size grade
WTG1P13	Proportion of weight in G1 across G1, G2, and G3
WTG2P13	Proportion of weight in G2 across G1, G2, and G3
WTG3P13	Proportion of weight in G3 across G1, G2, and G3
NOG1P13	Proportion of frequency in G1 across G1, G2, and G3
NOG2P13	Proportion of frequency in G2 across G1, G2, and G3
NOG3P13	Proportion of frequency in G3 across G1, G2, and G3
NRAT13	NOG1/NOG3
NRAT23	NOG2/NOG3
WRAT13	WTG1/WTG3
WRAT23	WTG2/WTG3
MEANG1	Mean weight of debitage in G1 size grade (0 if NOG1=0)
MEANG2	Mean weight of debitage in G2 size grade (0 if NOG2=0)
MEANG3	Mean weight of debitage in G3 size grade (0 if NOG3=0)
G1G3	Ratio of mean weight of G1 size grade to mean weight of G3 size grade(MEANG1/MEANG3)
G2G3	Ratio of mean weight of G2 size grade to mean weight of G3 size grade (MEANG2/MEANG3)

Experimental data from Ahler's database and from our replication program were used to create discriminant models that first segregated block core reduction, tool edge maintenance, and biface production. Block core reduction is the removal of flakes from a large block of stone, without intending to shape the stone itself into any other implement. Tool edge maintenance comprises fine retouching or resharpening of either bifacially or unifacially shaped tools. Biface production is the reduction of a block or flake of stone by flaking on both faces to produce a regularized core (i.e., biface). This first model does not distinguish stages of biface reduction.

A second model then was built to separate early stage biface production (prior to Stage 3.5, following Callahan [1979]; cf. Chapter 6) from late (Stage 3.5 and later) and mixed (early and late) biface production. A third model was generated to separate mixed from late biface production. The classificatory pathway for each debitage sample is shown in Figure 69. Discriminant models were built using SPSS procedure Discriminant (SPSS 1986). Stepwise inclusion and exclusion of variables in the models were permitted to create the most accurate models.

The first set of discriminant functions separates reduction type into three general groups: core reduction, biface production, and tool edge maintenance or resharpening. These correspond roughly to block core flaking (including, to some extent, the production of flakes suitable for biface production), biface production from Stage 2 (initial bifacial flaking) to finished product, and sharpening or rejuvenating tool edges, often by pressure flaking. The data used to build the discriminant model consisted of 550 assemblages drawn from Ahler's database (n=492) and our own replicative program (n=58). Reclassification of the experimental cases achieved close to 80% accuracy. Examination of misclassified cases indicated that misclassified

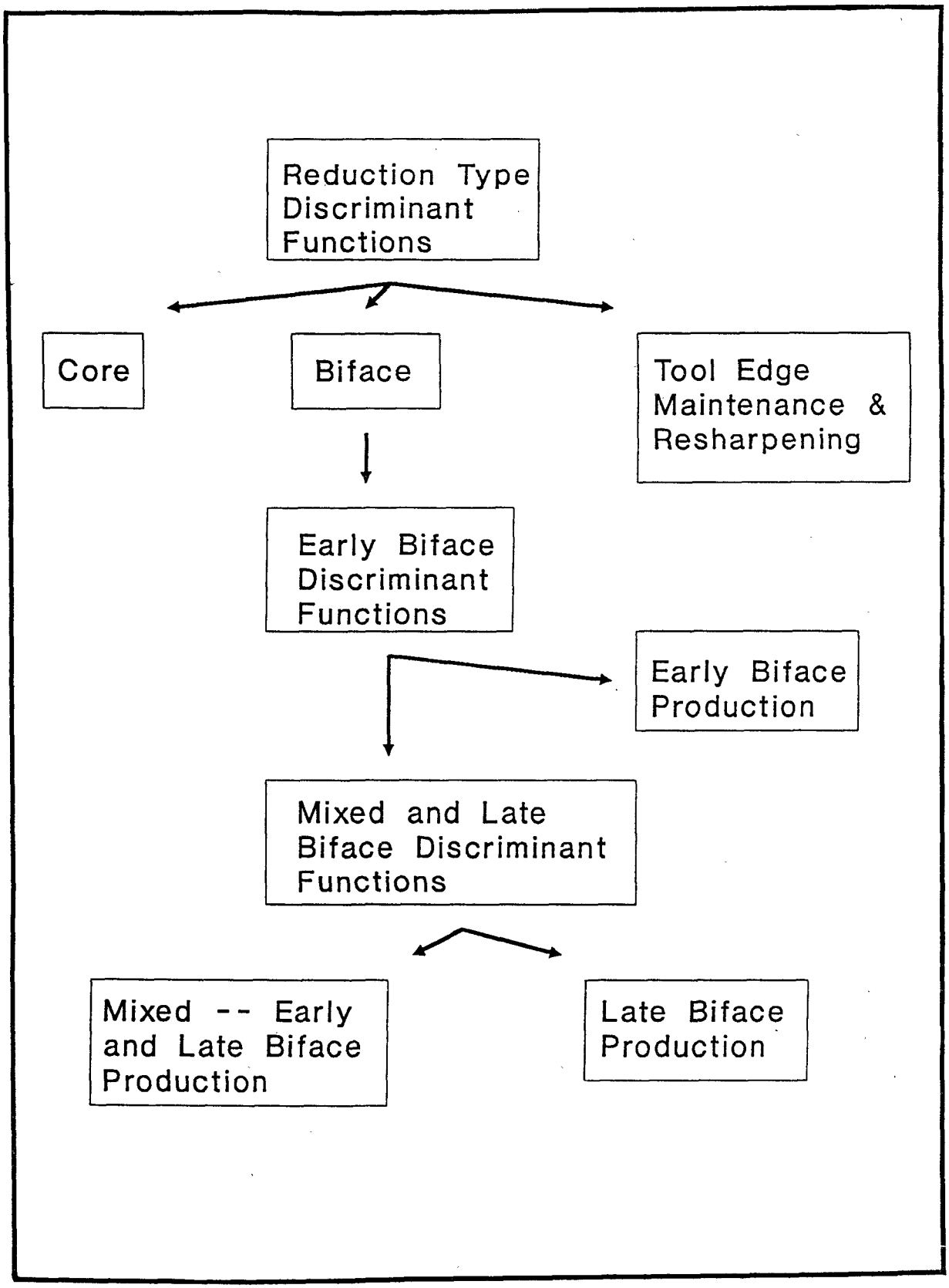


Figure 69. Classificatory pathway for mass analysis debitage samples.

core reduction cases (11% of the 290 cases) were small initial cores. Misclassified biface production cases were from unusually large cores (17.5% of the 246 cases) misclassified as core reduction assemblages by the discriminant function, or from unusually small initial bifaces (3.3% of the 246 cases) misclassified as tool edge maintenance assemblages. None of the tool maintenance debitage assemblages were misclassified.

The second set of discriminant functions separates mixed and late biface production debitage assemblages from early stage assemblages. Initial attempts to classify biface production debitage assemblages sought three functions in a single discriminant analysis to separate these three groups. This strategy, however, produced less reliable *post hoc* reclassification of the experimental assemblages. The use of two distinct sets of discriminant functions provides a more accurate classification, at least of the experimental assemblages.

One hundred eighty-one assemblages from our own experiments and Ahler's database were used in the creation of the first biface production discriminant function (58 and 123 cases, respectively). This set of discriminant functions correctly reclassified more than 87% of the experimental cases. Examination of the misclassified cases revealed that early stage bifaces wrongly classified as late bifaces were all quite small and may have started from more regular blanks. The converse errors, in which late and mixed assemblages were misclassified as early stage assemblages, also seem to reflect blank morphology. In the latter case, blanks generally were larger and, perhaps, less regular than those used to produce other cases in these groups.

The third and final set of discriminant functions (derived from 77 experimental assemblages) separates late stage biface production from mixtures of late and early stages. This set of discriminant functions accurately classified more than 83% of the experimental cases from which it was built. The misclassified cases are more nearly correct in this function than in either of the other two. That is, the mixed cases wrongly classed as late stage biface production (16% of the 50 mixed cases) are all experiments in which reduction began just prior to manufacturing Stage 3.5, and so are almost entirely "late." The single misclassified late stage production assemblage came from a larger initial biface than any of the other late assemblages.

Before turning to the archaeological cases, it is important to consider some of the shortcomings of these models. As the discussion of each model shows, the discriminant procedure seems to be quite sensitive to variations in initial core form and size. The frequent association of misclassified debitage assemblages and unusually large or small cores (whether bifacial or not) suggests that core morphology and size are very important components in determining the outcome of discriminant modelling. Most of Ahler's experimental assemblages are scaled to the products which he has studied -- tools at the Knife River flint source area in North Dakota. It is our impression that Knife River flint generally occurs in nodules somewhat smaller than the essentially unrestricted core sizes available at Tosawihi. The nature of Tosawihi opalite deposits places no effective stricture on the size of artifacts than can be produced. To work around this problem, only cases from Ahler's experimental database within the size range of recovered Tosawihi bifaces were used in deriving the two biface discriminant functions. The accuracy of the discriminant functions in classifying archaeological assemblages is subject to the *a priori* assumption that prehistoric flintknappers produced products similar to those made in the experimental programs. While several lines of evidence suggest that this is so, that it *is* an assumption should be borne in mind when considering mass analysis results.

Technological Debitage Analysis

The goal of technological analysis is to characterize the production of debitage assemblages. The importance of the approach lies in its ability to examine both core forms and (for biface reduction assemblages) stages of biface reduction present in a debitage sample. The occurrence of distinctive production actions, such as heat-treatment, at specific times in tool

production also can be discovered through technological analysis. Such analysis is an independent line of inquiry into reduction activities that produced debitage assemblages. The results thus serve as a control and refinement of mass analysis results. Because lithic reduction at Tosawihi is dominated by extraction and reduction of quarry blocks into biface blanks or flakes suitable for biface blanks, and by the production of bifaces, technological analysis of debitage can address both the techniques, as well as the organization, of biface production.

Two methods of technological analysis are common in current lithics research: "attribute analysis" and "typological analysis." In attribute analysis the analyst objectively records specific attributes of individual flakes. Relationships between attributes are then analyzed and combined to interpret the reduction techniques present in an assemblage (e.g., Mauldin and Amick 1989; Ingbar et al. 1989). In contrast to attribute analysis, typological analyses record the "flake type" of individual flakes (Ahler 1989a:88, Table 1; Flenniken 1987; Flenniken and Ozbun 1988). Recognition of flake types relies on the subjective observation of many of the same attributes measured and recorded in attribute analyses, but these are observed as morphological characteristics or sets of associated attributes. The typological analyst must recognize morphological characteristics diagnostic of reduction technique.

Typological analysis is used in technological analysis of selected Tosawihi debitage assemblages, an approach favored over attribute analysis because different reduction techniques tend to generate morphologically distinct kinds of flakes. These distinctive kinds of flakes are better indicators of reduction technology than are clusters of individual flake attributes (Ahler 1989a:88; Flenniken 1984). Clustering of individual attributes often can be misleading, in that not all flake attributes are equally important. Typological analysis skirts this problem by allowing subjective differential weighting of attributes in creating flake type classifications. As well, flakes can be classified relatively quickly by a trained analyst without the time consuming task of measuring attributes precisely.

Data Collection Methods

Significantly fewer samples underwent technological analysis than mass analysis. The technological analysis samples were selected carefully to provide a contrast to mass analysis, a glimpse of the spatial organization of lithic reduction, and some data on the internal spatial arrangement of biface production activities at specific sites.

All debitage samples selected for technological analysis first were subjected to mass analysis. Size-graded samples then were sorted into three categories of flakes: angular debris or shatter, "whole" flakes, and flake fragments (Figure 70; cf. Sullivan and Rozen 1985). Angular debris or shatter has no distinctive flake morphology. Whole flakes and flake fragments have flake morphology. Whole flakes generally retain platforms, and are interpretable through technological analysis. Flake fragments are pieces of flakes (usually flake margins) uninterpretable by technological analysis. The two categories not analyzed technologically were separated into four groups: pieces with cortex, pieces with heat-treatment, pieces with neither attribute, and pieces with both. The frequencies of these groups were recorded, but no further technological analysis of angular debris or flake fragments took place.

Whole, size-graded flakes were classified further, first by raw material sources. Opalite was the predominant material analyzed, though jasper was classified when present. Opalite color was not recorded specifically, although general color diversity was noted. Obsidian and basalt were analyzed separately. Thermal alteration or heat-treatment provided a second level of segregation of opalite flakes. Within each flake sample, six general flake types and five subtypes were distinguished:

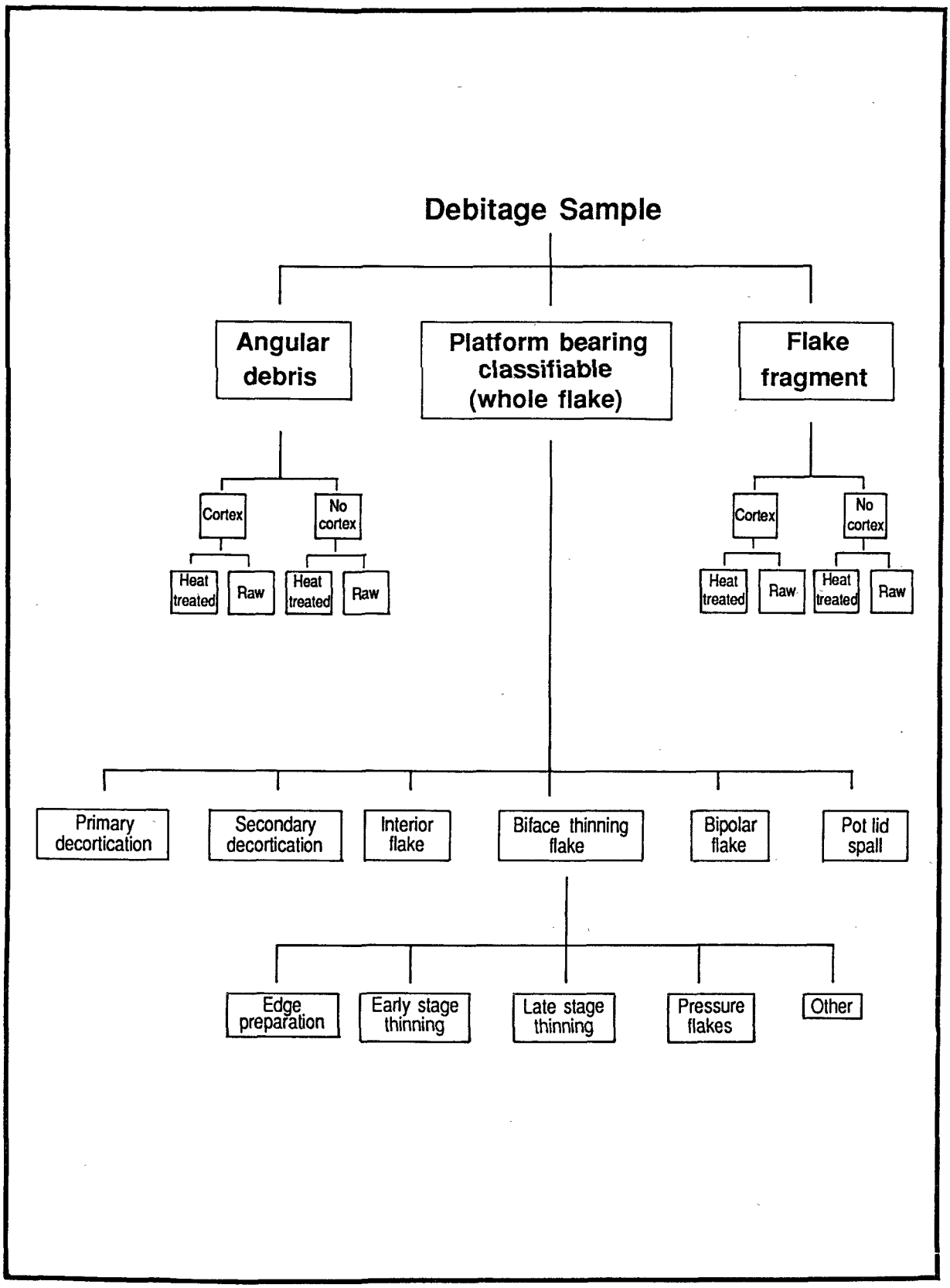


Figure 70. Classificatory pathway for technological analysis debitage samples.

Primary Decortication Flakes have cortex covering the entire dorsal surface. Platforms may be cortex covered, or may be unweathered interior surfaces. They are indicative of primary core reduction.

Secondary Decortication Flakes have cortex on the dorsal surface, but lack complete cortex cover. The platform surface may be cortex covered, or may be an interior surface. Like primary decortication flakes, secondary decortication flakes generally indicate initial core reduction.

Interior Flakes have no cortex on the dorsal surfaces and lack characteristics that would permit placing them in any other flake type. Usually, they are relatively thick, have straight longitudinal profiles, and lack complex patterns of dorsal flake scars. Interior flakes generally are produced during the later stages of core reduction. Biface reduction flakes lacking characteristics distinctive to biface reduction also are classed as interior flakes; these usually are produced early in biface reduction.

Bipolar Flakes are created by block-on-anvil percussion of a core (Binford and Quimby 1963). They are flat or wedge shaped in lateral cross-section, may have pronounced concentric rings, and can have crushed platforms and distal ends. No bipolar flakes were found in the Tosawihi samples.

Pot Lid Flakes result from thermal exposure that causes differential expansion inside a piece of stone. They are not a product of intentional knapping. They often are approximately circular in plan view with a flat dorsal surface and a convex ventral surface. They are thickest in the center, and taper rapidly toward the edges.

Biface Reduction Flakes have one or more characteristics distinctive to flakes removed in biface reduction. These characteristics include acute angled platforms, lipping of ventral surfaces of platforms, complex flake scar patterns on the platform surface, evidence of platform preparation through abrasion or release flakes adjacent the platform, complex dorsal scar patterns, and overall ribbon-like flake morphologies. Among biface reduction flakes, five subgroups were distinguished:

> **Edge preparation flakes** consist of flakes struck to remove the bulb of a flake blank, flakes resulting from alternate edge removals to strengthen an edge to be used as a platform, and flakes removed to prepare an edge to serve as a platform (but not removed in alternate fashion). Edge preparation flakes generally are indicative of Stage 2 biface reduction.
>
> **Early stage thinning flakes** are struck by percussion to remove the mass of material on the faces of the biface. Early stage thinning flakes are percussion struck, generally with somewhat blocky morphology and low dorsal scar pattern complexity. Early stage thinning flakes generally are indicative of Stage 2 and early Stage 3 biface reduction.
>
> **Late stage thinning flakes** are struck by percussion to regularize the cross-section profiles of the biface. They reduce mass less than early stage thinning flakes. They generally are thinner and more even in longitudinal section than early stage thinning flakes, and can have more complex dorsal and platform scar patterns. Late stage thinning flakes are generally indicative of late Stage 3 and Stage 4 biface reduction.

Pressure flakes are removed by pressure and so generally have diffuse bulbs of percussion and less pronounced platforms. Notch flakes form a specific subtype, consisting of pressure removals to form the basal notches of eared projectile points. Pressure flakes generally are indicative of late Stage 4 and Stage 5 biface reduction.

Other biface reduction flakes include margin removal flakes that remove the edge of a biface accidentally, and outrepasse (or overstruck) flakes that cross a face to remove a portion of the opposite edge as the termination of the flake. They are not considered good indicators of the biface reduction stage, although outrepasse flakes are at least Stage 2 or later in biface reduction.

Previous typological analyses (Flenniken 1987; Flenniken and Ozbun 1988) have shown a strong relationship between these analytical flake classes and reduction technology. For core reduction, the general flake types listed above serve as the primary analytical data. Further analysis of biface reduction is accomplished using the biface reduction analytical classes.

Most debitage samples examined in technological analysis were quantified using the flake classes described above. Analytical models for these are described below. In addition to debitage samples selected for quantified data collection, some samples from the same proveniences and some from backhoe trenches were analyzed qualitatively. Qualitative technological analysis consists of observation of the same diagnostic flake types as in quantitative analysis, but without tabulation of frequencies. Instead, the ability of the analyst to interpret reduction by general examination of flake types is employed. While less rigorous than quantitative analysis, the technique is rapid. The samples selected for qualitative analysis often came from proveniences not as well sampled by quantitative analysis (especially backhoe trenches), so the qualitative characterizations serve as adjunct data; in some cases, they constitute the only characterization of a sample.

Analytical Models and Interpretive Methods

Although the analytical flake classes described above have strong general linkages to reduction technology, specific reduction sequences and technologies can cause their occurrence to vary. Thus, an important element of any technological analysis is a program of replication. Replication experiments provide controls on the frequencies and types of debitage generated in the production of specific tool forms (Ahler 1989a, 1989b; Callahan 1979; Flenniken 1981, 1985).

Replication requires context, however, so we first examined the Tosawihi assemblages to determine which stone tool forms and reduction technologies should be replicated. Bifaces are the primary tool forms produced at Tosawihi, so most of our replication experiments attempted to reproduce the sizes and shapes of bifaces recovered, using some of the same techniques of blank procurement, platform preparation, and thinning that we observed on the archaeological specimens. Preliminary analysis of both whole and incomplete bifaces indicated a reduction continuum approximating the first five stages of the biface reduction trajectory described by Callahan (1979; cf. Chapter 6). The continuum proceeds from core reduction producing large flake or slab blanks (Stage 1), through edge preparation and initial shaping (Stage 2), primary thinning (Stage 3) and secondary thinning (Stage 4), to final shaping of the biface prior to use or further reduction to produce hafting elements (Stage 5).

Beginning in 1988, we initiated a series of replication experiments that (to date) has resulted in 15 quantitatively analyzed replications and 43 qualitatively analyzed ones, all produced on Tosawihi opalite. The replications began with the production of large Stage 1 flake

blanks, by reducing large angular opalite boulders recently quarried from a bulldozer cut at the east edge of the quarries. Reduction Stages 2 through 4 were replicated, in turn, as raw or heat-treated opalite flake blanks were reduced. Archaeological evidence of heat-treatment is common in certain contexts at Tosawihi, and appears to have been a significant step in biface reduction. Heat-treatment increases the compliance of silicious toolstone. Because heat-treatment occurs in different biface reduction stages in the archaeological assemblages (cf. Chapter 6), samples of experimental bifaces from each stage were heat-treated regardless of whether the knapper perceived a need for it. Heat-treatment was conducted in the laboratory using an electric deep fryer and pyrometer. Specimens were bedded in silty sand to facilitate an even radiance of heat and subsequent cooling. Experiments using different durations of exposure to heat and various maximum temperatures revealed that gradual heating to a maximum temperature of between 210 and 232 degrees produces successful heat-treatment of Tosawihi opalite.

Fifteen replications comprise the quantitatively analyzed experimental data set; Table 86 lists comparative data for every replication within the analytical data set. Replications were conducted sporadically over the course of two years, but all followed the trajectory of biface reduction suggested above. Two methods were employed most often. During the earliest experiments, size data were recorded at the beginning and end of each replication, debitage was collected only at the end of the replication, and notes on various aspects of knapping technique and compliance of the toolstone were taken. Throughout later replications, under better controlled circumstances, size data were recorded at the beginning of each stage of reduction and at the end of the continuum. Debitage was collected after each stage of reduction, and was kept separate for subsequent analysis. Knappers recorded the time used to complete each stage, compiled technical notes, and commented on toolstone compliance.

Table 86. Comparative Data on Replications Used in Quantitative Technological Analysis.

Specimen ID	Treated	Reduction Stages	EP/EBT	INT/EBT
1/1	No	Core reduction	5.08	6.62
51/1	No	Stages 1 to 3	0.79	0.30
55/1	Yes	Stages 1 to 3.4	0.35	0.25
none	No	Stages 1 to 3.6	1.20	2.58
16/1	No	Stages 1 to 3.7	0.88	0.47
19/1	No	Stages 1 to 3.7	0.47	1.05
52/1	Yes	Stages 1 to 3.7	0.21	0.01
54/1	No	Stages 1 to 3.8	0.46	0.13
56/2	Yes	Stages 1 to 4.5	0.19	0.09
none	No	Stage 2	0.53	1.11
none	Yes	Stages 2 to 4.5	0.39	0.11
30/1	No	Stages 2.5 to 3.7	0.68	0.05
none	No	Stages 3 to 4.5	0.06	0.18
51/2	Yes	Stages 3 to 4.9	0.18	0.26
52/2	Yes	Stages 3.7 to 6	0.10	0.00

EP/EBT = Ratio of edge preparation to early biface thinning flakes
INT/EBT = Ratio of interior to early biface thinning flakes

The resulting debitage was analyzed using the technological and mass analysis techniques described above. We then examined the relative ratios and proportions of debitage types to see if they usefully reflected core reduction, biface reduction, and the stages of biface reduction that we employed in analysis of the Tosawihi biface collection (cf. Chapter 6). Determination of core reduction is relatively straightforward, since core reduction assemblages contain mostly primary decortication flakes, secondary decortication flakes, and interior flakes with few flakes exhibiting the morphology of biface thinning flakes. As well, core reduction assemblages have high frequencies of shatter.

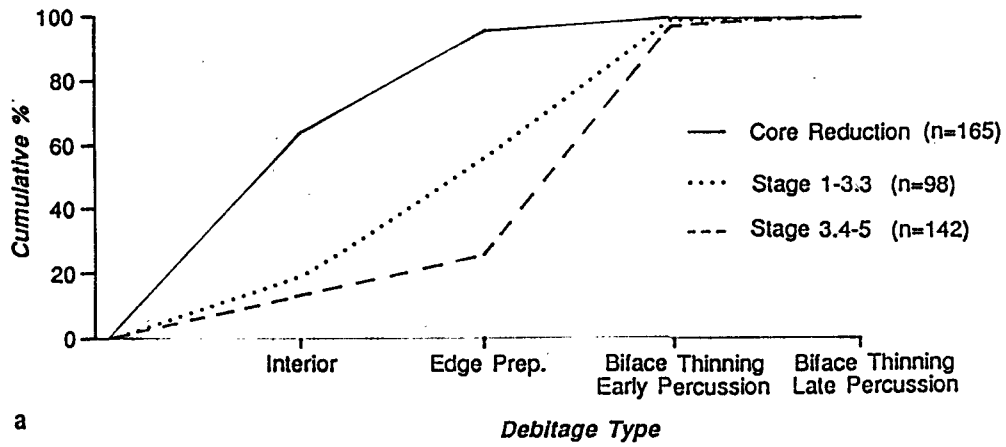
Determining biface reduction stages on the basis of technological analysis is less straightforward. Each biface reduction flake class has a relatively ordinal place in the overall production scheme; as reduction continues through the trajectory from flake blank production (Stage 1) to final shaping (Stage 5), the relative proportions of each flake type vary. High proportions of a flake class reflect the stage(s) of biface reduction most likely to produce it. Relative proportions of the flake types were graphed as cumulative curves or ogives (Blalock 1979); the ogive indicates the contribution of each flake type to the analyzed assemblage. Specific patterns of ogives indicate predominance of a generally early (Stage 1 to 3.3) or late (Stage 3.4 to 5.0) stage of biface reduction (Figure 71a).

The Kolmogorov-Smirnov two sample test (Blalock 1979) was applied to compare the cumulative proportions of flake types generated by biface reduction replications, to test whether distinctions among cumulative graphs were statistically significant, and to test for significance among replication curves that were not obviously distinct. At the 0.05 probability level, Kolmogorov-Smirnov tests distinguished early from late stage experimental biface reductions in only 60% of the replicated assemblages. The tests were not run again at lower confidence levels because both early and late stage debitage assemblages apparently can produce ogives of similar shape that the Kolmogorov-Smirnov test cannot separate. For example, in one case a replication beginning at Stage 1 and ending approximately middle Stage 3 biface was compared to a replication beginning early in Stage 3 and ending late in Stage 4. The Kolmogorov-Smirnov test did not distinguish between the two, possibly because the proportions of interior flakes were similar and the cumulative proportions of early biface thinning flakes were similar. By considering all classes of equal importance, the Kolmogorv-Smirnov test ignored what turns out to be an important difference in the ratios of edge preparation flakes to early biface thinning flakes (denoted as the EP/EBT ratio). The early stage replication had an EP/EBT ratio of 0.35, and the late stage replication had a ratio of 0.18.

The two gross characterizations of biface reduction stages, "early" and "late," are segregated better by ratios than by Kolmogorov-Smirnov tests (Figure 71b). Ratios of edge preparation (EP) to early biface thinning (EBT) flakes have a bimodal distribution that matches early and late stage biface reduction. The EP/EBT ratios for experimental reductions that include early stages are generally greater than 0.35. This pattern is reflected in 84% of the replications, and all the cases that do not fit this pattern have been heat-treated. Heat-treatment increases the number of successful removals resulting in distinctive biface thinning flakes rather than edge preparation or interior flakes. To a lesser extent, idiosyncratic variation in knapping technique and variation in flake blank proportions probably also account for some of the assemblages that do not follow this pattern.

A second useful measure is the ratio of interior (INT) flakes to early biface thinning flakes (denoted as the INT/EBT ratio). It is a less consistent separator of early and late stages of biface reduction, because interior flakes can be generated during later stages of reduction (though usually in low frequencies), and their creation depends in part on the technical preferences of individual knappers. Bimodal patterning is not as apparent as EP/EBT ratios (Figure 71b), but low INT/EBT values generally correlate with later stages of reduction.

We used both EP/EBT and INT/EBT ratios to discover whether early or late stage biface reduction is evident in archaeological samples. A third, cross-cutting, measure of reduction activities in archaeological samples is the ratio of heat-altered to unaltered debitage. In the archaeological biface assemblage, the proportion of heat-altered specimens correlates positively with increasing reduction stage (cf. Chapter 6). So, the proportion of heat-altered debitage is an indirect measure of biface reduction stages represented in a sample. Since all debitage resulting from a heat-altered biface will exhibit heat-alteration, separate INT/EBT and EP/EBT ratios were calculated for heat-altered and unaltered portions of the debitage samples, as well as for overall heat-altered proportions of debitage in the sample as a whole.



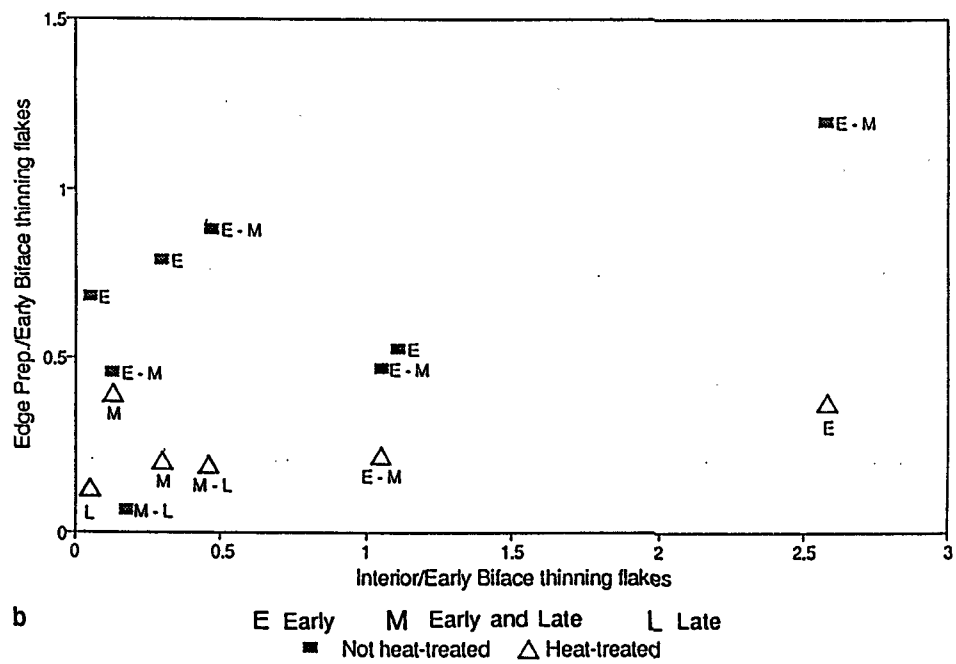


Figure 71. a. Cumulative proportions of flake types, quantitatively analyzed biface replications; b. EP/EBT vs. INT/EBT values for quantitatively analyzed experimental biface replications. Stages are indicated adjacent symbols, heat-treated cases are shaded.

Analytical Results

Mass Analysis of Archaeological Samples

Five thousand four hundred thirty-one debitage samples were recovered. Screened surface scrapes and excavations contributed the majority of these assemblages, from 2724 locations. Four hundred thirteen additional samples were collected from stratigraphic units in trench walls. The results presented here reflect composite site samples, composite feature samples, and trench wall samples, discussed by general geographic area. Cases having fewer than 50 flakes were excluded from sample classification, since below this threshold a single error in counting or size-grading would result in a 4% or greater error in proportions. Samples lacking flakes in the G3 size-grade also were excluded from classification, since G3 values were used as denominators in the discriminant functions. Variation in finer-grained provenience units is discussed for only a few cases. Not all obsidian samples were subjected to mass analysis, and of those that were, many are too small to characterize reliably; consequently, obsidian mass analysis results are not discussed here.

Characterization of Site Samples

The data used to characterize reduction within discrete sites and localities are compilations of all feature and non-feature samples. The compiled data were classified using the discriminant procedures described above. Further analysis of the classifications of sites was undertaken to examine whether different raw materials were reduced in different ways among the four geographical subareas of investigation. Table 1 in Appendix I summarizes characterizations of composite site samples.

Opalite reduction follows a regular pattern (Table 87). Opalite occurs naturally in and around the Quarry and in some parts of the Eastern and Western Peripheries. The seven localities in the Quarry are dominated by core reduction debitage samples. Early stage biface reduction dominates the Eastern and Western Peripheries, but core reduction is present in over a quarter of the composite site samples. In the Northern Corridor, mixed stage biface reduction characterizes most sites. These results are at least intuitively sensible, in that distance from opalite sources generally is reflected in site samples: close to sources, the mass analysis characteristics of composite samples indicate core reduction. Within a few kilometers of opalite sources, at non-quarry sites in the Eastern and Western Peripheries, early stage biface reduction prevails. Finally, at an even greater distance from raw material, a full range of biface reduction is evident.

Table 87. Mass Analysis Composite Site Sample Characterizations by Geographic Area.

		Geographic Area				
Material	Characterization	North	East	West	Quarry	Total
Opalite	Core reduction	0	10	5	7	22
	Early stage biface	2	20	13	0	35
	Early and late biface	5	7	1	0	13
Jasper	Core reduction	0	3	1	0	4
	Early stage biface	1	1	2	0	4
	Early and late biface	1	0	4	0	5
Basalt	Core reduction	0	0	3	0	3
Other	Early stage biface	0	0	1	1	2
	Early and late biface	1	0	0	0	1

The use of jasper (Table 87), which outcrops in the West, differs from that of opalite. Most known sources of jasper lie in the Western Periphery, yet the seven sites in this area are dominated by mixed stage biface reduction and some early stage biface reduction. Farther from jasper sources, in the Eastern Periphery, three of four site samples containing jasper reflect core reduction. No localities in the Quarry contained jasper debitage samples with more than 50 flakes. In the Northern Corridor, the two sites with jasper samples are split evenly between early and mixed stage biface reduction. The latter distribution suggests that jasper may have been used differently from opalite, insofar as it was transported as cores, rather than bifaces, to the Eastern Periphery.

Basalt (Table 87) occurs naturally in the West, and the three sites yielding basalt samples are all in this subarea; each reflects as core reduction.

Miscellaneous, non-local raw materials were collected in frequencies greater than 50 from only three sites; as a group, they reflect biface reduction (Table 87).

Characterization of Feature Samples

The site characterizations presented above yield generally simple patterns. However, most sites or localities contain discrete individual features. Since there is every reason to consider site samples as the result of many visits to the same place over time, it is instructive to break down the monolithic site sample characterizations into their component features, and examine variation in feature debitage sample characterizations. This, of course assumes that features have some integrity or a high degree of repetitive use, so that samples provide a characterization that is meaningful. Composite samples from surface scrape units and excavation units were compiled for each feature, and mass analysis results from all non-feature surface scrape and excavation units were compiled into a single non-feature ("Feature 0") sample. The results are presented in Table 2, Appendix I. Only opalite raw materials are discussed here, since very few features or sites contain the other four materials, and at the feature sample level, virtually never in numbers exceeding 50.

The pattern of opalite reduction observed above in the overall site samples is more complicated at the feature level (Table 88). As Table 88 shows, the relationship between geographic areas and reduction type characterizations is not independent, nor is it easy to summarize on the basis of frequency alone. Everitt (1977) suggests the use of standardized adjusted chi-square residuals to isolate significant dependencies in cross-tabulations, and we rely on the technique here. In essence, this simple technique examines the probability of obtaining a particular chi-square residual; the standardized adjusted residual is a z-score, so probability can be directly equated with it. Thus, the cells with asterisks next to the standardized adjusted residuals in Table 88 have z-scores greater than 1.96 or less than 1.96, and so have associated probabilities of less than 0.05. These are the most significant cells in the matrix.

Table 88. Mass Analysis Composite Feature Sample Characterizations by Geographic Area. (Opalite samples only)

		Geographic Area				
Material	Characterization	North	East	West	Quarry	Total
Opalite	Core reduction	0	24	8	8	40
	adjusted std. resid.	*-2.3	*2.3	*-2.9	*3.8	
	Early stage biface	3	32	36	2	73
	adjusted std. resid.	*-2.1	-0.2	*2.5	*-2.0	
	Late stage biface	1	0	0	0	1
	adjusted std. resid.	*3.2	-0.9	-0.8	-0.3	
	Early and late biface	9	9	13	0	31
	adjusted std. resid.	*4.4	*-2.0	0.3	*-1.7	

*Adjusted standardized residuals with p<.05

The use of opalite in the Northern Corridor is dominated by higher than expected frequencies of late stage biface and mixed stage biface feature samples. At the same time, core reduction and early stage biface reduction is much less frequent than would be expected in a chi-square model.

In the Eastern Periphery, opalite debitage samples grouped at the site level were characterized as predominantly early stage biface reduction. At the feature sample level, the use of opalite is revealed to be much more variable. Features with core reduction samples are much more frequent and those with mixed biface reduction samples are much less frequent than would be expected in a chi-square model.

The Western Periphery, characterized at the composite site sample level as similar to the Eastern Periphery, is quite different from it at the feature sample level. There are significantly fewer feature samples characterized as core reduction, and many more characterized as early stage biface reduction, than would be expected.

Characterization of localities within the Quarry does not change much when samples at the feature level are examined. As would be expected, core reduction is the predominant activity in Quarry features.

In summary, examination of the opalite composite feature samples shows a much more complex pattern of opalite use than revealed when debitage is compiled into overall site samples. While the general patterns indicated by the site level of analysis still hold, the Eastern and Western Peripheries are not as similar to each other when considered as aggregations of features.

Characterization of Quarry Feature Strata

Trenching of quarry pits often revealed well-stratified deposits containing lenses of debitage. These lenses tend to exhibit a regular pattern of variation, with generally smaller items at the edges of the feature, and large pieces of debitage in the center (usually its lowest point). The assumption employed above was that features provide a meaningful grouping for samples. Yet, analysis of samples drawn from distinct stratigraphic lenses of debitage in quarry pits lends only partial support to this notion, since within any given quarry feature there sometimes is variation in the mass analysis characterizations of different strata. Table 3, Appendix I presents characterizations of stratigraphically recovered debitage samples from the trenched features at several sites. Samples of the same material type from the same stratum and feature are lateral samples along the face of the trench.

In general, core reduction is the predominant characterization of all trench strata samples. Variation in the location of reduction activities around quarry pits, often quite evident visually within a single stratum, is detected by mass analysis in only some cases. For example, in Stratum 2 of Feature 1 at 26Ek3170, three opalite samples are characterized as core reduction and one sample as mixed stage biface reduction. The latter sample is from the edge of the quarry pit, the others, closer to its center. Other examples include the opalite samples from Stratum 2 of Feature 2 at 26Ek3171, where the four samples closest to the center of the feature are characterized as core reduction, and a fifth sample away from the center is characterized as early stage biface reduction. As discussed above, mass analysis in many ways is a gross characterization of debitage samples. Yet, the results of strata characterization show that this technique is capable of detecting fairly detailed variation within a single stratum. Variation between strata, or vertical variation, is evident as well. For example, in Feature 2 at 26Ek3195 many strata are characterized differently by mass analysis. This could owe to earlier quarrying in adjacent features, with post-quarrying reduction occurring in the (then) unused Feature 2 (cf. Chapter 22).

Discussion

Mass analysis of composite site and feature samples revealed patterns in chipped stone reduction at two levels. At the composite site sample level, it is evident that with greater distance from natural sources of opalite, chipped stone reduction is increasingly late in stage, and is predominantly bifacial. Basalt exhibits this pattern as does jasper, although there also is indication of reduction of jasper cores away from source areas. Only opalite seems to have been transported extensively in the Tosawihi vicinity, since the frequencies of jasper and basalt are quite low in the Northern Corridor. Nonetheless, basalt and jasper may have been important sources for expedient tools (cf. Chapter 8).

At the composite feature sample level, much more variation is evident in the use of raw opalite. The role of site setting becomes important, since those sites with feature samples characterized as core reduction outside of the Quarry are on or very close to opalite sources as well. The general tendency is for feature samples from the Eastern and Western Peripheries to be distinct: in the East, the portion of the reduction spectrum represented is earlier than that in the West. This is due largely to the presence of opalite quarries in the East; when samples associated with quarry pit features are removed from the comparison, the two areas are substantially similar. Mass analysis clearly shows samples from features in the Northern Corridor to be different from all other areas. Features in the North area are primarily lithic scatters, mostly characterized as late stage biface reduction or mixed biface reduction. Very few early stage biface reduction, and no core reduction, debitage samples were recovered from the Northern Corridor.

Mass analysis supports the field observation that bifaces were the primary product produced at and around the Tosawihi Quarries. Over half the composite site and composite feature samples of opalite debitage are characterized as biface reduction, even though core size and morphology can influence mass analysis results.

Mass analysis can be used to estimate the number of bifaces and cores produced to create the debitage sample as a whole. The average weight of debitage produced in experimental replications of biface production from Stages 1 to 3.5 is 1330 grams. The average weight of debitage produced in Stage 3.5 to later stage reduction is 1082 grams. Since analysis of the Tosawihi bifaces (cf. Chapter 6) shows that the majority of opalite biface reduction occurs up to Stage 3 and not beyond, the 1330 gram average can be used to estimate the number of bifaces that could have been produced in the sampled features. For each feature sample, the areal proportion of the feature scraped or tested was used to estimate the total mass of debitage in the feature. This estimate was then divided by the 1330 gram average to yield a very rough approximation of the number of bifaces produced within a feature (cf. Table 2, Appendix I). This calculation assumes that the estimated total weight of debris is entirely biface reduction debitage. This assumption probably is not true, skewing upward the estimated number of bifaces produced. However, subsurface volumes of debitage are not included in the estimated debitage weights and, since many of the features are fairly deep, the estimated number of bifaces probably is much too low. This latter factor almost certainly is more influential than the former, so the estimated number of bifaces actually is conservative.

Table 89 summarizes the estimated number of opalite bifaces for each feature type. The estimated total number of opalite bifaces from all sampled features (n=123) excluding non-feature contexts is 28,913. Since 378 features (of all kinds) were recorded at the Tosawihi sites discussed here, the sampled features constitute only about one-third of the total feature population. Extending the estimated number of opalite bifaces produced across all of these features yields nearly 89,000 bifaces. While this is only a very rough estimate (and probably is conservative), it gives some picture of the scale of quarrying and reduction activities in and around Tosawihi quarries.

Table 89. Summary of Estimated Opalite Biface Frequencies by Feature Type, for Features Having Known Percentages Sampled.

Feature Type	Estimated No. of Bifaces	n of cases
Quarry	11,600	14
Reduction locus	1,002	58
Unknown type	14,002	36
Other	2,309	15
Total	28,913	123

Technological Analysis of Archaeological Samples

Technological analysis was employed as a technique secondary to and supportive of mass debitage analysis, but not all debitage samples could be analyzed. Even though typological analysis is the least time consuming form of technological analysis, time limitations necessitated the analysis of only a few specific contexts. Field records from the testing and data recovery programs, as well as personal recollection, were employed in the selection of samples. One aim of our sample selection was to discover the range of reduction present in the Tosawihi vicinity. Investigation of the degree of redundancy among debitage samples was another important goal, so samples were chosen that seemed to illustrate this issue as well. A third target of sample selection was the association of debitage assemblages with evidence of other activities (e.g., hearth use), and samples were drawn subjectively from appropriate settings.

Discrete lithic scatters formed the primary contexts for sampling; these had been designated *reduction features* during fieldwork. Sample proportions varied with feature size and inferred complexity. Generally, the majority of samples from most reduction features were collected from surface scraped 1 x 1 meter units. At most such features the upper two centimeters of deposit contain almost all of the debitage, so surface scrapes should provide a comprehensive sample of the debitage assemblage.

Trench samples are debitage samples collected from distinct strata in profiled walls of backhoe or hand-excavated trenches. Trenching was employed to investigate the subsurface structure of quarry pits and debitage deposits adjacent outcrop quarries (cf. Chapter 16, Chapter 17). Four trenched quarry features were chosen for technological debitage analysis; two quarry pits from the Eastern Periphery (26Ek3032/Locality 23 and 26Ek3200) and two outcrop quarries from the Western Periphery (26Ek3084 and 26Ek3208) were selected. These offered the clearest and most distinctive stratigraphy for sampling.

Qualitative technological analysis was employed primarily to characterize the large quantities of debitage recovered from trench strata; quantitative analysis examined single localities in greater detail. The goals of analysis were to identify the reduction activities which created the sampled strata and to examine patterns within strata relative to their position in the quarry feature. To this end, we selected from various stratigraphic contexts in quarry pit bottoms, the inward pit slope, the pit berm, and the outer berm slopes. We expected distinct assemblage characteristics to be evident in each of these settings, even within the same stratum, because of our assumptions about the use of space around quarry features (cf. Chapter 3, Chapter 22; Jones and White 1988). In brief, we expected that debitage in pit bottoms should consist primarily of angular quarry debris and tuff resulting from the quarrying of opalite. The inward pit slope was expected to be a complex mixture of primary quarrying debris tossed up on the slope, primary core reduction debris, and, perhaps,

later reduction debris. The latter two could have been generated on the pit slope itself, or could have slumped onto the inward pit slope from the top of the berm. Slumping of berm deposits into a small pit also could cause the pit bottom to appear similar to the pit berm. Since the berm and outward berm slopes are the most level and generally comfortable places around a quarry pit, we expected that a considerable amount of actual core and biface reduction would have occurred in these settings (cf. Binford and O'Connell 1984; Jones and White 1988:76-77). At outcrop quarries we expected the same general patterns, but with fewer constraints, since outcrop topography may not place equal restrictions on physical activity.

The results of technological analysis presented below proceed from a discussion of debitage resulting from quarrying and early stages of biface reduction in quarry-related contexts, then tracks the continuum of reduction activities across the East, West, and North subareas.

Quarry Pits and Outcrop Quarries

In the following discussions, the reader should assume the presence of debitage from quarrying unless its absence has been noted specifically. Quarrying debris is quite common, characterized by shattered tuff, shattered toolstone, fragmentary flakes, and low proportions of interior flakes. A greater proportion of interior flakes, especially those with prepared platforms, was considered indicative of core reduction. The flake types indicative of all other stages of reduction reflect those presented above in the discussion of the reduction models.

Quarry Pit, 26Ek3032/Locality 23. Locality 23 is a relatively large feature with two adjacent pits on the southeastern margin of 26Ek3032 and at the northwestern edge of 26Ek3170 (cf. Chapter 17). A trench was cut through the middle of the principal pit, exposing 43 strata along the south wall (cf. Figure 156). Structures visible in the profile include pits excavated through colluvium and into bedrock, the pit berm, and the inward and outward slopes of the berm. Thirty-four samples were collected from 29 strata dominated by debitage; they span the range of variation in stratum composition perceived in the field.

Toolstone quality varies from poor quality opal and poorly silicified tuff to good opalite. The best material appears to be somewhat brittle, resembling more the jasper from other locales. Opalite color varies from white through pink, blue, and purple; much of the best quality material is mottled and variegated. Debitage from bifacial thinning often occurs as the better quality mottled or white opalite. Quarry debris more often is white or pink opalite and poorly silicified tuff.

Many of the debitage samples are too small or only minimally sufficient for interpretation by qualitative analysis. Interpretation of the larger samples was less problematic.

Most of the analyzed samples resulted from quarrying and core reduction (Table 90). Of the 27 interpreted samples, 16 (59%) exhibit definite evidence of Stage 2 biface reduction, while six (22%) contain debitage indicative of blank preparation (the removal of major irregularities from a flake blank). Blank preparation thus overlaps early Stage 2 reduction, but does not extend to edge preparation for primary thinning. It usually reflects the reduction of large irregular flake blanks, and often comprises the first step in Stage 2 reduction of such blanks.

Table 90. Qualitative Technological Analysis Characterizations of Trench Strata Samples from 26Ek3032, Locality 23.

Reference-Specimen No.	Trench Number	Stratigraphic Unit	TECHNOLOGICAL CHARACTERIZATION Core Reduction	Blank Prep.	Stage 2 Biface Red.	Stage 3 Biface Red.
2599 74	Trench 1	1	-	-	++	++
2599 280	Trench 1	1	++	-	++	-
2599 86	Trench 1	1	++	++	+	-
2599 69	Trench 1	5	+	+	++	++
2599 70	Trench 1	6	+	+	++	++
2599 71	Trench 1	7	-	-	-	-
2599 73	Trench 1	8	-	+	++	++
2599 72	Trench 1	10	-	-	-	-
2599 75	Trench 1	11	-	++	++	-
2599 77	Trench 1	12	++	++	+	+
2599 76	Trench 1	13	+	-	+	-
2599 78	Trench 1	14	++	-	++	+
2599 102	Trench 1	17	++	+	-	-
2599 103	Trench 1	19	++	-	-	-
2599 104	Trench 1	21	+	-	-	-
2599 85	Trench 1	23	++	-	-	-
2599 83	Trench 1	24	++	-	+	-
2599 105	Trench 1	25	-	-	-	-
2599 101	Trench 1	26	++	-	+	-
2599 82	Trench 1	28	++	++	++	-
2599 79	Trench 1	30	-	++	++	-
2599 81	Trench 1	31	+	-	+	+
2599 106	Trench 1	32	-	-	-	-
2599 97	Trench 1	33	+	-	-	-
2599 92	Trench 1	35	++	++	++	++
2599 87	Trench 1	36	++	-	+	-
2599 91	Trench 1	36	-	-	-	-
2599 94	Trench 1	36	++	-	++	++
2599 88	Trench 1	38	++	-	-	-
2599 95	Trench 1	38	++	-	+	-
2599 90	Trench 1	40	++	++	++	-
2599 89	Trench 1	41	++	-	+	-
2599 96	Trench 1	42	-	-	-	-
2599 93	Trench 1	43	-	-	-	-

+ reduction type present in minor amounts
++ reduction type present in major amounts

Stage 3 biface reduction is evident in seven samples (25%). Most of the evidence for Stage 3 reduction occurs on the pit berm or on the outer berm surfaces. Some Stage 3 reduction is evident in the pit bottom and inward slopes, but only in strata that appear to have slumped inward from the berm. Stratum 14 may contain *in situ* deposits of debitage indicative of Stage 3 reduction in the very bottom of the pit. It is noteworthy that before the Stratum 14/Stratum 15 contact was buried, the pit bottom would have been fairly flat with gently sloping sides (cf. Figure 156).

In addition to the backhoe trench, three separate 1x1 m units were surface scraped in concentrations of debitage (cf. Figure 155. Unit 1 was placed on the berm of the quarry pit, Unit 2 centered on a reduction locus approximately 10 m northwest of the pit, and Unit 3 was placed at the center of a third concentration approximately 10 m northeast. The northwest quadrant of each unit was screened through 1/8 in. mesh, while the remainder was screened through 1/4 in. mesh. The debitage from each unit was analyzed quantitatively.

Unit 1 sampled a concentration of debitage on the pit berm. The sample is comprised overwhelmingly of large, non-heat-treated interior flakes indicating core reduction (Figure 72a, Table 91). Some early stage reduction of large flake blanks is indicated by the presence of edge preparation flakes and early stage biface thinning flakes (Figure 72a). In light of our data from replicated core reduction assemblages, the high frequencies of flake fragments and shatter are further indication that core reduction was the primary reduction activity occurring on the berm of the pit.

Table 91. Quantitative Technological Analysis Results and Data from 26Ek3032, Locality 23 Samples.

Unit	Feature/ Locus	Feature Type	Character-ization	Non-heat-treated EP/EBT	Non-heat-treated INT/EBT	Heat-treated EP/EBT	Heat-treated INT/EBT	% heat-treated	sample n
All	F1	Quarry pit	ESB	0.16	0.76	0.17	0.33	4.0	224
1	F1	Quarry & Reduction	Core red. & ESB	0.25	2.40	0	0	3.3	30
2	F1	Reduction	ESB	0.04	0.45	0.20	0.20	5.3	131
3	F1	Reduction	ESB	0.57	1.40	0	0	1.6	63

Characterizations: Core red. = Core reduction; ESB = Early biface

EP/EBT = Ratio of edge preparation to early biface thinning flakes
INT/EBT = Ratio of interior to early biface thinning flakes

Unit 2 was placed to sample a distinct debitage concentration within the general out-of-pit scatter; we wanted to investigate the diversity of reduction occurring close to the pit. The quantitative data indicate an early biface reduction assemblage (Figure 72b, Table 91). A high proportion of interior flakes indicates that core reduction or the reduction of large irregular flake blanks contributed importantly to the sample, and that biface production extended from Stage 1 to approximately early Stage 3. This sample reflects the latest stage of biface production evident near the pit.

Unit 3 sampled another concentration of obvious, but less discrete biface reduction activity. It reflects very early biface reduction, probably initiated on large irregular flake blanks, and perhaps some core reduction (Figure 72c, Table 91).

Together, the three units exhibit the same diversity of stone reduction found in qualitative analysis of debitage recovered from the quarry pit strata. Predominant reduction activity shifts from core reduction near the pit to increased early stage biface reduction away from it. There is no evidence in either trench strata or surface scrapes of systematic heat-treatment of opalite. The very few heat-treated flakes recovered in each of the three surface samples (Table 91) probably resulted from lithic reduction associated with activities other than quarrying, or from initial quarry processing of opalite.

Quarry Pit, 26Ek3200. 26Ek3200 is located at the eastern margin of the Eastern Periphery and contains a single quarry pit (cf. Chapter 17). During testing, one east/west trench was excavated to investigate the quarry pit deposits (Elston 1989). The south wall was profiled and 17 debitage samples were collected, comprising most of the strata. Eight additional samples were collected later, but, due to slumping of the walls, their relationship to the profiled stratigraphic units is problematic and their proveniences, at best, are approximations. Six samples from each of the two sample sets were subjected to qualitative technological analysis (Table 92). They were selected to reflect variation in the spatial arrangement of reduction activities relative to the subsurface structure of the quarry pit (cf. Figure 165).

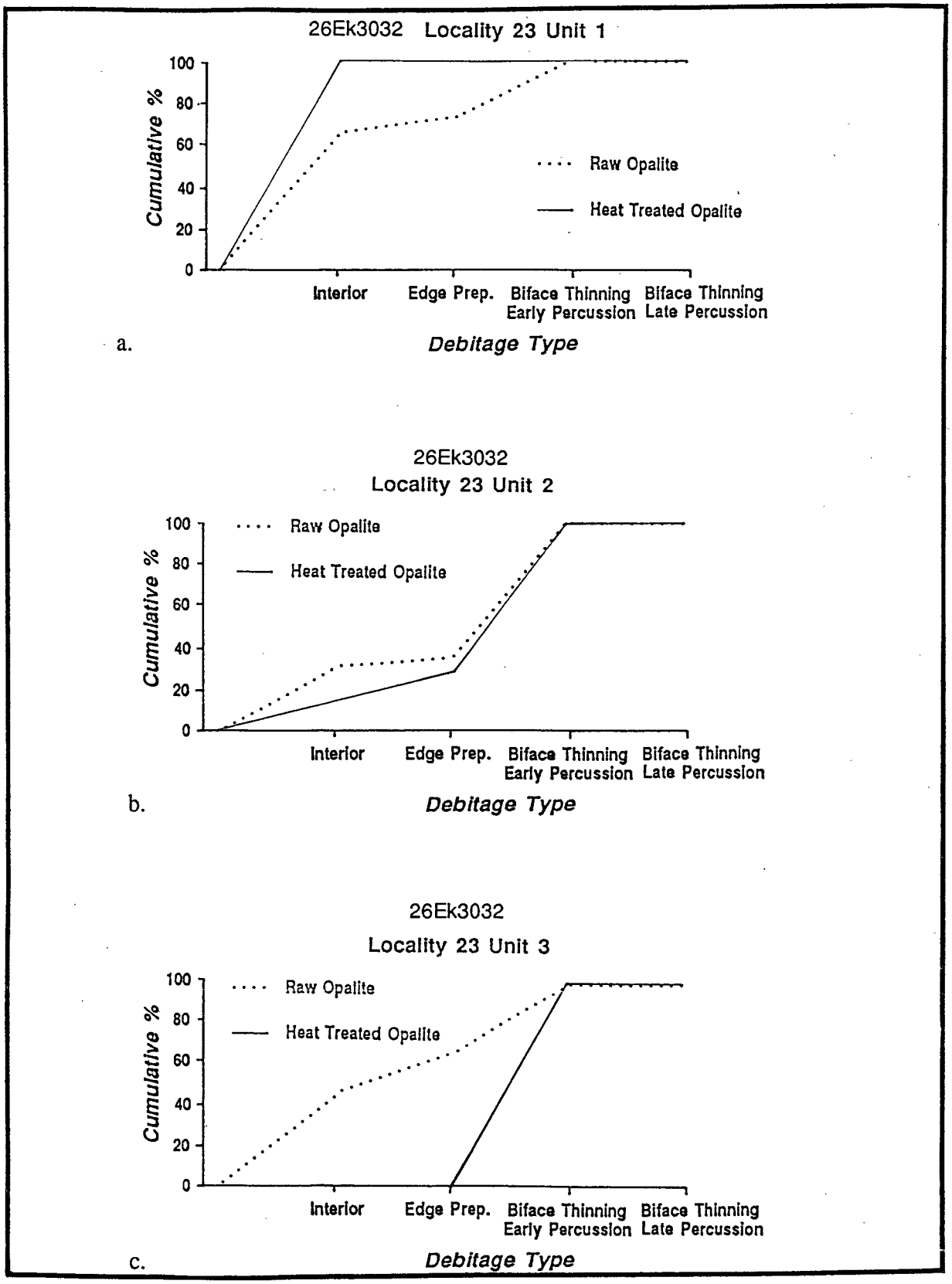


Figure 72. Ogives of diagnostic flake types, 26Ek3032, Locality 23.

Table 92. Qualitative Technological Analysis Characterizations of Trench Strata Samples, Trench 1, 26Ek3200.

Reference-Specimen No.		Trench Number	Stratigraphic Unit	TECHNOLOGICAL CHARACTERIZATION Core Reduction	Blank Prep.	Stage 2 Biface Red.	Stage 3 Biface Red.
636	8	Trench 1	11	++	++	-	-
636	12	Trench 1	6	+	-	+	-
636	13	Trench 1	6	-	-	++	+
636	15	Trench 1	3	-	-	++	++
636	16	Trench 1	2	++	-	++	-
636	17	Trench 1	1	-	-	++	-
2599	136	Trench 1	3	+	-	-	-
2599	141	Trench 1	4	+	-	+	-
2599	137	Trench 1	6	+	-	-	-
2599	138	Trench 1	6	+	-	+	-
2599	139	Trench 1	13	++	-	++	-
2599	140	Trench 1	16	++	-	++	-

+ reduction type present in minor amounts
++ reduction type present in major amounts

Toolstone quality in the analyzed debitage is variable, ranging from pink/white poorly silicified opal-like material to white, white/pink, and white/blue well-silicified material. The well-silicified material may have occurred in small pockets within a poorly silicified matrix. Much of the quarry debris reflects the breakup of this poor opalite and tuff to gain access to better toolstone. Once good quality material was attained, it was reduced to late Stage 2 and early Stage 3 bifaces at the pit; even some of the poorer material was reduced to Stage 3 bifaces.

Stage 3 reduction debitage *in situ* in Stratum 3 (Table 92, Sample #15) at the bottom of the pit indicates some indifference to the location of early primary thinning. In fact, Stage 3 reduction is represented clearly only in the lower strata. Most other strata contain evidence of core reduction and Stage 2 biface reduction. Sample 13 from Stratum 6 may have slumped into the pit from higher on the berm, but the debitage in Sample 15 from Stratum 3 formed a mound in the pit bottom, undoubtedly in primary depositional context.

Outcrop Quarry, 26Ek3208. 26Ek3208 is located in the eastern part of the Western Periphery (cf. Chapter 16). It contains a large outcrop of excellent quality white and bluish white opalite. The base of the outcrop is surrounded by an apron of quarry waste and debitage two to four m deep and over approximately 45 sq. m. Three backhoe trenches were excavated into this apron perpendicular to the face of the outcrop (cf. Figures 103, 104, 105, 108). These give a merely adequate window into this huge deposit of debitage. Each stratum is a complex mixture of *in situ* reduction debris, redeposition from prehistoric excavation into older debitage deposits, and natural redeposition on the sloping surfaces of the strata. Although the strata undoubtedly are complex in origin, and the three trenches have not been linked directly to each other stratigraphically, general technological patterns can be discerned.

Trench 1 consists of 48 sampled lenses, each of which was analyzed qualitatively (Table 93). As in all quarry localities, debris from extraction of toolstone from bedrock is common. Aside from toolstone extraction, forty (83%) of the sampled lenses indicate core reduction as the predominant reduction activity, and 94% of the samples exhibit some evidence of core reduction. Blank preparation is apparent in 83% of the samples, occurring without core reduction in only three samples. Stage 2 biface reduction is evident in 52% of the sampled lenses, and always appears in association with core reduction or blank preparation. Stage 2 biface reduction occurs in all topographic contexts: in the bottom of the quarry pit, on the inward pit slope (though slump from the top of the slope may have created this association), and on the berm and flat margins above the pit. Stage 3 biface reduction is an important component of only one debitage sample, from Stratum 18. Other evidence of Stage 3 biface reduction occurs chiefly on the back slope of the berm or in the pit near the present surface.

Table 93. Qualitative Technological Analysis Characterizations of Trench Strata Samples, 26Ek3208, Feature 3.

Reference-Specimen No.	Trench Number	Stratigraphic Unit	TECHNOLOGICAL CHARACTERIZATION Core Reduction	Blank Prep.	Stage 2 Biface Red.	Stage 3 Biface Red.
2599 199	Trench 1	3	++	++	+	-
2599 200	Trench 1	4	++	++	++	-
2599 192	Trench 1	4	++	-	++	+
2599 188	Trench 1	12	++	++	++	+
2599 174	Trench 1	18	++	+	-	+
2599 175	Trench 1	17	++	++	-	-
2599 156	Trench 1	23	++	++	++	-
2599 155	Trench 1	24	++	-	-	-
2599 163	Trench 1	25	-	++	-	-
2599 165	Trench 1	24	++	++	++	-
2599 164	Trench 1	26	++	++	++	-
2599 171	Trench 1	26	++	+	-	-
2599 168	Trench 1	27	++	++	-	-
2599 167	Trench 1	29	++	++	+	-
2599 189	Trench 1	29	++	++	++	-
2599 166	Trench 1	30	++	++	+	-
2599 191	Trench 1	31	++	+	-	-
2599 169	Trench 1	31	++	+	-	-
2599 190	Trench 1	32	++	-	-	-
2599 170	Trench 1	33	++	+	-	-
2599 159	Trench 1	34	++	-	-	-
2599 162	Trench 1	35	++	++	++	-
2599 161	Trench 1	37	++	++	+	-
2599 160	Trench 1	38	++	++	+	-
2599 172	Trench 1	39	++	+	-	-
2599 176	Trench 1	40	++	++	++	-
2599 193	Trench 1	41	++	++	-	-
2599 194	Trench 1	42	++	++	+	-
2599 198	Trench 1	43	-	++	+	-
2599 186	Trench 1	44	++	++	-	-
2599 185	Trench 1	45	++	-	-	-
2599 178	Trench 1	47	+	+	-	-
2599 184	Trench 1	48	++	-	-	-
2599 187	Trench 1	49	++	++	-	-
2599 177	Trench 1	50	++	++	++	-
2599 183	Trench 1	51	++	++	++	-
2599 182	Trench 1	52	++	++	-	-
2599 181	Trench 1	53	++	++	-	-
2599 180	Trench 1	54	++	++	-	-
2599 179	Trench 1	55	++	-	-	-
2599 152	Trench 1	56	++	++	+	-
2599 154	Trench 1	57	++	++	+	-
2599 151	Trench 1	58	++	++	++	-
2599 153	Trench 1	59	++	++	-	-
2599 42	Trench 2	7	++	-	-	-
2599 45	Trench 2	10	++	-	-	-
2599 46	Trench 2	10	++	-	-	-
2599 50	Trench 2	19	++	+	+	-
2599 51	Trench 2	21	++	-	+	-
2599 63	Trench 2	25	++	-	+	-
2599 62	Trench 2	26	++	-	+	-
2599 68	Trench 2	39	++	-	++	+
2599 150	Trench 2	41	++	+	+	-
2599 145	Trench 2	43	++	++	++	-
2599 144	Trench 2	44	++	-	++	-
2599 233	Trench 3	4	++	+	-	-
2599 230	Trench 3	9	++	-	-	-
2599 227	Trench 3	12	++	++	+	-
2599 226	Trench 3	13	++	-	-	-
2599 224	Trench 3	15	++	+	-	-
2599 212	Trench 3	34	++	+	-	-
2599 207	Trench 3	39	++	+	-	-
2599 206	Trench 3	41	+	-	-	-
2599 263	Trench 3	42	++	-	-	-
2599 260	Trench 3	43	++	-	-	-
2599 261	Trench 3	43	++	+	-	-

+ reduction type present in minor amounts
++ reduction type present in major amounts

Most of the Trench 2 profile is composed of turbated lenses that are remnants of inward pit slopes and outward edges of old berms (cf. Chapter 16). Many pits evidently were excavated through previous deposits, truncating most earlier strata (cf. Figure 105). Only a few samples were analyzed, selected on the basis of expectations generated from the analysis of Trench 1 (Table 93). Overall, reduction activities in the vicinity of Trench 2 consisted of core and Stage 2 biface reduction (Table 93). Stage 3 reduction is minimally evident in only one sample (from stratum 39); its provenience on the berm, however, away from quarrying activity and above the more steeply sloping sloped lenses, fits the expected organization of reduction.

Trench 3 resembles Trench 1 more than Trench 2 in profile; long lenses of reduction debitage and quarry debris slope in toward the pit at the base of the opalite outcrop. The sloping strata occupy the upper portion of the profile and overlie remnants of a more complex association of relatively flat, inslope, and outslope strata. Eleven samples were chosen for qualitative analysis on the basis of expectations derived from Trench 1 (Table 93). Core reduction predominates in all samples (Table 93); Stage 2 reduction is evident only in two of them.

Quarrying, core reduction, and some Stage 2 biface reduction were the major lithic reduction activities at 26Ek3208. Stage 2 biface reduction does not exhibit a clear spatial pattern, but in general it occurs adjacent, but not within, the quarry feature. The contexts of the few samples with early Stage 3 biface reduction debitage suggest that edge preparation may have occurred in or adjacent the quarry feature, but that further facial thinning was undertaken elsewhere.

Outcrop Quarry, 26Ek3084. 26Ek3084 is located in the eastern part of the Western Periphery, approximately 200m southwest of 26Ek3208 (cf. Chapter 16). Toolstone available at 26Ek3084 consists of an outcrop of jasper. The jasper is less silicious and more brittle than high quality opalite, but it is quite flakeable. The material is dominantly golden yellowish brown or dark chocolate brown; white, pink, dark red, and purple variants occur less frequently. Different colors often co-occur in mottled or variegated combinations.

One hand-excavated trench (Trench 1) was dug in the apron of debris and debitage adjacent the outcrop during testing. Debitage samples from various strata were collected, but were not analyzed technologically. During data recovery, a second trench (Trench 2) was excavated over Trench 1, expanding the original trench. Eighteen samples were collected from most of the debitage lenses in the east wall of this trench (Chapter 16:Figure 102). These samples were subjected to technological analysis (Table 94).

Table 94. Qualitative Technological Analysis Characterizations of Trench Strata Samples, Trench 2, 26Ek3084.

			TECHNOLOGICAL CHARACTERIZATION			
Reference-Specimen No.	Trench Number	Stratigraphic Unit	Core Reduction	Blank Prep.	Stage 2 Biface Red.	Stage 3 Biface Red.
2599 913	Trench 2	1	-	-	-	-
2599 919	Trench 2	1	++	-	++	-
2599 917	Trench 2	6	++	-	++	-
2599 918	Trench 2	7	++	-	++	-
2599 911	Trench 2	10	+	-	-	-
2599 915	Trench 2	11	+	-	-	-
2599 909	Trench 2	13	+	-	-	-
2599 908	Trench 2	14	-	-	-	-
2599 905	Trench 2	15	+	-	-	-
2599 920	Trench 2	15	++	-	++	-
2599 914	Trench 2	17	++	-	+	-
2599 906	Trench 2	18	-	-	-	-
2599 908	Trench 2	20	-	-	-	-
2599 904	Trench 2	21	++	-	+	-
2599 903	Trench 2	24	++	-	++	-
2599 901	Trench 2	25	-	-	-	-
2599 900	Trench 2	34	-	-	-	-
2599 921	Trench 2	35	++	-	++	-

+ reduction type present in minor amounts
++ reduction type present in major amounts

Only Stratum 25 and Stratum 34 in the pit at the bottom of the outcrop exhibit evidence of primary toolstone extraction. Perhaps other evidence was cleaned out successively and thrown to the southern edge of the pit during later quarrying episodes. Most samples indicate the occurrence of core reduction. Stage 2 biface reduction is evident in 44% of the samples. Samples indicating edge preparation lie mostly on the gentle inward berm slope, adjacent the actual quarry area. No Stage 3 biface reduction was recognized.

The Eastern Periphery

Many sites in the Eastern Periphery were characterized as lithic reduction sites during testing (cf. Chapter 17), yet several also contain features that appear to have resulted from activities other than reduction. Samples from the Eastern Periphery were selected for technological analysis to investigate differences both between small and large lithic scatters and between lithic scatters and seemingly more complex features. Seven features from four sites were sampled for quantitative technological analysis (Table 95).

Table 95. Quantitative Technological Analysis Results and Data, Eastern Periphery Samples.

Site	Feature/ Locus	Feature Type	Character- ization	Non-heat-treated EP/EBT	Non-heat-treated INT/EBT	Heat-treated EP/EBT	Heat-treated INT/EBT	% heat- treated	sample n
3170	F8/Loc A	Reduction	Mixed Bif (ht) ESB	0.40	0.39	0.26	0.13	26.3	457
3170	F8/Loc B	Reduction	ESB	0.55	0.42	0.88	0	5.1	897
3184	F8	Reduction	Mixed Bif (ht) ESB	0.82	0.42	0.33	0.13	57.2	236
3184	F12	Reduction	ESB	0.33	0.63	0	0	1.7	359
3184	F23	Reduction	LSB	0.15	0.18	0	0	2.4	1307
3192	F1	Residential?	LSB	0.22	0.14	0.17	0.03	11.9	1084
3198	F1	Reduction & residential?	LSB	0.12	0.16	0.09	0.27	7.2	418

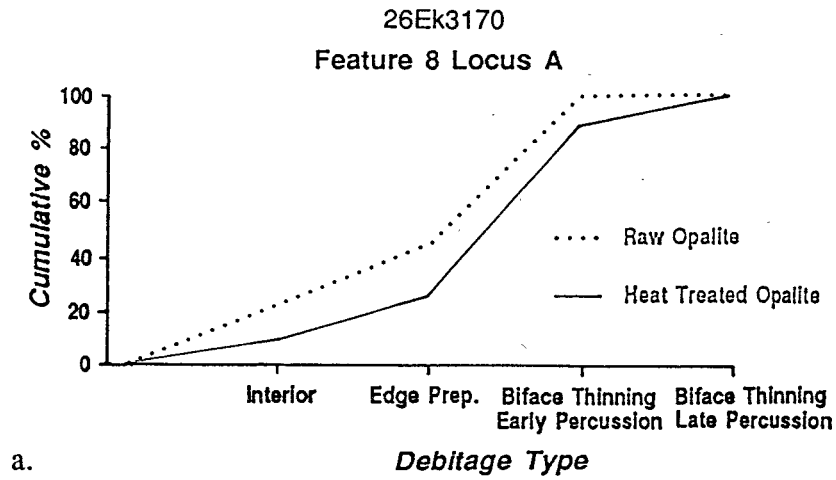
Characterizations: ESB = Early biface, Stage 1 to Stage 3.5
LSB = Late biface, Stage 3.5+
Mixed Bif = early and late biface.

EP/EBT = Ratio of edge preparation to early biface thinning flakes
INT/EBT = Ratio of interior to early biface thinning flakes

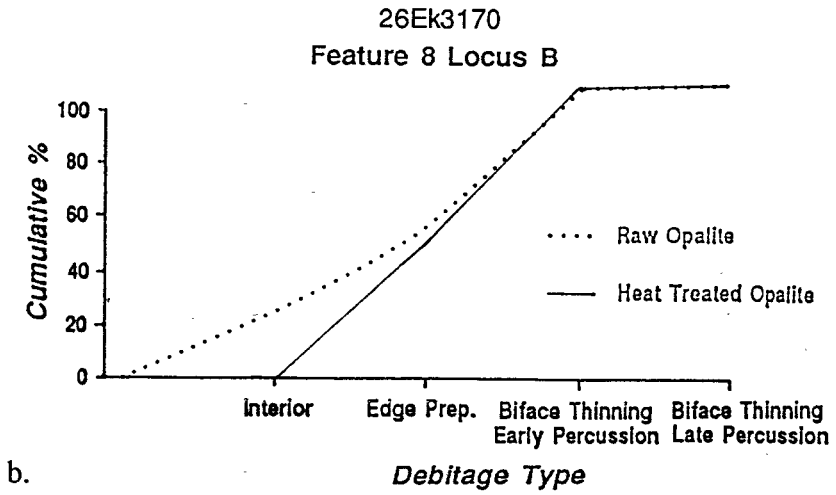
In general, technological analysis of the Eastern Periphery samples indicates a wide range of reduction activities, ranging from core reduction and early biface production on non-heat-altered opalite to projectile point manufacture on heat-treated opalite. Overall, complex features are strongly associated with debitage samples from later stages of biface production and projectile point manufacture. Later stage biface reduction is not *restricted* to complex features, however, so it cannot be used as a likely indicator of multiple activity features or sites.

26Ek3170. 26Ek3170 is a generally diffuse lithic scatter covering a gently sloping ridge (cf. Chapter 17). Within it, broad areas of high and low debitage density, distinct concentrations of debitage, and quarry pits are present. Feature 8, consists of a large area of higher debitage density; two concentrations were designated, Locus A and Locus B. Each locus of Feature 8 was collected in 16 1x1 m surface scraped units.

Debitage from five randomly selected units from Locus A of Feature 8 (roughly 31% of the surface area of the feature) was analyzed technologically (Figure 73a, Table 95). Quantitative



a.



b.

Figure 73. Ogives of diagnostic flake types, 26Ek3170, Feature 8.

analysis of this sample shows that reduction of non-heat-treated opalite (74% of the flakes in the sample) is dominated by early stages of biface production. Heat-treated opalite (26% of the sample) reflects reduction of already heat-treated Stage 2 and late Stage 3 bifaces to produce late Stage 3 and perhaps some Stage 4 bifaces.

Four randomly selected units from Locus B of Feature 8 (approximately 25% of the surface area of the feature) were analyzed as well (Figure 73b, Table 95). A high ratio of flake fragments to whole flakes indicates that core reduction contributed importantly to the sample. High frequencies of interior flakes and edge preparation flakes within the larger size-grades indicate that the reduction of relatively large flake blanks into early Stage 2 bifaces also was important. Heat-treated flakes comprise only 5% of the sample, and cannot be distinguished from background scatter; heat-treated bifaces were reduced infrequently, if at all, in this part of Feature 8.

26Ek3184. 26Ek3184 is a moderately dense lithic scatter with 26 discrete, concentrated features (cf. Chapter 17). Three features were chosen for technological analyses. Feature 12 and Feature 23 are tightly bounded concentrations which may have resulted from single reduction events. Feature 8 contrasts with these because it contains a fairly high number of artifacts; it may be a complex deposit of many different reduction events.

Feature 12 covers approximately 22 sq. m and contains two distinct concentrations of debitage. The larger concentration was collected in fifteen 1 m x 1 m surface scrapes. Three of these units were selected randomly for technological analysis. Opalite, generally in larger size-grades, is the major raw material. Heat-treatment is infrequent, and is not distinguishable from background scatter. The debitage sample exhibits reduction from large Stage 1 blanks or irregular early Stage 2 bifaces, yielding early Stage 3 bifaces (Figure 74a, Table 95). High values for EP/EBT and INT/EBT ratios as well as the presence of large (G1 size-grade) thinning flakes all support this interpretation.

Feature 23 covers approximately 63 sq. m, of which 25 were surface scraped; five 1 m x 1 m units were selected for technological analysis (Figure 74b, Table 95). White opalite is the most common raw material, and heat-treatment frequencies are not distinguishable from background scatter. Biface production is the dominant activity evident in the sample. High values of EP/EBT and INT/EBT flake ratios, large size-grade biface thinning flakes, and the reduction profile indicate the reduction of non-heat-treated middle Stage 2 bifaces or symmetrical flake blanks to produce late Stage 3 and early Stage 4 bifaces.

Feature 8 covers a 64 sq. m area and was collected with 30 1 m x 1 m surface scrapes. Four units were chosen randomly for technological analysis; three were analyzed qualitatively and one was analyzed quantitatively.

The single sample analyzed quantitatively from Feature 8 (Unit 134; Figure 74c, Table 95) contains two distinct biface production stages. Non-heat-treated opalite debitage was generated by early stages of biface production. Flakes from heat-treated bifaces or cores (57% of the flake sample) reflect both early and late biface production. Heat-treatment of flake blanks, followed by their reduction, is evident as differential luster on approximately one-third of the edge preparation flakes. Heat-treated flake blanks probably were reduced surficially prior to Stage 3 primary thinning, because some interior flakes and a few early biface thinning flakes show differential luster from heat-treatment. Very few later biface thinning flakes display this luster.

Qualitative analyses of three other units support the interpretation that the feature consists largely of debris from heat-treatment of flake blanks and subsequent reduction of them to approximately early Stage 3 of biface production. Two units (Units 129 and 132) are similar to Unit 134. The third (Unit 145) differs in that it is dominated by large, thermally fractured flake fragments and shatter. Although natural fire cannot be ruled out entirely as the cause of thermal alteration, a lack of crazing on flakes, minimal darkening of most heated flakes, and

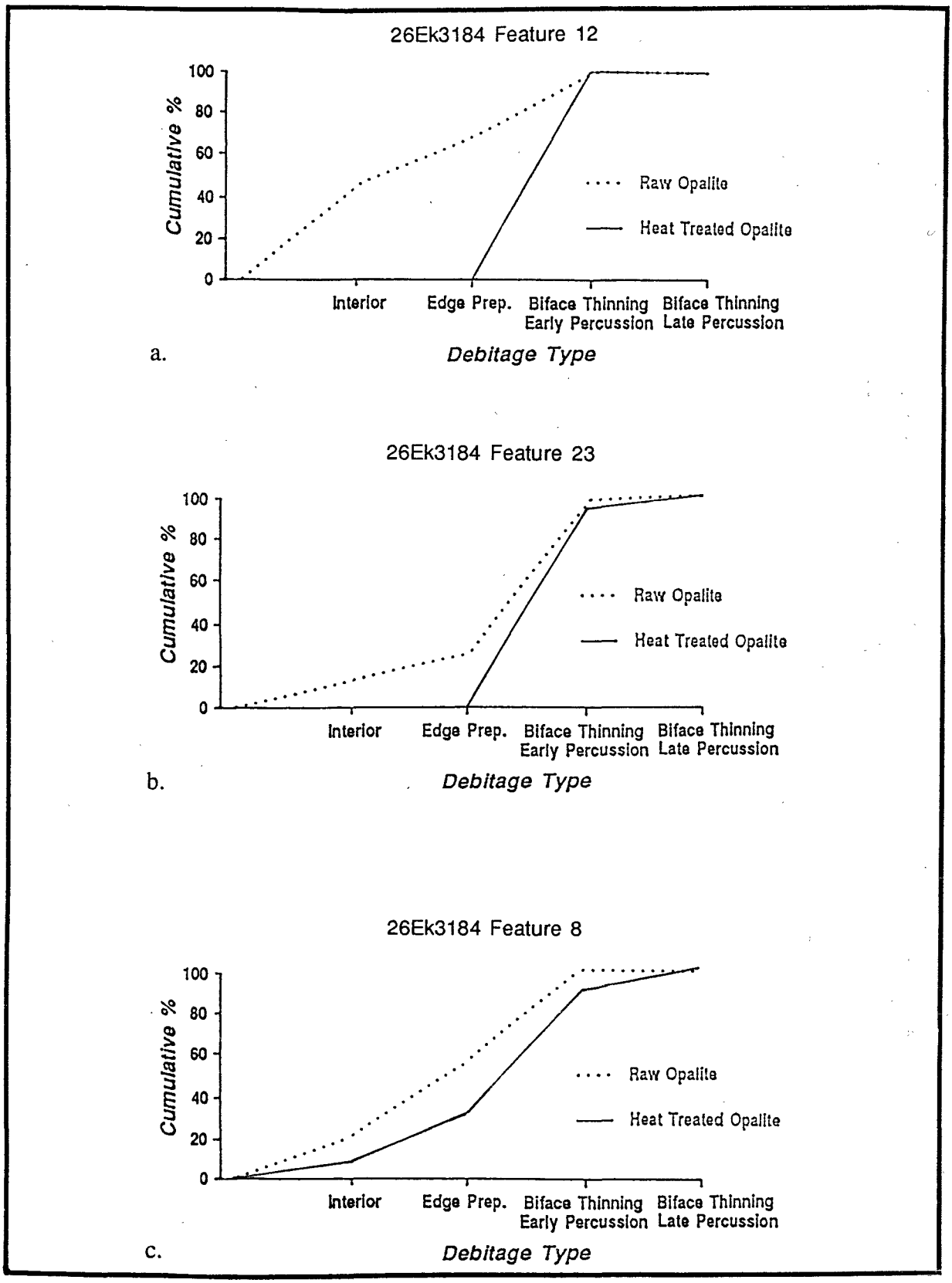


Figure 74. Ogives of analytical flake classes, 26Ek3184.

evidence of continued reduction of thermally altered specimens all make natural fire an improbable agent. Among the 794 pieces of debitage from Unit 145, 607 (76%) are fragmentary specimens; of those 164 (27%) are shatter, and, overall, 492 of the pieces (81%) are thermally fractured. All of the evidence from this unit points to failed heat-treatment, but flakes from the reduction of overly heated bifaces occur as well. These flakes indicate that overly heat-treated material still could be reduced without failing. Analysis of the Tosawihi biface assemblage (cf. Chapter 6) supports this conclusion.

26Ek3192. Feature 1 at this site was selected for technological analysis because it appeared in the field to have resulted from residential use (cf. Chapter 17). The 19 sq. m area of Feature 1 was sampled by 24 sq. m of surface scrape units which revealed a cache of 41 bifaces (cf. Chapter 6, Chapter 17). The 6 sq. m adjacent the biface cache were selected for technological analysis to evaluate whether the cache could have been produced on the spot. Two additional units were selected randomly to evaluate other parts of the feature.

Debitage from the six units around the biface cache was visually compared to the cached bifaces. The material qualities and colors in the debitage are generally quite similar to the bifaces; the larger size-grade (G1 and G2) specimens are especially close matches. Heat-treated debitage is not distinguishable from background scatter in these samples. Non-heat-treated debitage has a late biface production stage technological profile (Figure 75; Table 95), even though the cached bifaces represent early to middle stages of production (Stages 2 and 3). It is possible that late stage bifaces were transported away from the feature, and earlier stage bifaces cached there, but the late stage debitage is also explicable in terms of the biface blank morphology. The blanks apparently were already relatively thin and symmetrical (cf. Chapter 6) so, in proportion to early biface thinning flakes, fewer interior flakes and edge preparation flakes were struck. Low ratios of INT/EBT flakes and EP/EBT flakes are products of this blank morphology. In sum, it is likely that the debitage sample associated with the biface cache resulted from reduction of the cached bifaces or bifaces similar to them that were transported away.

The two randomly selected samples (Unit 2 and Unit 20) allow some assessment of feature integrity, at least as evident in the reduction profiles. These samples are similar in interpretation to those from the cache vicinity. A greater diversity of raw material is evident, however, so away from the cache more production events apparently helped create the feature.

26Ek3198. 26Ek3198 contains 24 features interpreted as lithic reduction areas and includes a small outcrop quarry (cf. Chapter 17). Feature 1 contained artifacts indicative of residential use. It was sampled with 30 1 m x 1 m surface scrape units. Eleven (37%) of these units were selected randomly for technological analysis. Two excavation levels in Unit 17 (2-10cm and 10-20cm below surface) were analyzed as well to test the densest concentration of debitage within the feature. Overall, Feature 1 reflects late stage biface reduction of mostly non-heat-treated opalite and some raw translucent chalcedony (Figure 75b, Table 95). Less than 8% of the debitage in the sample was heat-treated, suggesting that heat-treatment was not required for late stage reduction of this opalite and chalcedony. A distinctive characteristic of this locus consists of many small pressure flakes recovered from a small concentration on the surface and to a depth of 20cm below surface in Unit 17. Material colors include white, salmon pink, red, brown and yellowish white. The pressure flakes show heat-treatment and are more diverse in materials than other biface reduction debitage from the feature. They most likely were created in the manufacture of projectile points and preforms; direct support of this is offered by a single opalite notching flake.

The Western Periphery

The Western Periphery contains several very large sites, characterized during testing as both reduction and residential sites (cf. Chapter 16). Four small lithic scatters and three features from sites that may have been used residentially were subjected to technological analysis.

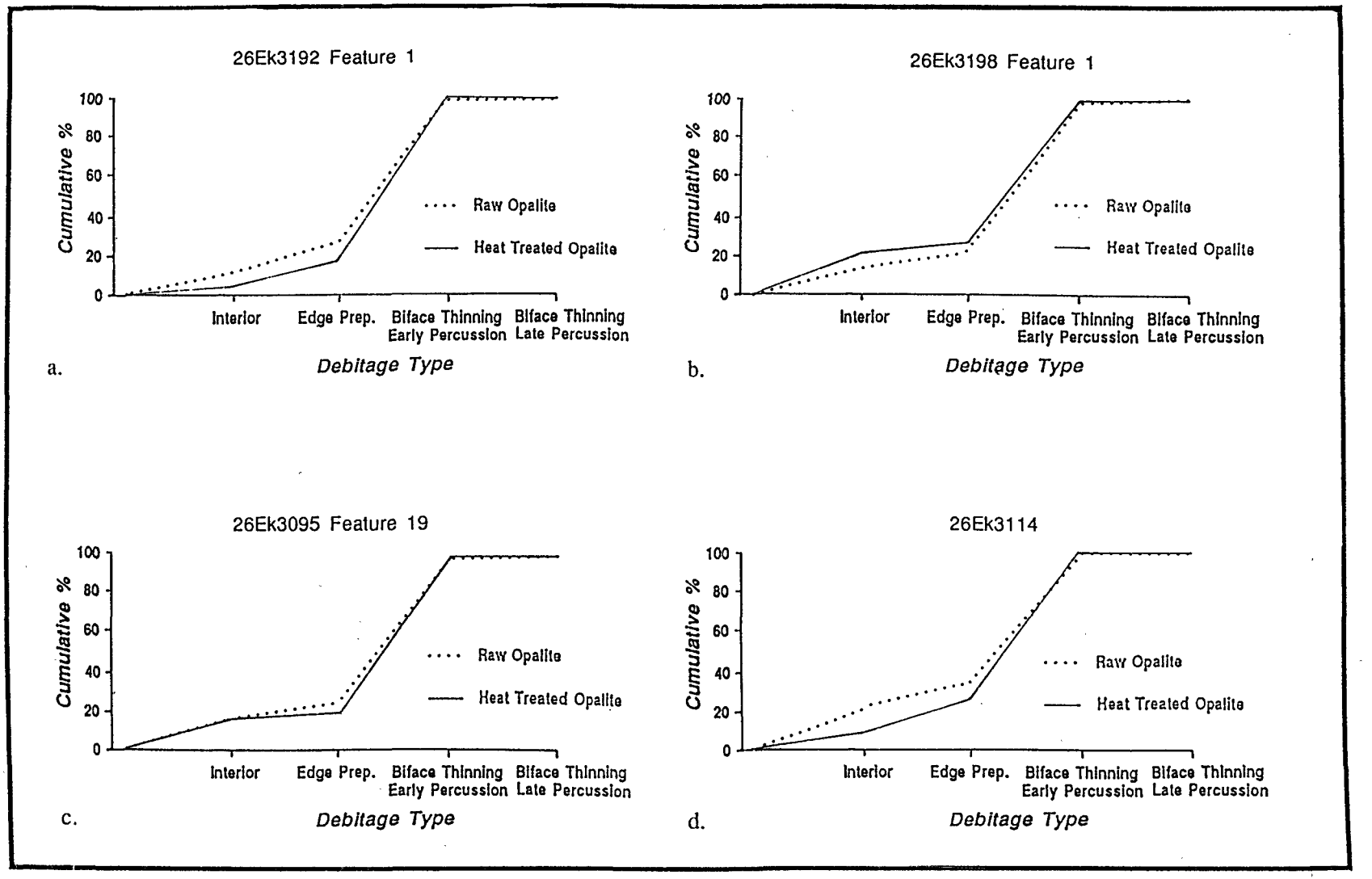


Figure 75. Ogives of analytical flake classes.

26Ek3095. This site contains 25 surface features (cf. Chapter 16); only Feature 19 was analyzed technologically. This feature was chosen for analysis because it appears to reflect both residential and lithic reduction activities. Two loci are present; only Locus 1, a dense debitage concentration associated with groundstone and a probable hearth, was analyzed. The debitage from the upper levels of two excavation units (Units 24 and 29) was selected for analysis. These samples were collected partially through 1/8 in. mesh and so provide an opportunity to distinguish debitage resulting from pressure flaking. Sampling in both units was restricted to the 0 - 10 cm. excavation level, which accounted for almost all the debitage recovered from Unit 29 and more than half that from Unit 24.

Debitage from the two units is predominantly white and pink opalite. Approximately 15.3% of the debitage was heat-treated. Pressure flakes were not found in the samples. The reduction profile for non-heat-treated and heat-treated debitage reflects late stage biface production (Figure 75c, Table 96). The EP/EBT ratios are low, indicating Stage 2 biface production contributed little to the assemblage. The larger, but still small, portion of interior flakes most likely is indicative of early Stage 3 biface thinning. Therefore, biface reduction at Feature 19/Locus 1 most often was initiated on late Stage 2 and early Stage 3 bifaces to produce late Stage 3 and Stage 4 bifaces. A scarcity of larger size-grade flakes suggests that bifaces at all stages were relatively small.

Table 96. Quantitative Technological Analysis Results and Data, Western Periphery Samples.

Site	Feature/ Locus	Feature Type	Character- ization	Non-heat-treated EP/EBT	Non-heat-treated INT/EBT	Heat-treated EP/EBT	Heat-treated INT/EBT	% heat- treated	sample n
3095	Feat. 19	Residential?	LSB	0.11	0.23	0.05	0.19	15.3	825
3106	Feat. 1	Reduction	ESB	0.34	0.95	0.17	0.50	11.9	793
3114	N/A	Reduction	Mixed Bif	0.21	0.28	0.20	0.10	15.4	254
3115	N/A	Reduction	Mixed Bif	0.09	0.29	0.11	0.11	31.4	70
3116	N/A	Reduction	ESB	0.34	0.45	0.13	0.13	7.0	142
3160	Feature 1	Residential?	LSB	0.11	0.15	0.20	0.10	25.3	1534
3160	Feature 2	Reduction		0.16	0.13	0.15	0.17	82.1	223
3160	Feature 3	Reduction	Mixed Bif	0.23	0.19	0.40	0.67	10.8	288
3160	Feat. 23	Residential?	Mixed Bif	0.26	0.36	0.16	0.29	25.4	437

Characterizations: ESB = Early biface, Stage 1 to Stage 3.5
LSB = Late biface, Stage 3.5+
Mixed Bif = early and late biface

EP/EBT = Ratio of edge preparation to early biface thinning flakes
INT/EBT = Ratio of interior to early biface thinning flakes

26Ek3114, 26Ek3115, and 26Ek3116. These three sites consist of small (less than 16 sq. m each), elongate lithic scatters clustered on a gentle southeastern slope (cf. Chapter 16). All were sampled with surface scrapes. The sampled area on each site was divided into upslope and downslope halves, and one unit from each half was selected randomly for technological analysis.

Analytical results (Figure 75d, Table 96) show that 26Ek3114 and 26Ek3115 are similar in material diversity and reduction profile. The frequency of heat-treated debitage is minimal in all analytical samples and cannot be interpreted. A low count of debitage from 26Ek3115 also constrains interpretation of cumulative debitage proportions, so the samples were not graphed. Comparisons of ratios thus constitute the primary data for interpretation of these samples. EP/EBT and INT/EBT ratios for 26Ek3114 are high for later stage reduction. These ratio values indicate biface production was initiated on irregular flake blanks, continued through Stage 2, and finished by producing late Stage 3 or early Stage 4 bifaces. At 26Ek3115, the EP/EBT ratio

is lower, suggesting that Stage 2 reduction was not a major contributor to the assemblage. Because the sample itself is small, this interpretation is tentative.

26Ek3116 is characterized by early stages of raw biface reduction (Figure 76a, Table 96). The consistent diversity of opalite colors across debitage types and among size-grades indicates a continuous reduction of possibly four to six raw flake blanks into the early and middle phases of Stage 3 primary thinning. The reduction of heat-treated bifaces is even less evident here than among the other two sites.

26Ek3160. 26Ek3160 is a large lithic scatter covering a long, gently sloping ridge (cf. Chapter 16). Twenty-three concentrations of debitage were designated as features. Some are large and have indistinct boundaries; they may have been generated during residential use of the site. Small discrete features are distinct from larger ones, and may have resulted from a limited number of lithic reduction events. Two of each kind of feature were sampled to characterize lithic reduction; Features 1 and 23 as representative of large lithic scatters, Features 2 and 3, to characterize small lithic scatters.

Feature 1 is a dense concentration of debitage and other artifacts (cf. Chapter 16) covering approximately 100 sq. m. Nine of the 43 sq. m collected from the feature were chosen for analysis, six units near the feature center and three toward its edge. The overall reduction profile shows low cumulative proportions of interior flakes and edge preparation flakes (Figure 76b), suggesting late biface production debitage; low values of the EP/EBT and INT/EBT ratios support this interpretation (Table 96). The proportion of heat-treated debitage is high at 25% (Table 96), and the overall reduction profile for heat-treated debitage indicates initiation of biface production on heat-treated blanks. Higher proportions of heat-treated late biface thinning flakes indicates that heat-treated bifaces more often were reduced further than non-heat-treated ones (Figure 76b). The production of bifaces on non-heat-treated pieces usually started with Stage 2 and early Stage 3 bifaces to produce late Stage 3 bifaces.

Feature 23 is a light density lithic scatter associated with artifacts suggesting food processing (cf. Chapter 16). The surface of the elongate scatter was scraped entirely in 21 1 m x 1 m surface scrape units. To choose a sample of these, we divided the feature into three segments based on grid locations relative to site slope (upper, middle, and lower slope). Two units from each division were analyzed technologically; two excavation levels from a randomly selected unit (Unit 55) were analyzed as well. The reduction profile for Feature 23 is early/late (Figure 76c, Table 96), i.e., both the cumulative curves and the diagnostic debitage ratios fall between those expected for either early or late biface reduction. The ratios of INT/EBT and EP/EBT for non-heat-treated opalite indicate that reduction of non-heat-treated bifaces was initiated frequently on irregular blanks and produced relatively few later stage bifaces. Heat-treated debitage comprises 25% of the samples. Reduction of heat-treated blanks from more regular Stage 1 blanks or early Stage 2 bifaces to produce late Stage 3 and Stage 4 bifaces is evident in low EP/EBT and INT/EBT ratios.

Feature 2 is a small (4.7 sq. m), isolated debitage concentration. The surface debitage is burned and fragmented. It was sampled to investigate the cause of thermal alteration and to characterize the lithic reduction that originally produced it. Two of the 4 1 m x 1 m surface scraped units were selected for technological analysis. The low frequency of whole flakes precludes meaningful graphical and statistical comparisons. Thermal alteration has affected most heavily the larger and thicker interior and early biface thinning flakes, further biasing interpretations based on frequencies of whole flakes. Many of these flakes probably were created during the reduction of large early Stage 2 and early Stage 3 bifaces. It also is possible that cores were reduced at Feature 2 to yield flake blanks for small bifaces, but no core fragments were found in the feature. The feature surface apparently burned after its use; the thermally altered debitage is extremely crazed, discolored, and often broken into blocky fragments.

Feature 3 covers approximately nine sq. m. It was selected for technological analysis because the scatter is tightly delineated and the debitage appears to vary little. Two of eight

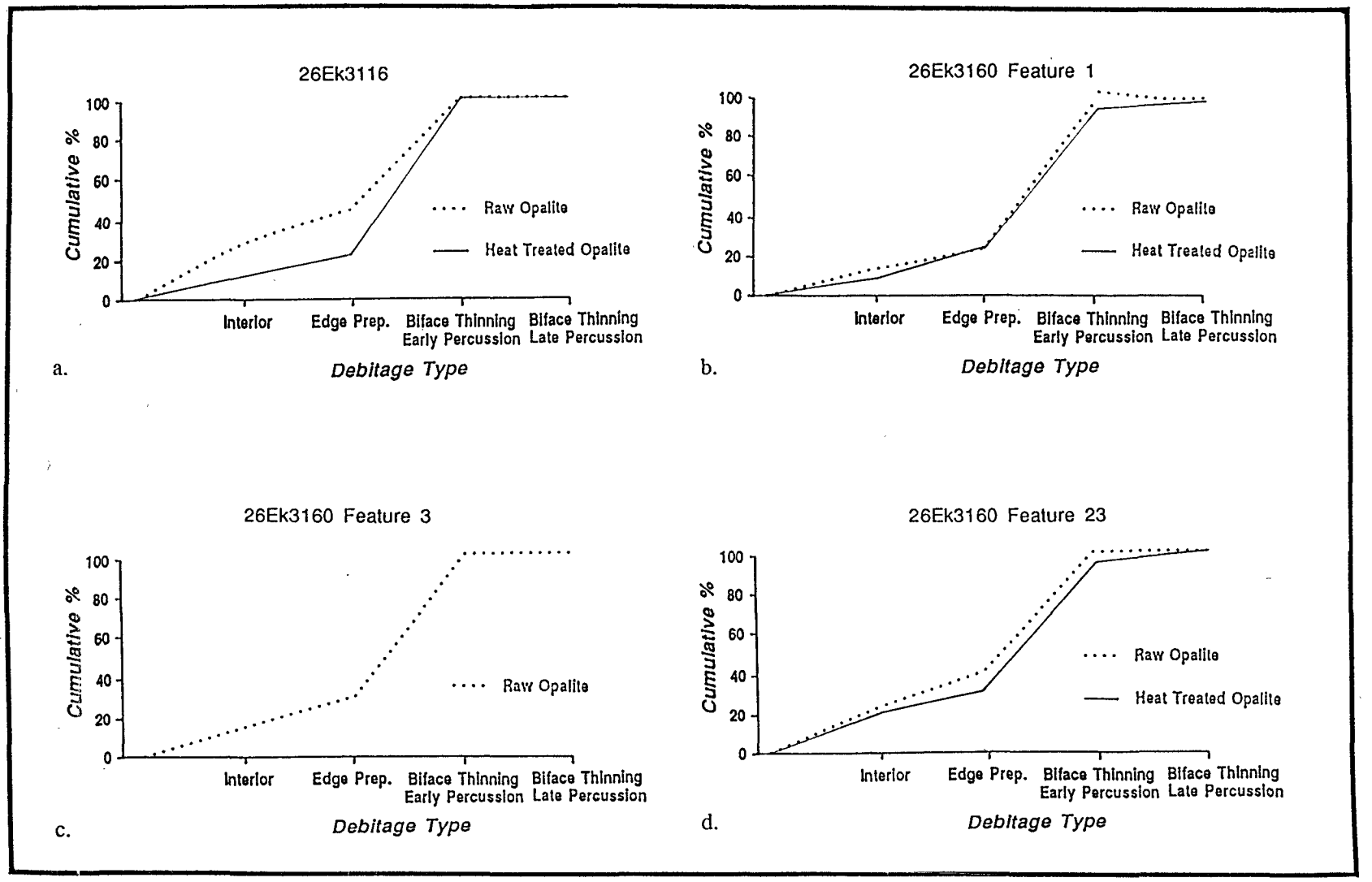


Figure 76. Ogives of analytical flake classes.

surface scrape units were selected for technological analysis. The reduction profile (Figure 76d) is late, but also is slightly skewed to the earlier part of late biface production by a high EP/EBT ratio of non-heat-treated flakes (cf. Table 96). The contrasting INT/EBT ratio of 0.19 for non-heat-treated opalite reflects late reduction. This difference in ratios indicates that blanks reduced here already were relatively symmetrical. Blanks of non-heat-treated opalite were reduced through Stages 2 and 3, and perhaps into early Stage 4. The thermal alteration evident in much of the debitage assemblage from Feature 3 probably is post-depositional; the feature lies close to Feature 2, and many of the thermally altered flakes are similar to those in Feature 2 in discoloration, cuboid fragmentation, and crazing.

26Ek3106. This site is situated in Rodent Valley, a portion of the Western Periphery in many ways similar to the Eastern Periphery (e.g., high proportions of heat-treated bifaces; cf. Chapter 6). The reduction profile for Feature 1 reflects early biface production (Figure 77a, Table 96). A fairly high proportion of non-heat-treated interior flakes indicates that much of the biface production occurred on large irregular blanks, producing early Stage 2 and Stage 3 bifaces; core reduction also may have contributed interior flakes to the sample. The proportion of heat-treated interior flakes is high, indicating the heat-treatment of irregular blanks and probably early Stage 2 bifaces as well (Figure 77a, Table 96). Many flakes and some bifaces (Chapter 6) exhibit failure due to heat-treatment. Successful reduction of heat-treated bifaces is evident in a higher than usual proportion (but not frequency) of heat-treated biface thinning flakes relative to non-heat-treated biface thinning flakes. Overall, the feature appears to have been near a quarry, and to have been a place where heat-treatment of blanks and roughly edged Stage 2 bifaces was followed by production of large, late Stage 2 and early Stage 3 bifaces.

The Northern Corridor

The Northern Corridor begins approximately 6 km from the northern edge of the quarries (cf. Chapter 2, Chapter 18). Technological analysis examined samples from two sites here because they are the best candidates for residentially used locations unrelated to the Tosawihi quarries. 26Ek3237 is located at the south end of the corridor and thus is closest to the quarries; 26Ek3251 is located at the north end of the subarea, approximately 12 km from the quarries.

Site 26Ek3237. 26Ek3237 is a large site adjacent Ivanhoe Creek (cf. Chapter 18). Three loci of concentrated debitage and other artifacts lie within a larger, generally light lithic scatter. Debitage from Locus C was selected for technological analysis because of the presence of stratified and dated hearths (Features 3 and 4); these features were the focus of technological analysis.

Debitage samples from surface and subsurface proveniences in the vicinity of Features 3 and 4 were analyzed qualitatively to discover if distinct assemblages were associated with each feature. Debitage from a surface scrape and from 2 to 10 cm below surface in Unit 59 was analyzed quantitatively. The qualitative analysis found that debitage samples associated with Features 3 and 4 are not qualitatively distinct from each other. The dominance of early and late stage biface thinning flakes in the G3 size-grade of the samples indicates thinning of small Stage 2 bifaces to produce Stage 3 and Stage 4 bifaces, as well as thinning of Stage 3 and Stage 4 bifaces. Quantitative technological analysis of Unit 59 (Figure 77b, Table 97) supports this interpretation.

A relatively large proportion of heat-treated debitage (Table 97) contains a high frequency of biface thinning flakes, indicating the reduction of heat-treated bifaces. An almost complete lack of differential luster on the dorsal surfaces of the biface thinning flakes shows that initial reduction of the bifaces after heat-treatment did not occur around the features.

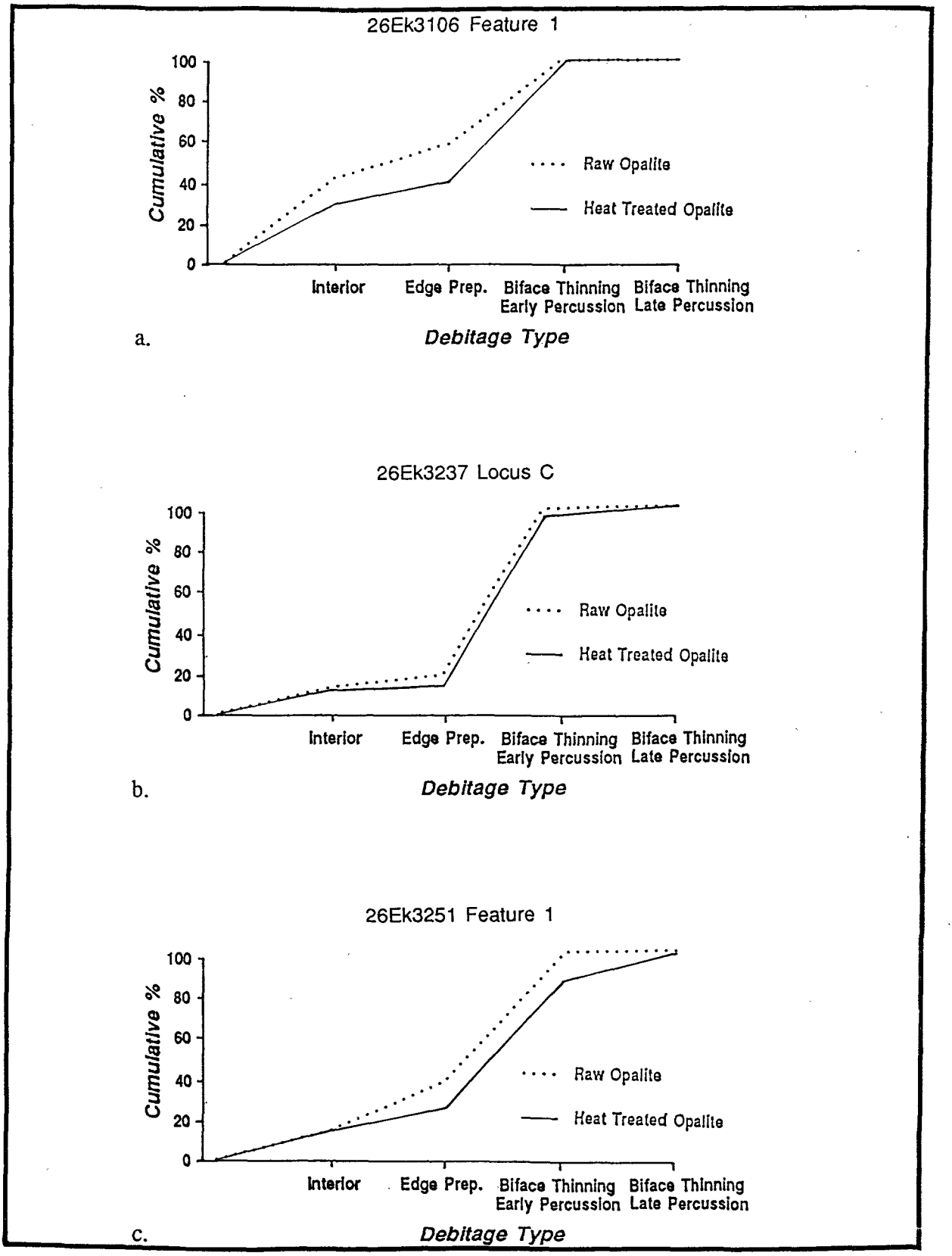


Figure 77. Ogives of analytical flake classes.

Nonetheless, a few biface fragments exhibit distinctive thermal fractures, suggesting that some heat-treatment occurred near (but not necessarily in) Features 3 and 4.

Table 97. Quantitative Technological Analysis Results and Data, Northern Periphery Samples.

Site	Feature/ Locus	Feature Type	Character- ization	Non-heat-treated EP/EBT	Non-heat-treated INT/EBT	Heat-treated EP/EBT	Heat-treated INT/EBT	% heat- treated	sample n
3237	Locus C	Residential?	LSB	0.06	0.15	0.03	0.13	47.3	448
3251	Feat. 1	Residential?	Mixed Bif						
			LSB (ht)	0.39	0.21	0.23	0.19	85.0	1235

Characterizations: ESB = Early biface, Stage 1 to Stage 3.5
LSB = Late biface, Stage 3.5+
Mixed Bif = early and late biface

EP/EBT = Ratio of edge preparation to early biface thinning flakes
INT/EBT = Ratio of interior to early biface thinning flakes

Toolstone in the samples is diverse in quality and color; this is particularly true of interior flakes. Toolstone sources other than Tosawihi opalite undoubtedly were reduced adjacent these two features. Some non-opalite toolstone probably was obtained locally as stream cobbles, since there are a few G1 and G2 size-grade fragments and secondary flakes with incipient cones and cobble cortex.

Conjoinable fragments also occur; their proveniences often are fairly widely separated, indicating turbation of the deposit. For example, a large potlid recovered in the 2-10 cm level of Unit 59 conjoins a burned biface in the 30-40 cm level. Turbation may have increased the apparent homogeneity of all the debitage samples.

In order to examine lithic reduction outside feature contexts, a sample from Unit 60 was examined qualitatively. Technologically, the assemblage resulted from the reduction of non-heat-treated opalite bifaces. Raw material color and quality are typical of Tosawihi opalites. The debitage indicates reduction of early Stage 2 bifaces to produce middle Stage 3 to early Stage 4 bifaces. The opalite bifaces reduced around Unit 60 apparently were larger than those reduced around Feature 3 and Feature 4, since the proportion of G2 size-grade specimens is higher in the Unit 60 sample than in those from around the two features.

In sum, the debitage samples from Locus C of 26Ek3237 suggest the presence of two distinct reduction technologies. One, which can be considered a "non-Tosawihi" strategy, is the reduction of local toolstone, perhaps collected as stream cobbles, to produce small bifaces and probably a variety of other tools. The second technology, yielding a more characteristic "Tosawihi assemblage," is the reduction of fairly large opalite bifaces. The debitage samples from around Feature 3 and Feature 4 reflect combinations of both technological strategies, and those from Unit 60 reflect solely the latter.

26Ek3251. This site contains six lithic concentrations (features) subsumed by a lighter density scatter (cf. Chapter 18). Technological analysis was restricted to Feature 1, apparently a composite of multiple activities containing food processing artifacts as well as lithic reduction debris. The feature covers approximately 66 sq. m, and was sampled with a grid of 22 1 m x 1 m units. Samples for technological analysis were drawn from two randomly selected units (Units 15 and 21) and from two other units sieved through 1/8 in. mesh (Units 14 and 16). The latter samples were selected to assess the presence of pressure flakes. All samples underwent quantitative technological analysis.

The reduction profiles reflect reduction of non-heat-treated bifaces from Stage 2 to approximately early Stage 4 or late Stage 3 and late stage reduction of heat-treated bifaces (Figure 77c, Table 97). Heat-treated debitage comprises 85% of the sample (Table 97). Differential luster is common on the dorsal surfaces of interior flakes, edge preparation flakes, and biface thinning flakes in the small size-grades. This indicates the reduction of small heat-treated flake blanks and bifaces. Absence of G1 size-grade debitage and a paucity of G2 size-grade debitage indicates that reduction of small bifaces predominated in creating the samples. These observations concur with the results of biface analysis (cf. Chapter 6). Pressure flakes are abundant in each of the 1/8 in. samples examined, and also were recovered in 1/4 in. mesh. Pressure flaking was restricted to the reduction of heat-treated small bifaces, some of which probably were projectile point preforms.

Discussion

The results of technological analysis disclose regular patterns in debitage samples from the Tosawihi vicinity. Samples (containing more than fifty items) analyzed technologically can be compared to each other reliably by plotting the values of the INT/EBT ratio against the EP/EBT ratio values for each sampled site (Figure 78).

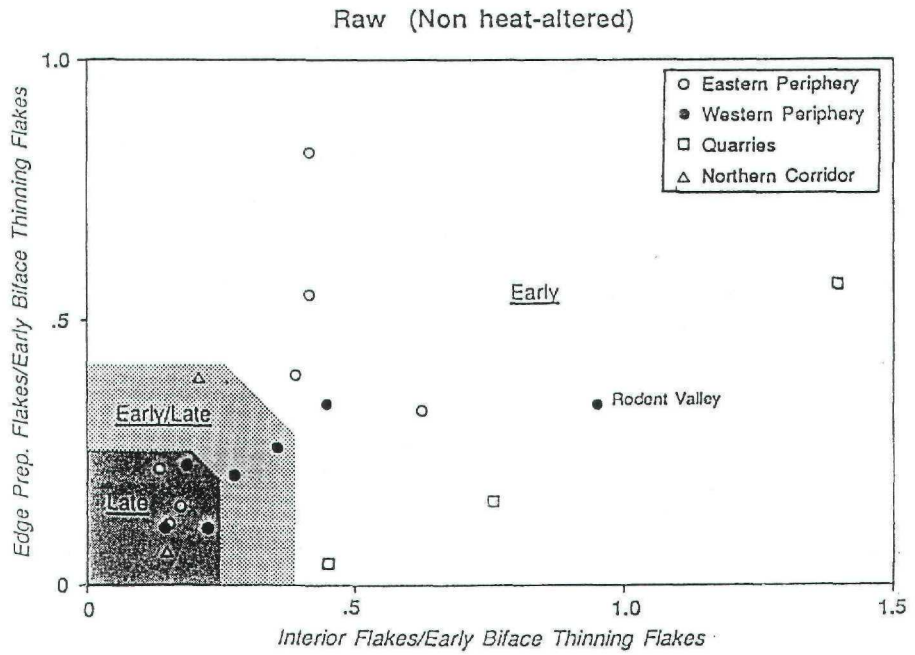
A scatter plot of non-heat-treated opalite samples encompasses most of the sites examined by technological analysis (Figure 78a). Among the sites characterized as early biface reduction, the majority lie in the Eastern Periphery and the main quarry area. Eastern Periphery sites differ from those in the main quarry in more subtle ways. Samples from the main quarry area always have a higher INT/EBT ratio than EP/EBT ratio. In Eastern Periphery samples, the order of ratio values is reversed. These ratios indicate that the main quarry samples are dominated by core reduction and the Eastern Periphery samples by early biface reduction. The Western Periphery samples mostly are characterized as late stage biface production, although there is a secondary trend of early *and* late stage biface production. The two Northern Corridor sites sampled show very late stages of biface production on Tosawihi opalite, and early to late stage biface production on probably local toolstone.

Debitage from heat-treated bifaces, blanks, or cores occurs most commonly in samples interpreted as late stage biface production and early to late stage biface production (Figure 78b). In the main Quarry, heat-treated debitage shows that heat-treatment regularly occurred near the middle of Stage 3 biface thinning. Samples from the Eastern Periphery suggest much more variable occurrence of heat-treatment, ranging from early stages to late stages of biface production. Western Periphery samples containing heat-treated debitage are late in the biface reduction continuum, although some early reduction of heat-treated bifaces was found in the Rodent Valley assemblage. In Northern Corridor samples, heat-treatment is associated only with late stages (late Stage 3 or early Stage 4) of biface reduction.

Summary and Conclusions

The debitage analyses indicate clearly that biface production was the major focus of toolstone exploitation at Tosawihi. While there are differences in how the two analytical techniques characterize debitage samples, the overall results are substantially similar.

Biface sizes and shapes are documented directly in the analysis of opalite bifaces recovered here, and our analytical results simply reinforce the conclusions drawn in Chapter 6. Although bifaces themselves provide direct testimony of lithic production at Tosawihi, they do not provide an accurate estimate of how many bifaces were made there. We have attempted



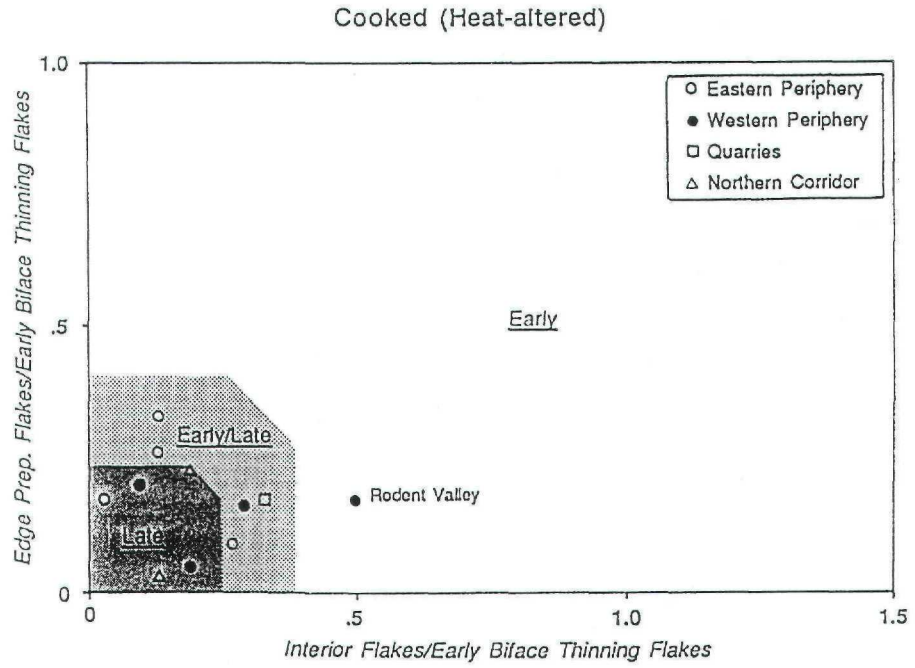


Figure 78. INT/EBT vs. EP/EBT values for technologically analyzed sites.

to answer this question by examining the extrapolated weight of debris present in the Tosawihi vicinity, and by calculating the number of bifaces that this extrapolation represents. The result is a conservative estimate of approximately 87,000 bifaces having been produced in the Tosawihi vicinity. There can be no doubt that biface production at Tosawihi exceeded by far the demands of local use around the quarries.

Both the analytical techniques applied to debitage shed some further light on the form in which bifaces departed the Tosawihi vicinity. Technologically distinctive debitage samples are directly associated with toolstone sources. The dominant reduction activity in quarry pits and outcrops was core reduction and probably the direct reduction of bedrock to produce large flake or slab blanks. A large proportion of the interior flakes (which indicate core reduction) probably resulted from removing irregularities from large thick slabs of opalite. Technically, these are not flake blanks, but block or slab blanks (Mark Moore, personal communication 1990). Biface production was a secondary activity in the immediate vicinity of toolstone quarry pits or outcrops. When present, biface production ceased with preparation and regularization of blank edges (Stage 2) or after a few initial thinning flakes had been removed (early Stage 3). Technological analysis even of surface scraped biface reduction assemblages outside, but near, the Locality 23 quarry pit reflect the early part of Stage 3 reduction.

While the procurement of suitable blanks for bifaces left the unsurprising bulk of evidence in quarry features, opalite biface production is the dominant technological action away from quarries. There are differences between the three areas peripheral to the Quarry proper. The general trend is for increasingly late stage biface reduction to be associated with increasing distances from opalite sources. Yet, part of these differences may be due more to how places or sites were used than to a direct relationship between distance to opalite sources and biface reduction stage.

In broad terms, biface production at Tosawihi, as evident from technological analysis of the debitage, can be divided into two distinct parts. The first involves the procurement of toolstone, production of blanks, initial edging (Stage 2), and some initial thinning (early Stage 3). The second involves the continued thinning (Stage 3), often accompanied by heat-treatment, final thinning (Stage 4), and edge shaping (Stage 5), of bifaces. Initial procurement and production is very closely associated with toolstone sources, i.e., early stages of biface production diminish with distance from sources. The later portion of the biface production sequence appears to be unrelated to distance to toolstone source.

If later reduction of bifaces, and heat-treatment of bifaces, are not parts of lithic procurement *per se* but instead parts of "normal" lithic reduction strategies, then we expect late biface production debitage assemblages to be associated with a greater diversity of activities than earlier ones. Insofar as a greater diversity of activities in a given location may be invited by residential use of a place, it is possible that late biface production is an indirect measure of "residentiality."

If the occurrence of late biface production is due more to how prehistoric forays to toolstone sources were scheduled and organized, then we also should expect to see an association between the heterogeneity of debitage sizes (as discussed above) and the characterization of debitage samples as late stage biface reduction. Mass analysis characterizations, because they are based on distributions within size-grades, are a partial measure of heterogeneity. Mixed (early and late) biface reduction characterizations indicate the most heterogeneous debitage samples in terms of item size. At the other end of the spectrum, the core reduction characterizations generally are dominated by items in large size-grades, while edge maintenance characterizations almost uniformly are composed of small flakes. Between these extremes, debitage size distributions in early and late stage biface characterizations are more heterogeneous than core reduction samples, and less heterogeneous than mixed bifacial reduction. Early stage biface reduction characterizations are skewed toward larger size-grades, and late stage biface reductions towards smaller ones.

There is a general association between mass analysis characterization of composite feature samples as late stage biface reduction and the associated presence of other features characterized as mixed biface reduction on the same sites (cf. Table 2, Appendix I). This lends partial support to the hypothesis that Tosawihi toolstone most often was exploited as part of a larger round of resource collection, and not through specific logistical forays. Alternatively, however, logistical use of toolstone sources may have left few traces except at outcrops and pits, where they are indistinguishable from diurnal or residential exploitation debris. Thus, we can provide support only for a model of residential use, but this in no way negates the likelihood of logistically organized forays having also been used. In any case, the testable implication of this argument is that evidence of late biface production should be positively associated with artifact classes whose use is independent of biface production. For example, late stage biface production could be associated with flake tools, groundstone, or food preparation hearths. Although examination of such associations is not undertaken here, it is feasible to do so (cf. Chapter 24).

Chapter 11

HAMMERSTONES AND OTHER COBBLE TOOLS

Dave N. Schmitt

Some things never change.
- Anonymous

Throughout hominid evolution and especially in the recent past, we have witnessed many dramatic changes in the types, shapes, and sizes of prehistoric artifacts. Clearly, the metamorphosis of implements and the introduction of new tools owe to many sources, including environmental, behavioral, and technological factors, none of which operates independently. In the prehistoric Great Basin, for example, changes in projectile point morphology over the past 8,000 years include numerous innovations in size and style (cf. Thomas 1981); these temporally constrained modifications were the result of a number of ecological and technological adaptive responses, including the replacement of the atlatl with the bow and arrow.

While most prehistoric tool forms changed in response to local conditions and within local technologies, the simple cobble tool has remained virtually the same, due, in part, to its low cost of procurement and its functional efficiency. Whether unmodified for rough percussion tasks or minimally flaked to achieve a sharp working edge, hammerstones and choppers are persistent features of the archaeological record global in extent and spanning more than a thousand millennia.

Simple percussion and processing tools were recovered from most sites at Tosawihi (Table 98). Not surprisingly, hammerstones are common and occur in a variety of contexts, including quarry sites as well as small, isolated reduction stations (cf. Schmitt 1989a). This chapter describes hammerstone assemblages collected at Tosawihi (cf. Table 98), together with discussions of choppers, scratched stones, stone shovels, and scraper planes. Materials recovered from initial testing of excavated sites are combined with data recovery collections. Although some attributes and locational data are mentioned here, piece-specific proveniences and metric data are presented in Appendix J (also cf. Schmitt 1989a).

Hammerstones

The assemblage of 82 hammerstones (from 19 sites; cf. Table 98) contains an array of shapes and sizes (cf. Appendix J); most abundant are fist-sized cobbles that can be held and used with one hand (e.g., Figure 79a, c), usually exhibiting two or more battered edges/surfaces. Two hammerstones, however, are spalls from large basalt cobbles recovered from quarry pits (at 26Ek3084 and 26Ek3208); they probably represent fragments of "throw-stones" (i.e., projectile hammerstones) employed in the removal of opalite from bedrock exposures. More than half of the hammerstones (n=46, 57%) are complete.

Excavations and surface collections at nine sites returned 10 shaped hammerstones. Bifacial percussion flaking has produced one or more thin, often "pointed" working edges, probably to facilitate controlled flake removal when used in biface reduction (cf. Figure 79d). A few additional specimens may have been shaped superficially, but extensive use wear (e.g., spalling, step fracturing) and/or fragmentation precludes inferences on purposeful shaping. Similarly, two shaped opalite hammerstones may have functioned as cores before they were battered (cf. Thomas and Bierwirth 1983:230); their "shaping" thus may have been a product of assaying or flake removal rather than enhancement as percussion tools.

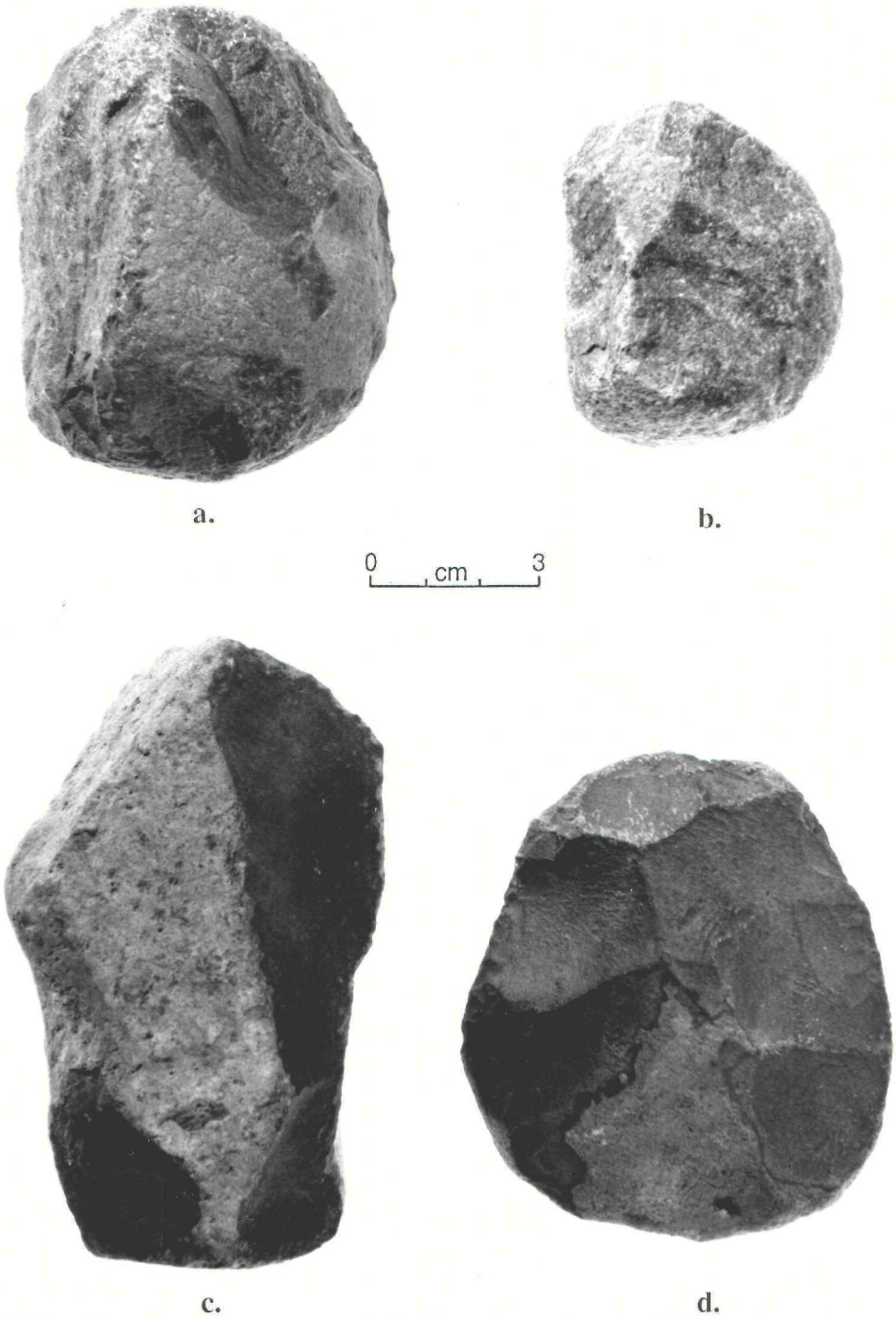


Figure 79. Selected hammerstones.

Table 98. Percussion, Processing, and Digging Tools by Site.

Site* (Locality)	Hammerstones	Scratched Stones	Choppers	Hammer-Choppers	Shovels	Scraper Planes	Totals
3032 (19)	2	-	-	-	-	-	2
3032 (23)	2	-	-	-	-	-	2
3032 (25)	4	-	1	-	-	-	5
3032 (98)	1	-	-	-	-	-	1
3084	4	-	-	-	1	-	5
3085**	1	-	1	-	-	-	2
3092	17	-	5	-	-	-	22
3093**	-	-	1	-	-	-	1
3095	10	1	2	-	-	-	13
3096**	2	-	1	-	-	-	3
3099**	1	-	1	-	-	-	2
3101**	-	-	1	-	-	-	1
3104**	1	-	1	-	-	-	2
3106**	1	1	-	-	-	-	2
3107**	-	-	1	-	-	-	1
3114**	-	1	-	-	-	-	1
3149**	-	-	1	-	-	-	1
3160	6	1	1	-	1	3	12
3170	2	-	1	-	-	1	4
3171	2	1	-	-	-	-	3
3177**	1	-	-	-	-	-	1
3184	3	-	1	-	-	-	4
3185**	2	1	-	-	-	-	3
3192	4	2	-	-	-	-	6
3193**	-	1	-	-	-	-	1
3195	6	-	-	-	-	-	6
3196**	8	-	-	-	-	-	8
3197**	6	-	-	-	-	-	6
3198	2	-	-	-	-	-	2
3200	1	-	-	-	1	-	2
3201**	4	1	-	-	-	-	5
3204	8	1	-	-		-	9
3208	4	1	-	1	-	-	6
3237	4	-	3	-	-	-	7
3238**	1	-	-	-	-	-	1
3239**	2	-	3	-	-	-	5
3251	1	-	2	-	-	-	3
3271**	7	2	9	-	-	-	18
Totals	120	14	36	1	3	4	178

* 26Ek prefix omitted
** Materials recovered from tested sites (cf. Schmitt 1989a)

From Whining Rock Shelter (26Ek3204, in the Eastern Periphery), a unique, small rounded hammerstone (Figure 80) shaped by pecking and abrasion was recovered. It possesses a number of striations, probably resulting from employment in edge preparation (i.e., repeatedly dragging its surface across biface edges to improve edge angles or strengthen platforms). Five additional hammerstones display braided scratches on one or more surfaces from use in similar tasks.

Like the metate assemblage (cf. Chapter 12), hammerstones reflect exploitation of the immediate environment for raw material (cf. Schmitt 1989a). For example, most (61%) hammerstones collected from sites in the Eastern Periphery are quartzite cobbles (Figure 81); aside from opalite, informal survey of Undine Gorge and portions of Little Antelope Creek during field operations found quartzite cobbles to be common. Similarly, basalt hammerstones are most abundant at sites in the Western Periphery (Figure 81), where basalt is a common, often dominant rock type in the Bitterroot Ridge area and adjacent Basalt Canyon.

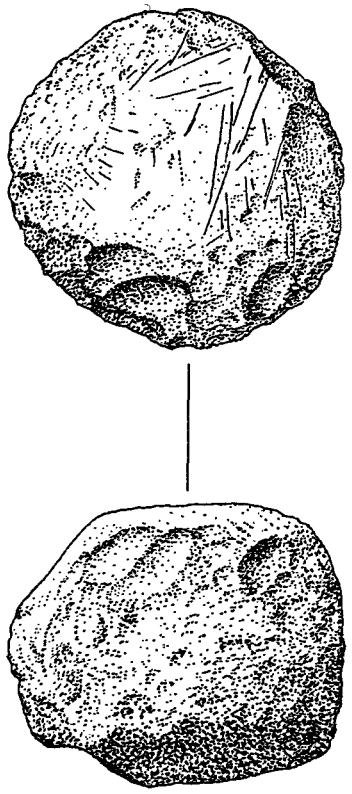


Figure 80. Shaped basalt hammerstone.

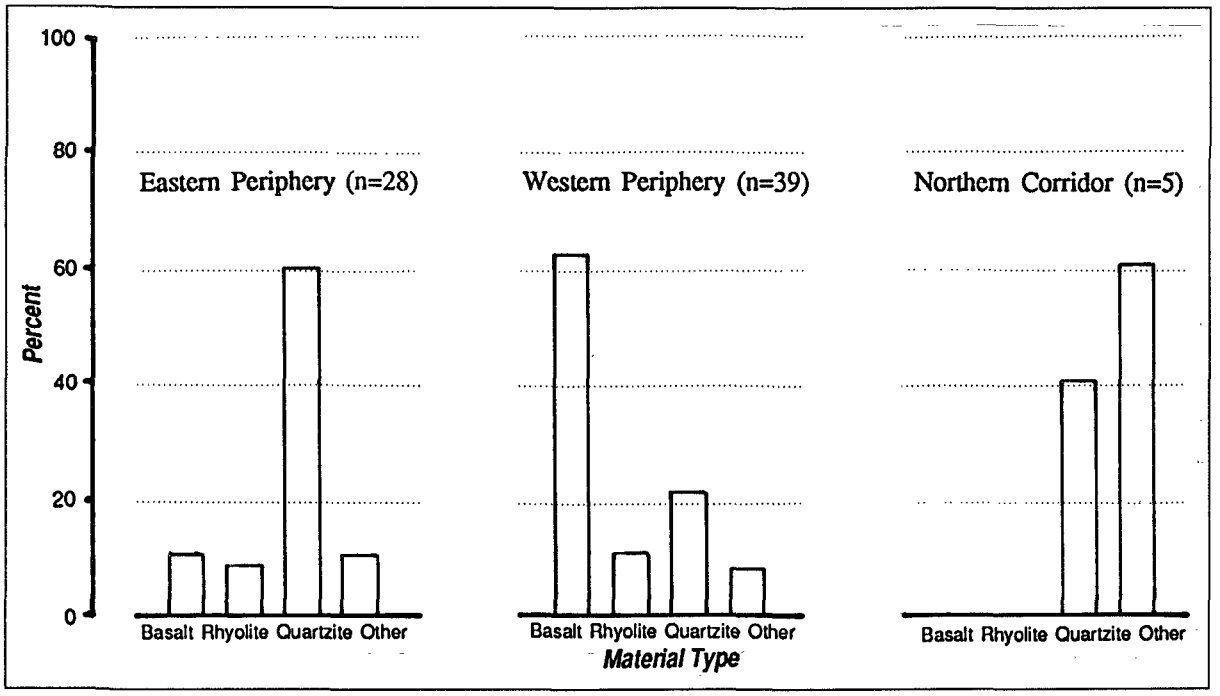


Figure 81. Percentage of hammerstone raw material type by area.

Most hammerstones on "imported" raw materials exhibit inordinate battering when compared to those manufactured on locally available materials. For example, five (63%) of the quartzite hammerstones recovered from the Western Periphery are small, easily portable (probably curated) cobbles displaying pronounced use wear as a result of multiple and extensive use episodes. Although few, those collected from sites in the Northern Corridor reflect the use of "imported" raw materials (including opalite and quartzite cobbles), most of which exhibit pronounced battering and spalling (e.g., Figure 82), also suggesting use histories perpetuated by curation.

While the inferred function of these artifacts is the reduction of toolstone, some may have been used in other percussion tasks, such as the sharpening of exhausted grinding surfaces and the processing of resistant organics (e.g., bone, plant fiber). Two hammerstones apparently were used to process pigment; both are stained with ochre. Specimen 500-331, recovered from the surface of 26Ek3237, has a pitted, crushed area central to a slightly convex surface (cf. Schmitt 1989a:Figure 19a), possibly from use as a percussor during bipolar core reduction (cf. Ahler 1986:60-63; Elston 1986b:106-109). Finally, three specimens are fire-blackened and/or cracked from use as hearth rocks.

Scratched Stone

A collection of seven scratched stones (cf. Table 98) comprises one of the more interesting artifact classes. Much like scratched hammerstones, these distinctive artifacts possess numerous, often deep, striations (cf. Figure 80) indicative of use in biface edge preparation, but they display no evidence of use in percussion tasks (e.g., battered margins).

During field operations and in the laboratory, we produced virtually identical damage on rhyolite and tabular basalt pieces by dragging surfaces across biface margins to prepare

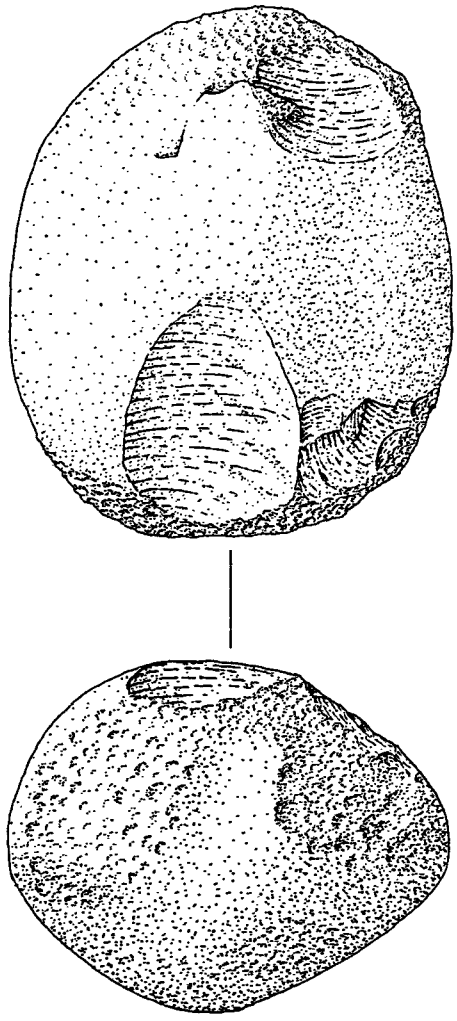


Figure 82. Quartzite hammerstone.

edge angles and platforms prior to subsequent flake removal. Initial damage consists of a series of linear striations; subsequent use produces polished facets that obscure most of the striations. These polished, faintly striated surfaces are very similar to use wear on what others have referred to as small grinding stones or palettes (e.g., Thomas and Bierwirth 1983), but further scrutiny of our specimens disclosed scratches within low (i.e., unpolished) areas of the working surface indicative of contact with a sharp, undulating surface or edge.

Three Tosawihi specimens manufactured on welded tuff unequivocally were utilized in biface edge abrasion, not for subsequent controlled flake removal due to their friability. Two rhyolitic scratched stones and one of basalt may have been employed in expedient percussion, but evidence of battering on each is disjunct and superficial, suggesting that they, also, served only in the abrasion of biface margins.

The seventh stone is a large (847.7 gm) piece of hematite possessing numerous, often pronounced scratches within a slightly concave facet. Although it may have been used as an abrader to strengthen biface margins, it probably served as a portable source of pigment.

Choppers

Excavations at eight sites yielded 16 choppers (cf. Table 98; Appendix J). The assemblage contains a variety of shapes, sizes, and raw material types (including opalite, basalt, and rhyolite), but most were manufactured on cobbles or tabular slabs easily manipulated with one hand (Figure 83). Although choppers may have been used in an array of processing tasks (including toolstone reduction), they probably were employed most frequently in processing organic materials (e.g., wood, fiber, and dried meat; cf. Elston 1986b).

Manufacturing techniques involved removal of three or more flakes (commonly unifacial) by percussion to achieve a sharp, roughly linear working edge; working edge angles vary between 48° and 68°, with a mean of 56°. Differences in working edge angles may represent purposeful modification for a specific task, or they simply may be functions of raw material type (i.e., hardness and initial morphology). Similarly, a few "shaped" specimens may be products of edge damage (i.e., spalling rather than purposeful shaping) of the naturally sharp edges of tabular pieces (Figure 84c); likewise, some may represent reuse of spalled hammerstones for expedient chopping tasks. All these implements display some degree of use wear, but attrition is most apparent on opalite choppers where extensive step fracturing is common.

Hammer-Chopper

Investigation of a quarry pit at 26Ek3208 returned a single hammer-chopper (specimen 501-1). Manufactured on a flake detached from a large basalt cobble (i.e., cortex is still present on 50% of its dorsal surface), the distal end and lateral margins have been flaked bifacially (edge angles range between 28 and 40°) to achieve an oval/spatulate outline for employment in chopping and/or digging tasks, probably to excavate soft tuff layers between lenses of opalite to isolate toolstone. Its proximal end is blunt and extensively battered indicating that it served as a hammer as well.

Shovels

The morphology of three unifacially flaked tabular pieces suggests that they served as shovels; two were collected in association with quarry pits and one from a reduction/ residential locus on Bitterroot Ridge. The context of the former specimens suggests they were employed in quarrying; their uses probably included excavation and removal of tuff and other non-siliceous

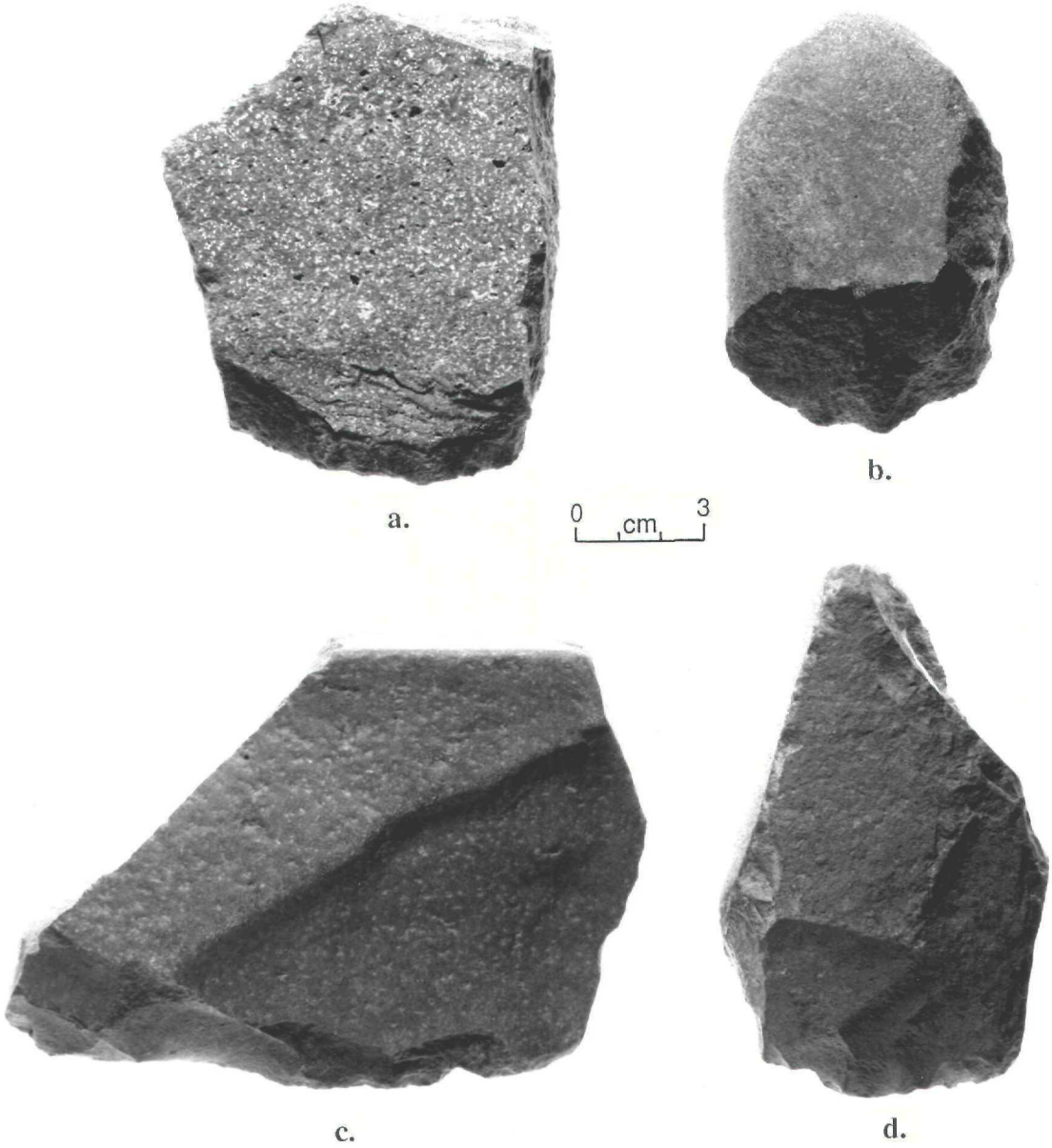


Figure 83. Selected choppers.

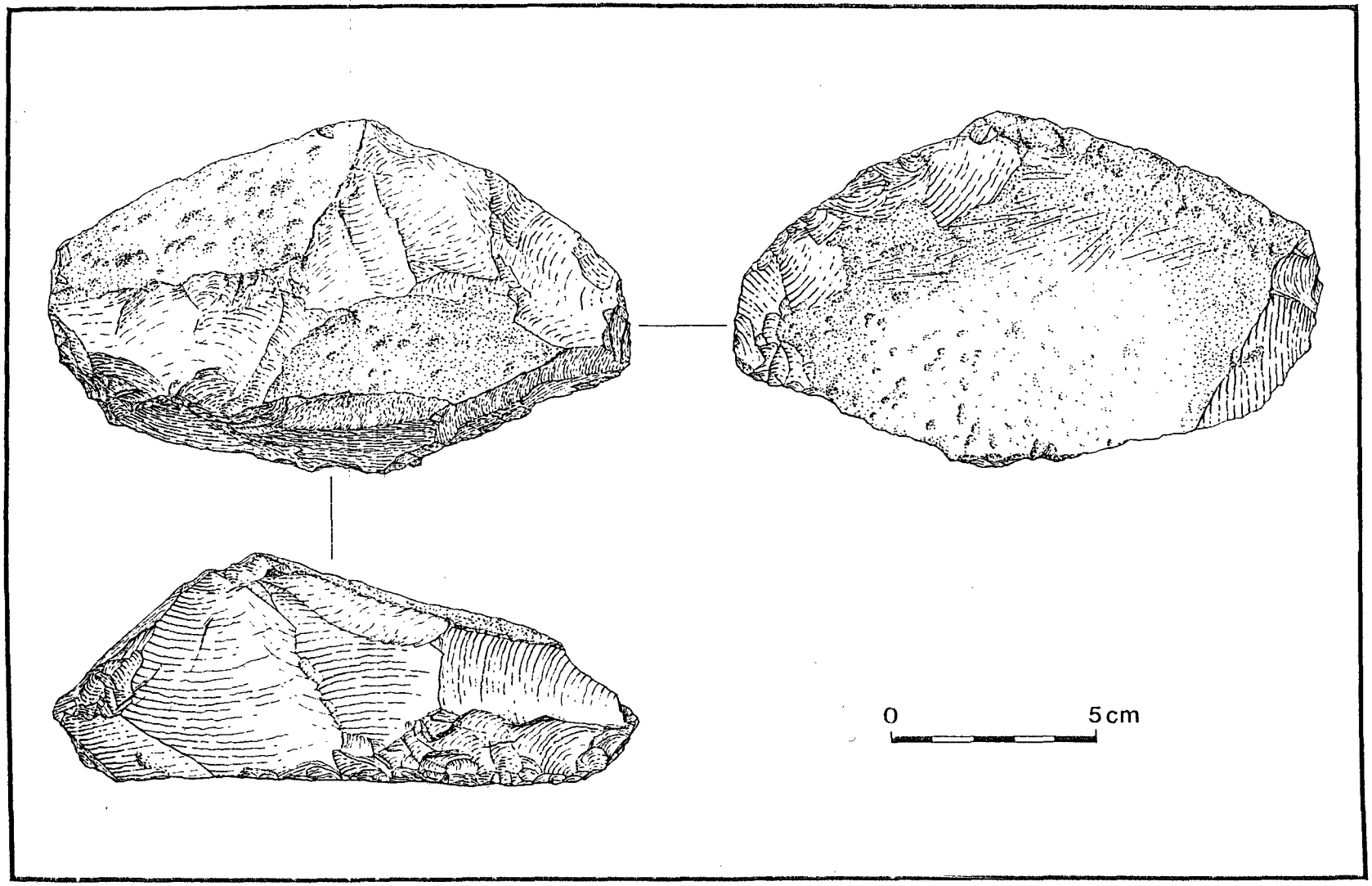


Figure 84. Basalt scraper plane.

debris, and served as "dust pans" in removal of hash and waste flakes. Although they might also have been utilized in the extraction of toolstone, minimal edge damage suggests less rigorous tasks.

One specimen is a large tabular piece of basalt exhibiting manufacture and light edge damage along 30 cm of one margin. The artifact may have served as a quarrying tool, but its provenience, large size, and overall morphology suggest it functioned as a digging tool for non-quarrying activities (e.g., soil excavation).

Scraper Planes

Three nearly identical specimens collected from 26Ek3160 (cf. Appendix J) and a larger, dome shaped specimen collected from the surface of 26Ek3170 share sufficient morphological characteristics that they constitute a separate artifact class. Each of the 26Ek3160 specimens is triangular in cross section and exhibits purposeful decortication on two or more surfaces to create sharp edges (cf. Figure 84). Further flake removal along these edges is reflected by small flake scars and step fractures that resulted from scraping and/or battering tasks. Two specimens display large polished and striated areas on their flat ("bottom") surfaces and adjacent flaked margins (cf. Figure 84); lateral edge damage and polished lower surfaces suggest these artifacts were pushed across another surface (after Thomas and Bierwirth 1983:229).

Although functionally ambiguous, these artifacts may have been used in a number of tasks, including the processing of dried meat and vegetal materials, and the sharpening of exhausted grinding surfaces (cf. Kowta 1969 and references therein). Scraper planes are often abundant in certain southern California sites where they were utilized in the processing of agave and yucca (e.g., Kowta 1969; Salls 1985). Based on the context of the Tosawihi specimens (most are from Bitterroot Ridge), these artifacts may have been utilized in the processing of bitterroot or other tubers; their polished surfaces resulted from abrasion against a hard grinding surface. In the Great Basin, Thomas and Bierwirth (1983:226-229) report similar artifacts at Gatecliff Shelter.

Discussion

Whether associated with single-episode reduction stations, extensive quarry pit complexes, or residential loci, percussion and processing cobble tools were encountered throughout the Tosawihi Quarries vicinity; their abundance is predictable in and near the quarries. While hammerstone frequencies at some quarry pit localities are seemingly low (e.g., site 26Ek3200), this may be a product of data recovery strategies; most such sites were investigated by backhoe trench excavations and subsequent stratigraphic documentation rather than by large scale systematic collection; a number of hammerstones (including "throw-stones"), however, were observed in quarry pit stratigraphic profiles. Conversely, some reduction and/or residential loci returned numerous hammerstones, due probably, in part, to extensive horizontal and vertical excavations (cf. especially site 26Ek3092; Table 98; Chapter 16).

The assemblages also contain choppers and scraper planes used in the processing of resistant organics, and additional toolstone processing and extraction tools, including shovels, a multifunctional hammer-chopper, and scratched stones used to abrade biface margins. A number of hammerstones possess striated surfaces from use in similar tasks, but their battered margins indicate they remained in the knapper's grip for subsequent flake detachment.

Although a few of the hammerstones display evidence of purposeful shaping, most are ovate cobbles that can be held comfortably and controlled with one hand. Variations in overall

morphology and use wear suggest some were collected on or near- site for use in an expedient task, but acquisition of most, especially the quartzite specimens (cf. Figure 82), probably involved extended search time for cobbles possessing the desirable shape, size, and weight. The wealth of simple percussion cobble tools in the quarries, and the multitude of elegant opalitic bifaces and tools they produced, dramatically reflects the persistence and functional utility of the class.

Chapter 12

GROUND STONE

Dave N. Schmitt

Archaeological excavations in and adjacent the Tosawihi Quarries returned 127 ground stone artifacts (Table 99). Although some specimens appear to have been employed in two or more tasks and the function of a few others remains ambiguous, assemblage components can be segregated into seven analytic categories: manos, metates, mortars, pestles, abraders, shaft abraders/smoothers, and other modified stone (e.g., beads and pipes). Combining materials collected from initial testing and subsequent excavations, this chapter focuses only on the 108 ground stone artifacts recovered from sites subject to data recovery (cf. Table 99); attributes of ground stone from all Tosawihi sites are presented in Appendix K, but discussions of specimens recovered from sites subject only to testing are presented elsewhere (Schmitt 1989a).

Table 99. Ground Stone Artifacts by Site.

Site* (Locality)	Manos	Metates	Mortars	Pestles	Abraders	Shaft Abraders	Beads	Misc. Ornaments	Pipes	Total
3032 (19)	-	1	-	-	-	-	-	-	-	1
3032 (93)	-	1	-	-	-	-	-	-	-	1
3092	-	7	1	-	1	-	-	-	-	9
3095	1	11	-	1	1	2	13	-	1	30
3096**	1	-	-	-	-	-	-	-	-	1
3106**	-	1	-	-	-	-	-	-	-	1
3149**	1	1	-	-	-	-	-	-	-	2
3160	3	9	4	2	-	1	-	1	-	20
3165	-	4	-	-	-	-	-	-	-	4
3170	1	1	-	-	-	-	-	-	-	2
3171	1	-	-	-	-	-	-	-	-	1
3181**	1	-	-	-	-	-	-	-	-	1
3184	1	-	-	-	-	1	-	-	1	3
3185**	1	-	-	-	-	-	-	-	-	1
3190**	-	1	-	-	1	-	-	-	-	2
3192	2	5	-	-	-	-	-	-	1	8
3196**	-	1	-	-	-	-	-	-	-	1
3198	-	-	-	-	-	1	-	-	-	1
3201**	1	1	-	-	-	-	-	-	-	2
3204	1	-	-	-	-	-	-	-	-	1
3228**	-	1	-	-	-	-	-	-	-	1
3237	-	8	-	-	-	-	-	1	-	9
3238**	-	1	-	-	-	-	-	-	-	1
3251	6	11	-	-	1	-	-	-	-	18
3271**	2	2	1	1	-	-	-	-	-	6
Total	23	67	6	4	4	5	13	2	3	127

* 26Ek prefix omitted
** Materials recovered from tested sites (cf. Schmitt 1989a)

Each specimen was assigned to an analytic category on the basis of gross morphology, ethnographic observations, and comparison with other Great Basin archaeological assemblages. Documentation of each artifact included provenience, raw material type, degree of use wear, dimensions, and completeness; these and additional attributes are presented in Appendix K. When possible, fragmented artifacts were reconstructed.

Manos

A total of 16 manos was recovered from data recovery at eight sites (cf. Table 99; Appendix K). Eight are unifacial, four are shaped and bifacial, and four are unshaped handstones reflecting the expedient use of small cobbles (e.g., Figure 85a). Shaped manos (12-1b-d) are commonly ovoid to sub-rectangular (i.e., "breadloaf;" Kramer and Thomas 1983b:234-235), possess slightly convex working surfaces, and have a mean thickness of 4.2 cm. Most of the shaped manos (n=8, 67%) exhibit light use wear, but some display rather extensive surface fatigue.

Additional to the commonly inferred function of manos (processing/milling of seeds and nuts), some handstones may have been used to process animal hides or wood (cf. Adams 1989). While Tosawihi manos may have been so employed, the only clear evidence of such use is revealed by battering, staining, and fire alteration. Three manos have battered ends and/or margins suggesting percussive use; damage probably accrued while resharpening other grinding surfaces (e.g., pecking a metate), pounding roots, bone and/or dried meat, or from use as hammerstones in lithic reduction.

One mano, shaped and unifacially utilized, bears ochre staining on its working surface and along one margin, suggesting pigment processing or manufacture (cf. Drews 1986; Juell 1990; Kramer and Thomas 1983). Finally, four manos are fire-blackened and cracked, suggesting re-use for lining roasting pits and/or hearths.

Metates

Represented largely by specimens displaying unifacial use wear (n=47, 84%), 58 metates were recovered (cf. Table 99; Appendix K). While most are fragmentary (n=51) and a few may represent palettes (e.g., Juell 1987a:68-72; Kramer and Thomas 1983b:238), all are classified here as metates.

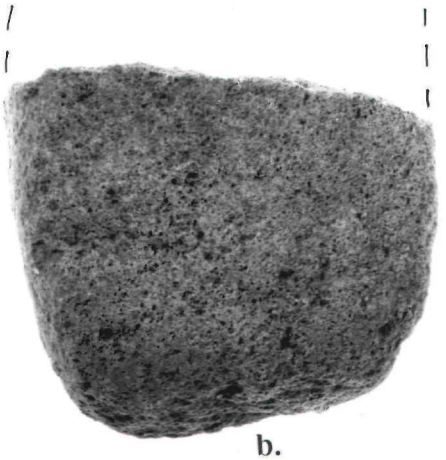
The assemblage contains both thin, "portable" tabular specimens (often exhibiting pronounced surface fatigue; cf. Figure 86), and thick, heavy boulder types (compare, for example, attributes of specimens 26Ek3095-1002-7 and Locality 93-01-1 in Appendix K, respectively). Fourteen specimens were shaped by percussion, mostly (n=9) to achieve an oval outline (cf. Steward 1941:325). Not surprisingly, most shaped metates (n=10, 71%) are portable (curated?) tabular types (thickness range = 1.2 - 3.3 mm, mean = 2.5 mm) recovered from sites containing residential toolkits.

Although raw material types vary, stone utilized as metates reflects locally available rocks (cf. Schmitt 1989a). In the Western Periphery, for example, especially along Bitterroot Ridge and its vicinity, exposures of exfoliated tabular basalt are abundant. Although basalt metates were found elsewhere, this rock type was favored in the Western Periphery (Figure 87). Similarly, rhyolite outcrops are common in the Northern Corridor (especially in and adjacent Perron Canyon), and metates in this region reflect local raw material (Figure 87).

Six metates displaying multiple, parallel use wear striations were recovered from three sites. While linear striae probably were produced during seed grinding (i.e., stone-against-stone abrasion), deep striae truncating superficial use wear on two specimens suggest use as cutting slabs as well (cf. Juell 1990).

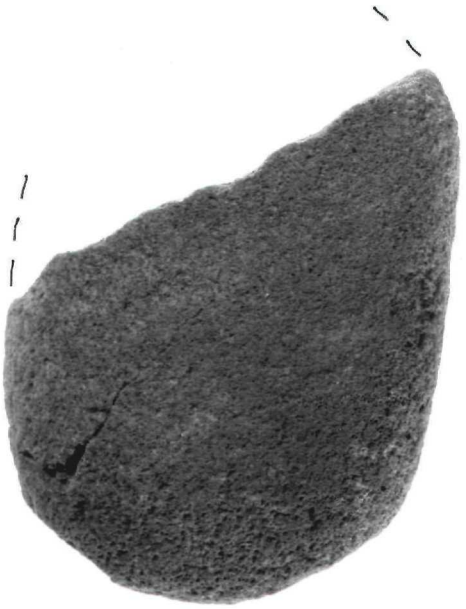
Ochre-stained, fragmented, and fire-blackened specimens evidence use other than food processing (cf. Schmitt 1989a for additional examples at Tosawihi). One item bears red ochre residues suggesting pigment manufacture, probably in addition to food processing. At 26Ek3095,

a.



b.

c.



d.

Figure 85. Selected manos.

Figure 86. Tabular shaped, resharpened metate.

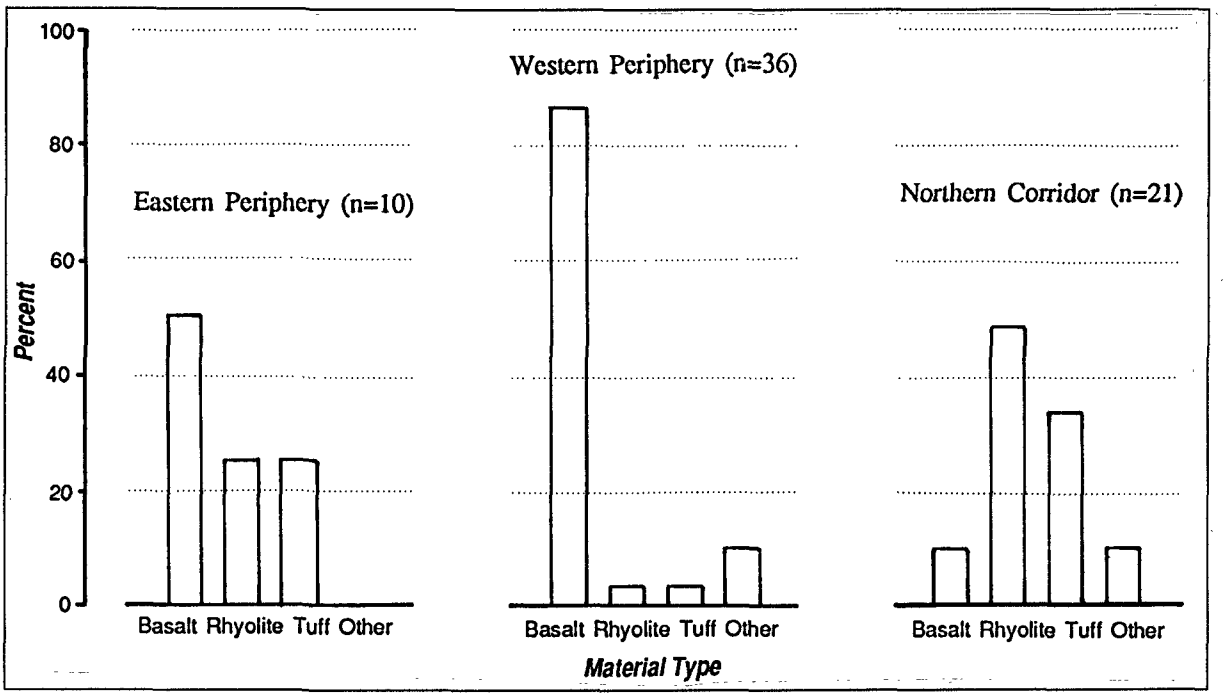


Figure 87. Metate raw material types by area at Tosawihi.

fragments of a single brecciated ignimbrite metate (comprised of macroscopic crystals of quartz, feldspar, and biotite in a glassy matrix [cf. Prinz et al. 1977:349]) were recovered from Features 15 and 19, ca. 25 m apart. Context suggests that fragments of a broken metate were scavenged from Feature 15 for use as boiling stones/hearth rocks by the later inhabitants of Feature 19, where numerous angular fragments were found in association with an ashy hearth-like feature (Budy 1989:231-232). The ignimbrite rock of which this artifact is made is highly distinctive; its source has been identified as an outcrop approximately 3 km east of the site (Mark Bartlett, personal communication).

Finally, also at 26Ek3095, neighboring Features 24 and 25 each yielded single conjoining fragments of a basalt metate; these features are only 5 m apart, suggesting transport via natural processes (e.g., slope wash) rather than human intervention.

Mortars

Five incipient basalt mortars were found at two sites in the western periphery (cf. Table 99; Appendix K). Two complete mortars and two mortar fragments were collected at 26Ek3160, two as extra-feature surface isolates and one each from Features 19 and 23. Specimen 26Ek3160-519-8 is manufactured on a large (6.4 kg) basalt cobble. The artifact exhibits a circular, blackened, slightly polished facet (diameter = 6.5 cm) central to its planar surface. Although fragmented, specimen 26Ek3160-523-14 displays a similar, centrally worn area (diameter ca. 6.0 cm) on a slightly concave surface. The two remaining specimens exhibit similar use wear zones, each approximately 6.5 cm in diameter, centered on a slightly concave surface. Non-feature excavations in Unit 12, 26Ek3092 also yielded a large (13.6 kg) incipient mortar. Similar to specimens at 26Ek3160, the artifact exhibits a polished, circular facet, ca. 6.5 cm in diameter, central to a slightly concave surface, partially truncated by battering.

Although these artifacts probably were used in conjunction with pestles (and possibly hopper baskets) to process plant foods including bitterroot and other tubers, each also may have functioned as metate and/or anvil. Steward (1941:235) notes that "a few small mortars, adopted by the (Snake River) Shoshone from the Plateau or Northwest, were used only by toothless old people to grind their food."

Pestles

Three pestles were recovered on Bitterroot Ridge in the Western Periphery. One (Figure 88a) consists of two refitted pieces encountered ca. 20 meters apart. It is oval in cross section, battered (spalled) and lightly polished on each end, and exhibits overall polish and striations perpendicular to its long axis; these latter modifications appear to be the result of manufacturing techniques (e.g., shaping by transverse abrasion) rather than of use wear. Specimen 26Ek3160-01-208 (Figure 88b) is a complete pestle (subrectangular in cross section) with a slightly polished and battered distal (working) end, suggesting use with a stone mortar. The artifact shows no distinct evidence of shaping and may represent the expedient use of an elongated basalt cobble.

The remaining pestle is an end fragment (oval in cross section and subrectangular in plan outline) displaying superficial polish and spalling from use.

Abraders

Three artifacts were classified as abraders (cf. Appendix K). One has been modified extensively to a rectangular shape, and exhibits further modification in overall polish and faint striations from use wear; it probably was employed in the finishing stages of bone or wood tool manufacture (e.g., awls, needles). Similarly, specimen 26Ek3095-6381-4 is shaped overall and exhibits use wear polish and striations along one edge and on one surface; it, too, possesses a lightly polished trough on one end (1.3 cm in width) which may have been used to finish/resharpen pointed organic artifacts (e.g., bone awls). Both artifacts are small and can be employed easily using thumb and two or three fingers.

Surface collections at Feature 6, 26Ek3251 returned a rhyolitic cobble with a single abraded edge. The facet displays rather extensive polish and multiple, parallel striations, probably from working wood and/or bone, or processing animal hides (cf. Adams 1989). Kuffner (1982) reports similar artifacts collected from Rossi Mine sites.

Shaft Abraders/Smoothers

Five shaft abraders/smoothers were recovered from four sites (cf. Table 99; Appendix K). Four are manufactured on sandstone and one on a piece of coarse-grained welded tuff. Groove width/diameters are similar, ranging between 7.1 mm and 8.0 mm (mean = 7.6 mm). These artifacts probably were employed to smooth arrow mainshafts, but may have been used in the manufacture of bone awls.

At 26Ek3095, two shaft abraders were recovered from Features 15 and 19; each is manufactured on sandstone and possesses one linear trough. The specimen from Feature 15 is interesting in that it retains manufacture marks (i.e., pecking) in the groove, suggesting

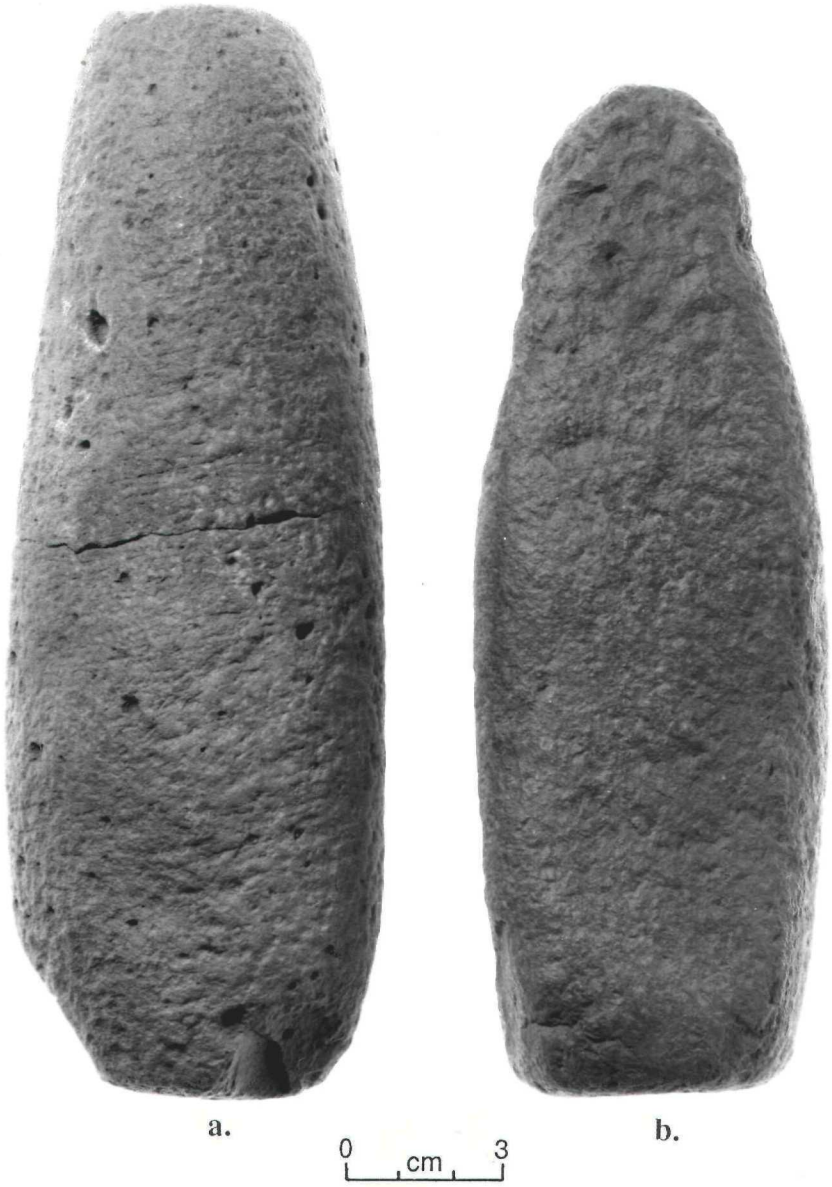


Figure 88. Selected pestles.

minimal use (Figure 89a). While the other four specimens represent single artifacts, this groove, manufactured on a flat surface, may represent half of a paired abrader (cf. Flenniken and Ozbun 1988). Specimen 1002-7 (Feature 19) was found in association with two Desert Side-notched projectile points, suggesting post A.D. 1300 manufacture/use.

Surface collections at Feature 3, 26Ek3184, recovered a sandstone shaft abrader associated with a Cottonwood projectile point. The abrader possesses three linear troughs on one surface, two of which intersect near the middle of the working surface to form an "X", with the third offset to one side. Specimen 26Ek3198-1003-1 is a small rectangular piece of sandstone with shallow, linear troughs truncating each of its four flat surfaces (Figure 89b); associated diagnostic projectile points include four Desert Series specimens. Finally, specimen 26Ek3160-515-1, an ovate shaft abrader/smoother exhibiting one groove (Figure 89c), is similar to one recovered from Horizon 3 (A.D. 700 - ca. A.D. 1300) at Gatecliff Shelter (cf. Kramer and Thomas 1983:Figure 105; Thomas 1983b:491-492).

Most of the Tosawihi shaft abraders are associated with Desert Series points. Although they appear to have been used prior to the introduction of the bow and arrow (i.e., pre-A.D. 500; see, for example, Aikens 1970:28-29, 67-69), stratigraphically provenienced specimens from selected northern and central Great Basin sites suggest that they flourished after ca. A.D. 500 (Figure 90).

Other Modified Stone

The remainder of the ground stone assemblage consists of extensively shaped, "exotic" specimens, including 13 tuff beads, two ornamental (?) objects, and three cylindrical stone fragments representing various stages of pipe manufacture.

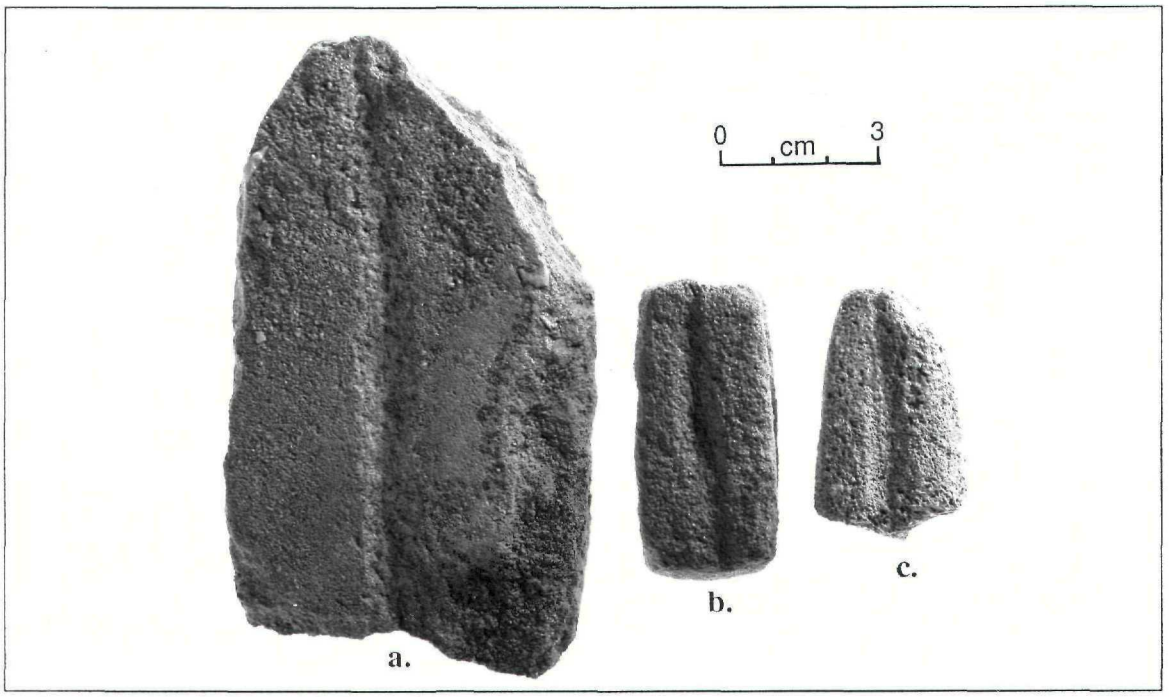


Figure 89. Selected shaft abraders/smoothers.

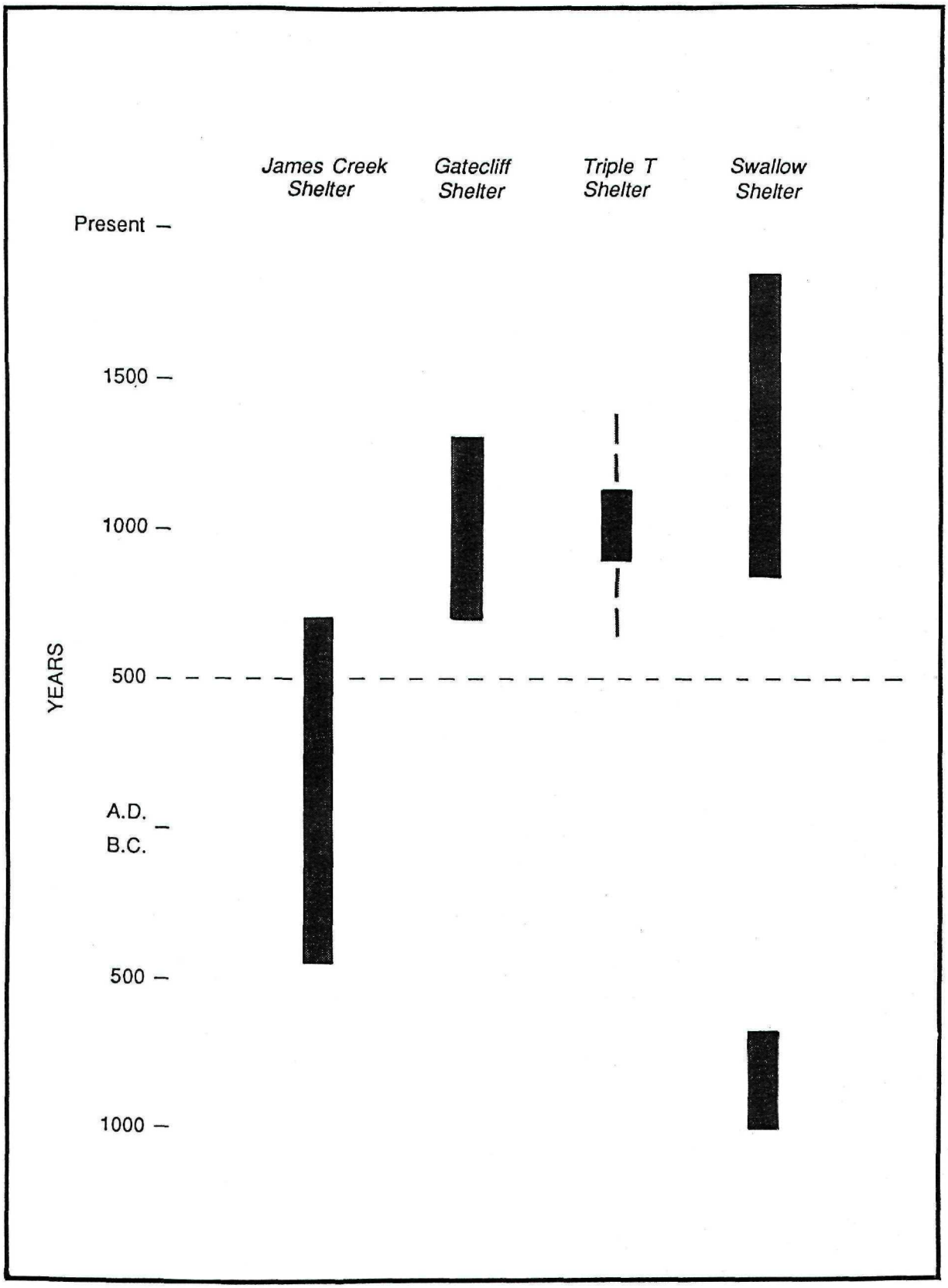


Figure 90. Chronological distribution of shaft abraders/smoothers at selected Great Basin sites (compiled from Elston and Budy 1990; Thomas 1983; Thomas and Kelly 1988; Dalley 1976).

Beads

Excavations at Features 19 and 22, 26Ek3095, yielded eight tuff beads and five bead preforms (Table 100; Figure 91). The raw material of their manufacture is a weathering, friable tuff (much like blackboard chalk), commonly possessing an off-white interior with a weathered pink outer surface. Both the complete beads and preforms display multiple (often random) striations from limation against a slightly abrasive surface, and each of the finished (i.e., perforated) specimens bears evidence of biconical drilling. The recovery of these unique beads and preforms suggests contemporaneous occupation of the neighboring features sometime after A.D. 1300, a date signaled by a Desert Side-notched point at Feature 19.

Table 100. Provenience and Attributes of Tuff Beads and Bead Preforms, 26Ek3095.

			mm				
Spec. No.	Fea.	Unit	Length	Width	Thick.	Figure	Type
6381-5	19	24	11.7	10.6	1.4	12.7g	Complete
6381-6	19	24	13.7	9.0	1.9	-	Fragment
6381-7	19	24	12.9	8.5	2.2	12.7e	Fragment
9381-4	19	24	5.1	6.6	1.4	-	Fragment
6221-1-1	22	16	11.6	8.8	5.9	12.7a	Preform
6221-1-2	22	16	15.4	11.1	9.5	-	Preform
6221-1-3	22	16	10.5	6.3	1.8	-	Fragment
6241-7	22	17	11.8	9.9	2.0	12.7h	Complete
6241-8	22	17	10.7	10.3	1.8	12.7c	Preform
6281-4-1	22	19	8.8	11.3	1.9	12.7f	Fragment
6281-4-2	22	19	10.3	7.5	3.0	-	Fragment
6301-1	22	20	13.2	12.6	2.5	12.7b	Preform
6302-1	22	20	9.6	9.1	2.5	12.7d	Preform

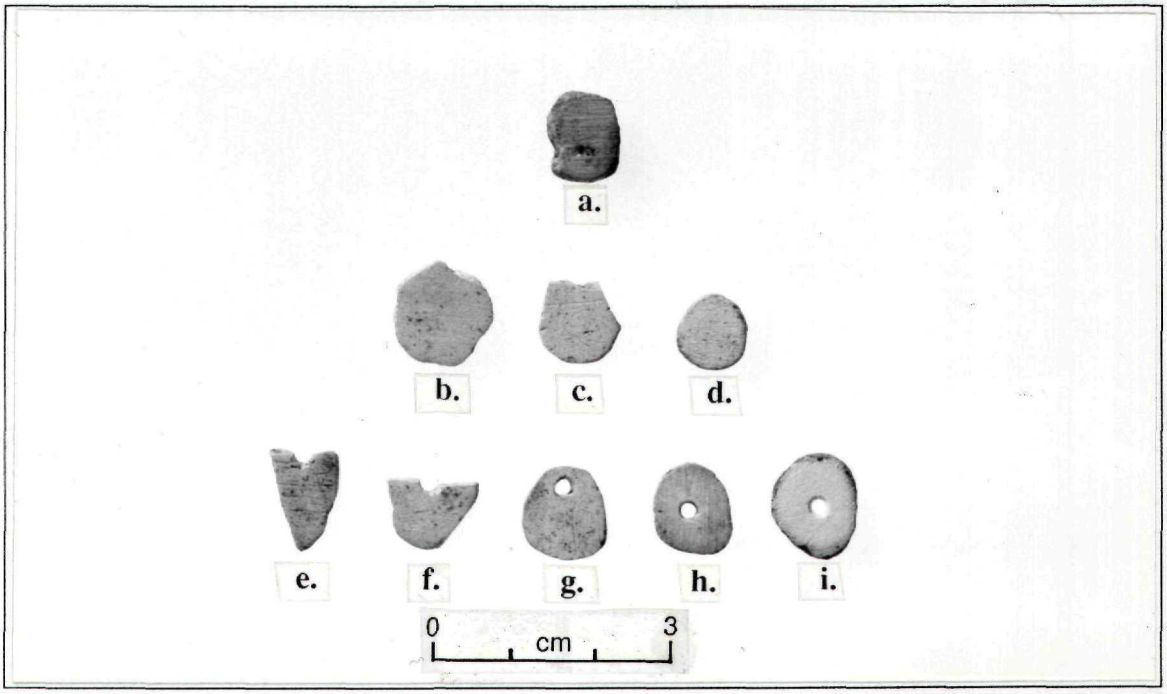


Figure 91. Selected tuff beads and preforms, 26Ek3095 (cf. Table 100). Specimen *i* was manufactured on-site by the author.

Additionally, numerous small, pink tuff nodules were retrieved from Feature 22. In an attempt to replicate the recovered ornaments, I manufactured a bead from one of these nodules by bifacially reducing (i.e., thinning) its surfaces with abrasion against a small basalt slab. I perforated the uniformly thinned disc biconically with a thin, elongated opalite flake (total manufacture time ca. four minutes); the result was a bead very similar to those recovered from the archaeological deposits (cf. Figure 91). Clearly, the archaeological recovery of unfinished beads and bead preforms suggests that such beads were manufactured on-site.

Ornaments

Non-feature surface collections at 26Ek3160 yielded a fragment of an incised tuff disc (Figure 92a). The artifact bears evidence of numerous attempts to perforate its center biconically (i.e., three drilled pits truncate one surface and four the other), one of which succeeded in creating an aperture 6.5 mm in diameter. Numerous decorative linear striae are present on one surface, creating a "sunburst" pattern radiating from the perforation. The artifact is 17 mm thick, weighs 18.7 gms, and its estimated (complete) outer diameter is ca. 80 mm.

Similar artifacts, manufactured on a variety of material (including stone, baked clay, and pitch), have been found in numerous Great Basin sites, particularly along the western and eastern margins (e.g., Drews and Schmitt 1986; Hattori 1982; Heizer 1974; Hull and White 1980; Pendleton 1985b). These artifacts are functionally enigmatic, but may have been used as pendants, charms, transits, and/or spindle whorls employed in the manufacture of cordage (cf. Tuohy 1986a). In the eastern Great Basin, stone and ceramic discs have been found in Fremont contexts dating from about A.D. 500 - 1300 (Tuohy 1986a:237).

Specimen 2142-1 was retrieved from subsurface deposits immediately adjacent a hearth at 26Ek3237. The artifact possesses a scored neck near one end (neck diameter = 12.7 mm) truncating an otherwise unmodified chalcedony nodule (Figure 92b). This puzzling artifact probably served as an ornament/effigy, but might have been utilized in fishing (e.g., a net sinker or lure weight). It weighs 11.2 gm and has a maximum diameter of 21.8 mm.

Pipes

Two fragmented smoking pipes and an unfinished pipe were collected. Excavations at Feature 19, 26Ek3095, retrieved a shaped tuff cylinder with a small pit in one end (maximum diameter = 8.4 mm; Figure 92c); the opposite end is truncated. This fragment probably represents a pipe preform that broke early in manufacture; two apparently associated Desert Side-notched points suggest that the event occurred after A.D 1300.

Specimen 26Ek3195-502-10 is a schist pipe in several fragments (outer diameter = 22 mm; reconstructed in Figure 92d) exhibiting multiple, longitudinal manufacture striations within its aperture. The external surface is decorated; deep, isolated striations circumscribe its short axis. The aperture is flared at one end, tapering gradually to a smaller opening at the other, a trait characteristic of ethnographic Shoshone pipes illustrated by Steward (1941: Figure 4 c-d).

A small pipe (stem?) fragment was recovered from excavations at Feature 2, 26Ek3184 (Figure 92e). Manufactured on a piece of welded tuff, the artifact possesses a small ridge adjacent to its aperture on one end, indicating that it had been scored around its circumference and then snapped from a larger cylindrical segment, a technique commonly employed in the manufacture of bone beads (cf. Aikens 1970; Schmitt 1990). Its internal surface is blackened from use and its estimated outer diameter is 18 mm.

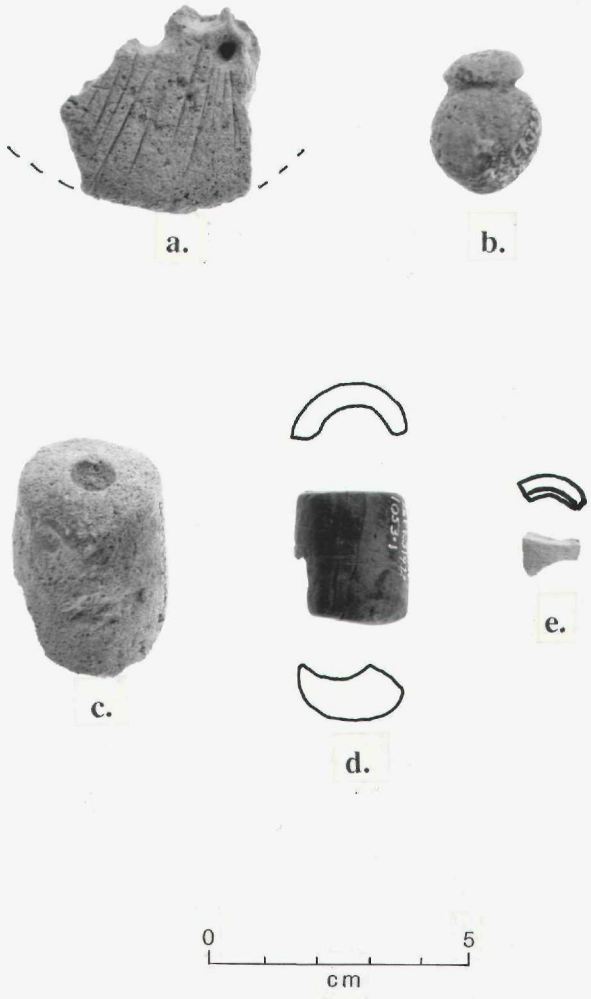


Figure 92. Ornaments (a-b) and pipes (c-e).

Although infrequently, complete pipes, pipe fragments, and pipe preforms have been recovered from archaeological sites throughout the Great Basin, including single specimens retrieved from James Creek Shelter (Horizon II-III; A.D. 700 - 1300; Juell 1990; Budy and Katzer 1990) and Gatecliff Shelter (Horizon 4; 1250 B.C. - A.D. 700; Kramer and Thomas 1983:236; Thomas 1983b). Budy (1987) reports an elaborate stone pipe from Panaca Summit.

Discussion

The presence of metates and other grinding implements at Tosawihi clearly attests the coincidence of subsistence resource processing and toolstone acquisition and reduction. Although ground stone assemblages at most sites are small and commonly display only superficial use wear (cf. Table 99; Appendix K; also cf. Schmitt 1989a), the abundance of ground stone in association with multifunctional toolkits at some of the larger sites supports inferred residential use, *especially at 26Ek3095, 26Ek3160, and at 26Ek3251 where differences in morphology and* raw material types indicate at least nine different metates are represented.

To quantify the relative role of these assemblages at Tosawihi, Table 101 presents projectile point to milling tool ratios for five selected Great Basin sites and three Tosawihi sites containing abundant ground stone associated with multifunctional toolkits. Although occupational intensity of the former sites was variable through time, each contained ample evidence of campsite use, including the presence of hearths, butchered and burned artiodactyl bone, and/or expedient brush shelters (Aikens 1970; Dalley 1976; Elston and Budy 1990; Rusco et al. 1979; Thomas 1983b). The ratios of "hunting versus gathering" assemblages at these sites and those at Tosawihi are markedly similar, suggesting that the Tosawihi sites sometimes served as campsites and/or short-term base camps.

Table 101. Projectile Point to Mano/Metate Ratios at Selected Great Basin Sites.

Sites	Projectile Points	Manos and Metates	Ratio
Hogup Cave	648	319	2:1
Swallow Shelter	279	21	13:1
James Creek Shelter	194	44	4:1
Maggie Creek (Ek1670)	18	37	.5:1
Gatecliff Shelter	561	158	4:1
26Ek3095	33	12	3:1
26Ek3160	58	12	5:1
26Ek3251	40	17	2:1

At Features 15 and 19, site 26Ek3095, evidence of metate scavenging and reuse by later site occupants is quite clear. Although direct testimony of similar activities at other Tosawihi sites was not identified, most sites contain ample evidence of multiple occupations (often spanning up to four millennia), and one must suspect that the scavenging and use/reuse of toolstone and ground stone was quite common (cf. Simms 1983).

Chapter 13

CERAMICS

Dave N. Schmitt

Fragmentary ceramics occur frequently in some regional Great Basin assemblages. While basic attributes (wall thickness, color, morphology, composition) usually suffice to classify sherds to the level of *type* (e.g., Shoshone Brownware, Fremont Grayware), *varietal* classification often is beyond reach. This is the case with our modest Tosawihi assemblage. The present chapter, then, while it offers some typological classifications and chronological inferences, focuses more on provenience, raw material identification, and production techniques (cf. Griset 1986:122).

We collected 242 ceramic sherds from nine Tosawihi sites. In the Western Periphery, 26Ek3092 and 26Ek3160 yielded 60 and 61 sherds, respectively, and 26Ek3239 and 26Ek3251 in the Northern Corridor each returned two specimens. From five sites in the Eastern Periphery we recovered 117 sherds, most (102) collected from Features 1 and 2 at 26Ek3192. Fremont Grayware and Shoshone Brownware overwhelmingly dominate all Tosawihi assemblages; only six sherds defy classification.

Analytic Methods

Sherds were sorted by vessel on the basis of thickness, color, and provenience, supplemented, where possible, by refitting to confirm single vessels of origin. Ceramics were described and classified by color, decorative technique and style, manufacture technique, and wall thickness (cf. Juell 1987b). Temper initially was identified by examining freshly broken edges under 25-30x magnification. Provenience, color, thickness, and preliminary observation of temper constituents contributed to the selection of 10 sherds for petrographic analysis (Table 102); in some instances, results of thin-section analysis assisted typological classification and the assignment of fragments to individual vessels.

Table 102. Results of Petrographic Thin-section Analysis of Selected Sherds.

	Ref.				RAW MATERIALS						PASTE	TEMPER COMPOSITION (%)						
Site No.	No.	Unit	Level	Fea.	A	Q	B	S	T	C	% Clay	F	Q	P	A	T	M	Type
26Ek3092	6041	6	1	-	+	-	-	-	-	-	40	20	5	10	15	-	-	B
	6243	16	3	-	-	+	-	-	-	-	80	~8	~10	-	-	-	-	(G)
	6285	18	2	-	+	+	-	-	-	-	50	16	12	5	5	-	-	B
	8285	18	2	21	-	+	-	+	-	-	70	5	>20	1	1	-	-	(G)
	6582	33	2	-	+	+	+	-	-	-	45	30	~25	<1	<1	-	-	B
26Ek3160	1013	13	S	1	+	-	-	-	+	-	50	15	5	12	10	-	-	B
26Ek3192	6201	26	1	2	-	+	+	-	+	-	60	>20	5	5	5	-	-	B
	6600	46	S	1	-	+	+	-	+	-	60	20	5	5	5	-	-	B
26Ek3198	509	-	S	9	+	-	-	-	-	-	45	25	10	10	10	~1	<1	?
26Ek3251	3006	-	S	6	+	-	-	-	+	+	40	25	7	12	5	-	<1	B

Key:

Level	RAW MATERIALS (clay and temper)	TEMPER	Type
S = Surface	A = Andesite	F = Feldspars	B = Brownware
1 = S-10 cm	Q = Quartzite	Q = Quartz	G = Grayware
2 = 10-20 cm	B = Basalt	P = Pyroxene	? = Indeterminate
3 = 20-30 cm	S = Schist	A = Amphibole	( )= Corrugated
	T = Welded Tuff	T = Magnetite	
	C = Chert	M = Mica	

Following definitions advanced by R. Madsen (1977), Fremont Graywares were identified by temper and mineral inclusions added to the paste, as well as color, wall thickness, and overall morphology; tentative identification of graywares as the Great Salt Lake Gray Fremont variant is based largely on the proximity of the Tosawihi Quarries to this Fremont core area (cf. D. Madsen 1986:Figure 4; Marwitt 1970:Figure 84). Shoshone Brownwares were classified on the basis of surface color, wall thickness, surface manipulation, and temper (cf. D. Madsen 1986; Tuohy 1986b).

Brownware

Surface collections and excavations at six sites returned Shoshone Brownware (or "Shoshone ware;" cf. Thomas 1988:225 and references therein) sherds representing at least eight fragmentary vessels (Table 103). Two vessels were identified in the "boulder" activity area of 26Ek3092, one north of the boulder in Units 33 and 36, and one in Unit 18 (cf. Table 103 and Chapter 16). The northernmost sherds (n=7) are composed of fine to very coarse (ca. 7 mm) andesitic/basaltic and quartzite clay and temper; large shrinkage cracks surround the coarse temper particles, probably resulting from differences in thermal expansion rates of quartzite and andesites/basalts. The temper particles are parallel to the well laminated clays, suggesting that the vessels were shaped by coiling. All sherds lay immediately above a fire hearth (Feature 9) which returned radiocarbon dates of 650 ± 50 B.P. and 750 ± 70 B.P. (ca. A.D. 1250).

Excavations south of the boulder at 26Ek3092 recovered two Brownware sherds in Unit 18 (Table 103; cf. Figure 112); they are composed of andesite and quartzite particles, both water worn. The andesite clays and temper were ground prior to vessel formation; most of the quartzite appears unground. Although there is no detectable lamination of the clay to suggest coiling, both fragments are very small, precluding reliable inferences of manufacturing technique.

Table 103. Provenience and Attributes of Tosawihi Vessels by Site.
All measurements are in millimeters.

Site No.	Unit(s)	Depth (cm B.S.)	Fea.	No. Sherds	WALL THICKNESS Range	Mean	Coiled	Type*
26Ek3092	6,7,9	0-10	-	5	4.2 - 6.0	5.4	+	B
26Ek3092	18	10-20	-	2	5.9 - 6.7	6.3	-	B
26Ek3092[a]	3, 16-19, 23, 28, 37	10-60	[b]	46	3.2 - 5.5	4.2	+	(G)
26Ek3092	33, 36	10-30	-	7	5.0 - 6.0	5.4	+	B
26Ek3160	13-17, 27, 42	0-2	1	61	5.3 - 7.5	6.5	+	B
26Ek3171	--	Surface	-	8	6.2 - 6.7	6.4	?	G
26Ek3174	--	Surface	2	1	-	9.4	?	B
26Ek3181	10, 11	0-2	1	2	6.5 - 6.6	6.6	+	B
26Ek3192	[c]	0-20	1,2	102	4.5 - 9.1	7.0	?	B
26Ek3198	2	0-2	9	4	6.3 - 6.7	6.4	+	?
26Ek3239	1	0-10	1	2	5.8 - 5.9	5.9	?	?
26Ek3251	--	Surface	6	2	6.1 - 6.9	6.5	+	B

* See Table 102 key
[a] May represent two fragmentary pots
[b] Sherds were found throughout Features 7, 14, 20, 21, and 23, and associated non-feature unit/levels
[c] Sherds were found throughout Units 5-7, 14-16, 22-25, 42, 43, 46, and 47 in Feature 1, and in Units 26, 29, 39, and 40 in Feature 2

Fragments of a third vessel were recovered from the middle terrace of 26Ek3092 (Units 6, 7, and 9; cf. Table 103 and Figure 114). Forty percent of these sherds consist of grainy andesitic clays (cf. Table 102) derived directly from the decomposition of materials used as temper. Both clay and temper appear to have been ground prior to vessel construction, but the range of particle size does not suggest winnowing of raw materials. Each sherd is uniform light brown throughout, suggesting firing under uniform conditions.

One hundred two Brownware sherds were collected at 26Ek3192; 89 were recovered from block excavations in Feature 1 and 13 from random excavations at Feature 2 (cf. Table 103; Chapter 17). Although provenience suggests two vessels of origin (i.e., the features are ca. 15 m apart, and no sherds were found intervening), petrographic compositions of sherds from each are virtually identical (cf. Table 102). Similarly, each feature returned sherds with isomorphic "fingernail" decorations (Figure 93d; also cf. Tuohy 1986b:Figure 6) and are a similar red/brown, indicative of a poorly controlled firing atmosphere.

The paste is composed of rock and mineral fragments, including basalt, welded tuff, and quartzite. There is no apparent lamination of the clay, but petrographic analysis observed numerous parallel shrinkage cracks, indicating that the vessel may have been shaped by coiling. Most surfaces are deeply striated from brushing/smoothing (Figure 93a); interior striae are commonly random while exterior brush-marks tend to run parallel. Many sherds have a thin, dark, noncarbonaceous rind on their interior surfaces.

Excavations in Feature 1 at 26Ek3160 yielded 61 ceramic fragments; based on provenience, morphological similarities, and refitting, they probably represent a single pot (cf. Chapter 16). Temper consists largely of water worn andesite and tuff particles with sparse rounded quartzite grains. Similar to specimens collected at 26Ek3192, most surfaces are striated (often deeply) from scraping prior to firing. One specimen possesses a biconically drilled hole (Figure 93c), probably employed to repair a crack (cf. Tuohy 1986b:Figure 5); it may, however, represent an opening to facilitate hanging and/or carrying (cf. Heizer, Baumhoff, and Clewlow 1968; also cf. Butler 1979:Figure 4). Laminations in the clay, although faint, indicate that the

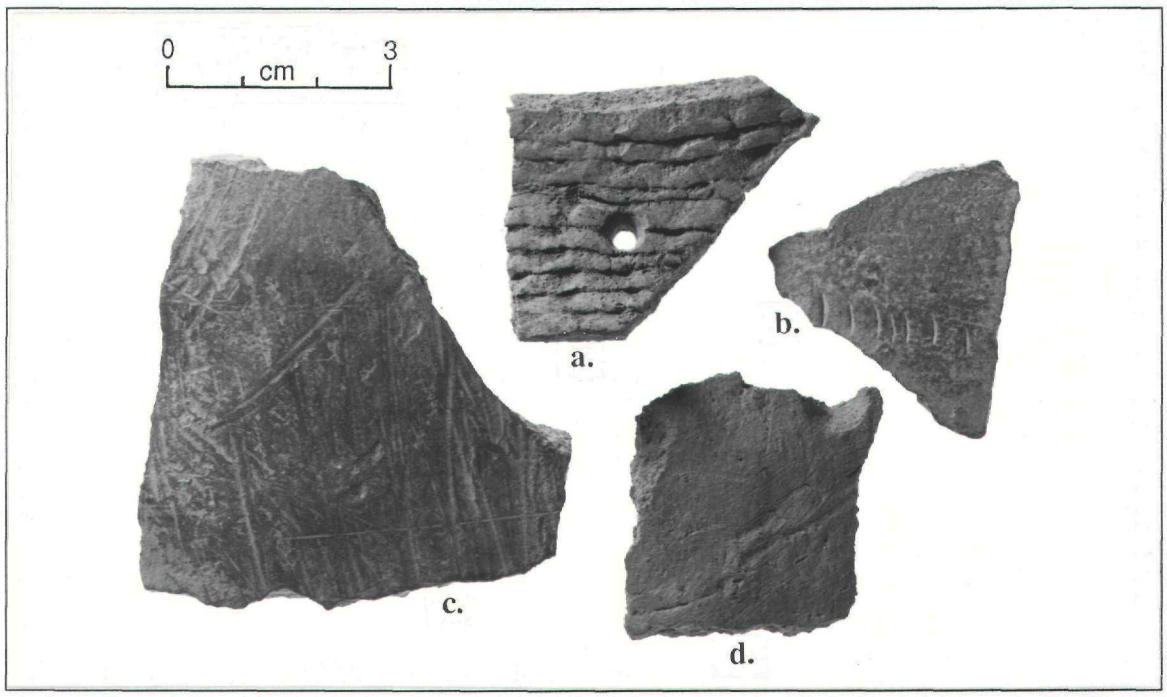


Figure 93. Selected Brownware (a, c-d) and Grayware (b) sherds.

vessel probably was shaped by coiling. Associated artifacts include flake tools, preforms, ground stone, and a projectile point assemblage dominated by Desert Series types (cf. Chapter 16).

A single, thick (9.4mm) Shoshone Brownware sherd was collected from the surface of Feature 2 at 26Ek3174 (cf. Table 103). A biconically drilled hole (diameter = 6.2mm) occurs along one margin, probably to facilitate vessel repair. The sherd has a very slight lateral and longitudinal curvature and may represent a basal fragment of a flat-bottomed jar. Its interior surface is deeply striated from manufacture and is covered with a black noncarbonaceous residue.

Two small brownware fragments were recovered from the surface of Feature 1 at 26Ek3181 (cf. Chapter 17). They are composed largely of feldspars and quartzite, and have uniform brown interior surfaces and a reddish brown rind on outer surfaces indicative of firing in an uncontrolled oxidizing atmosphere. Provenience, overall morphology, and similarity in temper and color suggest they pertain to the same vessel.

Also representing fragments of a single vessel, two sherds were collected from the surface of Feature 6 at 26Ek3251 (cf. Table 103); they lay approximately 2m apart in association with several bifaces, flake tools, preforms, and ground stone fragments (cf. Chapter 18). The sherds are composed of a mixture of decomposed andesite, welded tuff, and chert; the presence of tuff and "chert" may signal local manufacture, but the particles are too small to compare with Tosawihi tuffs and opalites. Very crude laminations in the clay and slight orientation of the rock fragments to these laminations indicate that the vessel was shaped by coiling. Petrographic analysis identified extensive shrinkage cracks, probably the result of different thermal expansion rates between the temper and clay.

Although the highly fragmented condition of brownwares at Tosawihi often precludes inferences of vessel type, rim sherds recovered from 26Ek3160 and 26Ek3192 (exhibiting straight-to-slightly curved profiles; Figure 94) suggest that these specimens are fragments of large, wide-mouthed, flat-bottomed jars (cf. D. Madsen 1986:214; Thomas 1988:224-227), or wide-mouthed conical pots (cf. Tuohy 1986b:Figures 2-4).

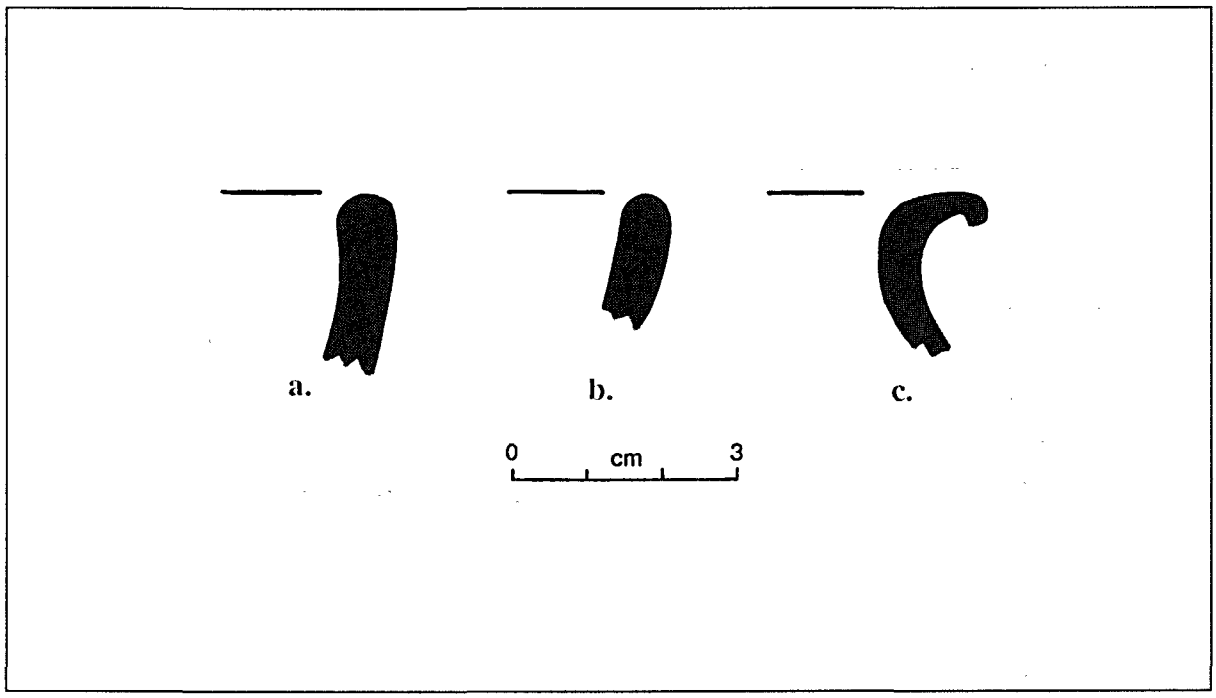


Figure 94. Selected Brownware (a-b) and Grayware (c) rim sherd cross-sections.

Brownware sherds have been recovered from numerous sites in the central and eastern Great Basin (e.g., Dalley 1976; Dean 1983; Jennings 1957; Magee 1964; Spencer et al. 1987; Thomas 1988; cf. especially Fowler 1968). Although Shoshone Brownware remains poorly dated, it probably postdates A.D. 1300 in the region (cf. D. Madsen 1986:214).

Grayware

Great Salt Lake Gray, the Salt Lake variant of Fremont ceramics (D. Madsen 1986), was recovered from two sites peripheral to the Tosawihi Quarries (cf. Table 103). At 26Ek3171, eight sherds were collected just south of Feature 3. Temper constituents include rounded and subangular quartz grains, feldspar, and mica. Exterior surface colors range from light to dark gray with dark gray-to-black interiors; some interior surfaces exhibit a thin, blackened, organic residue.

Excavations at 26Ek3092 returned 46 corrugated grayware sherds; provenience and overall morphology suggest a single vessel of origin, but differences in clay and temper observed in thin-section analysis may signal two pots (cf. Tables 102 and 103). The clay and temper are composed of quartzite and potassium feldspar particles which have been ground prior to manufacture. A number of sherds exhibit well-laminated, overlapping coils and distinctive dark brown rinds on interior surfaces, possibly the result of a thin slip applied to diminish porosity. Steward (1941:294) notes that several ethnohistoric groups in Nevada added vegetal material to the clay or applied it to vessel surfaces, but the residues on specimens from 26Ek3092 do not appear carbonaceous. One (neck?) fragment is drilled biconically, either for vessel hanging or repair (cf. Figure 93b), and two outcurving ("everted") rim sherds (cf. Figure 94c) suggest a wide-mouthed, short-necked jar or cooking pot (cf. Dalley 1976:54-57; Juell 1987b:110-113; also cf. D. Madsen 1986:208).

Great Salt Lake Gray has the widest temporal range of all Fremont ceramics, dating between A.D. 500 and A.D. 1300 (Marwitt 1970; D. Madsen 1986). Elsewhere in the region, Zeier and Zeanah (1987) report a Great Salt Lake Gray sherd collected in Toano Draw, and from James Creek Shelter D. Madsen (1990) reports a single sherd stratigraphically bracketed by hearths dated to 930 B.P. and 1240 B.P. (see also James 1986:108-111 and references therein for additional occurrences). Fremont graywares also have been recovered from sites along the Snake River in southern Idaho (Butler 1979) and at South Fork Shelter on the Humboldt (Heizer, Baumhoff, and Clewlow 1968).

Unidentified Types

Excavations at two additional Tosawihi sites yielded six small, typologically ambiguous sherds (cf. Table 103); four were recovered from Feature 9 at 26Ek3198, and one was petrographically analyzed (cf. Table 102). All are grayish brown, with interior and exterior surfaces exhibiting rinds slightly darker than their cores; the rinds may constitute organic residues. Temper is comprised largely of andesite, and all materials appear to have been ground prior to vessel formation. It is unclear whether the vessel was shaped by coiling, as no detectable laminations are present.

At 26Ek3239, excavations at Feature 1 yielded two small sherds. Similar to those from 26Ek3198, they are grayish brown and are composed largely of andesitic clay and temper; their small size precludes inferences on manufacture techniques. Although their cultural affinity remains unknown, they probably were manufactured and subsequently deposited sometime after A.D. 500 (i.e., the earliest known occurrence of pottery in the region; D. Madsen 1986:211-214).

Summary

Save for the prominence of welded tuff, the raw materials of Tosawihi pottery are similar to those from other sites in northern Nevada, western Utah, and at least one site in southern Idaho (the Wamuza site, 10Bk26; P. Dean, personal communication 1990). Welded tuff has been identified in sherds from a few sites in the region (e.g., Danger Cave), but generally is scarce. Consequently, the abundance of tuff across the Tosawihi landscape (cf. Chapter 2; Chapter 5) and its presence in brownwares recovered here may signal local ("on-site") manufacture of ceramic vessels.

To explore this possibility, we had a piece of welded tuff from a quarrying locality on Red Hill petrographically analyzed. Some tuff particles in the sectioned Tosawihi sherds appear vastly different from the raw material sample, suggesting manufacture elsewhere, but the specimens from 26Ek3192 contain grains identical in crystalline structure to the Red Hill tuff; the possibility of local manufacture cannot be rejected. Conversely, because local tuffs probably were produced by a pyroclastic event and not by flow, their distribution may be widespread and their inclusion in our sherds fortuitous.

Perhaps the most significant aspect of the vessels recovered at Tosawihi is the function they once served. Most resources are seasonal in the vicinity (cf. Chapter 2), and, even at their peak, many are scanty at best. Some of the pots appear to have been brought to the quarries and it is probable that they served a number of tasks, including food transport (doubtless supplemented with baskets and pouches) to support subsistence in the Tosawihi countryside, and as water and food storage containers during quarrying episodes. If vessels were manufactured at the quarries, we must suspect that they served similar functions, less, of course, the transport of goods. Although interior rinds on most Tosawihi sherds appear to be products of vessel firing, and slips on some interior surfaces are noncarbonaceous, a few sherds possess blackened, seemingly carbonaceous interior residues, probably relics of prehistoric storage or preparation of food.

Chapter 14

FAUNAL REMAINS

Dave N. Schmitt

The analysis of archaeological faunal assemblages can be difficult and often frustrating. Quantitative, ethnoarchaeological, and taphonomic faunal studies conducted in the past two decades have helped redefine the approaches, goals, and reliability of analysis (e.g., Binford 1978b, 1981a; Gifford 1981; Grayson 1984; Lyman 1982, 1985; Lyon 1970; Thomas and Mayer 1983; Yellen 1977b), but many questions remain unanswerable owing to the plethora of taphonomic mechanisms that deposit and modify bony remains. Even when a particular taphonomic agent can be identified, functional interpretations may remain ambiguous (e.g., Lyman 1987).

Archaeofaunas recovered from excavations in and adjacent the Tosawihi Quarries prove no exception. The assemblages contain a host of mammalian species displaying various degrees of skeletal attrition, often within the same taxa or animal size class. In order to identify the subsistence practices and taphonomic agents responsible for assemblage compositions, analysis of the Tosawihi archaeofaunas focused largely on the segregation of human from non-human accumulations through the detailed examination of bone damage. While the precise taphonomic history of the Tosawihi fossils remains unknown, many aspects are revealed by butcher marks, evidence of partial digestion (i.e., scat bones), or the presence of complete, unmodified elements, often in aggregates representing whole individuals, indicative of on-site or near-site natural death.

Analytic Methods

Faunal remains were identified by comparison with Nevada State Museum osteological collections and with specimens of known identity held by the author. Fragmented, non-diagnostic elements and post-cranial rodent remains were sorted into animal size classes (Table 104) on the basis of size and overall morphology. The number of identified specimens per taxon was quantified (Grayson 1984).

Table 104. Bone/Animal Size Classes (after Thomas 1969).

Class I	-	Mice, Voles
Class II	-	Ground Squirrels, Wood Rats
Class III	-	Rabbits, Hares, Marmot
Class IV	-	Coyote, Badger
Class V	-	Deer, Pronghorn, Sheep
Class VI	-	Bison, Wapiti, Cow
Class 0	-	Indeterminate

Attritional data were recorded during identification and sorting to allow inferences on depositional processes and human subsistence. These data included documentation of butcher marks, rodent and carnivore gnawing, weathering, and burning. Recently, I documented the

faunal contents of 40 Great Basin coyote scats, (Schmitt 1988a; Schmitt and Juell 1989; cf. Schmitt 1986), and found pitting (especially of long bone metaphyses), staining, overall polish, and/or rounding of fractured surfaces to be characteristic of partially digested bone. Identification of two or more of these attritional characteristics served to isolate numerous scat bones in the Tosawihi assemblages.

Artifactual bones were identified to species (when possible) and were described, measured, weighed, and compared with ethnographic and archaeological specimens in order to infer function.

Descriptive Summary

Archaeological excavations at Tosawihi retrieved 2,339 animal bones representing four vertebrate classes. Mammalian remains of at least 20 taxa dominate the faunal assemblage. A descriptive summary by site of the species identified and the anatomical portions recovered follows below, together with observations on modern and prehistoric mammalian distributions in the northern Great Basin and remarks on the methods employed in taxonomic identification.

Class Mammalia - Mammals

Order Lagomorpha - Rabbits, Hares, and Pikas

Family Leporidae - Rabbits and Hares

Sylvilagus sp. - Rabbits

MATERIAL:

26Ek3092: 1 radius shaft fragment, 1 metapodial fragment: 2 specimens.

26Ek3204: 1 skull fragment, 2 mandible fragments, 2 isolated tooth fragments, 1 distal humerus, 1 radius shaft fragment, 1 proximal metapodial fragment: 8 specimens.

Sylvilagus idahoensis - Pygmy Rabbit

MATERIAL:

26Ek3204: 1 mandible fragment, 1 distal humerus, 1 proximal radius, 1 proximal femur: 4 specimens.

Sylvilagus cf. *nuttallii* - Nuttall's Cottontail

MATERIAL:

26Ek3092: 2 isolated teeth, 1 femur, 1 proximal tibia: 4 specimens.

26Ek3204: 3 mandible fragments, 2 isolated teeth, 1 innominate fragment, 1 astragalus, 1 calcaneum, 1 calcaneum fragment: 9 specimens.

26Ek3251: 1 distal humerus, 1 radius, 1 proximal metapodial: 3 specimens.

Sylvilagus nuttallii - Nuttall's Cottontail

MATERIAL:

26Ek3092: 3 mandible fragments, 1 isolated tooth: 4 specimens.

26Ek3204: 1 mandible fragment: 1 specimen.

REMARKS: The pygmy rabbit and Nuttall's cottontail are the only rabbits found currently in the Tosawihi vicinity (Hall 1946). Although Audubon's cottontail (*Sylvilagus audubonii*) is not represented in Tosawihi archaeofaunas and presently is unknown in northeast Nevada, *S. audubonii* occurs in western Utah (Hall 1981; Zeveloff 1988) and once may have been present in the Tosawihi area. Accordingly, many fragmented large rabbit remains are identified only tentatively (cf. Grayson 1990).

Pygmy rabbits were abundant during field operations in the quarries, especially in dense stands of big sagebrush along Undine Gorge and in Velvet Canyon. Grayson (1990) reports a wealth of pygmy rabbit remains throughout the deposits of James Creek Shelter.

Lepus sp. - Hares

MATERIAL:

26Ek3092: 1 skull fragment, 1 mandible fragment, 1 distal scapula, 2 proximal ulnae, 1 patella, 1 metapodial: 7 specimens.

26Ek3095: 1 skull fragment, 1 mandible fragment: 2 specimens.

26Ek3170: 1 proximal ulna, 1 distal humerus: 2 specimens.

26Ek3192: 1 radius shaft fragment: 1 specimen.

26Ek3204: 4 skull fragments, 4 mandible fragments, 3 isolated teeth, 1 distal scapula, 1 proximal ulna, 3 innominate fragments, 1 vertebra, 2 proximal femora, 1 femur shaft fragment, 1 patella, 1 proximal tibia, 1 distal tibia, 2 calcanea, 1 proximal metapodial: 26 specimens.

26Ek3251: 1 mandible fragment: 1 specimen.

REMARKS: Two species of *Lepus*, the black-tailed jackrabbit (*L. californicus*) and white-tailed jackrabbit (*L. townsendii*), currently are found in Elko County (Hall 1946). Although *L. townsendii* tends to be larger than *L. californicus* (cf. Grayson 1977, 1983:106-108), identification of the small, fragmented Tosawihi jackrabbit assemblage was not carried past the genus level. I observed numerous jackrabbits (especially *L. townsendii*) throughout the project area during 1987-1989 field investigations.

Order Rodentia - Rodents

Family Sciuridae - Squirrels and Relatives

cf. *Marmota flaviventris* - Yellow-bellied Marmot

MATERIAL:

26Ek3092: 1 vertebra: 1 specimen.

26Ek3095: 1 distal humerus: 1 specimen.

26Ek3184: 1 innominate fragment: 1 specimen.

26Ek3192: 1 skull fragment, 2 mandible fragments, 1 vertebra: 4 specimens.

26Ek3251: 1 distal femur: 1 specimen.

Marmota flaviventris - Yellow-bellied Marmot

MATERIAL:

26Ek3092: 2 skull fragments, 1 mandible, 4 mandible fragments, 4 isolated teeth, 2 proximal humeri, 1 distal humerus, 2 proximal ulnae, 2 innominate fragments, 1 femur: 19 specimens.

26Ek3095: 1 isolated tooth, 2 distal humeri, 1 radius, 1 proximal femur, 1 tibia, 1 fibula, 2 astragalus fragments: 9 specimens.

26Ek3160: 1 proximal femur: 1 specimen.

26Ek3184: 1 distal humerus, 1 radius, 1 proximal ulna: 3 specimens.

26Ek3192: 12 skull fragments, 2 mandibles, 8 mandible fragments, 2 isolated teeth, 1 proximal humerus, 1 humerus shaft fragment, 2 distal humeri, 1 distal radius, 2 proximal ulnae, 2 femora: 33 specimens.

26Ek3204: 2 isolated teeth: 2 specimens.

26Ek3251: 1 skull fragment, 1 isolated tooth, 1 ulna: 3 specimens.

REMARKS: The yellow-bellied marmot occupies rock piles, boulders, and outcrops throughout northern Nevada (e.g., Hall 1946). Marmots were observed throughout the project area, particularly in late afternoon near the craggy terrain west of Buttercup Spring (elevation 5807 ft. [1770 m]).

Spermophilus sp. - Ground Squirrels

MATERIAL:

26Ek3092: 52 Skull fragments, 22 mandible fragments, 7 isolated teeth: 81 specimens.

26Ek3095: 1 skull fragment, 2 mandible fragments: 3 specimens.

26Ek3160: 1 skull fragment, 2 isolated teeth: 3 specimens.

26Ek3170: 1 mandible fragment: 1 specimen.

26Ek3184: 1 skull fragment: 1 specimen.

26Ek3192: 1 skull fragment, 1 mandible fragment: 2 specimens.

26Ek3204: 4 skull fragments, 1 mandible fragment, 2 isolated teeth: 7 specimens.

26Ek3237: 3 skull fragments, 4 mandible fragments, 7 specimens.

26Ek3251: 1 skull fragment, 2 mandible fragments: 3 specimens.

Spermophilus cf. *townsendii* - Townsend's Ground Squirrel

MATERIAL:

26Ek3204: 1 mandible fragment: 1 specimen.

26Ek3237: 2 mandible fragments: 2 specimens.

Spermophilus townsendii - Townsend's Ground Squirrel

MATERIAL:

26Ek3092: 2 mandibles: 2 specimens

26Ek3095: 1 mandible: 1 specimen.

Spermophilus cf. *lateralis* - Golden-mantled Ground Squirrel

MATERIAL:

26Ek3092: 3 mandible fragments: 3 specimens.

Spermophilus beldingi and/or *elegans* - Belding's or Wyoming Ground Squirrel

MATERIAL:

26Ek3092: 31 skull fragments, 9 mandibles, 28 mandible fragments: 68 specimens.

26Ek3095: 1 skull fragment: 1 specimen.

26Ek3184: 1 skull fragment, 3 mandible fragments: 4 specimens.

26Ek3204: 3 skull fragments, 1 mandible fragment: 4 specimens.

26Ek3237: 2 skull fragments, 4 mandible fragments: 6 specimens.

26Ek3251: 3 skull fragments, 3 mandible fragments: 6 specimens.

REMARKS: All of the squirrels recovered at Tosawihi are ubiquitous in the project area (Hall 1946). Because I did not have access to comparative skulls and mandibles of *Spermophilus elegans* (*richardsoni*), no attempt was made to distinguish the remains of this large squirrel from those of *S. beldingi* (cf. Grayson 1990). Interestingly, numerous least chipmunks (*Tamias minimus*) were observed during field investigations, but chipmunk remains are absent from the collection.

Family Geomyidae - Pocket Gophers

Thomomys sp. - Smooth-toothed Pocket Gophers

MATERIAL:

26Ek3092: 1 skull fragment, 4 mandible fragments: 5 specimens.

26Ek3095: 1 mandible fragment: 1 specimen.

26Ek3204: 1 isolated tooth: 1 specimen.

26Ek3237: 1 skull fragment, 2 mandible fragments: 3 specimens.

Thomomys talpoides - Northern Pocket Gopher

MATERIAL:

26Ek3092: 1 skull fragment, 1 mandible, 3 mandible fragments: 5 specimens.

26Ek3095: 1 skull fragment, 1 mandible fragment: 2 specimens.

26Ek3165: 1 skull fragment: 1 specimen.

26Ek3237: 1 skull fragment: 1 specimen.

REMARKS: Both the northern pocket gopher and Townsend's pocket gopher (*Thomomys townsendii*) occur in Elko county (Hall 1946). Specimens identified as *T. talpoides* retain sufficient cranial and/or dental morphology for specific ascription (cf. Grayson 1983 and references therein). Most recovered *Thomomys* cranial and mandibular fragments are gracile, and probably represent *T. talpoides*.

Family Heteromyidae - Pocket Mice, Kangaroo Mice, and Kangaroo Rats

Perognathus sp. - Pocket Mice

MATERIAL:

26Ek3092: 1 skull fragment: 1 specimen.

26Ek3204: 4 mandible fragments: 4 specimens.

Perognathus parvus - Great Basin Pocket Mouse

MATERIAL:

26Ek3092: 1 skull fragment, 2 mandibles, 2 mandible fragments: 5 specimens.

26Ek3204: 1 skull fragment, 1 mandible, 3 mandible fragments: 5 specimens.

REMARKS: The Great Basin pocket mouse is the only member of the genus currently known to reside in the Tosawihi vicinity (Hall 1946). Although the distribution of the little pocket mouse (*Perognathus longimembris*) extends into western Elko county (Hall 1946:360-361), this species is smaller than both *P. parvus* and the skeletal remains reported here.

Although no elements were identified in the Tosawihi assemblage, an Ord's kangaroo rat (*Dipodomys ordii*) was found trapped in an excavation unit at 26Ek3092 (elevation 5627 ft. [1715 m]).

Family Muridae - Murids

Peromyscus sp. - White-footed Mice

MATERIAL:

26Ek3092: 1 skull fragment, 1 mandible fragment: 2 specimens.

26Ek3237: 1 skull fragment: 1 specimen.

Peromyscus cf. *maniculatus* - Deer Mouse

MATERIAL:

26Ek3204: 1 edentulous mandible: 1 specimen.

REMARKS: Two species of white-footed mouse, the canyon mouse (*Peromyscus crinitus*) and deer mouse (*P. maniculatus*), currently reside in the project area (Hall 1946; Zeveloff 1988). My tentative identification of a mandible from 26Ek3204 as *P. maniculatus* is based on metric comparison (alveolar length [m1-m3] = 3.62mm) with modern *Peromyscus* alveolar lengths (cf. Grayson 1985:147-149).

Neotoma cinerea - Bushy-tailed Wood Rat

MATERIAL:

26Ek3092: 1 skull fragment with M1, isolated M3, isolated m1: 3 specimens.

26Ek3204: 1 edentulous mandible (alveolar length [m1-m3] = 9.5mm), isolated M1, isolated m1, isolated m2: 4 specimens.

REMARKS: Although the occurrence of *Neotoma cinerea* is well documented throughout Elko County, distributional data presented by Hall (1946:529-530) suggest the desert wood rat (*N. lepida*) to be marginal to the Tosawihi Quarries (the nearest record being northeast of Iron Point at 4610 ft. [1405 m amsl), while Zeveloff's (1988:210) distributional map reports the species throughout northern Nevada.

In order to identify isolated *Neotoma* remains, I compared measurements in concert with morphological attributes (cf. Grayson 1990). Metric comparison of the Tosawihi *Neotoma* materials (cf. above and Table 105) with modern data presented by Grayson (1985:Table 31) identified all Tosawihi wood rat elements as *N. cinerea*; the two recovered upper first molar anterior prisms also possess deep reentrant angles, a trait characteristic of the species. In July of 1989, I observed a single N. cinerea in a rock crevice east of site 26Ek3204 (elevation 5,690 ft. [1734 m]).

Table 105. Occlusal Lengths (mm) of Wood Rat Molars Assigned to *Neotoma cinerea*.

	26Ek3092	26Ek3204
M1	3.69	3.48
M2	-	-
M3	2.42	-
m1	3.58	3.62
m2	-	3.09
m3	-	-

Microtus sp. - Meadow Voles

MATERIAL:

26Ek3092: 1 skull fragment, 1 mandible fragment: 2 specimens.

26Ek3204: 5 mandible fragments: 5 specimens.

26Ek3237: 1 skull fragment, 3 mandible fragments: 4 specimens.

26Ek3251: 1 skull fragment: 1 specimen.

Microtus longicaudus - Long-tailed Vole

MATERIAL:

26Ek3092: 1 skull fragment: 1 specimen.

26Ek3237: 1 skull fragment: 1 specimen.

Lagurus curtatus - Sage Vole

MATERIAL:

26Ek3198: 1 skull fragment, 1 mandible: 2 specimens.

26Ek3204: 2 skull fragments, 1 mandible fragment: 3 specimens.

Microtine Rodent - Montane, Long-tailed and/or Sage Vole

MATERIAL:

26Ek3092: 2 mandible fragments: 2 specimens.

26Ek3204: 2 skull fragments, 3 mandible fragments: 5 specimens.

REMARKS: Both the montane vole (*Microtus montanus*) and long-tailed vole (*M. longicaudus*) occur throughout northern Nevada (Hall 1946). Identification of *M. longicaudus* skulls was based on the presence of expanded incisive foramina (Maser and Storm 1970).

Order Carnivora - Carnivores

Family Mustelidae - Weasels, Skunks, and Allies

cf. *Taxidea taxus* - Badger

MATERIAL:

26Ek3251: 1 phalanx: 1 specimen.

Taxidea taxus - Badger

MATERIAL:

26Ek3092: 1 scapula, 1 scapula fragment, 1 proximal ulna, 1 innominate fragment, 1 femur shaft fragment, 1 tibia: 6 specimens.

26Ek3192: 1 skull fragment: 1 specimen.

26Ek3204: 1 proximal ulna: 1 specimen.

REMARKS: Badgers are extant throughout most of western North America, including all of the state of Nevada (Hall 1946; Zeveloff 1988); their burrows are abundant in the project area, and a carcass was noted south of Big Meadows.

Order Artiodactyla - Even-toed Ungulates

Small Artiodactyl - Deer, Pronghorn, Domestic Sheep, and/or Mountain Sheep

MATERIAL:

26Ek3092: 10 tooth fragments, 1 vertebra fragment, 1 radius shaft fragment, 1 distal tibia shaft fragment: 13 specimens.

26Ek3160: 2 tooth fragments: 2 specimens.

26Ek3204: 4 tooth fragments: 4 specimens.

26Ek3251: 4 tooth fragments, 1 radius shaft fragment, 1 distal humerus shaft fragment: 6 specimens.

Large Artiodactyl - Bison, Domestic Cow, and/or Wapiti

MATERIAL:

26Ek3092: 5 tooth fragments, 1 rib fragment: 6 specimens.

26Ek3204: 3 tooth fragments: 3 specimens.

26Ek3208: 1 scapula fragment: 1 specimen.

REMARKS: The 26Ek3208 scapula blade fragment is artifactual, representing either bison (*Bison bison*) or wapiti (*Cervus elaphus*).

Family Cervidae - Cervids

Cervus elaphus - Wapiti (Elk)

MATERIAL:

26Ek3032, Loc. 23: 1 antler fragment: 1 specimen.

REMARKS: This single specimen is artifactual (cf. below) and may have been transported some considerable distance by people. Elsewhere in northern Nevada, Heizer et al. (1968) report *Cervus* at South Fork Shelter and Grayson (1988) reports 9 specimens from

Last Supper Cave; reasonably, he concludes (1988:57), "the growing number of Holocene records for these animals in the more northerly parts of the Great Basin suggests that these animals were once widespread here, though apparently nowhere abundant." Our specimen was recovered from a backhoe trench, and lacks precise provenience.

Odocoileus cf. *hemionus* - Mule Deer

MATERIAL:

26Ek3160: 1 tooth fragment: 1 specimen.

26Ek3251: 2 tooth fragments, 1 distal humerus: 3 specimens.

REMARKS: Mule deer occur throughout the Great Basin and most of western North America (Hall 1981). I observed numerous mule deer browsing in the project area, especially in Big Meadows and Velvet Canyon during early morning and at sunset.

Family Antilocapridae - Pronghorn

Antilocapra americana - Pronghorn

MATERIAL:

26Ek3092: 2 phalanx fragments: 2 specimens.

REMARKS: Pronghorn presently occur throughout northern Nevada (Hall 1946), and their remains have been recovered from numerous Great Basin archaeological sites (e.g., Dansie and Ringkob 1979; Grayson 1985, 1988). In July, 1989, I observed a buck with a harem of six does approximately 4 km south of the quarries. Both specimens from 26Ek3092 exhibit parallel grooves created by rodent gnawing (cf., for example, Lyman 1988:Figure 26).

Family Bovidae - Bovids

Bos sp. - Domestic Cow

MATERIAL:

26Ek3032, Loc. 22: 1 tooth fragment: 1 specimen.

26Ek3160: 17 tooth fragments: 17 specimens.

REMARKS: Much of the Tosawihi vicinity is open rangeland for cattle grazing; the recovery of *Bos* remains from these open sites is not surprising.

Bison bison - Bison

MATERIAL:

26Ek3092: 1 humerus shaft fragment: 1 specimen.

26Ek3200: 1 distal scapula fragment: 1 specimen.

REMARKS: Bison were distributed widely throughout the Great Basin during the Holocene, though nowhere were they abundant (Grayson 1982). Elsewhere in northeast Nevada,

Dansie (1982) reports a bison ulna at 26Ek2304, and Grayson (1990) documents the largest archaeological bison assemblage in the region at James Creek Shelter; Grayson (1988) also reports bison at Danger Cave.

cf. *Ovis canadensis* - Mountain Sheep

MATERIAL:

26Ek3092: 1 tooth fragment, 2 dorsal ribs: 3 specimens.

26Ek3204: 1 tooth fragment: 1 specimen

Ovis canadensis - Mountain Sheep

MATERIAL:

26Ek3092: 3 isolated teeth, 1 mandible fragment, 1 proximal femur: 5 specimens.

REMARKS: Mountain sheep remains are common constituents of Great Basin archaeofaunal assemblages, often representing the most abundant artiodactyl (e.g., Grayson 1982, 1988; Thomas and Mayer 1983).

Class Aves - Birds

MATERIAL:

26Ek3092: 1 phalanx, 1 longbone shaft fragment: 2 specimens.

26Ek3095: 1 skull fragment, 2 proximal humeri, 1 distal humerus, 1 carpometacarpus, 1 distal tarsometatarsus, 1 proximal phalanx: 7 specimens.

26Ek3204: 1 phalanx (talon): 1 specimen.

26Ek3251: 1 innominate fragment, 1 proximal carpometacarpus, 1 tarsometatarsus: 3 specimens.

REMARKS: Although lack of sufficient comparative collections precludes identification of avian remains at this time, differences in size and morphology indicate at least three different species are represented.

Class Osteichthyes - Bony Fishes

MATERIAL:

26Ek3204: 1 facial bone: 1 specimen.

Class Reptilia - Reptiles

Order Squamata - Lizards and Snakes

MATERIAL:

26Ek3204: 1 skull fragment, 1 dentary fragment, 6 vertebra: 8 specimens.

Site Data: Small Faunal Assemblages

Twelve sites yielded small faunal assemblages containing fewer than 70 bones. These are described briefly below, together with pertinent data on taxonomic presences, bone distributions, and taphonomic processes.

26Ek3032; Localities 22 and 23

One weathered *Bos* molariform was recovered from Unit 1 at Locality 22 and a modified wapiti (*Cervus elaphus*) antler from backhoe trench backdirt at neighboring Locality 23. The latter specimen is artifactual, and is discussed below.

26Ek3095

Fifty bones were recovered from 26Ek3095. Most (n=36, 72%) were retrieved from surface collections and excavations at Feature 19; they include the remains of marmot, ground squirrel, and jackrabbit. The remainder were collected from Features 15 (n=2), and 22 (n=11), and a complete, probably intrusive *Thomomys talpoides* mandible from Feature 10. Burned bone was present across the site, and, although few (n=10), some elements (e.g., a marmot distal humerus and astragalus, and a rodent distal tibia) may have been burned via cooking/roasting.

26Ek3160 and 26Ek3165

Excavations at 26Ek3160 returned 7 fragmented bones and 25 teeth. A large portion of the assemblage consists of domestic cow molariform fragments (n=17, 15 recovered from the surface of Feature 1), clearly representative of recent, non-cultural accumulations; an additional five small, weathered tooth fragments identified only as "artiodactyl" may also be cattle remains as well. Other faunal specimens include the remains of ground squirrel (*Spermophilus* sp.) and an isolated marmot proximal femur, neither exhibiting evidence of cultural modification.

26Ek3165 yielded only four rodent bones, all retrieved from non-feature excavation units in Locus A.

26Ek3170 and 26Ek3171

Excavations at 26Ek3170 recovered three rodent bones (including a *Spermophilus* sp. mandible) and a jackrabbit proximal ulna and distal humerus. The latter specimens exhibit extensive rounding of fractured surfaces and overall gloss characteristic of carnivore scat bones (cf. Andrews 1990:Figure 3.28; Schmitt and Juell 1989). One Class II bone fragment was collected from the surface of Feature 1 at 26Ek3171.

26Ek3184 and 26Ek3198

A total of 17 faunal items was recovered from these sites, 14 from 26Ek3184 and 3 from 26Ek3198. The assemblage from 26Ek3184 includes remains of marmot, ground squirrel (*Spermophilus beldingi/elegans*), and large mammal (i.e., Classes IV and V). All marmot remains were clustered on the surface of Feature 20, probably representing recent, unassociated deposition. A burned large mammal long bone fragment and a ground squirrel maxilla may represent human subsistence refuse, but little can be determined of such a small, diffuse assemblage.

Three rodent bones were collected at 26Ek3198; they include a sage vole (*Lagurus curtatus*) skull fragment and mandible and a Class II innominate. With the exception of the fragile, fragmented cranium, these complete and undamaged elements probably were deposited naturally (e.g., on-site mortality).

26Ek3200 and 26Ek3208

The few faunal remains retrieved from these quarry pits are artifactual and are discussed below. The bison scapula scoop/shovel from 26Ek3200 exhibits butcher marks; mark type and location are also presented below (cf. Table 107).

26Ek3237

Sixty-five faunal specimens were collected from excavations at 26Ek3237. Most (n=56, 86%) were retrieved from block excavations adjacent the Feature 3 and 4 hearths (Locus C). Most of the identified taxa consist of complete, unmodified rodent remains (including ground squirrel, white-footed mouse, pocket gopher, vole, and miscellaneous Class II long bones and vertebrae), probably reflecting recent, on-site natural deaths. Fourteen Class V specimens recovered from this area, however, may represent human subsistence refuse; all are fragmented, and 8 (57%) are burned.

Site Data: Large Faunal Assemblages

Large faunal assemblages are defined here as those containing more than 100 items. Four sites yielded large assemblages, ranging from 115 specimens at 25Ek3251 to 955 at Whining Rock Shelter (26Ek3204). The site assemblages are discussed below, together with inferences on human subsistence, faunal distributions, and animal-bone accumulative mechanisms.

26Ek3092

Excavations at 26Ek3092 returned a large and diverse archaeofaunal assemblage; 927 faunal items (including four bone artifacts) representing at least 16 taxa were recovered. Rodent remains (Classes I and II) are most abundant (n=685, 74% of the total assemblage), including

the remains of ground squirrel, pocket gopher, pocket mouse, white-footed mouse, wood rat, and vole (Table 106). Although some isolated, fragmented elements were recovered, Class I and II remains are largely undamaged, and often were encountered as complete skeletons in unit/level aggregates (i.e., burrow deaths). Similarly, excavations revealed abundant active rodent burrows, subsurface nests, and krotovina. Burrow death accumulations often account for increases in unit/level faunal frequencies (compare, for example, small and large mammal bone counts in Levels 5 and 6, Table 106).

Additional non-human accumulations includes 25 scat bones, recovered throughout the site; a small concentration from Level 3 of Unit 1 probably represents of a portion of a single, disaggregated scat. A few burned and broken rodent bones may represent human subsistence refuse (n=16, 2.3%), but this small assemblage easily could have burned naturally (e.g., a brush fire), or could be the product of non-subsistence related human activities (e.g., a hearth constructed over/adjacent a natural rodent accumulation).

Fragmented Class III and large mammal (Classes IV, V, and VI) bones were discovered throughout the deposits at 26Ek3092, including the remains of rabbit, hare, marmot, badger, pronghorn, bison and mountain sheep (Table 106). Although the bones of large mammals were recovered across the site, most (n=175, 12.5 bones per unit) were retrieved from non-feature random 1 x 1 m excavation units placed south of the boulder area, including small concentrations in Units 8 (n=28) and 12 (n=18). Conversely, block excavations adjacent the boulder disclosed a host of activity areas (including numerous reduction and hearth features; cf. Chapter 16), but large mammal remains are scarce (n=40, 1.4 bones per unit). This suggests that the small meadow south of the boulder served as a "toss-zone" (Binford 1983a:153; also cf. Thomas 1988) where large mammal bones were redeposited from the hearth areas.

Based on the number of bones, variety of taxa, and the fragmented, often burned nature of the class III-VI mammal assemblage at 26Ek3092, I suspect most are remnants of carcasses acquired by people for diverse resources (e.g., hides, sinew, meat, and marrow). Subsistence exploitation of large animals is evident in five bones possessing butcher marks (Table 107). Three bones exhibit cut marks, including a mountain sheep (cf. *Ovis canadensis*) rib with multiple striations along its caudal border (Figure 95c) and a marmot ulna and mandible fragment, both recovered from Level 2 of Unit 8. The ulna (Figure 95b) has two parallel cuts on its posterior surface; they are most similar to Binford's (1981a) filleting mark RCp-7, but may have been produced during dismemberment as variation in cut mark location and orientation may be conditioned by prey size (i.e., Binford's locational/functional cut mark data are based on artiodactyls, not marmot-sized carcasses).

Similar to cut marmot mandibles recovered from Last Supper Cave and Hanging Rock Shelter (Grayson 1988:72-73), one marmot mandible fragment displays two striae on the buccal face of the ascending ramus (Figure 95a). These marks probably were produced while severing the masseter muscle during removal of the mandible (Grayson 1988:72), a likely prelude to consumption. Finally, a bison humerus and an undifferentiated artiodactyl tibia shaft (Figure 95d) display distinct impact scars (i.e., "dull dynamic loading;" Lyman 1987:292) produced by percussion to facilitate the extraction of marrow.

In sum, the 26Ek3092 archaeofaunas contains a mixture of culturally and naturally deposited bone. Rodent bones appear to have accumulated via natural (e.g., senile) mortality and non-human predation while those of larger mammals (e.g., marmots, mountain sheep, and bison) have accumulated largely through human subsistence activities as evident by the recovery of highly fragmented and butchered specimens.

Table 106. Numbers of Identified Specimens per Taxon/Animal Size Class by Excavation Level at Site 26Ek3092.

Level (10 cm)	*Sylvilagus* sp.	*Sylvilagus* cf. *nuttallii*	*Sylvilagus nuttallii*	*Lepus* sp.	cf. *Marmota flaviventris*	*Marmota flaviventris*	*Spermophilus* sp.	*Spermophilus townsendii*	*Spermophilus* cf. *lateralis*	*Spermophilus beldingi/elegans*	*Thomomys* sp.	*Thomomys talpoides*	*Perognathus* sp.	*Perognathus parvus*	*Peromyscus* sp.	*Neotoma cinerea*	*Microtus* sp.	*Microtus longicaudus*	Microtine	*Taxidea taxus*	Artiodactyl	*Antilocapra americana*	*Bison bison*	cf. *Ovis canadensis*	*Ovis canadensis*	Aves	I-II	III	IV	V	V-VI	VI	0	Total*
1	-	-	-	2	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	4	1	-	2	3	2	-	18
2	-	-	-	4	1	8	19	-	-	9	-	-	1	1	-	-	-	-	-	1	3	-	1	-	-	-	74	21	2	1	4	12	2	164
3	-	1	-	-	-	5	17	-	-	10	-	-	-	3	1	1	1	-	-	1	7	-	-	1	1	-	100	24	10	11	1	8	7	210
4	-	-	3	1	-	3	6	-	1	5	-	-	-	1	-	-	-	-	1	-	4	-	-	-	2	-	64	6	-	3	4	1	-	105
5	-	1	-	-	-	-	11	-	-	12	2	1	-	-	-	-	-	-	-	1	1	-	-	1	1	-	39	4	2	2	7	2	-	87
6	-	1	-	-	-	-	10	-	-	8	-	1	-	-	-	-	-	-	-	-	2	1	-	-	-	2	109	3	-	-	1	2	-	140
7	-	-	1	-	-	1	9	2	2	9	2	2	-	-	-	1	1	1	-	1	1	1	-	1	-	-	45	1	-	4	-	-	-	85
8	2	1	-	-	-	1	5	-	-	9	1	-	-	-	-	-	-	-	1	1	-	-	-	-	1	-	46	-	-	2	1	1	1	73
9	-	-	-	-	-	1	3	-	-	4	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	20	2	-	1	-	-	1	34
10	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	3
11	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	3
12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
Total	2	4	4	7	1	19	81	2	3	68	5	5	1	5	2	3	2	1	2	6	19	2	1	3	5	2	505	62	14	27	21	28	11	923

* Does not include 4 bone artifacts.

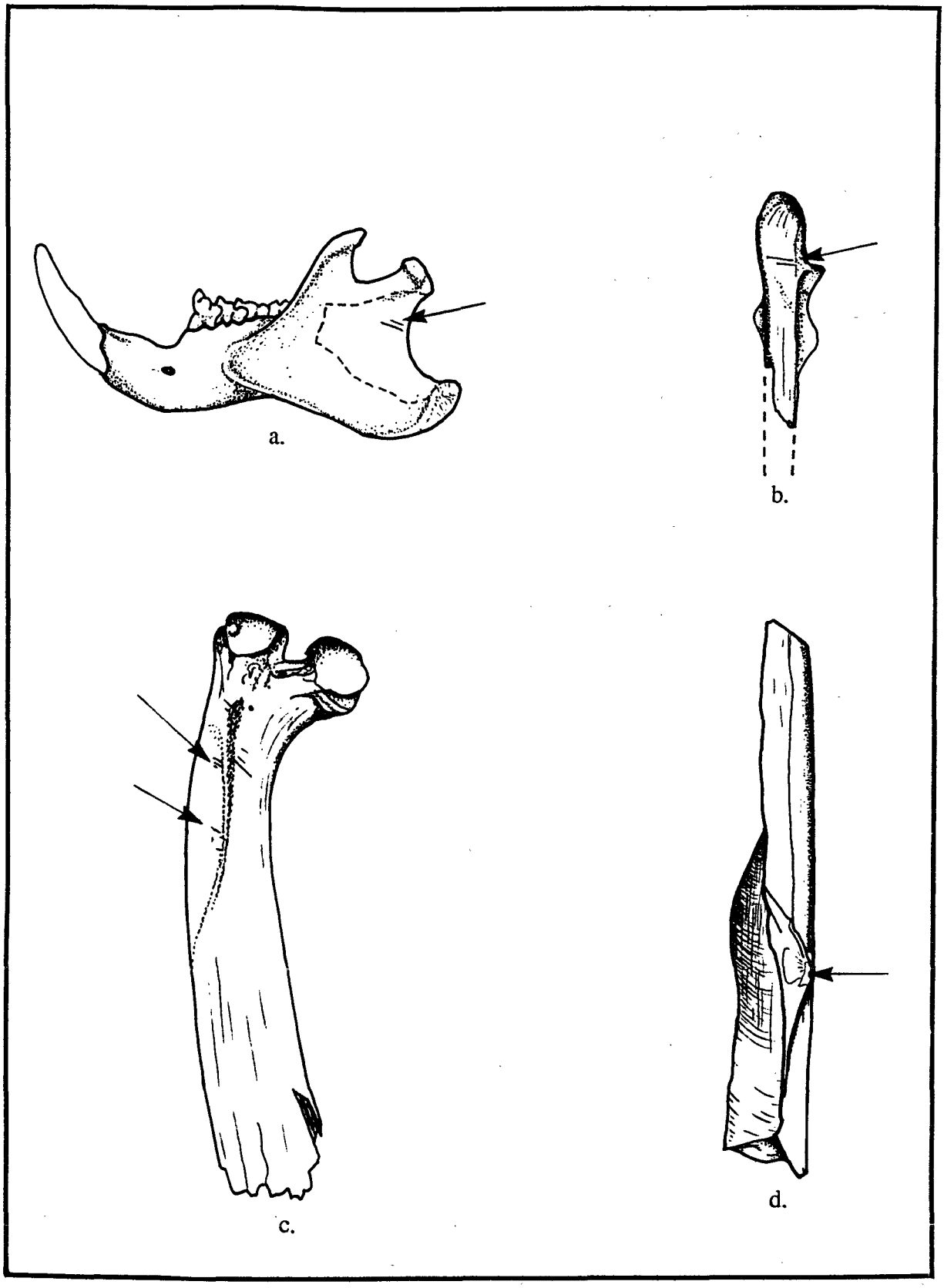


Figure 95. Butchering marks on selected mammal bones, 26Ek3092. No scale.

Table 107. Butchering Marks on Mammal Bones by Site.

Site (26Ek)	Spec. No.	Species	Element	Type, Location	Figure	Type*	Function
3092	6042-9	*Bison bison*	Humerus mid shaft	Large, pronounced impact scar, latero-anterior	--	--	Marrow extraction
3092	6067-4-1	cf. *Ovis canadensis*	Dorsal rib	Multiple, parallel striae, distal to tubercle on ventral surface	95c	RS-3	Dismemberment
3092	6082-15-1	*Marmota flaviventris*	Dorsal mandible	Two horizontal striae, buccal face of the ascending ramus	95a	M-5	Dismemberment
3092	6082-15-2	*Marmota flaviventris*	Proximal ulna	Two horizontal striae, posterior surface of the olecranon ca. 8 mm distal to the proximal terminus	95b	RCp-7	Filleting
3092	6107-1-1	Artiodactyl	Mid-distal tibia shaft	Impact scar, posterior	95d	--	Marrow extraction
3200	2501-1	*Bison bison*	Distal scapula	Multiple, deep acute striae (chop marks?), medio-cranial border of the neck ca. 30 mm proximal the tuber scapulae	--	S-2	Dismemberment
3251	6065-3-1	Artiodactyl	Distal humerus shaft	Multiple transverse striae, postero-medial surface just proximal the olecranon fossa	--	Hd-7	Filleting

* Binford's (1981) Most Similar Type

26Ek3192

Represented largely by the remains of marmot and other (undifferentiated) Class III bone fragments, archaeological excavations at 26Ek3192 yielded 155 bones. Most (n=106, 68%) were recovered from a single unit/level in block excavations at Feature 1. Identified taxa include badger, marmot, and round squirrel, as well as a wealth of taxonomically unidentifiable Class III fragments (Table 108). Based on the clustered context of these remains and the recovery of two *Marmota* left mandibles (i.e., a minimum number of two individuals are represented), I suspect most of the undifferentiated class III remains to be marmot.

Table 108. Faunal Remains Recovered from Unit 42, Level 2, Feature 1, 26Ek3192.

Species/Class	Element	Total No.	No. Burned
Taxidea taxus	Skull fragment	1	0
Marmota flaviventris	Skull fragments	11	4
Marmota flaviventris	Mandible fragments	4	0
Marmota flaviventris	Isolated teeth	2	0
Marmota flaviventris	Humerus shaft	1	1
Marmota flaviventris	Distal humerus	1	1
Marmota flaviventris	Distal radius	1	1
Marmota flaviventris	Proximal ulnae	2	2
cf. *M. flaviventris*	Mandible fragments	2	0
cf. *M. flaviventris*	Vertebra	1	0
Spermophilus sp.	Skull fragment	1	0
I - II	Skull fragments	2	0
I - II	Innominate	1	0
III	Skull fragments	15	10
III	Misc. fragments	59	33
V	Long bone fragments	2	2
Totals		106	54

Approximately one-half (51%) of the bones are burned (most are fire-blackened, but some variation in color and cracking is evident) and, except for a complete (probably intrusive) rodent innominate and two marmot teeth, all are highly fragmented. These data, and the recovery of only 19 additional faunal items from Feature 1, strongly suggest that the aggregation represents human subsistence refuse. It may reflect a food preparation locus and/or a refuse dump resulting from hearth cleaning, or the disposal of bones charred prior to stewing.

Elsewhere at 26Ek3192, excavations in Feature 2 recovered 30 bones (33% burned); this assemblage, too, is dominated by marmot and undifferentiated Class III skeletal fragments.

26Ek3204

Limited excavations at Whining Rock Shelter returned the largest faunal assemblage recovered at Tosawihi. Represented primarily by the remains of Class I, II, and III mammals (n=835, 87% of the total assemblage), 955 faunal specimens were recovered (Table 109). With the exception of two *Bos* or *Bison* molariform fragments in Unit 2 outside the dripline, all were retrieved from units excavated within the shelter; 497 specimens came from Unit 1 near the center of the shelter, and 456 specimens from Unit 3 adjacent the rear wall. Faunal remains were particularly abundant in the upper 30 cm of the deposits (Table 109), with the highest unit/level frequency (n=218) recovered from Level 3 of Unit 1.

Table 109. Numbers of Identified Specimens per Taxon/Animal Size Class by Excavation Level at Site 26Ek3204.

Level (10 cm)	*Sylvilagus* sp.	*Sylvilagus idahoensis*	*Sylvilagus* cf. *nuttallii*	*Sylvilagus nuttallii*	*Lepus* sp.	*Marmota flaviventris*	*Spermophilus* sp.	*Spermophilus* cf. *townsendii*	*Spermophilus beldingi/elegans*	*Thomomys* sp.	*Perognathus* sp.	*Perognathus parvus*	*Peromyscus* cf. *maniculatus*	*Neotoma cinerea*	*Microtus* sp.	*Lagurus curtatus*	Microtine	*Taxidea taxus*	Artiodactyl	cf. *Ovis canadensis*	Aves	Osteichthyes	Reptilia	I-II	II-III	III	V	VI	0	Total
1	1	-	2	-	4	-	2	-	-	1	-	-	-	1	-	-	-	-	1	-	-	-	4	56	9	54	6	-	6	147
2	1	1	1	-	11	-	-	1	1	-	1	1	-	1	1	2	2	-	1	-	-	-	-	64	6	62	6	-	10	173
3	2	3	1	-	5	1	3	-	1	-	1	2	1	1	1	1	2	1	3	1	-	1	2	89	9	137	17	-	28	313
4	2	-	-	1	4	-	2	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-	1	32	5	37	-	-	5	92
5	1	-	3	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	1	32	6	30	6	-	8	89
6	1	-	-	-	1	-	-	-	-	-	2	1	-	1	-	-	-	-	-	-	-	-	-	24	3	36	3	-	4	76
7	-	-	2	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-	1	-	-	17	5	16	-	-	-	44
8	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	1	6	-	3	1	21
Total	8	4	9	1	26	2	7	1	4	1	4	5	1	4	5	3	5	1	5	1	1	1	8	323	44	378	38	3	62	955

Attritional analysis of the Whining Rock Shelter faunas disclosed many partially digested specimens. Scat bones occurred throughout the deposits (Table 110), with the highest frequencies found in the upper 30 cm; two partially dissagregated coyote scats were found in Level 1 of Unit 1 and a scat fragment in Level 2, while another was collected from the surface in a small, cleared (denning?) area inside the dripline. The shelter also evidenced occupation by wood rats ("pack rats"), which often accumulate scatological and other organic material (Stones and Hayward 1968; Wells 1976).

Class I and II scatological bones dominate the assemblage (n=175, 48.2%; Table 110), especially between 10 and 20 cm below surface, followed closely by Class III specimens (n=174, 40.7%). Although scat bones appear to have been introduced by coyotes, some specimens (especially rodent remains) may have been deposited by raptors; regurgitated (i.e., pellet) bones often display similar corrosive modification (cf. Dodson and Wexlar 1979; Mayhew 1977). Similarly, some small animal bones may represent human subsistence refuse deposited in coprolites (cf. Heizer and Napton 1970), but most, especially the Class II and III skeletal fragments, appear too large for humans to digest and pass (cf. Dansie 1984); their attributes compare favorably with coyote scatological bone breakage and attrition (Andrews 1990:Figure 3.28; Schmitt and Juell 1989).

Table 110. Attributes of Small Mammal Bones by Size Class*
by Excavation Level at Site 26Ek3204.

SIZE CLASS	LEVEL (10 cm)								
I - II	1	2	3	4	5	6	7	8	TOTAL
Total No. Bones	60	74	102	37	34	28	19	9	363
No. Scat	25	43	48	17	13	15	11	3	175
% Scat	41.7	58.1	47.1	45.9	38.2	53.6	57.9	33.3	48.2
No. Burned	0	1	2	0	2	0	0	0	5
II - III									
Total No. Bones	9	6	9	5	6	3	5	1	44
No. Scat	3	2	2	1	1	1	2	0	12
% Scat	33.3	33.3	22.2	20.0	16.7	33.3	40.0	0	27.3
No. Burned	0	0	2	1	0	0	0	0	3
III									
Total No. Bones	61	76	149	44	34	38	19	7	428
No. Scat	29	32	62	16	16	13	4	2	174
% Scat	47.5	42.1	41.6	36.4	47.1	34.2	21.1	28.6	40.7
No. Burned	3	8	9	4	0	0	2	0	26
TOTALS									
Total No. Bones	130	156	260	86	74	69	43	17	835
No. Scat	57	77	112	34	30	29	17	5	361
% Scat	43.8	49.4	43.1	39.5	40.1	42.0	39.5	29.4	43.2
No. Burned	3	9	13	5	2	0	2	0	34

* Includes all taxonomically identified specimens.

In sum, the occurrence of dissagregated coyote feces, the number of identifiable scat bones, and the presence of some complete, undamaged elements suggest most, if not all, of the Whining Rock Shelter fauna accumulated through non-cultural mechanisms. Although some burned bone was recovered (cf. Table 110), the paucity and diffuse distribution of charred remains inhibit confident assignment, particularly in the presence of wood rat occupation (cf. Hockett 1989).

26Ek3251

One hundred fifteen faunal items were recovered from 26Ek3251. Remains were most abundant at Feature 6 (n=100, 87%); Feature 1 and non-feature excavations units yielded the remainder (11 and 4 specimens, respectively).

With the exception of a single marmot maxilla, Feature 1 yielded only fragmented Class V mammal bones and teeth; mule deer have been identified specifically. While the assemblage is small (possibly due to the shallow cultural deposits), large mammal bone fragments, including 4 burned specimens associated with a multifunctional tool kit and fire-cracked rock suggest that it represents human subsistence refuse.

Faunal remains were recovered throughout Feature 6; they include fragmented, often burned, large mammal bones and intrusive, unmodified rodent remains. Forty-eight large mammal bone fragments (Classes IV - V) were collected, including 14 specimens (29%) which display various degrees of burning (i.e., black to "chalky" white; cf. Shipman et al. 1984). Large mammal bones were collected across the feature, with two small clusters in neighboring Units 31 (n=10, 50% burned) and 32 (n=19, 37% burned).

Although these fragmented and burned bones *probably* represent human subsistence refuse, only a single artiodactyl distal humerus fragment displays unequivocal evidence of human manipulation (cf. Table 107). These markings resemble Binford's (1981a) filleting mark Hd-7, but easily could have been produced during dismemberment (mark code Hd-3); they are separated by only a few millimeters and ca. 45° in orientation (compare Figure 4.30 [mark Hd-3] vs. Figure 4.39 [mark Hd-7] in Binford 1981a). Although striations on the specimen from 26Ek3251 were produced by human action, the intent of that action is ambiguous; numerous factors (e.g., dietary status of hunters, distance to camp, time of day, condition of carcass) can affect any butchering episode (Lyman 1987).

The remaining fauna from Feature 6 consist largely of Class I and II bones and teeth; the remains of vole (*Microtus* sp.), Belding's and/or Wyoming ground squirrel (*Spermophilus beldingi/elegans*), and undifferentiated ground squirrels are included. Although some specimens are fragmented, the small mammal assemblage lacks evidence of human utilization. Seven scat bones deposited by carnivores and 11 complete, undamaged elements (probably reflecting burrow deaths), as well as sparse occurrences of cottontail jackrabbit, and marmot appear to be results of natural accumulation as they, too, are largely undamaged.

Artifactual Bone

Five sites returned 15 bone artifacts. Although small, the assemblage contains an array of functional classes; bone beads, awls, a flaking tool, an expedient (i.e., utilized) bone fragment, and three quarrying tools were recovered (Table 111).

Beads

Excavations at 26Ek3092 and 26Ek3208 retrieved a total of eight bone beads. At 26Ek3092, a single large bead manufactured on a bird ulna was collected from level 5 of Unit 8 (Table 111, Figure 96a). The artifact displays numerous manufacture and/or use wear striations parallel and perpendicular to its long axis and is polished by use wear at and within each scored end. Large beads much like this specimen have been recovered from James Creek Shelter (Schmitt 1990), the Vista site (Drews and Schmitt 1986), and Gatecliff Shelter (Thomas 1983b).

Table 111. Provenience and Attributes of Bone Artifacts.

Site (26Ek)	Spec. No.	Unit	Depth (cm)	Feature	Species	Element	Complete	Max. Length (mm)	Max. Width (mm)	Max. Thick. (mm)	Weight (gm)	Type
3032/L23	2599-1	a	-	1	*Cervus elaphus*	Antler	+	249.5	58.4	52.7	319.0	WE
3092	6109-6	9	80-90	-	Artiodactyl	Femur Shaft	?	67.1	23.1	4.3	10.3	EX
3092	6403-6	24	20-30	-	Artiodactyl	Long bone	-	31.9	9.5	3.1	0.5	AL
3092	8382-1	23	10-20	13	Artiodactyl	Rib ?	-	33.7	9.4	1.7	0.4	FL
3092	9085-5	8	40-50	-	Bird	Ulna	+	52.0	9.0	7.9	2.7	BE
3200	2501-1	b	43	1	*Bison bison*	Scapula	-	183.0	70.2	43.3	109.6	SO
3208	2500-1	c	157	3	*Bison* or *Cervus*	Scapula	-	152.1	36.3	25.4	30.1	SO
3208*	2599-19	d	82-84	3	Rabbit or bird	Long bone	+	(11.6)	(4.3)	(2.4)	(0.1)	BE
3251	6122-5	31	10-20	6	Artiodactyl	Scapula	-	47.6	9.9	3.4	1.3	AL

*Seven beads (5 complete and 2 fragmented) were recovered. Parentheses bracket mean measurements and weights of the 5 complete specimens.

Unit
a = Discovered in backhoe trench backdirt.
b = Discovered in south wall of backhoe Trench 1, Horizon II.
c = Discovered in east wall of Trench 1, Stratum 23.
d = Discovered in east wall of Trench 1, Stratum 22.

Type
AL = Awl
BE = Bead
EX = Expedient Tool
FL = Flaker
SO = Scoop, Shovel
WE = Wedge

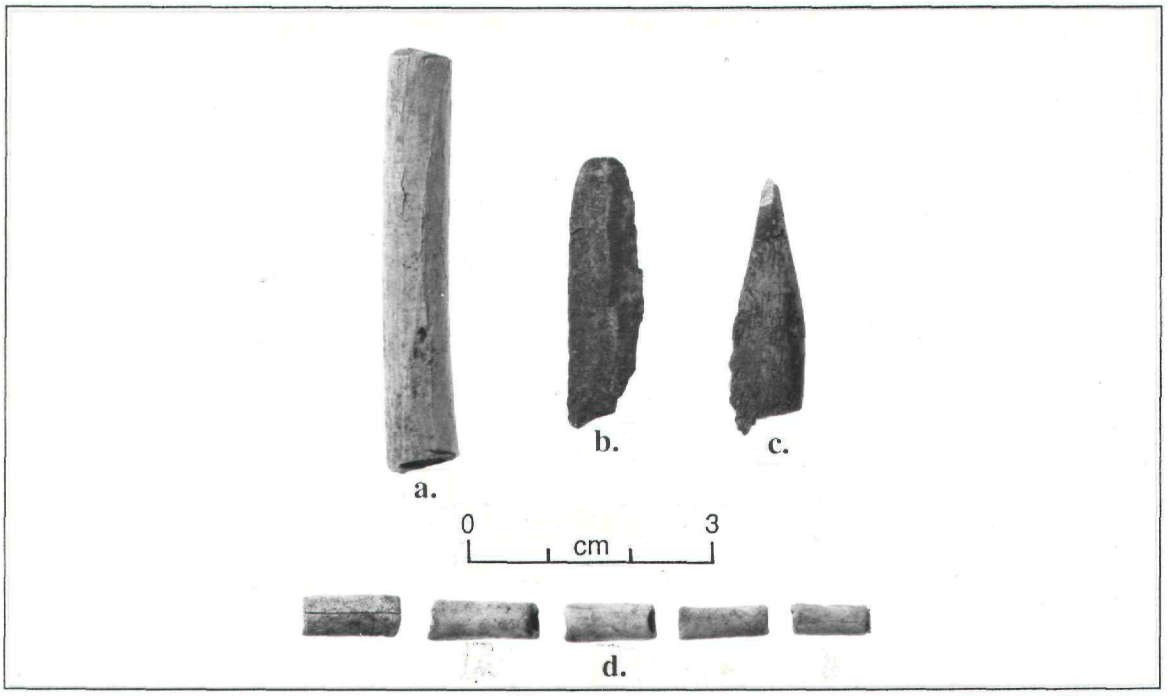


Figure 96. Selected bone artifacts. a. bead; b. flaker; c. awl; d. beads.

Five complete and two fragmented beads were discovered in the Feature 3 quarry pit wall profile at 26Ek3208 (Table 111, Figure 96d). All occurred in a small cluster in Stratum 22, probably representing a portion of a single adornment (Stewart 1941) lost during toolstone acquisition; similarly, size and overall morphology indicate they were manufactured from the same long bone (cf. Figure 96d).

Awls

Two awls (a tip from Unit 24 at 26Ek3092 and a "handle"/midsection from Feature 6 at 26Ek3251) were recovered (Table 111). The former, manufactured on an artiodactyl bone, appears to represent fortuitous use of a long bone splinter; manufacturing techniques involved simple transverse abrasion of one end to create a gradually tapering point, terminating at small shoulders ca. 18 mm back from the tip (cf. Figure 96c).

The specimen from 26Ek3251 is a proximal awl fragment manufactured from a large mammal scapula (Table 111). Although truncated, the distal end exhibits a remnant of purposeful tapering/rounding indicative of use in weaving and/or perforating. The artifact is highly polished from "hands-on" use and is slightly fire blackened, perhaps from purposeful fire-hardening. Complete and fragmentary awls have been recovered from archaeological deposits throughout the Great Basin (e.g., Aikens 1970; Ambro 1970; Lucius 1980; Pendleton 1985a; Schmitt 1988b, 1990; Thomas 1983b).

Flaking Tool

A single pressure flaking tool was recovered from Level 2, Unit 23, at 26Ek3092 (cf. Table 111, Figure 96b). It apparently was manufactured on an artiodactyl rib, an element

commonly employed in lithic flaking (for example, cf. Pendleton 1985a:227 and references therein). Its tip/end is blunted from use wear is and slightly ground along its margins, possibly from resharpening (cf. Pendleton 1985a; Schmitt 1988b). Although fragmentary, it appears that the flaker was small enough for hafting. Bone and antler flaking tools have been described ethnographically in the Great Basin (e.g., Steward 1937; Stewart 1941), and have been identified in numerous archaeological assemblages (e.g., Dalley 1970; Hattori 1982; Pendleton 1985a; Schmitt 1988b).

Expedient Tool

Unit 9 at 26Ek3092 yielded an undifferentiated artiodactyl femur midshaft fragment displaying use wear along a slightly convex fractured edge (cf. Table 111). The artifact displays no evidence of modification other than contiguous microflaking and slight polish along one edge as a result of expedient use, probably as a scraper/flesher (cf. Dalley 1970; Schmitt 1990; Thomas 1983b:308).

Quarrying Tools

Quarrying tools of bone consist of two scapulae scoop/shovels and a wapiti antler billet/wedge (cf. Table 111). Although both of the scapulae lack evidence of modification/use as tools and each is fragmentary (i.e., the 26Ek3200 specimen is a distal portion [also cf. Table 107] and the 26Ek3208 specimen is a blade/spine fragment), they are considered artifactual on the basis of actualistic studies, additional archaeological evidence, and context.

First, Carambelas and Raven (1991) conducted quarrying experiments during field investigations at Tosawihi and found large mammal (i.e., cow) scapulae to be of great utility in digging (i.e., toolstone exposure/acquisition), and as "dust pans" for the removal of debitage. Second, two bison scapula exhibiting spine removal, battering, and striations, probably from use as digging tools or shovels, were recovered from the Knife River Flint Quarries (Ahler 1986:75-76 and references therein). Finally, the context of the Tosawihi large mammal scapula fragments supports this functional interpretations, since both were retrieved from quarry pits and comparable specimens were recovered from no other context.

One of the most striking artifacts recovered at Tosawihi is a wapiti ("elk") antler wedge discovered in trench backdirt from backhoe operations at Feature 1 (a quarry pit), Locality 23. Manufacturing techniques involved longitudinal splitting of a portion of the antler in order to create a beveled (25°) working edge on the distal end (Figure 97). Both ends exhibit various degrees of use wear; the distal end is blunt, polished, and slightly battered from use, and the proximal end (i.e., the horn core) is faintly battered, probably from use as a hammer (e.g., assaying extracted toolstone).

Although usually smaller (shorter) and more extensively modified than the specimen from Locality 23, elk antler wedges have been recovered from numerous archaeological sites in Oregon and Washington, often in association with toolkits and relative and absolute dates of great antiquity (for example, cf. Brauner 1985). Similarly, in the Great Basin, a single, small, highly modified elk antler wedge retrieved from Stratum 4 of Hogup Cave may be as old as 8,000 years B.P. (Aikens 1970:28, 91, 93). Obviously, this does not confer early Holocene age on the Tosawihi specimen, but it signals that the artifact may be of great antiquity. Regardless of context, the artifact represents a durable, high utility quarrying tool.

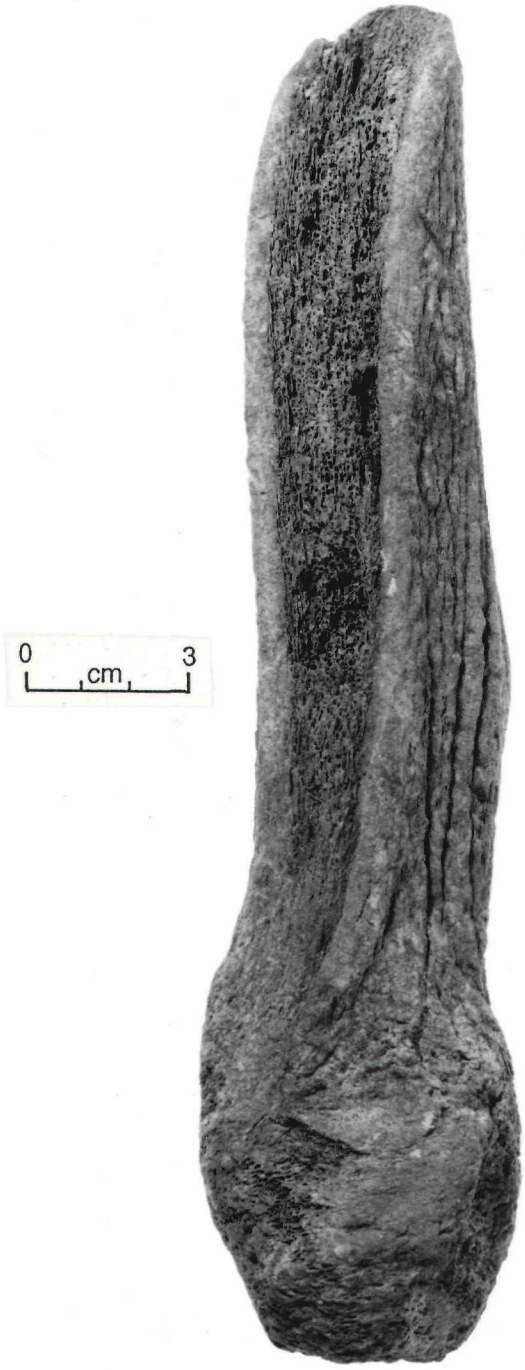


Figure 97. Antler wedge, 26Ek3032, Locality 23.

Summary and Conclusions

Analysis of the Tosawihi archaeofaunas has identified the remains of a variety of mammalian taxa and, through attritional studies, has disclosed evidence of human subsistence, non-human fossil accumulations, and artifactual bone. At sites 26Ek3092, 26Ek3192, 26Ek3251, and, to a lesser extent, 26Ek3237, unequivocal evidence of human exploitation of large (i.e., Class III-VI) mammals for subsistence resources is demonstrated by numerous burned, fragmented, and/or butchered bones. Large mammal presences, inter- and intra-site large mammal attritional comparisons, and intra-site bone distributions (especially at 26Ek3092 and 26Ek3192) suggests that many of these remains have passed through a "cultural filter" (Daly 1969:146), whether or not they are *unequivocally* artifactual. Similarly, multifunctional toolkits (often in association with hearth features) at each of these sites indicate use as camps where faunal and floral subsistence debris should be anticipated in the archaeological record. This pertains particularly to 26Ek3237 and 26Ek3251, both located some distance from the quarries in rich riparian settings; habitation there probably was not conditioned exclusively by the occurrence of the Tosawihi Quarries.

Most small mammal skeletal remains appear to be products of natural mortality (e.g., burrow deaths) or non-human predation. This is the case especially at Whining Rock Shelter, where conservative identification of scatological remains found approximately one-half of the Class I-III bones to have been deposited by terrestrial carnivores. The problem (and frustration) here is in discerning the taphonomic origin of the remaining specimens.

Small mammals, including rats, chipmunks, and squirrels, were encountered daily during our field operations in the quarries and surrounding areas, often in great abundance. Because rodents possess a high ratio of edible meat to total weight (Stahle 1982), offer higher caloric return rates than most Great Basin plant resources (Simms 1987), and often were described as common constituents of prehistoric aboriginal diets (e.g., Steward 1941; Stewart 1941), I suspect the rather healthy Tosawihi rodent population to have been exploited for food by prehistoric inhabitants. Unfortunately, due to our small, scattered rodent assemblages and our present naivete regarding small animal taphonomy, archaeological evidence of such activities remains scarce.

Regardless of taphonomic origin, animal bones at most Tosawihi sites are scarce, posing at least two scenarios. First, if the paucity of "food bones" truly reflects the intensity of food-animal exploitation, virtually all of the sites investigated represent palimpsest accumulations resulting from a series of *extremely* short-term forays to the quarries; the caloric value represented would sustain few people for a very limited amount of time. Alternately, the multitude of reduction features and debris suggest that prehistoric peoples often expended a great deal of time and energy while acquiring toolstone, and I suspect the rarity of food bones largely to be a product of poor bone preservation in the shallow contexts of most Tosawihi sites.

Chapter 15

PLANT MACROFOSSILS

Elizabeth E. Budy

Thirty-seven sediment samples from carbonized features at four sites (26Ek3251, 26Ek3237, 26Ek3092, and 26Ek3198) were floated and their light fractions examined for charcoal, seeds, and other plant macrofossils. The intent was to isolate data informative of feature function, subsistence patterns, season of site use, and past plant communities.

Methods

Two liter sediment samples were processed through an agitated flotation system segregating light organic material (e.g., woody charcoal, rootlets, seeds) from the soil matrix (cf. Wagner 1982). The light fraction was collected in a series of graduated meshes (3.2 mm, 1.5 mm, and cheesecloth), dried, and scanned under 10x - 20x magnification. The heavy fraction was collected in 1.5 mm mesh screen.

Where possible, seeds were identified by comparison with known specimens collected by the author and seminal collections at the University of Nevada (Reno) Herbarium. Additional light fraction constituents (e.g., woody charcoal, feces, rootlets) were noted and/or weighed, but species identifications were not attempted systematically.

26Ek3251

One sample was collected at 26Ek3251 from a faint charcoal stain 26 cm below surface (Feature 6). The light fraction contained tiny bits of woody charcoal (mostly *Artemisia tridentata*) and a number of charred seeds (Table 112).

Table 112. Light Fraction Recovery from Feature 6, Site 26Ek3251.

Sample Number	Charcoal (gm)	Charred Seeds	Fresh Seeds	Inclusions
1	<1	3 *Carex* sp. 28 POACEAE (cf. *Phleum, Muhlenbergia, Poa*) 1 Unidentified	2 *Chenopodium* (cf. *album*)	rootlets

The sample is dominated by small grass seeds (POACEAE), including alpine timothy (*Phleum* cf. *alpinus*) and either muhly (*Muhlenbergia* sp.) or bluegrass (*Poa* sp.). Alpine timothy generally is a high elevation plant, but it can be found at lower elevations in wet environments (Linda Nelson, UNR Herbarium, personal communication 1990). All these grasses are common inhabitants of wet streambanks (Cronquist et al. 1977); the assemblage of grass and sedge (*Carex* sp.) seeds suggests a more productive riparian habitat near the site in the past than prevails at present.

Willow Creek now is deeply entrenched (ca. 3 m), and its former floodplain (occupied by 26Ek3251) is blanketed by a thick cover of big sage and a sparse understory of cheatgrass. In the past, such areas likely hosted rich and diverse stands of native grasses as did similar streams tributary to the upper Humboldt (Tremewan 1964). The invasion of shrubs into former grasslands as a result of fire suppression and intensive livestock grazing is well documented (Young et al. 1976). Charred seeds from Feature 6 suggest a wider riparian belt when 26Ek3251 was occupied (little grows in the steep cut of Willow Creek channel today); spring or early summer visits concurrent with seedripe (Munz and Keck 1973) may have exploited the seasonal harvest.

The charred seeds from Feature 6 are not unequivocally the products of food processing. Fowler (1986:73, 76) lists species of *Poa*, *Muhlenbergia*, and *Carex* as common aboriginal food plants in the Great Basin, but our recovered seeds are very small and their harvest would have entailed high costs relative to caloric returns (cf. Simms 1985). On the other hand, they are unusually numerous considering the small amount of associated woody charcoal. Seed coats generally are intact, suggesting transformation under very low heat (as from parching). Apart from two fresh lambsquarter seeds (*Chenopodium album*), an introduced plant common to disturbed or over-grazed areas, there are few recent inclusions. The charcoal stain of Feature 6 may be the remnant of a seed parching area associated with a hearth, most of which has been lost to deflation or erosion.

26Ek3237

Sediment samples from site 26Ek3237 were taken from three hearth-like charcoal concentrations (Features 2, 3, and 4) and one rock pile (Feature 5). All but one were collected as vertical sections of feature interiors (i.e., from central charcoal concentrations). The hearth samples are characterized by abundant woody charcoal (mainly *Artemisia tridentata*) and a sparse scattering of diverse charred seeds (Table 113).

Table 113. Sample Provenience and Light Fraction Constituents, Site 26Ek3237.

Sample Number	Feature Number	Depth (cm below Surface)	Feature Context	Woody Charcoal (gm)	Charred Seeds	Fresh Seeds	Other Inclusions
1	2	2-10	Inside	23	1 *Plantago* sp.	none	rootlets
2	2	10-20	Inside	13	none	none	rootlets
3	3	16-20	Inside	6	none	none	rootlets
4	3	16-20	Outside	<1	none	none	1 leaf
7	3	20-30	Inside	20	none	1 POACEAE	rootlets
6	4	40-50	Inside	5	1 Unidentified *4 *Carex* sp.	1 *Chenopodium* (cf. *album*)	rootlets
8	4	30-40	Inside	18	1 *Brassica* (?) (cf. *nigra*)	none	rootlets
9	4	40-50	Inside	22	none	none	rootlets
11	5	30-40	Rock Pile	<1	1 POACEAE	none	rootlets

* These consist of split perigynia that are only lightly charred (or perhaps merely stained dark).

Charred seeds from the hearths include one plantain (*Plantago* sp.) in Feature 2, and four *Carex* perigynia, one possible mustard seed (*Brassica* sp.), and one unidentified specimen from Feature 4. Feature 5, the rock pile, included one charred grass seed. All species represented were used aboriginally for food or medicine (Fowler 1986; Train, Henricks, and Archer 1957), but sample interpretation is problematic. The possible mustard seed is similar

to the introduced *Brassica nigra*. The *Carex* perigynia (fragile papery covers enclosing the seeds) may simply be stained rather than charred. Great Basin peoples used plantain for medicine, the leaves to reduce swellings and root decoctions for colds (Train, Henricks, and Archer 1957:79-80); more generally, however, the seeds are known for their laxative powers (Munz and Keck 1973:405), with no record of their use as food.

The charred seeds from 26Ek3237 may well be incidental inclusions rather than subsistence products. As environmental indicators, plantain and sedge signal persistently wet riparian habitats, while mustard is common to disturbed and over-grazed dry sites.

26Ek3198

Plant macrofossils from two samples from a hearth at 26Ek3198 provide little evidence of prehistoric subsistence or environment (Table 114).

Table 114. Sample Provenience and Light Fraction Constituents, Site 26Ek3198.

Sample Number	Feature Number	Depth (cm below Surface)	Feature Context	Woody Charcoal (gm)	Charred Seeds	Fresh Seeds	Other Inclusions
14	25	15-20	Outside	<1	1 Unidentified	1 *Chenopodium* (cf. *ambrosioides*)	rodent feces, insect casings, rootlets
23	25	10-20	Inside	3.3	1 fruit fragment (cf. *Amelanchier* sp.)	none	rootlets

Sample 14 included many recent inclusions, among them a pigweed seed resembling introduced *Chenopodium ambrosioides*; a single unidentifiable charred seed also was recovered. Sample 23 included the apparently charred remains of a small fruit, probably serviceberry (*Amelanchier* sp.), a local resident species.

26Ek3092

Most of the sediment samples analyzed are from 26Ek3092 (Table 115). Two charcoal features thought to be heat-treatment hearths (Features 9 and 24) were examined with multiple samples. Two samples were taken from a nonfeature column for control, and one is from fire-altered soil below a charcoal stain (Feature 18).

Fourteen samples from Feature 9 were selected at different depths from both inside and outside the hearth basin. Charred seeds recovered from the hearth and its vicinity include buckwheat (*Eriogonum* sp.), sedge (*Carex* sp.), plantain (*Plantago* sp.), and various grasses (POACEAE), including one specimen from Sample 24 that looks like bent grass (*Agrostis* sp.). Except for plantain, the seeds are from plants used aboriginally for food (Fowler 1986:69-79; Stewart 1941:374; Steward 1938:306-310), and all of which grow in the vicinity today.

The small number of charred seeds does not suggest intensive subsistence functions for Feature 9; rather, it would appear that some seeds were altered incidental to primary use of the hearth for heat-treatment of stone. The restricted distribution of charred seeds in samples adjacent the hearth and on its south side (i.e., between the fire pit and the large boulder; cf.

Chapter 16) supports the notion. A food preparation or eating area may be located here, maximizing shelter provided by the boulder.

Table 115. Sample Provenience and Light Fraction Constituents, Site 26Ek3092.

Sample Number	Feature Number	Depth (cm below Surface)	Feature Context	Woody Charcoal (gm)	Charred Seeds	Fresh Seeds	Other Inclusions
4	9	20-30	Outside/ adjacent	<1	none	1 *Chenopodium* (cf. *album*)	rootlets
5	9	20-30	1 meter outside	<1	1 *Eriogonum* sp. 1 POACEAE	none	rootlets
13	9	27-30	Outside/ adjacent	<1	none	none	rootlets
14	9	27-30	1 meter outside	<1	none	none	rootlets
15	9	33	Inside	26	1 POACEAE	3 *Chenopodium* sp. 2 *Bromus tectorum*	rootlets
18	9	33	Outside	<1	none	1 grass spike frag. (*Bromus tectorum* ?)	rootlets, grass chaff
19	9	33	Outside/ adjacent	<1	2 *Eriogonum* sp.	1 *Chenopodium* (cf. *album*)	rootlets, grass chaff
24	9	34-40	Outside/ adjacent	48	1 POACEAE (cf. *Agrostis*)	none	rootlets
26	9	40-47	Bottom/ inside	15	2 *Carex* sp. 2 Unidentified (possible CYPERACEAE)	none	rootlets
27	9	40-48	Bottom/ inside	<1	none	none	rootlets, grass chaff
33	9	33-40	Inside	17	none	3 *Bromus tectorum* 1 *Chenopodium* sp.	rootlets
37	9	40-43	Bottom/ inside	8	none	2 *Chenopodium* sp.	rootlets, grass chaff
38	9	40-44	Bottom/ inside	<1	none	none	rootlets
39	9	33-35	Outside/ adjacent	<1	1 *Plantago* sp.	5 *Chenopodium* (cf. *ambrosioides*)	rootlets
12	18	18-30	Below F.17 Basin	<1	none	4 *Chenopodium* (cf. *album*)	rootlets, matted fiber (cf. rodent nest)
28	N/A	10-20	Column Sample	<1	2 Unidentified	none	rootlets, grass chaff, insect casings
30	N/A	30-40	Column Sample	<1	none	none	rootlets
43	24	63	Below Cobbles	<1	1 Unidentified	16 *Chenopodium* (cf. *ambrosioides*)	rootlets
45	24	60-70	Inside	<1	none	none	rootlets
46	24	65-67	Inside	<1	none	none	rootlets
48	24	67-70	Inside	<1	1 POACEAE	1 *Chenopodium* (cf. *album*)	rootlets
50	24	72-76	Inside	<1	none	none	rootlets
52	24	80	Inside	<1	none	1 *Chenopodium* (cf. *album*)	rootlets
55	24	85-90	Inside	<1	none	3 *Chenopodium* sp.	rootlets, lichen (?), rodent feces
57	24	80-90	Inside	<1	1 POACEAE	1 *Chenopodium* sp.	rootlets, rodent feces

Likewise, it is possible that seeds naturally introduced from the nearby stream (e.g., *Carex* and *Plantago*) and adjacent dry slopes (e.g., *Eriogonum*) were burned incidentally during use of the Feature 9 hearth. However, nonfeature column samples (Samples 28 and 30) include none of the species found charred in Feature 9. In any case, seed samples provide some indications of season of aboriginal use; as grasses ripen in early summer (March-July) and buckwheat matures variously by species throughout summer (May-August; cf. Munz and Keck 1973), an early summer use of Feature 9 is suggested.

The eight samples from Feature 24 yielded only two charred grasses and one unidentified specimen (cf. Table 115); all are severely modified as if from high heat, although virtually no charcoal was recovered. The samples provide little clear indication of subsistence, season, or environment. Recent rodent disturbance is noted in these deep deposits, both from feces in Samples 55 and 57 as well as from the numbers of introduced pigweed seeds (*Chenopodium album* and *C. ambrosioides*).

Finally, Sample 12 from Feature 18 included no burned seeds, but matted plant fiber in the light fraction resembles rodent nesting material.

Chapter 16

ARCHAEOLOGY OF THE WESTERN PERIPHERY

Melinda Leach, Daniel P. Dugas, and Robert G. Elston

West of the Tosawihi Quarries lies a steeper, more dissected terrain that offered prehistoric quarriers a wholly different suite of resources (Figure 98). In this Western Periphery are the occasionally watered canyons, seeps and pools, and root-bearing slopes that provided temporary campsites, foraging opportunities, and tool production workshop locales. The area subsumes approximately 480 acres (194 hectares) of moderately sloping terrain adjacent the principal Quarries (Figure 99). The physical settings of the larger Tosawihi study region and the more confined Western Periphery have been described in detail by others (Elston, Raven, and Budy 1987; Budy 1988, 1989; Budy, Elston, and Raven 1989). We provide a brief review here.

Moderate (10–30%) to steeply (30–50%) sloping ridge lines broken by small flats, basins, terraced knolls, and saddles characterize the topography of the western area. From Twin Buttes (6125 ft, 1867 m amsl) at the northwestern extreme, the study area descends across a series of southeast-trending ephemeral drainages that empty into Little Antelope Creek Canyon (5425 ft, 1654 m amsl) on the east, terminating at a ridgecrest. Rodent Valley, a small elevated basin, lies at the northern edge of the area and marks a transition zone between the primary toolstone sources in the Quarries to the north and the intensively exploited, though localized, outcrops on Red Hill to the south (Budy 1989).

Red Hill (5820 ft, 1774 m amsl) is a distinctively colored, terraced knoll punctuating the southern edge of Rodent Valley. Intensive minerals exploration since 1963 has circumscribed the knoll with jeep trails, dirt roads, and drill pads. The south slope of Red Hill descends abruptly to Basalt Canyon, a narrow, steep-sided drainage that bisects the study area and flows ultimately into Little Antelope Creek Canyon. The canyon is bordered on the southwest by a series of thinly-mantled, southeast-trending ridgelines that comprise the Bitterroot Ridge Complex (Budy 1989).

Unlike the adjacent Quarries, the Western Periphery is not a rich repository of lithic sources; abundant deposits of opalite are rare, save for small outcrops on Red Hill and in Rodent Valley. Occasionally, prehistoric quarriers collected opalite cobbles from the drainage gravels of Basalt Canyon. As well, cobbles and slabs of tabular andesitic basalt, which surface along knolls forming prominent talus stripes on the steeper slopes of the study area, were transported to nearby localities for use in the manufacture of percussion and digging tools and seed-grinding implements (Budy 1988:10).

Undifferentiated tuff caps Red Hill and adjacent portions of the Western Periphery above about 5700 ft (1737 m) amsl on the northeastern slopes of Basalt Canyon (Cornucopia 1987). The tuff contains pockets of silicified reworked tuffaceous sediments and is capped here and there by patches of sinter. The lower southern slopes and nearly all the terrain southwest of Basalt Canyon are mapped as basalt (Cornucopia 1987). A relict cap of tuff with some silicification occurs on the top and southeastern slopes of Prospector Point, and a couple of small silicified basalt ("jasper") outcrops have been mapped, but these do not appear to have been quarried prehistorically.

No permanent water sources exist within the Western Periphery. Ephemeral seeps and streams in the Little Antelope Creek, Velvet, and Basalt Canyon drainages provide water only seasonally, as do several temporary springs just beyond the boundaries of the subarea.

The western area supports vegetative communities typical of the Sagebrush-Grassland zone that dominates the high desert valleys and foothills of the northern Great Basin (Elston,

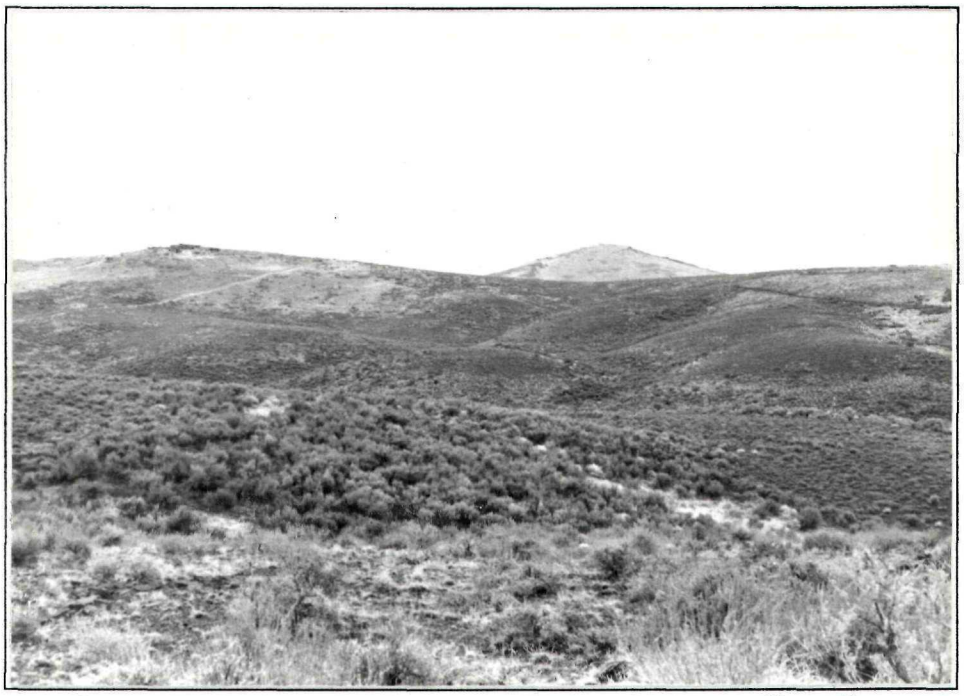


Figure 98. Overview (north) of the Western Periphery. Twin Butte on western horizon, Red Hill on eastern horizon, Basalt Canyon at photo center, and Big Butte in background.

Raven, and Budy 1987:7). A low sage community, converging on basaltic ridges where soils are thin, includes low sage, phlox, snakeweed (*Gutierrezia sarothrae*), green rabbitbrush (*Chrysothamnus viscidiflorus*), and occasional bunch grasses, such as squirreltail and Idaho fescue (*Festuca idahoensis*). Several plants with edible tubers are moderately abundant, as well, on thin soils edging the ridgetops of Bitterroot Ridge (Budy 1989:213). These include, not surprisingly, bitterroot, onion (*Allium* sp.), and sego lily (*Calochortus nuttalli*). Big sage, with occasional rubber rabbitbrush (*Chrysothamnus nauseosus*), Great Basin wildrye, and bluebunch wheat grass grow on steep north-facing slopes, in drainage bottoms, and where soils attain some depth on ridge tops (Budy 1988:11).

Recently observed fauna include coyote, cottontail rabbit, chipmunk, and badger. Antelope and mule deer also are known to frequent the area seasonally (Elston, Raven, and Budy 1987:8).

Descriptive Site Summary

Unlike the virtually continuous distribution of prehistoric materials in the primary quarry zone north and east, the 129 prehistoric sites identified in the Western Periphery are spatially distinct (Figure 100; cf. Budy 1988), and many are functionally diverse. These sites include quarries focused on opalite exposures, possible short-term residential loci containing food-processing implements and exotic materials, small lithic scatters, lithic reduction loci, and isolated artifacts (Budy 1988:i).

From the 129 sites identified in our initial reconnaissance, 30 quarry and non-quarry locales were selected for testing of surface and subsurface deposits (cf. Figure 100; cf. Budy 1989). Seven proved significant particularly for the information they could provide in support

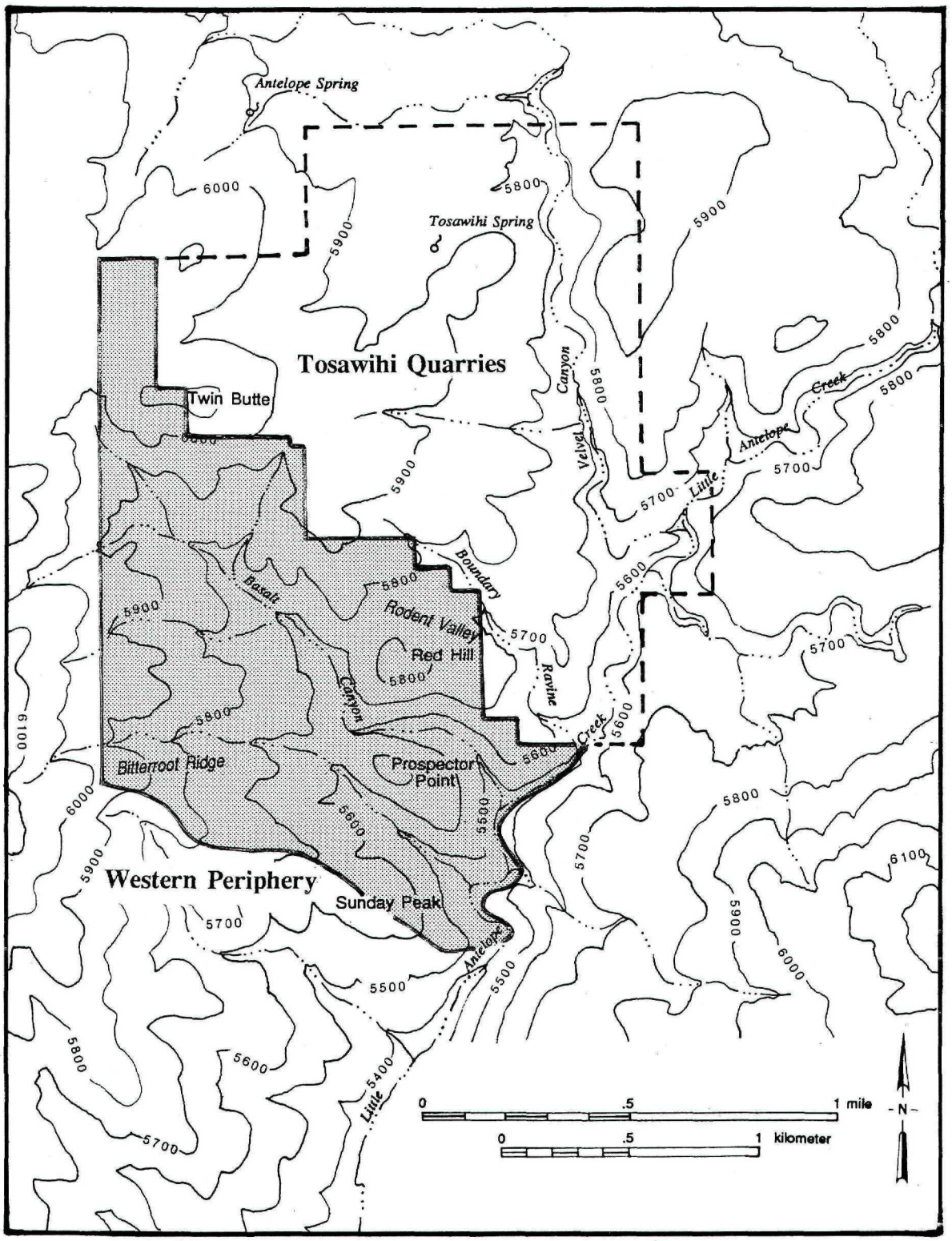


Figure 99. Topography of the Western Periphery.

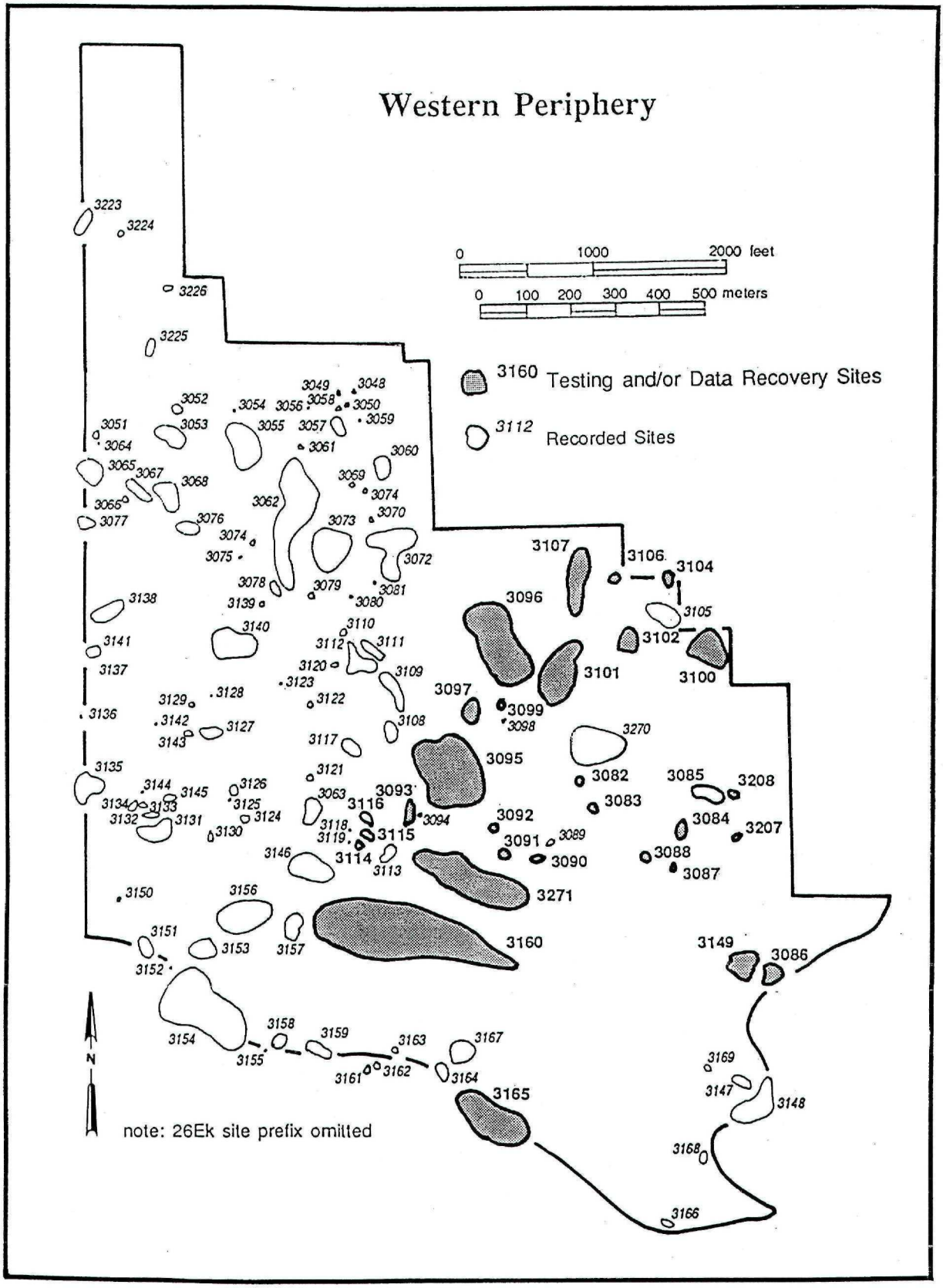


Figure 100. Locations of sites in the Western Periphery.

of research issues outlined for the Tosawihi study area (cf. Elston 1988a; Intermountain Research 1988b). These sites warranted more intensive data recovery, and in 1989 we returned to them for further excavation (Table 116).

Table 116. Sites Investigated in the Western Periphery.

Site	Quarry Features (n)	Non-Quarry Features† (n)	Elevation (ft. amsl)	Maximum Site Area (sq m)
26Ek3082 (T)	+	3	5775	300
26Ek3083 (T)	+	-	5700	2,000
26Ek3084 (T,DR)	1	1	5600	4,250
26Ek3085 (T,DR)	5	-	5750	1,178
26Ek3086 (T)	-	-	5750	1,100
26Ek3087 (T)	-	-	5530	300
26Ek3088 (T)	-	-	5545	650
26Ek3090 (T)	-	-	5595	150
26Ek3091 (T)	-	-	5605	400
26Ek3092 (T,DR)	-	24	5625	4,800
26Ek3093 (T)	-	6	5750	1,875
26Ek3095 (T,DR)	-	25	5650	15,000
26Ek3096 (T)	-	7	5775	14,250
26Ek3097 (T)	-	-	5700	500
26Ek3099 (T)	-	4	5735	750
26Ek3100 (T)	-	2	5725	5,850
26Ek3101 (T)	-	-	5775	11,250
26Ek3102 (T)	-	5	5850	2,400
26Ek3104 (T)	+	-	5775	600
26Ek3106 (T)	-	7	5800	5,175
26Ek3107 (T)	-	5	5800	6,750
26Ek3114 (T)	-	1	5765	100
26Ek3115 (T)	-	1	5775	100
26Ek3116 (T)	-	1	5780	200
26Ek3149 (T)	-	3	5500	2,500
26Ek3160 (T,DR)	-	25	5575	46,000
26Ek3165 (T,DR)	-	2	5670	4,500
26Ek3207 (T)	+	-	5670	1,200
26Ek3208 (T,DR)	3	-	5740	10,367
26Ek3271 (T)	-	22	5650	19,500

† Prehistoric features only
(T) Testing only performed
(T,DR) Testing and data recovery performed
+ Sites with on-site opalite sources, yet which lack discrete quarry features

Quarry Locales

Quarry locales in the Western Periphery range from exposed opalite outcrops (associated with accumulations of quarry debris) to prehistorically excavated quarry pits, to surficial cobble beds from which quarrying material was collected. Toolstone sources vary in both quality and quantity of exploitable material. With little evidence of on-site activities other than toolstone procurement, quarry assemblages are dominated by debitage and shatter, numerous assay chunks, cores, hammerstones, biface blanks, and fragments.

Rimrock exposures on the steep southern slope of Red Hill constitute the primary opalite outcrops in the West, and these were used enthusiastically by prehistoric quarriers. Indeed, one

Red Hill quarry pit complex (26Ek3208) is among the most intensively exploited opalite outcrop so far observed at Tosawihi. Its numerous pits and deeply stratified accumulations of quarry and reduction debris reflect extraordinary expenditures.

Six quarry sites (26Ek3082, 26Ek3083, 26Ek3084, 26Ek3085, 26Ek3207, and 26Ek3208) oriented around the Red Hill opalite exposures were tested, and three (26Ek3084, 26Ek3085, 26Ek3208) received additional data recovery (cf. Budy 1989; Intermountain Research 1988b). We also tested one small outcrop quarry (26Ek3104) situated in Rodent Valley, north of Red Hill.

Non-quarry Locales

Lithic Reduction Stations and Complexes

These sites generally are characterized by relatively little tool diversity and a notable scarcity of projectile points and maintenance or processing tools. They are the archaeological remains of discrete core and biface reduction episodes, yielding cores, bifaces, occasional flake tools, debitage, and shatter. Small reduction scatters may represent single episodes of tool production, while larger complexes with overlapping features may result from multiple visits and/or longer-term use.

Seven of the non-quarry locales we investigated (26Ek3086, 26Ek3087, 26Ek3088, 26Ek3090, 26Ek3091, 26Ek3097, 26Ek3099) rest on the lower slopes of steep-sided Basalt Canyon (cf. Figure 100); four others (26Ek3093, 26Ek3114, 26Ek3115, 26Ek3116) lie on elevated benches along Bitterroot Ridge, overlooking Basalt Canyon (Budy 1989). The remaining reduction complexes we examined (26Ek3096, 26Ek3100, 26Ek3101, 26Ek3102, 26Ek3106, 26Ek3107) consist of large, diffuse sites clustered in Rodent Valley.

Reduction/Residential Complexes

Reduction/residential sites characteristically reveal diffuse to concentrated deposits of toolstone-processing debris, sometimes arrayed in discrete activity areas, accompanied by diverse assemblages suggesting domestic activities. Assemblages may include projectile points, preforms, pottery, choppers, flake tools, abraders, ground stone, cooking and heat-treating hearths, scrapers, hammerstones, bifaces, and cores. In the Western Periphery, residential complexes appear to represent relatively short-term campsites, although they unquestionably were re-occupied, sometimes over millennia.

We investigated six residential complexes to define the structure of social groups exploiting the Quarries and to clarify the logistical patterning of their toolstone collection and subsistence forays (cf. Chapters 4, 24, 26). One stratified, buried site (26Ek3092), probably occupied over many, relatively short-term episodes, lies in the broad meadow adjacent the seasonally-watered floor of Basalt Canyon (cf. Figure 100). 26Ek3149, hosting several features and a diverse tool assemblage, is located on the rocky eastern slope of Basalt Canyon, above its confluence with Little Antelope Creek. We investigated four additional reduction loci with subsistence-related assemblages (26Ek3160, 26Ek3165, 26Ek3095, 26Ek3271) among the elevated ridges and slopes of the Bitterroot Ridge Complex.

Testing and Data Recovery Methods and Results

Testing at 30 sites in the Western Periphery consisted of intensive surface reconnaissance, mapping, and systematic artifact collections based on close-order transect survey. All formal artifacts

and obsidian suitable for sourcing were collected, and discrete features were defined by characterizing surface debitage patterns.

In specific instances, where concern with site structure, site function, or site formation processes demanded, we undertook controlled surface scrapes and subsurface excavation, sampling both discrete reduction features and inter-feature areas where present (Table 117).

Table 117. Summary of Collection Procedures, Western Periphery.

		FEATURES RECORDED		FEATURE CONTEXT		NONFEATURE CONTEXT	
Site Number	Phase	Total (n)	Sampled (n)	Surface Scrape (m^2)	Subsurface Excavation (m^3)	Surface Scrape (m^2)	Subsurface Excavation (m^3)
26Ek3082	T	3	1	0.06	-	-	-
26Ek3083	T	-	-	-	-	-	-
26Ek3084	T	2	2	0.50	- *	-	-
	DR	-	1	-	- *	-	-
26Ek3085 - See 26Ek3208							
26Ek3086	T	-	-	-	-	-	-
26Ek3087	T	-	-	-	-	-	-
26Ek3088	T	-	-	-	-	-	-
26Ek3090	T	-	-	-	-	-	0.45
26Ek3091	T	-	-	-	-	-	-
26Ek3092	T	6	-	-	-	-	2.30*
	DR	19	19	-	1.51	-	22.75*
26Ek3093	T	6	1	49.00	0.09	-	-
26Ek3095	T	25	5	28.31	0.59	-	-
	DR	-	6	-	11.23	-	-
26Ek3096	T	7	1	4.00	-	-	-
26Ek3097	T	-	-	-	-	-	-
26Ek3099	T	4	-	-	-	-	-
26Ek3100	T	2	1	2.00	-	-	-
26Ek3101	T	-	-	-	-	2.00	0.70*
26Ek3102	T	5	1	8.00	-	-	-
26Ek3104	T	-	-	-	-	-	0.03
26Ek3106	T	6	2	42.00	0.24	1.00	-
26Ek3107	T	5	1	4.00	-	-	0.01*
26Ek3114	T	1	1	10.00	-	-	-
26Ek3115	T	1	1	-	-	10.00	-
26Ek3116	T	1	1	12.00	-	-	-
26Ek3149	T	3	1	4.00	-	-	0.25
26Ek3160	T	23	6	50.00	0.09	-	1.20
	DR	2	6	57.00	2.16	-	9.30
26Ek3165	T	2	2	16.00	-	-	0.25
	DR	-	1	32.00	0.64	-	3.70
26Ek3207	T	-	-	-	-	0.06	-
26Ek3208/3085	T	8	1	-	- *	-	-
	DR	-	1	-	- *	-	-
26Ek3271	T	22	5	67.00	0.56	-	0.20

* Backhoe or hand excavated trenches were placed in these contexts; their volume is not included.

Because quarrying locations regularly manifest massive accumulations of lithic debris that defy standard collection procedures, we employed in these settings methods aimed at reducing the bulk of redundant material while still recovering adequate information about reduction strategies. Each quarry locale was scrutinized for surface artifacts, time-markers, and toolstone extraction features. We documented physical characteristics of the geological formation, noted dimensions and density of associated lithic scatters, and mapped discrete features. Artifacts were collected, as were samples of opalite for chemical sourcing studies. We conducted no further collection at sites with little surface variability or cultural depth. Where quarry pit features and thick reduction debris deposits were evident, however, we opened backhoe trenches; profile drawings recorded natural and cultural stratigraphy. We collected measurable charcoal for ^{14}C assay, as well as strata-based bulk samples for mass debitage analysis.

A detailed discussion of the character and findings at each of the investigated sites follows. Formal artifacts recovered during the Tosawihi testing and data recovery phases are shown in Table 118, where frequencies differ, occasionally, from those reported in earlier volumes of testing phase results (Intermountain Research 1988b; Elston 1989). With increased insight gained from in-depth analyses, we have re-evaluated some classes of artifacts, and present new ascriptions here.

Table 118. Artifacts Recovered from Sites in the Western Periphery During Testing and Data Recovery.

	DEBITAGE[b]		FORMED ARTIFACTS										
Site	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
26Ek3082	4	17.9	-	-	-	-	-	-	-	-	-	-	0
26Ek3083	-	-	-	-	-	-	-	-	-	-	-	-	0
26Ek3084	8,476	25,651.4	-	-	2	-	3	-	4	-	-	1	10
26Ek3085	-	-	-	-	1	-	-	-	2	-	-	-	3
26Ek3086	-	-	-	-	4	-	2	-	-	-	-	-	6
26Ek3087	-	-	-	-	4	-	-	-	-	-	-	-	4
26Ek3088	-	-	-	-	3[a]	-	1	-	-	-	-	-	4
26Ek3090	120	616.5	-	-	5	-	1	-	-	-	-	-	6
26Ek3091	-	-	-	-	6	1	-	-	-	-	-	-	7
26Ek3092	132,194	177,392.5	37	29	530[a]	13	147	7	22	8	60	5	858
26Ek3093	2,575	2,925.8	2	6	38	2	3	-	1	-	-	-	52
26Ek3095	82,493	76,690.8	36	17	480[a]	7	59	4	13	13	-	17	646
26Ek3096	790	996.9	-	-	13	-	-	1	3	1	-	-	18
26Ek3097	-	-	-	-	-	-	-	-	-	-	-	-	0
26Ek3099	-	-	1	-	7	1	-	-	2	-	-	-	11
26Ek3100	845	2,883.3	-	-	-	-	-	1	-	-	-	-	1
26Ek3101	2,120	1,818.5	1	-	21	-	3	1	1	-	-	-	27
26Ek3102	1,369	6,677.0	1	-	11	-	1	1	-	-	-	-	14
26Ek3104	1,328	3,856.8	-	-	7	4	-	1	2	-	-	-	14
26Ek3106	12,420	26,416.1	2	-	50	2	3	1	2	1	-	-	61
26Ek3107	1,614	4,822.7	1	-	4	-	-	-	1	-	-	-	6
26Ek3114	3,772	5,024.9	1	-	15	-	2	-	1	-	-	-	19
26Ek3115	1,787	1,887.7	-	-	8	-	4	-	-	-	-	-	12
26Ek3116	2,383	3,500.4	6	3	11	-	8	-	-	-	-	-	28
26Ek3149	468	561.3	3	-	12	-	4	-	1	2	-	-	22
26Ek3160	47,034	62,673.4	58	51	756[a]	2	83	4	11	18	61	3	1,047
26Ek3165	13,067	16,331.4	3	3	75[a]	-	10	1	-	4	-	-	96
26Ek3207	7	184.5	-	-	-	-	-	-	-	-	-	-	0
26Ek3208	175,455	244,122.5	1	-	-	-	3	-	6	-	-	2	12
26Ek3271	53,252	67,525.2	23	10	372[a]	6	44	2	18	6	-	-	481
Totals	543,573	732,577.5	176	119	2,435	38	381	24	90	53	121	28	3,465

[a]Count includes "possible" bifaces
[b]Includes obsidian surface debitage isolates

Quarry Locales

26Ek3082, 26Ek3083, and 26Ek3207

26Ek3082, 26Ek3083, and 26Ek3207 surround small outcrop exposures on the south slope of Red Hill, and are characterized by amorphous zones of quarry debitage. These outcrops were exploited minimally, and their assemblages reflect mostly primary material assay and preliminary toolstone reduction (Budy 1989:169–176). Evidently, the quality of the toolstone did not warrant more labor-intensive exploration. No intrusive quarry pit features are present, although a shallow adit-like excavation was observed in the outcrop at 26Ek3082; three small (< 2 m^2) reduction features were noted along the outcrop as well.

26Ek3082 and 26Ek3207 lie in the vicinity of bedrock mapped as silicified reworked tuffaceous sediments, exposed on the southern margin of the tuff beds capping Red Hill. 26Ek3083, however, lies farther down the southern flank of Red Hill, well within the basalt that underlies the tuff. A small, white opalite outcrop in this terrain suggests that a chunk of silicified tuff broke off the margin of the tuff cap and slid down the colluvial slope to rest on the basalt erosional surface.

We tested 26Ek3082 and 26Ek3207 by employing a series of small (25 cm x 25 cm) surface scrapes to recover technological information (cf. Table 118 for debitage yields from this exercise). We collected nothing at 26Ek3083 save a rock sample for potential chemical sourcing and lithic comparison. None of these small quarry sites warranted additional data recovery, owing to the minimal variability reflected in surface deposits and the apparent lack of subsurface accumulations (Budy 1989:172).

26Ek3084

26Ek3084, the smallest of the Red Hill quarry pit sites, lies on the steep (25–45%) southern slope of the knoll. Prehistoric toolstone procurement was directed at a colorful, high quality, jasper outcrop producing reduction debris in various shades of greenish-white, brown, yellow, orange, red, maroon, and purple. Indeed, the distinctive colors and composition of the material at this source make it possible to trace lithic material transport from 26Ek3084 to nearby reduction stations.

Excavation Methods and Rationale

At this discrete, intensively exploited quarry we observed a shallow depression, apparently the remnant of a prehistoric quarry pit (Feature 1), an associated pile of quarry rubble (Feature 2) surfacing midway down the slope near the center of the site, and a larger lithic scatter (Figure 101) from which we collected an early stage biface. The two features provided an opportunity to collect specific information about opalite extraction strategies, raw material variability, and staged reduction trajectories.

Features 1 and 2 were transect-sampled via small, regular surface collections for the recovery of debitage samples. The Feature 1 depression, truncated by a jeep trail, was trenched through its midline to verify its subsurface identity, to isolate the source of the toolstone, and to expose its internal structure for stratigraphic profiling. Once trenching was accomplished, dangerously unstable slope deposits prohibited our planned column excavations in exposed walls. Data collection was limited therefore to stratigraphic analysis and lithic sampling.

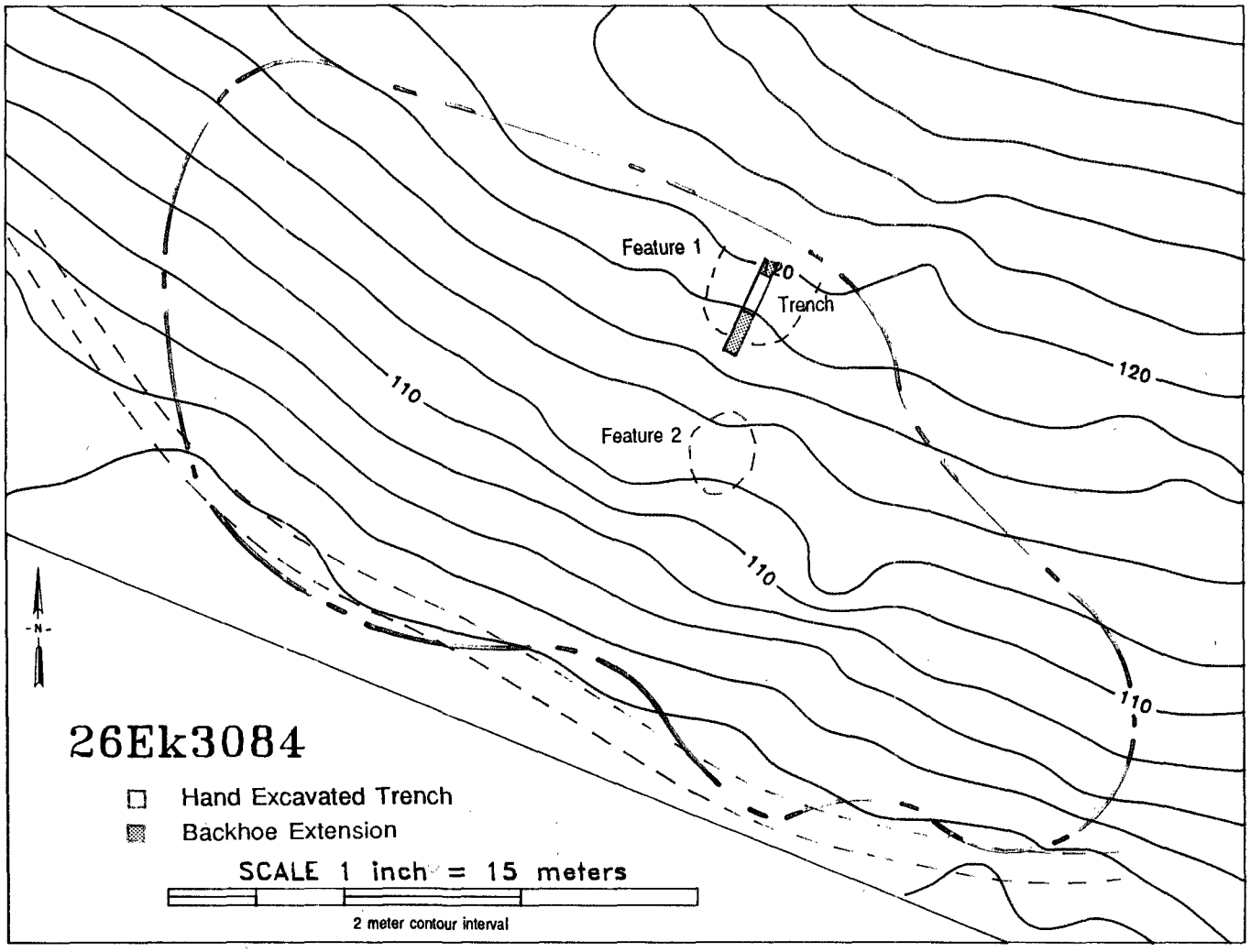


Figure 101. 26Ek3084 site map.

Feature 1

Feature 1, a shallow surface depression measuring approximately 1.5 meters in diameter, was plan mapped and a systematic surface collection was undertaken during testing phase. We aligned a four-meter transect across the north-south axis of the feature, parallel to the slope, to crosscut the depression and intersect its berm (cf. Figure 101). Four surface scrapes (25 cm x 25 cm x 2 cm) were executed at one meter intervals along the transect, and the proceeds screened through 1/4 inch mesh. Opalite and jasper debitage, comprised mostly of core reduction debris, and a single retouched flake were recovered (Table 119).

Table 119. Summary of Artifacts Collected from Feature 1 at 26Ek3084.

		DEBITAGE			
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Flake Tools	Total
1 (SF)	.00125	6	10.9	-	0
2 (SF)	.00125	55	239.6	-	0
3 (SF)	.00125	51	459.4	1	1
4 (SF)	.00125	40	82.6	-	0
15 (TR)	N/A	8,177	22,946.1	-	0
Totals	.005	8,329	23,738.6	1	1

(SF) = Surface Scrape
(TR) = Backhoe or Hand-dug Trench

We then hand-excavated a trench (3 m x .6 m x 1.6 m) through the middle of the depression, exposing the berm and downhill edges of a prehistoric quarry pit. The revealed cross-section reflected several strata sloping north opposite the trend of the surface, varying in particle size, artifact content, and sediment color—the product of discrete quarrying events, including pit floor excavation and quarry waste disposal (cf. Budy 1989:178–182 for a detailed description of Feature 1 cultural stratigraphy revealed during testing).

Because our hand-excavated trench exposed only the margin of the quarry feature, and we surmised that the center of the pit and the toolstone extraction area must lie farther north under road fill, we deemed that further exposure was necessary to address research questions about site formation and toolstone extraction strategies more specifically (cf. Elston 1988a). In 1989, we returned to remove the overlying road fill that obscured the subsurface jasper formation, and extended the exposure with the use of a backhoe (Trench 2). Characterization of the revealed toolstone source was completed and a new stratigraphic profile (described below) was produced.

Twenty-three reduction debris samples were collected from discrete strata in the east wall of Trench 2 for technological characterization (cf. Table 119). Analysis of eighteen of them indicates at least two technological trajectories, including core reduction and Stage 2 biface reduction (cf. Chapter 10).

Quarry Pit Stratigraphy at Feature 1

Our 1989 backhoe trench (Trench 2) extended the hand-dug exposure (Trench 1) one meter to the north and three meters to the south, deepening it by approximately one meter. Retrenching also moved the profile face 50 cm east of the original. Stratigraphy remarkably

different in both extent and character was revealed in the new profile (Figure 102). Despite these differences, however, the overall depositional story is similar. An approximate match between the original and new profiles occurs where the 2.0 meter point of the 1989 profile (Figure 102) aligns with the 1.6 meter point of the 1988 profile (cf. Budy 1989:Figure 37a).

The following description of the stratigraphy of the Trench 2 profile provides definition of the strata as grouped by major horizons. Particle size, artifact content, and sediment color often change within a few centimeters, but it is possible to organize groups of strata into horizons, each a broad time-stratigraphic unit including one or more related events marked by surfaces and conformable strata. Horizon boundaries are virtually all truncation surfaces created by excavation through one or more strata of the underlying horizon. The reader should note that this unit horizon connection is used whenever possible in subsequent stratigraphic descriptions.

The duration of stratigraphic events probably varies considerably. For instance, surfaces were created through excavation (pit floors) and by deposition (surfaces of depositional units). Cultural surfaces, pit floors and slopes, and strata (layers deposited through quarrying and processing waste disposal) were created instantaneously in archaeological terms, while strata created through natural processes (colluviation, slope wash, eolian deposition) no doubt took longer to accumulate.

As described above, the bedrock at this location is highly altered material. Bedrock strata appear to dip toward the north. The lowest stratum in the stack observed here is soft, fine grained, tuff-like, white, orange, and pink rock. Originally identified as tuff (Budy 1989), it is more likely altered, leached, andesitic basalt (Bartlett, Enders, and Hruska 1991; Chapter 4, this volume). This is overlain by at least three layers or lenses of highly silicified, jasper-like rock, the object of quarrying here. From lowest to highest, the predominant colors of the layers are reddish-purple, white, brown, purple, and banded yellowish-brown to chocolate brown. The brown jasper is overlain by a dark purple layer ca. 50 cm thick of what appears to be clay loam, resulting from intense hydrothermal alteration that has completely transformed the parent material into clay. The argillicized layer in turn is overlain by ca. 1.5 m of altered, tuff-like bedrock containing angular gravel to cobble sized clasts, suggesting a colluvial origin.

The argillization and bright colors of the bedrock here are due to alteration and silicification of a paleosol (now the argillic layer) developed on middle to late Miocene basalt (Bartlett, Enders, and Hruska 1991:15–16). The silicified, jasper-like toolstone retains flaggy to bouldery structure reminiscent of that observed in unaltered basalt outcrops to the west, and probably is altered basalt.

The present south slope of Red Hill is an erosional surface that truncates all the strata described above, exposing the toolstone. Bedrock weathering from that surface in a zone 40–50 cm thick forms Units 2, 31, and 33. Unit 30 is older colluvium, with carbonates, that predates quarry pit excavation.

A series of generally alternating fine and coarse depositional episodes in the new profile form four distinct stratigraphic horizons in sediments filling quarry pits. *Horizon IV*, the oldest, is comprised of Units 2, 30, 31, 33. These natural deposits probably covered much of the bedrock surface before pit excavation took place. Units 23–29, 32, 34, and 35 of *Horizon III* are silty and compact with a fair amount of carbonate accumulation. They comprise the fill of the deepest pits visible, which were excavated through Units 30–33 into the bedrock. The units of Horizon III give the impression of having been in place for a fair amount of time and may have undergone pedogenesis; certainly,strata are less distinct. Unit 26 of this horizon appears to have formed from illuviation of carbonate, acquiring a distinct reddish color in the process. The truncation of the upper units (Units 23 and 23/25) is easily observed.

Deposits of *Horizon II* include Units 5–22, a series of complex, stratified coarse quarry debris and fine sediments. These are not as compact as units in Horizon III, but they do have notable carbonate accumulation, especially on the underside of the opalite clasts. Such carbonate accumulation in quarry debris is rare in the Tosawihi area. These units fill a pit excavated through Units 23 and 23/25 on the south and possibly Unit 2 on the north. The alternating coarse units of opalite chunks and debitage (6, 8, 11, 13, 15, 17, 19, 21) and fine sediments (7, 9, 10, 13, 14, 16, 8, 20, 22) appear to represent episodes of quarrying and processing on the one hand and periods of slope wash accumulation on the other. Many of the coarse units are characterized as "open framework," that is, deposits in which coarse pieces of rock lie on or against one another with open spaces between the clasts. These are divided into poor, moderate, or typical open frameworks, depending on the relative amount of space and finer matrix present. When matrix is abundant, and the larger pieces do not rest on one another, the deposit is described as "matrix supported."

Trenching apparently cut through the eastern quadrant of the quarry pit. Horizon II units exposed in the western trench wall were much thicker and coarser with larger overall particle size. This wall was not profiled because we anticipated collapse of the coarse, openwork sediments during wall cleaning.

Horizon I is comprised of Unit 1 and possibly Unit 4. Unit 1 is a poorly sorted mix of sandy silt with common subangular to subrounded pebbles and rare large tuff blocks. Although the deposit generally is homogeneous, pebble lines, vague color changes, and mottling are present. This unit probably originated by colluvial slopewash processes, but it has been disturbed by road construction as well.

The flaggy-bouldery structure of the toolstone seems to have made it relatively easy to extract. The virtual absence of charcoal in the pit deposits (unlike most of the other quarry features described in this report) suggests that fire setting was not necessary to assist procurement of toolstone from this source.

Feature 2

Feature 2, a thick deposit of quarry rubble located midway on the slope near the center of the site and about 10 m below Feature 1, supports no obvious outcrop or extraction features. Barring the possibility that there remain undiscovered subsurface quarry features, Feature 2 likely represents a colluvial deposit of larger items discarded from Feature 1. Lending support, the average weight per debitage item in Feature 2 is significantly larger than that in Feature 1 (12.5 gm and 3.7 gm, respectively; cf. Budy 1989:178).

We sampled Feature 2 by retrieving four hammerstones from the surface and by taking four small (25 cm x 25 cm) surface collections of opalite artifacts at one-meter intervals along the north/south axis of the talus pile (Table 120). This systematic sampling yielded a biface, a retouched flake, an end scraper, and a shaped, opalite shovelling implement (probably used for scraping quarrying debris out of the active pit).

Table 120. Summary of Artifacts Collected from Feature 2 at 26Ek3084.

		DEBITAGE		FORMED ARTIFACTS				
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Bifaces	Flake Tools	Perc./ Cobble Tools	Other/ Exotic	Total
1 (SF)	.00125	3	353.6	-	-	-	1	1
2 (SF)	.00125	21	656.8	1	1	-	-	2
3 (SF)	.00125	65	285.7	-	1	-	-	1
4 (SF)	.00125	58	616.7	-	-	-	-	0
Surface	N/A	-	-	-	-	4	-	4
Totals	1.005	147	1,912.8	1	2	4	1	8

(SF) = Surface Scrape

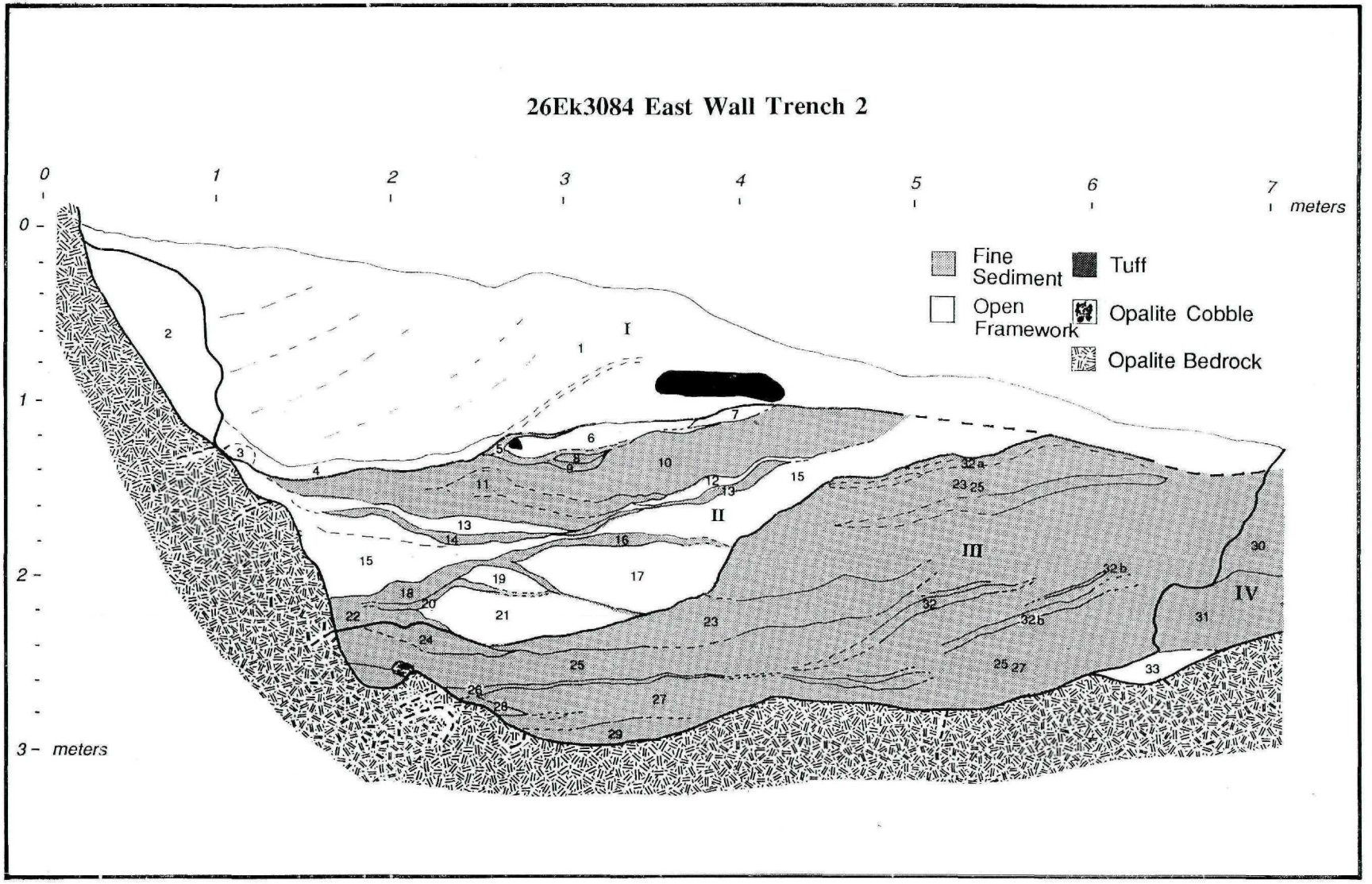


Figure 102. Description of stratigraphic units, Trench 2, Feature 1, 26Ek3084.

Figure 102. Description of stratigraphic units, east wall of Trench 2, Feature 1, 26Ek3084.

Horizon	Stratum	Description
I	1	Light brownish gray (2.5Y 6/2) dry; weak coarse mottling, brownish gray (10YR 6/2) dry; sandy, vesicular, silt, with common slope debris of sand to medium subangular to subrounded tuff pebbles; rare coarse angular tuff clasts; common fine to medium roots; boundary clear and irregular.
	3	Dusky red to weak red (10YR 3/2 to 5/4) dry; weathered bedrock clasts with chalky to clayey texture.
	4	Matrix supported, poor open framework, coarse to very coarse angular, banded yellow and purple, tuff chunks; sandy silt matrix as in Unit 1; strong reaction on calcareous coatings on the underside of large clasts, weak reaction in matrix.
II	5	Same as Unit 1.
	6	Moderate open framework, medium to coarse, yellowish brown to purple opalite chunks; moderate matrix as in Unit 1; along the bottom of this unit there is an accumulation of fine opalite chips.
	7	Dusky red (10YR 3/2) dry and grayish brown (10Yr 5/2) dry; sand and silt with common fine yellowish brown to purple opalite chunks.
	8	Poor open framework, fine to medium, yellowish brown to purple, opalite and tuff chunks and chips; common matrix as in Unit 7.
	9	Similar to Unit 7, except for a more grayish matrix from common charcoal.
	10	Pale brown (10YR 6/3) dry; silty sand; common poorly sorted sand to gravel; rare medium tuff and opalite chunks; moderate acid reaction of carbonate accumulated on underside of larger clasts.
	11	Matrix supported, poor open framework, medium to coarse, yellowish white, opalite and tuff chunks; matrix and carbonate as in Unit 10.
	12	Same as Unit 11.
	13	Moderate open framework, medium to coarse, yellowish brown to purple, opalite and tuff chunks; moderate silty sand matrix, pale brown (10YR 6/3) dry; strong acid reaction on carbonate accumulation on the bottom of clasts.
	14	Poor open framework, very pale brown to pale brown (10YR 7/3 to 6/3) dry; silty sand; common to rare medium opalite chips and chunks; moderate acid reaction on carbonate accumulations on the bottom of some larger tuff clasts.
	15	Typical to moderate, medium to coarse, open framework, fine to coarse, yellowish brown to purple opalite chips and chunks with some tuff; sorted generally coarse to fine from north to south in unit; sparse to common matrix and carbonate as in Unit 14.
	16	Same as Unit 14.
	17	Same as Unit 15.
	18	Same as Unit 14.
	19	Poor to moderate open framework, fine to very coarse, yellowish brown, opalite chips and chunks; moderate silty sand matrix same as Unit 14.
	20	Dusky red to weak red (10YR 3/2 to 5/4) dry; silty sand; common fine to medium yellowish brown to purple tuff chunks.
	21	Same as coarse parts of Unit 15.
	22	Same as Unit 23.
III	23	Pale brown to light brownish gray (10YR 6/3 to 6/2) dry; sandy silt loam; common fine to medium pebbles; moderate acid reaction on dispersed carbonate. Unit 23/25 is a combination of Unit 23 and Unit 25-like materials with intermittent pebble lenses; also some minor lenses of gray silt; 23/25 grades into Unit 1.
	24	Moderate open framework, fine to coarse yellowish brown and purple to gray opalite chunks, chips, and some possible flakes, also some tuff; general fining of clast size north to south; moderate sandy silt loam matrix as in Unit 23.
	25	Very pale brown to pale brown (10YR 7/3 to 6/3) dry, with weak mottling, reddish brown (10YR 5/3) dry; silty sand; common to rare medium opalite chips and chunks; strong acid reaction on carbonate accumulations on the bottom of some larger tuff clasts; firmly cemented by dispersed carbonate.
	26	Very distinct silty lens, banded and filamentous, white to weak red (10YR 4/2), with some yellowish red (10YR 5/6) banding in lowest part of unit; this material appears to be illuvial deposited.

Figure 102, continued.

	27	Same as Unit 25.
	28	Grayish brown (10YR 5/2) dry; sandy clayey silt; rare fine tuff pebbles and purple sand-size grains.
	29	Fine chalky weathered bedrock, mottled and vaguely banded, dusky red to red (10YR 3/2 to 4/8) dry.
	32	Pale red to weak red (10YR 6/2 to 5/2) dry; sandy silt occurring in discontinuous bands.
	34	Reddish brown, clayey sand with purple to brown opalite clasts; reddish orange clay about 2 cm thick along bedrock.
	35	Gravel in silty matrix grading to coarse opalite flakes; carbonate accumulations on clast bottoms.
IV	30	Very pale brown to pale brown (10YR 6/3 to 7/3) dry; vesicular, loam; rare to common fine pebbles; moderately cemented and mottled with carbonate.
	2	White chalky weathered bedrock; mottled reddish yellow (7.5 YR 8/6) dry; gravelly to blocky; moderately calcareous in places.
	31	Fine gravelly weathered tuff, white, with reddish yellow coatings (7.5YR 7/6).
	33	Chalky weathered tuff, yellow (10YR 8/8 to 7/8) dry.

Summary

26Ek3084 is a singular opalite source, relative to others at Tosawihi Quarries. Although the upper surface of the Miocene basalt at Tosawihi frequently is altered and argillicized, less often is it silicified. Consequently, brightly colored, jasper-like toolstone, like that seen here, is considerably less common than white or pink opalite. Jasper-like rocks are less compliant, more brittle, and require higher temperatures for heat treatment. Nevertheless, this outcrop provided highly flakeable toolstone that, by virtue of its distinctive visual characteristics, can be traced to several nearby reduction stations. Finished artifacts contribute little to the total assemblage, confirming our impression that site activities focused on toolstone extraction at the exposed jasper outcrop, material assay, and early stage toolstone (mostly core) reduction.

26Ek3208 and 26Ek3085

Sharing the south-facing slopes of Red Hill with 26Ek3084, 26Ek3208 and 26Ek3085 lie to the north on a pronounced saddle, along the southeast edge of the ridgeline (Figure 103). When first observed, they were thought to be distinct. During later testing, however, we discovered that they represent a quarry pit complex centering on a single geologic formation with disparate surface outcrops (Budy 1989:183–184).

At 26Ek3208 (as originally defined), a thick debris talus containing many biface and core fragments and basalt and rhyolite hammerstones, extended below the base of a prominent opalite ledge (13 m east/west) containing superb quality white and blue/green-white toolstone. A road cut through the talus cone 10 m below the outcrop revealed a rich deposit of debitage and quarry debris. Two large, shallow pits (Features 2 and 3), averaging approximately 5 meters in diameter, were visible on the surface at the foot of the steep opalite outcrop, and a smaller pit (Feature 1) was noted below a lesser outcrop to the east. Features 4–10 consist of historic mining pits, scrapes, and trenches that intruded on prehistoric quarry deposits. These historic features were not sampled for archaeological data, save for the collection of a basalt Great Basin Stemmed projectile point from the margin of one (Feature 5; Table 121). Additionally, Feature 5 was trenched to expose a clean profile for stratigraphic analysis.

Associated with a low opalite exposure atop the saddle and west of the prominent outcrop at 26Ek3208, 26Ek3085 contains a more restricted debris scatter and a cluster of five shallow quarry pits ranging in diameter from 2 to 4 meters (Features 3 and 5–8; cf. Figure 103). Unlike the large pits directed at the prominent ledge at 26Ek3208, the shallow quarry pits at 26Ek3085 were excavated into narrow colluvial pockets intruding low bedrock ledges. These pockets might have contained fractured opalite bedrock or cobbles suitable for reduction (Budy 1989:184). Features 1, 2, and 4 are historic phenomena (e.g., pits and bulldozer trenches).

We noted few formal artifacts in the pits at 26Ek3085, and collected only three—a basalt hammerstone and a tabular basalt chopping tool from Feature 8, and a Stage 3 opalite biface from Feature 5.

We compiled a detailed surface map of quarry pit complex 26Ek3208/26Ek3085, documenting the structural relationships between exposed outcrops and prehistoric pit features (cf. Figure 103). Backhoe trenches were excavated in Features 2, 3, and 5 at 26Ek3208, revealing an astonishingly complex deposit of quarry debris, several meters thick, overlying multiple pits in the heavily battered bedrock surface. A single trench was placed at 26Ek3085 as well. The exposed toolstone was of comparatively low quality, and the shallow quarrying deposits testified to far less energetic investment.

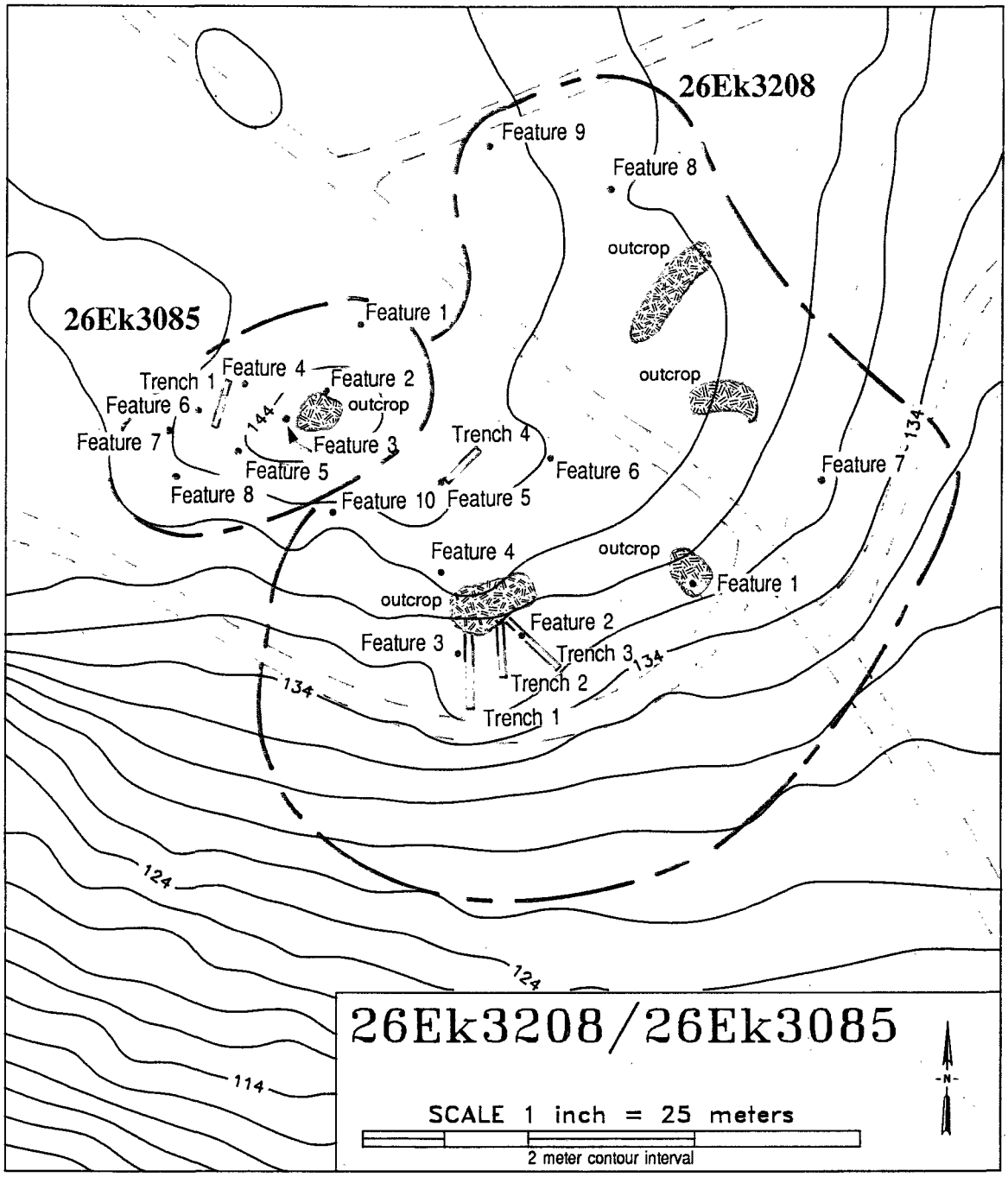


Figure 103. 26Ek3208/3085 site map.

Though we inventoried all features at 26Ek3208, we limited our collections to the few formal tools and ornaments observed on the surface or in trench sidewalls (bone beads, a scapula scoop, flake tools, hammerstones, a scratched stone), taking no systematic surface collections (Table 121). We did, however, collect 153 debitage and sediment samples from discrete strata in Feature 3 trench walls. The debitage was subjected to mass analysis and technological assessment, and was found to consist chiefly of the debris from core reduction, blank preparation, Stage 2 biface reduction, and rare Stage 3 reduction (cf. Chapter 10).

Table 121. Summary of Artifacts Collected from Features at 26Ek3208.

	DEBITAGE[a]		FORMED ARTIFACTS				
Feature	n	wt. (gm)	Proj. Points	Flake Tools	Perc./ Cobble Tools	Other/ Exotic	Total
1	-	-	-	1	2	-	3
3	175,455	244,122.5	-	2	3	2	7
5	-	-	1	-	-	-	1
8	-	-	-	-	1	-	1
Totals	175,455	244,122.5	1	3	6	2	12

[a]Debitage samples collected from discrete stratigraphic units in trench walls.

Trench 1, excavated during testing through the Feature 3 surface depression, revealed deposits composed of complex strata extending over two meters below surface (stratigraphy described by Budy 1989:185–190). Remains of several quarrying-related activities were revealed, including debris from sequential episodes of pit excavation against the bedrock face, toolstone processing and reduction, waste discard, pit filling, berm buildup, and reworking of older quarry waste in pit fill. Natural processes of slope wash between quarrying episodes were observed as well. A bison scapula fragment, found in Horizon V, probably served as a shovel or scoop for removing quarry waste from the pit. Large quarrying tools such as battered andesitic basalt boulders and hammerstones also were recovered.

The backhoe was used to face up the road cut running parallel to and below the outcrop. The resulting "trench" was shallow and uninformative; the deposits appeared highly turbated and poorly stratified. We subsequently noticed the same phenomenon at other localities in trenches cut perpendicular to the axis of quarrying. In any case, a stratigraphic profile of this trench was not prepared, nor was it given a formal number. (Its cross section appears in Figure 104, labelled as "Back filled cross trench.")

The deeply stratified deposits of quarry waste and colluvium found at the Red Hill quarries are, on occasion, interlaced with small charcoal lenses and fragments of burned tuff and opalite. These lenses may indicate use of fire set against massive bedrock faces to weaken tuff or, alternatively (and more likely), to break off isolated masses of toolstone and ease extraction. At 26Ek3208, we found such charcoal lenses in basal strata of Trench 1 through the Feature 3 quarry pit. Charcoal samples from these lenses returned two radiocarbon dates, 650 ± 60 B.P. (Beta-26755) and 800 ± 60 B.P. (Beta-26754).

Three additional backhoe trenches were excavated in 1989: Trench 1 was extended, and Trench 2 was located to crosscut an adjacent segment of Feature 3 (cf. Figure 103). Trench 3 intersected Feature 2, the second large pit visible on the surface. We obtained several additional radiocarbon dates from charcoal lenses in these new exposures, ranging from 480 ± 60 B.P. to 840 ± 60 B.P. (Appendix L). The dates appear stratigraphically reversed, reflecting probable disturbance caused by complex pit clearing and dumping; they are summarized in Table 122. Detailed stratigraphy of the 1989 trenches is described below.

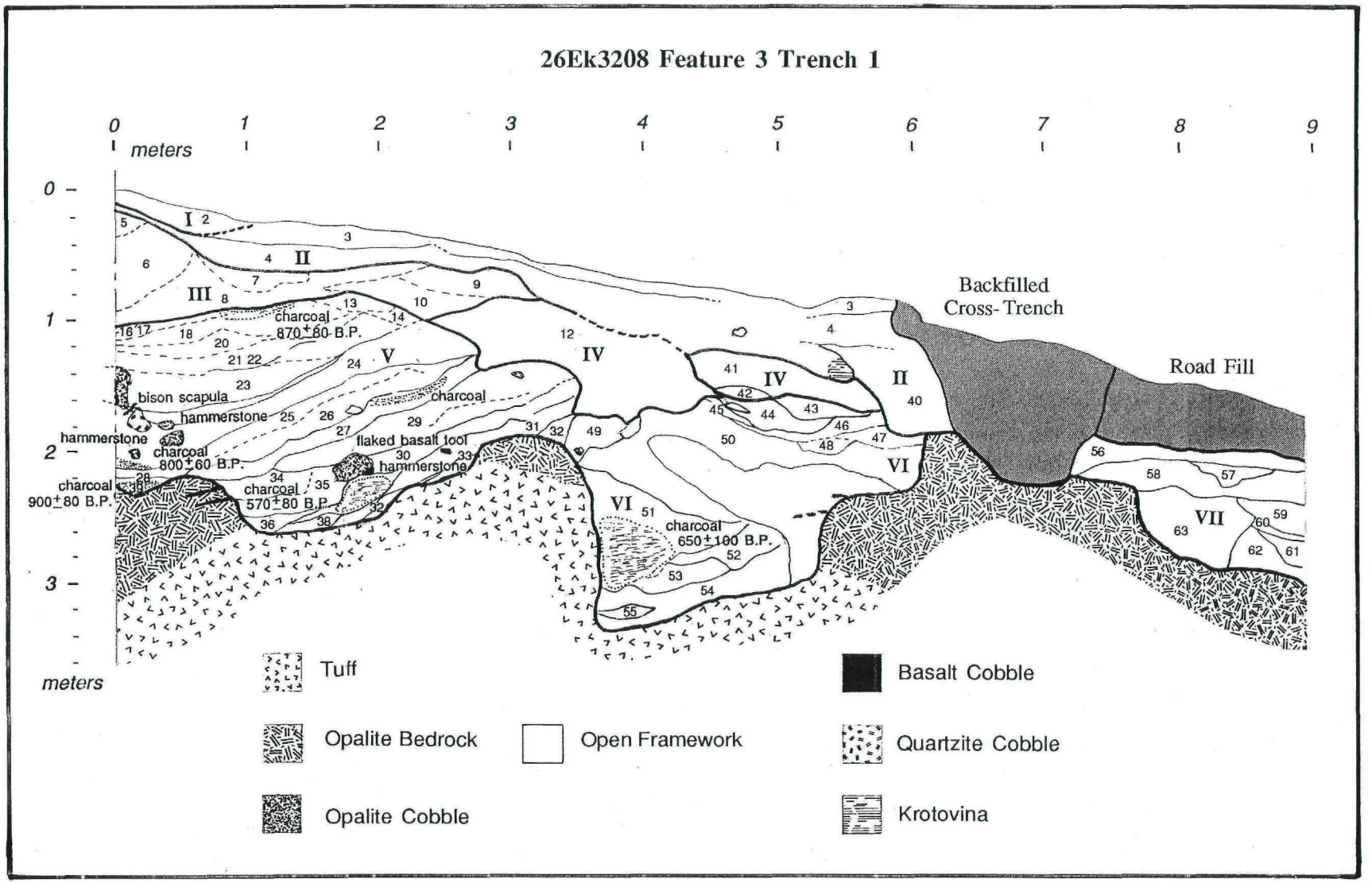


Figure 104. Description of stratigraphic units, Trench 1, Feature 3, 26Ek3208.

Figure 104. Description of stratigraphic units, Trench 1, Feature 3, 26Ek3208.

Horizon	Stratum	Description
I	1	Very dark brown (10YR 2/2) moist; silt ; weak fine granular; rare to common medium opalite and tuff chunks, rare opalite flakes; boundary clear and smooth. Observed in test - not shown on this profile.
	2	Moderate open framework, very dark grayish brown (10YR 3/2) moist; very fine to coarse opalite and tuff chunks, rare flakes and cores, clasts are generally coarser to the south.
	3	Black (10YR 2/1) moist; abundant organics with very common very fine flakes; possibly old ant midden.
II	4	Moderate to poor open framework; medium to coarse opalite chunks, some flakes; moderate sandy silt matrix, very dark brown (10YR 2/2) moist.
	40	Same as Unit 12, except for some areas of open framework coarse opalite chunks and flakes with sparse matrix.
III	5	Brown (10YR 5/3) moist; silty tuff sand; rare opalite flakes.
	6	Moderate to typical open framework; coarse tuff and opalite chunks; sparse sandy silt matrix, dark grayish brown (10YR 4/2) moist.
	7	Moderate open framework, medium to coarse opalite and tuff chunks; moderate sandy silt matrix, brown (10YR 5/3) moist.
	8	Dark grayish brown (10YR 4/2 moist; weathered tuff with coarse opalite flakes.
	9	Moderate open framework; medium tuff chunks and rare opalite flakes..
	10	Decomposed tuff with angular chunks of rubble.
	11	Black (10YR 2/1) moist; organic layer with no free charcoal. Observed in test - not shown on this profile.
IV	12	Dark grayish brown (10YR 4/2) slightly moist; poor open framework; silty sand matrix, with sand size tuff clasts and rare opalite flakes.
	41	Typical open framework, coarse opalite flakes and chunks, some tuff; sparse silty sand matrix, light brownish gray to grayish brown (10YR 6/2 to 5/2) dry; rare medium angular basalt chunks; rare charcoal flecking.
	42	Coarse hash; dark grayish brown (10YR 4/2) slightly moist; medium to coarse tuff sand in silt loam, with common fine opalite chips; some medium to coarse opalite and tuff chunks.
V	13	Grayish brown (10YR 5/2) slightly moist; poor open framework; silty sand, with rare opalite flakes.
	14	Grayish brown (10YR 5/2) slightly moist; silty sand, with rare to common medium to coarse opalite and tuff chunks.
	16	Dark grayish brown (10YR 4/2) slightly moist; silty sand, with medium to coarse opalite flakes.
	17	White (10YR 8/2) slightly moist; pulverized tuff with medium to coarse opalite and tuff chunks and common medium to coarse opalite flakes.
	18	Typical open framework, fine to coarse opalite chunks and flakes.
	20	Dark grayish brown (10YR 4/2) slightly moist; silty sand, with abundant flakes; flakes are larger in upper portion, smaller below but forming more open framework toward bottom.
	21	Dark gray (10YR 4/1) slightly moist; silt sand, with abundant charcoal flakes.
	22	Moderate open framework, medium to coarse opalite and tuff chunks, also large 20 cm x 25 cm) rhyolite boulder, and rhyolite hammerstones; moderate silty sand matrix, dark grayish brown (10YR 5/2) slightly moist, with abundant charcoal. Observed in test - not shown on this profile.
	23	Grayish brown to pale brown (10YR 5/2 to 6/3) slightly moist; decomposed tuff and angular chunks, unit becomes finer to the south; notable large rhyolite boulder (20x 35 cm); abundant charcoal. A bison scapula was found in Unit 23 at contact with Unit 24.
	24	Moderate open framework, medium to coarse opalite and tuff chunks; moderate silty sand matrix, dark grayish brown (10YR 4/2) slightly moist; abundant charcoal.
	25	Very dark gray (10YR 3/1) slightly moist; silty opalite sand; common fine chunks of burned opalite and tuff; abundant charcoal. Radiocarbon date.

Figure 104, continued.

	26	White to pale brown (10YR 8/2 to 6/3) slightly moist; sandy silt with common medium opalite chunks, becoming very dark grayish brown (10YR 3/2) slightly moist, pulverized tuff sand with flakes toward south.
	27	Moderate to poor open framework, medium opalite chunks and flakes; moderate to common pulverized tuff sand, light brownish gray (10YR 6/2) slightly moist.
	28	Very dark gray (10YR 3/2) slightly moist; silty sand, with burned fine opalite and tuff chunks. Observed in test - not shown on this profile.
	29	Typical to moderate open framework, medium to coarse opalite chunks; moderate silty sand, dark gray (10YR 4/1) slightly moist, sometimes forming partial lenses.
	30	Dark grayish brown (10YR 4/2) slightly moist; pulverized tuff hash, with fine tuff chunks; contains narrow lenses of charcoal.
	31	Moderate to open framework, medium to coarse tuff and opalite chunks; common silty tuff sand, pale brown (10YR 6/3) slightly moist.
	32	Dark gray (10YR 4/1) slightly moist; silty sand with charcoal; rare to common fine opalite and tuff chunks.
	33	Light gray (10YR 4/1) slightly moist; pulverized tuff hash; rare charcoal flecking.
	34	Moderate open framework, medium opalite and tuff chunks and flakes, and rare coarse opalite chunks; moderate silty sand matrix, light brownish gray to pale brown (10YR 6/2 to 6/3) slightly moist; common charcoal flecking.
	35	Similar to Unit 34, except for generally more tuff and less opalite, coarser clasts, with less matrix.
	36	Same as Unit 31.
	37	Grayish brown to dark grayish brown (10YR 5/2 to 4/2) slightly moist; silty tuff sand, with fine opalite chips, chunks and flakes; rare basalt and quartzite fragments; common charcoal flecks.
	38	Same as Unit 37, except generally less matrix and coarser clasts.
	39	Same as Unit 26, except for abundant charcoal and burned opalite chips.
VI	43	Dark brown (10YR 3/3) slightly moist; silt loam, with some medium opalite and tuff chunks.
	44	Typical to moderate open framework, coarse opalite chunks and flakes; moderate silty sand matrix, light brownish gray (10YR 6/2) dry.
	45	Coarse hash, mixture of pulverized tuff, white (10YR 8/2) slightly moist, and sandy silt with fine tuff clasts, grayish brown (10YR 5/2) slightly moist.
	46	Brown (10YR 4/3) slightly moist; vesicular silt loam, with some coarse sand-sized tuff, fine and opalite chips, chunks and flakes; rare coarse tuff clasts.
	47	Typical open framework, coarse opalite chunks and some tuff; sparse silty sand matrix, brown (10YR 5/3) dry.
	48	Same as Unit 45.
	49	Poor open framework; dark grayish brown (10YR 4/2) slightly moist; sandy silt loam, with common medium to coarse sand-sized opalite and tuff grains; common coarse to very coarse opalite chunks and rare basalt.
	50	Dark grayish brown (10YR 4/2) slightly moist; sandy silt loam, with common medium sand-size to coarse opalite and tuff chunks and flakes.
	51	Same as Unit 50, except generally coarser clasts.
	52	Poor open framework; dark grayish brown (10YR 4/2) slightly moist; sandy silt loam, with common medium sand-sized to coarse opalite and tuff chunks and flakes.
	53	Same as Units 50 and 51, except generally larger clast size.
	54	Poor open framework, white to very pale brown (10YR 8/2 to 8/4) slightly moist; typical pulverized opalite and tuff hash, with common medium to coarse opalite and tuff chunks.
	55	Moderate open framework, fine to medium opalite and tuff chunks; sparse to common tuff hash matrix, grayish brown to dark grayish brown (10YR 5/2 to 4/2) slightly moist; common charcoal flecking.
VII	56	Poor open framework; brown (10YR 5/3) slightly moist; silt loam, moderately hard; common fine to medium opalite chunks, some tuff.
	57	Same as matrix in Unit 56, except coarser and more abundant opalite and tuff clasts.

Figure 104, continued.

58	Yellowish brown (10YR 5/4) slightly moist; similar to Unit 56, except for color.
59	Moderate open framework, coarse to very coarse opalite and tuff chunks and flakes; moderate sandy clay loam, dark grayish brown (10YR 4/2) slightly moist.
60	Very dark grayish brown (10YR 3/2) slightly moist; sandy clay loam; fairly massive; rare fine tuff chunks; matrix has very organic rich appearance.
61	Dark brown (10YR 4/3) slightly moist; sandy clay loam, similar to Unit 60, except for more abundant and coarser tuff clasts, with some opalite chunks.
62	Brown to pink (7.5 5/4 to 7/4) slightly moist; weathered tuff with coarse clasts.
63	Highly jointed, somewhat loose and flaggy, chalky white weathered tuff, with staining, brown (7.5YR 5/4) slightly moist.

Table 122. Provenience of Radiocarbon Dates from 26Ek3208.

Reference Number	Laboratory Number	Date (Years B.P.)	Provenience
2500-2/4	Beta-26754	800±60	Trench 1, Unit 25, Horizon V
2500-4/5	Beta-26755	650±60	Trench 1, Unit 28, Horizon V
2599-15	Beta-36983	900±80	Trench 1, Unit 39, Horizon V
2599-21	Beta-36984	870±80	Trench 1, Unit 20, Horizon V
2599-22	Beta-36985	650±100	Trench 1, Unit 51, Horizon VI
2599-23	Beta-36986	570±80	Trench 1, Unit 37, Horizon V
2599-24	Beta-36987	480±60	Trench 2, Unit 32, Horizon VIII
2599-25	Beta-36988	840±60	Trench 2, Unit 23, Horizon VI
2599-28	Beta-36989	560±70	Trench 2, Unit 29, Horizon VIII
2599-31	Beta-36990	770±80	Trench 3, Unit 14B, Horizon III
2599-33	Beta-36991	740±80	Trench 3, Unit 18, Horizon V
2599-36	Beta-36992	590±80	Trench 3, Unit 26, Horizon V

Quarry Pit Stratigraphy at 26Ek3208 and 26Ek3085

At 26Ek3208, three backhoe trenches were placed on the large talus cone of quarry debris that extends below the prominent opalite outcrop (cf. Figure 103). Topography suggests that, under natural conditions, most colluvial deposition below the outcrop was derived from debris coming around its east side. At 26Ek3085, we excavated a single backhoe trench (Trench 1).

As at 26Ek3084, trench profiles at 26Ek3208 revealed a complex stratigraphy of coarse quarry debris commonly alternating with fine deposits originating from quarrying activities or from natural processes such as slopewash and eolian deposition. Major stratigraphic horizons were recognizable in each profile, delineated by truncation surfaces (contacts defined by truncated depositional units). Each horizon demarcates a set of strata deposited during one or more quarrying episodes. The truncation surfaces appear to have been created by renewed digging through older deposits, and are buried by subsequent deposition of younger debris. Thus, younger units commonly abut or overlie older deposits along truncation surfaces. Some older deposits, and those that apparently remained undisturbed at the surface for extended periods, exhibit physical and chemical evidence of weak soil development in the fine matrix. Too, we encountered a new type of deposit for which we invented the term "hash." Hash consists of very fine opalite chips and chip-like fragments mixed with pulverized tuff, silt, and, sometimes, clay. In experimental quarrying, we have produced hash by battering bedrock during toolstone extraction.

26Ek3208, Trench 1, Feature 3

As noted previously, this trench was initiated during testing and was described by Budy (1989:185–190). The second phase of backhoe excavation in 1989 extended the original depth, length, and width of the trench (cf. Figure 104). The widening moved the location of the profile at least a meter to the west. At other quarry sites where profiles are disturbed similarly, the resulting stratigraphy can differ dramatically from the original profile due to the complex nature of the deposits. In this trench, however, the stratigraphic units previously profiled were still identifiable, possibly because of large scale depositional activity. The original unit numbers were retained and newly exposed deposits begin with Unit 35. Also, the extent of Horizons II, IV, and V were increased in the new trench, and Horizons VI and VII were added.

Radiocarbon dates from charcoal found in Horizons V and VI of 570 ± 80 B.P. (Beta-36986) and 650 ± 100 B.P. (Beta-36985), respectively, are inverted stratigraphically. If standard error is considered, however, they are roughly equivalent. On the other hand, it is also possible that older quarry debris and associated charcoal have been mixed with more recent units, creating the inverted order of dating (cf. "Implications," below).

Bedrock

The bedrock at this site is mapped as undifferentiated sinter and replacement sinter at or near the surface of the Upper Tuff (Cornucopia 1987). As can be seen in Figure 105, silicified sinter overlies unsilicified or poorly silicified tuff; sinter was the object of quarrying. The white sinter of the outcrop exposed at and just below the surface is very deeply checked and cracked. Frost and thermal stress wedge off angular, gravel to cobble sized fragments that accumulate below the outcrop as talus. The quarried rock, in contrast, was protected below the surface, and is massive and much smoother in texture.

Sinter toolstone occurs in bands or lenses, ranging in thickness from 5 cm to 75 cm, that dip to the north (cf. Figure 105). Layers of higher quality toolstone alternate with poorly silicified layers of white chalky or brittle opal rock. The highest quality toolstone (among the best so far observed at Tosawihi) is well silicified, massive chalcedonic sinter, ranging from white to translucent, very pale blue or green. Seams of this material up to 75 cm thick crop out between 145 cm and 220 cm below the surface. Toolstone also occurs in other layers of lesser thickness and is usually intercalated with opal or poorly silicified material. The thicker layers of very pale blue or green toolstone offered much higher quality material, but at greater cost because its massiveness made it more difficult to extract. The quarriers appeared to have taken advantage of the alternating rock densities and friability by removing underlying soft tuff and intervening chalky or opal layers to isolate masses of toolstone that then could be broken off with hammerstones and small fires.

Horizon VII

The deposits of *Horizon VII* comprise Units 56–62 and appear to be derived primarily from slopewash and natural accumulations of opalite talus, rather than from quarrying. The majority of clasts are angular chunks of tuff and opalite, while opalite flakes are rare. Horizon VII is isolated from other deposits owing to disturbance from road construction and an earlier backfilled trench. Since no radiocarbon samples were obtained from Horizon VII, it is impossible to determine stratigraphically whether it is the oldest. Arguing for greater age is the moderate consolidation of the fine matrix in Horizon VII, and its similarity to stratigraphically early deposits in Trenches 2 and 3. Alternatively, the notable compaction of the deposits may be a result of road construction over the site. While it is possible that the deposits of Horizon VII are equivalent to Horizon II (among the last to be deposited), we suspect that Horizon VII represents pre-quarry colluvial deposits that naturally blanketed the slope below the outcrop.

Horizon VI

Units in this horizon include debris that filling the remarkably deep central pit. The exact division between units in this horizon and Horizon V is not clear, but a general change in manner of deposition from a series of rather chaotic units in the central pit to a more uniform

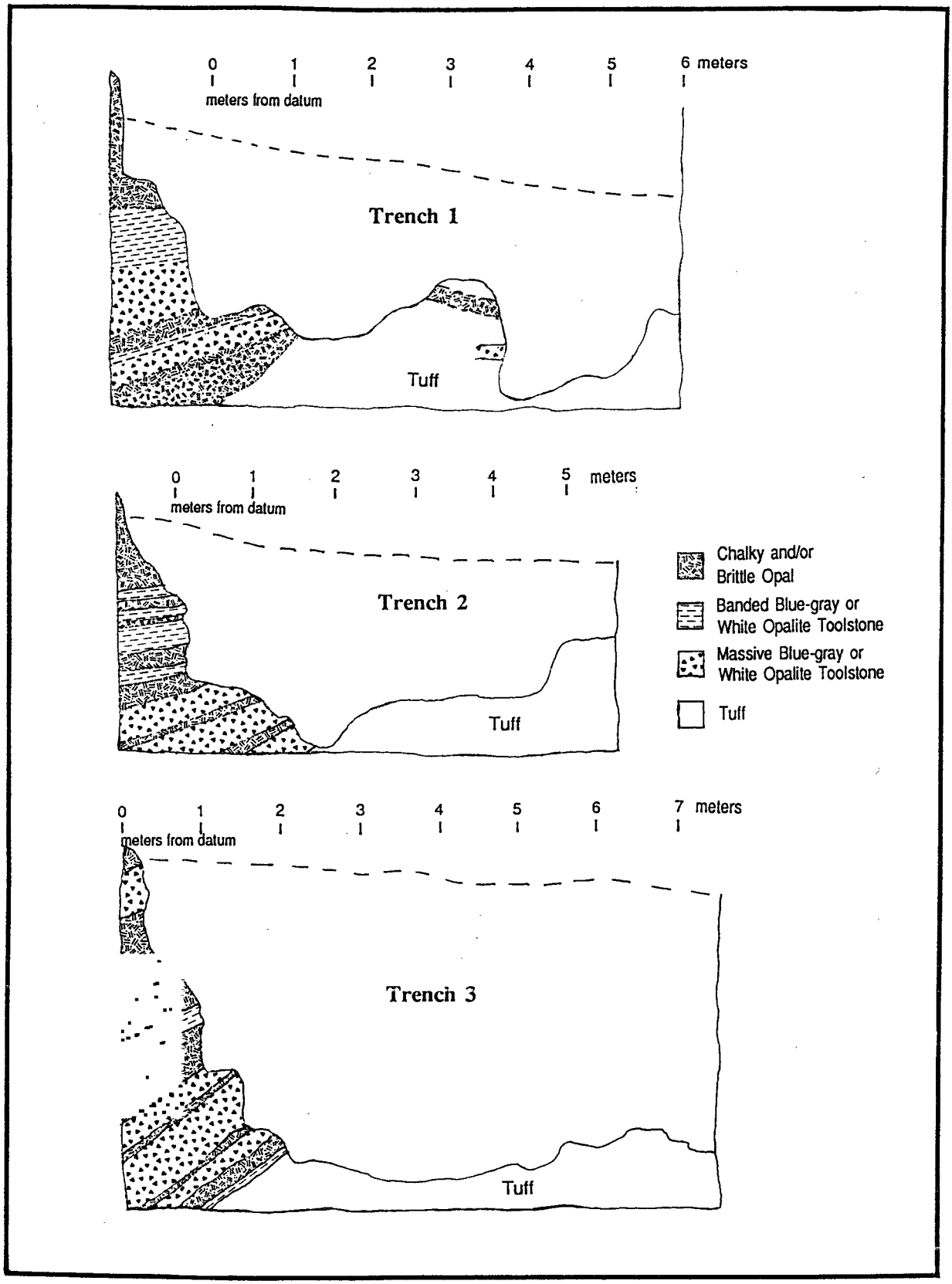


Figure 105. Bedrock profiles at site 26Ek3208.

progression in the northern pit is quite apparent, suggesting that the demarkation lies somewhere between Units 32 and 49. The upper limit of Horizon VI also is unclear, but has been placed immediately below Units 12, 41, and 42 of Horizon IV.

Some units in Horizon VI, such as Units 53, 54, and 55, probably were formed during quarrying of the central pit itself, while much of the debris overlying these may have resulted from backfilling during quarrying of adjacent pits. Units 50 and 51, especially, contained abundant matrix and appeared poorly sorted and reworked.

Horizon V

This horizon is composed of the most uniformly deposited units in the trench. This arrangement is very similar to sequences in Trenches 2 and 3 that also abut the vertical opalite bedrock face. These units appear the least disturbed after initial deposition, and they provide the clearest stratigraphic record of quarrying. Despite the primary nature of this sequence of units, it remains difficult to reconstruct clearly the specific order of quarrying activities. Higher units are sequentially displaced northward, suggesting some northward retreat of the opalite bedrock face as it was mined. From the general, though not perfect, alteration of layers of coarse tuff and opalite rubble and sandy or loamy fine units, it is likely that specific techniques switched between the battering of bedrock, producing fine units, and the reduction of large extracted cobbles and boulders of opalite, producing coarse units. The often clear distinction between the two types of units and the large volumes they contain implies that each technique may have been employed for extended periods until the desired conditions or materials were produced. The presence of distinct units composed of a single type of bedrock, such as the white pulverized tuff of Unit 17, suggests that one section of the bedrock face may have been preferentially worked at any one time. The presence of such distinct units ideally *could* be traced to a specific location on the bedrock face, but we were not able to do this with confidence.

Finally, it should be noted that some fine grained units, especially those with abundant gray silt, probably were derived from natural slopewash and eolian activities that added materials while pits were abandoned temporarily. That fine units are not concentrated along horizon boundaries provides further support for the hypothesis that truncation surfaces usually were not exposed for long.

Horizon IV

This horizon is dominated by the poorly sorted silts and opalite and tuff debris of Unit 12, which probably are products of reworking and backfilling primary quarry debris. The lower boundary truncates several units of Horizons V and VI, and provides the earliest clearly defined example of primary debris being reworked with previously mined opalite debris. This distinct removal of older deposits and the subsequent filling with reworked debris without apparently reaching bedrock was recognized in several instances in quarry debris at this site, especially in Trench 2. We add the caveat that, although bedrock was not reached by some pits seen in these profiles, it is possible they extend deeper in unexposed sediments beyond the limits of the trench wall. Indeed, a pit extending through older debris to reach bedrock may have to have been very wide due to the unstable nature of some of the deposits; trench profiles may expose only the margins of these re-excavations.

Horizons I, II, and III

Previously described (Budy 1989), these horizons contain coarse opalite chunks and flakes in vaguely defined lenses that, together, comprise fairly uniform, massive accumulations of quarry debris with sparse to common silty matrix. They represent the final episodes of quarrying at the site. In Horizons I and II there is an overprinting from present soil development and organic activity. Slopewash also has reworked these materials to some degree.

26Ek3208, Trench 2, Feature 3

Trench 2 exposed the most complex stratigraphy of the three (Figure 106). In its western profile, several episodes of re-excavation and renewed digging into older deposits are reflected, and at least ten major stratigraphic horizons are present. It is likely that, were any position chosen for renewed digging into previously quarried debris without foreknowledge of the composition and character of underlying materials, it would be near the center of the debris cone and outcrop. Here, the resource is most abundant and the option of shifting the excavation laterally is maximized.

Since this trench displayed interesting complexity, had several truncation surfaces, and was freshly exposed, it was chosen for detailed analysis to determine the quantities of several chemical oxides in the fine matrix component. These chemical data are used in the following discussion to examine the presence of possible weak soil formation on formerly stable surfaces in the quarry pit deposits.

Radiocarbon dates from charcoal samples taken from Horizons VI, VII and VIII were inverted in a manner similar to those in Trench 1 (840 ± 60 B.P., 560 ± 70 B.P., and 480 ± 60 B.P., respectively, for each horizon). These dates probably are inverted because of the reworking of older sediments with stratigraphically younger materials and horizons. Differences between the subsets of the two oldest and two youngest dates are not significant, but the oldest and youngest dates clearly are different (critical value of t at .05 level = 1.96).

Horizon X

Stratigraphically, this horizon is the oldest exposed in the trench; in addition, the degree of compaction and signs of weak soil development indicate a relatively old age. A chemical profile through Units 44, 45, 34, and 46 provides evidence for soil development (Figure 107). There is increased leaching of iron and aluminum at the surface of this sequence, especially in the distinctive silty Unit 44. The presence of a higher phosphorus percentage also suggests that this was a former stable surface. The high base content of Unit 44 may be the result of high carbonates in this apparently partially eolian-derived sediment. The overlying Unit 43 also may be a later addition to the soil surface. Despite the dominance of fine matrix, the presence of opalite flakes indicates that deposits of this horizon originate partly from quarrying activity.

Horizon IX

These units appear stratigraphically to be the second oldest in the trench. Their gentle slope to the north suggests that once may have been in contact with a vertical outcrop face, in a fashion similar to some s in Horizon VI. However, it also is possible that they are equivalent to deposits in Horizon

Figure 106. Description of stratigraphic units, Trench 2, Feature 3, 26Ek3208.

Horizon	Stratum	Description
I	1	Dark gray to dark grayish brown (10YR 4/1 to 4/2) dry; silt; weak fine granular, common medium opalite and tuff chunks, and rare to common opalite flakes; boundary clear and smooth.
	2	Moderate to poor open framework, medium opalite flakes and chunks with sparse matrix of silt and dry organic matter; opalite with yellowish "patina" distinguishes this unit from Unit 1.
	3	Poor open framework; gray to dark gray (10YR 5/1 to 4/1) dry; silt with abundant coarse sand to medium opalite and tuff clasts, generally finer clasts than Unit 1.
II	4	Poor open framework; grayish brown (10YR 5/2) dry; silt with common chunks of opalite and tuff and common opalite flakes.
III	5	Moderate open framework, coarse opalite chunks with some tuff; sparse sandy silt matrix as in Unit 4.
	6	Poor to typical open framework with coarse chunks of yellowish opalite as in Unit 2, and some tuff, matrix greyish brown to brown (10YR 5/2 to 5/3) dry; silt to silt loam, common against bedrock, becoming more sparse to the south; matrix appears slightly ashy, possibly from matrix in Unit 7.
	7	Moderate to poor open framework, medium opalite chunks and flakes; matrix sandy silt with abundant ash and charcoal, grey to very dark gray (10YR 5/1 to 7.5YR N3/1) dry; framework is typically open with sparse silt matrix in charcoal rich area, while in peripheral areas of unit, matrix is more abundant and opalite and tuff chunks are generally finer; charred upper surfaces of opalite pieces in base of ashy areas is notable, while opalite pieces are charred on all surfaces within ashy area.
	8	Poor open framework to coarse hash; gray (10 YR 5/1) dry; sandy silt with abundant medium sand to medium gravel sized opalite and tuff chunks and flakes; matrix also has an ashy appearance.
	9	Typical open framework, medium opalite chunks and flakes, sparse matrix of sandy silt as in Unit 8.
IV	10	Moderate open framework, medium to coarse opalite chunks and flakes with some tuff; matrix of fine sandy silt and pulverized tuff, light gray to light brownish gray (10YR 7/2 to 6/2) dry; vague subunits are indicated by subhorizontal flake bands, and lenses of finer flakes and matrix.
V	11	Coarse hash; light brownish gray (10YR 6/2) dry; sandy silt with rare fine, common medium, and rare coarse opalite chunks and flakes.
	12	Moderate open framework, medium to coarse opalite chunks and flakes; common matrix increases downward, distinguishing Unit 12 from 13, matrix same as sandy silt of Unit 11.
	13	Same as Unit 12.
	14	Same as Unit 11.
VI	15	Moderate open framework, fine to coarse opalite chunks and flake with some tuff; matrix sparse to common sandy silt, light gray (10YR 7/2) dry.
	16	Coarse hash to poor open framework; light gray (10YR 7/2) dry; sandy silt with common fine to medium opalite and tuff chunks and flakes.
	17	Typical open framework, medium to coarse, opalite and tuff chunks and flakes; sparse matrix same as sandy silt as in Unit 16, also minor amounts of pulverized chalky opalite. Distinct large rhyolite hammerstones and a fist-sized angular piece of basalt.
	18	Light brownish gray (10 YR 6/2) dry; fine sandy vesicular silt, with a "fine" open framework of coarse sand to fine gravel-size opalite and tuff clasts, some fine to medium opalite flakes; rare orangish red cinnabar patches.
	19	Typical open framework, medium to coarse opalite chunks and flake with some tuff; sparse matrix same as sandy silt of Unit 18; notable large opalitic rhyolite cobbles.
	20	Light gray to gray (10YR 7/1 to 6/1) dry; fairly massive, vesicular sandy silt, with matrix supported fine to medium gravel-size opalite chunks and flakes, some rare tuff; rare to common charcoal flecking.

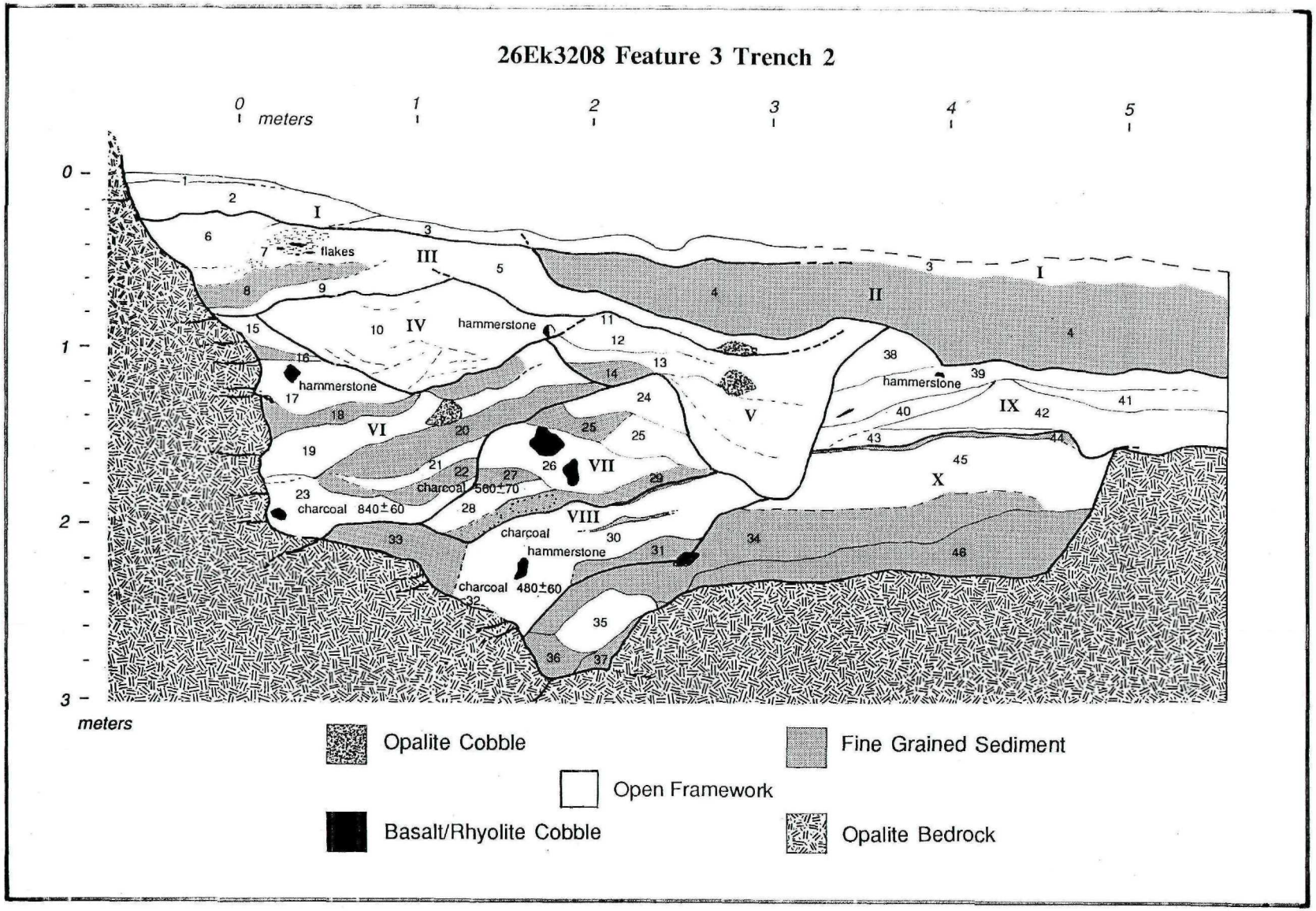
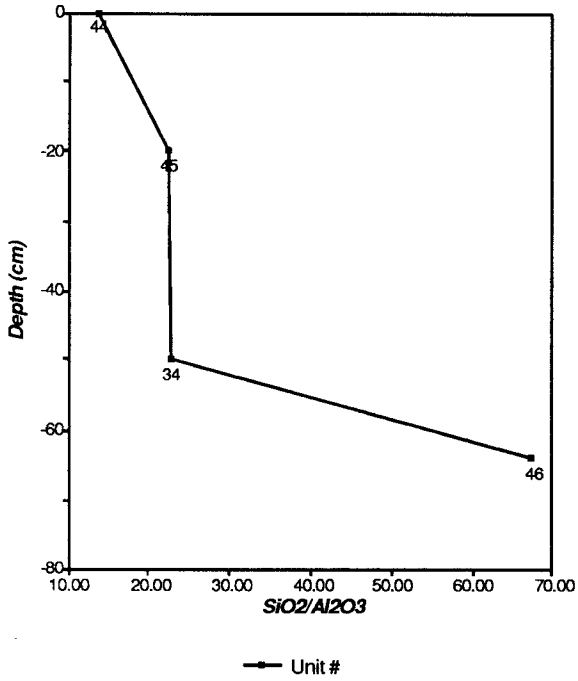


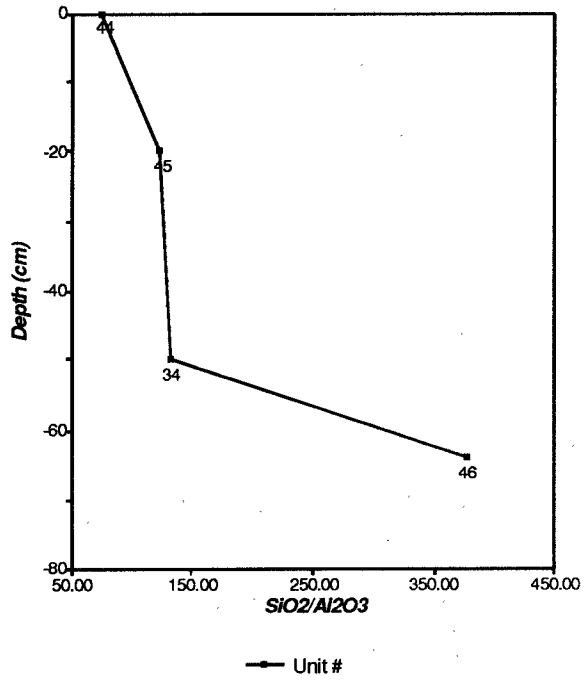
Figure 106. Description of stratigraphic units, Trench 2, Feature 3, 26Ek3208.

Figure 106, continued.

	21	Typical to moderate open framework, medium opalite chunks and flakes; varying amounts of sandy silt matrix as in Unit 20.
	22	Same as Unit 20.
	23	Same as Unit 19.
VII	24	Moderate, fine open framework, predominantly subhorizontal, fine to medium opalite flakes and some chunks; fairly common matrix of sandy silt, light brownish gray (10YR 6/2).
	25	Fine half of unit, light gray to light brownish gray (10YR 6/1 to 6/2) dry; silt, with "hashy" abundant fine to coarse sand-sized opalite and tuff chunks and chips; Coarse half of unit, moderate open framework, medium to coarse opalite chunks and flakes, fairly common matrix as in fine part of this unit.
	26	Typical open framework, medium to very coarse opalite and tuff chunks, with large rhyolite clasts; sparse matrix same as silt in Unit 25.
	27	Same as Unit 25, except for slightly coarser matrix with fine gravels; some moderately coarse charcoal pieces.
	28	Poor open framework, medium to coarse opalite flakes; matrix common, same as Unit 27.
	29	Fine hash; white (10YR 8/1) dry; pulverized chalky opalite, with fine to medium opalite chips, chunks and flakes; some distinct charcoal accumulations.
VIII	30	Typical open frame work, medium to very coarse opalite chunks, and some tuff, also rare rhyolite and basalt cobbles; sparse matrix same as chalky opalite in Unit 29; some intermittent lenses of "hashy" fine to coarse sandy loam, brown (10YR 5/3), with charcoal flecking.
	31	Coarse hash, mixture of pulverized chalky opalite and sandy loam; fairly common matrix supported fine to medium opalite chunks and flakes.
	32	Charcoal lens with matrix similar to Unit 33.
	33	Fine hash; light brownish gray (10YR 6/2) dry; fine to coarse sandy silt, with common fine gravel-size tuff and medium opalite flakes.
IX	38	Poor open framework; same as Unit 20.
	39	Poor to moderate, fine open framework, medium to coarse opalite chunks and some medium flakes; fairly common sandy silt matrix, light gray to light brownish gray (10YR 7/8 to 6/2) dry; some possible basalt and opalite hammerstones.
	40	Poor open framework to coarse hash; very pale brown (10YR 7/3 to 7/4 dry, to light brownish gray (10YR 6/2) dry, pulverized tuff and minor silt, with common very fine to fine tuff chunks, rare to common medium opalite chunks and flakes; some charcoal flecking.
	41	Poor open framework; same as Unit 20.
	42	Poor to moderate open framework, fine to coarse opalite chunks, with fine to medium flakes; moderate matrix same as in Unit 40.
	43	Same as Unit 20; boundary between Units 40 and 43, a vague band of opalite flakes.
X	34	Fine hash; same as Unit 31. except more massive with fewer clasts and slightly more matrix.
	35	Typical open framework, medium to very coarse opalite and tuff chunks and flakes; sparse matrix, pulverized chalky opalite and brown (10YR 5/3) sandy silt loam, with abundant fine to medium opalite and tuff chunks.
	36	Fine hash; same as Unit 34, except fine sand dominates over silt.
	37	Brown (10YR 5/3) dry; sandy clay loam; common fine opalite and tuff chunks; some moderately coarse pieces of charcoal.
	44	Dark brown (10YR 3/3) slightly moist; sandy loam, slight coarsening downward of sand size; weak medium granular; fine to medium thin reduction flakes as fine lenses within loam.
	45	Coarse hash; brown (10YR 4/3) dry; sandy silt; common poorly sorted very fine to coarse opalite and tuff chunks and flakes; intermittent poor, texturally defined lenses.
	46	Typical fine pulverized hash tuff, with rare fine to medium flakes.



a.



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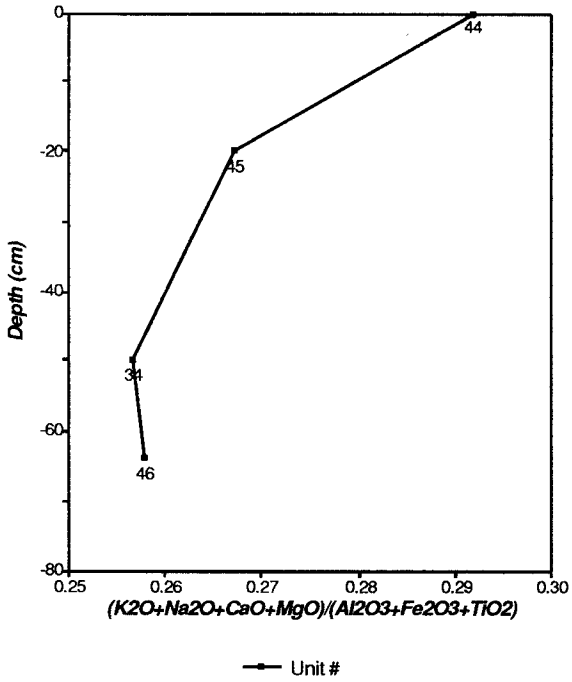

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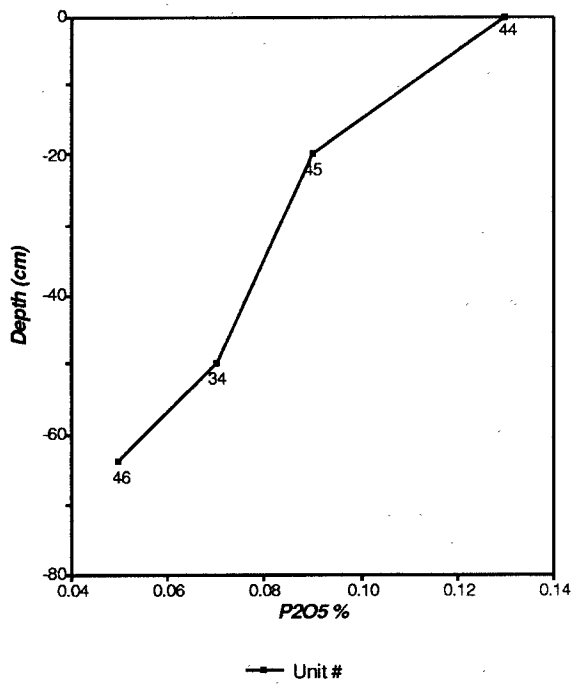


d.

Figure 107. Molecular weathering ratios for 26Ek3208, Trench 2, Feature 3, profile A displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

Horizon VIII

Deposits in this horizon lie directly on the truncated surface of Horizon X and on one of the lowest bedrock surfaces. The abrupt transition between the fine materials of Unit 33 and the coarse debris of Unit 30 probably is the result of excavation of the fines of Unit 33 and the subsequent filling by Unit 30. Alternatively, Unit 33 may be equivalent to Unit 34, thus making it part of the earliest stratigraphic horizon.

Horizon VII

These deposits probably were much more extensive at one time, judging by the truncated surface on which Horizons V and VI lie. The gentle slope of Horizon VII units away from the retreating outcrop face suggest that they may have been reworked, unlike the typical primary deposits that slope towards the bedrock face. The more uniform alternation of coarse and fine units, however, is similar to undisturbed debris.

An arbitrary chemical profile was plotted through units of Horizon V, Horizon VI above, and Horizons VIII and X below (Figure 108). This profile revealed consistent leaching of iron, aluminum, and calcium, as well as accumulations of phosphorous, from units immediately below truncation surfaces, including Units 18, 25, 27, 30, and 34. Unit 24, not included in the profile, also exhibited this trait. Such signs of surface weathering suggest that these truncation surfaces were stable for limited periods, and contradict the idea that pits were excavated and then filled by debris during the same quarry episode.

Horizon VI

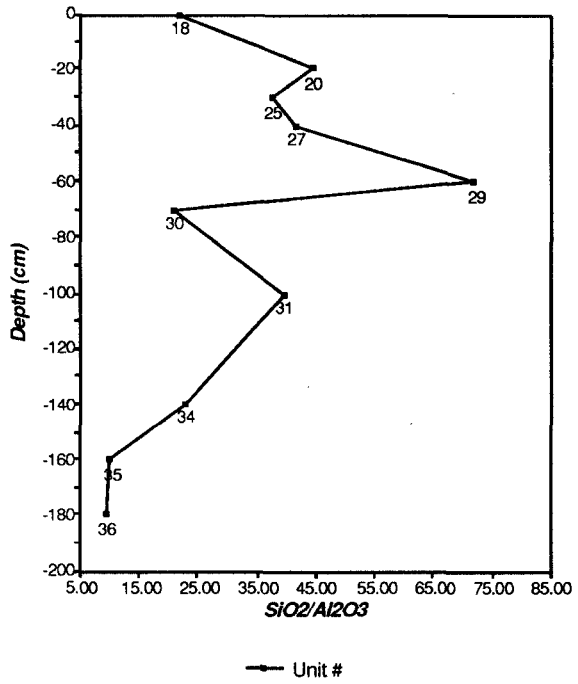
Units in this horizon form a typical sequence of well defined, alternating coarse and fine deposits that slope into the vertical outcrop face, much like those of Horizon V in Trench 1. They probably have experienced little or no reworking subsequent to initial deposition.

Horizon V

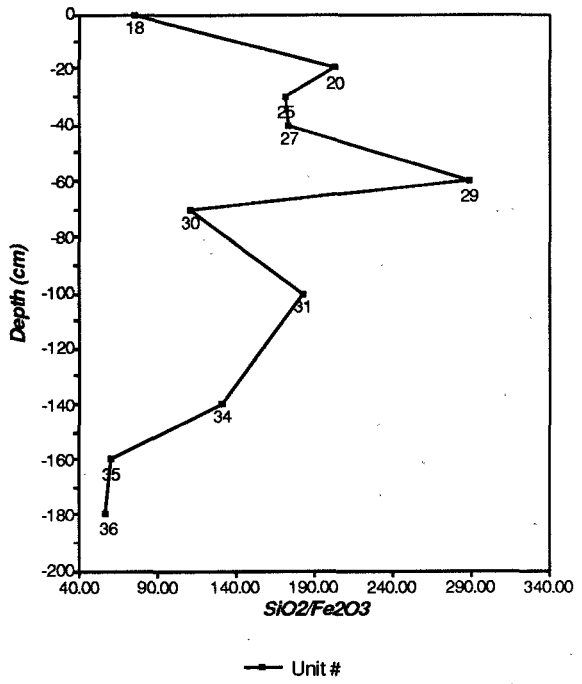
The cavity created by initial excavation of this horizon exhibits the greatest vertical relief of any such feature, yet it fails to reach bedrock in the exposed profile and may have been excavated to exploit large opalite chunks in Units 30 and 45. Alternatively, it may extend down to bedrock beyond the profile wall. This re-excavation truncated units in Horizons VI, VII, VIII, IX, and X. The debris filling the cavity generally is composed of coarse opalite flakes and chunks. Vague separations in the deposits are discernable by changes in the abundance of fine matrix and in poorly defined subhorizontal flake lines.

Horizon IV

Deposits in this horizon are essentially the same as the coarse opalite flakes and chunks in Horizon V. They are discernible from Horizon V by the configuration of the cavity that they fill, and the orientation of flakes vaguely parallel to its bottom.



a.



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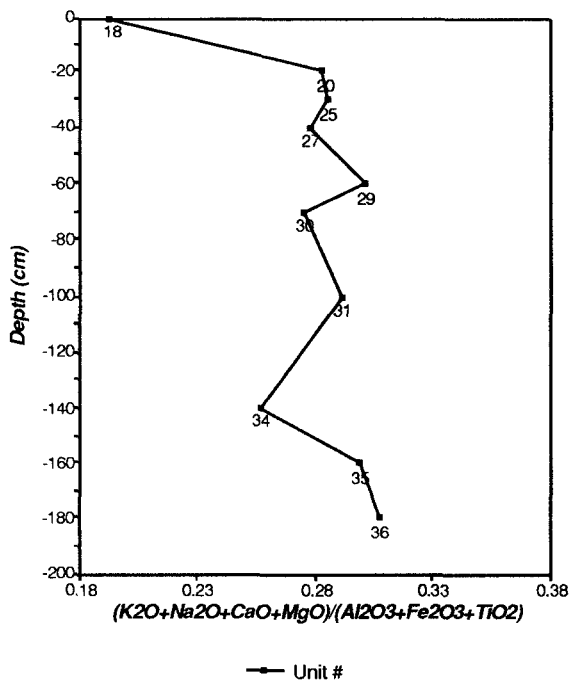

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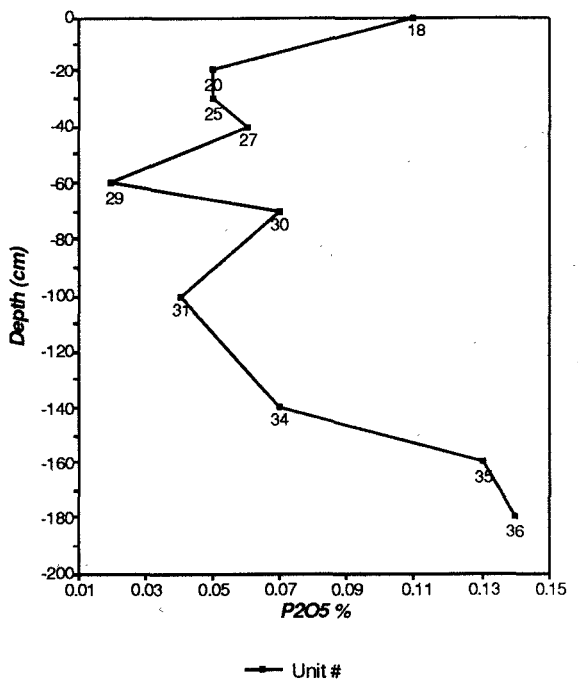


d.

Figure 108. Molecular weathering ratios for 26Ek3208, Trench 2, Feature 3, profile B displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

Horizons I, II, and III

These horizons are very similar to Horizons I, II, and III of Trench 1, and may be roughly equivalent. More fine matrix generally occurs between the coarse clasts, however, especially in Unit 4, a trend that continues into the near surface deposits of Trench 3. A notable accumulation of charcoal occurs in Unit 7 of Horizon 3, where medium and large flakes of opalite are charred on their upper surfaces. An equivalent accumulation of charcoal is present in the west wall of Trench 3 at this depth.

26Ek3208, Trench 3, Feature 2

The profile in Trench 3 is the most extensive exposure in the debris cone at 26Ek3208 (Figure 109); the deposits reach a depth of nearly four meters, and the stratigraphy suggests quarry pits more than 3 meters in depth. The stratigraphy is complex, but it differs from Trenches 1 and 2. Many fill units are massive and poorly sorted. Individual stratigraphic units, and their orientation within the more massive deposits, are difficult to trace, suggested only by vague flake lenses. Only five major stratigraphic horizons were recognized. This owes, in part, to the difficulty of discerning some stratigraphic divisions or hiatuses. It also appears that deposits in this easternmost side of the large debris cone have not undergone as much reworking and re-excavation as deposits nearer the central area of the opalite outcrop. Generally poor sorting also suggests that slopewash and debris flow may be more dominant depositional mechanisms, similar to the adjacent unquarried hill slope.

As in Trenches 1 and 2, radiocarbon dates from this trench are inverted; they are 770 ± 80 B.P. (Beta-36990), 740 ± 80 B.P. (Beta-36991), and 590 ± 80 B.P. (Beta-36992), in Unit 14 of Horizon III and Units 18 and 26 of Horizon V, respectively. These dates essentially are equivalent if standard error is considered.

An arbitrary chemical profile was plotted through Units 1 to 22, but, unlike the plots of Trench 2, we discerned no trends or characteristic leaching of iron, aluminum, and calcium or accumulation of phosphorus associated with truncated surfaces (Figure 110).

Horizon V

Deposits in this unit generally are massive sandy silts with common matrix supported opalite and tuff chunks, and flakes interspersed with isolated lenses of open frameworks of coarse opalite chunks and flakes. Much of the material is poorly sorted. It appears that extensive remixing or backfilling may have taken place, alternating with production of large opalite flakes and chunks, forming isolated lenses.

Although all these units have been grouped into one horizon, it appears that more than one episode of activity is represented; there may be three or more. Units 44–47 may represent one such episode; texturally, they differ little from adjacent units to the north, but a vague color difference suggests a stratigraphic break. A second division probably also occurs in Unit 17 at the bedrock berm lying approximately 6.5 meters along the profile. While there is no apparent division in the fine matrix character, the orientation of coarse lenses suggests two separate pit fillings. Units 39, 40, and 41, for example, slope to the south, while Units 28, 29, and 30 slope to the north.

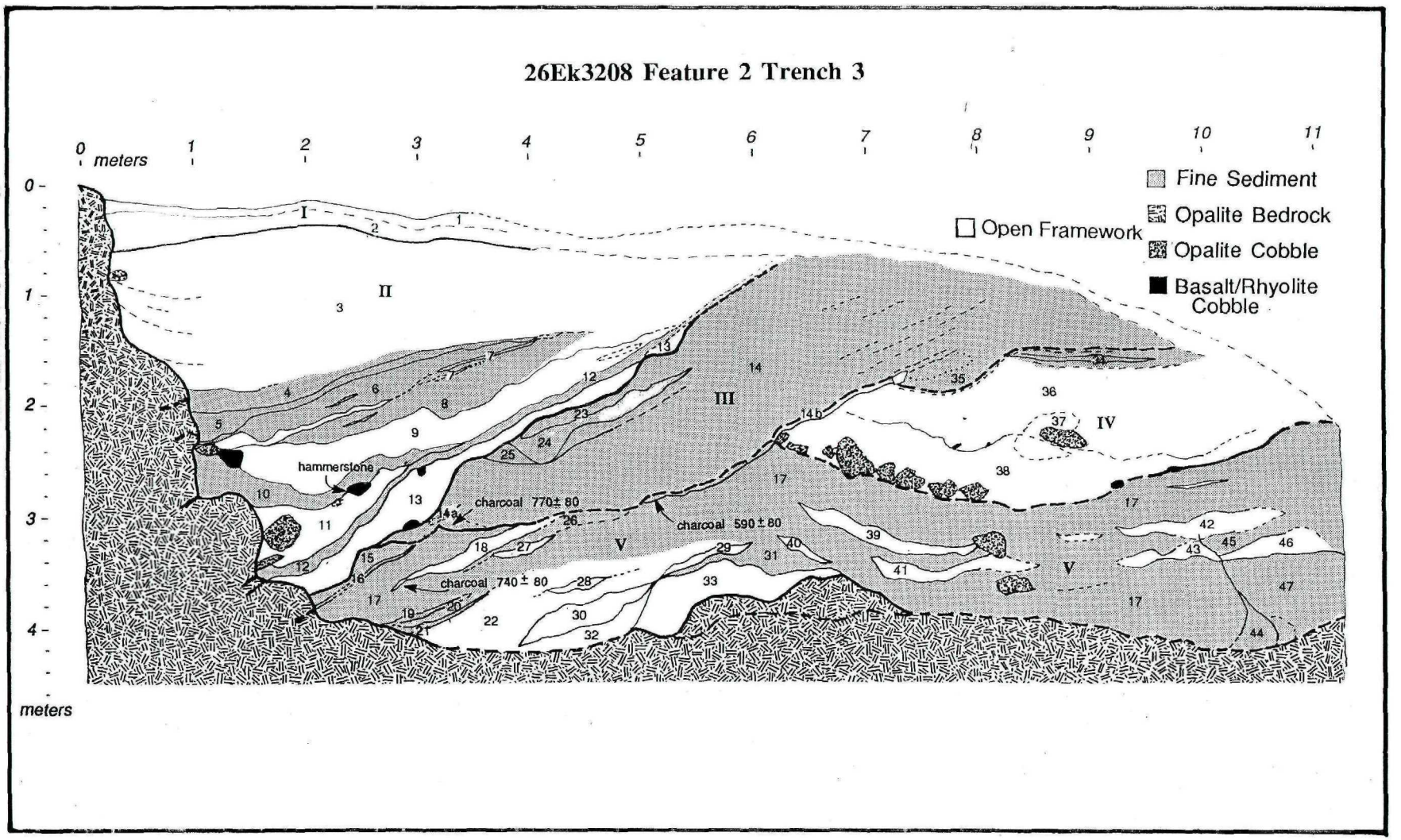


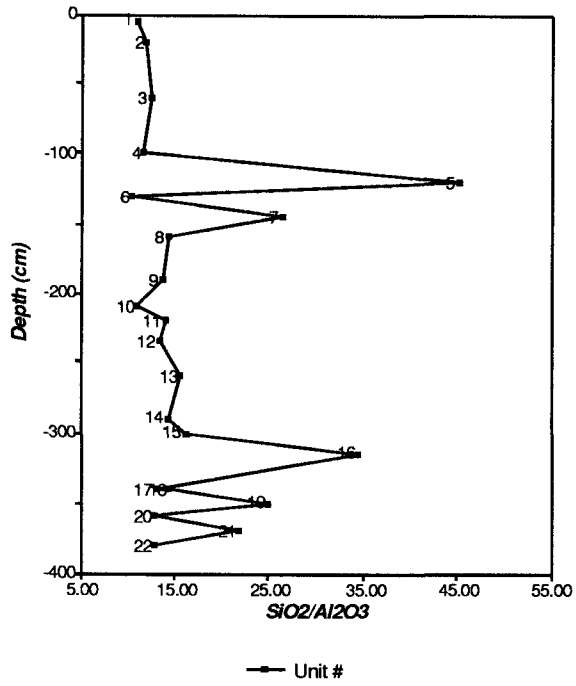
Figure 109. Description of stratigraphic units, Trench 3, Feature 2, 26Ek3208.

Figure 109. Description of stratigraphic units, Trench 3, Feature 2, 26Ek3208.

Horizon	Stratum	Description
I	1	Dark gray to dark grayish brown (10YR 4/1 to 4/2) dry; silt; weak fine granular, common medium opalite and tuff chunks, and rare to common opalite flakes; boundary clear and smooth.
	2	Moderate to poor open framework, medium opalite flakes and chunks with sparse matrix of silt and dry organic matter; opalite with yellowish "patina" distinguishes this unit from Unit 1.
II	3	Poorly sorted, moderately homogeneous, poor open framework, grayish brown to gray (10YR 5/2 to 5/1) dry, sandy silt to coarse opalite chunks and flakes, with some tuff; vague bedding suggested by some flake alignment.
	4	Well defined unit within Unit 3, moderate open framework, common fine to rare coarse opalite flakes.
	5	Poorly sorted, coarse hash, white to pinkish white (5YR 8/1 to 8/2) dry, very fine pulverized chalky opalite to medium chunks of chalky opalite, some medium opalite flakes.
	6	Grayish brown (10YR 5/2) dry; see description of Unit 3.
	7	Same as Unit 5.
	8	Same as Unit 6.
	9	Typical to moderate open framework, medium to very coarse opalite chunks with common medium flakes, some of the coarsest opalite chunks show signs of surface weathering; moderate matrix, grayish brown (10YR 5/2) dry, coarse sandy silt.
	10	Same as Unit 8.
	11	Same as Unit 9.
	12	Poor open framework, grayish brown (10YR 5/2) dry; silty sand, with common medium and rare coarse opalite chunks, some fine to medium flakes.
	13	Typical open framework, medium to coarse opalite chunks and flakes, generally more coarse upward; sparse matrix, silty sand with common fine to medium opalite chips and flakes, grayish brown (10YR 5/2) dry.
III	15	Same as Unit 14, except stratigraphically separated by an apparent erosional contact with a notable charcoal accumulation.
	16	Typical pulverized tuff hash.
	17	Mixture of materials similar to Unit 14 with bands of opalite flakes and chunks, with some tuff; also minor lenses of material similar to Unit 16.
	18	Moderate to typical open framework, common medium to coarse tuff and opalite chunks and flakes; moderate matrix of typical pulverized tuff hash mixed with sandy silt, grayish brown (10YR 5/2) dry; distinct charcoal accumulation in north end of unit.
	19	Same as Unit 16.
	20	Same as Unit 17.
	21	Same as Unit 16.
	22	Pale brown (10YR 6/3) dry; sandy silt loam, fairly massive, similar to Unit 17.
	23	Same as Unit 14.
	24	Moderate open framework, medium to coarse opalite chunks and flakes, opalite commonly with surface weathered appearance; sparse matrix, same as Unit 25.
	25	Pale brown (10YR 6/3) dry; sandy silt loam; hard granular silty clasts and randomly oriented clasts of fine to medium pebbles and fine to coarse opalite chunks and flakes forming fine poor open framework, possibly from saturated debris flow.
	26	Same as Unit 17.
	27	Same as open framework of Unit 18.
	28	Same as Unit 27.
	29	Moderate open framework, fine to medium opalite and tuff chunks and flakes; moderate matrix, sandy silt as in Unit 22.
	30	Same as Unit 28, except clasts are generally coarser tuff.
	31	Same as fine matrix of Unit 22.
	32	Same as Unit 22.
	33	Pinkish white to reddish yellow (7.5 YR 8/2 to 8/6) dry; tuff and chalky white weathered tuff and possibly quarried tuff in the form of coarse blocks and very fine to coarse chunks, with a pulverized coarse sand.

Figure 109, continued.

	35	Moderate open framework; coarse to very coarse weathered opalite and pink tuff, with some coarse opalite chunks and flakes; some basalt and rhyolite cobbles; moderate matrix, silt to coarse sand, light brownish gray (10YR 6/2) dry; in upper portions of unit, poorly sorted silt to coarse sand matrix is concentrated in vague lenses.
IV	34	Moderate open framework, common fine to medium tuff chunks, distinct lenses of fine to medium blue-green opalite; sparse matrix, silty fine to medium sand-sized tuff and very fine opalite flakes; unit bounded above and below by distinct poorly sorted silt with common sand-sized to medium chunks of opalite and chunks and flakes.
	36	Chaotic accumulation of vague coarse and fine lenses and poorly sorted silt to very coarse angular chunks of surface weathered opalite, quarried opalite, and tuff.
	37	Grayish brown to dark brown (10YR 5/2 to 3/3) slightly moist; silty clay loam, with common medium sand-sized to fine gravel-sized tuff and opalite chunks, and rare medium to coarse opalite and tuff chunks.
	38	Same as Unit 36, except slightly better sorting into vaguely defined lenses, less of a debris flow-like appearance.
V	14	Dark grayish brown to grayish brown (10YR 4/2 to 5/2) dry; sandy silt loam, fairly massive, with common very fine to fine opalite chips, chunks, and flakes, some chunks appear to be surface weathered; minor lenses, 14a and 14b, ashy clayey matrix, brown to pale brown (10YR 4/2 to 7/3) dry, with common charcoal.
	39	Moderate open framework lenses of very fine to slightly coarse brittle white opalite with some medium to coarse opalite and tuff chunks; moderate sandy silt matrix, light brownish gray to pale brown (10YR 6/2 to 6/3) dry, becoming more abundant to south.
	40	Same as Unit 39.
	41	Same as Unit 39.
	42	Poor open framework, medium to coarse opalite chunks and flakes, some tuff; common matrix, brown to grayish brown (10YR 5/3 to 5/2) dry, fine to coarse sandy silt.
	43	Same as Unit 42.
	44	Moderate, medium to fine open framework, fine to coarse opalite chunks, some with tuff rind; common matrix, silty sand, very pale brown to pale brown (10YR 7/3 to 6/3).



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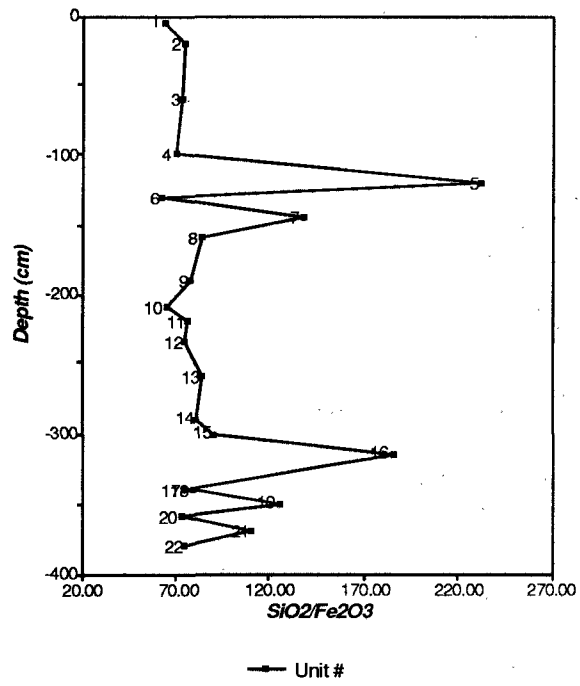

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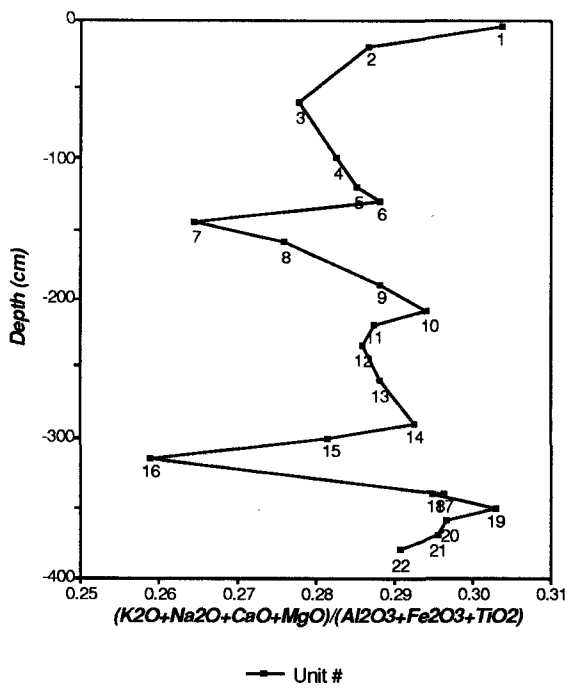

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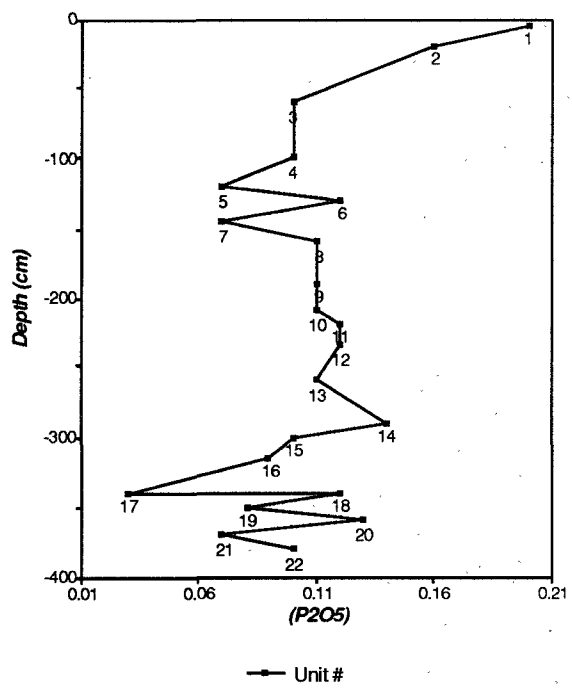

d.

Figure 110. Molecular weathering ratios for 26Ek3208, Trench 3, Feature 2 profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

The upper limit of Horizon V is delimited, at its northern end, by a truncation surface on which charcoal apparently has accumulated at the base of Unit 14. This truncation occurred after the deposition of Horizon IV units. A division between Horizons IV and V is placed below a line of large weathered opalite cobbles at the base of Unit 38.

The high degree of compaction and possible induration of the fine matrix indicates that these deposits may have undergone some pedogenesis, although the chemical profiles, as mentioned previously, showed no clear profile development. Stratigraphically these units are the oldest in the trench, and are similar to the oldest units in Trenches 1 and 2.

Horizon IV

Units of this horizon are poorly sorted, like those of Horizon IV, but generally exhibit less matrix. Although probable quarried debris is included, these units may be largely natural slopewash products. Horizons IV and V are truncated by the same surface on which lie the deposits of Horizon III.

Horizon III

Horizon III is dominated by Unit 14, an accumulation of poorly sorted debris similar to Unit 17 in Horizon V, but exhibiting less compaction and hardness in the fine matrix. Although vague flake lines are visible, and some units (such as 24 and 25) uniformly slope to the north in a manner similar to primary units in Horizon II, the deposits in Horizon III appear to be mostly remixed or derived from slopewash. Distinct accumulations of charcoal at the bottom of Unit 14 serve to emphasize the truncation surfaces of Horizons IV and V.

Horizon II

This horizon appears to consist of primary deposits that have undergone very little, if any, human reworking after initial formation. The units are typical of deposits near the vertical face of the opalite outcrop. They generally are more distinct and well defined than more remote deposits, and they slope uniformly toward the vertical face. Although the massive coarse Unit 3 is included here, it may be part of a separate horizon and a unit filling a re-excavated depression, in a manner similar to other near surface deposits (such as Unit 10 in Trench 1). Vague subhorizontal flake lines suggest the presence of separate events within Unit 3.

The vertical and horizontal extent of units in Horizon II are remarkable. Unit 12, for example, is over 5 meters in length with over 3 meters of relief. The scale of this and other units implies either that a lot of effort was expended in shoveling quarry debris up a rather steep slope away from the outcrop face, or that material was sliding downslope from above. For the latter process to occur, the presence of an outcrop source at least 5 meters from the current outcrop face is necessary. This could indicate a large overhang of the opalite outcrop, and, by implication, a large adit or cave below, where the lower units of Horizon II could accumulate. Alternatively, and perhaps more likely, extensive quarried incursions into the vertical face were made and the resulting flanking bedrock walls quarried back. In either scenario, the present bedrock face has been quarried extensively to its present location.

Horizon I

The coarse opalite chunk and flake debris of Units 1 and 2 are similar to the previously described, near-surface units of Trenches 1 and 2. They represent the final phases of activity at the site. They probably have been reworked by slopewash to some degree and are overprinted by modern soil processes.

Correlation of Horizons

Although the complex nature of the quarry debris exposed in the three trenches on the debris cone at 26Ek3208 makes correlation tenuous, the following relationships can be argued: (1) it is possible that Horizons I and II in Trenches 1 and 2, and Horizon I and the upper deposits of Unit 3 in Trench 3, correlate roughly; (2) the deposits of Horizon VI in Trench 1, Horizon V in Trench 2, and the lower units of Horizon II in Trench 3, also may correlate, although their resemblance may only reflect common formation mechanisms; (3) Horizons VII, VIII, or IX of Trench 2 may be correlated with Horizon III and possibly IV of Trench 3; and (4) Horizon X in Trench 2 may be correlated with Horizon V of Trench 3 and possibly with Horizon VI of Trench 1.

26Ek3208, Trench 4, Feature 5

Located uphill and north of the quarry debris talus cone, backhoe Trench 4 exposed the side of the Feature 5 bulldozer cut where a Great Basin Stemmed point was found on the surface (Figure 111). Four stratigraphic units were identified in the profile: Unit 1, a sandy silt loam at the surface; Unit 2, a sandy silt; Unit 3, a silty fine sand; and finally Unit 4, a chalky white tuff. Notable characteristics include the thickness of the upper silts (with a fairly high organic content), and strong carbonate accumulation in Units 2, 3, and the upper part of 4. These characteristics suggest a fairly old soil where carbonate accumulation is appreciable and the upper silts are an eolian deposited A horizon. The thick accumulation of silts around the perimeter of the opalite outcrop was seen also in Trench 1 at 26Ek3085. It is possible that a lack of surface runoff at the crest of the ridge prevented the removal of silts. Also, the outcrop may have acted as an obstruction to wind and allowed eolian deposition, especially on the lee side where the silt cover is thicker. This effect also may have been more pronounced before the outcrop was reduced through quarrying.

26Ek3085, Trench 1

Trench 1 revealed two, or possibly three, pit-like depressions containing silt with abundant opalite chunks and flakes. Since no opalite bedrock is present, but only a soft white kaolinitic tuff, these may be the marginal extent of quarry pits that lie farther to the east where opalite bedrock does occur. The stratigraphy generally can be summarized as a grayish brown silt cover over a brownish silt loam containing abundant opalite chunks and flakes that fill pit-like depressions. Below this are open matrix deposits of tuff and opalite clasts resting on orangish, iron stained, weathered tuff that grades into extremely white, somewhat platy, tuff bedrock. A thick gray silt mantle over the white tuff bedrock here is the same as in Trench 4 at 26Ek3208.

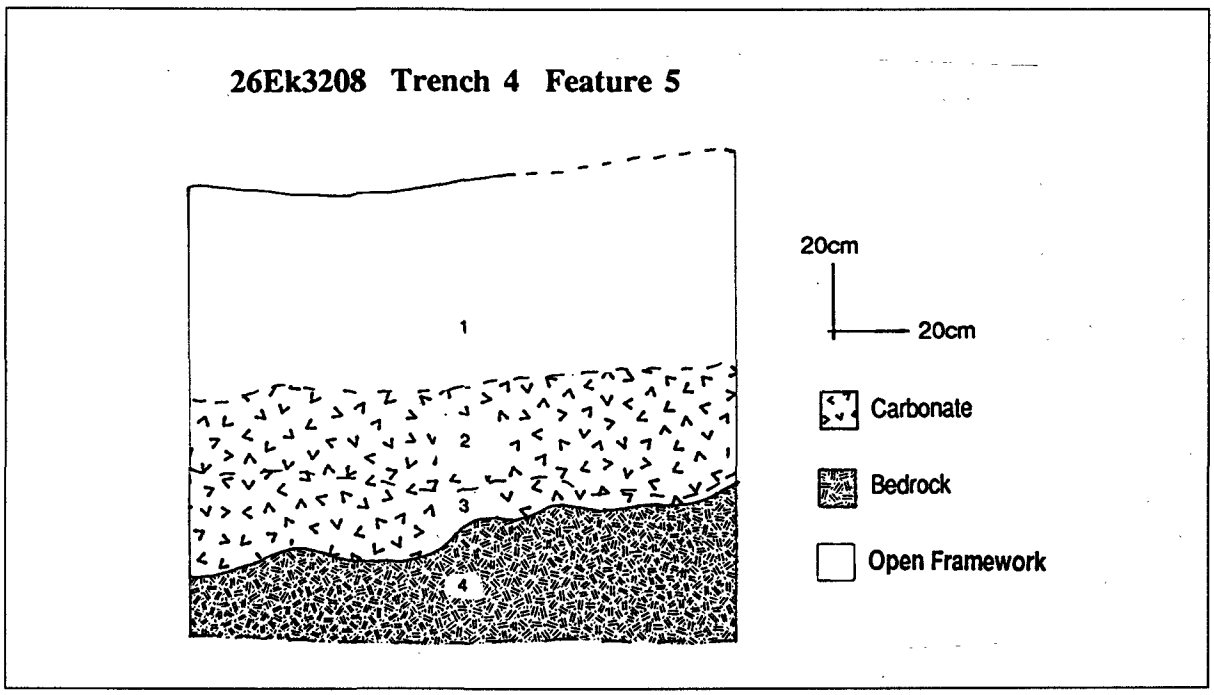

Figure 111. Description of stratigraphic units, Trench 4, Feature 5, 26Ek3208.

Stratum	Description
1	Very dark grayish brown (10YR 3/2) dry; sandy silt loam; vesicular, loose to weak granular; common fine to coarse angular sand-sized opalite and tuff, rare to common fine to coarse opalite and tuff chunks and flakes; common fine roots.
2	Grayish brown (10YR 5/2) dry; sandy silt; common sand-size to coarse opalite chunks, and common medium to coarse, tabular tuff clasts the result of bedrock jointing; strong acid reaction on disseminated carbonate, not visible in profile.
3	Pale brown (10YR 6/3) dry; silty fine sand; common fine to medium tabular and blocky chunks of tuff; strong acid reaction on disseminated carbonate.
4	Very white, weathered to fresh, chalky tuff bedrock with distinct tabular jointing; acid reaction strong in upper part of unit becoming weaker downward.

Implications

26Ek3208 is unique in the Western Periphery for its massive accumulations of quarry debris, for its complex stratigraphic history, and for what it reflects of the sheer energy expended in its formation. The variable depths of quarry pits and the complexity of debris scatters at 26Ek3208 and 26Ek3085 suggest at least three different strategies of toolstone extraction, each conditioned by the quality of source material. One strategy involved the exploitation of the vertical outcrop face, removing soft rock to undermine and expose masses of toolstone weakened by small fires and then broken off with hammerstones. Quarrying tools associated with this strategy include large (>25 cm diameter) basalt and rhyolite hammerstones, smaller hammerstones, and bison scapula scoops. A second strategy employed the excavation of vertical pits into bedrock, using the same tools and exploiting differences in rock density. A third strategy involved re-excavating quarry pit fill to secure opalite chunks formerly discarded as waste. Evidence for this strategy so far is restricted to pits observed in profile that do not appear to penetrate to bedrock (though we may not be observing the full extent of these pits). Large hammerstones and charcoal deposits typically are not associated with such shallow pits.

Continual reworking of quarry waste deposits provides the best explanation for the inverted radiocarbon dates recovered from all three backhoe trenches at 26Ek3208. The stratigraphy suggests that quarrying began 6 to 12 m to the south (downslope) of the present outcrop face, moving northward as the outcrop was quarried back. If quarrying shifted back and forth along the 13 m wide outcrop face, older charcoal easily could become incorporated in deposits overlying younger charcoal, although we might expect less perfect inversion than that modeled in Figure 112. In Table 123, radiocarbon dates are plotted by trench and horizon. Perfect inversion is seen only in the dates from Trench 2. In Trenches 1 and 3, the oldest dates are uppermost and lowermost in the stratigraphic column, while the youngest dates lie in the middle.

Table 123. 26Ek3208 Radiocarbon Dates by Trench and Horizon.

Horizon	Trench I	Trench II	Trench III
I	-	-	-
II			
III	-	-	770
IV			
V	870	-	590
	800	-	740
VI	650	840	-
VII	-	560	-
VIII	-	-	-
On Bedrock	900	480	-

What do radiocarbon dates in this context mean? We cannot assume that any of the dated charcoal deposits contain charcoal only of a single age. Nevertheless, those resting on bedrock are most likely to be in primary position and least likely to be contaminated. As it happens, the oldest *and* the youngest dates are those resting on bedrock. We advance, as an hypothesis subject to further testing, that these bedrock dates (900 B.P. and 480 B.P.) represent the true chronological range of the use of battering and fire setting techniques for toolstone extraction at the site. We do not suggest, however, that these dates represent the chronological extent of toolstone extraction at 26Ek3208. Flakes in older deposits resembling colluvium (Trench 1, Horizon VII; Trench 2, Horizon X), and the presence of small pits ceasing short of bedrock in upper horizons indicate less intensive methods of toolstone extraction during both earlier and later times.

The presence of dateable charcoal in stratified deposits should enable us to segregate quarrying episodes more finely, to calculate volume of debris generated in these discrete episodes, and to examine chronological differences in energy expenditure. Unfortunately (though not unexpectedly), complex stratigraphic mixing and inversion of charcoal deposits diminish our ability to pursue such explicit questions.

26Ek3104

26Ek3104 is a small (600 m^2) outcrop quarry on the south edge of Boundary Ravine, in Rodent Valley (cf. Figure 100). The outcrop is mapped as undifferentiated sinter and replacement

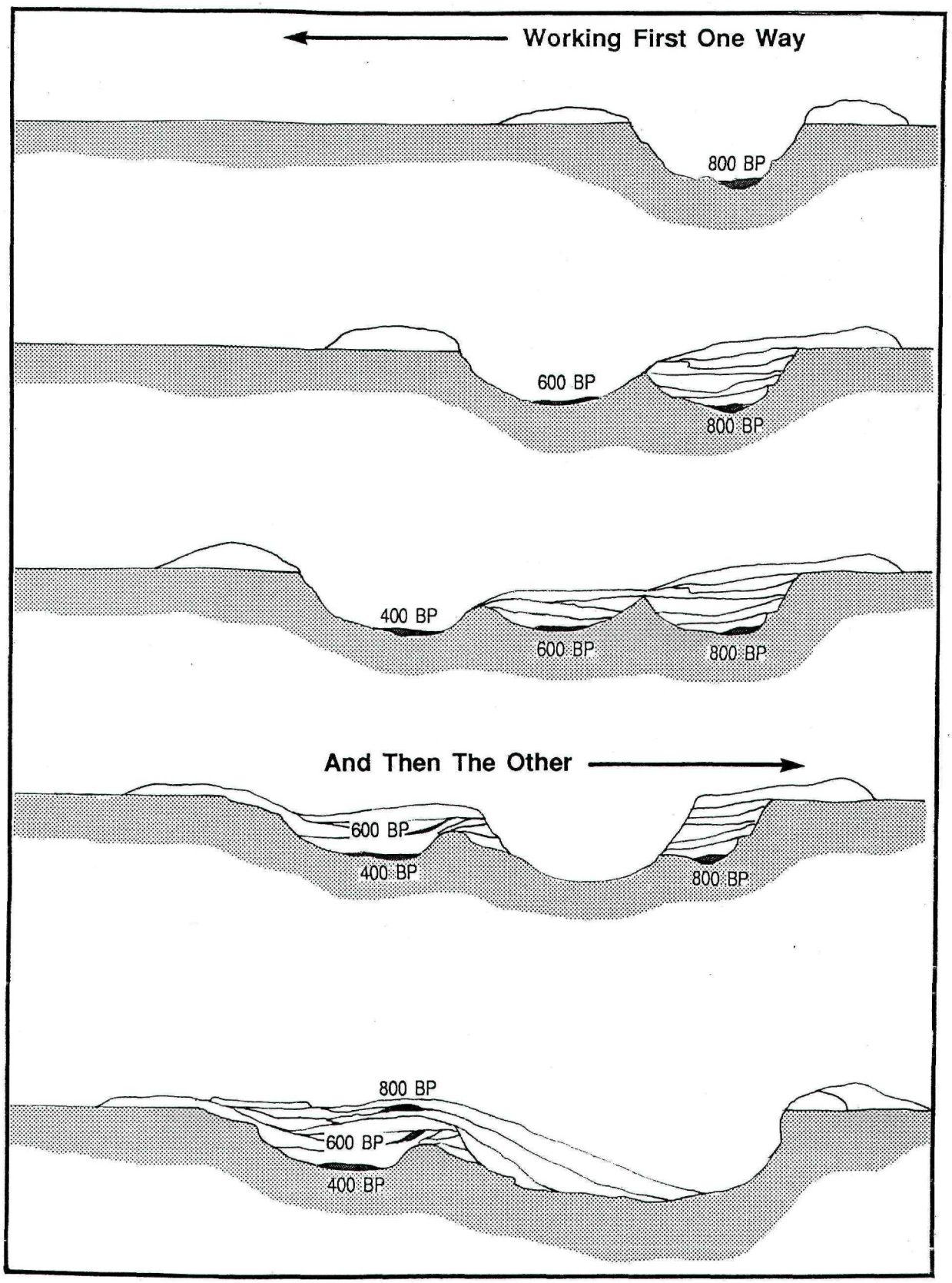

Figure 112. Model of chronological inversion of strata in quarry pit fill.

type silica (Cornucopia 1987). It lies downslope from several high-quality, intensively exploited opalite sources in the Tosawihi Quarries to the north. Here, only limited toolstone assay, as well as limited biface and core production, took place, owing perhaps, to the poor quality of the exposed opalite. No discrete artifact clusters were deposited. We collected surface artifacts and placed four small (25 cm x 25 cm x 10 cm) excavation units to sample cultural and noncultural materials along the slope of the opalite outcrop (Budy 1989:166). Over 1,000 opalite flakes, seven bifaces, four cores, and several percussion tools were collected.

Non-Quarry Locales

26Ek3086

Located on a gravel bar near the confluence of Basalt Canyon and Little Antelope Creek, 26Ek3086 (at 1,100 m^2) is a diffuse scatter yielding evidence of biface reduction and cobble assay (cf. Figure 100). We detected no surface features, and artifact distribution appeared unpatterned. Opalite cobbles and sparse opalite flakes were noted in the gravels, yet none of the four bifaces and two flake tools we collected appears to have been fashioned from on-site opalite (Budy 1989:197).

26Ek3087 and 26Ek3088

Reduction stations 26Ek3087 (300 m^2) and 26Ek3088 (650 m^2) lie on small terraces on the south side of Basalt Canyon (cf. Figure 100). On-site sediments at 26Ek3087 consist of 40 cm of rocky, sandy silt overlying large boulders; 26Ek3088 is mantled more thinly. Cultural deposits at both sites appear confined to the surface, and consist of thin scatters of debitage lacking clear concentrations. Bifaces and a single flake tool retrieved from 26Ek3088 compose the entire formed artifact assemblages (cf. Table 118).

26Ek3090

26Ek3090 is a small (150 m^2) reduction station that extends from a bedrock overhang, across a narrow bench, and downslope approximately 20 m to the streambed of Basalt Canyon (cf. Figure 100). A 1 m x 1 m test unit sampled deposits (to 30 cm below surface) at the base of the low overhang (Budy 1989:198). Below 30 cm, the unit was reduced to 50 cm x 1 m. Soil was screened through 1/8 inch mesh, yielding 120 pieces of opalite debitage, five bifaces, and a flake tool. We observed sediments stratified in three distinct soil units, including (from surface to 25 cm) a dark brown silt loam with abundant natural charcoal flecks and chunks, underlain by 20 cm of dark brown silt loam with cobbles of opalite. The lowest unit is a dark reddish brown silty clay loam containing abundant opalite cobbles and boulders.

26Ek3091

26Ek3091 (400 m^2), located on the moderately steep slopes of Basalt Canyon, is a highly disturbed, sparse reduction locus with no clear feature concentrations (cf. Figure 100). We recovered few formed artifacts (six bifaces and an opalite core) from the surface (Budy 1989:200).

26Ek3092

Basalt Canyon unquestionably was attractive for prehistoric settlement. The winding, steep-sided canyon has slowed the course of the stream, building up sediments in a series of small, vegetated terraces (Budy 1989:191). The terraces rise about four m above the north side of the channel, extending another 30 m to the base of Red Hill (Figure 113). Though the stream is ephemeral, water is forced close to the surface by underlying bedrock and is trapped by sediments, contributing to small, persistent pools that provided important seasonal habitat for large and small mammals and a potentially tappable source of drinking water (cf. Chapter 25; Budy 1989:191). Edible grass and sedge seeds are available in early summer (Intermountain Research 1988b).

Stratified alluvial deposits and buried residential and reduction features render 26Ek3092 unique among sites in Basalt Canyon. The site represents a series of short term residential camps and toolstone reduction loci. Its assemblage contains diverse food processing and equipment maintenance tools, pottery, and faunal remains, suggesting multiple uses of the place.

Massive boulders of replacement silica on the southeast flank of Red Hill in and near the bottom of Basalt Canyon are relict masses of the old, regional silica cap (Bartlett, Enders, and Hruska 1991). One of these, on the upper terrace, served as a focal point for many of the domestic activities undertaken at the site (Figure 114a and b). The clustered distribution of artifacts and features at its foot suggest that it was a repeated locus for lithic tool production and maintenance, food preparation, refuse dumping, and raw stone heat-treatment.

Excavation Methods and Rationale

Our goal was to identify buried cultural components in the terrace sediments and compile a relative occupation chronology. Discrete surface concentrations on the steep slopes above the drainage were recorded as Features 1–5; associated surface artifacts were plotted and collected (Table 124). We took no systematic debitage collections from these highly eroded surface features.

Table 124. Summary of Surface Collected Artifacts from 26Ek3092.

		FORMED ARTIFACTS							
Feature	Area (m^2)	Proj. Points	Bifaces	Cores	Flake Tools	Modif. Chunks	Ground Stone	Other/ Exotic	Total
1	14	-	1	-	-	1	-	-	2
2	25	-	3	-	2	-	-	-	5
3	7	-	-	-	-	-	-	-	0
4	6	-	1	-	-	-	-	-	1
5	5	-	2	-	-	-	-	-	2
Nonfeature		3	11	1	3	-	1	1	20
Totals		3	18	1	5	1	1	1	30

During testing, we opened Trenches 1–4 in nonfeature areas to expose cross sections (Budy 1989). These trenches were intersected subsequently by three controlled excavation units located to expose possible cultural surfaces indicated by flake and pebble lines in trench wall profiles (Budy 1989:194).

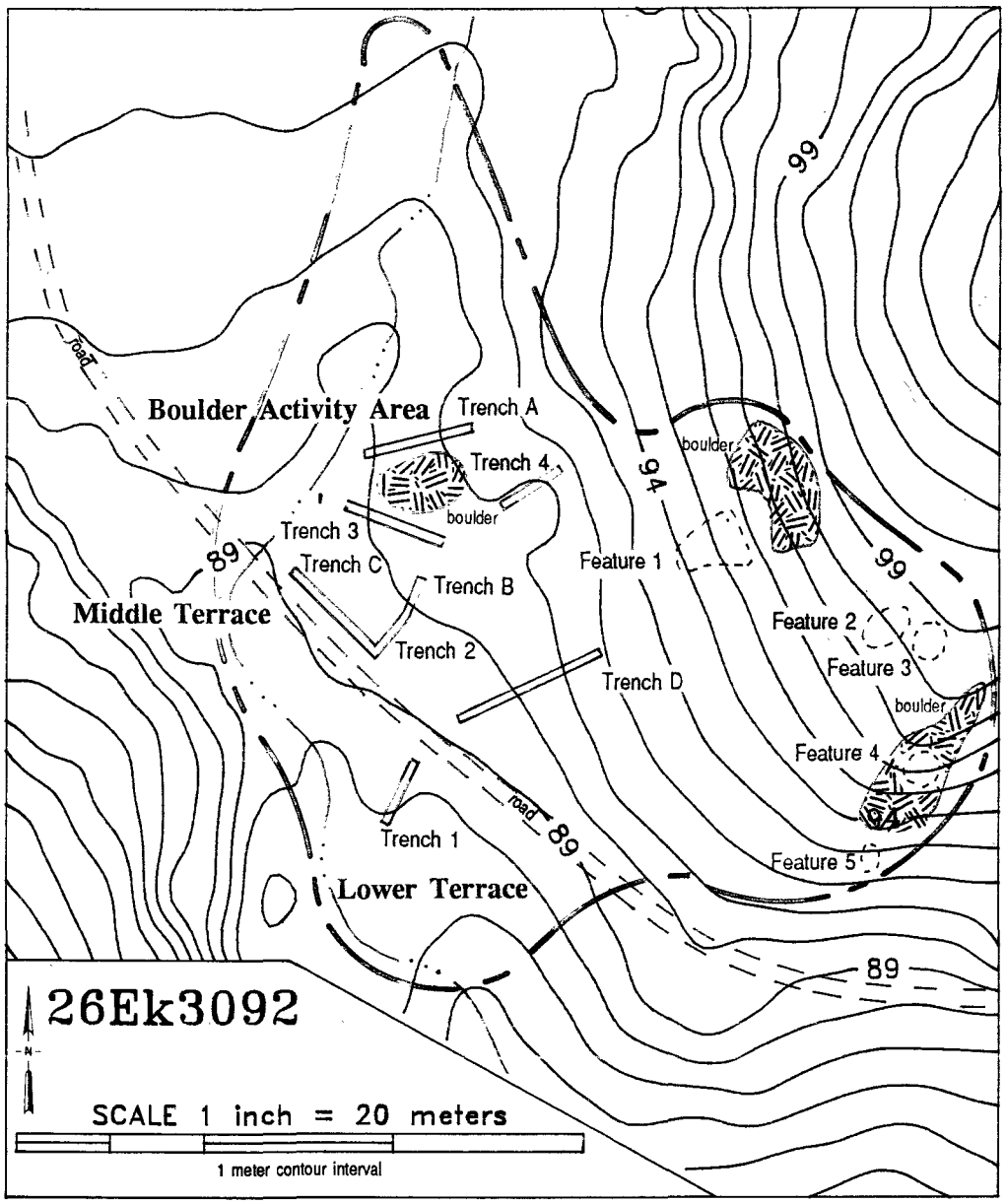

Figure 113. 26Ek3092 site map.

a.

b.

Figure 114. 26Ek3092. a. Large boulder that served as focal point for domestic activities seen at far left; b. Base of large bouler, revealing clustered feature remains.

In 1989, we investigated site stratigraphy more fully by extending Trenches 1–4 and excavating four additional trenches (Trenches A–D; cf. Figure 113). As well, a series of 1 m x 1 m units were excavated throughout the site to recover subsistence data, to assess artifact variability, to retrieve additional chronological indicators, and to search for potential residential features. We placed one block of contiguous excavation units to uncover the hypothesized activity area centered around the prominent boulder on the upper terrace. Twelve randomly drawn excavation units also were placed to sample approximately 10% of the surface area of the middle terrace, immediately south of the large boulder. Two additional units were excavated in the most recent (lower) terrace, close to the modern streambed.

Excavations in the Boulder Activity Area

Trench 3 ran along the southwestern edge of the prominent boulder to explore the depth and content of cultural materials on this portion of the terrace; Trench 4 crossed the steeper slope edging the north boundary of the site (Figure 115). A large, saucer-shaped soil feature and several flake lines were observed in the profile of Trench 3, prompting us to place a test excavation unit (TS 3) on the north wall of the trench, along the west edge of the feature. We recovered a large quantity of debitage and formed tools, including tens of thousands of pieces of opalite, obsidian, and basalt debitage, and many formed artifacts (Table 125). This sample reflects toolstone reduction, tool maintenance, and other more subsistence-oriented activities; a hammerstone and abrader, some expedient flake tools and scrapers, perforators, several projectile points, and numerous bifaces were retrieved. Three sherds of corrugated Great Salt Lake Grayware, including one neck sherd from a cooking jar, lay at about 30 cm (cf. Chapter 13). The unit was excavated to a depth of 70 cm.

Table 125. Summary of Artifacts Collected from Excavation Units in the Boulder Activity Area at 26Ek3092.

		DEBITAGE			FORMED ARTIFACTS										
Unit No. (Type)	Volume Excav. (m³)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Other/ Ceramics	Exotic	Total
SOUTH BOULDER UNITS														
3 (TS)[a]	0.7	16,286	7,105.7	2	-	11	1	8	1	1	-	4	-	28
3 (TR)	N/A	-	-	-	-	2	-	2	-	-	-	-	-	4
16 (EU)	0.6	1,847	2,834.5	-	1	8	-	-	-	1	-	4	-	14
17 (EU)[b]	0.9	16,803	16,809.0	2	1	39[d]	1	24	1	1	-	15	-	84
18 (EU)	0.9	10,895	17,412.6	1	-	33[d]	1	5	-	2	-	10	-	52
19 (EU)	0.8	5,026	9,670.7	3	-	18[d]	-	4	-	1	-	1	-	27
20 (EU)[b]	0.7	2,705	3,904.5	-	1	6	-	3	-	-	-	-	-	10
21 (EU)	0.6	1,468	3,096.0	-	3	6[d]	1	1	1	-	-	-	-	12
22 (EU)	0.5	2,048	4,316.2	2	1	17[d]	-	1	-	1	-	-	-	22
23 (EU)	0.5	2,615	5,379.4	1	-	12	-	2	-	1	-	2	1	19
24 (EU)	0.4	4,906	5,963.4	-	2	15[d]	-	4	-	2	1	-	1	25
25 (EU)	0.5	2,552	4,172.6	1	-	6[d]	-	2	-	-	-	-	-	9
26 (EU)[b]	0.4	2,413	2,329.2	-	1	12	-	1	-	-	-	-	-	14
27 (EU)	0.4	1,461	1,681.8	-	-	2	-	1	-	-	1	-	-	4
28 (EU)	0.4	1,650	2,853.4	1	-	9	-	1	-	1	-	1	-	13
29 (EU)	0.4	1,706	3,178.8	-	1	17	-	5	-	-	-	-	-	23
30 (EU)	0.5	1,769	3,242.2	-	-	23[d]	2	2	-	2	-	-	-	29
31 (EU)	0.5	1,273	4,220.3	1	2	17	2	2	-	-	1	-	-	25
32 (EU)	0.4	623	1,283.9	-	-	7	2	1	-	2	-	-	-	12
EAST, WEST, NORTH BOULDER UNITS														
33 (EU)	0.6	756	1,144.1	-	-	5	1	3	-	-	-	5	-	14
33/36 (EU)[c]	N/A	68	110.2	-	-	1	-	-	-	1	-	-	-	2
36 (EU)	0.4	500	929.5	-	1	4	-	1	-	1	-	2	-	9
37 (EU)	0.6	997	1,863.7	-	-	4	-	-	-	-	-	11	-	15
38 (EU)	0.3	243	846.4	-	-	4	-	4	1	-	-	-	-	9
39 (EU)	0.6	1,110	2,652.9	1	1	1	-	4	-	-	-	-	-	7
40 (EU)	0.8	720	1,420.3	2	-	1	-	-	-	-	-	-	-	3
41 (EU)	0.3	442	741.3	-	-	2	-	-	1	-	-	-	-	3
42 (EU)	0.5	586	1,558.4	-	1	3[d]	-	2	-	-	-	-	-	6
43 (EU)	0.9	1,714	3,629.8	2	-	7	-	2	-	-	-	-	-	11
44 (EU)[b]	0.3	833	1,127.4	-	-	2	-	3	-	-	-	-	-	5
45 (EU)	0.3	489	818.9	1	1	3[d]	-	2	-	-	-	-	-	7
Total	86,504	116,297.1		20	17	297	11	90	5	17	3	55	2	517

(TS) = Test Excavation Unit
(EU) = Excavation Unit
(TR) = Backhoe Trench

[a]Screened entirely through 1/8 inch mesh
[b]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[c]Feature 9 was excavated as a discrete unit, cross-cutting Units 33 and 36
[d]Includes "possible" bifaces

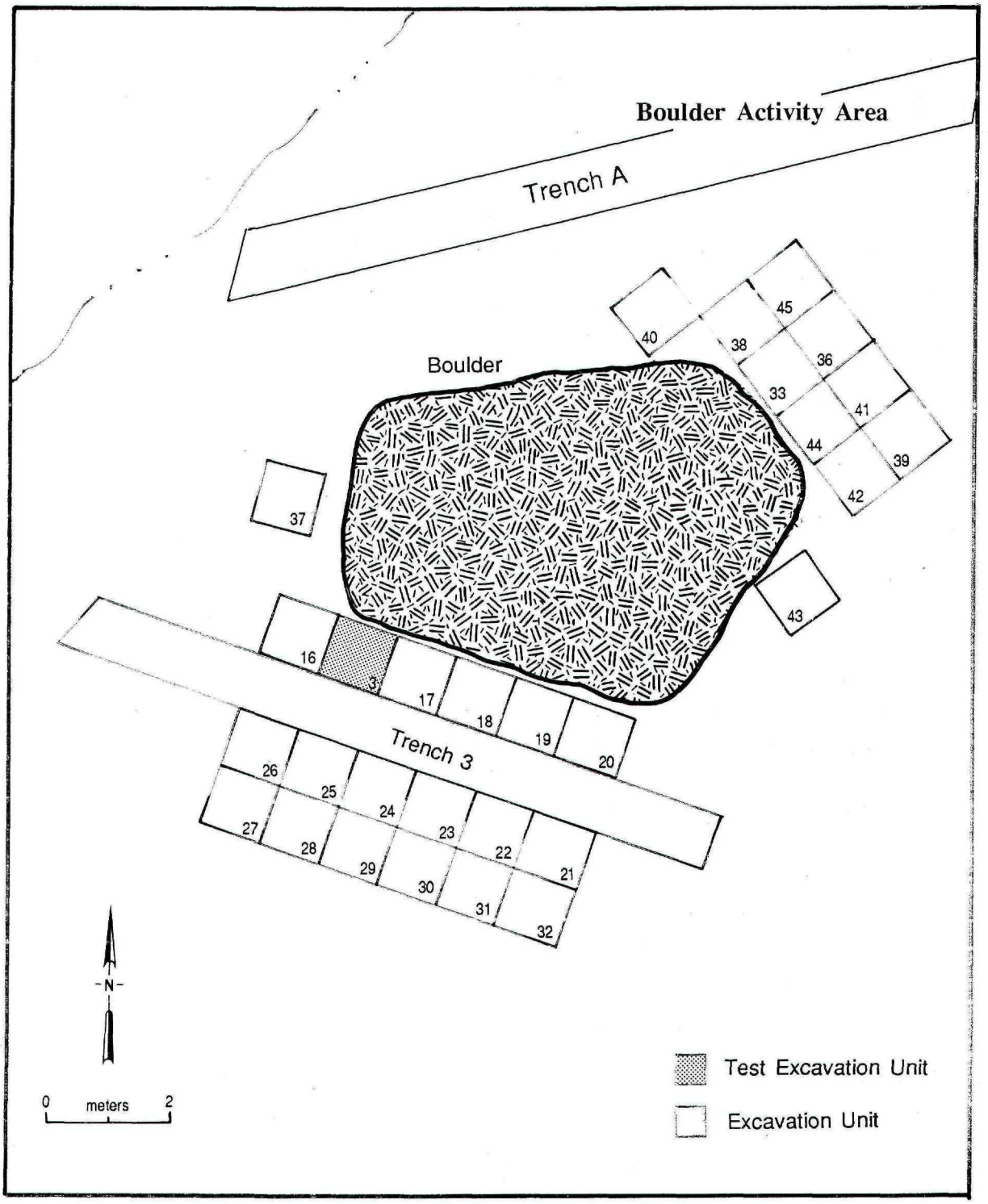

Figure 115. 26Ek3092, excavation units in the Boulder Activity Area.

The presence of this dense, subsurface deposit of reduction debris, specialized tools, and ceramic sherds, suggested that the boulder may indeed have served as a centralized locus for residential and tool production activities. We returned in 1989 to expose the area around the boulder and to search for buried residential features. We excavated a block of 18 1 m x 1 m units south of the boulder, arrayed on either side of Trench 3 (EUs 16–32), and 11 units to the sides (EUs 37 and 43) and north of the boulder (EUs 33, 36–45; cf. Figure 115).

We retrieved a variety of formed items, including additional Grayware ceramics and one sherd of Shoshone Brownware, diverse flake tool forms, a bone awl and a bone flaker, and three tabular basalt metate fragments. The presence of projectile points spanning the pre-Archaic and Archaic periods testifies to the persistent attraction of the boulder as a focal point of activity.

Too, we exposed a number of functionally-diverse subsurface features reaffirming that the boulder served as a long-used central activity area (Table 126 [following page]; cf. Figure 114a and b). Dense flake lenses, cobble accumulations, large tool aggregations, hearths, and ephemeral charcoal stains reflect various domestic uses. These often are interdigitated, reflecting a highly complex depositional history. We conclude, therefore, that use of the boulder area has been virtually continuous, with few episodes defined by discrete soil lenses.

Feature 9, a well-preserved hearth north of the boulder (Figure 116a) is unique at Tosawihi. We exhaustively sampled the soil matrix and recovered a few charred, edible seeds in flotation (cf. Chapter 15). More striking, however, was the presence of small bits of crumbled and heat-crazed opalite, indicating probable use of the facility for heat-treatment of toolstone. Two essentially equivalent radiocarbon dates of 750 ± 70 B.P. and 650 ± 50 B.P. (Beta-36976 and -36977) place the feature in the Late Archaic (Table 127).

Table 127. Provenience of Radiocarbon Dates from Site 26Ek3092.

Reference Number	Laboratory Number	Date (Years B.P.)	Provenience
8584-5	Beta-36976	750±70	Feature 9
8645-1	Beta-36977	650±50	Feature 9

The function of tool/flake/cobble concentrations, like Feature 13 pictured in Figure 116b, remains unclear. This feature, like others in the boulder activity area, is associated with a variety of tools and debitage suggesting an eroded domestic surface or areal cleaning of cobble-lined hearths.

Food residue is scarce in this portion of the upper terrace. Large mammal bones are found more commonly in the meadow to the south, where they appear to have been tossed from food preparation areas at the boulder (cf. Chapter 14).

Excavations on the Middle Terrace

Trenches B, C, and 2 were located on the broadest portion of the middle terrace, oriented to expose an 'L'-shaped profile of terrace deposits (Figure 117). Test Unit 1, placed off the west edge of Trench 2, disclosed deep terrace deposits to 90 cm below surface. The deposits were extremely disturbed by rodent burrowing; thus artifacts, like a Gatecliff projectile point found 85 cm below surface, may have been moved from their original contexts.

Table 126. Subsurface Features in the Boulder Activity Area at 26Ek3092.

Feature No.	Type	Feature Area (m^2)	Volume Excav. (m^3)	Depth Encountered (cm below surf.)	Excav. Unit No.	ASSOCIATED ARTIFACTS Debitage	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Perc./ Cobble Tools	Metate	Ceramics[†]	Bone Flaker
6-636	flake-filled pit	0.03	0.003	18	3	+									
6-638	flake concentration	1.00	0.020	12	18	+			+	+	+				
7/8	flake concentration	2.24	0.051	10	17, 18	+	+[a]		+		+	+		+	
9	hearth	0.46	0.050	33	33, 36	+			+			+			
10	cobble aggregation	2.00	0.160	20	25, 26	+									
11	charcoal stain	0.47	0.024	10	22	+									
12	tool/flake concentration	6.28	0.326	5	22-25, 28-31	+			+	+	+		+		
13	tool/flake concentration	7.00	0.308	10	22-24, 28-31	+		+	+		+	+			+
14	tool/flake concentration	1.00	0.087	13	17, 18	+	+[b]		+		+	+		+	
15	flake concentration	0.10	0.009	3	16	+									
16	soil feature	0.32	0.022	10	44	+			+						
17	soil feature	0.32	0.006	12	44	+									
18	soil feature	0.42	0.025	12	44	+									
19	cobble/tool aggregation	1.00	0.060	25	16	+			+						
20	cobble concentration	0.40	0.044	20	23	+			+					+	
21	flake concentration	1.95	0.088	13	18, 19	+			+					+	
22	cobble aggregation	0.71	0.035	45	23	+									
23	flake concentration	0.40	0.045	30	17, 18	+	+[a]		+		+			+	
24	cobble aggregation	0.53	0.138	45	17, 18	+			+			+			

[†]All Great Salt Lake Grayware
[a]Rosegate Projectile Point
[b]Cottonwood Projectile Point

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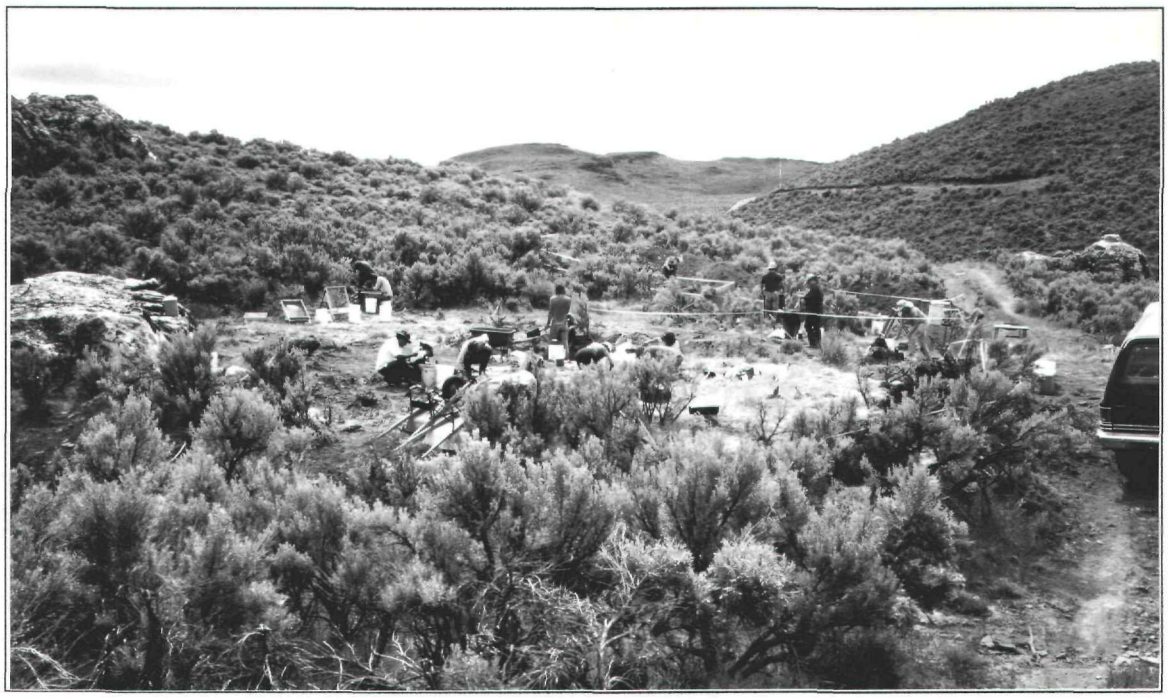
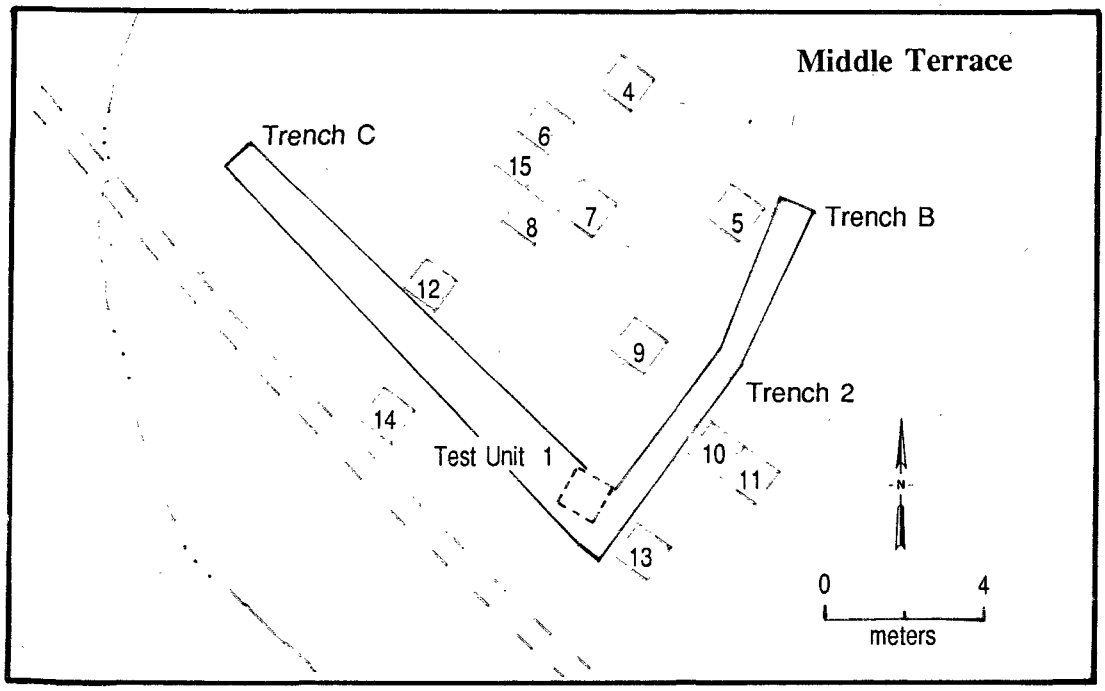


a.

b.

Figure 116. 26Ek3092. a. Feature 9; b. Feature 13.



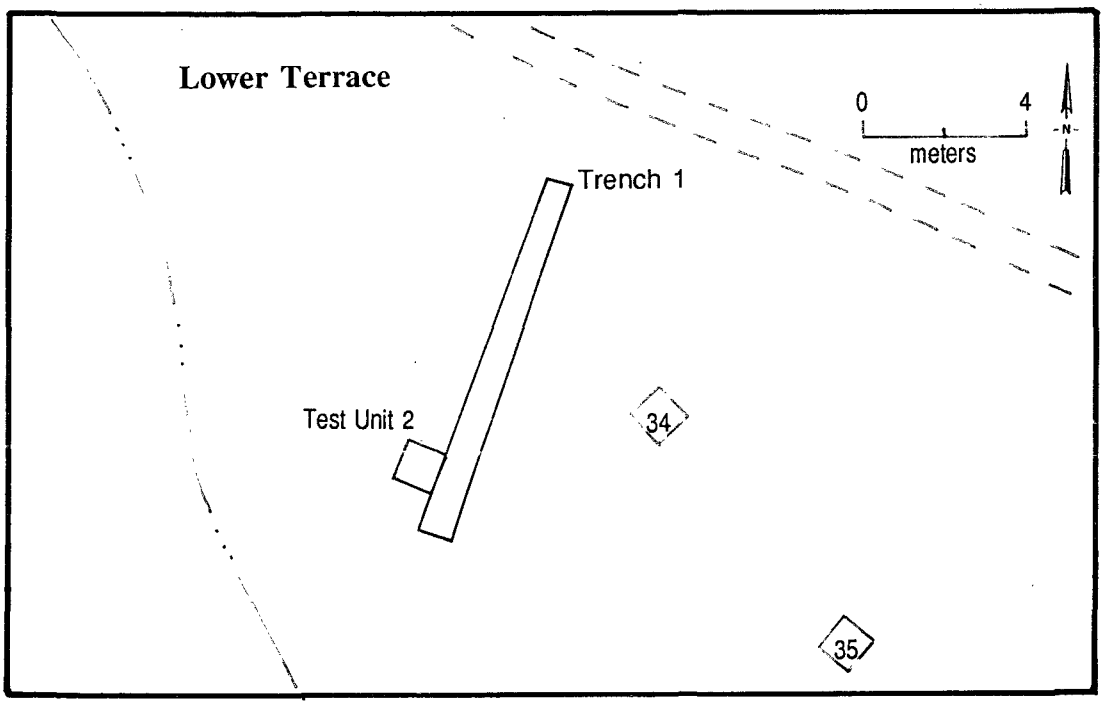


Figure 117. 26Ek3092, excavation units on the Middle Terrace and the Lower Terrace.

Our randomly placed 1 m x 1 m excavation units sampled over 10% of the meadow on the middle terrace. These units intruded deep soils, ranging from 40 cm to 1.1 m below surface. Fire-cracked rock and apparently heat-treated flakes were noted in several units, but no clear features could be discerned. As in our test excavations, all units reported substantial rodent disturbance. Dense flake yields were noted, and a variety of food preparation and processing tools were recovered. We also retrieved an expedient bone tool and a bone bead (Table 128).

Table 128. Summary of Artifacts Collected from Excavation Units in the Middle Terrace at 26Ek3092.

		DEBITAGE		FORMED ARTIFACTS										
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
1 (TS)[a]	0.9	9,525	6,022.4	2	-	17	-	6	-	-	-	-	-	25
2 (TR)	N/A	-	-	-	-	4	-	1	-	-	-	-	-	5
B (TR)	N/A	-	-	-	-	-	-	-	-	-	-	-	-	0
C (TR)	N/A	-	-	-	-	2	-	-	-	-	-	-	-	2
4 (EU)	0.4	941	1,675.2	-	-	5	-	-	-	-	-	-	-	5
5 (EU)	0.6	839	1,843.3	-	-	4	-	1	-	-	-	-	-	5
6 (EU)	0.4	1,906	3,367.2	1	-	17[c]	-	2	-	-	-	2	-	22
7 (EU)	0.9	2,841	3,878.7	2	-	14	-	4	-	2	-	1	-	23
8 (EU)[b]	0.8	8,476	11,237.8	-	2	25[c]	-	10	-	1	-	-	1	39
9 (EU)	0.9	1,461	3,005.6	1	-	7	-	1	-	-	-	2	1	12
10 (EU)[b]	0.5	1,604	1,677.7	-	1	10[c]	-	-	-	1	-	-	-	12
11 (EU)	0.6	725	1,052.6	-	3	5	-	1	-	-	-	-	-	9
12 (EU)	1.1	6,426	9,469.3	1	3	33[c]	-	7	-	1	2	-	-	47
13 (EU)	0.8	1,793	3,078.1	-	1	7[c]	-	6	1	-	-	-	-	15
14 (EU)	0.8	1,286	1,640.5	1	1	15[c]	-	2	-	-	-	-	-	19
15 (EU)	0.6	4,084	7,603.8	1	1	34[c]	1	6	-	-	1	-	-	44
Total	9.3	41,907	55,552.2	9	12	199	1	47	1	5	3	5	2	284

(TS) = Test Excavation Unit
(EU) = Excavation Unit
(TR) = Backhoe Trench

[a]Screened entirely through 1/8 inch mesh
[b]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[c]Includes "possible" bifaces

Most of the mammal remains (including rabbit, hare, marmot, pronghorn, bison, and mountain sheep) came from excavations in the middle terrace. Indeed, the meadow here may have been the refuse "toss" zone for bones prepared in the boulder activity area (cf. Chapter 14).

Several sherds of Shoshone Brownware as well as Desert Side-notched and Cottonwood projectile points, signal use of the meadow after A.D. 1300. A Gatecliff point may have been discarded much earlier (3000–1300 B.C.).

Excavations in the Lower Terrace

We placed Backhoe Trench 1 adjacent the modern streambed in order to characterize the geomorphologic nature of the lowest terrace (cf. Figure 117; cf. description below). Test Excavation Unit 2, off the west edge of Trench 1, penetrated moist meadow soils, and was terminated 70 cm below surface. We excavated two deep units (EUs 34 and 35) to the west of the backhoe trench, uncovering highly bioturbated deposits with associated flake tools, projectile points (Humboldt and Desert series points and unclassifiable fragments), and bifaces (Table 129).

Table 129. Summary of Artifacts Collected from Excavation Units in the Lower Terrace at 26Ek3092.

		DEBITAGE		FORMED ARTIFACTS			
Unit No.	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Bifaces	Flake Tools	Total
1 (TR)	N/A	-	-	1	-	-	1
2 (TS)	0.7	2,271	2,408.0	2	8	3	13
34 (EU)	0.6	739	1,992.5	1	6	2	9
35 (EU)	1.1	773	1,142.7	1	1	-	2
Totals	2.4	3,783	5,543.2	5	15	5	25

(TS) = Test Excavation Unit (EU) = Excavation Unit (TR) = Backhoe Trench

Terrace Stratigraphy

Four major stratigraphic horizons initially were recognized in Backhoe Trenches 1, 2, and 3 (Figure 118). A stratigraphic horizon contains a single stratum or a group of conformable strata that appear to represent an interval in which deposition dominates. In fluvial deposits, horizons essentially define inset terraces.

In 1989 trenches, the stratigraphic profiles not only confirmed the existence of these major depositional episodes, but also revealed additional complexity in the sedimentary record. For example, in Trench A (Figure 119), Units 3 and 4 are contemporaneous with units of Horizon IV, the oldest in the original trenches (Figure 118c), but these also are underlain by Unit 5 which has a truncated upper surface and a higher degree of pebble and cobble weathering. This suggests that Unit 5 may represent an even older sedimentary and pedogenic Horizon V. Molecular weathering ratios of the sediments in Unit 5, however, are not chemically distinct from Horizon IV (Figure 120). Both show a higher degree of leaching as indicated in the iron and aluminum ratios. The base ratio, which notably increases in Unit 3 in Horizon IV, suggests that Unit 3 is part of a truncated calcic soil horizon developed in these gravels, whereas bases decrease below. The higher phosphorus also suggests that Unit 3 may have been part of a stable surface in the past.

Deposits overlying the truncated surface of Units 3 and 5 in Trench A exhibit differences from other previously described deposits as well. These deposits, Units 6, 7, 8, and 9, have a coarser pebble component than their counterparts, although they are in the appropriate stratigraphic position to be equivalent to typical loamy Horizon III deposits elsewhere on the site. Horizon II (Unit 2), although of the same silty texture, is notably thicker than in other trenches. As with all other trenches at this site, except Trench 1, Horizon I is not present in Trench A. Finally, mantling the Trench A profile, there is the modern A horizon present over the entire surface of the site.

Trenches B and C best characterize the sediments that comprise the second highest (middle) terrace surface above the modern stream channel. Their profiles are typical of the stratigraphy encountered in most excavation units. Trench C (Figure 121) has a stratigraphic record identical to Trench B (equivalent to Trench 2 in Figure 118b) with a strongly weathered gravel Horizon IV, notable for its highly irregular surface relief, a result of extensive erosion and gullying; a Horizon III of strongly bioturbated, silty clay loam with a slightly cemented carbonate basal zone; Horizon II, a pebbly silt loam; and Horizon A, the typical silt loam surface layer. Horizons A, II, and possibly III, are also part of a poorly developed soil profile that probably has unrecognized aggradational surfaces within it. Chemically, a progressive leaching can be seen in the silty Units 1 through 3 (Figure 122). Unit 2a, however, may reflect the existence of a former stable surface. This is suggested by the slightly greater degree of iron leaching and the notable increase in phosphorus. This, however, also may be an effect of strong bioturbation.

Trench D, the eastern-most, provided a view not only of sediments from alluvial activity and the four main stratigraphic episodes, but also part of the colluvial slope above (Figure 123). It has a profile similar to those in Trenches B and C, with a lowermost gravel and cobble unit overlain by silt units. There is a difference, however, in the larger amount of clays present in the silts in Trench D. This may be a function of clays being mixed with the silts by slopewash. The very clay-rich Unit 6, present upslope, is probably the source. This reddish clay has a distinct fine columnar structure that indicates some stability on the hillslope; however, it also appears to be reworked to some degree with common incorporated colluvial gravel. Unit 6 appears the least reworked where it directly overlies Unit 5 at the extreme northeastern end of the trench. The stratigraphic position of Unit 6 here suggests soil development on the surface of an older terrace. Molecular weathering ratio plots for these sediments show an interesting trend beginning with Unit 4 (Figure 124). At this point the aluminum ratio shows decreased clay formation while iron indicates increased oxidation. Also, the phosphorus percentage increases.

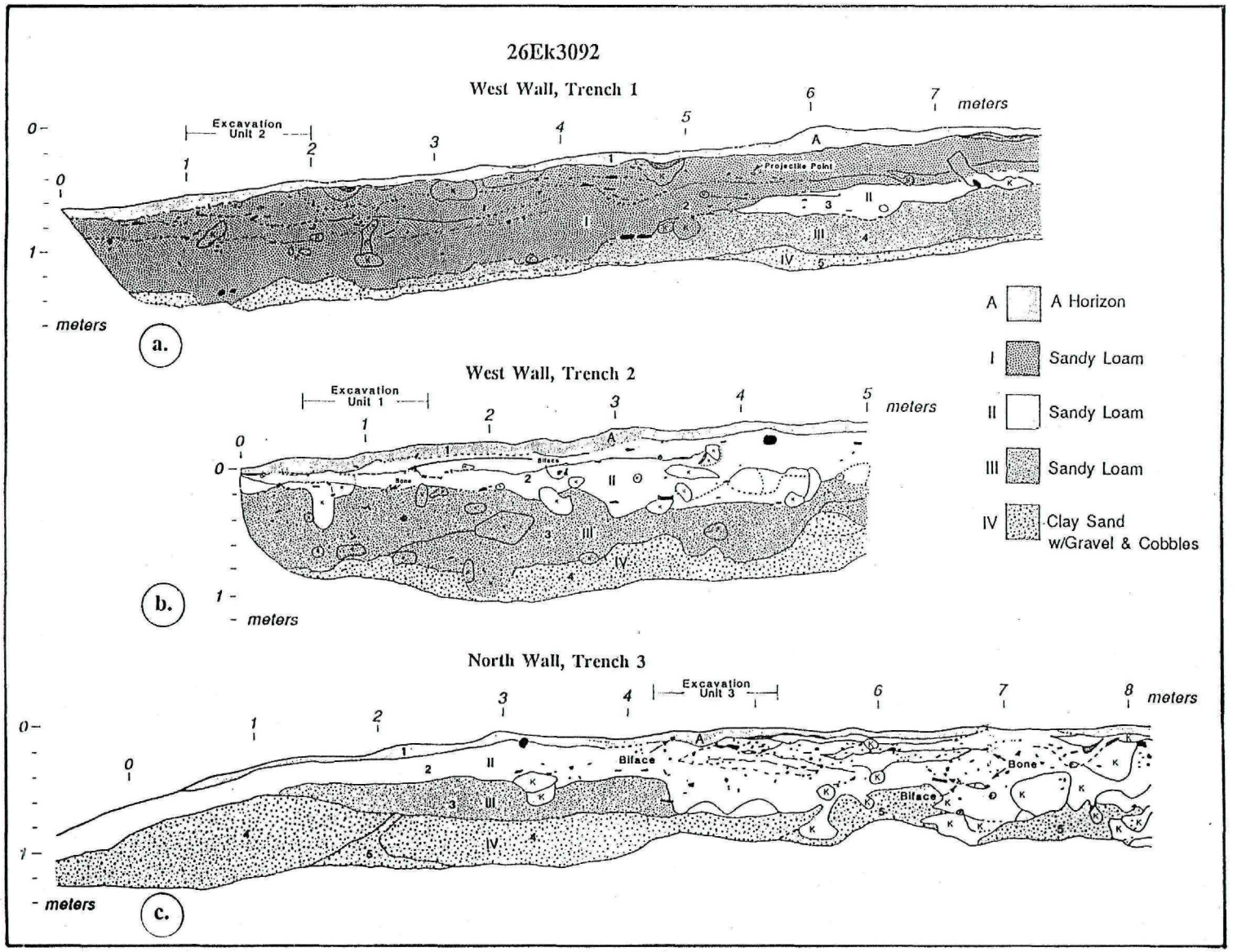


Figure 118. 26Ek3092. Stratigraphic profiles of Trenches 1, 2, and 3, excavated during 1988 Testing. a. West wall, Trench 1; b. West wall, Trench 2; c. North wall, Trench 3.

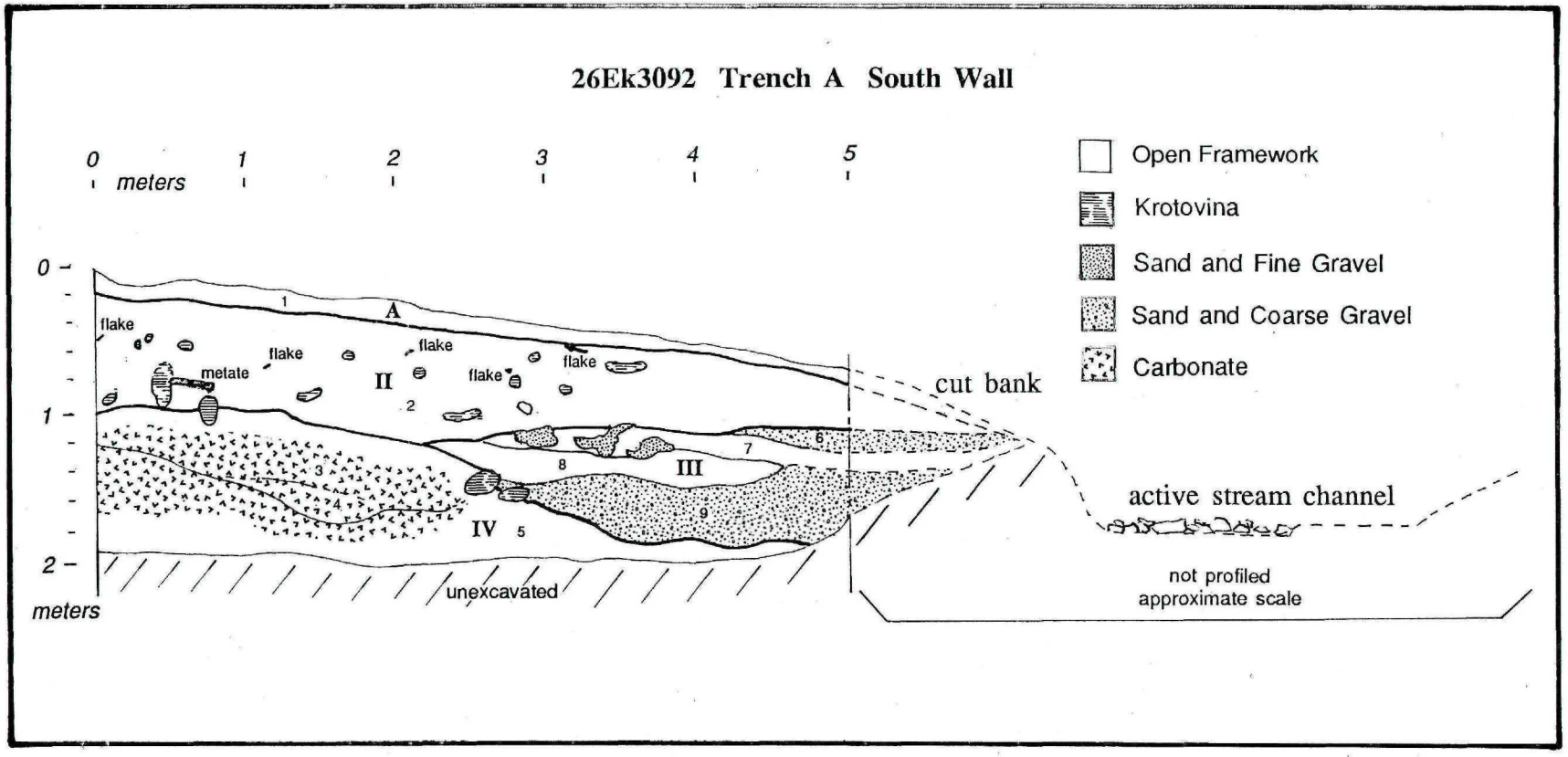
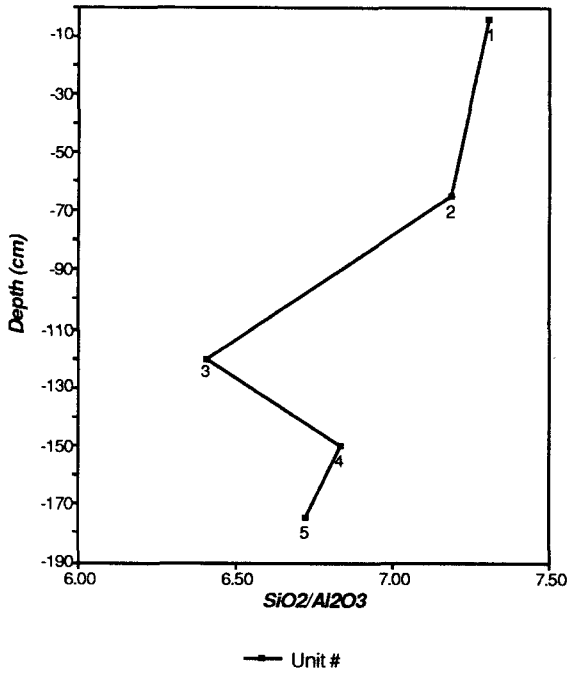


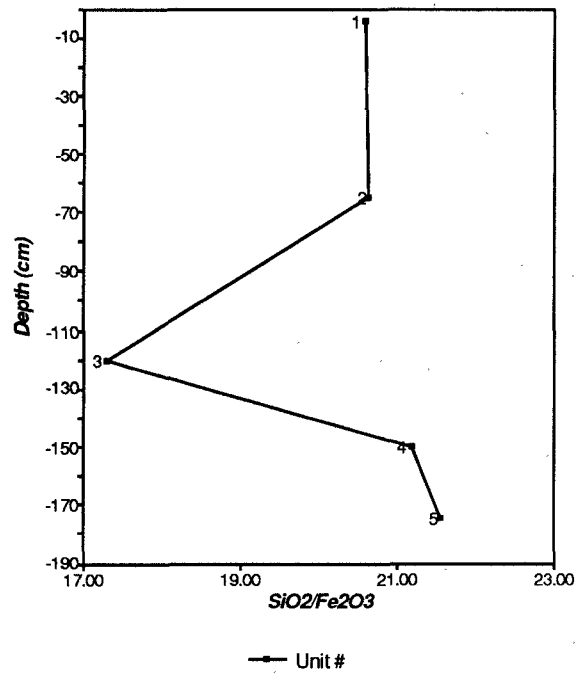
Figure 119. Description of stratigraphic units, Trench A, 26Ek3092.

Figure 119. Description of stratigraphic units, south wall of Trench A, 26Ek3092.

Horizon	Stratum	Description
A	1	Grayish brown (10YR 5/2) dry; silt loam; loose to weak, fine to granular to fine platy; abundant fine, common medium roots; common fine to medium subangular to subrounded pebbles; boundary gradual to clear and smooth.
II	2	Dark brown (10YR 3/3) dry silt loam; mottling of dark yellowish brown (10YR 4/6) dry; as sandy patches in lowest 10–15 cm of unit; loose to weak fine granular to weak fine subangular blocky; common fine to medium roots and pores, common burrows; common fine to medium subangular to subrounded pebbles, rare fine opalite flakes; boundary abrupt and irregular.
IV	3	Yellowish red to dark reddish brown (5YR 4/6 to 3/4) moist; silty clay; weak fine angular blocky; rare fine to medium roots and pores; rare fine rounded pebbles in upper parts grading to medium to coarse gravels downward; moderate acid reaction on carbonate veins and pebble coating in lower half of unit; boundary clear and irregular.
	4	Dark grayish brown (10YR 4/2) moist; with clear mottling of very dark brown (10 YR 2/2), yellowish brown (10YR 5/6) and yellowish red (5YR 5/8) sandy clay, coarsening downward, abundant strongly weathered gravels; weakly columnar; moderate acid reaction on carbonate veins and pebble coatings; boundary clear and irregular.
	5	Dark yellowish brown (10YR 4/4) moist; with mottling as in Unit 4; clayey sand with abundant fine to coarse subangular to subrounded gravels and cobbles commonly strongly weathered, primarily matrix supported; strong acid reaction on well-developed carbonate accumulation that reaches down into the top 40 cm of this unit; boundary unexposed.
III	6d	Dark brown (7.5YR 4/4 dry) clayey sand matrix clast supported fine to medium subangular to subrounded gravels, rare fine subangular cobbles; boundary abrupt wavy.
	7	Gravels similar to Unit 6 with silts similar to Unit 2; extensively burrowed and disturbed.
	8	Similar to Unit 7, but with slightly more gravels.
	9	Strong brown to dark brown (7.5YR 5/6 to 4/4) clayey sand with gravels similar to Unit 5 except they are less weathered and generally coarser.



a.



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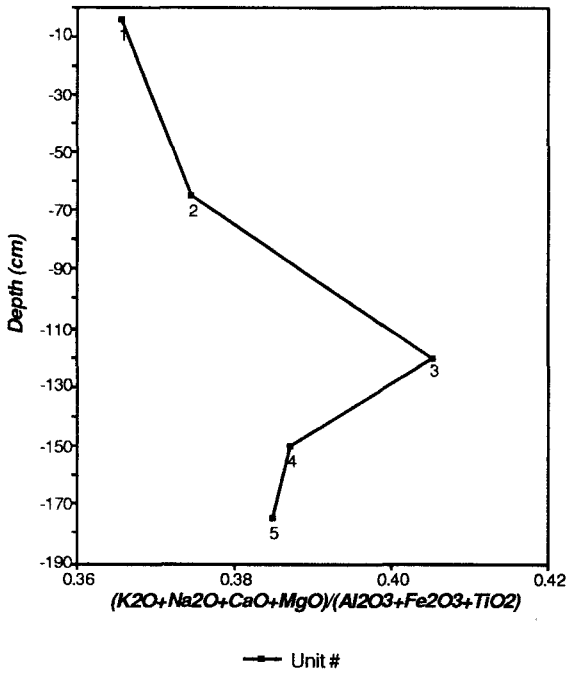

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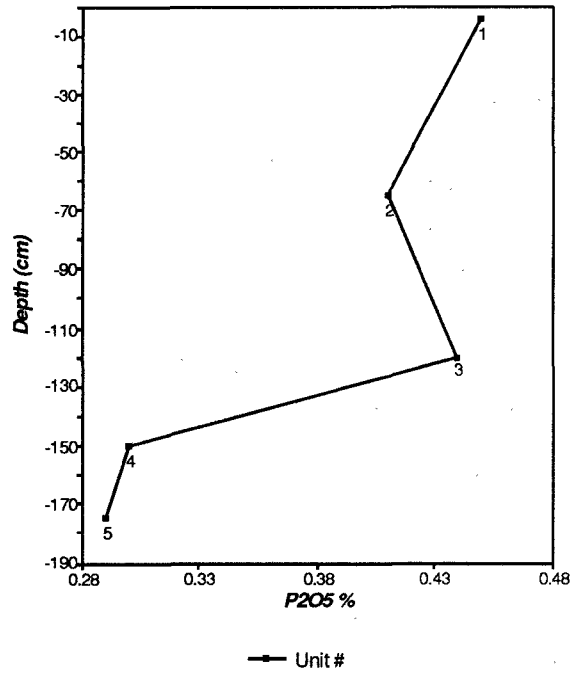


d.

Figure 120. Molecular weathering ratios for 26Ek3092, Trench A, profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

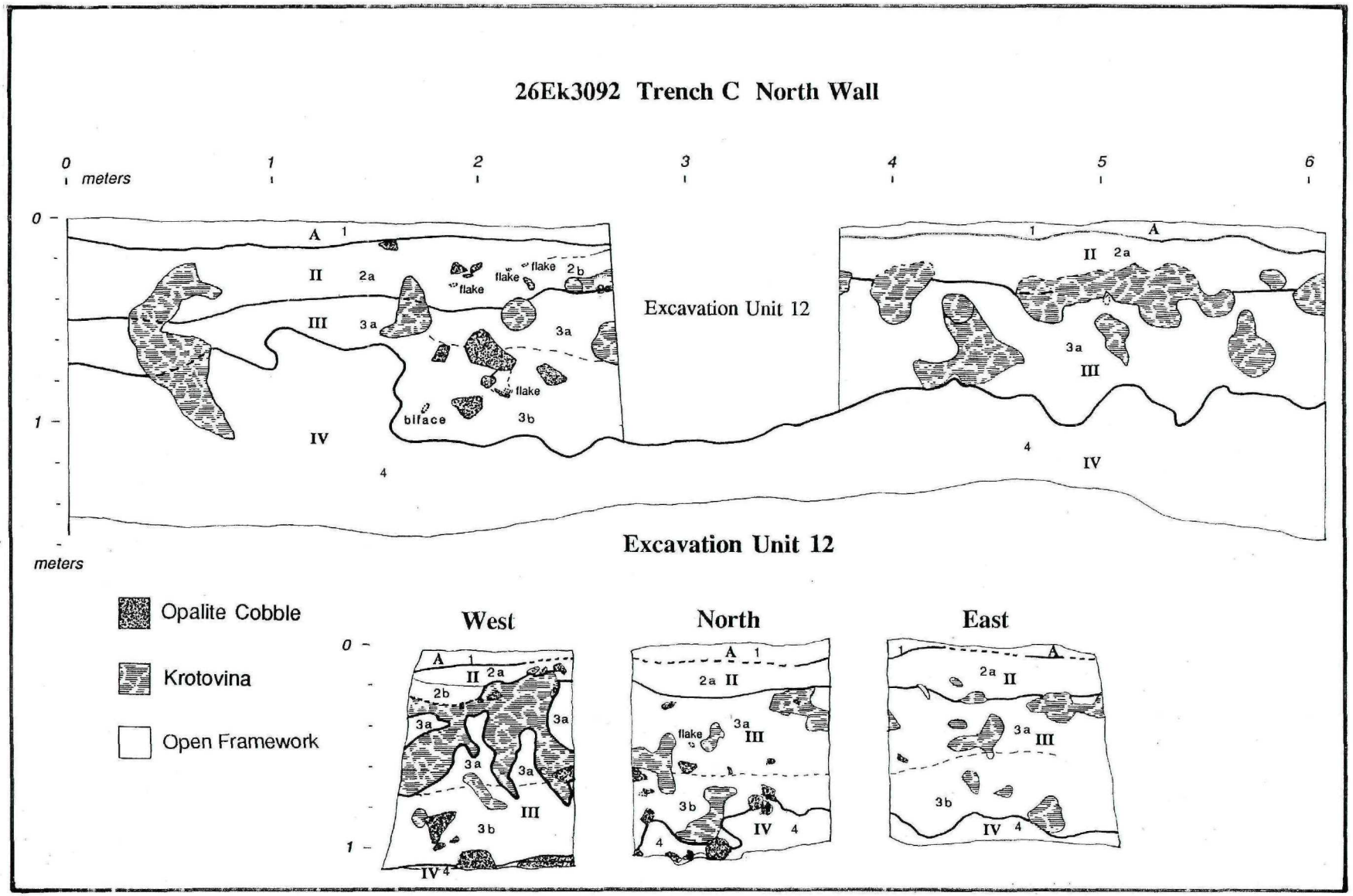
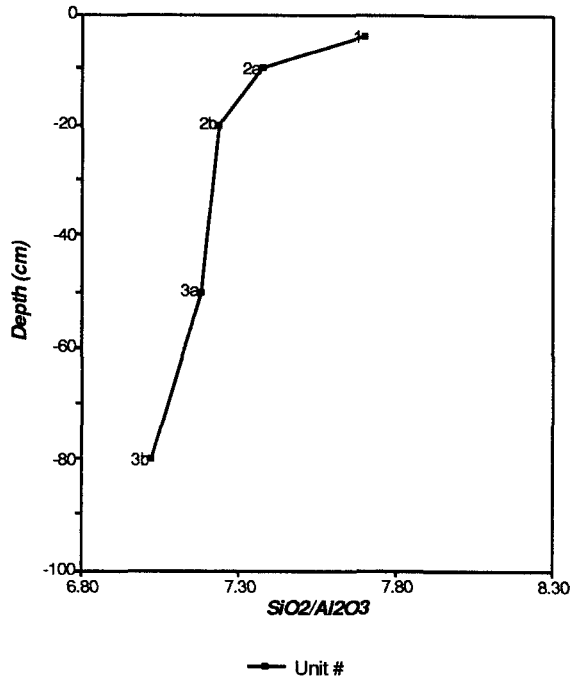


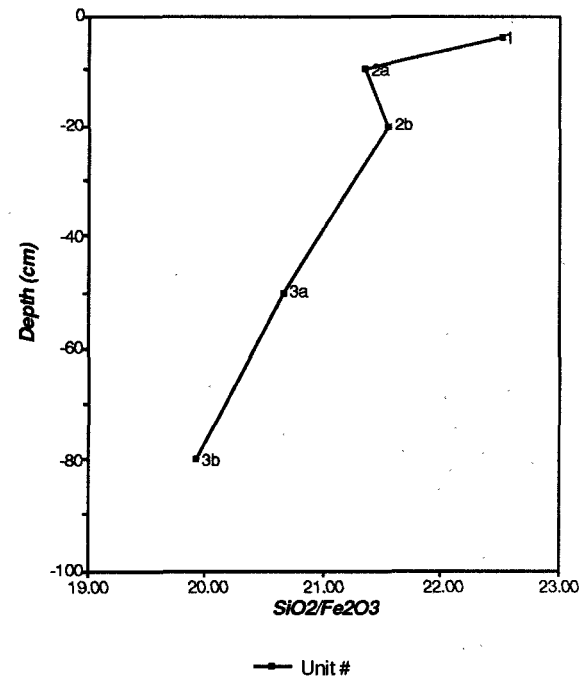
Figure 121. Description of stratigraphic units, Trench C, 26Ek3092.

Figure 121. Description of stratigraphic units, north wall of Trench C, 26Ek3092.

Horizon	Stratum	Description
A	1	Dark brown to very dark brown (10YR 3/3 to 3/2) dry; silt loam; loose to weak fine granular to weak fine platy; abundant fine to medium roots and abundant dry organics at surface; rare randomly distributed fine and medium opalite flakes and rare commonly subhorizontal opalite flakes along bottom of unit at boundary; boundary clear and smooth.
II	2a	Dark brown (10YR 3/3) dry; silt loam; loose to weak medium subangular blocky; common medium subangular to subrounded pebbles; abundant fine to medium roots, common krotovina; rare commonly subhorizontal fine to medium opalite flakes; flakes suggest additional unrecognizable boundaries within this unit; boundary diffuse to clear and irregular.
	2b	Dark grayish brown (10YR 4/2) dry; silt loam; moderately hard, no apparent structure; common fine to medium roots; distinct fine rounded pebble and fine flake lenses along lower boundary with Unit 2c.
	2c	Very dark grayish brown to very dark brown (10YR 3/2 to 2/2) dry; silt loam; loose to moderately compact, no apparent structure; common fine subangular pebbles; common fine roots; rare fine to medium opalite flakes; abundant charcoal flecks; this unit is possibly part of a krotovina.
III	3a	Very dark grayish brown to very dark brown (10YR 3/2 to 3/3) dry; silty clay loam to silt loam; loose to weak fine subangular blocky; common fine to medium subangular to subrounded pebbles; common fine roots, abundant krotovina; boundary with Unit 4 abrupt and irregular, boundary with Unit 3b clear and smooth.
	3b	Same as Unit 3 except sediment is weakly cemented with carbonate, slightly stronger carbonate accumulation is apparent on the upper surfaces of the larger stones in this unit, weak acid reaction; boundary abrupt and irregular.
IV	4	Strong brown to dark brown (7.5YR 5/6, 4/6, 4/4) dry; clast supported to matrix supported, matrix is hard, fine to coarse subrounded sand with clay, and fine subangular to subrounded pebbles to subangular to subrounded cobbles up to 20 cm, poorly defined coarsening of clasts downward in unit; the surface of this unit appears to have been highly eroded and also possibly burrowed in places.



a.



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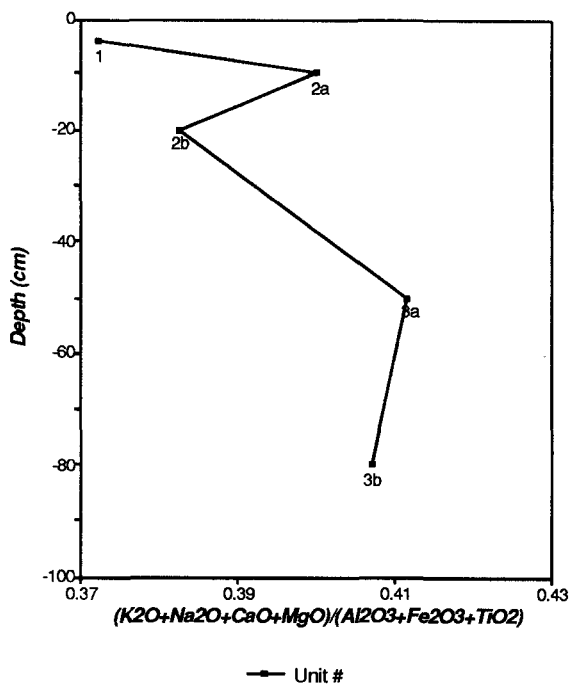

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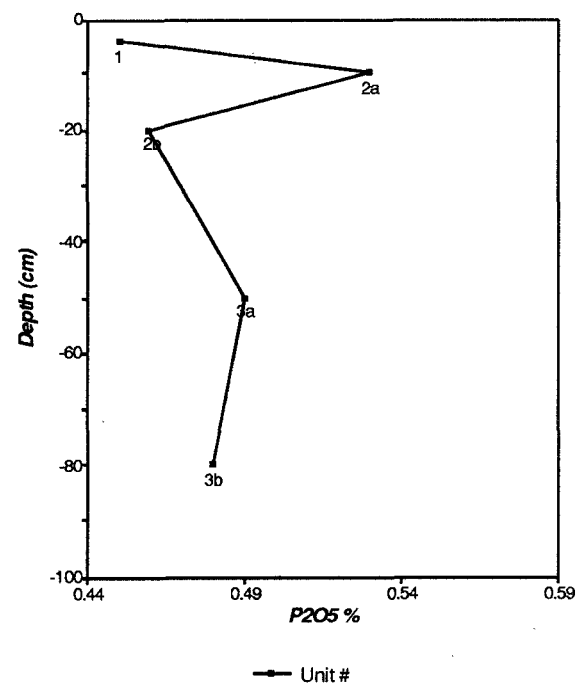


d.

Figure 122. Molecular weathering ratios for 26Ek3092, Trench C, profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

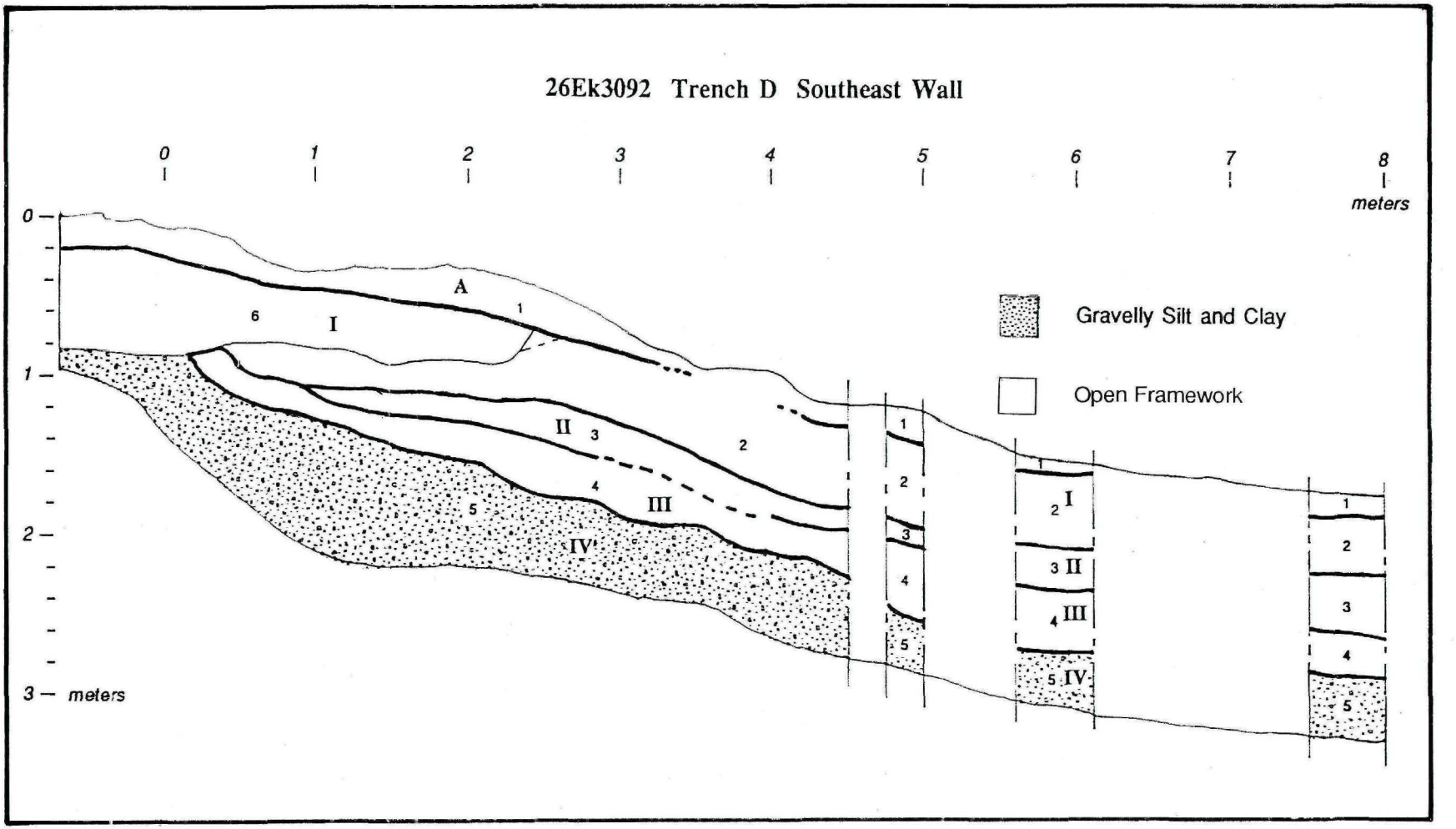
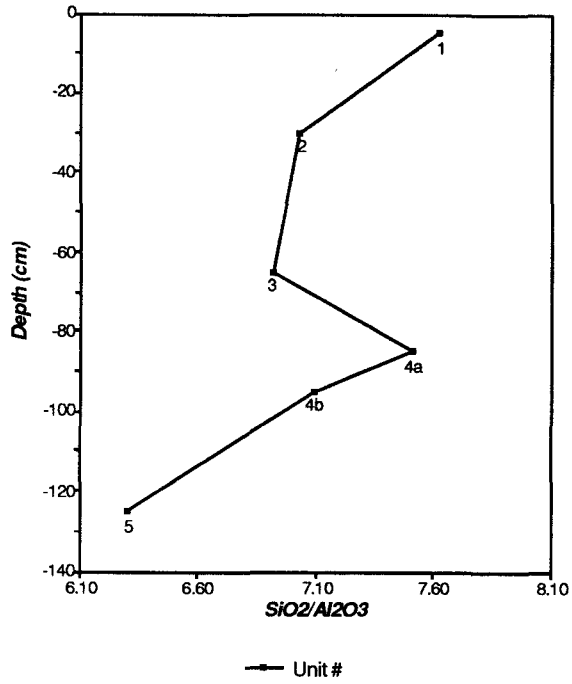


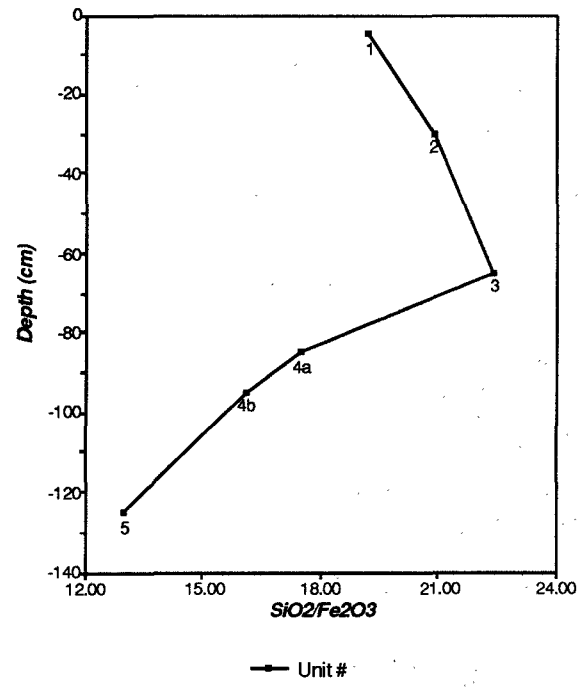
Figure 123. Description of stratigraphic units, Trench D, 26Ek3092.

Figure 123. Description of stratigraphic units, southeast wall of Trench D, 26Ek3092.

Horizon	Stratum	Description
A	1	Grayish brown (10YR 5/2) dry; silt loam; loose to weak fine granular to weak fine platy; common fine to medium subangular to subrounded pebbles; abundant fine and common medium roots; boundary clear and wavy over Unit 2, abrupt and irregular over Unit 6.
II	2	Dark yellowish brown (10YR 4/2) slightly moist; silty clay; weak fine subangular blocky; rare to common fine to medium subangular to subrounded pebbles; common fine roots and pores; common clay skins on ped surfaces; boundary clear and smooth.
	2b	Dark brown (10YR 3/3) moist; silty clay loam; loose to moderate fine granular to moderate fine subangular blocky; common fine to medium subangular to subrounded pebbles; abundant fine roots and pores; common clay skins on ped surfaces; boundary clear and smooth.
III	3a	Dark brown (10YR 4/3) moist; weakly mottled dark yellowish brown (10YR 4/4) moist; silty clay loam; weak to moderate fine subangular blocky; common fine to medium subangular blocky subangular to subrounded pebbles; poor clay skins on ped surfaces; contact clear and smooth.
IV	4	Dark brown (10YR 3/4) moist; silty clay loam; loose to weak fine subangular blocky; abundant to common fine to medium subangular to subrounded pebbles; common fine roots and pores; boundary abrupt and irregular.
V?	5	Strong brown (7.5YR 5/6 to 4/6) moist; matrix supported; clasts coarsening downward from fine subangular to subrounded pebbles to angular to rounded cobbles up to 30cm, matrix of clay to fine sand; poor to moderate carbonate accumulation as veins, pebble coatings and incipient angular nodules in clayey matrix; upper surface of this unit appears to be erosional; boundary unexposed.
	6	Strong brown (7.5YR 4/6) moist; sandy clay; strong medium prismatic peds; common fine to medium subangular sand; clays appear to be reworked from upslope, especially in the southwestern-most part of this unit; moderate to strong acid reaction on carbonate accumulation occurring on ped faces and as incipient nodules near lower boundary of this unit; boundary abrupt and slightly irregular.



a.



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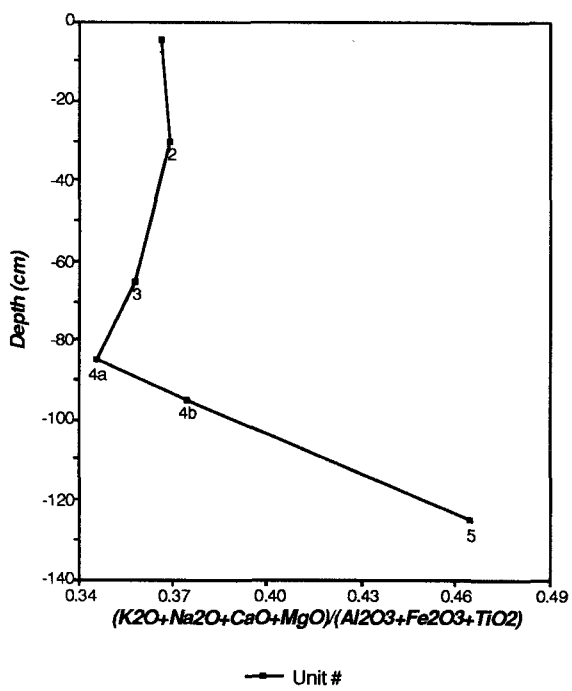

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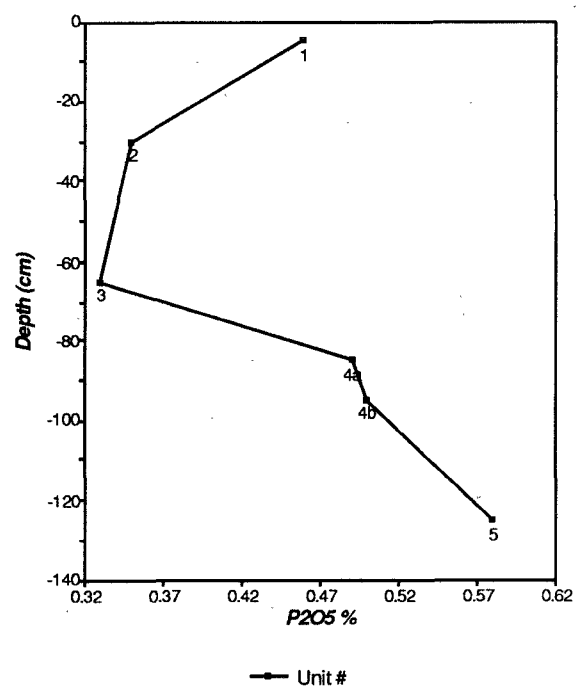


d.

Figure 124. Molecular weathering ratios for 26Ek3092, Trench D, profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

This suggests a former soil surface at this level. This may be equivalent to the Horizon IV surface noted in Trench A, thus implying that Unit 5 in Trench D is indeed part of the hypothesized Horizon V. The strong weathering of pebbles in Unit 5 and the degree of carbonate deposition also indicate a relatively old age.

Excavation Unit 35 (Figure 125) provided a good example of sediments on the lowest, most recent stream terrace adjacent to the modern alluvial channel. The profile was similar to Trench 1 except for an isolated pebble lens with silty clay matrix. This excavation, like Trench 1, also has loamy sediments of Horizon A. Horizons II and III also are present. The weathered gravels of Horizon IV were not encountered. Molecular weathering ratios for sediments in this excavation show an interesting change in trends beginning with Unit 4 (Figure 126). There appears to be increased leaching and phosphorus content starting here. This may be the product of former surface weathering in these sediments, or of bioturbation.

In summary, trench profiles at 26Ek3092 illustrate a history of alternating episodes of stream activity, slopewash, and stable surfaces. Horizons V and IV consist of weathered alluvial gravel and pebble deposits, probably of Pleistocene age. Erosion has truncated both horizons. The more recent irregular surface on Horizon IV gravels possibly occurred during a mid-Holocene erosional cycle that stripped Mazama ash from the area, as no evidence of it was found at the site. Horizons III, II, and I are part of later Holocene depositional episodes in which finer grained materials of alluvial, colluvial, and eolian origin predominated. The low terrace features recognized in the surface topography at the site are constructed of these finer sediments.

Summary

26Ek3092 contributes importantly to our understanding of residentiality peripheral to the Quarries. Activity area surfaces, residential features, refuse zones, food remains, and intense reduction loci shed light on both subsistence and technological energetics (cf. Chapters 10, 14, and 26). This Basalt Canyon terrace system was a singularly attractive place for short-term settlement. The co-occurrence of edible plants (both here and within easy reach on Bitterroot Ridge), potable water, and good game habitat is rare in the Tosawihi uplands (cf. Chapter 25). This quality made 26Ek3092 a particularly desireable resting place, and its proximity to the Quarries one of the more convenient campsites for groups who required an extended stay (high-quality toolstone sources are within relatively easy walking distance).

The place afforded multiple opportunities, including places for food gathering, food processing, food preparation, raw material heat treatment, tool manufacture, and maintenance. Many of these activities centered around a notable piece of "site furniture," the massive boulder situated on the upper terrace. The boulder activity area attracted intensive use, probably over several millennia. Indeed, this site is one of the few in our study area exhibiting such persistent spatial structure.

Seventy-three percent (n=16) of the classifiable projectile points date to Rosegate times and later, suggesting increased activity after 1250 B.P. This accords well with data from other sites around the Tosawihi Quarries which indicate Late Archaic intensification of use (cf. Chapter 19). More locally, the Fremont sherds and late projectile points recovered at 26Ek3092 fall within the radiocarbon date range recorded in the extraction pit at 26Ek3208. This temporal element, and the appearance in the debitage collection of jasper-like opalite, suggest a functional relationship between this campsite and quarrying at 26Ek3084 and 26Ek3208 (Intermountain Research 1988b:53).

26Ek3092 is one of the few places at Tosawihi that contain deep sedimentary deposits exhibiting multiple depositional forces. Extensive erosion and gullying, and alternating episodes of stream activity, slopewash, and stability have produced a complex sedimentary record, informative of past geomorphologic regimes.

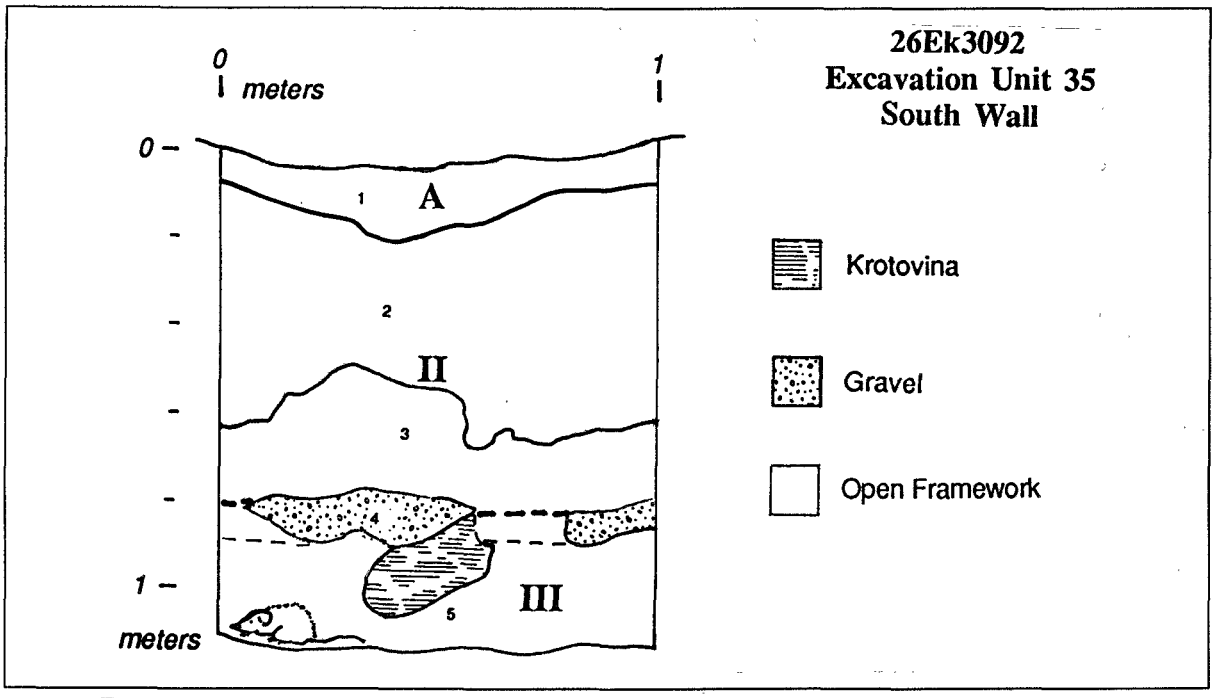
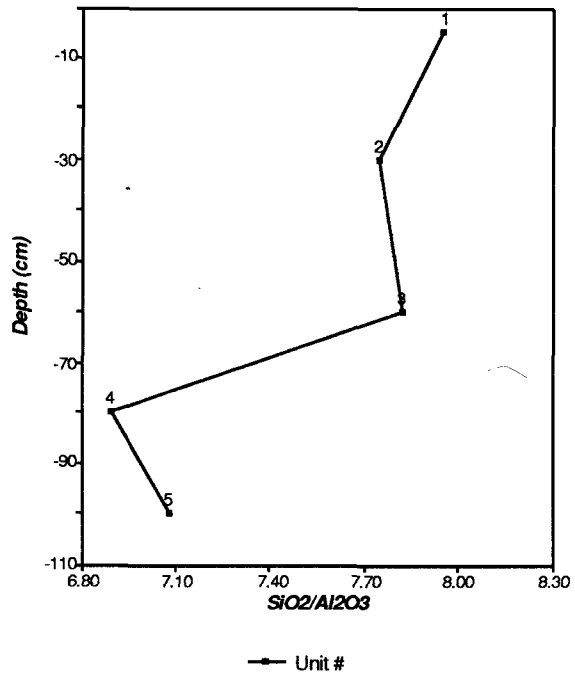
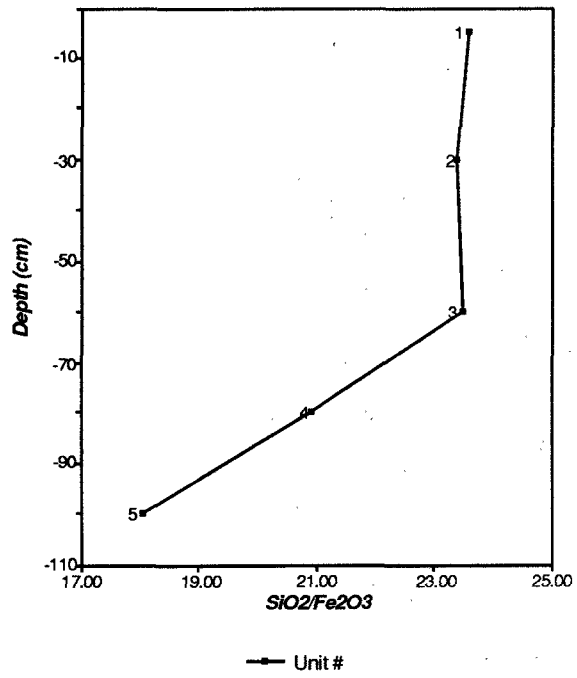


Figure 125. Description of stratigraphic units, Excavation Unit 35, 26Ek3092.

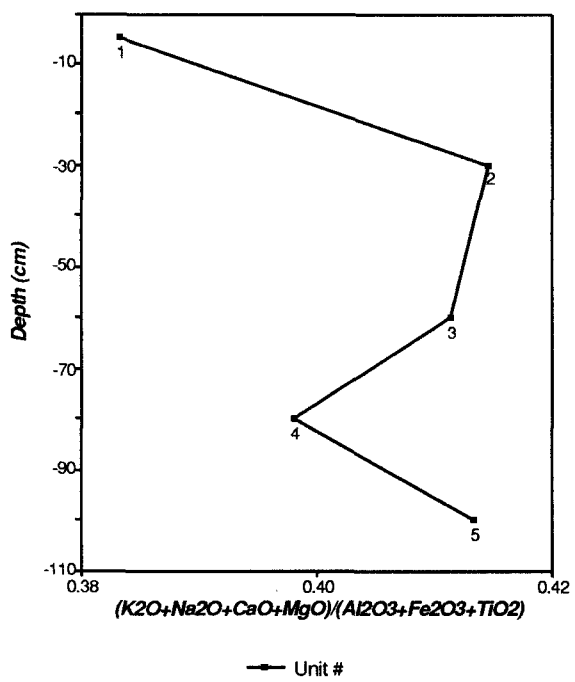
Horizon	Stratum	Description
A	1	Grayish brown (10YR 5/2) dry; silt loam; loose to weak, fine granular to fine platy; common fine to medium subangular to subrounded pebbles; common fine roots; boundary clear and smooth.
II	2	Dark grayish brown (10YR 4/2) dry; silty clay loam; weak to moderately strong, medium subangular blocky; common fine to medium subangular to subrounded pebbles; abundant fine roots and pores with common earthworm castings; moderate acid reaction on carbonate veins and pebble coatings; boundary abrupt and irregular.
	3	Very dark grayish brown (10YR 3/2) dry; silty clay loam; loose to weak medium subangular blocky; common fine to medium subangular to subrounded pebbles; abundant fine roots and pores, common earthworm castings, common rodent burrows; rare to common poor clay skins in pores; very weak acid reaction; boundary abrupt and irregular.
III	4	Strong brown (7.5YR 4/6) moist; clast supported fine to medium subangular pebbles in a matrix of silty clay; abundant burrows disrupting unit; boundary abrupt and irregular.
	5	Strong brown (7.5 YR 4/6) moist; sandy clay with rare to common medium subangular to subrounded pebbles; very weak subangular blocky; common fine roots; boundary unexposed.



a.



b.



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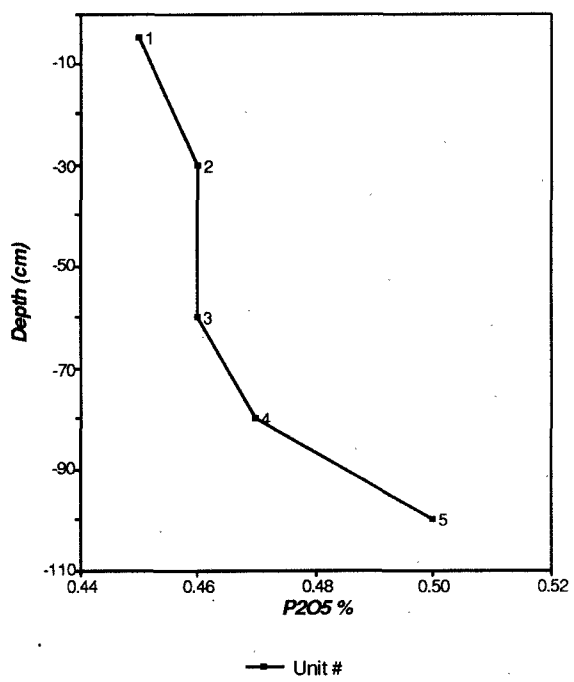


d.

Figure 126. Molecular weathering ratios for 26Ek3092, Excavation Unit 35, profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

26Ek3093

Reduction complex 26Ek3093, situated on the extreme southeast edge of a knoll in the Bitterroot Ridge Complex, encompasses a sparse debitage scatter (covering over 1,800 m^2) surrounding six discrete reduction features (Figure 127). We intensively sampled Feature 4 with a 7 m x 7 m block of contiguous, 2 cm deep surface scrapes (Figure 127). This enabled complete collection of all surface artifacts in the feature, and exposed an irregular ashy stain upon which we placed a 1 m x .5 m excavation unit. This phenomenon appears to be a small, unlined hearth—now considerably deflated by exposure—around which small-scale tool maintenance and processing took place (Budy 1989:222).

Our surface collections (from both feature and nonfeature contexts) yielded opalite and (rare) obsidian debitage, two projectile points, six point preforms, 38 bifaces, two cores, a multi-purpose chopping tool, a pointed flake tool, and retouched flakes (cf. Budy 1989). A Large Side-notched projectile point, which typically predates A.D. 1300 (Thomas 1981), was found in Feature 5, a large, two-lobed debitage scatter lying on a relatively steep slope below Feature 4.

The multi-purpose assemblage and probable hearth indicate a diverse, possibly domestic, activity at this site.

26Ek3095

On the north and east-facing slopes of Basalt Canyon lie 25 feature clusters comprising reduction/residential complex 26Ek3095. Here, prehistoric activity converged on a narrow bench, leaving distinct concentrations of debitage and formed tools, and relatively large numbers of millingstones (Figure 128). Bedrock rests very close to the surface; cultural deposits are, as a consequence, vertically limited. Nevertheless, the distinctive horizontal array of surface features here informs about prehistoric activity organization, and the diversity of millingstones and reduction debitage suggests a variety of prehistoric subsistence and tool production pursuits.

Vegetation presently is dominated by big sagebrush and lupine, but before grazing, this thinly-mantled ridgetop should have been an attractive place for gathering edible tubers. No permanent water sources surface nearby, but ephemeral pools sometimes collect in the lower reaches of Basalt Canyon.

The 25 features consist of fairly discrete activity zones. These include four loci containing profuse lithic debris and plant processing equipment, one large eroded tool scatter, one cache of bifaces, and 19 lithic reduction areas. Material types encountered in reduction features are dominated by opalite (99.7%), with trace frequencies of obsidian, basalt, quartzite, and rhyolite.

Excavation Methods and Rationale

Because bedrock restricts the depth of soils and the potential for buried cultural remains seemed limited, we focused our efforts on identifying surface artifact configurations, conducting limited subsurface testing only in certain features and depositional contexts. Six feature concentrations (Features 6, 10, 15, 19, 22, and 24) were deemed representative of feature variability across the site (small lithic scatters, tool aggregations, millingstone clusters, and biface caches), and were sampled by systematic surface scrapes and subsurface excavations. Surrounding surface artifacts were plotted and collected. The remaining 19 features were inventoried, mapped, and collected of formed artifacts.

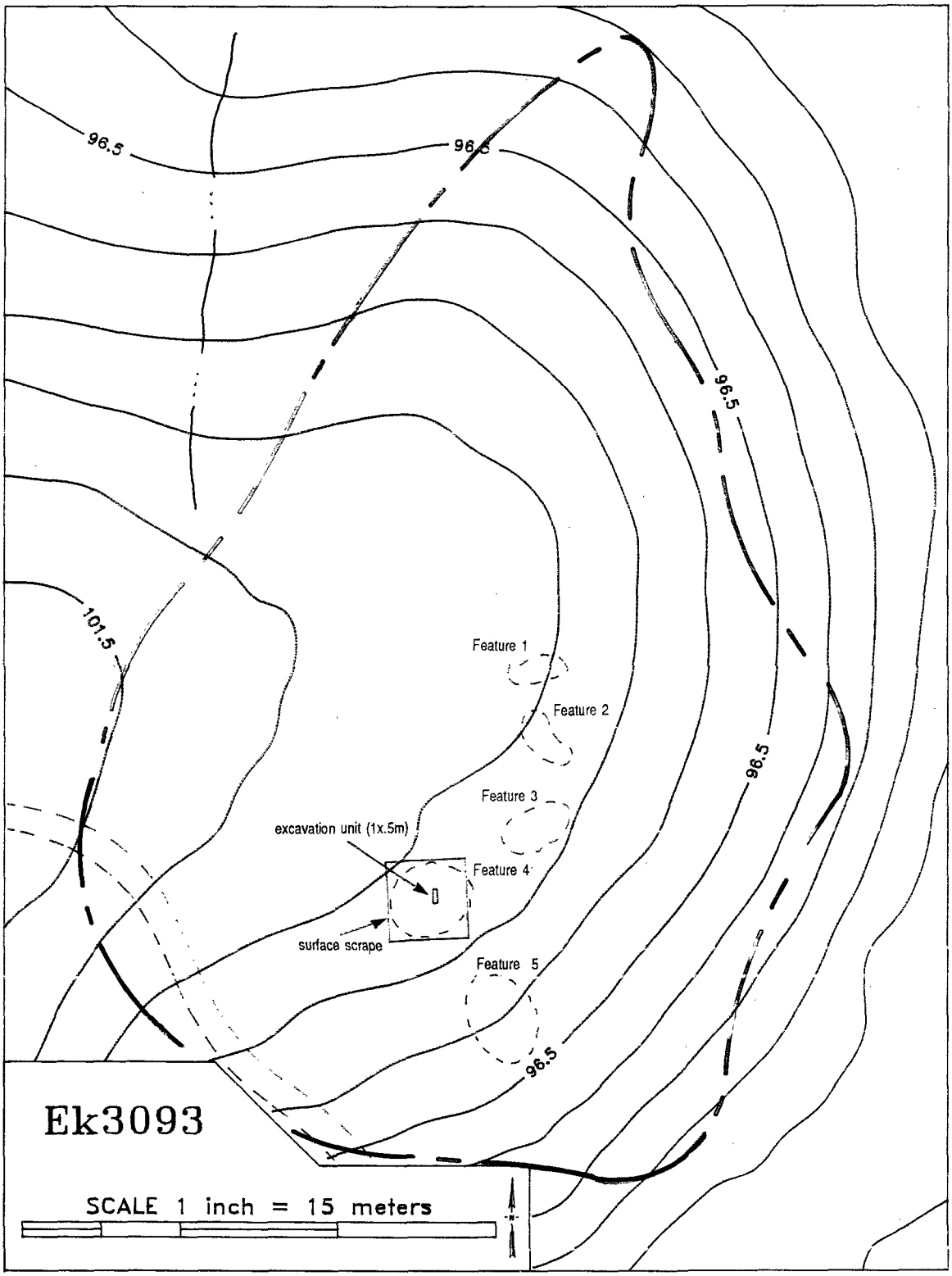


Figure 127. 26Ek3093 site map.

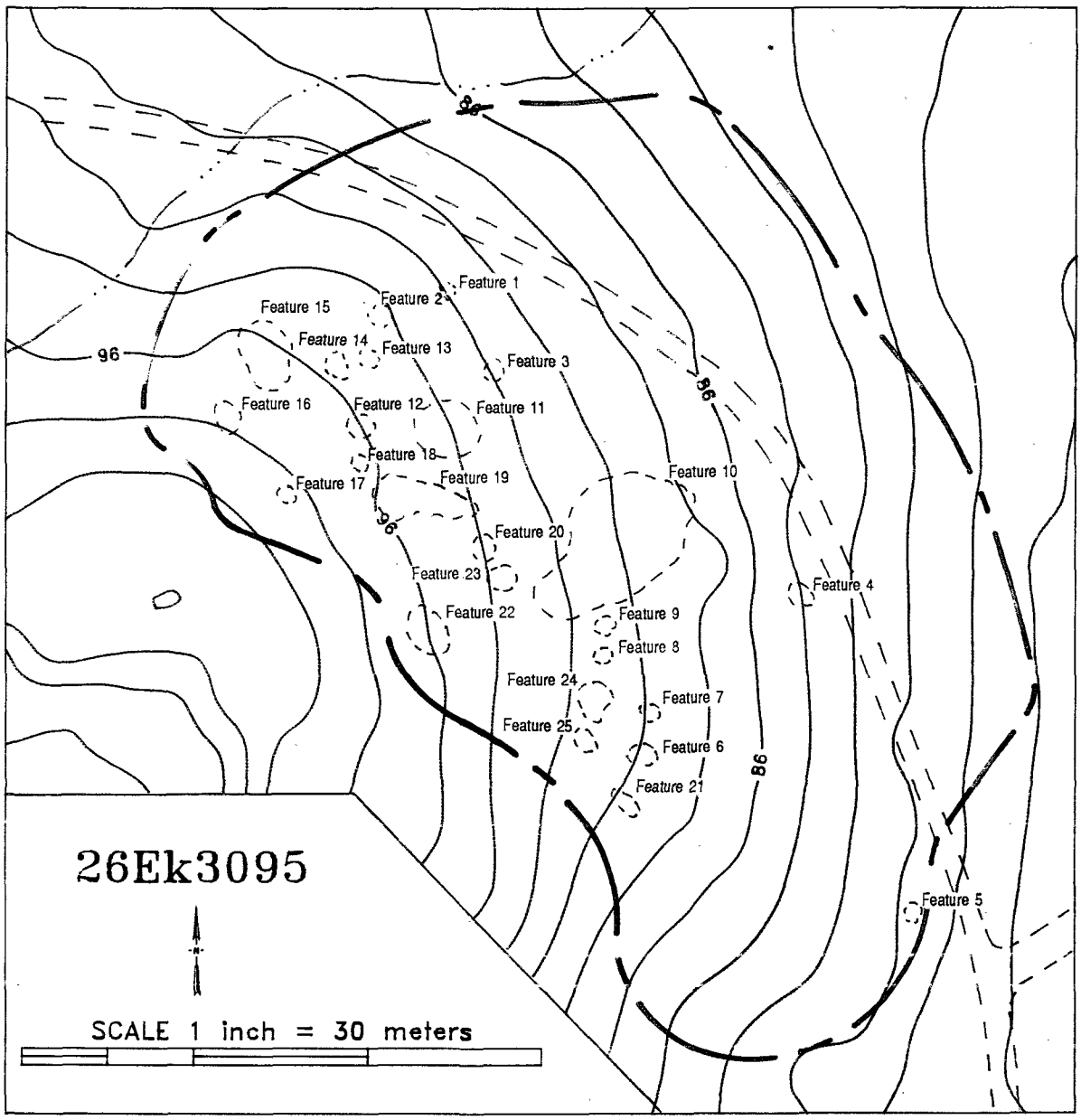


Figure 128. 26Ek3095 site map.

Nonfeature Contexts

The site was surveyed intensively for diagnostic artifacts beyond the boundaries of defined features. Dozens of formed artifacts were mapped and collected in extra-feature areas during testing and data recovery. We recovered numerous bifaces (73), several scrapers and retouched flakes (4), metate fragments (3) and a pestle, Rosegate (2) and Gatecliff (2) projectile points, a hammerstone, a scratched stone, a chopper, and a core. No additional collection strategies were employed in non-feature areas.

Inventoried Features

The features inventoried, but not excavated further, consist of lithic reduction stations (Features 1–5, 7–9, 11–14, 16–18, 20, 21, and 23) and an apparently functionally complex locus (Feature 25). The reduction stations tend to be rather small, averaging less than 24 m^2. Indeed, ten of these may represent the remains of single lithic reduction episodes, being restricted to less than 11 m^2 in area. The assemblages are dominated by debitage and bifaces, with infrequent cores, percussion tools, modified chunks, and flake tools (Table 130). Time markers include Cottonwood, Elko, and Gatecliff points.

Table 130. Summary of Formed Artifacts Collected from Inventoried Features at 26Ek3095.

Feature	Area (m^2)	Proj. Points	Preforms	Bifaces	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Total
1	5	-	-	-	-	-	-	-	0
2	7	-	-	4	-	-	-	-	4
3	7	-	-	6	1	-	-	-	7
4	7	-	-	1	-	-	-	-	1
5	48	-	-	10	1	-	1	-	12
7	28	1	-	7[a]	-	-	-	-	8
8	10	-	-	3	-	-	-	-	3
9	11	1	-	5	1	-	-	-	7
11	24	1	1	6	2	-	1	-	11
12	11	-	-	4	-	-	-	-	4
13	54	-	-	10	-	-	1	-	11
14	20	1	-	-	-	1	2	-	4
16	42	2	1	3	1	-	-	-	7
17	24	-	-	1	-	-	-	-	1
20	50	-	-	7	1	-	-	-	8
21	3	-	-	1	-	-	-	-	1
23	5	-	-	1	-	-	-	-	1
25	9	-	-	2	1	-	-	1	4
Totals		6	2	71	8	1	5	1	94

[a]Includes one "possible" biface

Feature 25 consists of a small cluster of metate fragments and several specialized tools, incorporated into a dense scatter of reduction debris. The presence of plant processing equipment and the spatially-restricted nature of the lithic scatter imply a short-term residential stay in conjunction with a tool production episode.

Feature 6

This 78 m^2 reduction feature was selected at random from our sample of reduction loci for focused data recovery. We excavated ten 1 m x 1 m units in this moderately dense debris scatter of mostly good-quality pink and white opalite. Six units were placed at two meter intervals along the long axis and parallel to the slope. Four more units were offset 1 m from this transect, two to each side, to sample the breadth of the feature. Rare obsidian debitage, primarily Stage 3 (n=12) and Stage 4 (n=4) bifaces, a modified chunk, a scraper, two retouched flakes, and a Gatecliff projectile point were recovered from the shallow deposits (Table 131). While the recovered bifaces indicate mid to late stage production, the debitage assemblage reflects the entire continuum of biface reduction (Appendix C, Table 1; W. Bloomer, personal communication).

Table 131. Summary of Artifacts Collected from Feature 6, 26Ek3095.

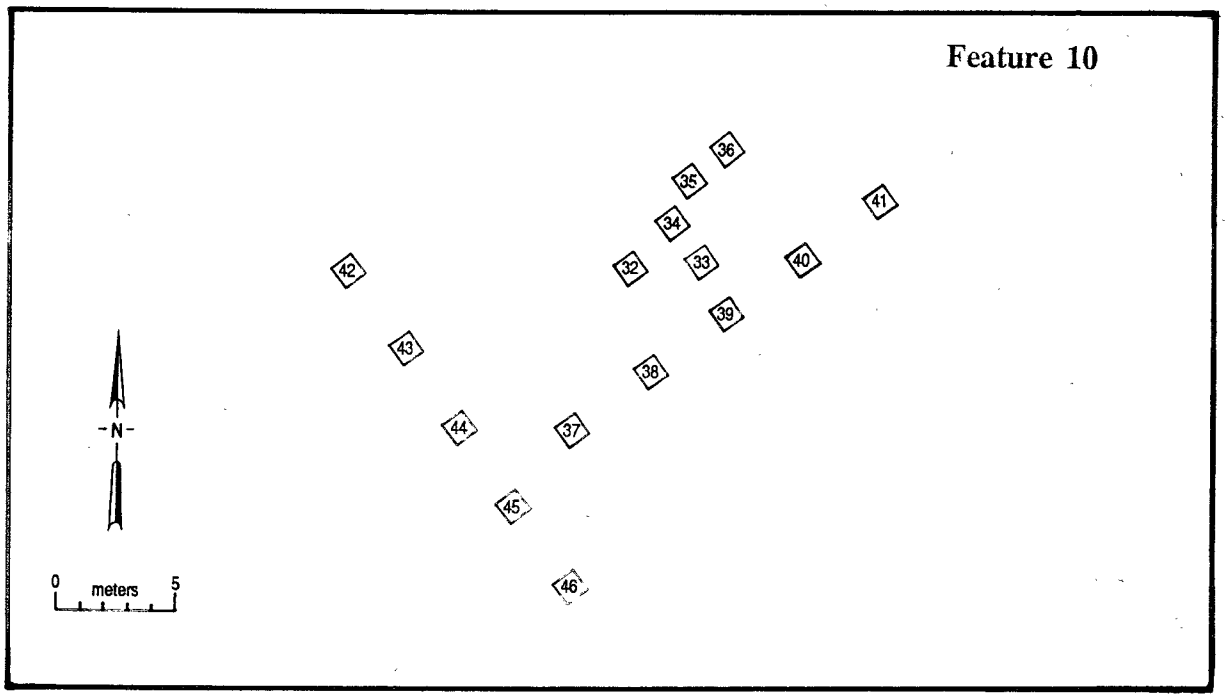
		DEBITAGE		FORMED ARTIFACTS				
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Bifaces	Flake Tools	Modif. Chunks	Total
47 (EU)	0.10	431	405.3	-	-	-	-	0
48 (EU)	0.20	1,481	1,634.6	-	6[a]	-	-	6
49 (EU)	0.10	817	743.1	-	1	1	-	2
50 (EU)	0.10	458	503.6	-	2	1	-	3
51 (EU)	0.10	369	404.1	-	1	1	-	2
52 (EU)	0.10	87	148.4	1	-	-	-	1
53 (EU)	0.10	109	76.3	-	-	-	-	0
54 (EU)	0.10	344	208.1	-	1	-	-	1
55 (EU)	0.10	106	55.2	-	-	-	-	0
56 (EU)	0.20	543	454.8	-	-	-	-	0
Surface	N/A	2	2.9	-	9	-	1	10
Totals	1.2	4,747	4,636.4	1	20	3	1	25

(EU) = Excavation Unit
[a]Includes one "possible" biface

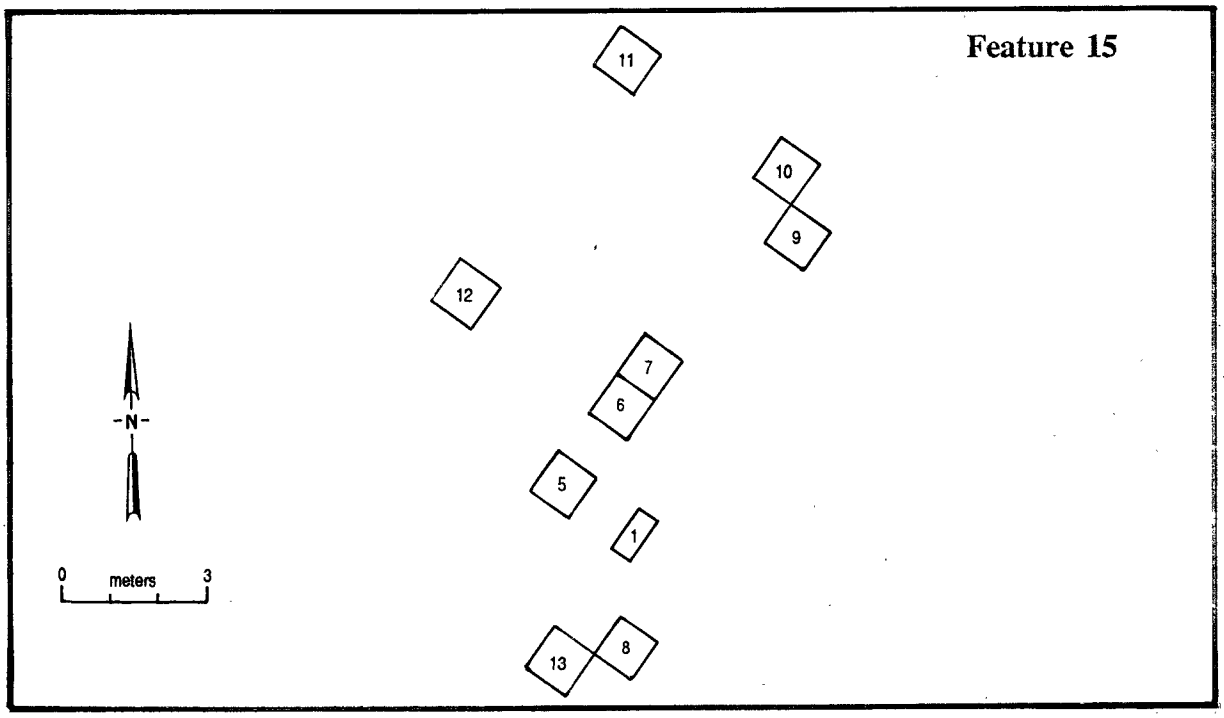
Feature 10

Feature 10 is the largest feature at the site (cf. Figure 128). This eroded scatter is sparsely littered with opalite and rarer obsidian debitage, but is marked by two lithic concentrations and abundant formed artifacts, including projectile points, preforms, numerous bifaces (dominated by Stage 3 and 4 forms), retouched flakes and pointed flake tools, and a single mano (Figure 129a).

We placed a transect of 12 regularly spaced, 25 cm x 25 cm surface scrapes parallel to the slope and through the densest tool array, and excavated five 1 m x 1 m units (EUs 37-41) leading off the north side of the transect (cf. Figure 129a). We also investigated the small bench above the scatter with a series of five units placed perpendicular to the slope, aimed at locating potential buried features that might have served as the source for the downslope array of tools. These units (EUs 42-46) provided smaller debitage yields than the downslope units; no subsurface features were encountered (Table 132). We sampled the reduction concentrations in the northern, downslope portion of the feature with EUs 32-36, recovering higher densities of debitage than from other units. This is accounted for by the use of finer screen mesh in 50 cm x 50 cm control quadrants, and by inevitable slopewash of surface artifacts.



a



b

Figure 129. 26Ek3095. a. Feature 10 plan; b. Feature 15 plan.

Table 132. Summary of Artifacts Collected from Feature 10, 26Ek3095.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Perc./ Cobble Tools	Ground Stone	Total
1 (SF)	0.00125	4	4.1	-	-	-	-	-	-	0
2 (SF)	0.00125	7	4.9	-	-	-	-	-	-	0
3 (SF)	0.00125	8	16.6	-	-	-	-	-	-	0
4 (SF)	0.00125	6	4.6	-	-	-	-	-	-	0
5 (SF)	0.00125	9	4.7	-	-	-	-	-	-	0
6 (SF)	0.00125	1	0.3	-	-	-	-	-	-	0
7 (SF)	0.00125	9	8.2	-	-	-	-	-	-	0
8 (SF)	0.00125	3	0.9	-	-	-	-	-	-	0
9 (SF)	0.00125	15	13.7	-	-	-	1	-	-	1
10 (SF)	0.00125	8	6.3	-	-	-	-	-	-	0
11 (SF)	0.00125	7	7.3	-	-	1	-	-	-	1
12 (SF)	0.00125	3	0.7	-	-	-	-	-	-	0
32 (EU)	0.10000	343	575.2	-	-	3	-	-	-	3
33 (EU)[a]	0.20000	1,013	1,478.5	-	1	5	-	-	-	6
34 (EU)	0.20000	672	723.9	-	-	-	-	-	-	0
35 (EU)[a]	0.20000	1,326	2,318.6	-	-	2	-	-	-	2
36 (EU)	0.20000	177	195.9	-	-	-	-	-	-	0
37 (EU)	0.20000	214	295.4	-	1	3	-	-	-	4
38 (EU)	0.20000	181	178.1	-	-	-	1	1	-	2
39 (EU)	0.10000	375	322.7	-	-	2[b]	-	-	-	2
40 (EU)	0.20000	596	431.2	-	-	-	2	-	-	2
41 (EU)	0.10000	69	50.9	-	-	1	-	-	-	1
42 (EU)	0.20000	46	33.4	-	-	-	1	-	-	1
43 (EU)	0.20000	180	315.9	-	-	3[b]	-	-	-	3
44 (EU)	0.30000	465	526.6	-	-	4	-	-	-	4
45 (EU)	0.30000	351	414.3	1	1	8	2	-	-	12
46 (EU)	0.20000	426	612.5	-	-	2[b]	-	-	-	2
Surface	N/A	23	344.0	6	5	52	7	-	1	71
Totals	2.9150	6,537	8,889.4	7	8	86	14	1	1	117

(SF) = Surface Scrape
(EU) = Excavation Unit

[a]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[b]Includes one "possible" biface

The highest density and widest variety of tools were recovered during intensive surface inventory. During excavation, platy tabular basalt bedrock usually was encountered within 20 cm. No subsurface features were observed, hence we conclude that Feature 10 is primarily a surface manifestation and not a secondarily deposited tool feature. We recovered several classifiable projectile points from the Desert and Elko series, suggesting occupation between 1300 B.C. and historic times.

Feature 15

Feature 15 resides on a flat bench at the northwest margin of the site (cf. Figure 128). The material remains of both seed-processing and biface reduction activities are represented abundantly, suggesting a residential component. Characterized by a cluster of metate fragments (comprising at least four different millingstones) and other specialized tools, in at least two moderately dense concentrations of biface reduction debris, the feature spans 48 m^2. A variety of materials compose the debitage, including pink and white opalite and lesser amounts of obsidian.

We centered a 3 m x 4 m surface scrape sample block and a shallow 1 m x .5 m excavation unit on the cluster of groundstone fragments (cf. Figure 129b). We then excavated

nine additional 1 m x 1 m units, six placed randomly inside the surface concentration to sample the region of the metate cluster and the surrounding flake scatter, and three (also randomly placed) at the perimeter of the feature.

Though we detected no subsurface residential features, our recovery of multiple groundstone fragments and a variety of formed artifacts including Cottonwood (2) and Rosegate (1) projectile points, a point preform, numerous Stage 3 and 4 bifaces (Appendix C, Table 1), several retouched flakes, a hammerstone, a core, and a heavily used sandstone shaft abrader lends credence to our initial assumption of short-term residential use (Table 133).

Table 133. Summary of Artifacts Collected from Feature 15, 26Ek3095.

		DEBITAGE		FORMED ARTIFACTS								
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Perc./ Cobble Tools	Ground Stone	Other/ Exotic	Total
1 (SF)	0.02	131	118.5	-	-	1	-	-	-	-	-	1
2 (SF)	0.02	154	259.3	-	-	3	-	-	-	-	-	3
3 (SF)	0.02	265	278.5	-	-	-	-	-	-	1	-	1
4 (SF)	0.02	293	346.1	-	-	3	-	-	-	-	-	3
5 (SF)	0.02	95	78.4	-	-	-	1	-	-	-	1	2
6 (SF)	0.02	904	659.8	-	-	1	-	-	-	-	-	1
7 (SF)	0.02	709	660.0	-	-	1	-	-	-	-	-	1
8 (SF)	0.02	436	316.1	-	-	1	-	-	-	-	-	1
9 (SF)	0.02	651	581.8	-	-	2	-	2	-	1	-	5
10 (SF)	0.02	465	574.3	-	-	3	-	-	-	-	-	3
11 (SF)	0.02	203	121.8	-	-	-	-	-	-	-	-	0
12/1 (TS)[a]	0.11	912	461.0	1	1	5	-	1	-	1	-	9
5 (EU)	0.18	551	471.6	1	-	4[c]	-	-	-	-	-	5
6 (EU)	0.28	696	1,283.9	1	-	5	-	-	-	-	-	6
7 (EU)	0.28	799	779.5	1	-	7	-	-	-	-	-	8
8 (EU)	0.20	115	99.4	-	-	2	-	-	-	-	-	2
9 (EU)[b]	0.20	270	278.9	1	-	3	-	-	-	-	-	4
10 (EU)	0.20	142	148.0	-	-	4	-	1	-	-	-	5
11 (EU)	0.20	59	36.2	-	-	1	-	-	-	-	-	1
12 (EU)[b]	0.20	228	167.9	-	-	2[c]	-	-	-	-	-	2
13 (EU)	0.20	42	37.2	-	-	-	1	-	-	-	-	1
Surface	N/A	-	-	-	-	9	-	1	1	1	-	12
Totals	2.27	8,120	7,758.2	5	1	57	2	5	1	4	1	76

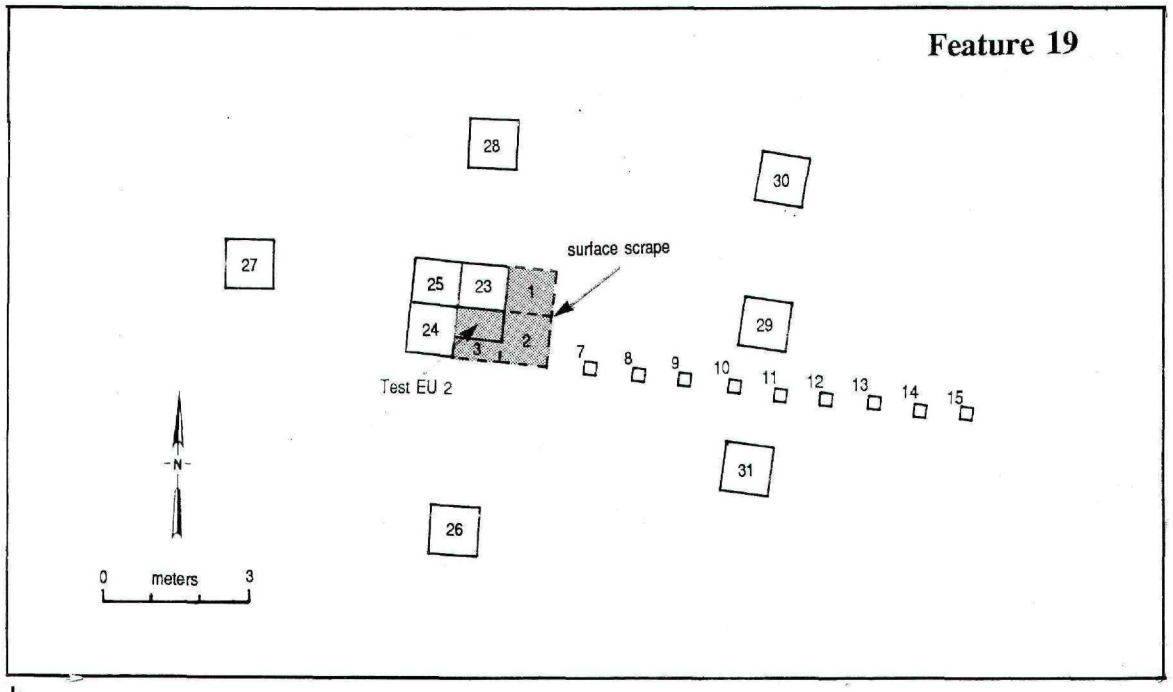
(SF) = Surface Scrape
(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Screened through 1/8 inch mesh
[b]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[c]Includes one "possible" biface

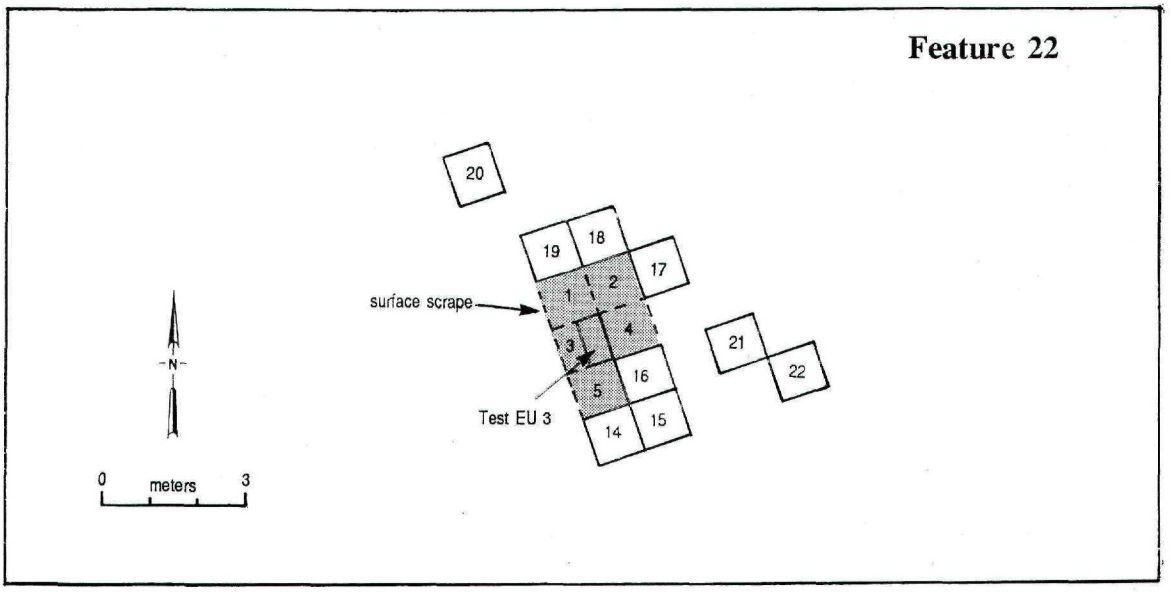
Feature 19

In the west-central portion of the slope, Feature 19 covers 75 square meters and incorporates two discrete lithic concentrations (cf. Figure 128; Figure 130a). A small cluster of metate fragments, a probable hearth, formed tools, and occasional obsidian and basalt flakes highlight the dense scatter of opalite reduction debris that extends downslope from the groundstone cluster. The presence of plant processing equipment and heavily used maintenance tools centered around the hearth suggests a short-term residential character for this portion of the feature. The lithic concentration, with an associated fragmentary projectile point, contains evidence of toolstone reduction only; bifaces and debitage are more widely dispersed suggesting longer exposure of the tool surface than that observed at the hearth (Budy 1989:232).

During testing, we conducted surface inventory and collections, and sampled separately the two loci of debitage (Figure 130a). One 2 m x 3 m block of surface scrapes and a 1 m x .5 m



b



a

Figure 130. 26Ek3095. a. Feature 19 plan; b. Feature 22 plan.

test excavation unit were centered on the hearth/groundstone cluster in Locus 1, and nine 25 cm x 25 cm surface scrapes were located at one meter intervals along the slope through Locus 2. In addition to several metate fragments, a large quantity of debitage, several flake tools, hammerstones, a core, a shaft abrader, a preform, numerous bifaces (mostly Stage 3 and 4), and projectile points (Desert series and an unclassifiable fragment) characterize the assemblages.

In 1989, we returned to Feature 19 to continue subsurface excavations in both loci. At the exposed hearth in the center of Locus 1, and below three earlier surface scrapes, we excavated three new units (EUs 26–28), with one 1/8 inch control, to a depth of 30 cm; we placed three additional units (EUs 23–25) just beyond the perimeter. Lastly, we cross-cut Locus 2 with three excavation units (EUs 29–31) intersecting its midline. Opalite, obsidian, and basalt debitage, Desert Side-notched and fragmentary projectile points, primarily mid- to late stage bifaces, scrapers and other flake tools, a hammerstone, an abrader, and four ground tuff beads were recovered (Table 134). Technological analysis of the debitage from Locus 1 (EUs 24 and 29) posited a relatively late stage biface reduction profile and a heat-treatment rate of over 15% (cf. Chapter 10). Over 35% of the bifaces also were heat-treated (Appendix C, Table 1).

Table 134. Summary of Artifacts Collected from Feature 19, 26Ek3095.

		DEBITAGE		FORMED ARTIFACTS								
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Perc./ Cobble Tools	Ground Stone	Other/ Exotic	Total
1 (SF)	0.02000	783	1,242.7	-	-	2	-	-	-	-	1	3
2 (SF)	0.02000	722	953.4	-	1	-	-	-	-	1	1	3
3 (SF)	0.02000	1,012	1,007.7	-	-	1	1	-	-	-	-	2
4/2 (TS)[a]	0.19500	3,926	2,769.1	1	-	7	1	3	1	-	-	13
5 (SF)	0.02000	638	503.3	-	-	1	-	-	-	-	-	1
6 (SF)	0.02000	450	295.2	-	-	2	-	-	1	-	-	3
7 (SF)	0.00125	45	67.5	-	-	-	-	-	-	-	-	0
8 (SF)	0.00125	56	46.8	-	-	-	-	-	-	-	-	0
9 (SF)	0.00125	76	262.1	-	-	1	-	-	-	-	-	1
10 (SF)	0.00125	66	102.7	-	-	-	-	-	-	-	-	0
11 (SF)	0.00125	86	203.2	-	-	-	-	-	-	-	-	0
12 (SF)	0.00125	43	24.3	-	-	-	-	-	-	-	-	0
13 (SF)	0.00125	40	47.4	-	-	-	-	-	-	-	-	0
14 (SF)	0.00125	28	41.6	-	-	-	-	-	-	-	-	0
15 (SF)	0.00125	1	0.1	-	-	-	-	-	-	-	-	0
23 (EU)	0.28000	1,418	1,433.4	-	-	5	-	1	-	-	-	6
24 (EU)[b]	0.28000	5,761	4,618.7	-	-	11[c]	-	2	-	-	5	18
25 (EU)	0.28000	2,127	2,626.4	-	-	7	-	1	-	-	-	8
26 (EU)	0.20000	71	48.2	-	-	1	-	-	-	-	-	1
27 (EU)[b]	0.20000	75	69.0	-	-	-	-	-	-	-	-	0
28 (EU)	0.20000	150	137.6	-	-	-	-	-	-	-	-	0
29 (EU)[b]	0.20000	2,313	1,494.2	3	-	2	-	-	-	-	-	5
30 (EU)	0.20000	501	655.6	2	-	2	-	-	-	-	-	4
31 (EU)	0.20000	79	53.9	-	-	1	-	-	-	-	-	1
Surface	N/A	7	13.6	1	-	11	1	2	1	1	-	17
Totals	2.34625	20,474	18,717.7	7	1	54	3	9	3	2	7	86

(SF) = Surface Scrape
(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Screened through 1/8 inch mesh
[b]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[c]Includes one "possible" biface

Feature 22

This small (approximately 20 m^2) feature incorporates a cluster of fragments from a single basalt metate and other specialized tools in a dense scatter of opalite and obsidian reduction debris (cf. Figure 130b).

To explore its vertical extent and characterize functional diversity, we aligned a 2 m x 4 m surface collection grid along the narrow bench that supported the metate fragments, crosscutting the encircling lithic concentration. We recovered numerous bifaces and a substantial quantity of debitage. We then placed a 1 m x .5 m excavation unit in the obsidian reduction area, encountering bedrock at 30 cm. The cultural materials clustered in the upper 10 cm, with few small opalite flakes appearing deeper. Tests recovered opalite debitage, several dozen obsidian and rare basalt flakes, biface fragments, and a pointed flake tool.

Data recovery was planned to explore further the possible residentiality of this feature. We placed nine additional excavation units (with three 1/8 inch controls) to sample subsurface deposits in the metate cluster area, the surrounding scatter, and the perimeter of the feature. These yielded yet more bifaces (dominated by mid- to late stage types; cf. Appendix C, Table 1), flake tools, and several beads and bead preforms.

The density and diversity of debitage, food-processing and maintenance tools, and ornaments recovered from Feature 22 suggest multiple domestic and toolstone reduction activities (Table 135).

Table 135. Summary of Artifacts Collected from Feature 22, 26Ek3095.

		DEBITAGE		FORMED ARTIFACTS				
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Bifaces	Flake Tools	Ground Stone	Other/ Exotic	Total
1 (SF)	0.02	978	1,349.1	4	-	-	-	4
2 (SF)	0.02	1,327	954.8	2	-	-	-	2
3/3 (TS)[a]	0.16	4,719	3,135.6	11	1	-	-	12
4 (SF)	0.02	1,833	1,543.0	3	-	1	-	4
5 (SF)	0.02	347	502.6	2	-	-	-	2
6 (SF)	0.02	1,201	1,378.8	8	-	-	-	8
7 (SF)	0.02	51	34.1	2	-	-	-	2
8 (SF)	0.02	551	867.1	3	-	-	-	3
14 (EU)	0.28	384	550.2	4	-	-	-	4
15 (EU)	0.28	1,221	1,570.9	4[c]	-	-	-	4
16 (EU)	0.28	2,223	2,584.6	7	1	-	3	11
17 (EU)	0.30	546	357.5	2	-	-	2	4
18 (EU)[b]	0.30	1,801	1,249.3	6	1	-	-	7
19 (EU)	0.30	770	703.6	7	-	-	2	9
20 (EU)	0.20	125	110.2	3	-	-	2	5
21 (EU)[b]	0.30	798	735.1	1	-	-	-	1
22 (EU)	0.20	75	50.1	-	-	-	-	0
Surface	N/A	-	-	4	-	-	-	4
Totals	2.74	18,950	17,676.6	73	3	1	9	86

(SF) = Surface Scrape
(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Screened through 1/8 inch mesh
[b]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[c]Includes two "possible" bifaces

Feature 24

Resting on a narrow bench at the south end of the site, Feature 24 is a biface cache surrounded by a scatter of lithic reduction debris (cf. Chapter 6 and Appendix C, Table 2). The feature was selected for detailed investigation in order to gather data on caching behavior peripheral to the Tosawihi Quarries (cf. Chapter 26).

The cache, one of only five such features found in the Tosawihi study area, is interesting for its association with considerable assemblage variety. The observed surface manifestations

included a four m^2 aggregation of greyish-white opalite flakes, several biface fragments, and a flawless, entire, late stage 3 biface. We placed a 1 m x 1 m test excavation unit in the feature, encountering bedrock at 20 cm; we retrieved 11 bifaces (one refitted), mostly later-stage implements fashioned from identical grey-speckled opalite almost certainly originating from a single source. They range from a very large, thick leaf-shaped specimen to a thin, lanceolate form with an incipient haft (Intermountain Research 1988b:66); their technological attributes are described in Chapter 6. We also retrieved over 5000 opalite flakes, mostly products of later stage biface reduction, a notched flake tool, and a modified opalite chunk.

We returned in 1989 to expose the feature fully. We excavated 15 1 m x 1 m units adjacent the test unit, with one 1/8 inch control unit; we recovered dozens of additional bifaces (largely Stage 3 and 4), many retouched flakes and flake tools, a Desert Side-notched point and several point fragments, two preforms, and a core (Table 136). Debitage was dominated by opalite flakes, with small amounts of obsidian.

Table 136. Summary of Artifacts Collected from Feature 24, 26Ek3095.

		DEBITAGE		FORMED ARTIFACTS						
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Total
1/4 (TS)[a]	0.20	5,002	3,332.3	-	-	12	-	1	1	14
57 (EU)	0.10	59	95.8	-	-	-	-	-	-	0
58 (EU)	0.10	351	297.5	-	-	-	-	-	-	0
59 (EU)	0.10	883	916.3	-	-	1	-	-	-	1
60 (EU)	0.10	673	454.4	-	-	1	-	1	-	2
61 (EU)	0.20	2,233	2,700.4	-	1	8	-	-	-	9
62 (EU)	0.10	93	53.1	-	-	-	-	-	-	0
63 (EU)	0.10	1,437	1,105.1	-	-	-	-	-	-	0
64 (EU)	0.10	1,978	1,275.9	2	1	-	-	3	-	6
65 (EU)	0.10	2,010	1,740.2	1	-	3	-	4	-	8
66 (EU)	0.10	773	601.2	-	-	5	-	-	-	5
67 (EU)[b]	0.10	2,905	2,001.3	1	-	3[c]	-	-	-	4
68 (EU)	0.10	316	192.3	-	-	-	-	-	-	0
69 (EU)	0.10	1,979	2,003.5	1	-	6	-	2	-	9
70 (EU)	0.10	1,613	1,419.9	-	-	3	1	1	-	5
71 (EU)	0.10	1,336	777.1	-	-	4	-	1	-	5
Surface	N/A	1	4.6	-	-	-	-	-	-	0
Totals	1.8	23,642	18,970.9	5	2	46	1	13	1	68

(SF) = Surface Scrape
(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Screened through 1/8 inch mesh
[b]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[c]Includes one "possible" biface

Summary

The opportunities (commodious work space, seasonal root crops, favorable wildlife habitat, and close-at-hand water) afforded on Bitterroot Ridge have been exploited for perhaps 5000 years. The discrete distribution and variable character of the 25 features at this locale provide ample evidence of a complex occupational history. Feature types range from limited-purpose reduction scatters to tool aggregations to multipurpose clusters of domestic artifacts and facilities.

In both feature and non-feature contexts, tool diversity signals a wide variety of support tasks—tool production and maintenance, and food gathering and processing—as well as relatively late stage biface production, possibly conducted during quarrying forays. Clusters of millingstones, reduction debris, various formed tools, and at least one hearth imply diverse residential activities, probably played out over multiple seasons. Several of these features—the

smallest and most discrete ones—may represent single, short-term campsites, possibly occupied by both men and women.

The diversity of raw materials in the lithic assemblage (including obsidian from several sources [Appendix N]) suggests that visitors ranged from a broad area and were engaged in lithic production and maintenance, beyond mere reduction of Tosawihi opalite.

26Ek3096

Reduction complex 26Ek3096 (14,250 m^2) consists of a light-density (fewer than 100 items per m^2), ridge-top lithic scatter (Budy 1989:158). Characterized by seven discrete reduction loci (Features 1–7), it lies on the west side of Rodent Valley among outcrops mapped as silicified reworked tuffaceous sediments (Cornucopia 1987; Figure 131). Surface rock appears poorly silicified, and we saw no sign that the site was used as a source of toolstone.

We surveyed the surfaces of these relatively small (all less than 12 m^2) loci for diagnostic tools, and selected Feature 1, a 4 m^2 biface reduction locus, for intensive surface scraping (Budy 1989:158). This operation, which collected the entire feature, yielded four bifaces and relatively slight quantities of debitage (204 items per m^2), suggesting limited biface reduction. No subsurface exercises were conducted.

26Ek3097

Reduction station 26Ek3097, on the moderately steep slopes of Basalt Canyon, is a briefly employed lithic station with no clear feature concentrations. We made no collections because the surface is eroded, and site deposits have been disturbed by road construction (Budy 1989:200–201).

26Ek3099

Discrete artifact concentrations at reduction complex 26Ek3099 (750 m^2) in Basalt Canyon were recorded as biface and core reduction features (Budy 1989:201). All associated artifacts were plotted and collected. These formed artifacts included seven bifaces, a core, a chopper-like tool, and an unclassifiable projectile point. The four features are located on a steep slope, and surface materials appear to have been redistributed by erosion and heavy vehicle movements. We elected, therefore, to undertake no systematic debitage collections.

26Ek3100

At 26Ek3100, a Rodent Valley knoll-top lithic complex covering 5,865 m^2, we documented two functionally-discrete reduction features. Feature 1 appears to have resulted from core reduction, indicated by two cores and a dense (481 items per m^2) scatter of early stage debitage (confirmed by mass analysis; cf. Appendix I). We collected the concentration entirely by scraping two 1 m x 1 m units (Budy 1989:158). Feature 2 consists of a restricted (1 m^2) surficial deposit of biface thinning flakes, none of which was collected.

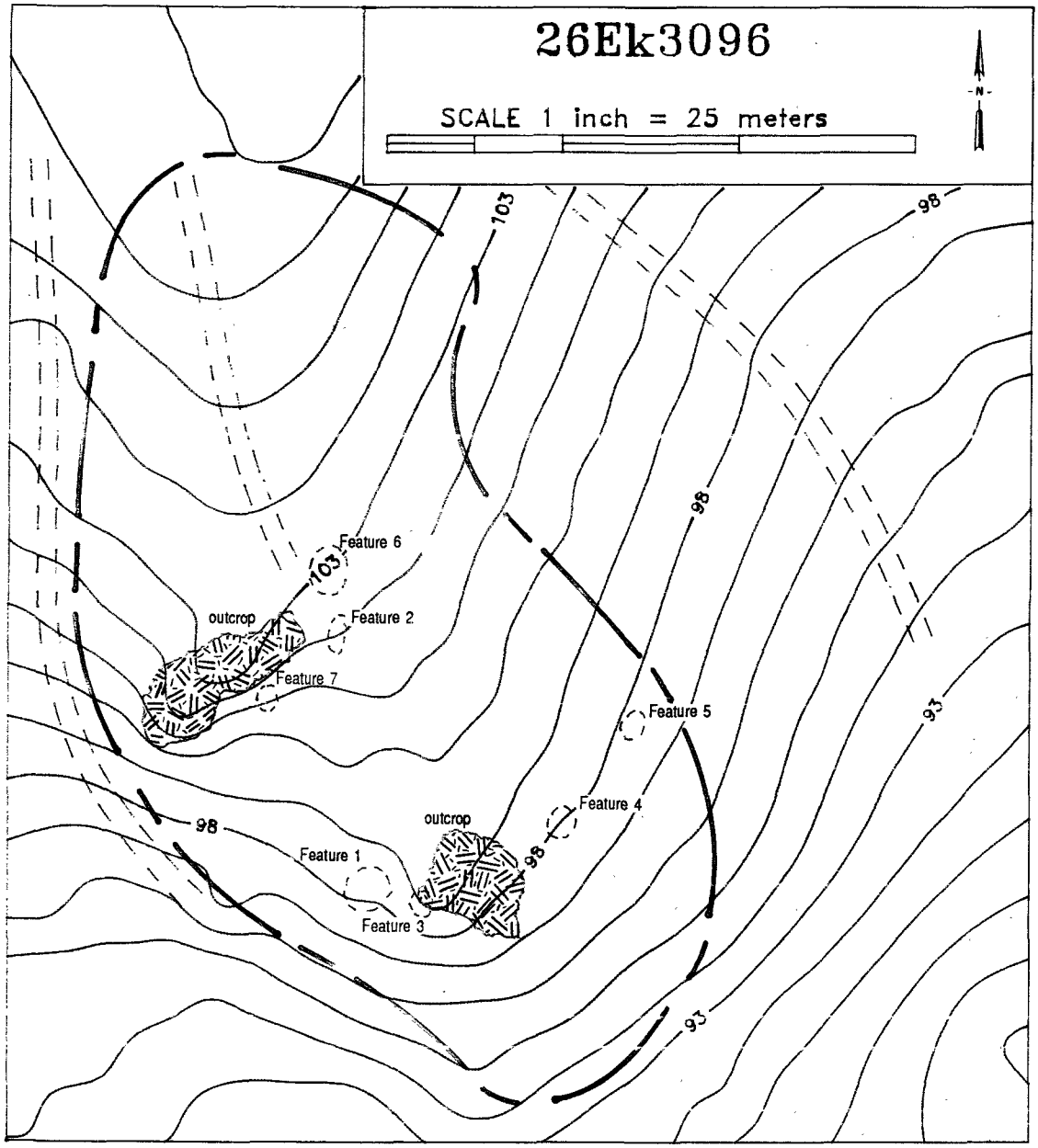


Figure 131. 26Ek3096 site map.

26Ek3101

On a saddle at the southwestern margin of Rodent Valley, reduction complex 26Ek3101 is characterized by a large, diffuse lithic scatter ranging over 11,250 m^2. The site has been disturbed by rodent activity and modern grass seeding. Surface scrapes (two 1 m x 1 m units) and a 1 m x 1 m subsurface excavation unit in a nonfeature area at the center of the saddle yielded 21, chiefly middle-stage, bifaces (Appendix C, Table 1), three flake tools, opalite and obsidian debitage (2,210 flakes), a modified chunk, a chopping/scraping tool, and a Great Basin Stemmed projectile point. A single backhoe trench, exposing about 80 cm of highly bioturbated silty loam overlying an ancient paleosol, failed to reveal any cultural stratigraphy.

26Ek3102

26Ek3102, a 2400 m^2 reduction complex resting on the toe of a ridge in eastern Rodent Valley, hosts five small, light density lithic reduction features. Only one feature was surface scraped (shovel skimmed over 8 square meters to a depth of 2 cm), while all others were surface collected (Budy 1989:162). The suite of formed tools collected across feature and extra-feature areas is dominated by middle-stage bifaces (complemented by a single flake tool and a modified chunk). A Rosegate series projectile point signals use of the area during Late Archaic times.

26Ek3106

A reduction complex with six well-preserved debitage concentrations, 26Ek3106 (5,175 m^2) lies on the east slope of a ridge overlooking Boundary Ravine (Figure 132). Two concentrations (Features 1 and 4/5; 6 m^2 and 36 m^2, respectively) were sampled by complete surface collection, shovel scraping to 2 cm depth, and limited subsurface excavation. These exercises yielded mostly early-stage biface production debris (Appendix I). Feature 1 was dominated by middle stage bifaces, with a single flake tool and a dense concentration of debitage, while Feature 4/5 yielded middle stage bifaces (Appendix C, Table 1), two flake tools, two percussion tools, and two cores. Projectile points recovered during excavation include Desert Series specimens. Surface scrapes at Feature 4/5 revealed a small, centrally-located hearth, composed of fire-cracked rocks and a burned millingstone fragment, suggesting plant processing and short-term domestic use of the site.

We subjected a charcoal sample from the hearth to radiocarbon assessment, obtaining a date of 300 ± 70 B.P. (Beta-26827) that indicates occupation during the latter part of the Late Archaic (ca. A.D. 1650). Relatively recent occupation is supported by the unusual spatial integrity of lithic features; such discrete distribution stems, perhaps, from the limited time they have been exposed to the surface (Budy 1989:163).

26Ek3107

Reduction complex 26Ek3107 consists of a debitage scatter, comprised of five lithic concentrations, blanketing 6,750 m^2 along the west slope of the Rodent Valley ridge that supports 26Ek3106 (Budy 1989:166). The surface of Feature 1 (4m^2), a spatially-discrete biface production and core reduction station atop a soil mound, was collected completely. Feature deposits were exposed by a backhoe trench, but we detected no distinct cultural stratigraphy.

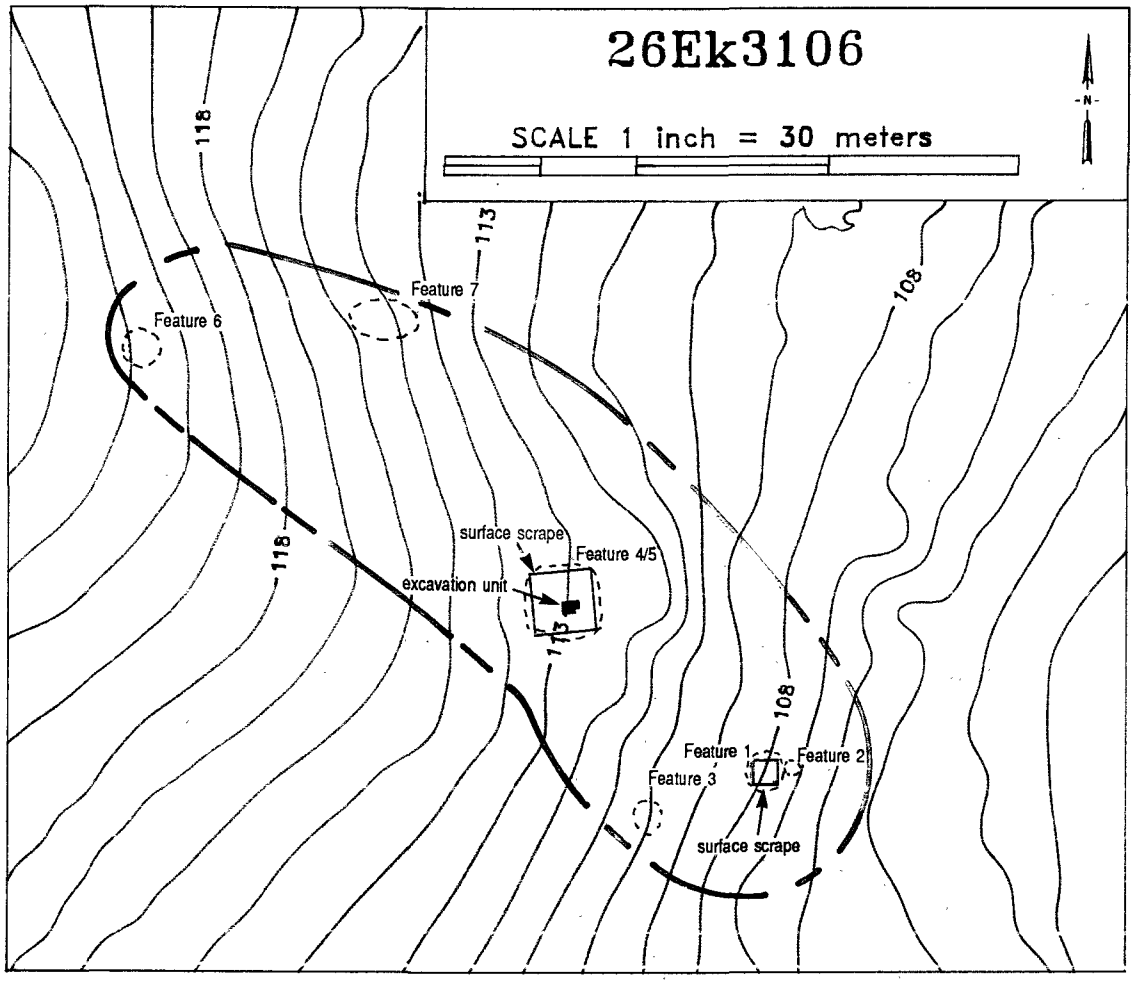


Figure 132. 26Ek3106 site map.

A series of 25 cm x 25 cm x 10 cm subsurface excavations intersected nonfeature areas, and yielded early stage biface reduction debitage of opalite and jasper (Appendix I). The recovery of a Great Basin Stemmed point base near Feature 5 suggests early (pre-Archaic) use of this location.

26Ek3114, 26Ek3115, and 26Ek3116

Three small reduction stations in the Bitterroot Ridge complex, each covering less than 200 m^2, contain single lithic concentrations. They occupy elevated positions above the Basalt Canyon and Antelope Creek drainages, and may have served as game trail overlooks and short-term biface production stations (Budy 1989:224).

Each reduction station was inventoried, mapped, and its surface collected. We also sampled features (over 60–100% of their surfaces) with systematic surface scrapes. 26Ek3114 and 26Ek3115 yielded early, middle, and late stage bifaces (Appendix C, Table 1) and flake tools and a scratched stone. 26Ek3116 contained a wide array of flake tools, projectile points, preforms, and middle and late stage bifaces, suggesting butchering/hide processing activities (Budy 1989:224). Late Archaic use is indicated by Desert Side-notched projectile points retrieved from 26Ek3114 and 26Ek3116.

26Ek3149

26Ek3149 (2,500 m^2) rests on the rocky eastern slope of Basalt Canyon, above its confluence with Little Antelope Creek (cf. Figure 100). The most intensive evidence of use occurs on the upper, western edge of the site, where two debitage features have been crosscut by a road, and along a series of narrow bedrock benches near the center of the site (Figure 133). Lateral artifact patterns do not appear to have been affected significantly by slopewash. Discrete artifact concentrations were recorded as Features 1–3, and associated artifacts were plotted and collected. Subsequently, we collected a representative sample feature (Feature 2, 1m x 4 m) for debitage classification and distributional studies. As well, a 1 m x .5 m unit was placed at the lower edge of the site, in recent canyon-bottom alluvium.

Collections included middle and late stage bifaces, a mano and metate, retouched or notched flakes, a chopping tool, and fragmentary projectile points (Table 137). This assemblage diversity and the presence of seed-processing equipment leads us to posit use as a campsite and reduction station.

Table 137. Summary of Artifacts Collected from 26Ek3149.

Feature	Area (m^2)	DEBITAGE n	DEBITAGE wt. (gm)	Proj. Points	Bifaces	Flake Tools	Perc./ Cobble Tools	Ground Stone	Total
-	-	192	315.9	1	8	2	1	2	14
1	43	-	-	-	1	-	-	-	1
2	3	276	245.4	2	3	2	-	-	7
3	4	-	-	-	-	-	-	-	0
Total		468	561.3	3	12	4	1	2	22

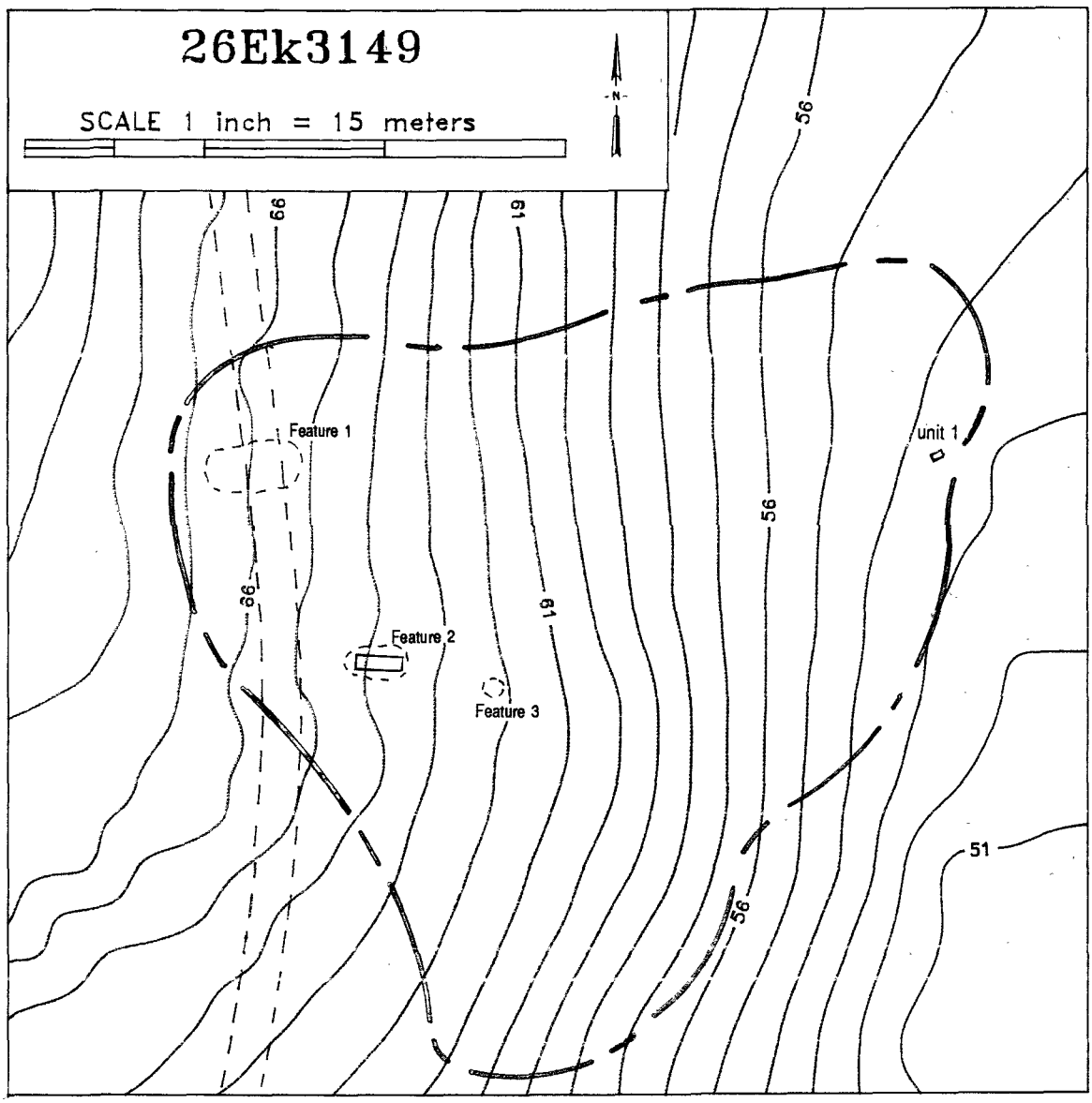


Figure 133. 26Ek3149 site map.

26Ek3160

26Ek3160, one of the largest sites recorded in the Tosawihi region, 46,000 m^2, is located on a broad, V-shaped ridge, bounded by seasonal drainages emptying into Little Antelope Creek (cf. Figure 100). The site rests on shallow, colluvial soils, and is peppered with big and low sagebrush and sparse grasses.

The ridge hosts diverse features, probably deposited over many occupational episodes, representing a wide variety of reduction and subsistence activities. They may represent repeatedly occupied reduction staging centers that also served as short-term campsites. The crest of the ridge is littered nearly continuously with debitage, hundreds of formal tools, and 23 artifact clusters defined as surface features (Figure 134). Investigated features variously reflected biface reduction and thinning, plant processing, hearth-focused activities, and ceramic vessel discard.

Excavation Methods and Rationale

Three site use areas (Loci A, B, and C) were identified on the basis of artifact densities and physical setting. Locus A rests at the center of the site, on a gentle slope with deeper soils, and extends over the south side of the ridgecrest. This aggregate consists of a light scatter of opalite debitage and three reduction loci (Features 17, 18, and 23). Locus B occupies the upper, western edge of the ridgecrest, and contains four reduction areas (Features 19–22) and a light to moderate density scatter of off-white opalite debitage and tools. Locus C incorporates the toe of the ridgeline and many dense, overlapping scatters of debitage and tools. We identified 16 discrete features in Locus C, composed of 11 early and mixed stage biface reduction areas (Features 3–7, 9, and 12–16; Appendix I), four burned reduction features (Features 2, 8, 10, and 11), and one component (Feature 1) containing millingstones and pottery sherds.

After intensive survey for feature identification, mapping, and collection of artifacts, we selected six particularly discrete features representing a diversity of types across each locus for preliminary testing (Features 1, 2, 3, 14, 17, and 20). Initially, only three areas subsurface—Feature 1 and two inter-feature locations in the deeper sediments of Locus A—were explored.

We returned in 1989 to conduct more focused data recovery at Features 1, 12, and 23. We also investigated one of the burned reduction scatters (Feature 11) and probed the deeper deposits in Locus A and Locus C.

Nonfeature Contexts

Cultural materials abound beyond the borders of the 23 defined features eroding off the ridgecrest onto the slopes below. Background lithic debris is continuous, and hundreds of isolated formed tools litter the ground. We collected from inter-feature areas a remarkable array, surpassing the number of isolates seen on any other site in the project area (525 items). Cultural remains were both focused and dispersed, signifying reoccupation as well as visits of relatively short duration.

We placed two 1 m x 1 m test excavation units in nonfeature contexts in Locus A (Figure 135). In Unit 2, a surprising depth of 60 cm was attained and 470 pieces of debitage and seven formed artifacts, including a rhyolite mano, were retrieved (Table 138). Unit 4, a control unit in which one 50 cm x 50 cm quadrant was screened through 1/8 inch mesh, was both shallower (40 cm) and sparser in yield. Each unit was profiled stratigraphically.

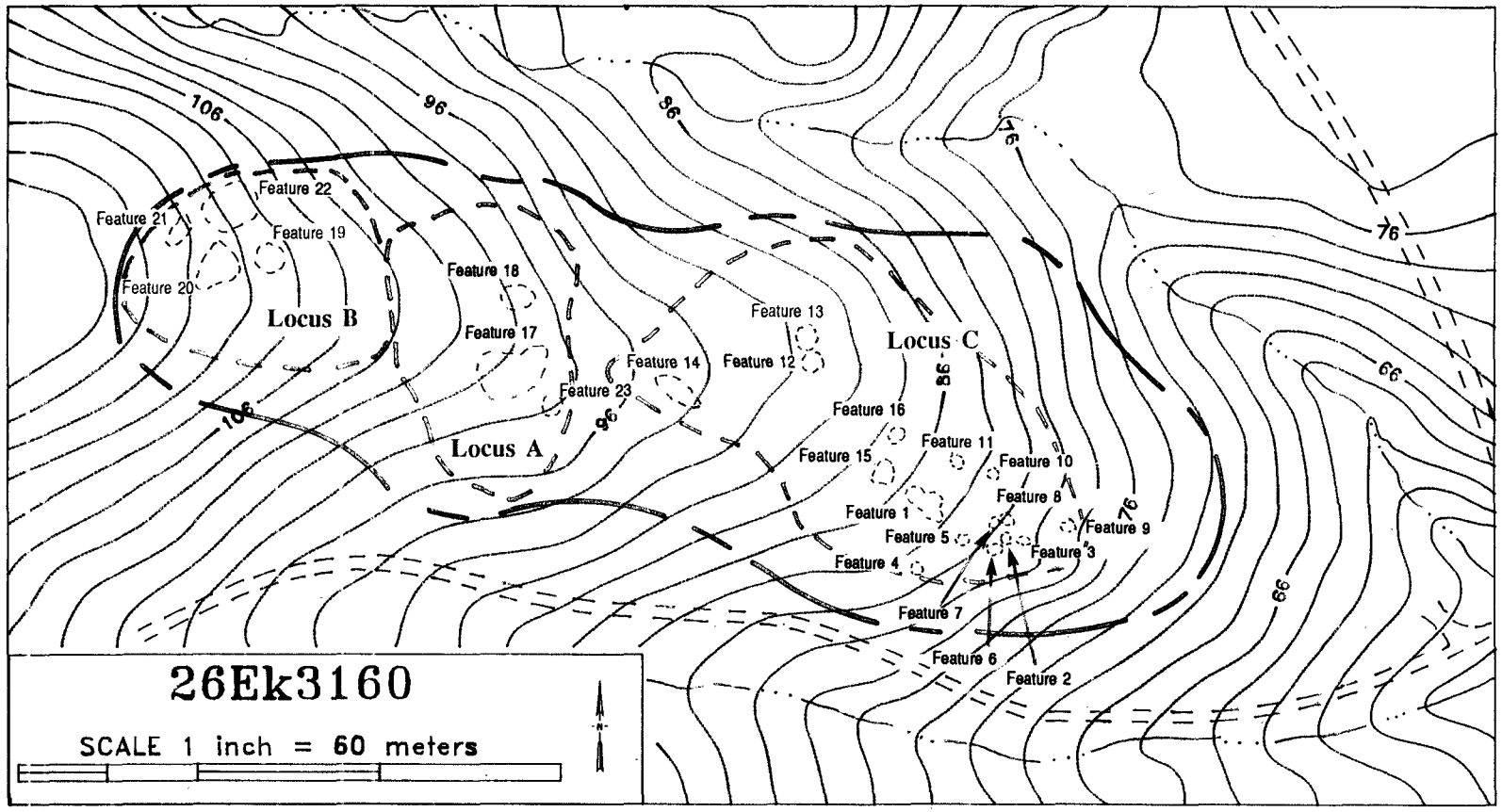


Figure 134. 26Ek3160 site map.

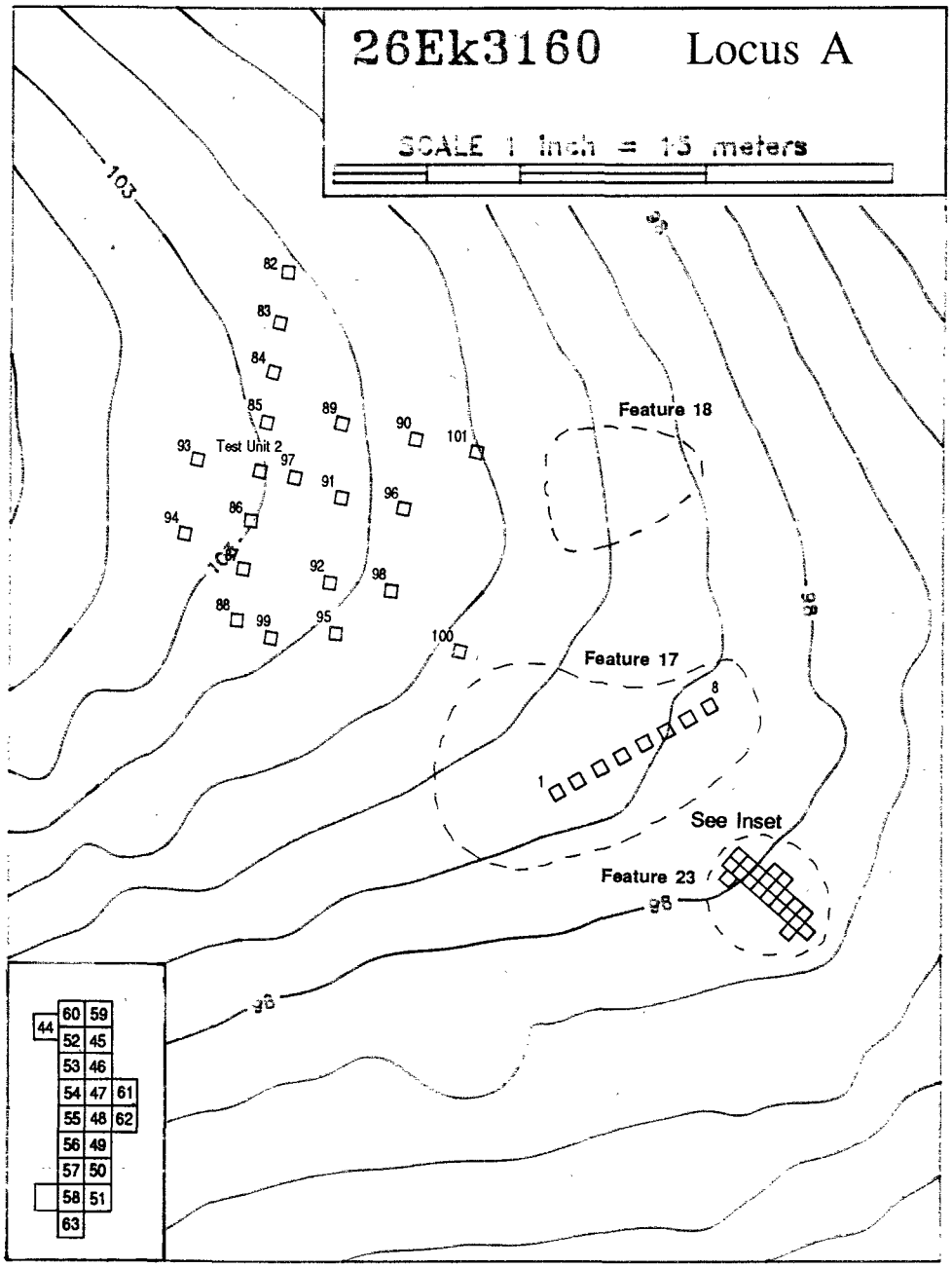


Figure 135. 26Ek3160, excavation units in Locus A.

Table 138. Summary of Artifacts Collected from Non-Feature Contexts in Locus A and All Surfaces at 26Ek3160.

		DEBITAGE		FORMED ARTIFACTS									
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Other/ Exotic	Total
2 (TS)	0.6	454	464.3	-	-	5	-	1	-	-	1	-	7
4 (TS)[a]	0.4	45	31.4	1	-	-	-	-	-	-	-	-	1
82 (EU)	0.3	23	25.8	-	-	-	-	-	-	-	-	-	0
83 (EU)	0.4	157	203.1	-	-	1	-	-	-	-	-	-	1
84 (EU)[a]	0.4	357	680.5	-	-	6[b]	-	-	-	-	-	-	6
85 (EU)	0.6	360	257.7	-	3	2	-	1	-	-	-	-	6
86 (EU)	0.7	701	766.9	2	1	4	-	1	-	-	-	-	8
87 (EU)	0.4	143	158.1	-	-	2	-	1	-	-	-	-	3
88 (EU)	0.3	133	215.0	-	-	2[b]	-	-	-	-	-	-	2
89 (EU)	0.4	193	215.9	-	-	-	-	-	-	-	-	-	0
90 (EU)	0.4	364	354.3	1	-	1	-	-	-	-	-	-	2
91 (EU)	0.3	132	122.3	-	1	1	-	-	-	-	-	-	2
92 (EU)	0.3	88	86.7	-	1	-	-	-	-	-	-	-	1
93 (EU)	0.5	362	333.7	-	-	6	-	1	-	-	-	-	7
94 (EU)	0.5	303	661.3	-	-	4	-	-	-	-	-	-	4
95 (EU)	0.2	36	34.8	-	-	-	-	-	-	-	-	-	0
96 (EU)[a]	0.3	130	179.8	-	-	1	-	-	-	-	-	-	1
97 (EU)	0.4	229	181.2	-	1	3	-	-	-	1	-	-	5
98 (EU)	0.4	38	35.8	-	-	-	-	-	-	-	-	-	0
99 (EU)	0.2	119	124.6	-	-	-	-	-	-	-	-	-	0
100 (EU)	0.2	37	48.3	-	-	2	-	-	-	-	-	-	2
101 (EU)	0.2	108	132.9	-	-	2	-	-	-	-	-	-	2
Surface	N/A	21	66.8	22	10	449[b]	1	27	1	3	11	1	525
Totals	8.4	4,533	5,381.2	26	17	491	1	32	1	4	12	1	585

(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Contains a 50 x 50 1/8 inch mesh control quadrant
[b]Includes "possible" bifaces

The deep deposits around Test Unit 2 were explored further with a block of systematically placed excavation units, achieving equivalent depth in only two units (EUs 85 and 86). We recovered numerous bifaces, flake tools, preforms, projectile points, and a hammerstone from this central portion of the site, indicating long-term and varied tool production and tool use activities (Appendix D).

Time markers from nonfeature contexts chronicle occupation during the pre-Archaic and the entire span of the Archaic. Great Basin Stemmed, Large Side-notched, Humboldt and Gatecliff Split Stem, Elko, Rosegate and Cottonwood series are represented.

Locus A; Features 17, 18 and 23

Features 17 (240 m^2) and 18 (110 m^2) are large flake scatters whose clarity has been compromised somewhat by slopewash or re-use. Feature 17 contains three flake concentrations and a large assemblage of formed artifacts. We sampled the feature with eight surface scrapes at two meter intervals along its long axis (cf. Figure 135), recovering various artifact types including a Rosegate projectile point, mid- to late stage bifaces, preforms, several flake tools, and a core (Table 139). Though bifaces dominate the cultural remains, other functionally diverse tools reflect processing activities as well as lithic production.

Table 139. Summary of Artifacts Collected from Feature 17, 26Ek3160.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Total
1 (SF)	0.02	255	163.1	-	-	3	-	-	3
2 (SF)	0.02	188	156.3	-	-	-	-	1	1
3 (SF)	0.02	328	253.7	1	-	-	-	-	1
4 (SF)	0.02	460	384.3	-	-	-	-	-	0
5 (SF)	0.02	437	260.9	-	-	-	-	-	0
6 (SF)	0.02	394	321.8	-	-	1	-	-	1
7 (SF)	0.02	188	149.4	-	-	-	-	-	0
8 (SF)	0.02	188	129.6	-	-	-	-	-	0
Surface	N/A	-	-	1	1	11	1	1	15
Totals	.16	2,438	1,819.1	2	1	15	1	2	21

(SF) = Surface Scrape

Feature 18 was inventoried for formed artifacts, yielding a single opalite biface.

Feature 23 contains a more diverse assemblage, apparently the remains of a series of food preparation and tool production activities in a campsite context (cf. Figure 135). Dispersed within a light density (30 items per m^2) debitage scatter are numerous specialized tools. A mortar, 20 projectile points, 19 point preforms, pointed flake tools, scrapers and retouched flakes, and dozens of mostly mid- to late stage bifaces were recovered from the surface and in subsurface excavations (Table 140).

Table 140. Summary of Artifacts Collected from Feature 23, 26Ek3160.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Ground Stone	Total
45 (SF)	0.02	162	295.4	-	3	7[b]	1	-	11
46 (SF)	0.02	236	295.7	-	-	4	-	-	4
47 (SF)	0.02	240	247.2	-	-	2	3	-	5
48 (SF)	0.02	151	209.2	-	-	2	3	-	5
49 (SF)	0.02	125	100.4	2	-	2	-	-	4
50 (SF)	0.02	95	114.7	-	-	-	-	-	0
51 (SF)	0.02	100	82.9	-	-	1	-	-	1
53 (SF)	0.02	72	98.3	2	-	-	-	-	2
54 (SF)	0.02	115	227.7	-	-	3	1	-	4
56 (SF)	0.02	191	193.2	1	-	2	1	-	4
57 (SF)	0.02	83	87.7	-	-	-	-	-	0
58 (SF)	0.02	127	108.5	-	-	4	-	-	4
59 (SF)	0.02	184	171.3	-	1	-	1	-	2
61 (SF)	0.02	117	78.3	-	1	1	-	-	2
62 (SF)	0.02	134	145.4	1	1	2	-	-	4
63 (SF)	0.02	78	83.4	-	-	-	-	-	0
64 (SF)	0.02	82	79.3	-	-	-	-	-	0
44 (EU)	0.30	796	1,016.6	6	3	11	5	-	25
52 (EU)[a]	0.30	618	781.5	5	4	7[b]	1	-	17
55 (EU)	0.20	355	383.7	-	2	4	4	-	10
60 (EU)	0.30	484	955.9	3	1	6	2	-	12
Surface	N/A	-	-	-	3	9	1	1	14
Totals	1.44	4,545	5,756.3	20	19	67	23	1	130

(SF) = Surface Scrape
(EU) = Excavation Unit

[a]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[b]Includes "possible" bifaces

We scraped 21 1 m x 1 m surface units to sample the bulk of visible remains, and then placed 4 excavation units in tool-rich areas. A subsurface cobble accumulation with carbon-stained matrix (Feature 24) was encountered in Units 44, 52, and 60. No artifacts were associated clearly; a functional ascription of "hearth" remains indefinite. No carbonized seeds were retrieved, nor was a radiocarbon date returned. Projectile points included Elko and Desert series specimens, as well as a dozen unidentifiable fragments.

Locus B Features (Features 19–22)

Most features in Locus B are large, ranging from 76 to 185 m^2, and have suffered considerable downslope movement and bioturbation (Budy 1989:241–243). Surface collections at Features 19 and 20 yielded processing tools and milling equipment (a mortar and a metate, respectively), suggesting that they may be short-term campsites (Table 141). Features 21 and 22 are reduction loci where we collected several bifaces, a modified chunk of opalite, and a scraper. Features 19, 21 and 22 were not sampled beyond collection of surface artifacts.

Feature 20 yielded controlled surface collections. No subsurface excavation was conducted due to the shallow soils in this part of the locus. We placed five 1 m x 1 m surface scrapes at two meter intervals parallel to the slope, and recovered a diverse flaked tools, in and a metate. This assemblage suggests a suite of food preparation and processing activities beyond mere lithic production. A single projectile point was not classifiable.

Table 141. Summary of Artifacts Collected from Locus B Features, 26Ek3160.

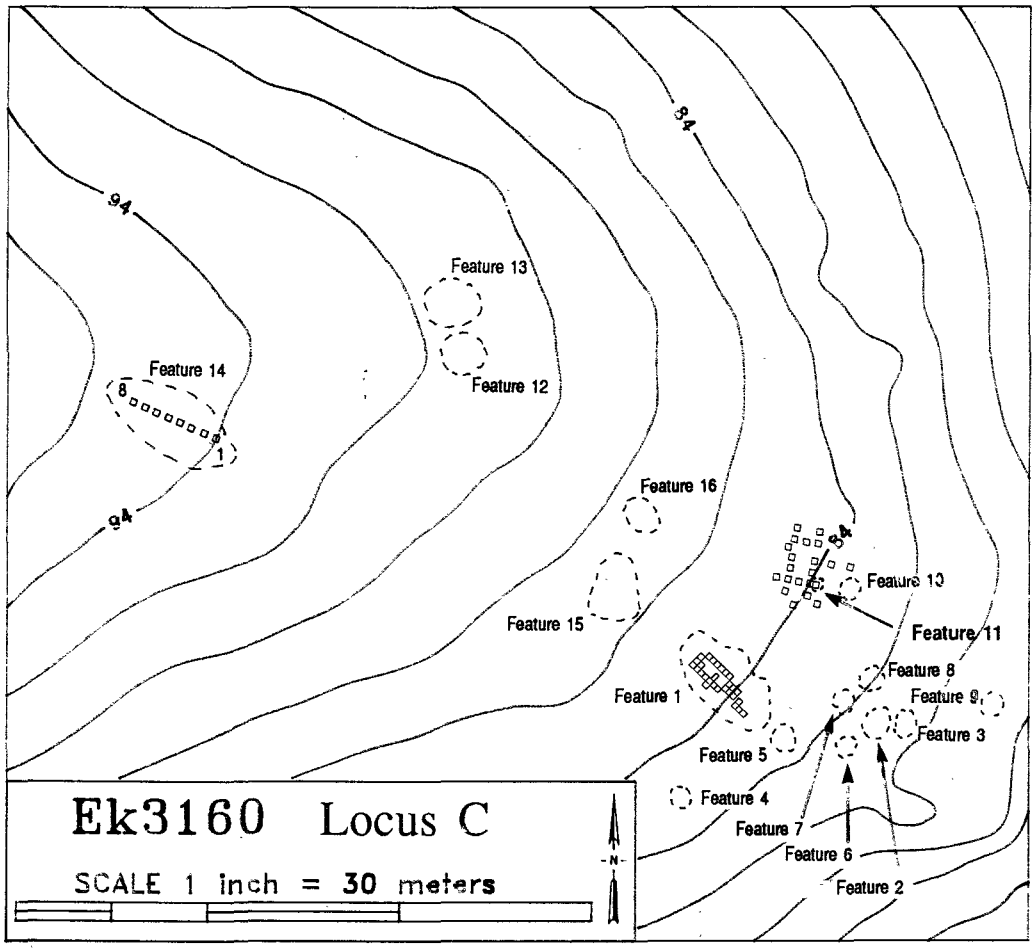
			DEBITAGE		FORMED ARTIFACTS						
Feature	Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Perc./ Modif. Chunks	Ground Stone	Total
19	Surface	N/A	-	-	-	-	6	1	-	1	8
20	1 (SF)	0.02	125	104.8	-	-	-	-	-	-	0
20	2 (SF)	0.02	142	165.7	-	-	-	-	-	-	0
20	3 (SF)	0.02	140	224.4	-	-	-	-	-	-	0
20	4 (SF)	0.02	258	326.4	-	1	1	-	-	-	2
20	5 (SF)	0.02	228	241.6	-	-	1	-	-	-	1
20	Surface	N/A	-	-	1	1	6	-	-	1	9
21	Surface	N/A	-	-	-	-	3	-	1	-	4
22	Surface	N/A	-	-	-	-	4	1	-	-	5
Totals		0.10	893	1,062.9	1	2	21	2	1	2	29

(SF) = Surface Scrape

Locus C Features (Features 1–16)

Feature 1

Feature 1 is unique at 26Ek3160. It is large (135 m^2) and complex, containing two discrete debitage concentrations and a scatter of Shoshone Brownware pottery (Figure 136). With a surface and subsurface assemblage containing seed-processing equipment (manos and a metate), a variety of flake tools (scrapers, notched/denticulate and pointed tools, and retouched flakes), hammerstones, a scraper plane, a tabular basalt shovel, a shaft abrader, obsidian and other exotic debitage, numerous mid- to late stage bifaces, and several Late Archaic projectile points (Desert Side-Notched, Cottonwood, Rosegate), the feature exhibits a functional diversity not seen elsewhere on the site.



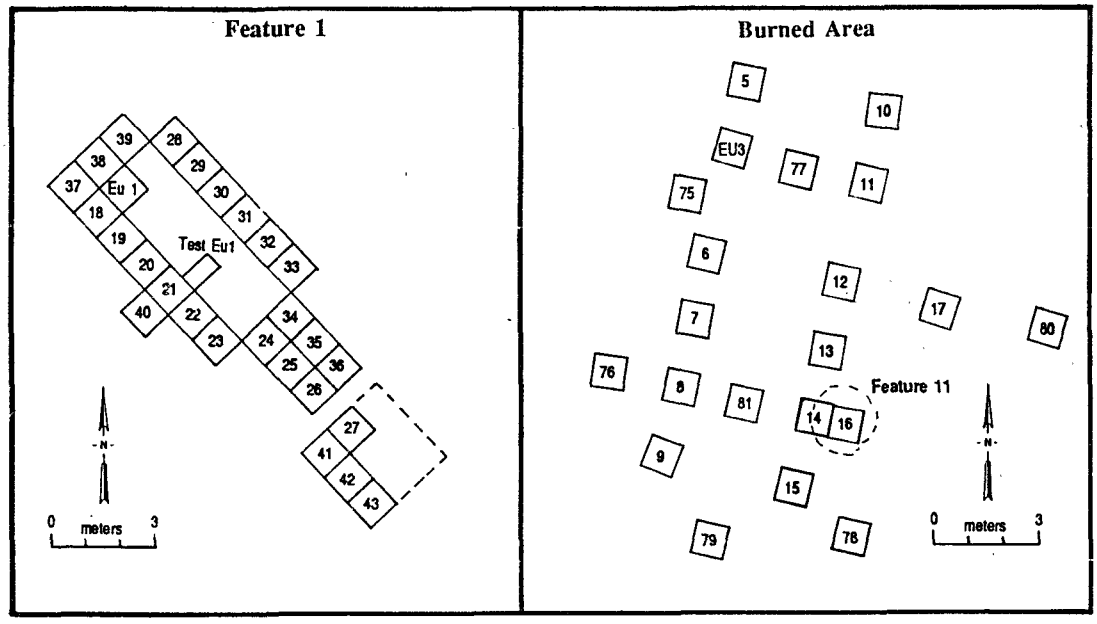


Figure 136. 26Ek3160, excavation units in Locus C.

We scraped a 2 m x 6 m block, centered in the westernmost (upslope) reduction area of the feature, and excavated a 1 m x .5 m unit in the center of the surface scrape block, encountering bedrock at 20 cm. We also placed five 1 x 1 m scrape units approximately five meters downslope to collect a scatter of 39 Shoshone Brownware ceramic sherds, apparently the remnants of a single pot drop.

In 1989, we expanded our exposure with 26 additional surface scrape units, connecting the two reduction loci, and then continued subsurface excavations in four prior scrape locations (EUs 1, 21, 24, and 31). We discovered several intensive reduction areas, more pottery (for a total of 61 sherds), a variety of flake tools, and opalite and obsidian debitage (Table 142). We failed to expose any subsurface hearths or other features.

Table 142. Summary of Artifacts Collected from Feature 1, 26Ek3160.

		DEBITAGE		FORMED ARTIFACTS									
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
1 (SF)	0.02	1,138	1,023.7	-	-	5	-	-	1	-	-	-	6
2 (SF)	0.02	263	170.1	1	1	-	-	-	-	-	-	-	2
3 (SF)	0.02	1,708	1,319.5	2	-	6	-	-	-	-	-	-	8
4 (SF)	0.02	587	398.3	-	-	1	-	-	-	-	-	-	1
5 (SF)	0.02	1,167	911.9	1	-	6	1	-	1	1	-	-	10
6 (SF)	0.02	722	488.6	-	-	1	-	-	-	-	-	-	1
8 (SF)	0.02	556	733.2	-	-	4	-	-	-	-	-	-	4
9 (SF)	0.02	742	1,744.8	1	-	1	-	-	-	-	-	-	2
10 (SF)	0.02	677	1,517.1	-	-	1	3	-	-	-	-	-	4
11 (SF)	0.02	349	465.1	-	-	1	1	-	-	-	-	-	2
12 (SF)	0.02	551	663.0	-	-	-	-	-	-	-	-	-	0
13 (SF)	0.02	116	87.0	-	-	-	-	-	-	-	17	-	17
14 (SF)	0.02	82	75.6	-	-	-	-	-	-	-	8	-	8
15 (SF)	0.02	207	169.3	-	-	-	-	-	-	-	3	-	3
16 (SF)	0.02	139	147.5	-	-	-	-	-	-	-	4	-	4
17 (SF)	0.02	89	78.2	-	-	1	-	-	-	-	7	-	8
18 (SF)	0.02	462	393.8	-	1	2	-	-	-	-	-	-	3
19 (SF)	0.02	616	588.4	-	1	2	-	-	-	1	-	-	4
20 (SF)	0.02	685	1,162.3	-	-	2	-	-	-	-	-	-	2
22 (SF)	0.02	629	808.0	-	-	3	1	-	-	-	-	-	4
23 (SF)	0.02	301	382.7	-	-	2[b]	-	-	-	-	-	-	2
25 (SF)	0.02	207	219.6	-	-	1	-	-	-	-	-	-	1
26 (SF)	0.02	178	144.2	-	-	-	-	-	-	-	-	-	0
27 (SF)	0.02	104	221.2	-	-	-	-	-	-	-	12	-	12
28 (SF)	0.02	63	41.7	-	-	-	-	-	-	-	-	-	0
29 (SF)	0.02	118	193.1	-	-	-	-	-	-	-	-	-	0
30 (SF)	0.02	151	122.6	-	-	4	-	-	-	-	-	-	4
32 (SF)	0.02	161	118.4	1	-	-	-	-	-	-	-	-	1
33 (SF)	0.02	219	192.3	-	-	1	-	-	-	-	-	-	1
34 (SF)	0.02	153	129.3	-	-	-	-	-	-	-	-	-	0
35 (SF)	0.02	88	92.6	-	-	-	-	-	-	-	-	-	0
36 (SF)	0.02	141	170.6	-	-	1	-	-	-	-	-	-	1
37 (SF)	0.02	363	376.0	-	-	-	-	-	-	-	-	-	0
38 (SF)	0.02	254	224.3	-	-	-	-	-	-	-	-	-	0
39 (SF)	0.02	89	77.7	-	-	-	-	-	-	-	-	-	0
40 (SF)	0.02	612	813.6	-	-	2	-	-	-	-	-	-	2
41 (SF)	0.02	130	138.7	-	-	-	-	-	-	-	-	-	0
42 (SF)	0.02	163	186.7	-	-	-	-	-	-	-	5	-	5
43 (SF)	0.02	141	162.4	-	1	-	-	-	-	-	-	-	1
7/1 (TS)[a]	0.11	1,301	3,296.0	-	-	7	1	1	2	-	-	-	11
1 (EU)	0.18	880	620.5	-	-	2	1	-	-	-	-	-	3
21 (EU)	0.20	1,896	6,274.3	-	-	12[b]	2	-	-	-	-	-	14
24 (EU)[a]	0.20	464	378.3	-	-	-	3	-	-	-	-	-	3
31 (EU)	0.20	198	198.2	-	-	4	-	-	-	-	-	-	4
Surface	N/A	6	13.0	-	-	13[b]	-	-	1	1	5	1	21
Totals	1.67	19,866	27,733.4	6	4	85	13	1	5	3	61	1	179

(SF) = Surface Scrape
(TS) = Test Unit
(EU) = Excavation Unit

[a]Contains a 50 x 50 cm 1/8 inch mesh control portion
[b]Includes one "possible" biface

Features 2–16

We submitted eight of the Locus C reduction stations to limited surface inventory and collection (Features 4–8, 13, 15–16; Table 143). Features 2 and 3 (adjacent 6–9 m^2 areas of moderate density debitage on the downslope, eastern edge of Locus C) and Feature 14 (140 m^2) at the west end of the locus were selected for intensive surface collection. At Features 2 and 3, we scraped a 2 m x 2 m grid and 2 m x 4 m grid, respectively, thereby recovering approximately 80% of the contents of the features (Table 143).

Table 143. Summary of Artifacts Collected from Inventoried and Tested Features in Locus C, 26Ek3160.

			DEBITAGE		FORMED ARTIFACTS						
Feature	Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Cobble Tools	Perc./ Other/ Exotic	Total
2	1 (SF)	0.02	240	227.8	-	1	-	-	-	-	1
2	2 (SF)	0.02	263	148.4	-	-	-	-	-	-	0
2	3 (SF)	0.02	360	281.9	-	-	1	-	-	-	1
2	4 (SF)	0.02	287	185.0	-	-	-	-	-	-	0
2	Surface	N/A	-	-	-	-	1	-	-	-	1
3	1 (SF)	0.02	280	649.8	-	-	-	-	-	-	0
3	2 (SF)	0.02	341	710.7	-	-	-	-	-	-	0
3	3 (SF)	0.02	403	1,042.0	-	-	-	-	-	-	0
3	4 (SF)	0.02	451	756.4	-	-	1	-	-	-	1
3	5 (SF)	0.02	327	660.8	-	-	-	-	-	-	0
3	6 (SF)	0.02	224	409.1	-	-	-	-	-	-	0
3	7 (SF)	0.02	100	186.8	-	-	-	-	-	-	0
3	8 (SF)	0.02	124	207.0	-	-	-	-	-	-	0
4	Surface	N/A	-	-	-	-	6	2	-	-	8
5	Surface	N/A	-	-	-	-	2	-	-	-	2
6	Surface	N/A	-	-	-	1	1	-	-	-	2
7	Surface	N/A	-	-	-	-	4	-	1	-	5
8	Surface	N/A	-	-	-	-	1	-	-	-	1
13	Surface	N/A	1	1.7	-	1	2	-	-	-	3
14	1 (SF)	0.02	38	31.9	-	-	1	-	-	-	1
14	2 (SF)	0.02	190	121.2	1	-	1	-	-	-	2
14	3 (SF)	0.02	394	244.6	-	-	-	-	-	-	0
14	4 (SF)	0.02	772	545.2	-	-	-	-	-	-	0
14	5 (SF)	0.02	337	306.9	-	-	-	-	-	-	0
14	6 (SF)	0.02	426	401.8	-	-	-	-	-	-	0
14	7 (SF)	0.02	391	369.2	-	-	-	-	-	-	0
14	8 (SF)	0.02	316	257.2	-	1	1	-	-	-	2
14	Surface	N/A	2	0.8	-	-	7	-	-	-	7
15	Surface	N/A	-	-	-	-	1	-	-	1	2
16	Surface	N/A	-	-	-	-	1	-	-	-	1
Totals		0.70	6,267	7,746.2	1	4	31	2	1	1	40

(SF) = Surface Scrape
(EU) = Excavation Unit

Features 9 and 10 (respectively, 54 m^2 and 3 m^2) were recorded and biface thinning flakes and core reduction were observed. We collected no artifacts.

A discontinuous line of surface scrapes parallel to the slope at Feature 14 yielded debitage samples, a preform, several bifaces, and a fragmentary projectile point (Table 143).

It was apparent that Features 2, 8, 10, and 11 had been exposed to some unknown source of fire, and, indeed, our collections at Feature 2 yielded quantities of blackened, crazed, and fractured debitage. In a non-feature, moderate density area in the eastern portion of Locus C, we excavated a shallow 1 m x 1 m unit (Unit 3) on the north edge of the burned area (cf. Figure 136), and recovered burned materials to a depth of 20 cm. We could discern no direct evidence of intentional heat-treatment of lithics in this locale, however, and concluded that burning was post-depositional (cf. Chapter 10).

Exploring for a buried heat-treating facility, we placed 20 shallow excavation units (typically confined to a single 10 cm level) at 1–2 m intervals across the area marked by burned opalite (cf. Figure 136; Table 144). Two of these units (EUs 14 and 16) fell within Reduction Feature 11. In EU 16, we exposed subsurface Feature 25, composed of a small (35 cm x 35 cm) concentration of fire-altered opalite chunks and flakes, fire-cracked cobbles, and charcoal. The function of this feature remains unclear in the context of the larger, post-depositional burn.

Table 144. Summary of Artifacts Collected from Burned Feature Cluster in Locus C, 26Ek3160.

		DEBITAGE		FORMED ARTIFACTS						
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Total
3 (TS)[a]	0.2	670	538.5	-	-	7	-	-	-	7
5 (EU)	0.1	146	157.6	-	-	1	-	-	-	1
6 (EU)	0.1	224	269.5	-	-	-	1	-	-	1
7 (EU)	0.1	147	176.2	-	-	-	1	-	-	1
8 (EU)	0.1	71	66.1	-	-	-	-	-	-	0
9 (EU)	0.1	34	21.0	-	-	-	-	-	-	0
10 (EU)	0.1	43	48.8	-	-	-	-	-	-	0
11 (EU)	0.1	184	155.0	-	-	1	-	-	-	1
12 (EU)	0.1	68	94.8	-	-	1	-	-	-	1
13 (EU)	0.1	157	174.1	-	-	-	-	-	-	0
14 (EU)	0.2	183	697.2	-	1	1	-	-	-	2
15 (EU)	0.1	55	82.9	-	-	-	-	-	-	0
16 (EU)	0.1	1,174	3,811.3	-	-	5	-	1	-	6
17 (EU)	0.1	82	276.3	-	-	1	-	-	1	2
75 (EU)	0.2	1,344	1,589.7	1	-	4[b]	-	-	-	5
76 (EU)	0.1	91	70.7	-	-	-	-	-	-	0
77 (EU)	0.1	146	274.9	-	-	-	-	-	-	0
78 (EU)	0.1	36	34.5	-	-	-	2	-	-	2
79 (EU)	0.1	28	50.4	-	-	-	-	-	-	0
80 (EU)	0.1	84	125.3	-	-	-	-	-	-	0
81 (EU)	0.1	134	207.4	-	-	-	-	-	-	0
Totals	2.4	5,101	8,922.2	1	1	21	4	1	1	29

(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[b]Includes a "possible" biface

At Feature 12, a relatively small (64 m^2) reduction station in the north-central portion of Locus C, we collected a projectile point fragment and other formed artifacts (a pointed flake tool, two preforms, and 8 bifaces) during initial inventory. Because of the density of tools in this scatter, and because a millingstone (collected as a nonfeature isolate) lay just beyond its boundaries, we decided that additional data recovery was warranted. We scraped a linear transect of ten 1 m x 1 m units, and excavated one of the high density scrapes (Unit 69) down an additional 28 cm. Primarily mid- to late stage bifaces and a variety of flake tools were retrieved (Table 145; Appendix C, Table 1). We observed no subsurface features.

Table 145. Summary of Artifacts Collected from Feature 12, 26Ek3160.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Total
65 (SF)	0.02	50	32.2	-	-	2	-	2
66 (SF)	0.02	88	74.7	-	-	-	-	0
67 (SF)	0.02	157	184.7	-	-	-	-	0
68 (SF)	0.02	379	561.4	-	-	2	-	2
70 (SF)	0.02	377	317.2	-	-	2	1	3
71 (SF)	0.02	187	181.1	-	-	-	-	0
72 (SF)	0.02	265	195.8	-	-	3	1	4
73 (SF)	0.02	207	179.2	-	-	-	-	0
74 (SF)	0.02	243	252.2	-	-	-	1	1
69 (EU)	0.30	1,437	2,271.8	-	1	7	1	9
Surface	N/A	1	1.8	1	2	8	1	12
Totals	*0.48*	*3,391*	*4,252.1*	*1*	*3*	*24*	*5*	*33*

(SF) = Surface Scrape
(EU) = Excavation Unit

Summary

26Ek3160, the largest site examined on the Western Periphery, exhibits multiple feature types and a diverse assemblage including pottery, seed-milling equipment, and a wide variety of processing tools. Reduction of opalite imported from elsewhere in the Tosawihi study area left the most visible record. Its occurrence within the context of other, subsistence-related, activities, however, adds an important dimension to our understanding of the behavior of groups procuring toolstone at Tosawihi; logistical convenience required quarriers to remain long enough that support activities were necessary. Hence, this ridgeline was the scene of repeated, if short-term, residential occupation.

The variable artifact constituents and intensity of use revealed by the 23 features and extensive non-feature areas testify to the site's complex occupational history. The enormous assemblage reflects heat-treatment of bifaces, mid-to-late biface reduction, tool production and maintenance, and food processing and preparation.

The attractiveness of Bitterroot Ridge was long-standing—the distribution of projectile points suggests occupation, at least intermittently, over the last 8000 years. Recovered projectile points both predate and span the entire Archaic period, and substantial vertical deposits allow us to engage in a long-term look at residentiality and tool production at the edge of the Quarries.

26Ek3165

26Ek3165 sits squarely on a broad saddle atop a northwest-trending ridgeline near the southern boundary of the Western Periphery (cf. Figure 100). Like the other reduction/residential sites that share its elevated position on Bitterroot Ridge, 26Ek3165 supports only shallow soils. We recognized, therefore, little opportunity for the preservation of buried cultural materials and so confined most of our investigations to defining the patterning of artifacts on the surface. We identified two remarkably pristine lithic reduction/ residential loci (Features 1 and 2; 10 m^2 and 38 m^2, respectively), and a rather diffuse scatter of tools and lithics (Locus A) in a sparser background array of debitage and isolated artifacts (Figure 137). Cultural materials also have been transported downslope, south of the site, probably by colluvial action.

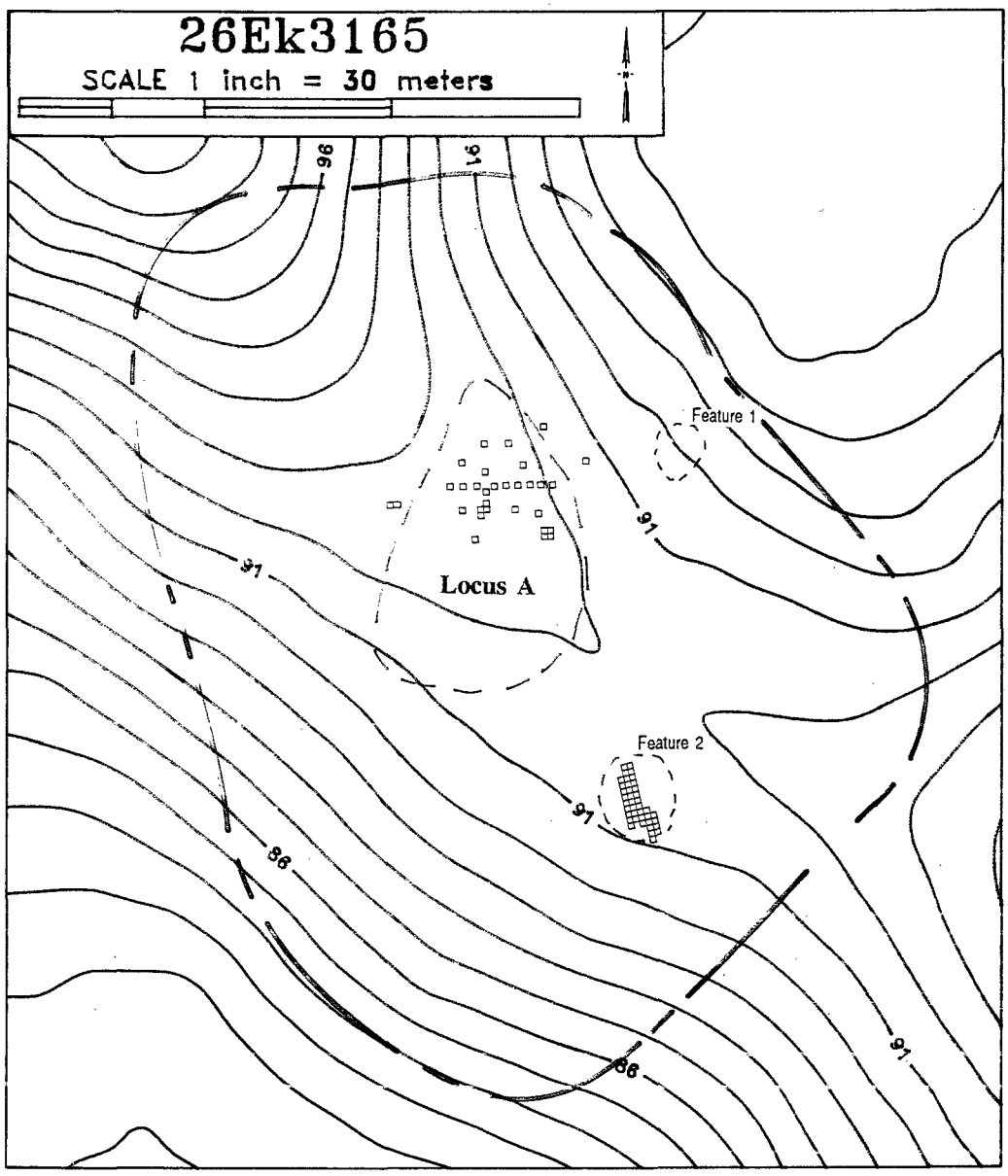


Figure 137. 26Ek3165 site map.

We sampled both features with extensive surface scrapes, and probed the deeper soils in Locus A to check for buried cultural remains. At Feature 2 we also employed subsurface excavations to test for buried residential features.

Nonfeature Contexts

In Locus A, the relatively sparse lithic and tool scatter at the center of the site, we collected surface isolates and excavated a 1 m x 1 m test excavation unit adjacent a partially exposed tabular basalt metate (Figure 138a). Excavating to a depth of 30 cm and screening all deposit through 1/4 inch mesh yielded debitage and formed artifacts (Table 146). To define the assemblage composition and subsurface extent of the concentration more specifically, we then excavated 32 1 m x 1 m units to an average depth of 10 cm. Twenty-two of these units examined vertical deposition in the heart of the locus, and ten additional units sampled the periphery of the scatter. Two units were selected as control units, in which one 50 cm x 50 cm quadrant was screened through 1/8 inch mesh.

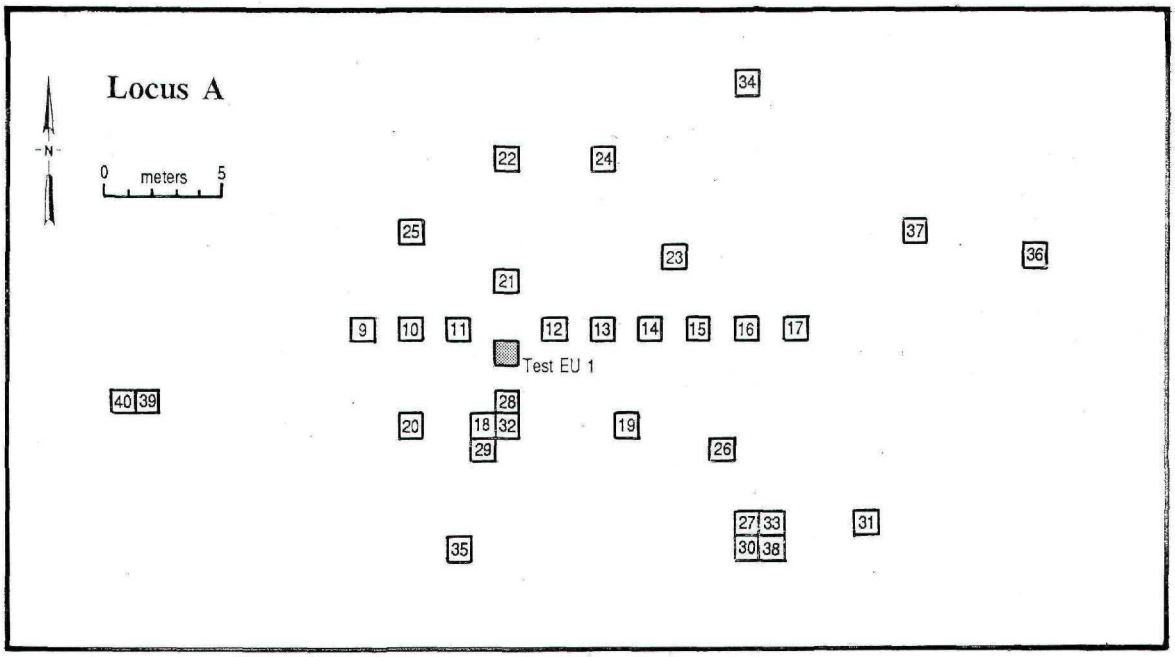
A variety of formed tools was retrieved from Locus A and other nonfeature surfaces (Table 146). The assemblage was dominated by bifaces, but functional diversity also was represented by a fragmentary projectile point, preforms, opalite and obsidian retouched flakes, a modified opalite chunk, and two tabular basalt metates. Opalite and rare obsidian and basalt reduction debris was collected, as well.

Table 146. Summary of Artifacts Collected from Nonfeature Contexts, 26Ek3165.

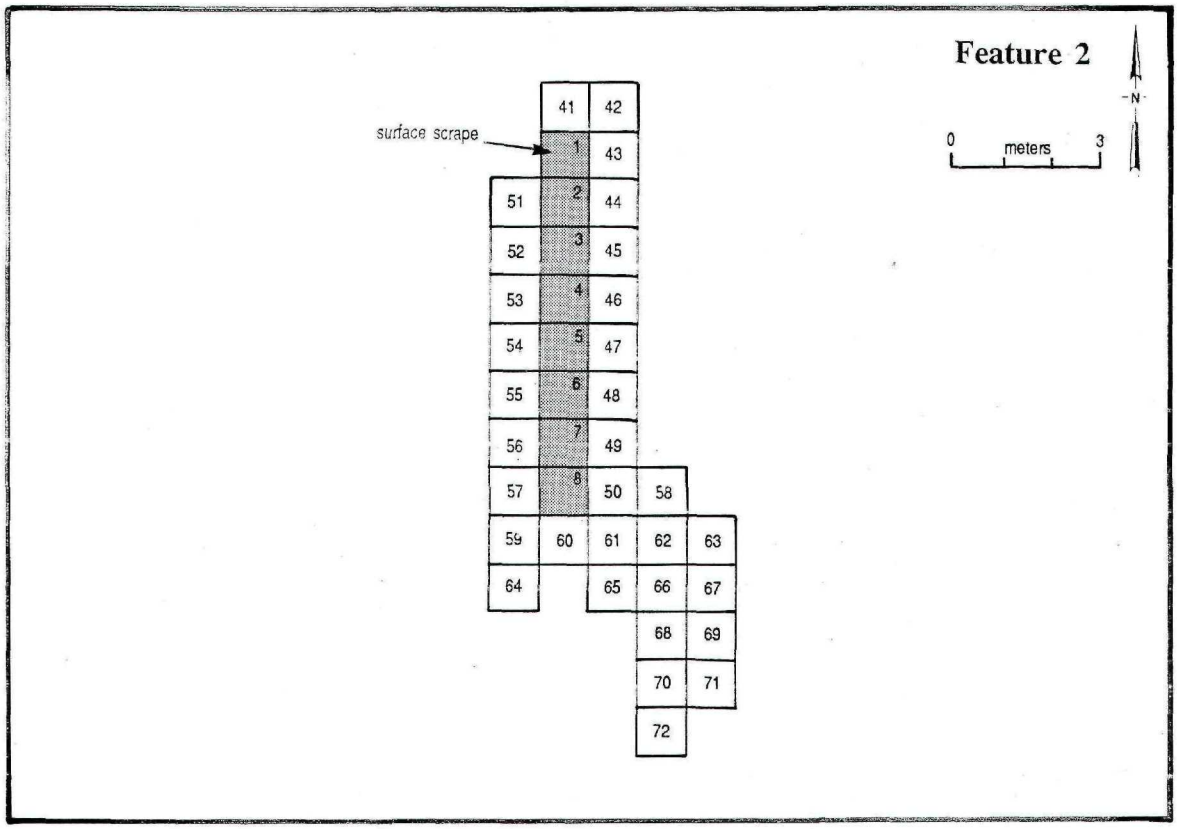
		DEBITAGE		FORMED ARTIFACTS						
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Modif. Chunks	Ground Stone	Total
1 (TS)	0.25	135	123.1	-	-	3	-	-	-	3
9 (EU)	0.10	16	17.9	-	-	-	-	-	-	0
10 (EU)	0.10	31	22.8	-	-	-	-	-	-	0
11 (EU)	0.10	19	25.8	-	-	2	-	-	-	2
12 (EU)	0.10	41	35.1	-	-	-	-	-	-	0
13 (EU)	0.10	9	5.1	-	-	-	-	-	-	0
14 (EU)	0.10	10	5.3	-	-	-	-	-	-	0
15 (EU)	0.10	7	27.9	-	-	-	-	-	-	0
16 (EU)	0.10	5	2.8	-	-	-	-	-	-	0
17 (EU)	0.10	15	20.6	-	-	-	-	-	-	0
18 (EU)	0.10	490	569.6	-	-	4	1	-	1	6
19 (EU)	0.10	20	11.5	-	-	-	-	-	-	0
20 (EU)	0.10	27	22.3	-	-	-	-	-	-	0
21 (EU)	0.10	16	13.6	-	-	-	-	-	-	0
22 (EU)	0.10	7	2.9	-	-	-	-	-	-	0
23 (EU)	0.10	6	2.9	-	-	-	-	-	-	0
24 (EU)	0.10	7	6.5	-	-	-	-	-	-	0
25 (EU)	0.10	23	31.8	-	-	-	-	-	-	0
26 (EU)	0.10	7	3.3	-	-	-	-	-	-	0
27 (EU)[a]	0.10	196	175.2	-	-	2	1	-	-	3
28 (EU)	0.10	588	764.7	-	-	2	-	-	-	2
29 (EU)	0.10	194	186.2	-	-	1	1	-	-	2
30 (EU)	0.20	357	252.4	-	-	-	-	-	-	0
31 (EU)	0.10	60	55.4	-	-	1	-	-	-	1
32 (EU)[a]	0.10	1,124	868.5	-	-	1	-	-	-	1
33 (EU)	0.10	90	152.2	-	1	-	-	-	-	1
34 (EU)	0.10	21	18.7	-	-	1	1	-	-	2
35 (EU)	0.10	7	4.5	-	-	-	-	-	-	0
36 (EU)	0.10	215	207.7	-	-	-	-	-	-	0
37 (EU)	0.30	172	143.2	-	-	2	-	-	-	2
38 (EU)	0.10	159	198.1	-	-	2	1	-	-	3
39 (EU)	0.30	146	904.0	-	-	-	-	-	-	0
40 (EU)	0.10	45	93.4	-	-	-	-	-	-	0
Surface	N/A	-	-	1	1	14	-	1	1	18
Totals	3.95	4,265	4,975.0	1	2	35	5	1	2	46

(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Contains a 50 x 50 cm 1/8 inch mesh control quadrant



a



b

Figure 138. 26Ek3165. a. Locus A; b. Feature 2.

Feature 1

We surface scraped approximately 75% (eight contiguous 1 m x 1 m units) of Feature 1 to a depth of 2 cm, and we inventoried and collected all formed artifacts from the remaining surface of the feature. An assemblage of opalite debitage (1710 pieces weighing 1561.7 gms), three biface fragments, a pointed flake tool probably used for scraping, and a complete tabular basalt metate suggest that a diverse suite of subsistence-related and processing activities produced the deposits.

Feature 2

Feature 2 is both larger (11 m x 6 m) and more dense than Feature 1. We established a 1 m x 8 m baseline transect through its long axis, and scraped eight contiguous 1 m x 1 m units to a depth of 2 cm (Figure 138b). The entire feature was then inventoried for formed artifacts.

For additional data recovery, aimed explicitly at characterizing the contents and spatial structure of the feature, we scraped 32 1 m x 1 m units (with a 1/8 inch control quadrant in one unit) to 2 cm, immediately surrounding our original surface scrape transect. We then placed three shallow, 1 m x 1 m excavation units in the scraped area in zones of particularly high density. Though no buried features were revealed, we recovered debitage, two unclassifiable projectile point fragments, a preform, several dozen early, middle and late stage bifaces, retouched flakes, pointed and microdenticulate flake tools, and a tabular basalt metate (Table 147).

Table 147. Summary of Artifacts Collected from Feature 2, 26Ek3165.

		DEBITAGE		FORMED ARTIFACTS					
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Ground Stone	Total
1 (SF)	0.02	617	693.0	-	-	1	-	-	1
2 (SF)	0.02	542	597.8	-	-	2	-	-	2
3 (SF)	0.02	115	132.3	-	-	-	1	-	1
4 (SF)	0.02	89	110.9	-	1	-	-	-	1
5 (SF)	0.02	131	244.8	1	-	-	-	-	1
6 (SF)	0.02	208	245.2	-	-	6	-	-	6
7 (SF)	0.02	276	334.3	-	-	-	-	-	0
8 (SF)	0.02	267	432.1	-	-	-	1	-	1
41 (SF)	0.02	69	327.0	-	-	-	-	-	0
42 (SF)	0.02	122	416.1	-	-	-	-	-	0
44 (SF)	0.02	104	91.0	-	-	2	-	-	2
45 (SF)	0.02	58	34.3	-	-	-	-	-	0
46 (SF)	0.02	83	85.5	-	-	-	-	-	0
47 (SF)	0.02	118	155.4	-	-	1	-	-	1
48 (SF)	0.02	137	160.0	1	-	-	-	-	1
49 (SF)	0.02	189	228.2	-	-	-	-	-	0
50 (SF)	0.02	88	113.3	-	-	-	-	-	0
51 (SF)	0.02	132	181.3	-	-	2	-	-	2
53 (SF)	0.02	44	40.6	-	-	-	-	-	0
54 (SF)	0.02	47	49.3	-	-	-	-	-	0
55 (SF)	0.02	104	156.4	-	-	-	-	-	0
56 (SF)	0.02	225	219.9	-	-	-	-	-	0
57 (SF)	0.02	148	336.2	-	-	3[b]	-	-	3
58 (SF)	0.02	62	49.2	-	-	-	-	-	0
59 (SF)	0.02	55	88.7	-	-	-	1	-	1
60 (SF)	0.02	94	117.6	-	-	-	-	-	0
61 (SF)	0.02	107	156.2	-	-	-	-	-	0
62 (SF)	0.02	104	147.3	-	-	3	-	-	3
63 (SF)	0.02	60	74.6	-	-	-	-	-	0
64 (SF)	0.02	48	117.5	-	-	-	-	-	0
65 (SF)	0.02	57	46.2	-	-	-	-	-	0
66 (SF)	0.02	141	237.1	-	-	-	-	-	0
67 (SF)	0.02	108	86.6	-	-	-	-	-	0
68 (SF)	0.02	150	266.1	-	-	-	-	-	0
69 (SF)	0.02	80	102.9	-	-	-	1	-	1
70 (SF)	0.02	131	221.9	-	-	1	-	-	1
71 (SF)	0.02	104	124.2	-	-	-	-	-	0
72 (SF)	0.02	113	115.4	-	-	-	-	-	0
6 (EU)	0.28	1,002	1,248.6	-	-	11	-	-	11
43 (EU)	0.20	410	531.8	-	-	1	-	-	1
52 (EU)[a]	0.20	353	677.9	-	-	2	-	-	2
Surface	N/A	-	-	-	-	2	-	1	3
Totals	1.44	7,092	9,794.7	2	1	37	4	1	45

(SF) = Surface Scrape
(EU) = Excavation Unit

[a]Contains a 50 x 50 cm 1/8 inch mesh control quadrant
[b]Includes one "possible" biface

The high density and diversity of formed artifacts, including milling equipment, suggest both a more discrete and more intense residential use of space at Feature 2 than at Feature 1.

Summary

26Ek3165 provides a strikingly clean glimpse of short-term residence at the rim of the Tosawihi Quarries. The site is relatively small and activity loci are clearly defined. The structure and content of features suggest brief, narrowly-focused occupational histories, incorporating food processing and subsidiary tool production. Metates were found in patterned clusters of tools and debitage, the remains of domestic activity.

The few projectile points and the restricted number and size of the artifact clusters contrast markedly with the extensive remains and repeatedly occupied surfaces at 26Ek3160 to the north. The constricted landform upon which the site rests and its relative isolation from potable water probably contributed to the limited occupation.

26Ek3271

The final Bitterroot Ridge reduction/residential complex, 26Ek3271 (19,500 m^2), lies on the steeply-sloping crest of a narrow, southeast-trending ridgeline and saddle above Basalt Canyon (Figure 139). The ridge was occupied intensively; there are multiple features, thick flake concentrations, and a wide variety of tools distributed along its crest and slopes. These features are not particularly distinct, probably due to recurring occupation and use of the ridgeline for reduction activities (Budy 1989:235). Reduction features occupying the more level ground of the saddle to the east and the bench at the northwestern portion of the site have been grouped into loci (Locus A and Locus C). Locus B, at site center, contains additional features, residing in a dense background of debitage.

A variety of tools (including millingstones) also occur in extra-feature contexts, indicating that activities were often conducted outside spatially-defined use areas. Alternately, the lack of boundary definition in these use areas may indicate greater antiquity and long-term natural transformation processes (cf. Chapter 22).

It appears that the major focus of lithic production was early stage biface reduction (cf. Chapter 10). Over 72% of the 22 features are biface reduction loci (Features 1, 3, 4, 8–11, 13–15, 17, 19–22), ranging in area from five to 250 m^2 (Budy 1989:235). Other features are more complex, with a diversity of maintenance and processing implements and reduction tools not exhibited at simpler biface reduction loci. Feature 12 (a well-defined 60 m^2 concentration of debitage surrounded by a diffuse lithic scatter) and Feature 18 (a 5 m^2 scatter of debitage associated with groundstone and fire-altered cobbles), for instance, reflect use as short-term campsites. They exhibit high tool diversity and/or groundstone in their assemblages (Budy 1989:235).

Testing recovered a wide variety of formed tools and debitage (Table 148). Feature 2, a spatially-limited reduction scatter with groundstone in Locus C, was collected entirely by systematic surface scrapes over its 18 square meters (Budy 1989:237). We recovered opalite and a very small amount of obsidian debitage, a single biface, a flake tool, and a mano. Feature 12 and Feature 18 in Locus B also were scraped to 2 cm over 73% and 40% of their areas, respectively. A 1 m x .5 m excavation unit was then placed in each feature. Yields from Feature 12 contained a large quantity of debitage (including opalite, basalt, and obsidian), projectile points (Rosegate and Humboldt), preforms, largely mid- to late stage bifaces, cores, and a variety

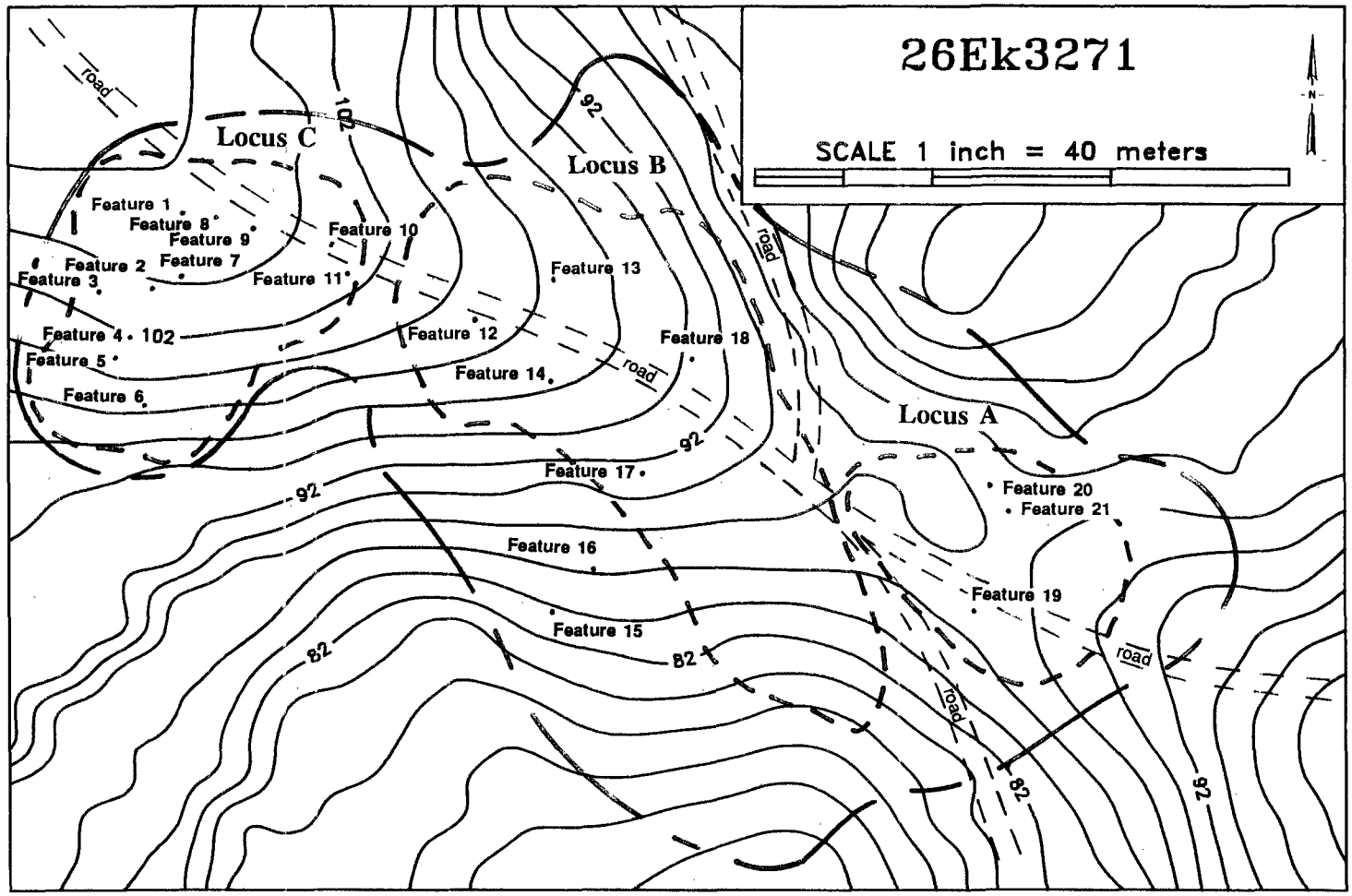


Figure 139. 26Ek3271 site map.

of flake and cobble tools. The assemblage from Feature 18 was considerably less diverse, with a few bifaces and flake tools. However, the recovery of a complete basalt mortar and some fire-cracked rock (though no associated hearth feature came to light) suggests a residential component.

Table 148. Summary of Artifacts Collected from 26Ek3271.

				FORMED ARTIFACTS								
	Area	DEBITAGE		Proj.				Flake	Modif.	Perc./ Cobble	Ground	
Feature	m(²)	n	wt. (gm)	Points	Preforms	Bifaces	Cores	Tools	Chunks	Tools	Stone	Total
-	-	4,053	2,951.3	15	3	215[a]	3	12	1	8	4	261
1	32	-	-	-	-	3	-	1	-	-	-	4
2	18	1,218	1,544.6	-	-	1	-	1	-	-	1	3
3	30	-	-	-	2	-	-	4	-	-	-	6
4	20	-	-	-	-	-	-	1	-	-	-	1
5	10	-	-	-	-	1	-	-	-	1	-	2
6	77	-	-	-	-	6	-	-	-	1	-	7
7	56	-	-	-	-	-	-	-	-	-	-	0
8	20	-	-	-	-	3	-	2	-	-	-	5
9	250	-	-	-	-	-	-	-	-	-	-	0
10	15	-	-	-	-	2	-	-	-	-	-	2
11	80	-	-	1	1	7	-	-	-	-	-	9
12	60	37,261	53,373	4	2	67	3	17	-	5	-	98
13	40	1	2.0	1	-	8	-	-	-	-	-	9
14	30	1	0.7	-	2	15	-	1	-	-	-	18
15	25	-	-	-	-	2	-	-	-	-	-	2
16	40	-	-	-	-	-	-	-	-	2	-	2
17	15	-	-	-	-	4	-	-	-	-	-	4
18	5	3,908	2,227.8	-	-	7	-	2	1	-	1	11
19	18	1,095	905.1	-	-	8	-	1	-	1	-	10
20	17	-	-	-	-	7	-	-	-	-	-	7
21	5	5,715	6,520.7	-	-	14	-	2	-	-	-	16
22	20	-	-	1	-	2	-	-	-	-	-	3
Totals		53,252	67,525.2	22	10	372	6	44	2	18	6	480

Features 19 and 21, and several extra-feature areas on the thinly mantled eastern periphery of the site, were explored for additional campsite use via limited surface scrapes and several 1 m x 1 m or 1 m x .5 m excavation units (cf. Budy 1989:237). We discovered no subsurface hearths or food preparation areas.

In summary, 26Ek3271 exhibits the high feature and assemblage diversity (with mid-stage bifaces dominating) characteristic of other large residential sites in the Bitterroot Ridge Complex.

Chronology

The Western Periphery has a long and complex occupation history (Figure 140). Projectile points, our chief time markers in this area, are distributed widely and both predate and span the entire Archaic period.

The earliest exploitation of the area (perhaps from 8000 B.C.) is signalled by Great Basin Stemmed point fragments or preforms recovered from 26Ek3208 on Red Hill, from 26Ek3101 and 26Ek3107 in Rodent Valley, from residence 26Ek3160 and from the Basalt Canyon terrace deposits of 26Ek3092. Large Side-notched points, dating sometime between 5000 B.C. and A.D. 1300, were recovered from Bitterroot Ridge, at 26Ek3093, 26Ek3160, and 26Ek3271.

An obsidian Gatecliff Split Stem point collected at 26Ek3092 indicates use of Basalt Canyon between 3000 and 1300 B.C. Occupation on Bitterroot Ridge during this time also is

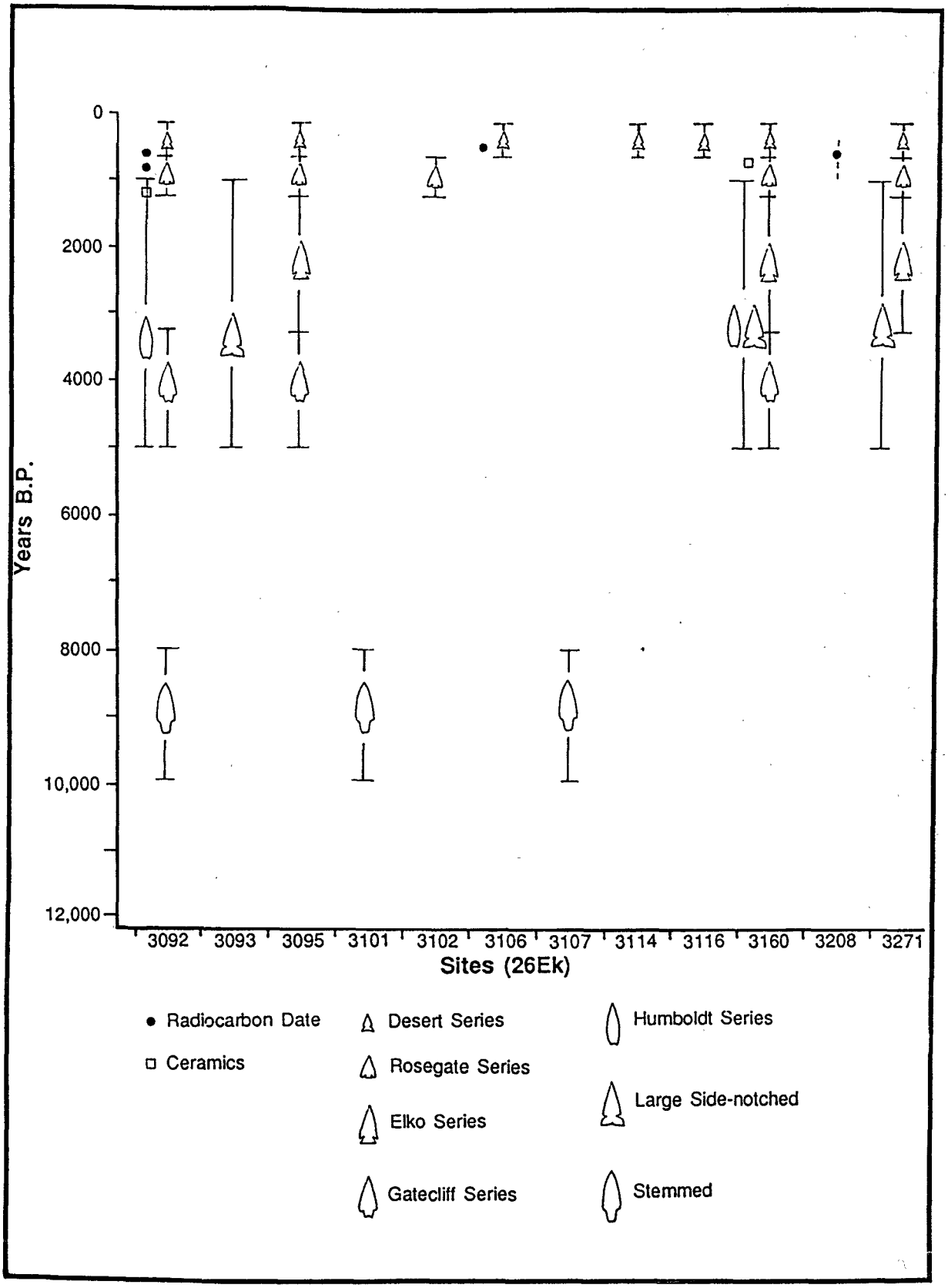


Figure 140. Chronology at investigated sites in the Western Periphery.

documented by Gatecliff points at residential complexes 26Ek3095 and 26Ek3160. Humboldt Concave Base points, retrieved from 26Ek3092, 26Ek3160, and 26Ek3271, may have been manufactured between 3000 B.C. and A.D. 700. Elko projectile points, dating between 1300 B.C. and A.D. 700, occur at these residential sites, as well as at 26Ek3095.

Late Archaic time markers (Rosegate points post-dating A.D. 700, and Cottonwood or Desert Side-notched points manufactured after A.D. 1300) also were recovered in these complexes. In addition, Shoshone Brownware pottery fragments from Feature 1 at site 26Ek3160 place reflect Late Archaic activity; this pottery dates between A.D. 1300 and 1850. Desert Side-notched and Cottonwood projectile points occur at several Bitterroot Ridge reduction loci (26Ek3114 and 26Ek3116), as well.

Several chronological indicators from the benches of Rodent Valley, Basalt Canyon, and Red Hill point to Late Archaic exploitation of these regions. A Rosegate point suggests use of reduction complex 26Ek3102, in Rodent Valley, sometime after A.D. 700. Neighboring reduction complex 26Ek3106 provided a radiocarbon date of 300 ± 70 B.P., corroborated by Desert Series time-markers. And Fremont (Great Salt Lake Grayware) and Shoshone Brownware pottery (A.D. 500 to after A.D. 1300), Rosegate, Cottonwood, and Desert Side-Notched projectile points, and two radiocarbon dates (750 ± 70 B.P., 650 ± 50 B.P.) place components at 26Ek3092 squarely in the Late Archaic. Radiocarbon dates from Red Hill (26Ek3208, 26Ek3085) bracket quarry pit deposits between ca. A.D. 1000 and 1500.

Our investigations in the Western Periphery yielded more than 100 classifiable projectile points; over 62% were discarded in the Late Archaic (represented by Rosegate and Desert Series types). The Middle Archaic (signalled by Elko, Humboldt, and Large Side-notched types) and Early Archaic (characterized by Gatecliff points) contributed substantially fewer points—23% and 9%, respectively. Pre-Archaic Stemmed points represent less than 5% of the recovered point population. Intensification of point discard in the Western Periphery during the Middle and Late Archaic periods, a pattern recognized in other regions of the Tosawihi study area as well, may signify increased hunting, increased population size, and/or intensification of use of the quarries area.

Summary

The functionally diverse Western Periphery sites provide a valuable data set for examining prehistoric decision-making in the context of the larger Tosawihi economic system. Debris scatters here are patterned and often remarkably discrete, reflecting a variety of reduction and subsistence activities. Indeed, Western sites illustrate all elements of the Tosawihi Quarries system—quarrying locales, reduction features, campsites, and food processing stations.

How these data can be used to address the interdigitation of subsistence and technological strategies will be discussed in subsequent chapters (cf. Chapters 20, 24, 25, 26). Groups occupying the Western Periphery engaged in large-scale reduction of Tosawihi opalite (access to toolstone sources must have been one of the principal attractions), yet local assemblage contents indicate that hunting and plant gathering also must have been embedded in toolstone procurement and processing forays. Indeed, important subsistence opportunities in the West may well have dictated how quarry scheduling decisions were made (cf. Chapters 20 and 26).

The West provides discrete, often well-dated, lithic reduction features that have allowed us to characterize episode-specific reduction strategies (cf. Chapters 6, 10 and 21). These features represent, generally, a later stage in the continuum of biface reduction than do features in the Eastern Periphery or the Quarries. Stage 3 and 4 bifaces overwhelmingly dominate assemblages in this area.

The Western Periphery is distinguished by its residential character. People camped here, not only because it was a convenient location for biface reduction on the way out of the Quarries, but also because the place provided access to critical, sustaining resources (water, plants, and game) that could be exploited when visits to the Quarries had to be extended beyond a day or two. The co-occurrence of these resources, in fact, must account for the notable frequency with which western ridges and drainages were revisited.

As a result, large residential complexes like the stratified buried site in Basalt Canyon (26Ek3092) and the Bitterroot Ridge sites exhibit particularly complex patterning. Observable site structure (hearth and millingstone activity areas, features clustered around permanent site furniture), highly diverse assemblages, relatively high rates of heat-treatment (suggesting extended stays), and considerable material diversity (indicating broad-scale territorial movements) contribute to the unique importance of the Western Periphery as a window onto the Tosawihi economic sphere.

Chapter 17

ARCHAEOLOGY OF THE EASTERN PERIPHERY

Steve Botkin, Daniel P. Dugas, and Robert G. Elston

The Eastern Periphery occupies ca. 170 acres along the middle reach of Little Antelope Creek (Figure 141). Most of the subarea lies outside, but contiguous, the southeastern quadrant of the Tosawihi Quarry, encompassing the lower portion of the valley drained by Undine Gorge, with a western leg subsuming a narrow, 10 acre swath in the southern extreme of 26Ek3032. It expresses in microcosm virtually the entire range of physical settings and aboriginal behaviors so far observed at Tosawihi.

The topography of the Eastern Periphery is diverse, largely the product of down-cutting by Little Antelope Creek, Undine Gorge, and their tributaries. Only the western half of the area has been mapped geologically; nevertheless, broad trends in bedrock geology can be projected eastward with some confidence. Overall, the area juxtaposes several zones of contrasting relief, geology, and archaeological content.

The southern portion of the area is gently rolling, and incorporates three locally prominent landforms (Ramadan Ridge, Holeplug Ridge, and Corral Fan). Sloping down to the north from a high rhyolite prominence, they are mildly dissected; a series of broad finger ridges and intervening shallow gullies coalesce to form numerous low knolls at the southern margin of Undine Gorge. Much of the bedrock of Ramadan Ridge, Holeplug Ridge, and Corral Fan is undifferentiated tuff. No silicification has been mapped, yet we know that small pockets of opalite occur on Ramadan Ridge, variously along Undine Gorge, and in an isolated pocket near the far eastern margin of Corral Fan. Soils over most of the southern area are shallow, silty to sandy loams derived largely from in-place weathering and eolian deposition. Where tested, they achieve depths of ca. 40 cm, and vary chiefly in the quantities of rhyolite tuff gravels and cobbles they contain. On some knoll tops eolian deposition dominates and loess-like deposits appear to have buried some cultural features.

Further north the landscape assumes a different character; topography is dominated by the sinuous, deeply incised channel of Undine Gorge and the prominent rimrock at the southern edge of Italian Mesa. The mesa itself is comprised of flowbanded rhyolite overlain by undifferentiated sinter and massive replacement silica. Rhyolite forms its lower southern slopes and the southern margin of Undine Gorge. Gradients are steep (in places, precipitous), rising from 5600 feet (1707 m) amsl in the bed of the gorge to 5700 feet (1737 m) amsl in only 200 horizontal feet. Vertical bedrock faces interspersed with narrow rocky ledges and steep talus cones punctuate the escarpment; various points along the rim served as toolstone sources, and several overhangs at the contact between sinter/silica and rhyolite were exploited as rockshelters. Although opalite stream cobbles abound in the bed of the gorge, quartzite cobbles used as hammerstones were its more visible archaeological product.

The western end of the area encompasses terrain intermediate between those described above. Occupying a ten acre strip within the southern jut of the Tosawihi Quarry, it extends from the crest of Lower Holmes Ridge on the west to the western flank of Ramadan Ridge on the east, incorporating a short segment of Little Antelope Creek. Most slopes are quite steep (ca. 20-40%) save for where they are moderated by stream terraces. Where tested, soils proved to be shallow, very gravely sandy colluvium ca. 20 cm deep. Opalite bedrock exposures occur as low ledges on the crest of Holmes Ridge and more sporadically along the stream terraces. Chert stream cobbles in the bed of Little Antelope Creek offer an abundant but apparently little-used supply of toolstone as well.

Water is scarce in the Eastern Periphery. Little Antelope Creek and Undine Gorge channel copious flows during spring snow melt but dry soon thereafter. More reliable water

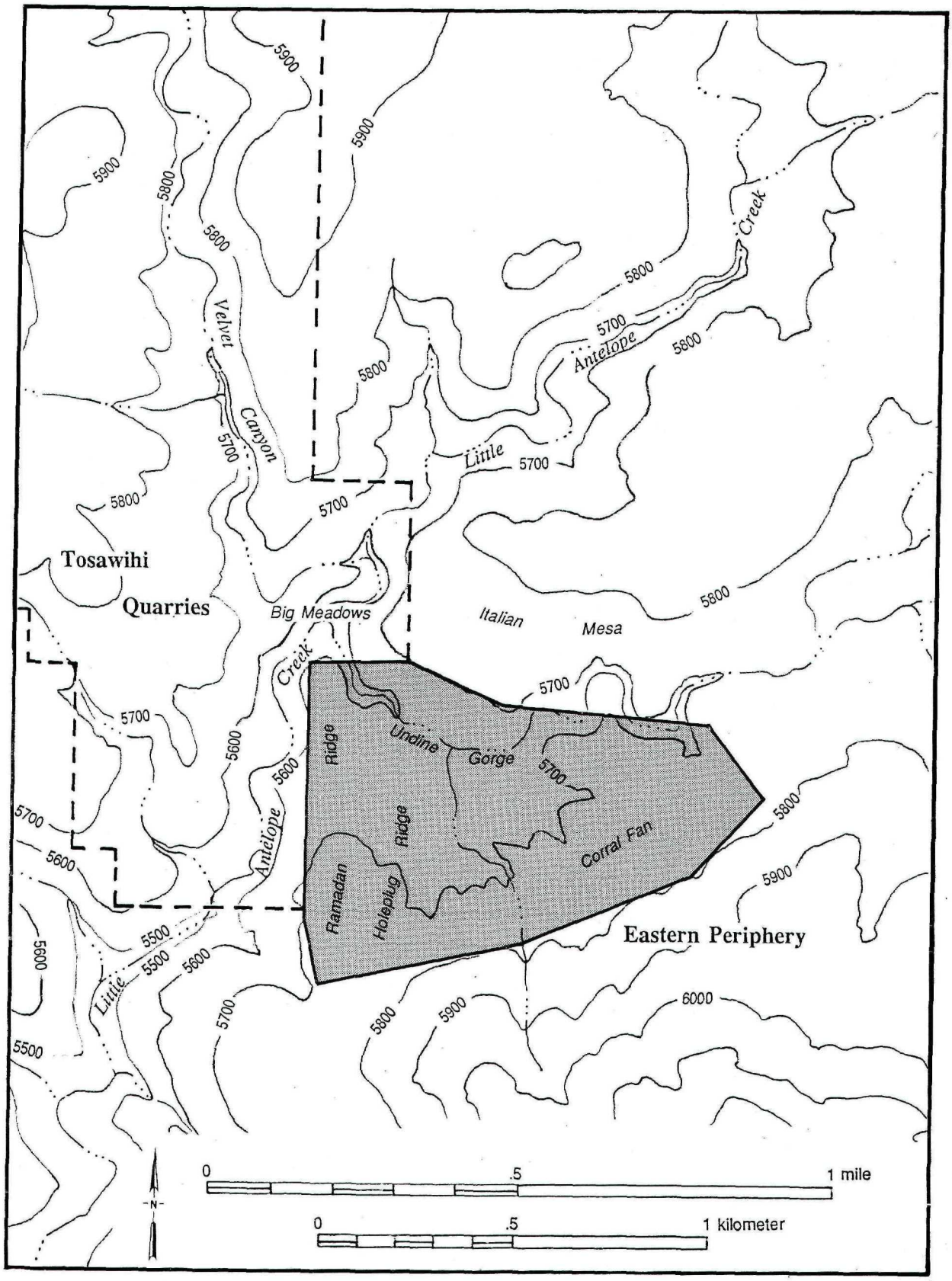


Figure 141. Eastern Periphery project area.

occurs in Big Meadow, some 300 meters north of the project area, where an apparently perennial spring now feeds a stock pond. Aside from its seasonal water, Little Antelope Creek is a link in the most direct foot route between Tosawihi and the Humboldt River; for people traveling this corridor, Ramadan Ridge and the flats immediately north offer the campsites nearest the opalite sources of the Eastern Periphery and the Quarries.

The biosphere of the Eastern Periphery is much like that of the surrounding countryside, and offered no unique attractions. Vegetation consists of an edaphically constrained mosaic where shallow soils along ridgelines host a sparse cover of low sage, rabbitbrush, and phlox, while locally dense stands of tall sage and understory grasses grow in patches of deeper soils on lower ridge slopes. Abundant bitterbrush complements this assemblage at the highest elevations at the eastern extreme of the area. Ground squirrels, badgers, and rabbits are the most commonly encountered mammals; deer and antelope transit seasonally.

At the time of fieldwork the Eastern Periphery remained relatively undisturbed by modern and historic modifications; aboriginal opalite quarrying accounted for the most noticeable human alteration of the place. A dirt road crosses east to west, transecting several sites, and prospects and claim cairns dot many site precincts. Stock grazing and modern wildfires have affected site contents through trampling, crazing of artifacts, and exacerbated erosion. Among non-human agents of disturbance, rodent turbation and slope wash are the most pronounced; subsurface deposits are heavily churned by burrowing animals everywhere save in some impenetrable quarry pit berms consisting almost exclusively of lithic debris. Colluviation undoubtedly has resulted in the translocation of artifacts within general site contexts and appears to account for the characteristic, elongated, slope-mimicking, fan-shaped configuration of many reduction features. Almost everywhere, solifluction lobes sequentially capture, transport, and bury cultural debris, and apparently contribute significantly to the marked seasonal differences in the surface visibility of archaeological remains.

Descriptive Site Summary

The Eastern Periphery encompasses forty-five prehistoric sites and localities. Of these, "sites" (n=37) are archaeological locations recorded during survey of that portion of the area outside the Tosawihi Quarry proper (Raven 1988). "Localities" (n=8) are loci of site 26Ek3032, documented formally during reconnaissance of the Tosawihi Quarry (Elston, Raven, and Budy 1987). Here we use the term "site" generically, to refer to both the localities of 26Ek3032 and the individually enumerated sites. Table 149 and Figure 142 preview the archaeological content of the Eastern Periphery.

Archaeological sites in the Eastern Periphery contain assemblages and features displaying considerable variety in composition and size; they occur in all geographic contexts. At all sites however, remains are derived primarily from extraction and/or processing of opalite. Toolstone related sites include pit, outcrop, and cobble quarries of assorted sizes, discrete concentrations of reduction debris, and numerous rockshelters. As well, several sites contain assemblages reflecting residential use.

For reasons not yet understood, but probably owing in part to the abundance of opalite sources in the Eastern Periphery, and the ephemeral, easily dispersed nature of reduction features, surficial site boundaries there are less clear cut than they are in the West and North. Boundaries in the East tend to be less topographically constrained and often are blurred by a background lithic scatter of variable density. Site boundaries, then, are archaeological constructs enclosing constellations of cultural features grouped on the basis of inferred function, mutual proximity, and/or shared topographic position.

Table 149. Sites and Localities Investigated in the Eastern Periphery.

Site/Locality	Quarry Features n	Non-Quarry Features n	Elevation (ft. amsl)	Site Area (sq. m)
26Ek3170	1	13	5,620	31,000
26Ek3171	3	5	5,670	7,540
26Ek3172	-	6	5,720	2,420
26Ek3173	-	4	5,725	530
26Ek3174	-	2	5,745	590
26Ek3175	-	1	5,700	90
26Ek3177	-	1	5,700	70
26Ek3178	-	4	5,710	910
26Ek3179	-	2	5,645	110
26Ek3180	-	1	5,655	12
26Ek3181	-	1	5,685	235
26Ek3183	-	1	5,680	90
26Ek3184	1	25	5,640	11,309
26Ek3185	-	7	5,660	910
26Ek3186	-	2	5,650	185
26Ek3187	-	1	5,645	40
26Ek3188	-	1	5,660	95
26Ek3189	-	4	5,640	1,320
26Ek3190	-	11	5,630	4,241
26Ek3191[a]	-	1	5,660	6,600
26Ek3192	-	5	5,660	3,190
26Ek3193	1	6	5,670	3,610
26Ek3195	7	1	5,700	9,425
26Ek3196	4	3	5,720	11,800
26Ek3197	6	5	5,720	4,556
26Ek3198[b]	4	21	5,740	12,724
26Ek3200	1	-	5,760	242
26Ek3201	1	3	5,730	2,474
26Ek3202	-	1	5,700	8
26Ek3203[a]	-	-	5,710	8,230
26Ek3204	-	1	5,680	60
26Ek3032				
Locality 19[c]	-	1	5,600	10
Locality 20	-	3	5,630	200
Locality 21	-	1	5,600	100
Locality 22	-	1	5,580	5
Locality 23	1	-	5,640	30
Locality 25[a]	-	7	5,700	2,250
Locality 93	-	-	5,600	1
Locality 98	1	-	5,600	900

[a]Amorphous scatter outcrop/cobble quarrying debris
[b]Includes subsurface hearth
[c]Possible disturbed quarry pit

Eight sites contain quarry pits. While many also include additional cultural features reflecting the entire range of toolstone extraction techniques observed at Tosawihi, the excavation of quarry pits appears to have contributed most of the raw material acquired at them; this differentiates these sites from others in the East. Numerous reduction stations complement quarry features, and the debitage comprising the berms and fill of pits suggest that raw toolstone was reduced at least partially at the sources. Such sites seem to have been located where opalite outcrops presaged the occurrence of toolstone quality substrate in near-surface contexts. Quarry pits generally are confined to the bedrock-controlled crest of Ramadan Ridge and the rimrock of knolls at the southern margin of Undine Gorge. Two exceptions consists of isolated pit excavations at the eastern limit of the subarea and on the midslope of Lower Holmes Ridge.

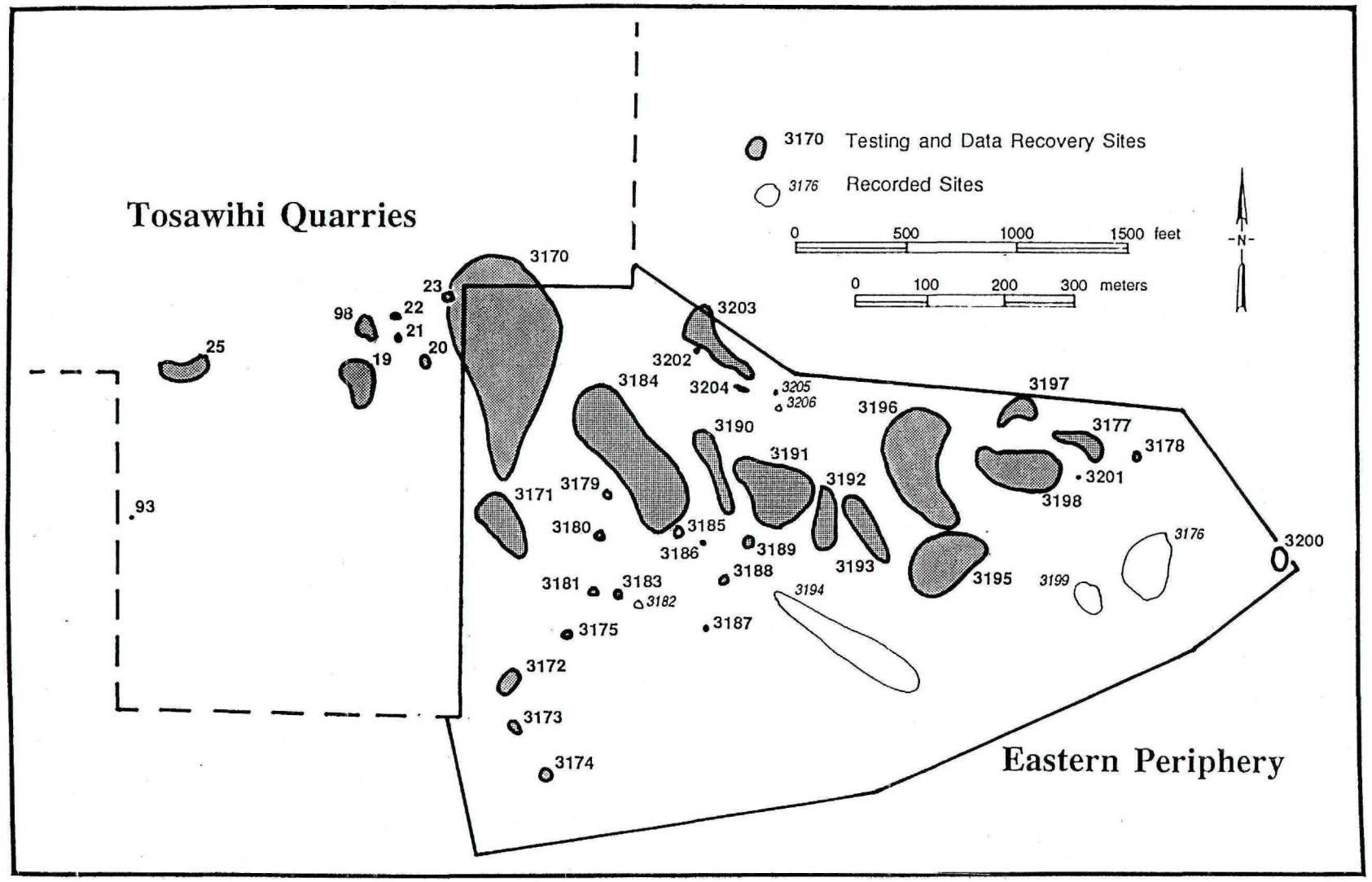


Figure 142. Eastern Periphery site location map.

Eight sites reflect the extraction of toolstone from exposed sources only (opalite ledges and, to a lesser degree, colluvial accumulations of opalite cobbles). Although outcrop quarries are numerous across the East, they appear for the most part to represent episodic, expedient use of low quality or low volume sources. Most such minimal exploitations of outcrops are juxtaposed with numerous reduction features bearing dense accumulations of processing debris; we infer that the presence of raw material at these sites did little to condition their use. Instead, most appear to have offered commodious workspace near other, higher quality toolstone sources. Outcrop quarries occur on microtopographic flats on Lower Holmes Ridge, amid the bedrock exposures rimming knoll tops along the southern edge of Undine Gorge, and at the brink of Italian Mesa (cf. Figure 141).

Twenty sites in the Eastern Periphery lack exploited toolstone sources and are defined almost exclusively by concentrations of reduction debris, differing chiefly in overall size and number of features. The largest occur along the foot slope of Holeplug Ridge, coincident with the broad, relatively flat knoll tops overlooking Undine Gorge (cf. Figure 141). High quality toolstone is available to these locations in abundance and within easy access at nearby quarries to the west and east. Both sites cover areas exceeding 2000 m^2 and are punctuated by cultural features consisting, for the most part, of concentrations of opalite reduction debris. Numerous smaller, but apparently functionally equivalent, sites are widespread throughout the subarea. Their size owes perhaps to topographic constraints (they occur on steeper slopes) their somewhat greater distance from material sources than the larger sites along Undine Gorge. Most are located on the midslopes of Holeplug Ridge and along the highest bench of Ramadan Ridge (cf. Figure 141).

The remainder of the open sites in the Eastern Periphery are defined exclusively by amorphous, diffuse lithic scatters topping finger ridges in the apparently little used hinterland of Corral Fan. Their assemblages are dominated by opalite reduction debris.

Four rockshelters occupy recesses in the southern face of Italian Mesa and one occurs in rimrock above the southern verge of Undine Gorge. All are rather small, offering only minimal weather protection. None contains remains indicating intensive residential use. They appear to have functioned chiefly as semi-enclosed reduction stations; the walls of two seem to have been exploited for toolstone as well.

An isolated andesitic basalt metate was found in an area otherwise devoid of cultural remains on the east slope of Red Hill at the western margin of the Tosawihi Quarry. Designated Locality 93, it is described in Chapter 12.

Testing and Data Recovery Results

Fielded during the spring and summer of 1988, the testing program constituted the first systematic post-reconnaissance examination of the archaeology of the Eastern Periphery. The eight localities within the Tosawihi Quarry were tested by non-invasive techniques; no artifact collection or excavation occurred at this time. Instead, the localities were transected by close interval inspections, their surficial boundaries determined, and the contents of their cultural features described. More intensive means were employed outside 26Ek3032; 31 of the 37 sites in the Eastern Periphery were tested. Test data were reviewed to evaluate the significance of the sites examined; we assumed significance to be reflected by the degree to which test results promised information pertinent to identified research issues (Intermountain Research 1988a; cf. Chapter 4). Sixteen sites appeared to merit further investigation.

The sites and localities identified for expanded sampling included at least one representative of each variety of quarry and a selection of reduction stations thought to reflect the full range of size and complexity in the Eastern Periphery. Eight of the sites lie outside the Tosawihi Quarry proper; they include 26Ek3170, 26Ek3171, 26Ek3184, 26Ek3192, 26Ek3195, 26Ek3198, 26Ek3200, and 26Ek3204. The remainder consists of Localities 19, 20, 21, 22, 23, 25, and 98 of 26Ek3032.

Intermountain Research (1988b; 1988c) designed a program for data recovery at these sites and implemented it in spring and summer of 1989. The remainder of this chapter describes the archaeological content of the Eastern Periphery as revealed by these investigations on a site by site basis. Emphasis is on the results of data recovery; test phase results are treated more summarily, as they are reported elsewhere (Botkin 1989). Table 150 provides an overview of field actions employed during both phases of work; Table 151 summarizes the collections that resulted.

Table 150. Summary of Collection Procedures, Eastern Periphery.

Site/ Locality Number	Phase	FEATURES RECORDED Total (n)	Sampled (n)	FEATURE CONTEXT Surface Scrape (m^2)	Subsurface Excavation (m^3)	NONFEATURE CONTEXT Surface Scrape (m^2)	Subsurface Excavation (m^3)
26Ek3170*	T	14	2	9.75	-	5.00	0.78
	DR	-	3	33.00	0.19	-	6.58
26Ek3171*	T	8	3	5.44	-	-	1.40
	DR	-	3	-	0.49	-	5.42
26Ek3172	T	6	1	8.00	-	-	-
26Ek3173	T	4	1	40.00	0.07	-	-
26Ek3174	T	2	0	-	-	-	-
26Ek3175	T	1	0	-	-	-	-
26Ek3177	T	1	1	0.75	0.025	-	-
26Ek3178	T	4	1	5.00	-	-	-
26Ek3179	T	2	1	13.00	-	-	-
26Ek3180	T	1	0	-	-	-	-
26Ek3181	T	1	1	24.00	0.04	-	-
26Ek3183	T	1	1	15.00	-	-	-
26Ek3184*	T	26	4	9.00	0.17	-	-
	DR	-	6	113.00	0.58	76.00	-
26Ek3185	T	7	1	20.00	0.04	-	-
26Ek3186	T	2	0	-	-	-	-
26Ek3187	T	1	0	-	-	-	-
26Ek3188	T	1	0	-	-	-	-
26Ek3189	T	4	0	-	-	-	-
26Ek3190	T	11	2	40.00	0.07	-	-
26Ek3191	T	1	1	4.00	-	-	-
26Ek3192*	T	5	2	29.00	4.31	-	-
	DR	-	2	-	11.13	-	-
26Ek3193	T	7	2	7.00	-	-	-
26Ek3195*	T	8	2	1.13	-	-	-
	DR	-	2	-	-	-	-
26Ek3196	T	7	2	6.00	0.28	-	-
26Ek3197	T	11	3	1.25	0.50	7.00	-
26Ek3198*	T	25	4	37.75	0.13	-	-
	DR	-	3	-	5.57	-	-
26Ek3200*	T	1	1	0.75	-	-	-
	DR	-	1	-	-	-	-
26Ek3201	T	4	3	10.50	0.10	-	-
26Ek3202	T	1	1	0.50	0.24	-	-
26Ek3203	T	-	0	-	-	3.75	-
26Ek3204*	T	1	1	1.00	0.48	-	-
	DR	-	1	-	0.40	-	-
26Ek3032							
Locality 19	DR	1	1	8.00	-	-	-
Locality 20	DR	3	3	7.00	-	-	-
Locality 21	DR	1	1	2.00	0.30	-	-
Locality 22	DR	1	1	6.00	0.20	-	-
Locality 23*	DR	1	1	3.00	-	-	-
Locality 25	DR	7	2	10.00	-	-	-
Locality 93	DR	-	0	-	-	-	-
Locality 98	DR	1	1	10.00	-	-	-

* Trenches were placed in these locations; volume is not included.

T = Test Phase
DR = Data Recovery Phase

Table 151. Artifacts Recovered from Sites in the Eastern Periphery During Testing and Data Recovery.

	DEBITAGE		FORMED ARTIFACTS										
Site	n	wt. (gm)	Proj. Points	Preforms	Bifaces*	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
26Ek3170	42,014	78,544.5	11	5	226	3	46	3	4	2	-	-	300
26Ek3171	30,870	192,534.4	2	4	103	8	16	6	3	1	8	-	151
26Ek3172	1,258	1,969.9	-	-	6	-	-	-	-	-	-	-	6
26Ek3173	3,856	8,704.5	2	-	9	1	4	-	-	-	-	-	16
26Ek3174	-	-	-	-	1	-	-	-	-	-	1	-	2
26Ek3175	-	-	-	-	1	-	-	-	-	-	-	-	1
26Ek3177	726	588.2	2	1	3	-	-	-	1	-	-	-	7
26Ek3178	3,737	6,463.7	3	-	14	-	-	1	-	-	-	-	18
26Ek3179	1,219	1,421.5	-	-	2	-	3	-	-	-	-	-	5
26Ek3180	-	-	-	-	1	-	-	-	-	-	-	-	1
26Ek3181	3,585	6,297.8	-	-	11	-	5	-	-	1	1	-	18
26Ek3183	2,175	2,454.0	-	-	4	-	-	-	-	-	-	-	4
26Ek3184	56,011	156,462.6	7	6	287	9	76	5	4	1	-	2	397
26Ek3185	2,117	3,199.9	8	4	22	-	13	-	3	1	-	-	51
26Ek3186	-	-	-	-	1	-	-	-	-	-	-	-	1
26Ek3187	-	-	-	-	-	-	-	-	-	-	-	-	0
26Ek3188	-	-	-	-	-	-	-	-	-	-	-	-	0
26Ek3189	-	-	-	1	2	-	-	-	-	-	-	-	3
26Ek3190	8,875	11,228.8	9	2	69	2	17	-	-	1	-	1	101
26Ek3191	23	79.3	1	-	7	1	5	-	-	-	-	-	14
26Ek3192	39,246	69,157.5	16	4	231	4	69	4	6	7	102	1	444
26Ek3193	3,296	12,204.2	-	-	22	-	1	-	1	-	-	-	24
26Ek3195	44,888	42,604.3	-	-	46	-	4	-	6	-	-	-	56
26Ek3196	4,785	21,414.4	-	-	23	-	3	4	8	1	-	-	39
26Ek3197	1,171	6,738.0	-	-	35	-	1	-	6	-	-	-	42
26Ek3198	8,230	26,269.6	27	15	66	7	13	-	2	-	4	1	135
26Ek3200	240	1,012.1	-	-	12	-	1	-	-	-	-	2	15
26Ek3201	4,086	6,088.7	-	-	38	-	1	-	5	2	-	-	46
26Ek3202	3,111	2,128.6	-	-	3	-	-	-	-	-	-	-	3
26Ek3203	388	1,745.5	-	-	6	-	-	2	-	-	-	-	8
26Ek3204	123,915	73,990.0	6	5	90	2	21	6	9	1	-	-	140
26Ek3032													
Locality 19	14,673	73,017.8	-	-	65	5	23	-	2	1	-	-	96
Locality 20	9,587	32,983.5	1	-	21	4	6	-	-	-	-	-	32
Locality 21	1,794	39,896.1	-	-	7	8	2	4	-	-	-	-	21
Locality 22	2,067	13,681.6	-	-	6	3	1	-	-	-	-	-	10
Locality 23	38,487	104,890.4	6	1	70	10	26	3	2	-	-	1	119
Locality 25	25,716	81,379.8	-	-	103	6	13	2	5	-	-	-	129
Locality 93	-	-	-	-	-	-	-	-	-	1	-	-	1
Locality 98	1,287	12,303.3	-	-	9	-	1	-	1	-	-	-	11
Totals	483,433	1,091,454.5	101	48	1622	73	371	40	68	20	116	8	2,467

* Count includes "possible" bifaces

Quarry Pit Sites

Sites containing quarry pits were the focus of a significant proportion of fieldwork in the Eastern Periphery. In addition to the quarry pits themselves, whose stratified, often charcoal-laden deposits chronicle how most of the toolstone obtained in the East was extracted, the largest sites encompass the widest variety of cultural features; at several, quarry pits are accompanied by outcrop and cobble quarries, reduction stations, and biface caches.

From its base in Big Meadows at the confluence of Little Antelope Creek and Undine Gorge, Ramadan Ridge rises gradually southward in a series of broad, nearly flat benches to span the southwestern quarter of the Eastern Periphery. Three of the seven sites containing quarry pits (26Ek3170, 26Ek3171, and Locality 23) occupy two of its largest benches. In light of their shared topography and archaeological similarities, the following remarks are pertinent to each.

Unlike other quarry pit sites in the subarea, quarry and reduction assemblages from the Ramadan Ridge sites are augmented by implements commonly associated with maintenance and subsistence chores, e.g., ceramics, flake tools, ground stone, projectile points, and preforms. Given this, and the nearness of the most reliable water source in the East, it is tempting to regard the residential qualities of quarry sites on Ramadan Ridge geographical extensions of the domestic behavior more evident around the spring in Big Meadows (Leach and Botkin 1991).

The importance of the ridge as a place to acquire and process toolstone eclipses its residential qualities. A relatively shallow colluvium of sandy silt with abundant gravels overlies a tuff substrate, in places sufficiently well silicified to provide high quality opalite. At several widely scattered locations along the western slope, and especially on slope risers between benches, opalite bedrock is exposed in low ledges or is weathered into extensive cobble fields. These exposures were exploited, in four instances, by the excavation of pits. Utilization of the cobble fields was common but less spatially focused; as a result, little of this activity left discrete cultural features.

Vegetation occupying the ridge is essentially identical to that of the surrounding countryside, a broken mosaic of big sage and low sage grasslands. More productive plant assemblages occur immediately adjacent the ridge, however, in riparian settings around Big Meadows and along Little Antelope Creek.

26Ek3170

26Ek3170 encompasses the entire first bench of Ramadan Ridge (Figure 143). Its northern boundary is coterminous with that of the Tosawihi Quarry and is more an administrative convention than an archaeological judgement; only a slight undulation in the ridgeline differentiates 26Ek3170 from habitation Locality 27 in Big Meadows. As defined by topography and artifact distribution, 26Ek3170 also subsumes the quarry pits of Localities 23 and 26 (cf. Figure 142).

Even with these localities deleted, the site remains the most extensive in the Eastern Periphery, covering 31,000 m^2 of the ridgeline between 5585 feet (1702 m) and 5660 feet (1725 m) amsl. Close interval inspection during testing resulted in the detection of twelve reduction stations and a quarry pit. An additional feature (a biface cache) was discovered after the conclusion of data recovery.

Nonfeature Contexts

An abundant and diverse assemblage of artifacts lies outside features. Surface collections recovered scores of bifaces and other reduction forms, as well as an assortment of maintenance and subsistence implements (Table 152). Cultural remains are particularly abundant in the northwestern quadrant of the site, where the ground surface is overlain by a nearly continuous, moderate density scatter of debitage and formed artifacts. Visual assessment of the content of this area proved difficult, as its structure is reflected by subtle differences in surface artifact density over a broad expanse. To help quantify variation within it, a discontinuous series of five 1 m x 1 m units was surface scraped along a baseline spanning the scatter from ridgecrest to western midslope.

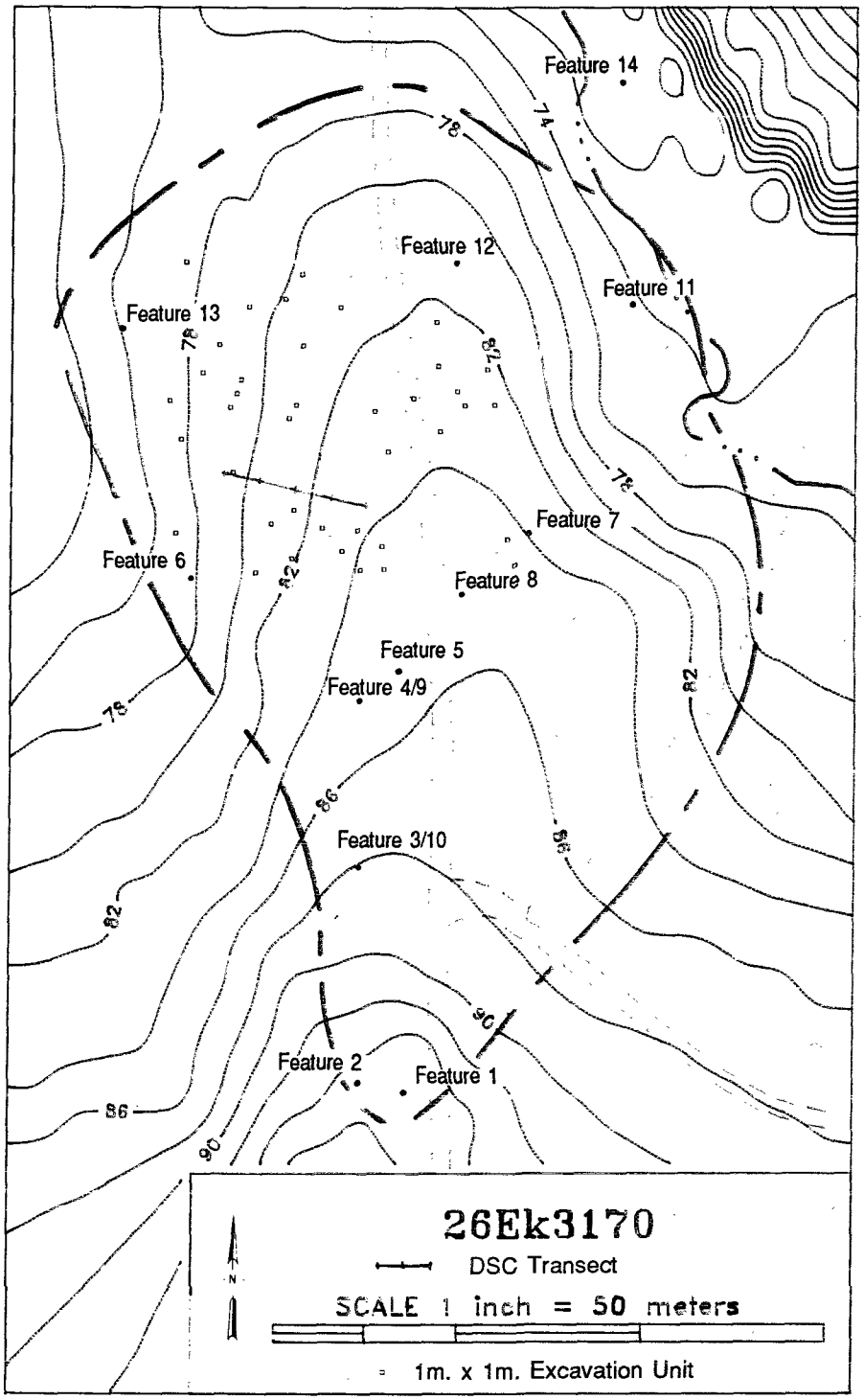


Figure 143. 26Ek3170 site map.

Table 152. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3170.

Feature	Total Area (m²)	DEBITAGE[a] n	DEBITAGE[a] wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces[b]	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Total
1*	145	895	4,215.2	-	-	5	-	-	1	-	-	6
2	75	-	-	-	-	2	-	-	-	-	-	2
3	13	1[c]	1.2	-	-	1	-	-	-	-	-	1
4	63	6[c]	6.6	-	-	-	-	1	-	-	-	1
5	50	-	-	-	-	6	-	1	-	-	-	7
6	44	-	-	-	-	4	-	-	-	-	-	4
7	560	5[c]	24.9	-	-	9	-	1	1	-	-	11
8*	79	20,538	32,131.5	3	1	27	-	15	-	-	-	46
9*	6	2,664	5,784.6	-	-	2	-	-	-	-	-	2
10	71	2[c]	7.6	-	-	2	-	2	-	-	-	4
11	5	-	-	-	-	1	-	-	-	-	-	1
12	1,420	-	-	-	-	18	-	-	-	-	-	18
13	189	1[c]	18.6	-	-	7	-	1	-	-	-	8
14*	0.22	129	183.7	-	-	11	-	1	-	-	-	12
Surface Isolate		10[c]	40.7	3	1	89	1	14	1	4	1	114
Other Nonfeature		11,187	21,122.1	5	3	42	2	10	-	-	1	63
		35,438	63,536.7	11	5	226	3	46	3	4	2	300

* Sample feature
[a]Does not include trench samples
[b]Includes "possible" bifaces
[c]Obsidian only

The results of the exercise merit note in two particulars. First, absolute flake density peaks strongly toward the center of the area, as does the frequency of flakes of smallest mean size. Second, the ratio of flakes to shatter also reaches its peak at this point. This suggests that, generally, later stage reduction occurred in the center of the area, earlier stage reduction along the peripheries. Noteworthy too, is the great color diversity of opalite recovered from all collection units, suggesting that the zone consists of a palimpsest of reduction episodes, often involving material from diverse off-site sources.

Because of the abundance and variety of surface materials in this area, as well as the possibility of depth in the silty deposits, two 1 m x 1 m excavation units tested the vertical distribution of artifacts. One coincided with the upslope surface collection unit; the other explored an expanse to the north. The units exposed basically similar profiles, revealing rhyolite tuff bedrock at a depth of ca. 40 cm, overlain by bioturbated, moderately compact gravely silty loam. Opalite debitage and formed reduction products dominate the assemblages, and as in surface contexts, tools not directly associated with toolstone processing (i.e., Desert Series projectile points, preforms, and a metate fragment) were recovered as well (Table 153).

Subsequently, 42 excavation units were dug in the northwest quadrant in order to clarify its cultural content. This large sample was inspired by the recovery of groundstone and by the observed diversity of other artifact types suggesting residential function. Too, the proximity of the spring in Big Meadows and relatively flat local topography suggested that prehistoric activities might not have been limited to toolstone processing. The additional units were selected at random to compose a sample stratified by topographic contour. Units measured 1 m x 50 cm; their contents were passed through 1/4 inch mesh save for Units 12 and 28, for which 1/8 inch mesh was used.

The results of the expanded sampling reflect those of test excavations. Subsurface contexts are shallow. Only in Unit 43 had deposits accumulated to 50 cm; most units encountered tuff bedrock between 30 cm and 40 cm. The sandy, gravelly silt loams that characterize the soils are heavily bioturbated. Cultural accumulation is relatively homogeneous; although artifact densities are somewhat higher in the upper 10 cm, cultural materials occur in all unit levels, and artifact compositions mirror those of surface contexts. Opalite debitage is ubiquitous, and constitutes the entire cultural content of nearly one-third (n=13) of the units. Obsidian waste was recovered in scant quantities, and then only by capture in 1/8 inch screens. Small numbers of bifaces and flake tools comprise the formed artifact component of most units. Excavations encountered no subsurface cultural features.

Table 153. Artifacts Recovered from Excavation Units and Discretionary Surface Collection in Nonfeature Contexts, 26Ek3170.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Ground Stone	Total
1 (TS)[a]	0.38	2,373	3,509.4	3	2	-	-	1	-	6
2 (TS)	0.40	911	3,163.4	-	-	4	1	-	1	6
3 (EU)	0.20	83	378.3	-	-	1	-	-	-	1
4 (EU)	0.20	63	66.7	-	-	-	-	-	-	0
5 (EU)	0.20	47	47.9	-	-	-	-	-	-	0
6 (EU)	0.20	94	332.7	-	-	1	-	-	-	1
7 (EU)	0.15	66	82.8	-	-	1	-	-	-	1
8 (EU)	0.20	139	164.4	-	-	-	-	-	-	0
9 (EU)	0.15	81	153.5	-	-	-	-	-	-	0
10 (EU)	0.20	84	358.9	-	-	-	-	1	-	1
11 (EU)	0.20	70	71.2	-	-	2	-	-	-	2
12 (EU)[b]	0.15	208	89.9	-	-	1	-	-	-	1
13 (EU)	0.10	30	31.7	-	-	-	-	-	-	0
14 (EU)	0.15	94	148.3	-	-	-	1	1	-	2
15 (EU)	0.10	66	602.2	-	-	2	-	-	-	2
16 (EU)	0.15	175	187.6	-	-	2	-	-	-	2
17 (EU)	0.15	128	480.4	-	-	1	-	-	-	1
18 (EU)	0.15	58	170.8	-	-	-	-	-	-	0
19 (EU)	0.20	129	632.5	-	-	1	-	-	-	1
20 (EU)[b]	0.20	181	116.8	-	-	1	-	-	-	1
21 (EU)	0.15	114	226.1	-	-	1	-	-	-	1
22 (EU)	0.10	111	217.8	-	-	-	-	1	-	1
23 (EU)	0.20	201	347.4	-	-	2	-	1	-	3
24 (EU)	0.20	311	530.3	-	-	3	-	-	-	3
25 (EU)	0.10	79	91.1	-	-	1	-	-	-	1
26 (EU)	0.15	82	64.9	-	-	1	-	-	-	1
27 (EU)	0.20	305	613.6	-	-	4	-	1	-	5
28 (EU)[b]	0.10	115	215.7	-	-	2	-	-	-	2
29 (EU)	0.15	203	506.0	-	-	2	-	-	-	2
30 (EU)	0.15	129	196.8	-	-	3	-	-	-	3
31 (EU)	0.10	43	41.7	-	-	-	-	-	-	0
32 (EU)	0.10	44	158.4	-	-	-	-	1	-	1
33 (EU)	0.15	33	24.8	-	-	-	-	-	-	0
34 (EU)	0.10	35	23.6	-	-	1	-	-	-	1
35 (EU)	0.15	38	43.7	-	-	1	-	-	-	1
36 (EU)	0.10	36	33.4	-	-	-	-	-	-	0
37 (EU)	0.15	89	210.7	-	-	-	-	-	-	0
38 (EU)	0.20	65	136.4	-	-	-	-	-	-	0
39 (EU)	0.20	94	163.7	-	-	2	-	-	-	2
40 (EU)	0.15	20	49.9	-	-	-	-	1	-	1
41 (EU)	0.10	49	159.0	-	-	-	-	1	-	1
42 (EU)	0.20	263	271.7	-	-	-	-	-	-	0
43 (EU)	0.25	302	397.8	-	-	-	-	-	-	0
44 (EU)	0.20	173	242.1	1	-	-	-	-	-	1
1 (DS)	0.02	48	155.7	-	-	-	-	-	-	0
2 (DS)	0.02	122	285.2	-	-	-	-	-	-	0
3 (DS)	0.02	1,164	1,815.3	-	-	-	-	-	-	0
4 (DS)	0.02	62	111.4	-	-	-	-	-	-	0
5 (DS)	0.02	51	167.6	-	-	-	-	-	-	0
Totals	7.58	9,461	18,291.2	4	2	40	2	9	1	58

(TS) = Test Excavation Unit
(EU) = Excavation Unit
(DS) = Discretionary Surface Collection Unit

[a]Excavated below DS Unit 3
[b]Includes a 50 x 50 cm 1/8 inch mesh control quadrant

Overall, the northwestern zone hosted a variety of activities, none spatially focused enough or the remains of any sufficiently well preserved to be isolated from the general accumulation. Toolstone processing left the most abundant remains. Debitage and biface assemblages reflect core reduction as well as biface production from early through late reduction stages. One-third (n=40) of the 123 bifaces recovered from extra-feature contexts have been heat-treated (cf. Chapter 6). While common white opalites, probably from the quarries immediately upslope or elsewhere in the East, dominate the assemblage, the range of distinctive, colorful opalites implies utilization of raw materials from a variety of off-site sources as well. From the incidence of flake tools, projectile points, preforms, groundstone, and non-opalitic (obsidian) raw material we infer that activities other than toolstone processing took place here; however, evidence for residential use of the place is not incontrovertible (cf. Chapter 24).

Cultural Features

The remainder of fieldwork focused on cultural features. Feature 1, the quarry pit, was sampled and trenched during testing, and was revisited for additional stratigraphic work during data recovery. Most of the twelve reduction features are known exclusively from surface inventories conducted during the test phase. Varying chiefly in size, they consist of dense artifact accumulations dominated by opalite debitage, bifaces, and, less common, cores. Flake tools and other implements augment a number of the assemblages (cf. Table 152). Features 8 and 9 were selected for sampling and received systematic scrutiny during data recovery, and the inventory of Feature 12 was expanded. Subsequently the biface cache, Feature 14, was discovered, recorded, and collected in full.

Feature 1

The quarry pit and associated reduction debris at the southern extreme of the site was manifest on the surface as a shallow depression ca. 3 m long, adjacent the downslope side of a low opalite outcrop (Figure 144). The outcrop is small, occurring in a matrix of highly weathered red tuff. It is impossible to say whether the opalite is the end of a stratum of silicified rock between two strata of tuff, or more likely, a localized pocket or lens. During testing a discontinuous series of 12 25 cm x 25 cm surface scrape units spanned the feature at 1 m intervals. In addition to a large quantity of opalite debitage, units yielded a small collection of formed reduction products. Density and average weight of debitage is greatest upslope of the pit, marking the feature's principal workshop (Table 154).

A backhoe trench excavated during tests proved uninformative. The trench transected the pit from the edge of the outcrop through the downslope extent of the berm, revealing only that the depression is 30 cm deep and that, in sharp contrast to pits tested elsewhere, its berm contains very little quarry debris. This suggests that the toolstone source was not exploited intensively. A second trench was excavated during data recovery. Analysis of the resulting stratigraphic profile served to clarify the internal structure of the feature and amplifies our initial impression that it is relatively incipient.

Trench 2 intersects the trench dug during testing along a roughly perpendicular east-west axis and exposes a profile nearest the downslope edge of the opalite outcrop. The profile shows a very simple sequence of quarry debris overlain by a disturbed silt mantle (Figure 145). Unit 5 is a mixture of fine opalite chips in a clay loam matrix, typical of the hashy stratum commonly mantling quarry pit floors at Tosawihi. Unit 3 is composed of medium to coarse opalite flakes and chunks in an abundant matrix of dark brown silty clay loam with a weak granular structure. There appears to be a fair amount of bioturbation and some soil development here and in other units in this shallow pit. Unit 3 does not appear to have extended very much farther west, across the gap now formed by Trench 1. Unit 2 is a weakly granular silt loam with common tuff clasts and opalite flakes and chunks. The opalite and tuff clasts probably were introduced into the silts both by disturbance during quarrying and from subsequent slopewash and bioturbation. Unit 1 is a thin veneer of organically rich silt that is less pronounced on the east side of the profile.

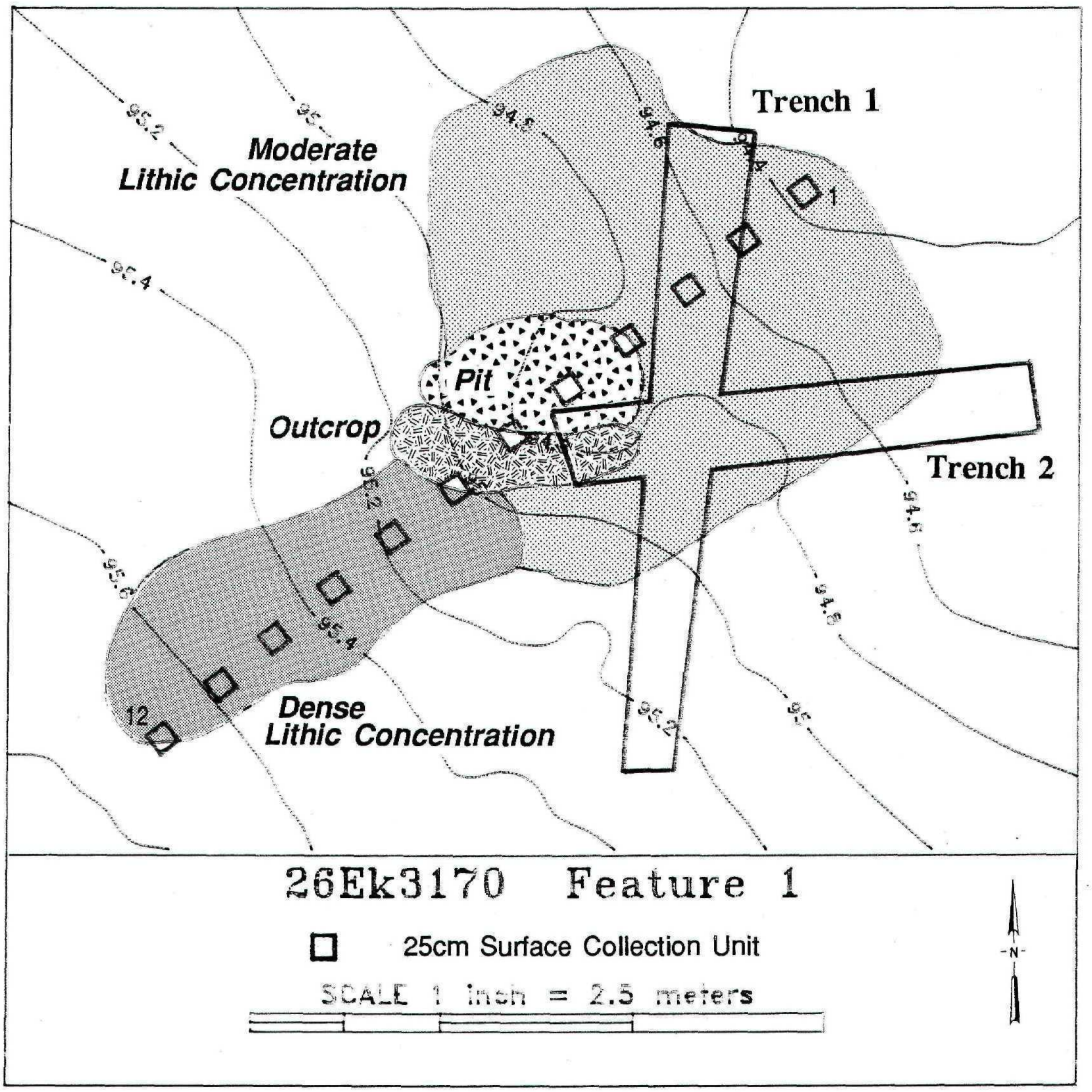


Figure 144. Feature 1 plan, 26Ek3170.

Table 154. Artifacts Recovered from Feature 1, 26Ek3170.

Unit No. (Type)	Surface Scrape (m^2)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Bifaces	FORMED ARTIFACTS Modif. Chunks	Total
1 (SF)	0.063	304	506.1	-	-	0
2 (SF)	0.063	48	290.9	-	-	0
3 (SF)	0.063	38	33.7	-	-	0
4 (SF)	0.063	88	281.4	-	-	0
5 (SF)	0.063	145	281.8	-	-	0
6 (SF)	0.063	35	63.9	-	-	0
7 (SF)	0.063	49	94.5	1	-	1
8 (SF)	0.063	87	866.4	-	-	0
9 (SF)	0.063	124	590.2	-	-	0
10 (SF)	0.063	145	874.4	-	-	0
11 (SF)	0.063	79	615.3	-	-	0
12 (SF)	0.063	16	61.4	-	-	0
Surface Inventory	N/A			4	1	5
Trench Samples	N/A	6,601	15,107.4	-	-	0
Totals	0.756	7,759	19,667.4	5	1	6

(SF) = Surface Scrape

Feature 8

Located on the eastern slope (cf. Figure 143), Feature 8 covers 79 m^2 and consists of a moderate to dense scatter of debitage; it was sampled in order to assess the contents of one of the largest reduction features at the site. Two close-set 16 m^2 artifact concentrations in the center of the feature were the focus of sampling. The entire surface of each was scraped by a block of 16 1 m x 1 m units. Unit recovery rates reveal the contents of both loci to be similar (Table 155). Where surface density was greatest, one 1 m x 50 cm excavation unit explored subsurface contexts. Dense artifact concentrations similar in composition to those on the surface were found throughout the deposit until bedrock was encountered at 40 cm (Table 155). These remains appeared to be concentrated in a slight subsurface depression, but soil turbation renders this tentative.

Table 155. Artifacts Recovered from Feature 8, 26Ek3170.

Locus/ Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	FORMED ARTIFACTS Preforms	FORMED ARTIFACTS Bifaces	FORMED ARTIFACTS Flake Tools	Total
LOCUS A								
45-60 (SF)[a]	0.32	6,564	10,147.2	1	-	7	4	12
55 (EU)[b]	0.14	1,340	2,242.2	-	-	1	2	3
LOCUS B								
61-76 (SF)[c]	0.32	12,634	19,742.1	2	1	16	9	28
Surface Inventory[d]	N/A	-	-	-	-	3	-	3
Totals	0.78	20,538	32,131.5	3	1	27*	15	46

(SF) = Surface Scrape
(EU) = Excavation Unit
*Includes "possible" bifaces

[a]Includes 50 x 50 cm 1/8 inch mesh control quadrant in SF Unit 15
[b]1 m x 50 cm; below SF Unit 55
[c]Includes 50 x 50 cm 1/8 inch mesh control quadrant in SF Unit 68
[d]Combines Locus A and Locus B

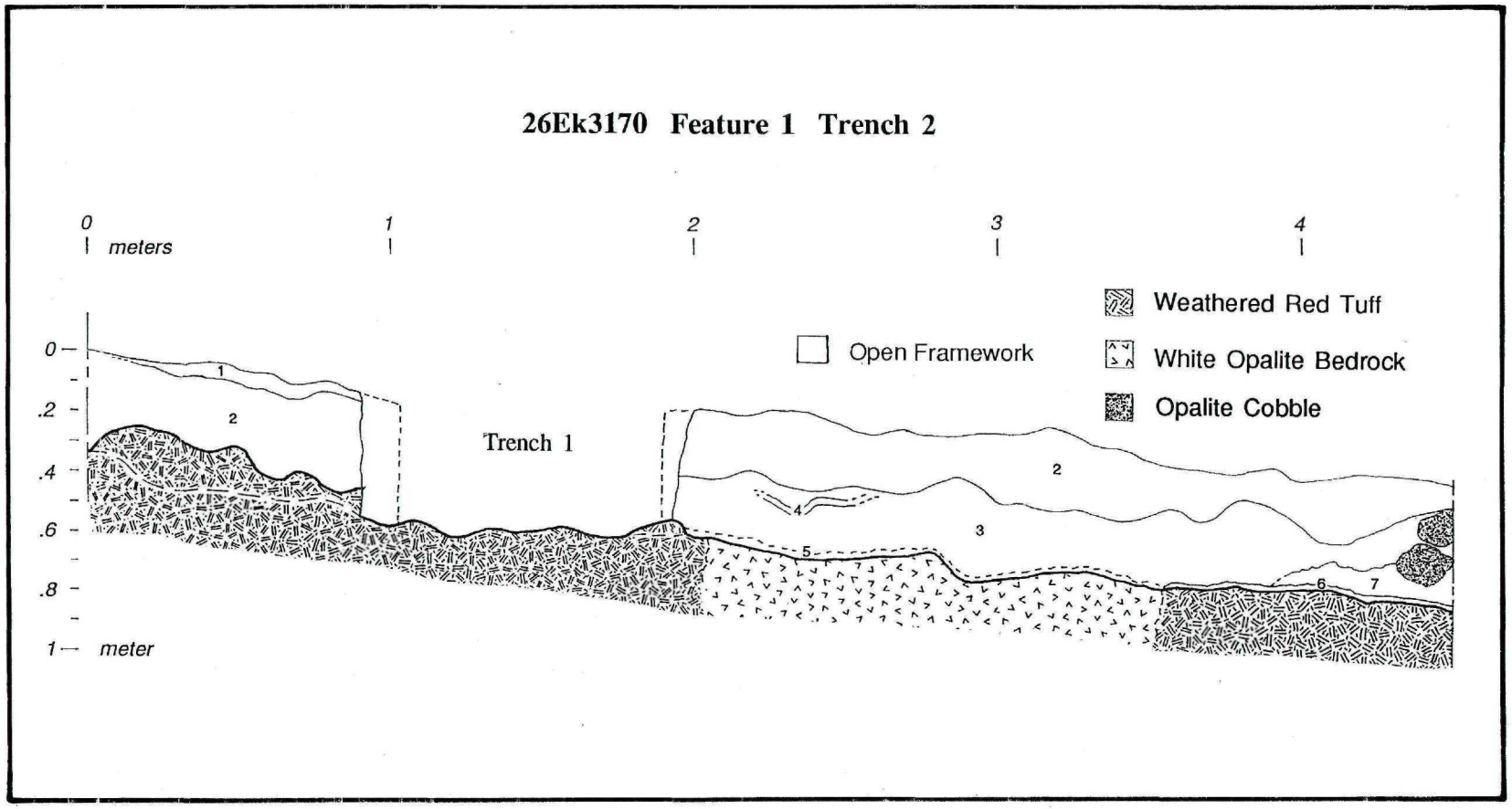


Figure 145. Description of stratigraphic units, Trench 2, 26Ek3170.

Figure 145. Description of stratigraphic units, Trench 2, 26Ek3170.

Stratum	Description
1	Very dark brown (10YR 3/1) dry; silt; loose; abundant charred organic matter; boundary clear.
2	Dark brown (10YR 3/5) slightly moist; silt loam; loose to very weak granular; abundant small opalite and reddish tuff clasts, rare fine opalite flakes; abundant fine roots; boundary clear.
3	Dark brown (10YR 3/3) slightly moist; silty clay loam; weak granular; common fine to medium reddish tuff clasts, common medium to coarse opalite flakes and chunks; common roots.
4	Subhorizontal fine to medium opalite flakes forming a distinct lens.
5	Dark brown (10YR 3/3) moist; clay loam; abundant hashy fine opalite chips.
6	Dark reddish brown (5YR 3/4) moist; fine sandy clay, weathered tuff; rare angular tuff and opalite clasts.
7	Dark brown to dark yellowish brown (10YR 4/3 to 4/4) slightly moist; silty clay loam; common fine subrounded to subangular pebbles; boundary clear and irregular.

Predictably, vast quantities of opalite debitage dominate the assemblage; its character suggests early to intermediate stage biface manufacturing, and more than half the 26 chert bifaces recovered are heat-treated. The opalite debitage from one locus revealed an uncommonly high incidence of heat-treatment (cf. Chapters 6 and 10). Beyond this, however, both loci yielded small quantities of obsidian waste, and diverse flake tools. Unclassifiable projectile point fragments were encountered in both loci, and one contained a Stemmed Series point, a preform, and an obsidian biface as well.

Feature 9

Feature 9 lies on a nearly flat portion of the ridgecrest in the southern portion of the site (cf. Figure 143). It was selected for sampling due to its simplicity and clarity. Its entire 6 m^2 surface expression was collected by surface scrapes; the character of the resulting collection suggests that the feature served as a station for early stages of biface reduction (cf. Chapters 6 and 10). Three obsidian waste flakes hint that the location witnessed other tasks as well (cf. Table 151).

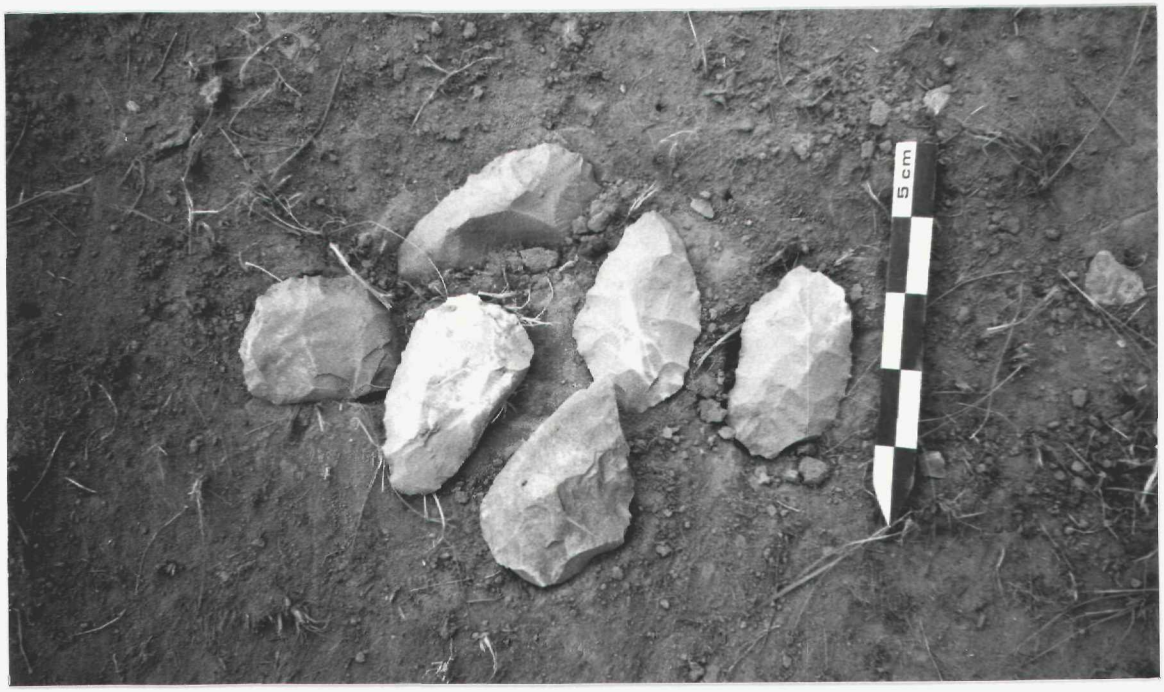
Feature 12

Feature 12 is the largest feature at 26Ek3170. Defined by a moderate to high density concentration of opalite debris, it covers 1420 m^2 on the eastern ridgeslope near the site's northern limit (cf. Figure 143). Our observation that additional bifaces had been exposed on its surface during the year-long hiatus between testing and data recovery led us to inventory it a second time. The exercise added seven bifaces to the 11 collected during testing. They reflect intermediate stage reduction, and imply that, as at Feature 8, much of this effort was performed on heat-treated specimens (cf. Chapter 6).

Feature 14

Located on the northern bank of the intermittent stream course that drains Undine Gorge, Feature 14 fell just outside the site boundary as originally defined and subsequently was included as a component of 26Ek3170 on the basis of proximity (cf. Figure 143).

At the time of its accidental discovery, Feature 14 was manifest as a tight cluster of eight opalite bifaces (Figure 146) exposed on the surface less than a meter higher than the creek bed in an area otherwise nearly devoid of cultural remains. A 1 x by 1 m surface scrape was superimposed to identify its full extent and to search for buried specimens. The excavation revealed that most of the cache already was exposed; two additional bifaces were found stacked beneath other specimens in the center. The pile clustered in less than 250 cm^2; most of the specimens touched on another. Scant debitage and a flake tool were recovered by screening soils from general contexts within the scrape. The ten bifaces are whole or nearly so; nine reflect intermediate reduction stages; (Stage 3), one is a large biface flake blank (Stage 1), and none has been heat-treated (cf. Chapter 6). The survival of the feature so near the seasonally flooded and occasionally torrential drainage seems miraculous. It appears to represent a store of bifaces stockpiled on the stream bank, intended for eventual heat-treatment and further reduction, but never retrieved.



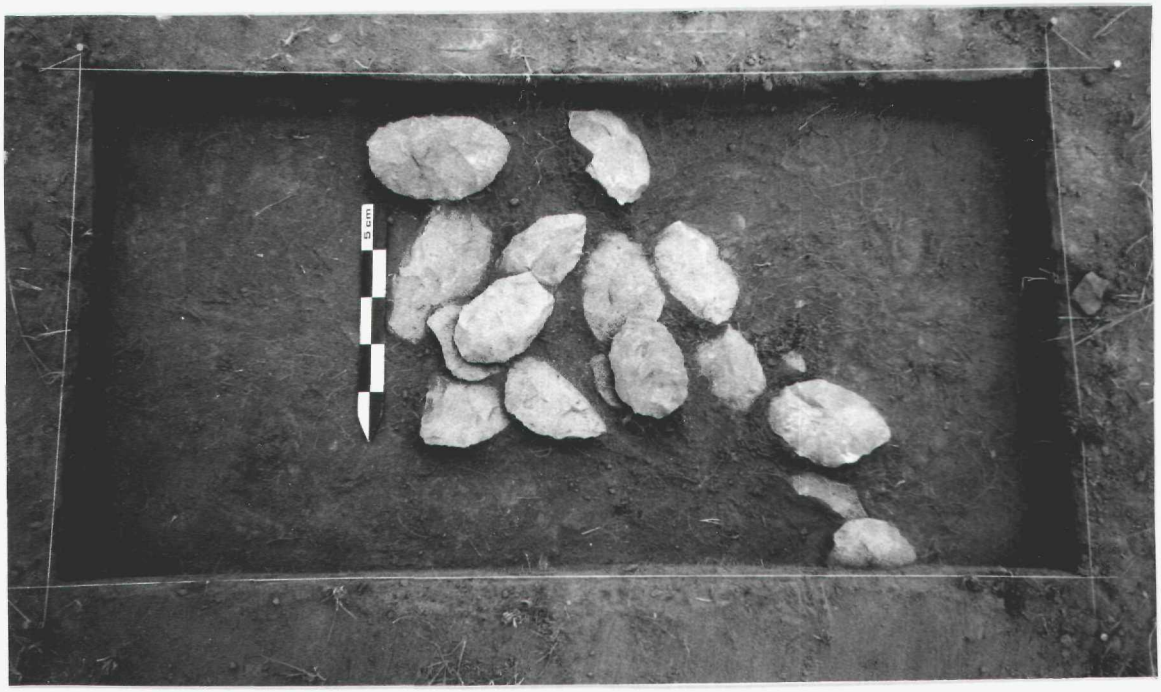


Figure 146. Biface cache, 26Ek3170.

Implications

The most overt aboriginal uses of 26Ek3170 left behind the copious, imperishable wastes of toolstone procurement and processing. But toolstone procurement appears to have been comparatively slight given the minimal development of the quarry pit at Feature 1, while the numerous reduction features contain vast quantities of processing debris incommensurately larger than likely to have been yielded by the meager on-site source. This, coupled with abundant, colorful opalite debitage in the northwestern quadrant, suggests that it served largely for the reduction of toolstone brought from elsewhere. As is the case for most sites tested in the Eastern Periphery where reduction forms dominate assemblages, flake tools (as well as other artifacts assumed to derive from maintenance and subsistence chores) occur in small numbers in many reduction features as well as throughout general site contexts. The degree to which their presence allows us to infer residential function remains problematical; the question is addressed from broader perspectives in Chapters 23 and 24.

26Ek3171

26Ek3171 occupies the second bench of Ramadan Ridge, immediately upslope and south of 26Ek3170. It covers some 7540 m^2 and contains two quarry pits, a cobble quarry, and five reduction stations. The quarries occur on the eastern slopes. The broad, moderately flat surface of the ridgetop appears to have constituted a "workshop zone" in which toolstone was processed. Here, in addition to distinct reduction features, the site is littered with a light to moderate density scatter of opalite debitage exhibiting considerable variety in color and texture (Figure 147).

Nonfeature Contexts

Close interval examination of nonfeature contexts isolated numerous bifaces as well as a variety of maintenance/subsistence tools and several obsidian waste flakes. Also, eight grayware ceramic sherds were recovered from the surface at the southern extreme.

Surficial evidence suggests that the silt loams hosting the lithic scatter in the northwestern portion of the site have undergone rodent churning sufficiently intense to have resulted in the dispersal and/or burial of cultural features. In light of this, three 1 m x 1 m excavation units probed the area during testing; each revealed cultural materials and depositional contexts generally similar to those found in the northwestern quadrant of 26Ek3170. Soils are heavily turbated and only weakly stratified. Artifacts, chiefly opalite debitage, occur throughout until bedrock is encountered (40 cm - 50 cm below the surface; cf. Table 156). The uppermost deposits (to 10 cm depth) contributed most artifacts recovered. Soils here consist of a loose silt loam stained a dark, midden-like color (presumably the result of a range fire that swept the ridge in 1985). This zone is underlain by about 20 cm of more compact silt loam in which, coincident with a general decline in cultural materials, the incidence of large clasts of opalite and unwelded tuff increases. Below this, soils become increasingly clayey and rocky and artifact densities diminish toward bedrock, much of which is well silicified and is of toolstone quality; most flakes in deposits immediately above it are of robust size. Thus, we suspect that the substrate may have served as a lithic source.

Expanded exposure of the nonfeature zone was undertaken during data recovery to clarify its possible quarry content and to assess its other functional characteristics. To provide this expanded perspective, 30 1 m x 50 cm excavation units were dug at randomly selected locations; cultural materials returned by the effort are summarized in Table 156. Overall, artifacts

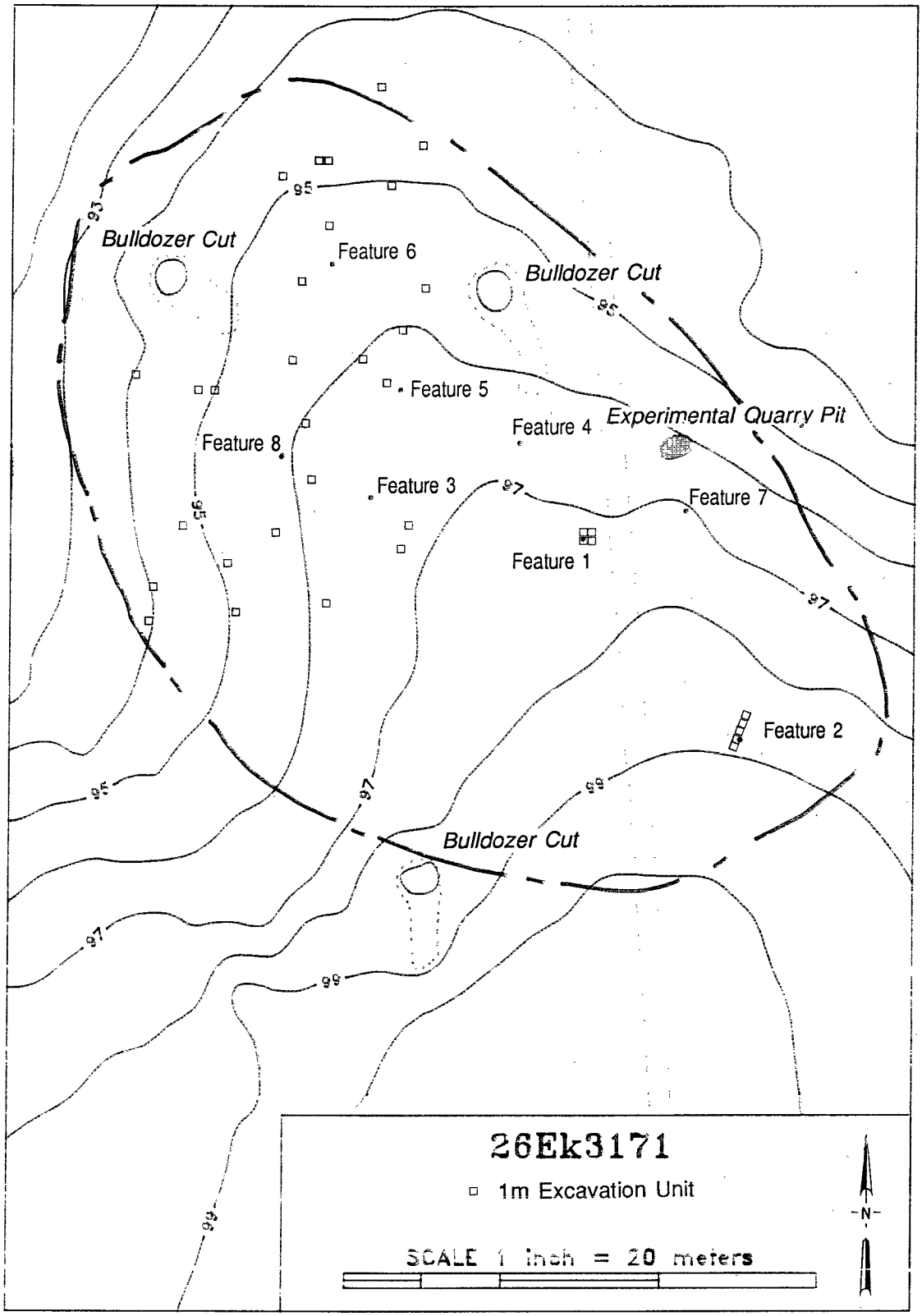


Figure 147. 26Ek3171 site map.

artifacts are distributed rather homogeneously throughout the horizontal extent of the area, and artifact accumulations and soils are essentially identical to those sounded during tests. The depth of deposits everywhere were constrained by subtle undulations of the tuff substrate. Most units encountered bedrock between 30 cm and 40 cm, a few as shallow as 20 cm, some as deep as 50 cm. Opalite debitage dominates all proveniences, and in nine units constitutes the *only* artifact class. Small numbers of bifaces and other reduction products accompany opalite waste in the remainder of the sample; at widely scattered locations these are supplemented by a few flake tools and preforms.

Table 156. Artifacts Recovered from Excavation Units in Nonfeature Contexts, 26Ek3171.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	Preforms	Bifaces	FORMED ARTIFACTS Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Total
1 (TS)	0.40	139	1,118.3	-	-	-	-	-	-	-	0
2 (TS)	0.50	269	773.9	-	2	-	-	-	-	1	3
3 (TS)	0.50	180	380.7	-	-	-	-	-	-	-	0
4 (EU)	0.20	72	233.3	-	1	-	-	-	-	-	1
5 (EU)	0.20	137	255.5	-	3	-	-	-	-	-	3
6 (EU)	0.20	84	609.4	-	2	-	-	-	-	-	2
7 (EU)	0.20	200	339.5	-	3	-	1	-	-	-	4
8 (EU)	0.15	194	474.3	-	1	-	-	-	-	-	1
9 (EU)	0.20	171	264.2	-	1	-	-	-	-	-	1
10 (EU)	0.20	117	173.4	-	-	-	-	-	-	-	0
11 (EU)	0.20	110	206.2	-	1	-	2	-	-	-	3
12 (EU)	0.25	139	570.5	-	3	-	-	-	-	-	3
13 (EU)[a,†]	0.15	10,613	19,414.8	-	7	-	2	-	-	-	9
14 (EU)[a]	0.20	155	428.2	-	-	-	-	-	-	-	0
15 (EU)	0.20	97	267.4	-	-	-	-	-	-	-	0
16 (EU)	0.25	94	194.3	-	-	-	-	1	-	-	1
17 (EU)	0.25	77	204.7	-	-	-	-	-	-	-	0
18 (EU)	0.20	126	147.2	-	1	-	-	-	-	-	1
19 (EU)	0.20	139	241.3	-	-	-	-	-	-	-	0
20 (EU)	0.25	43	142.5	-	1	-	-	-	-	-	1
21 (EU)	0.25	113	518.8	-	2	-	-	-	-	-	2
22 (EU)	0.25	542	1,019.1	1	3	-	-	1	1	-	6
23 (EU)	0.15	81	73.1	-	-	-	-	-	-	-	0
24 (EU)[a]	0.25	232	1,842.4	1	4	1	-	-	-	-	6
25 (EU)	0.10	57	234.6	-	1	-	-	-	-	-	1
26 (EU)	0.20	34	37.1	-	-	-	-	-	-	-	0
27 (EU)	0.15	71	1,226.5	-	1	-	-	-	-	-	1
28 (EU)	0.15	84	169.1	-	2	-	-	-	-	-	2
29 (EU)	0.25	116	1,123.2	-	3	2	-	-	-	-	5
30 (EU)	0.10	80	243.9	-	-	-	-	-	-	-	0
31 (EU)	0.15	100	340.2	-	1	-	-	-	-	-	1
32 (EU)	0.20	40	252.2	-	1	-	-	-	-	-	1
33 (EU)	0.15	58	240.9	-	-	-	-	-	-	-	0
Totals[b]	7.25	14,764	33,760.7	2	44*	3	5	2	1	1	58

(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Includes a 50 x 50 cm 1/8 inch mesh control quadrant
[b]Total excludes EU 13 artifacts
[†]Unit in Feature 3
*Includes 2 "possible" bifaces

No subsurface cultural features were found. Although toolstone-quality opalite occurs within the bedrock exposed by a numerous units, none of it had been exploited. The character of both debitage (cf. Chapter 10) and the biface assemblage (cf. Chapter 6) suggests that most culturally modified opalite recovered from the area is attributable to early to intermediate stage biface manufacture. Twenty percent of the bifaces have been heat-treated.

Cultural Features

The surface content of each cultural feature was inventoried during testing. The five reduction features (Features 1, 3, 5, 6, and 8) occur along the ridgecrest, and consist of moderate to high density accumulations dominated by opalite debitage. There are few formed artifacts. Several assemblages contain small numbers of bifaces and flake tools, and Feature 5 returned a Desert Side Notched projectile point. Reduction Feature 1 was sampled during testing.

At Feature 4, a cobble quarry, weathering of the opalite bedrock created a supply of naturally liberated raw material. Use of the source appears to have been minimal, but much of it has been obliterated by a bladecut of historical origin. The light to moderate density scatter of debitage and assayed cobbles remaining contain several biface fragments, a pair of flake tools, and an unclassifiable projectile point.

Features 2 and 7 lie on slopes east of the ridgecrest. Both are well developed quarry pits; they were sampled during testing and data recovery. Table 157 summarizes the artifact content of all features as revealed by both phases of fieldwork.

Table 157. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3171.

		DEBITAGE[a]		FORMED ARTIFACTS									
Feature	Total Area (m^2)	n	wt. (gm)	Proj. Points	Preforms	Bifaces[b]	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Total
1*	189	1,704	23,738.2	-	-	10	2	-	2	-	-	-	14
2*	140	8,865	124,206.8	-	-	15	1	1	1	1	-	-	19
3*	16	1,933	8,987.8	-	-	5	-	1	-	-	-	-	6
4	227	-	-	1	-	4	-	2	1	-	-	-	8
5	177	-	-	1	-	6	-	-	-	-	-	-	7
6	63	-	-	-	-	1	-	1	-	-	-	-	2
7*	55	-	-	-	-	6	1	-	-	-	-	-	7
8	28	-	-	-	-	2	-	-	-	-	-	-	2
Surface Isolates		3[c]	16.2	-	2	14	-	3	-	1	-	8	28
Other Nonfeature		12,831	24,772.9	-	2	40	4	8	2	1	1	-	58
Totals		25,336	181,721.9	2	4	103	8	16	6	3	1	8	151

* Sample Feature
[a]Does not include trench samples
[b]Includes "possible" bifaces
[c]Obsidian only

Feature 1

Feature 1 was sampled because of its small, spatially discrete nature that promised recovery of the residue of a single event of toolstone reduction. The feature was collected completely by four 1 m x 1 m surface scrapes. Raw materials are strikingly uniform in color and texture, dominated by robust items characteristic of core reduction. Cores and biface fragments comprise the total artifact assemblage, reflecting flake blank production through intermediate stage biface reduction (cf. Chapter 6). Absent chemical characterization of opalite, proximity and visual comparison of raw materials suggest that the scatter was created during the reduction of toolstone acquired from the quarry pit of Feature 7, ten meters east.

Feature 2

The smaller quarry pit, Feature 2, was manifest on the surface as a shallow, circular, 6 m diameter depression accompanied by a low berm of quarry debris issuing from its northern, downslope margin. The pit, berm, and surrounding ground surface are mantled by a moderate to high density lithic scatter encompassing about 140 m^2 (Figure 148).

During tests, surface contexts were sampled by scraping two discontinuous baselines of units arrayed in a cruciform pattern and centered on the pit interior. Unit contents consist almost exclusively of opalite debitage, densest on the pit berm. Formed artifacts are scarce, represented by a single core and three bifaces (Table 158). To explore the pit interior, we hand excavated a trench (Trench 1) that bisected the depression along its north-south axis. Although revealing stratified deposits to a depth of 70 cm, the trench proved too narrow to allow close assessment of the resulting profile.

Table 158. Artifacts Recovered from Feature 2, 26Ek3171.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	Bifaces	FORMED ARTIFACTS Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Total
1 (SF)	0.063	2	3.3	-	-	-	-	-	0
2 (SF)	0.063	26	39.1	-	-	-	-	-	0
3 (SF)	0.063	8	51.9	-	-	-	-	-	0
4 (SF)	0.063	45	352.5	-	-	-	-	-	0
5 (SF)	0.063	44	59.8	-	-	-	-	-	0
6 (SF)	0.063	45	101.6	-	-	-	-	-	0
7 (SF)	0.063	41	95.3	-	-	-	-	-	0
8 (SF)	0.063	21	68.6	-	-	-	-	-	0
9 (SF)	0.063	6	36.9	-	-	-	-	-	0
10 (SF)	0.063	16	58.2	-	-	-	-	-	0
11 (SF)	0.063	14	32.4	-	-	-	-	-	0
12 (SF)	0.063	9	15.6	-	-	-	-	-	0
13 (SF)	0.063	12	12.4	-	-	-	-	-	0
14 (SF)	0.063	21	198.8	-	-	-	-	-	0
15 (SF)	0.063	7	15.5	-	-	-	-	-	0
16 (SF)	0.063	11	30.0	-	-	-	-	-	0
17 (SF)	0.063	15	53.7	-	-	-	-	-	0
18 (SF)	0.063	30	151.5	-	-	-	-	-	0
19 (SF)	0.063	24	51.0	-	-	-	-	-	0
20 (SF)	0.063	23	118.3	-	-	-	-	-	0
21 (SF)	0.063	24	113.9	1	-	-	-	-	1
22 (SF)	0.063	36	164.6	-	-	-	-	-	0
23 (SF)	0.063	-	-	-	-	-	-	-	0
50 (EU)	0.300	8,385	122,381.9	12	-	1	1	1	15
Surface Inventory	N/A	-	-	2	1	-	-	-	3
Trench Samples	N/A	5,537	10,828.7	4	1	-	-	-	5
Totals		14,402	135,035.5	19*	2	1	1	1	24

(SF) = Surface Scrape
(EU) = Excavation Unit

*Includes "possible" bifaces

Field efforts during data recovery sought to clarify the internal structure and content of the pit. To this end, a backhoe trench (Trench 2) sectioned the depression perpendicular to the original cut. Trench 2 exposed a roughly northwest-to-southeast profile through the center of the pit (Figure 149). Prehistoric quarrying created a broad, shallow pit and a minor pit to the east, separated by a low septum of weathered tuff.

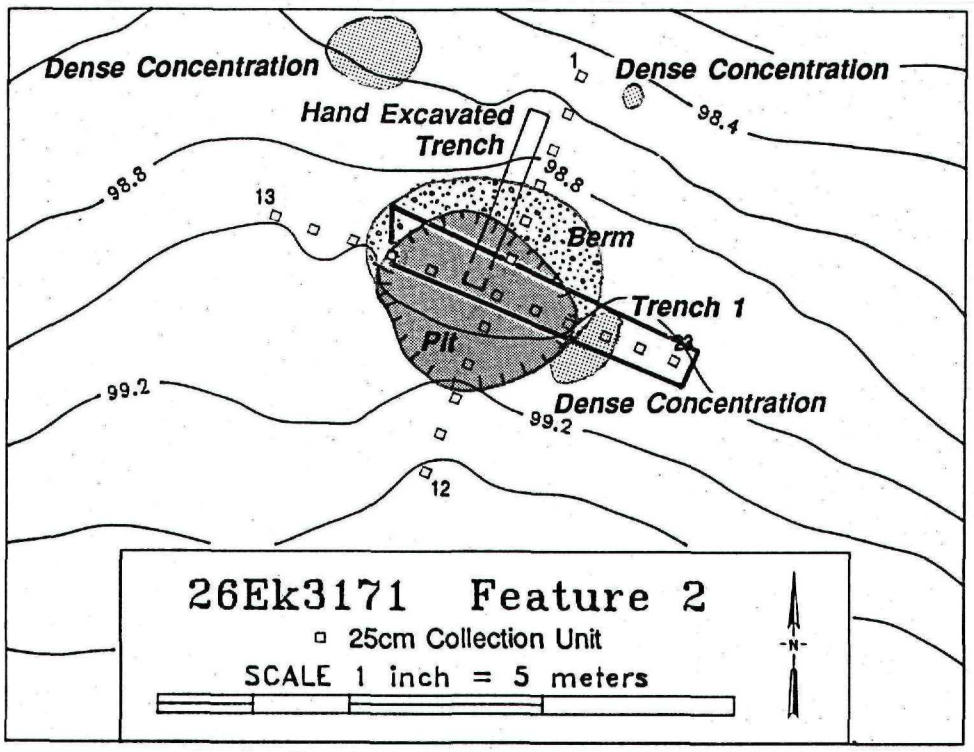


Figure 148. Feature 2 plan, 26Ek3171.

Bedrock consists of white tuff, both silicified and unsilicified. The unsilicified tuff has weathered to clay mixed with blocky clasts of soft "chalky" tuff. Silicified tuff opalite toolstone is exposed in the bottom of the large western pit, but not in the smaller eastern pit. This suggests that the eastern pit may represent a failed prospect. The opalite toolstone does not appear to form a layer below the weathered, unsilicified material; perhaps the opalite here is a "pod" or localized zone of silicification.

The stratigraphy is fairly simple, with relatively few distinct strata. Unit 12, for example, covers the entire floor of the main pit. This unit is composed of abundant, very fine to fine, angular opalite chips with a sandy pale brown clay matrix. Quite possibly, at least some of the fine sand and clay matrix in the "hash" is the product of natural slopewash.

Unit 11, like unit 12, extends across most of the pit. It is a poor, open framework of fine to medium opalite chunks and flakes with a brown, sandy, clay loam matrix. Vague lenses of alternating coarse and fine fill can be detected, none distinct enough to warrant division into separate stratigraphic units. Mantling Unit 11 over much of its surface is a grayish brown silt loam with common opalite and tuff gravel and cobbles and a few opalite flakes, especially in the accumulation of dry organic matter and charcoal nearest the surface. The slightly weathered opalite boulders and cobbles common in this unit and in Units 3 and 4 of the underlying clay-rich paleosol are relics of Pliocene/Pleistocene Little Antelope Creek (Bartlett et al. 1991).

The only moderately complex set of strata occur at the westernmost end of the pit, where Units 13-19 cover Units 11 and 12 and are overlain by the silt loam of Unit 2. Units 13-19 consist of quarry debris with varying sizes and amounts of opalite chunks and flakes in a sandy clay or sandy clay loam matrix. Bedrock also reaches its deepest point in this area. The smaller quarried area at the eastern end of the profile shows little extensive working; quarry waste consists of opalite chunks with a few flakes in a sandy clay loam matrix.

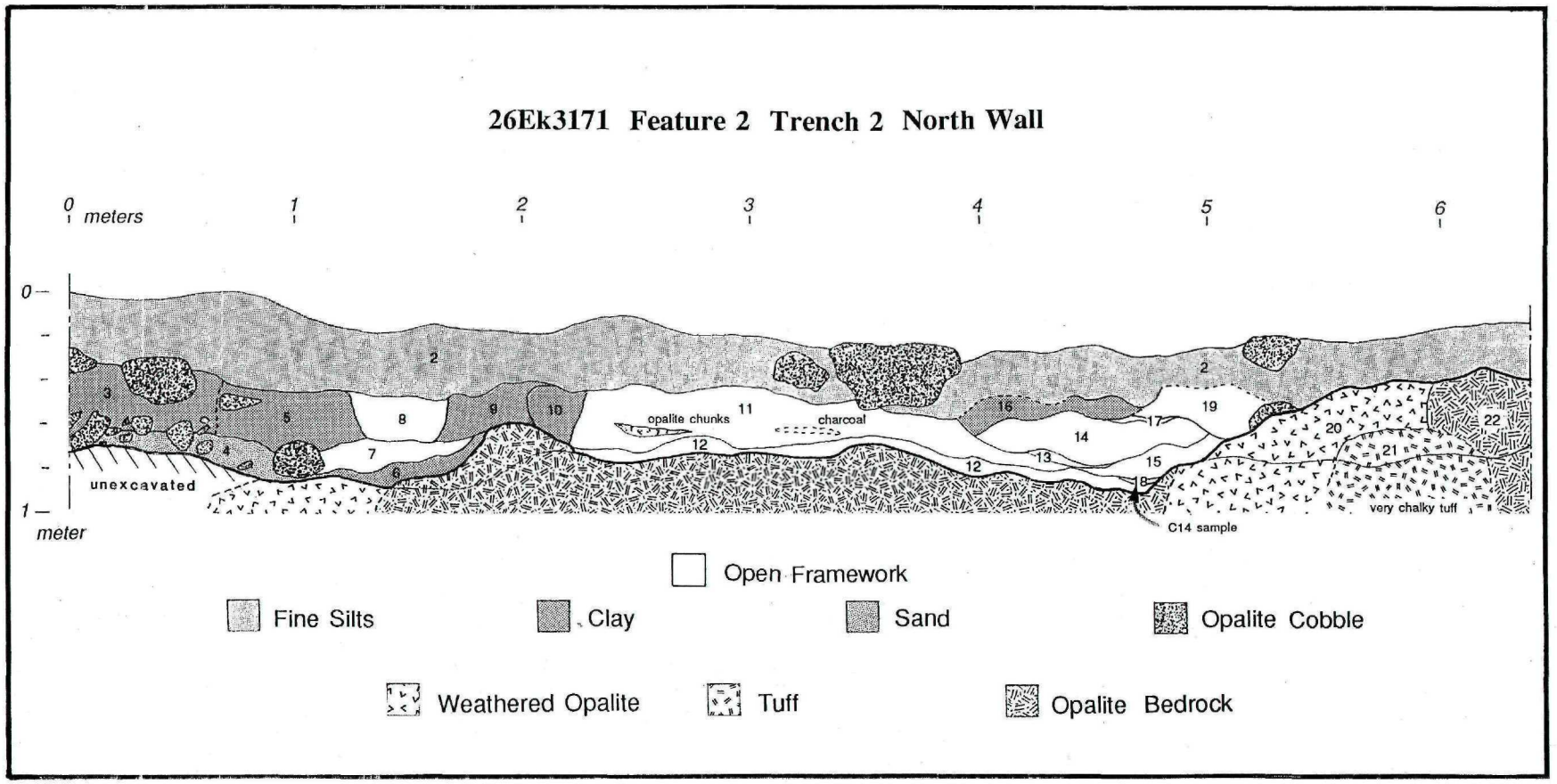


Figure 149. Description of stratigraphic units, Trench 1, 26Ek3171.

Figure 149. Description of stratigraphic units, Trench 1, Feature 2, 26Ek3171.

Stratum	Description
1	No typical silt loam unit 1 was identified at this trench.
2	Grayish brown (10YR 5/2) dry; silt loam; loose to weak medium granular; common medium angular to subrounded pebbles and common medium subangular to subrounded cobbles; common fine roots; common medium opalite chips, chunks and flakes; boundary clear and irregular.
3	Dark brown to strong brown (7.5YR 4/4 to 4/6) slightly moist; sandy clay; strong medium angular blocky; common fine to medium subrounded to rounded pebbles and common subangular to subrounded boulders; rare fine roots; moderate clay skins on ped surfaces; common fine opalite chips; boundary clear and irregular.
4	Very pale brown to yellow (10YR 7/4 to 7/6) dry; loamy sand, becomes more clay rich to west; common fine to medium subrounded to rounded pebbles, common subangular to subrounded boulders; boundary unexposed.
5	Mottled brown (10YR 4/3) slightly moist; silty clay loam; and brown (7.5YR 4/4) slightly moist; sandy clay; fine subangular blocky; common subangular to subrounded pebbles and cobbles; common fine roots; rare opalite chips; boundary clear and irregular.
6	Brown (10YR 5/3) moist; clay; with rare clasts of unit 4 material; possible manganese nodules, black (2.5YR 2/1) moist; boundary abrupt and irregular.
7	Moderate open framework, very fine to medium opalite chips, chunks, and flakes; moderate clayey opalite and tuff sand matrix, yellowish brown to brown (10YR 5/4 to 4/3) moist; boundary clear and irregular.
8	Moderate to poor open framework, medium to coarse opalite chunks and some flakes; moderate clay loam matrix, yellowish brown to brown (10YR 5/4 to 4/3) moist.
9	Brown (10YR 4/3) slightly moist; clay loam; no apparent structure; common medium chips and chunks, and rare fine opalite flakes; boundary clear and irregular.
10	Strong brown (7.5YR 4/6) slightly moist; sandy clay; no apparent structure; common medium opalite chips and chunks.
11	Poor open framework, with vague lensing of coarse and fine fill, common fine to medium opalite chunks and flakes; common hashy, sandy clay loam matrix, brown (10YR 4/3) slightly moist; boundary clear and smooth.
12	Pale brown to brown (10YR 6/3 to 5/3) moist; very fine clayey hash.
13	Moderate open framework, thin lense of fine to medium opalite flakes, and some medium opalite chunks and pebbles; moderate hashy, sandy clay matrix, dark brown (10YR 4/3) moist.
14	Poor open framework, very fine to coarse opalite and tuff chunks; common hashy, sandy clay matrix, dark brown (10YR 4/3) moist; boundary clear and smooth.
15	Poor open framework, fine to coarse opalite and tuff chunks and chips; common hashy, sandy clay loam matrix; strong brown to dark brown (7.5YR 4/6 to 3/4) moist; rare charcoal flecks.
16	Dark grayish brown (10YR 4/2) slightly moist; silt clay loam; weak fine granular; common fine to medium tuff and opalite chunks, rare coarse tuff chunks, and rare to common medium opalite flakes; this unit appears to be a mixture of units 2 and 14.
17	Subhorizontal fine to medium opalite flakes and chunks, and some chips, in a matrix similar to unit 16.
18	Abundant charcoal chunks and flecks in a matrix of brown (10YR 4/3) moist; sandy clay; the bedrock here is also burned or stained with carbon.
19	Similar to unit 16, except for more abundant weathered chalky and glassy tuff chunks, and some medium opalite flakes.
20	Dark brown (7.5 4/4) moist; clay to sandy clay; strong medium angular blocky; tuff fragments weathering in situ with clay filling joints; common clay skins on ped faces.
21	Lensed silty clay from weathered tuff, white (10YR 8/2) moist, and clay, yellowish brown (10YR 5/2) moist.
22	In situ weathering, glassy tuff bedrock, with clays as similar to unit 20 infiltrating joints.

Grouping strata by horizon was not attempted in Feature 2 because strata are intercalated lenses, many less than 2 m in length. While there are trends in their relationships, it seldom is possible to discern obvious stratigraphic horizons delimiting different episodes of use. Indeed, the total duration of use may have been short. Within the fill of the westernmost depression, for instance, the surface of Unit 11 appears to have been truncated by a shallow pit subsequently filled by Units 13 and 14; Unit 14 then was truncated by another shallow pit and filled by Units 16 and 19. No unit contains weathered material or exhibits the accumulation of fine residues associated with intervals of disuse.

After profiling, a 1 m x 50 cm excavation unit was dug into the north wall of Trench 2. This methodological experiment sought to develop a means for sampling quarry pit contents systematically, and, as well, to expose and sample the charcoal at the bottom of Feature 2. The unit spanned the depth of the pit from ground surface to bedrock, using depositional levels defined during stratigraphic analysis for vertical control. Formed artifacts were recovered at all depths (cf. Table 158). At the bottom of our probe, the westernmost end of stratigraphic Unit 12 ("hash") and a charcoal lens (cf. Figure 149: Unit 18) filled a shallow depression in the bedrock. The bedrock "floor" of this depression was charcoal-blackened over a 60 cm x 30 cm area, yielding a radiocarbon date of 410±70 B.P. (Appendix L). We surmise that it may have resulted from firing during the quarrying process.

Methodologically, the exercise disclosed that most strata are difficult to follow any distance into the sidewall due to pronounced changes in their composition. As well, the loose, often debris-rich, constitution of some strata resulted in wall collapses, confounding reliable vertical control. The results of these efforts led us to pursue other means of obtaining samples of stratigraphic units.

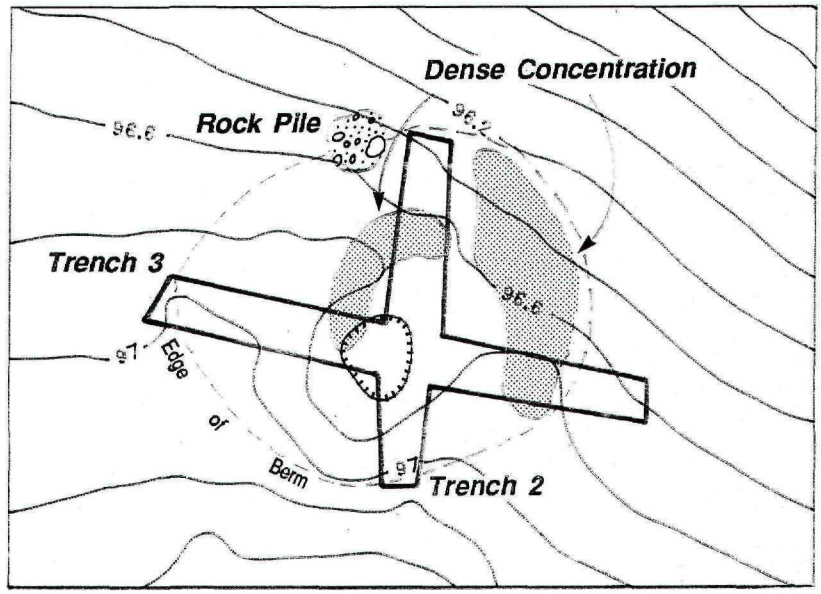
Feature 7

Feature 7 is an oval depression with its long axis running north-south, perpendicular to the slope. It lies ca. 30 m north and downslope of Feature 2. Save its larger depression (9 m maximum dimension), the pit, berm, and dense lithic scatter covering them present a surface manifestation similar to that of Feature 2 (Figure 150). Inventory revealed few formed artifacts, solely products of opalite processing (cf. Table 157).

The depression was quartered by two backhoe trenches arrayed in a cruciform centered on the pit. The north-south trench (Trench 2) was dug during testing and the east-west trench (Trench 3) during data recovery (cf. Figure 150). A stratigraphic drawing was made of the west wall of Trench 2, but strata were not described formally. The north wall of Trench 3 was drawn and described subsequently (Figure 151); Trench 3 is emphasized in the following discussion, but reference is made to Trench 2 as well.

Bedrock at Feature 7 is composed of white crystalline tuff and well silicified opalite. The upper 20-30 cm of tuff is weathered into blocky, angular, cobble sized clasts in an orange brown clay matrix. Opalite bedrock lies below the weathered horizon, varying in degree of silicification.

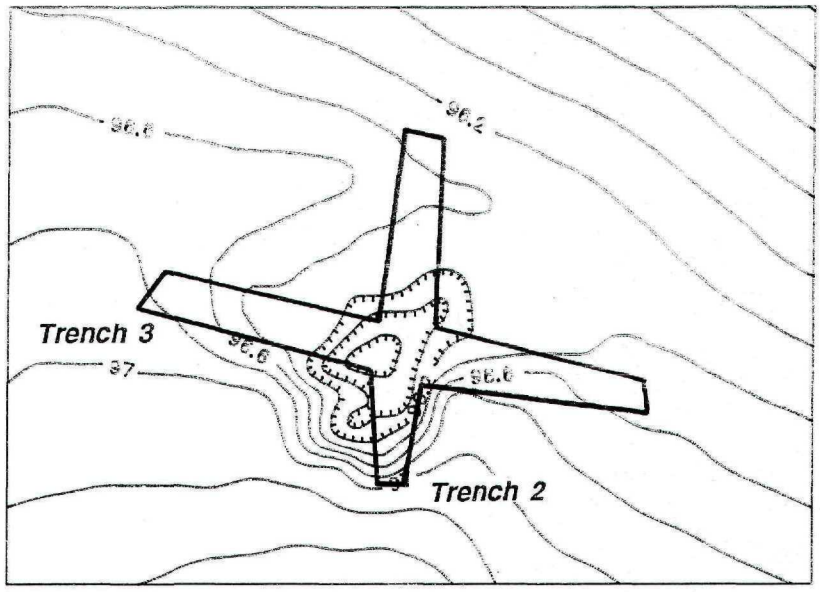
The intersecting trenches allowed a three dimensional examination of strata filling the quarry pit. While some stratigraphic units can be traced around the corner from the west wall of Trench 2 to the north wall of Trench 3, the limited size of most units makes them difficult to follow. Units such as 1 and 13 through 18 are traceable, however. Because of the gap created by the east-west trench, units in the eastern half of Trench 3 can be correlated only tentatively with units in the western profile. The fairly large Unit 14, basal Unit 18, and Unit 1 at the surface appear equivalent in both profiles, and Unit 16 may be equivalent to Unit 57. Units occurring farther west in the north wall profile of Trench 3 may be equivalent to other



26Ek3171 Feature 7 Surface

SCALE 1 inch = 5 meters

a



26Ek3171 Feature 7 Excavated Pit

SCALE 1 inch = 5 meters

b

Figure 150. Feature 7 plan, 26Ek3171. a. surface; b. excavated pit.

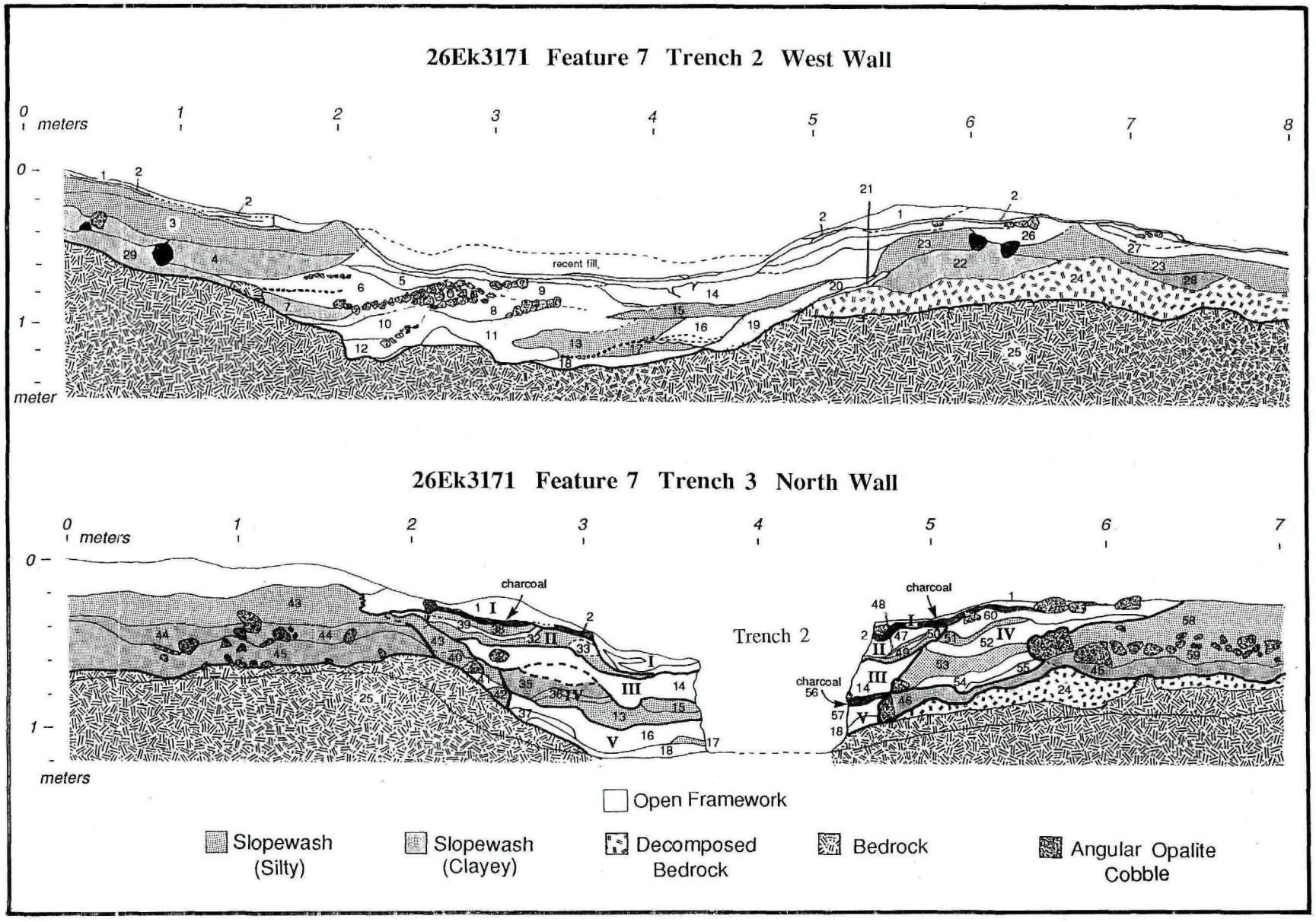


Figure 151. Description of stratigraphic units, Trench 3, Feature 7, 26Ek3171.

Figure 151. Description of stratigraphic units, Trench 3, Feature 7, 26Ek3171.

Stratum	Description
1	Pale brown (10YR 6/3) dry; sandy silt loam; common medium subrounded pebbles; common to abundant fine to coarse opalite chunks, chips and flakes; this unit has been strongly disturbed by backhoe and drilling activity, unit 1b is a pink hole plug that has contaminated unit 1 and parts of unit 14; boundary abrupt and irregular.
2	Light brownish gray (2.5YR 6/2) dry; silt loam; loose to fine granular; common fine subangular pebbles; common fine roots; common charcoal flecking; boundary abrupt and irregular.
13	Coarse hash; brown (10YR 5/3) dry; sandy clay loam with common very fine to fine chunks, rare fine flakes.
14	Moderate open framework, common medium to coarse opalite flakes, with less common fine to medium chunks and chips, in a moderate open framework; sparse matrix of brown (10YR 5/3) dry; sandy loam; matrix is generally sparser and opalite flakes and chunks coarser towards the center of the pit.
15	Fine hash; dark brown (10YR 3/3) dry; silt loam with common very to fine flakes and chips of opalite.
16	Moderate open framework, coarse flakes and chunks in a poor to moderate open framework with a moderate amount of pale brown (10YR 6/3) dry; medium subangular sandy loam matrix.
18	Fine hash; brown (10YR 4/3) slightly moist; silty clay with abundant fine opalite flakes and chips and rare fine chunks of tuff; rare charcoal flecking scattered in western half of unit.
25	Opalite bedrock exposed in trench wall.
26	Weathered white opalite bedrock, with silty clay as in unit 45 and 46, filling cracks.
32	Fine hash; brown (10YR 5/3) dry; sandy loam with common very fine to rare medium fine opalite chips and rare medium opalite flakes.
33	Coarse hash; dark grayish brown (10YR 4/2) dry; sandy silt with abundant fine to medium opalite flakes, and rare coarse flakes.
34	Poor open framework of abundant fine to medium, predominantly subhorizontal, opalite flakes with rare coarse flakes and chunks in a moderate matrix of pale brown (10YR 6/3) dry; fine to medium subrounded to angular sandy loam, with abundant fine opalite chips; rare charcoal flecks.
35	Coarse hash; brown (10YR 5/3) dry; clay loam with common medium opalite flakes, and rare fine chips and coarse flakes.
36	Moderate open framework, predominantly subhorizontal medium to coarse opalite flakes and chunks, with sparse matrix of brown (10YR 4/3) slightly moist; clay loam similar to unit 35.
37	Poor open framework of coarse opalite chunks with moderate matrix of pale brown (10YR 6/3) dry; sandy loam similar to unit 16.
38	Fine hash; dark brown (10YR 3/3) slightly moist; loose coarse sandy silt loam with rare medium opalite flakes and chunks.
39	Moderate open framework of commonly coarse rarely medium and fine, subhorizontal opalite flakes and chunks with sparse to moderate matrix of pale brown (10YR 3/3) slightly moist; coarse sandy silt as in unit 38.
40	Fine hash; dark brown (10YR 3/3 to 4/3 slightly moist) loam with common very fine to fine opalite chips and fine flakes; rare charcoal flecks.
41	Poor open framework to coarse hash, fine angular opalite chunks tightly packed with sparse matrix of dark yellowish brown (10YR 4/4 slightly moist) silty clay.
42	Fine hash; dark yellowish brown (10YR 4/4 slightly moist) silty clay with abundant fine opalite chips and chunks.
43	Dark brown (10YR 3/3 slightly moist) silty clay loam; loose to moderate granular; common subangular to angular pebbles; common fine roots and pores; boundary clear and wavy to irregular.
44	Brown to dark yellowish brown (10YR 4/3 to 4/4 slightly moist) silty clay loam; weak to moderate medium subangular blocky; common fine to medium pebble and opalite clasts; boundary clear and irregular.
45	Strong brown (7.5 YR 4/6 to 5/6 slightly moist) clay loam; moderate to strong medium subangular blocky; thick clay skins on ped faces; common medium and coarse subrounded to rounded cobbles; contact with bedrock is sharp.
46	Coarse hash; dark yellowish brown (10YR 3/4 to 4/6) slightly moist; sandy silty clay; weak fine granular; rare to common angular pebbles; rare to fine roots; unit generally coarsens westward to common medium to coarse opalite chunks in silty clay matrix; matrix also fills cracks in weathered bedrock of unit 26.

Figure 151, continued.

47 Poor open framework to matrix supported, medium to coarse opalite cores, chunks and flakes; abundant sandy silt loam matrix, very dark grayish brown (10YR 3/2) slightly moist.

48 Fine hash to poor open framework; dark brown (10YR 3/3) moist; sandy clay loam; rare fine to medium opalite flakes and chunks.

49 Moderate open framework, fine to medium opalite flakes, rare coarse flakes and cores; common sandy clay loam matrix as in unit 48.

50 Dark yellowish brown (10YR 4/4) moist; sandy clay loam; rare to common fine opalite flakes and pebbles.

51 Coarse hash; dark brown to brown (10YR 3/3 to 4/3) moist; sandy clay loam; common fine opalite flakes and chunks.

52 Moderate open framework; common coarse cores, chunks and flakes, rare fine to medium flakes; moderate sandy clay loam matrix same as unit 50.

53 Dark brown to dark yellowish brown (10YR 3/3 to 3/4) moist; silty clay; common fine opalite flakes and chunks; dispersed fine charcoal flecks.

54 Moderate open framework; medium to coarse opalite chunks, subrounded cobbles and fine flakes; sparse to moderate silty clay matrix as in unit 53.

55 Fine hash; brown (10YR 4/3) moist; silty clay; rare fine opalite chunks and flakes; some areas of this unit is fairly open framework.

56 Fine hash; dark brown (10YR 3/3) moist; silty clay; common fine opalite flakes and chips; abundant charcoal pieces.

57 Moderate open framework, fine to medium opalite flakes, rare fine opalite chunks and chips; moderate sandy clay matrix, dark brown (10YR 3/3) moist.

58 Brown (10YR 4/3) moist; silty clay; weak granular to subangular blocky; boundary clear and irregular.

59 Dark yellowish brown (10YR 4/4) moist; silty clay; common fine to medium angular to subangular pebbles; common very coarse subrounded cobbles; common fine opalite chips; boundary clear and irregular.

60 Poor open framework, poorly sorted, fine to coarse opalite flakes chunks and chips; common silt loam matrix, very dark grayish brown to dark brown (10YR 3/2 to 3/3). moist.

units farther north in the west wall of the original trench, but no confident correlations can be made. Units in Trench 3 have been numbered successively beginning with Unit 32, where numbering in the north-south trench terminated. Due to the complex intercalation of debris lenses in this pit, strata numbering may not reflect the vertical sequence seen in the stratigraphic column. The manner in which the strata develop in west wall profiles (cf. Figure 151), however, suggests that work in the pit progressed up-slope, from north to south.

Fill deposits were removed to ascertain the extent to which the pit had been mined into bedrock. The limits of quarrying activity were identified easily by the presence of an undisturbed soil profile around the pit margin. The bedrock excavation below the surrounding berm forms an approximately oval depression with a remarkably smooth floor.

Because of good exposure and the typical appearance of the fill in this pit, chemical analyses for several oxides were performed on samples from Trench 3. The chemical data have been arranged into profiles to reflect signs of weathering, soil development, and phosphorus enrichment in the pit fill and the results are discussed below.

The various strata filling Trench 3 are composed of debris from quarrying or of material introduced by natural processes. The quarry debris are composed primarily of coarse opalite chunks and flakes with only sparse sand filling voids between the larger clasts. Natural slopewash units typically have abundant fine sandy silt matrices, commonly with fine pebbles of opalite and tuff and a few coarse opalite flakes and chunks. While several units easily are classified into these basic types, others are more enigmatic. It is probable that some which appear silt-rich slopewash units may, in fact, consist of quarry debris where soil has been introduced during digging. This could occur easily during the lateral expansion of pits, or during backfilling, when debris was mixed as it was shoveled away from the outcrop face. The identification of units with abundant sandy clay silt matrix and common fine chips of opalite and tuff referred to as "hash" also is problematical. An example is Unit 18; although the deposit *could* be the result of fines washing out of courser strata and settling in the bottom of the pit, it is more likely that hash was created by hammering or bashing bedrock during quarrying. The sand-sized and smaller tuff and opalite material was mixed with clays from the paleosol and the overlying weathered tuff bedrock, and with silts from the surrounding surface soil washed into the pit. Debris similar in texture and appearance was produced during quarrying experiments. Caution must be exercised, however, when assigning such deposits either a quarrying or natural origin; undoubtedly, opportunity for the mixing of genetically different materials occurred often.

Because of the limited size of individual strata, their depositional complexity, and the difficulty of determining which may be of primary origin, an exact interpretation of the events that created the pit and its fill at Feature 7 can achieve only a simple iteration of the relative chronology based on seven stratigraphically apparent horizons. In addition, Trench 3 is perpendicular to the axis of quarrying activity, and provides no clue to the direction in which quarrying progressed. Quarrying began with the removal of overlying materials, in deposits such as Units 43, 44, 45, 58, and 59 of Horizon VIII. Following the initial removal of overburden, exploration for usable opalite progressed downward to a limited depth and laterally (generally southward), as indicated by the north-south trench profile (cf. Figure 151).

As quarrying continued, debris was thrown away from the working face. These debris deposits eventually filled the quarried area; they consist of Units 40, 41, 42, 50-55, and 60, and comprise stratigraphic Horizon VI. A truncation of these units on both sides of the pit suggest that they were more extensive in the past. This implies that a substantial amount of reworking and renewed digging occurred before the deposition of Horizon V. Horizon VI appears to be composed of alternating events of quarry deposition and slopewash. Units such as 53 clearly are mixtures of opalite flakes and chunks with the reddish clay of the adjacent soil.

Horizon V units which fill the depression left by the truncation of Horizon VI are composed predominantly of quarry debris with little slopewash apparent. Unit 18, for example, may be a product of hammering that produced "hashy" material, while Units 16 and 57 are processing debris. The separation of Horizon V from Horizon IV is based on a change to

generally finer debris and the charcoal accumulation of Unit 56. The actual time separating Horizons IV and V may have been very short. The separation of Horizon IV from III is more apparent owing to the truncation of Units 34, 35, 36, 13, and 15. Horizon III is a resumption of the deposition of coarse opalite flakes and chunks, and is composed only of Unit 14. There may be, however, some unrecognized divisions in this unit. Overlying Horizon III, the strata of Horizon II are again a mixture of slopewash and quarry debris similar to those of Horizon IV. Above these, the silty organic and charcoal rich Units 1 and 2 of Horizon I mantle the profile, representing the modern surface; charcoal probably is the result of recent brush fires. Several other units contain small bits of charcoal, particularly Unit 56. Samples were taken, but flotation failed to recover enough carbon for conventional radiocarbon dating.

Chemical profiles through selected vertical sections reveal interesting features. Profile A, of undisturbed deposits outside the pit, shows the structure of the natural soil (Figure 152). Increased leaching is indicated downwards in the profile. Eolian silts at the surface predictably show less leaching, increased carbonate, and enhancement of phosphorus. Profile B, through units of Horizon VI and VII, shows a similarly predictable trend of generally increased leaching of iron and aluminum (Figure 153). Bases, especially carbonates, increase nearing Unit 53, possibly reflecting an incipient calcic horizon formed in early deposits. The fluctuating phosphorus percentage, with increases in the coarser units, may be attributable to human origins, although such a clear distinction would be unusual. Profile C, through horizons I, II, III, IV, and V, show less developed chemical trends due, possibly, to their younger age (Figure 154). There is a slightly higher degree of leaching near Units 35 or 36 that may owe to extended exposure during a hiatus in quarrying. Unit 34 may be an early part of Horizon III rather than part of Horizon IV.

Feature 7 has suffered recent disturbance, apparently from drilling. A rectangular pit, 3 m long, 2 m wide, and 20 cm deep, was excavated in its center (cf. Figure 151). The recent pit intruded prehistoric deposits of quarry waste and opalite processing debris. The material was thrown out as backdirt onto the downslope (northern) berm of the prehistoric feature. The high surface density of debitage in the northwest quadrant is mostly the consequence of recent pit excavation.

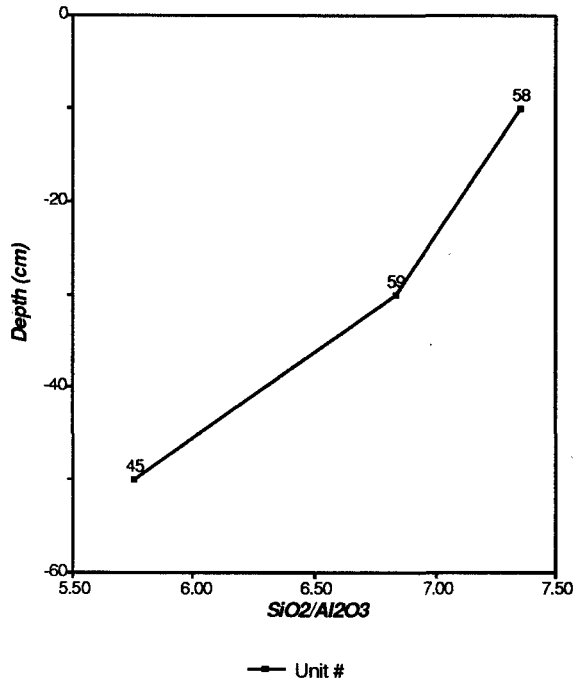
Gray drilling mud and a red slurry apparently comprised of drilling mud and drill cuttings forms a layer in the bottom of the recent pit and lenses at the surface of the pit margins. Slurry also is found in the interstices of prehistoric strata filling the pit, particularly in layers of coarse, openwork quarry debris (Units 14 and 16) on the north side. The slurry either has trickled into the lower strata from the bottom of the recent pit or has moved laterally from the drill hole.

In summary, the bedrock cavity and deposits at Feature 7 are typical of quarry pits intruding a soil cover to a horizontal bedrock surface. Individual horizons generally alternate between predominantly coarse or fine textured units. The main stratigraphic horizons appear to reflect episodes of coarse debris deposition or alternating fine and coarse deposition.

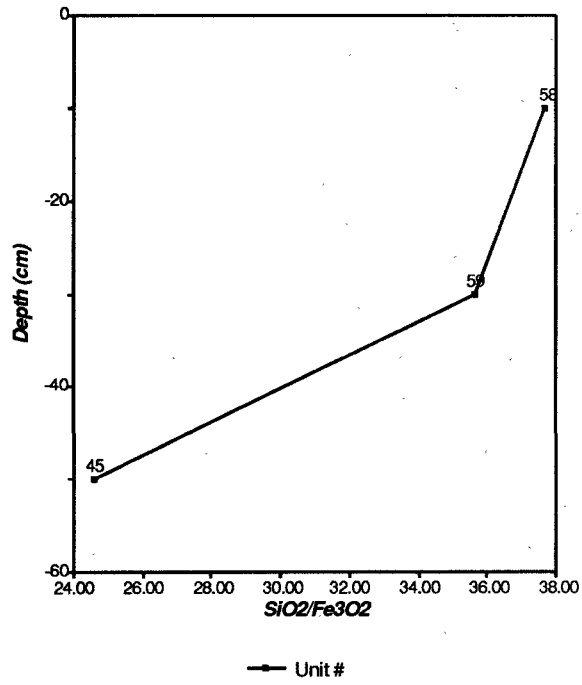
Subsequent to stratigraphic analyses, the entire contents of the depression were removed in order to expose the full extent of bedrock exploited. Upon the completion of all archaeological examination, and to address other questions, experimental quarrying was undertaken within the pit and nearby (cf. Chapter 22).

Implications

26Ek3171 appears to have witnessed behaviors similar to those carried out at 26Ek3170. Toolstone acquisition and processing produced prolific waste, much of which remains organized in cultural features. Quarry sources are more numerous, more highly developed, and, if the cobble quarry at Feature 4 is considered, more varied than those of 26Ek3170.



a.



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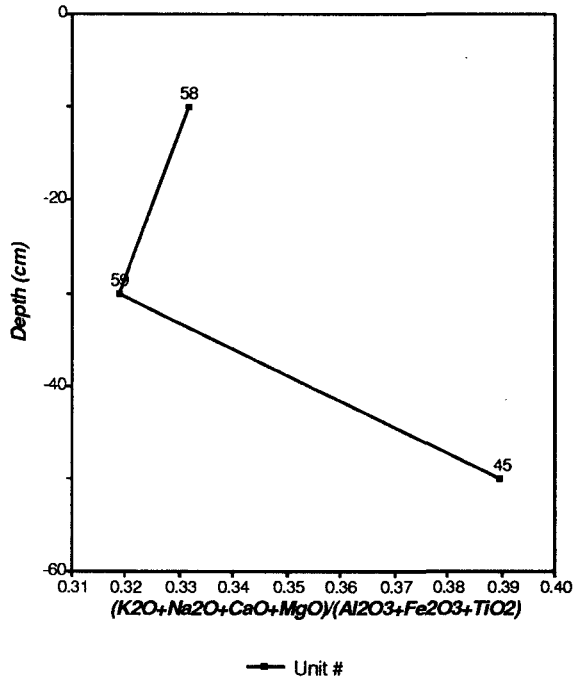

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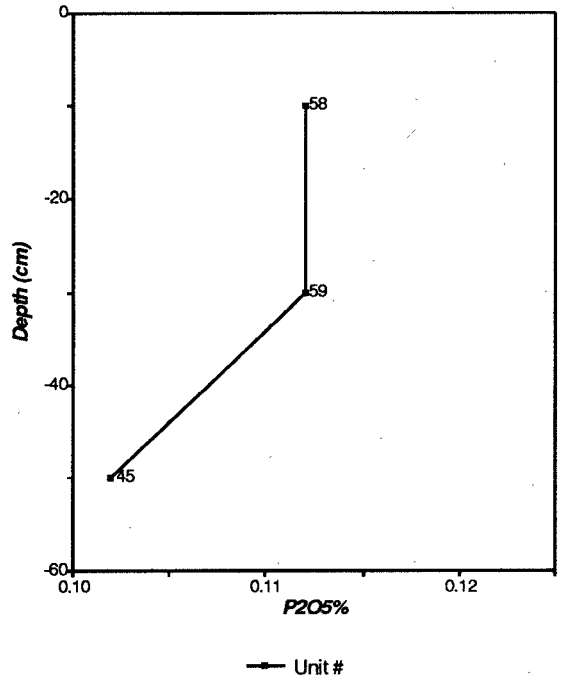
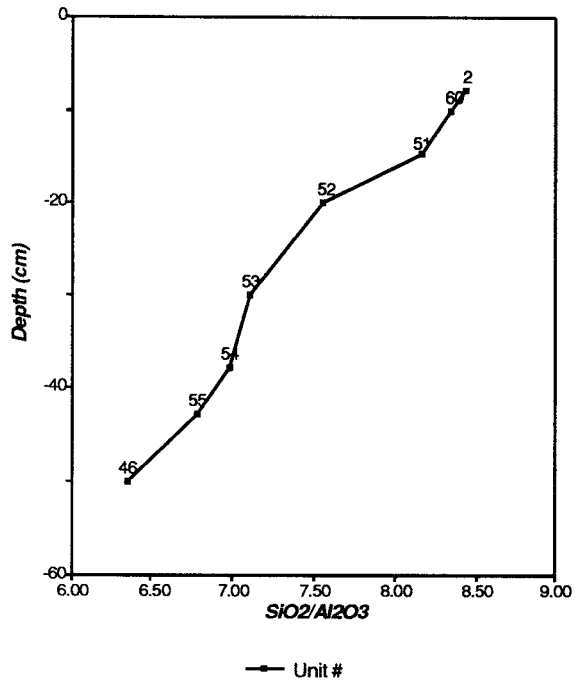


d.

Figure 152. Molecular weathering ratios for 26Ek3171, Trench 3, profile A, displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.



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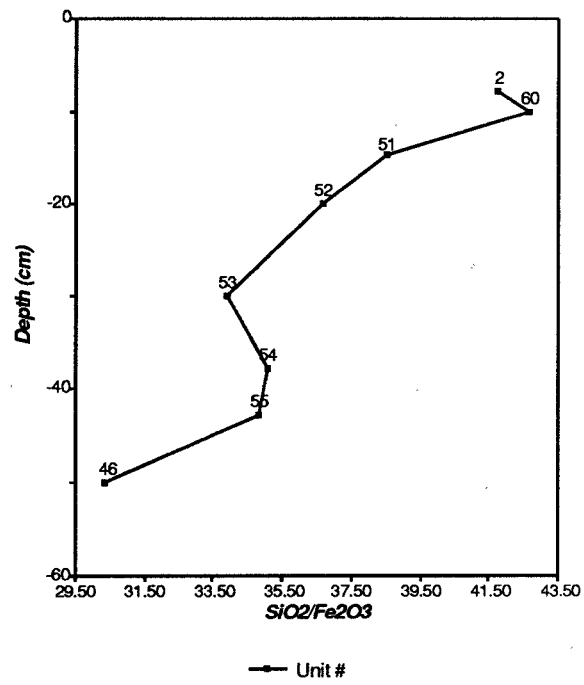

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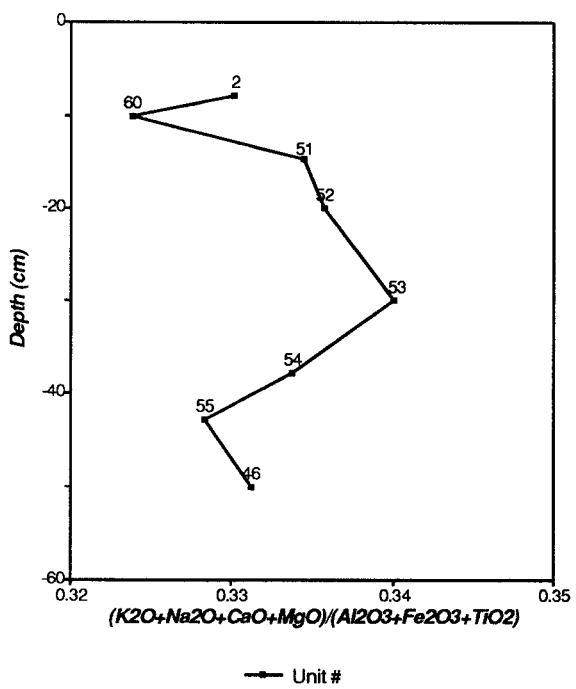

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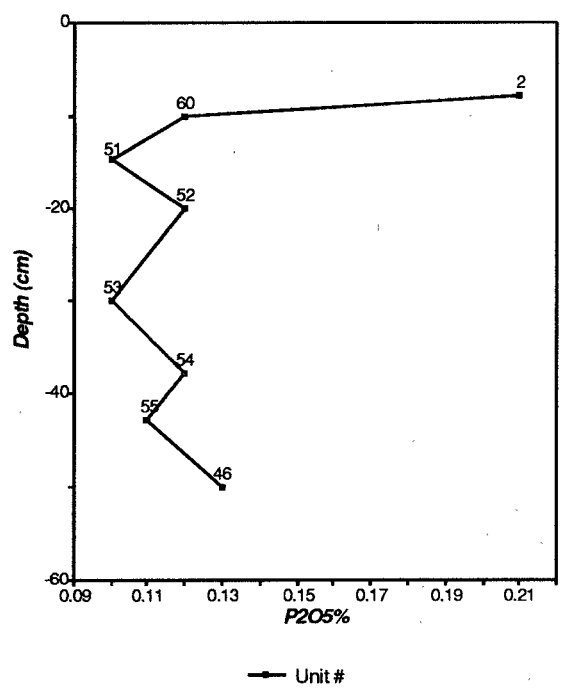
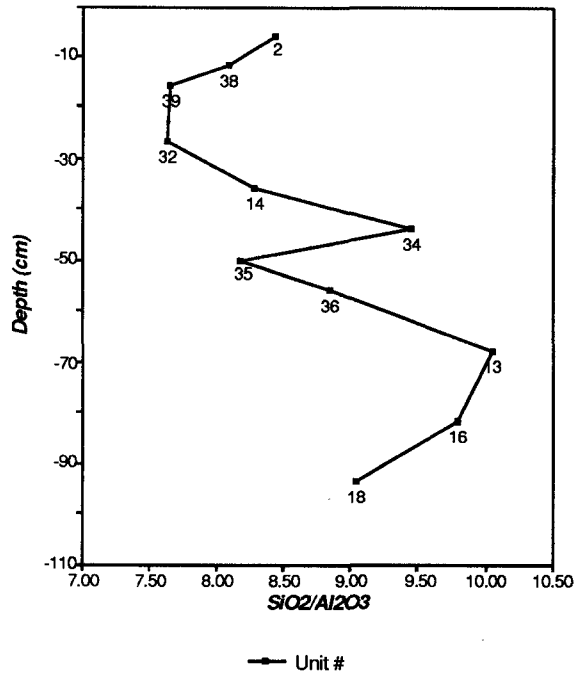
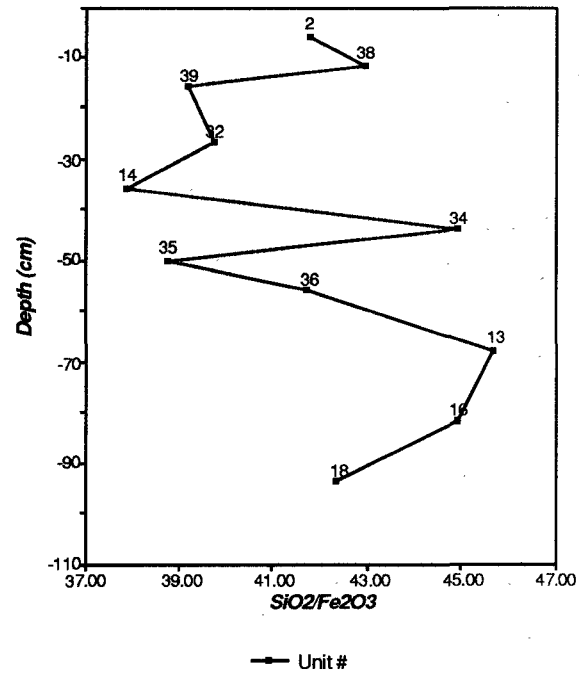


d.

Figure 153. Molecular weathering ratios for 26Ek3171, Trench 3, profile B, displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.



a.



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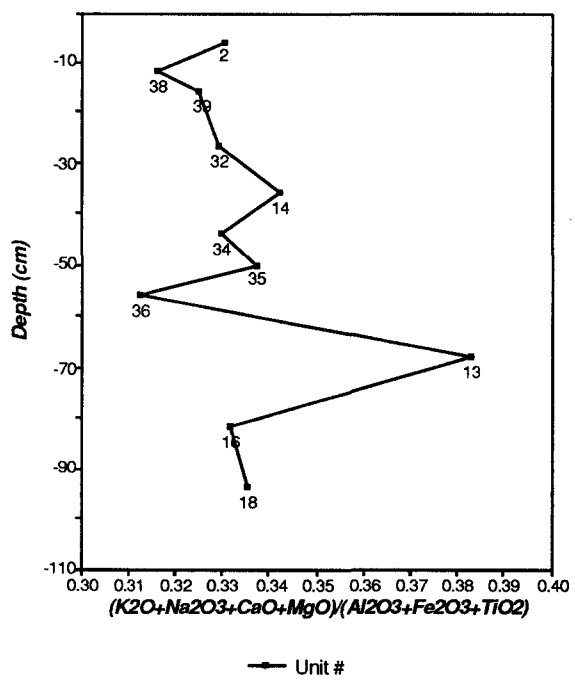

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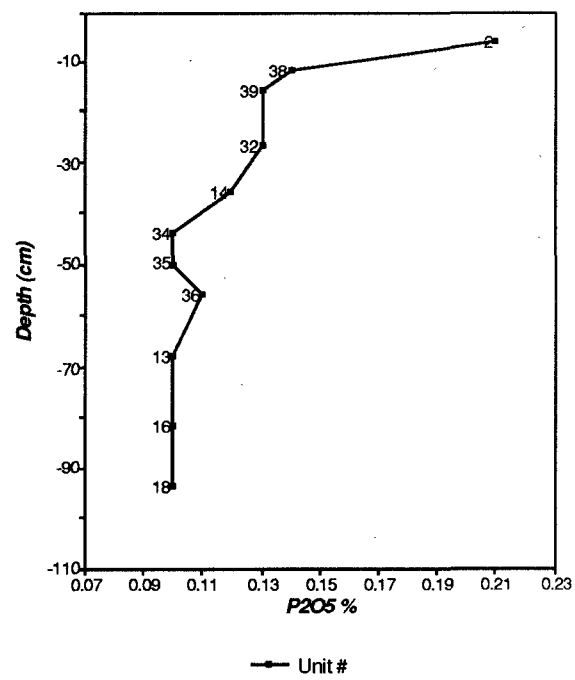


d.

Figure 154. Molecular weathering ratios for 26Ek3171, Trench 3, profile C, displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, (d) weight percent phosphorus.

Like 26Ek3170, however, nonfeature contexts in the northwestern quadrant of 26Ek3171 appear to have hosted a variety of activities; most involved processing toolstone from local as well as off-site sources, and some involved maintenance and subsistence chores. No use of this portion of the site, however, left more than the scantiest artifact accumulation.

26Ek3032/Locality 23

Locality 23 contains a pair of quarry pits. The larger (easternmost) was visible on the surface before testing. Later, in the course of trenching, a second, smaller excavation was revealed immediately west of the surface pit. The locality was selected for study owing to its apparently clear record of toolstone extraction and associated tasks. Lying wholely within the bounds of 26Ek3170, separate enumeration of Locality 23 was dictated by administrative convention. The pits and the surrounding accumulation of artifacts are prominent, however, and for the most part are reliably distinguishable from the very light lithic scatter manifest by the larger site.

The locality lies on the northwestern brink of the lowest bench of Ramadan Ridge, where the mildly inclined ridgetop gives way to steeper slopes toward Little Antelope Creek (cf. Figure 141). This break in slope (possibly a remnant terrace feature of Little Antelope Creek) appears to be controlled by the bedrock substrate, and it positions the site on a locally anomalous portion of Ramadan Ridge. In contrast to the deeper soils elsewhere on the western ridgeslope, Locality 23 occupies a zone where low, ground-hugging exposures of weathered opalite bedrock daylight sporadically from beneath a generally thin veneer of sandy colluvium covered with low sage and phlox. Tall sage is restricted almost exclusively to the quarry pit berm. Prehistoric miners probably were attracted to the place for the near-surface toolstone promised by the low outcrops.

Feature 1

Prior to testing, the quarry pit consisted of a roughly circular, mildly dished surface depression 50 cm deep and 8 m in diameter. A well developed arcuate berm, dense with quarry debris, 2 m wide and 50 cm higher than the surrounding ground, had accumulated about the western, downslope half of the pit. A dense lithic scatter of distinctive white and purple opalite covered the pit and berm and mantled the surrounding surface. These components comprised the totality of the 133 m^2 area of Locality 23, and defined sampling strata for our investigations (Figure 155).

The surface scatter proved densest on the berm top and the downslope surface. Formed artifacts include abundant bifaces (n=45), a pair of hammerstones, and a core. In addition, however, non-quarrying artifact classes proved numerous; they include three Great Basin Stemmed projectile points, an unidentified point fragment, three flake tools, and several obsidian waste flakes (Table 159).

Table 159. Artifacts Recovered from Feature 1, 26Ek3032, Locality 23.

	DEBITAGE		FORMED ARTIFACTS								
Unit Number	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Other/ Exotic	Total
1 (SF)†	3,200	36,929.6	-	-	10	5	12	3	-	-	30
2 (SF)†	6,029	13,675.6	1	1	5	1	2	-	-	-	10
3 (SF)†	8,000	25,386.4	1	-	10	3	9	-	-	-	23
Surface	-	-	4	-	45	1	3	-	2	-	55
TS	21,258	28,898.8	-	-	-	-	-	-	-	1	1
Totals	38,487	104,890.4	6	1	70*	10	26	3	2	1	119

SF = Surface Scrape
TS = Trench Samples

*Includes possible bifaces
† Includes 50 x 50 cm 1/8 inch control quadrant

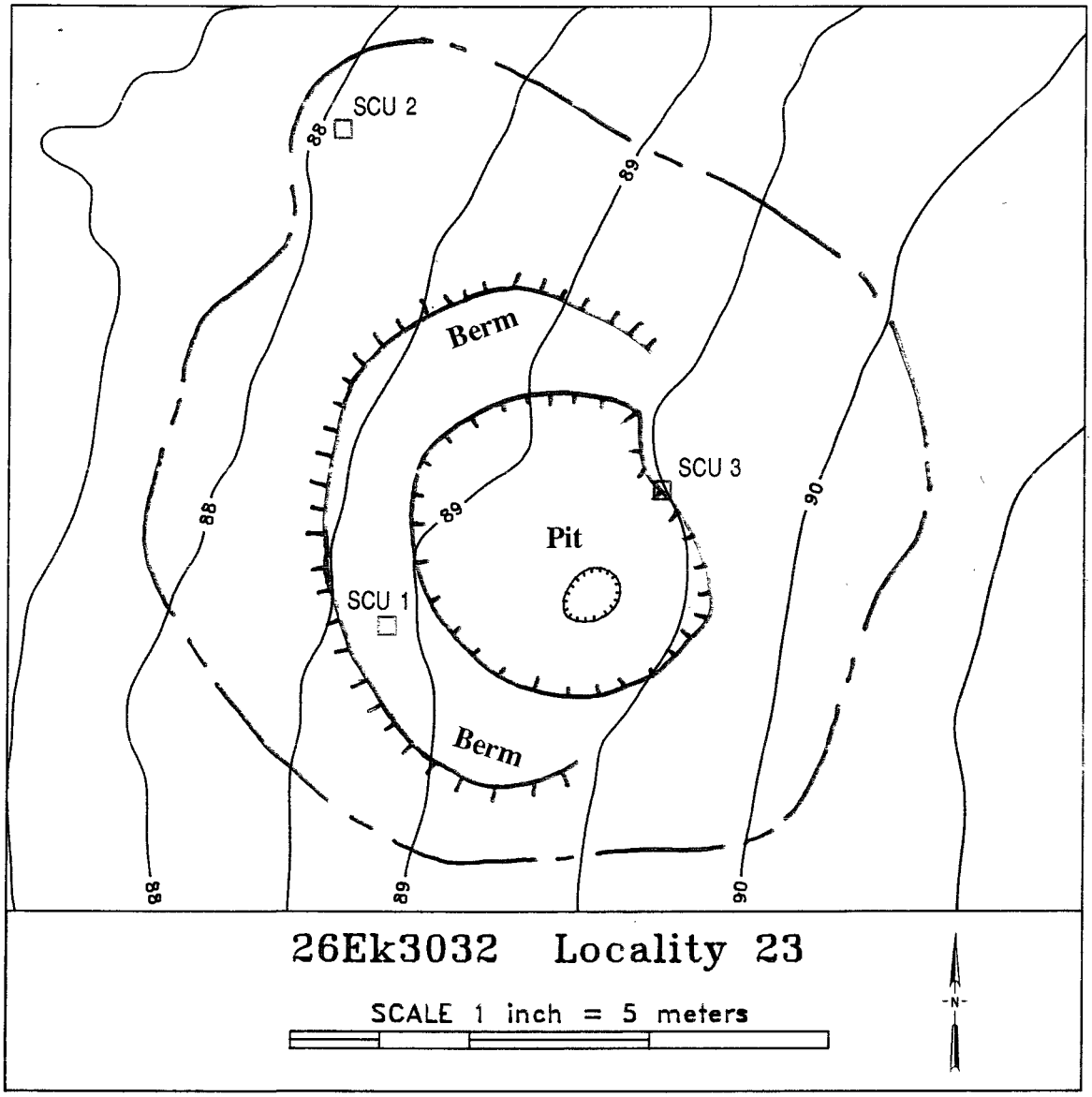


Figure 155. Locality 23 site map, 26Ek3032.

Three surface scrapes assayed the surface assemblage in greater detail. Each 1 m x 1 m unit included a 1/8 inch mesh control quadrant, and each sampled a spatially distinct component of the feature (the top of the berm, a concentration on the surface just downslope and northwest of the berm, and the upper margin of the pit; cf. Figure 155). Returns from the surface scrapes varied (Table 159).

All units returned vast quantities of opalite debitage and numerous formed artifacts. Debitage is dominated by robust specimens characteristic of quarrying and core reduction (cf. Chapter 10); the biface assemblage reflects production tasks ranging from the creation of blanks through intermediate stage reduction (cf. Chapter 6). The sample implies that on-site toolstone processing occurred directly around the pit. Cores and bifaces proved most common on the berm top, among the largest waste flakes (11.5 g average), and at the upper pit margin where they are accompanied by much smaller debitage (ca. 3 g/item). Flake tools are rare in these places. Away from the pit, the assemblage contains comparatively few formed artifacts and opalite debris of the smallest average size (ca. 2 g/item). Flake tools are scarce, but an unclassifiable projectile point, a preform, and several obsidian waste flakes suggest a variety of activities.

Other field efforts focused on the quarry pit itself. In order to expose a stratigraphic cross-section, a backhoe trench bisected the feature along its east-west axis from just above the upper margin, through the depression and berm, and into the slope below (cf. Figure 155). The worked proximal end of an antler was found in the trench backdirt; it had been used as a billet and possibly as a wedge for quarrying (cf. Chapter 14).

The stratigraphy revealed by trenching is illustrated and summarized in Figure 156. Two quarry pit features were recognized in the trench profile. They are separated clearly by a berm of intact red clay paleosol, designated Unit 32, over an in-place segment of weathered opalite and tuff bedrock. The eastern pit contains the more complex depositional record; as many as six horizons are present.

Horizon VI, comprising Units 16, 17, 19-26, and 29, alternates layers of common fine to medium opalite flakes with varying proportions of fine silts and clay matrix. Horizon VI units were truncated by an episode of re-excavation and deposition reflected by Unit 28 (Horizon V), consisting of medium to coarse opalite flakes in a sparse, brown silty matrix. Overlying Horizons VI and V, depositional Horizon III, is composed of Units 31 and 33 (brown sandy clay loams with rare opalite flakes). Horizon III is truncated at its west end and overlain by Units 14, 27 and 30 of Horizon II. Units 2-12 also belong to Horizon II.

Horizon I is a typical grayish brown, relatively organic rich, surficial silt cover. It covers most of the two quarry features, except where Unit 35 is present, probably the result of a recent range fire.

Horizons I and III overlie Horizon IV which comprises all the fill in the western quarry feature. These units are similar to those filling the eastern pit, but slightly less rich in matrix. Given the onlapping of units from Horizon III, it appears that the eastern pit was created first, then filled in part from debris excavated from the western pit.

Implications

Locality 23 served as a source of high quality, often colorful, toolstone. Flake tools and other maintenance/subsistence implements are relatively abundant as well. Perhaps the proximity of Locality 27 (a residential base immediately north) contributed to the observed assemblage complexity.

26Ek3184

Most of the low, nearly flat northern extension of Holeplug Ridge falls within the boundary of 26Ek3184 (Figure 157). Occupying some 12,680 m^2, the site is the second largest in the East. Twenty-six cultural features and an intervening lithic scatter fall within it; almost exclusively they are consequences of toolstone reduction (Table 160). Absent the quarrying debris that obscures reduction features elsewhere, features at this site reflect toolstone processing with remarkable clarity, and they offer the best opportunity in the East to study opalite reduction away from toolstone sources.

Table 160. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3184.

				FORMED ARTIFACTS								
	Total Area	DEBITAGE[a]		Proj.				Flake	Modif.	Perc./ Cobble	Other/	
Feature	(m^2)	n	wt. (gm)	Points	Preforms	Bifaces[b]	Cores	Tools	Chunks	Tools	Exotic	Total
1*	0.40	11	32.0	-	-	16	-	-	1	-	-	17
2*	2	1,989	8,797.4	-	-	1	1	1	-	-	-	3
3*	144	1,101	2,110.0	2	1	13	-	4	-	1	1	22
4	44	-	-	-	-	-	-	-	-	-	-	0
5	15	3[c]	13.1	-	-	4	-	1	-	-	-	5
6	2	-	-	-	-	1	-	-	-	-	-	1
7	1	-	-	-	-	-	-	-	-	-	-	0
8*	64	15,077	26,771.8	-	3	105	2	14	3	2	1	130
9	16	-	-	-	-	-	-	-	-	-	-	0
10	148	4[c]	13.8	-	-	10	-	1	-	-	-	11
11	16	-	-	-	-	1	-	-	-	-	-	1
12*	22	6,360	26,329.0	-	-	25	-	11	1	1	-	38
13	14	-	-	-	-	-	-	-	-	-	-	0
14*	2	2,016	3,332.7	-	-	1	3	-	-	-	-	4
15	86	-	-	-	-	1	-	-	-	-	-	1
16	23	-	-	-	-	4	-	-	-	-	-	4
17	2	-	-	-	-	-	-	-	-	-	-	0
18	50	-	-	-	-	3	-	1	-	-	-	4
19*	39	9,106	18,089.3	2	-	16	10	-	-	-	-	28
21	22	-	-	-	-	2	-	1	-	-	-	3
22	57	-	-	-	-	6	-	-	-	-	-	6
23*	63	11,868	20,120.0	-	-	36	2	12	1	-	-	51
24	177	-	-	1	-	1	-	-	-	-	-	2
25	12	-	-	-	-	-	-	-	-	-	-	0
26	112	2[c]	4.3	-	-	5	-	2	-	-	-	7
Surface Isolates	-	-	-	1	2	8	1	2	-	-	-	14
Other Nonfeature		3,103	7,280.3	1	-	16	-	8	-	-	-	25
		50,640	112,893.7	7	6	275	19	58	6	4	2	377

*Sample feature
[a]Does not include trench samples
[b]Includes "possible" bifaces
[c]Obsidian only

Soils generally are shallow, composed of a grayish brown silt loam with abundant inclusions of tuff gravels and weathered opalite fragments. On the somewhat higher eastern quadrant of the site, these deposits are overlain by thin accumulations of loess. Bedrock tuff underlies the site, and flow banded rhyolite occurs along its northeastern margin, forming the southern slope of Undine Gorge. Prehistoric quarrying occurred at only one location (Feature 20).

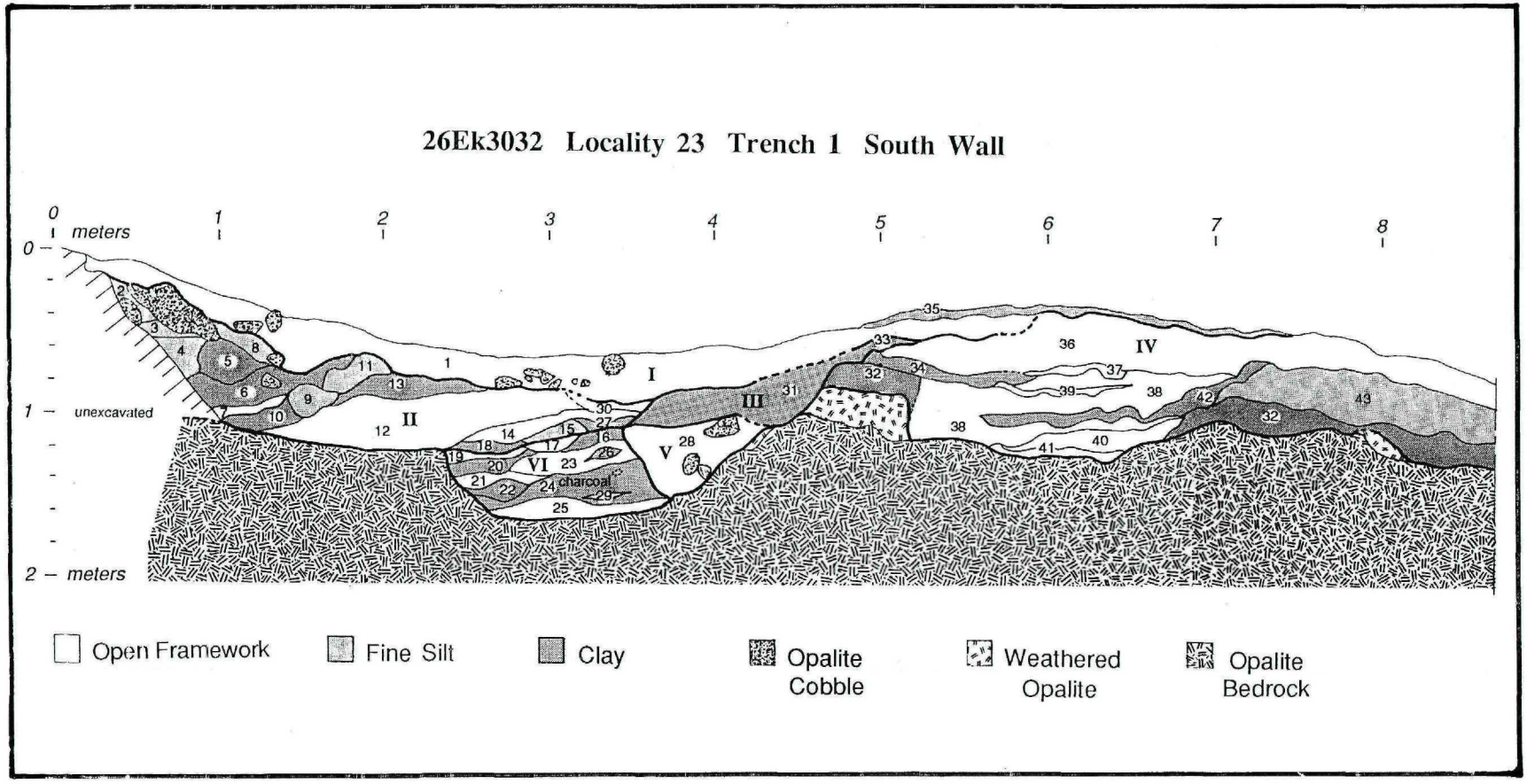


Figure 156. Description of stratigraphic units, Trench 1, 26Ek3032, Locality 23.

Figure 156. Description of stratigraphic units, Trench 1, 26Ek3032, Locality 23.

Stratum	Description
1	Grayish brown (10YR 5/2) dry; silt loam; weak to moderate granular; common pebbles and coarse cobbles; abundant fine to medium roots; common medium to coarse opalite flakes and chunks; boundary clear and smooth.
2	Reddish brown to yellowish red (5YR 4/4 to 4/6) dry; sandy clay; common fine to medium subangular pebbles; common fine roots; no cultural materials; boundary gradual.
3	Strong brown (7.5YR 4/6 to 5/6) dry; clay with coarse sand to fine gravel; common fine to medium subangular to subrounded pebbles; no cultural materials; boundary gradual and irregular.
4	Yellow (10YR 7/6) dry; silt to coarse sand with some clay; clasts from weathering tuff bedrock; no cultural material; boundary clear and irregular.
5	Dark brown (10YR 3/3) slightly moist; silty clay; weak fine granular; common medium opalite chunks and subrounded cobbles; rare clay clasts; rare medium opalite flakes; boundary clear and irregular.
6	Dark brown to strong brown (7.5YR 3/4 to 4/6) slightly moist; silty clay; strong granular to medium subangular blocky; abundant angular to subrounded coarse sand to fine pebbles; rare fine opalite flakes; rare charcoal flecks; boundary clear and irregular.
7	Moderate open framework, medium to coarse opalite chunks with some flakes; moderate matrix of silt loam clasts mixed with silty clay clasts, brown (10YR 4/3) moist; boundary clear and irregular.
8	Dark grayish brown (10YR 4/2) dry; silt loam; weak fine to medium granular; rare medium angular to subangular pebbles; abundant fine roots; rare fine to medium opalite flakes; boundary clear and irregular.
9	Brown (10YR 4/3) slightly moist; silty clay loam; common medium subangular to subrounded pebbles; no cultural material; boundary clear and irregular.
10	Dark yellowish brown (10YR 3/4) slightly moist; silty clay loam; rare medium opalite chunks; boundary clear and smooth.
11	Brown (10YR 4/3) slightly moist; silt loam; weak granular; rare medium subrounded pebbles; rare fine opalite chunks; boundary clear and irregular.
12	Strong brown (7.5YR 4/6 to 5/6) moist; compact, sand clay; abundant medium angular to subangular pebbles; common fine to coarse opalite flakes, and rare very coarse opalite flakes and cores; boundary abrupt to clear and irregular.
13	Brown (10YR 4/3) moist; clay loam; weak granular; rare medium subangular pebbles; rare fine opalite flakes and chunks; boundary clear and irregular.
14	Moderate open framework, medium opalite flakes and cores; sparse to moderate sandy clay matrix as in unit 12.
15	Brown (10YR 4/3) moist; sandy loam; common fine angular to subrounded pebbles and fine opalite chips and flakes.
16	Brown (10YR 4/3) moist; clay loam; common medium subangular to rounded pebbles; rare fine opalite flakes.
17	Moderate open framework; common, medium to coarse opalite chunks, abundant fine opalite flakes; moderate sandy clay matrix, dark yellowish brown (10YR 4/4) moist.
18	Dark yellowish brown (10YR 4/4) moist; sandy clay; common medium subangualr gravel; common fine opalite chips.
19	Moderate open framework, medium opalite flakes and chunks; moderate sandy clay loam matrix, brown (10YR 4/3) moist.
20	Dark yellowish brown (10YR 4/4) moist; sandy clay loam; common subrounded pebbles; rare to common fine to medium opalite flakes and chunks; similar to unit 12.
21	Poor open framework, medium opalite chunks and flakes; common clay loam matrix, brown to yellowish brown (10YR 4/3 to 4/4) moist.
22	Brown (10YR 4/3) silty clay; rare fine opalite flakes and chips; rare patches of red cinnabar.
23	Poor open framework, fine to medium opalite chunks and flakes; moderate to abundant silty clay matrix, brown (10YR 4/3) moist.
24	Yellowish brown to dark yellowish brown (10YR 5/4 to 4/4) slightly moist; sandy clay; common fine opalite flakes and chips; common fine subangular red cinnabar clasts; charcoal concentration as noted on profile.
25	Same as 24, except coarser opalite chunks.
26	Strong brown (10YR 4/6 to 5/6) slightly moist; sand clay; common very fine opalite flakes and chips.

Figure 156, continued.

27 Dark brown to strong brown (7.5YR 4/4 to 5/6) moist; sandy clay; rare very fine opalite chips.

28 Typical to moderate open framework, medium to coarse opalite flakes, rare medium pebbles; sparse sandy clay loam matrix, brown (10YR 4/3) moist; unit is generally finer to the west.

29 Poor open framework, fine to medium opalite chunks; common matrix as in unit 24.

30 Poor open framework, fine to medium opalite flakes; matrix of silts from unit 1.

31 Strong brown (7.5YR 4/6) moist; compact, sandy clay loam; common fine to coarse subrounded pebbles; rare fine to medium opalite flakes.

32 Strong brown (7.5 YR 4/6) moist; sandy clay; moderate to strong granular to subangular blocky; moderate clay skins of ped faces; clay becomes sandier near bedrock and fills cracks in weathered bedrock.

33 Same as unit 31, except it appears to be surface wash directed at western quarry pit.

34 Brown (10YR 4/3) slightly moist; silt loam; loose; rare subangular pebbles; common medium roots; no cultural material.

35 Very dark grayish brown to dark brown (10YR 3/2 to 3/3) slightly moist; silty fine sand; abundant organics and charcoal; common fine to medium flakes and cores.

36 Yellowish brown to dark yellowish brown (10YR 5/4 to 4/3) dry; silty fine sand; loose; abundant angular pebbles; abundant fine opalite chunks and flakes.

37 Poor open framework, fine to medium opalite flakes and chunks; common matrix as in unit 36.

38 Dark brown (10YR 3/3) moist; clayey silt loam; common to abundant angular to subrounded opalite clasts in common irregular lenses, with clasts of clay from unit 32.

39 Moderate open framework, fine to medium opalite flakes; moderate matrix as in 38.

40 Same as unit 39, except range of flake and chip size is greater.

41 Typical hash unit; occurring just above bedrock.

42 Dark brown (7.5YR 4/4) moist; reworked clay with abundant sand and silt, and fine angular opalite chunks and chips.

43 Dark grayish brown (10YR 4/2) moist; silt loam; weak granular to subangular blocky; rare fine to medium subangular to subrounded pebbles.

Nonfeature Contexts

Most of the site is littered with a light density lithic scatter of opalite waste and occasional obsidian debitage. Few formed artifacts lie within it (cf. Table 160). A series of 19 2 x 2 m surface scrapes spanned the site at 10 m intervals across its greatest dimension (cf. Figure 157); results of the exercise reflect the sparse cultural content of inter-feature contexts (Table 161). Most units yielded little, mostly opalite debitage. Contrasting retrievals were obtained only adjacent Features 20 and 10, and in a unit coinciding with a small lithic concentration.

Table 161. Artifacts Recovered from Surface Collection Units, 26Ek3184.

Unit	DEBITAGE		FORMED ARTIFACTS			
Number	n	wt. (gm)	Proj. Points	Bifaces	Flake Tools	Total
1	225	746.2	-	1	-	1
2*	-	-	-	-	-	0
3	13	11.2	-	-	-	0
4	5	2.8	-	-	-	0
5	9	15.8	-	-	-	0
6	79	82.3	-	-	-	0
7	20	37.7	-	-	-	0
8	8	34.2	-	-	-	0
9	16	35.0	-	-	-	0
10	58	58.6	-	-	-	0
11	28	84.7	-	-	-	0
12	23	161.0	-	-	-	0
13	24	54.1	-	-	-	0
14	51	52.3	-	-	-	0
15	202	239.6	1	2	1	4
16	227	368.7	-	1	1	2
17	1,127	4,344.6	-	11	3	14
18	784	691.2	-	-	3	3
19	107	109.7	-	-	-	0
20	97	140.4	-	1	-	1
Totals	3,103	7,280.3	1	16	8	25

*Unit not scraped; coincident with Feature 20

Cultural Features

All save two cultural features at 26Ek3184 are reduction stations; Feature 1 is a biface discard and Feature 20 reflects an incipient, abandoned effort at quarry pit excavation. The surface content of each feature was inventoried and four (Features 1, 2, 3, and 8) were sampled during testing. In data recovery, sampling of Feature 8 was expanded and five additional features were collected entirely. The selection of features sought to capture the full range of variation at the site, reflecting size, density of scatter, artifact diversity, and apparent reduction stage. Features 12, 14, 19, 20, and 23 were added to the analytic sample. Artifact yields of all fieldwork are summarized for each feature in Table 160.

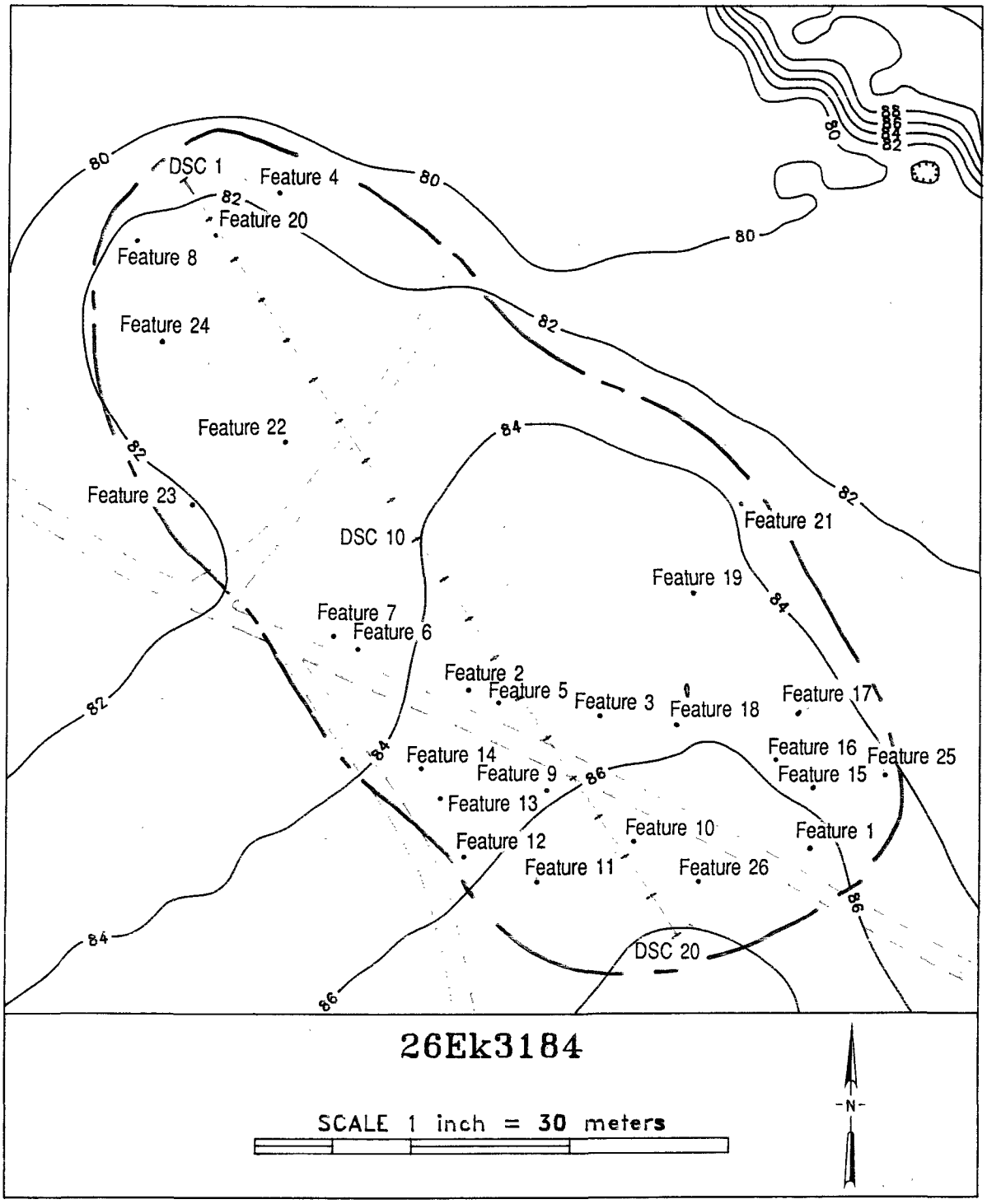


Figure 157. 26Ek3184 site map.

Feature 1

The surface of Feature 1, before we picked it up, consisted of a cluster of seven opalite bifaces and one obsidian biface adjacent a dirt road in an area otherwise devoid of cultural materials (cf. Figure 157). Surface scraping recovered eight additional opalite bifaces and paltry debitage. An excavation unit dug immediately below the scrape yielded only two additional waste flakes in 10 cm of deposit.

Each of the fifteen opalite bifaces are Stage 3 specimens. All are fragmentary (about 50% complete), roughly of similar size and shape; six were heat-treated. We suspect that the feature represents a discard pile rather than a cache; biface caches elsewhere in the Tosawihi vicinity consist almost exclusively of whole specimens. Since the biface cluster is confined to the surface (i.e. < 2 cm deep) and lies adjacent a prominent dirt road, we remain skeptical about its origin; while it may, indeed, represent a stockpile of rejects intended for redirection into smaller forms, it could as well be a pothunter's discard pile.

Feature 2

Feature 2 exemplifies the small reduction stations at the site (cf. Figure 157). It is defined by a dense 2 m^2 concentration of opalite debris with discrete boundaries. Our 4 m^2 block of surface scrape units apparently captured all material laying in primary deposition; no flakes were found below the scraped surface save in a zone of rodent disturbance. The assemblage consists almost entirely of opalite wastes indicative of core reduction, augmented by a single Stage 3 biface and a flake tool (cf. Table 160). The size of the feature and its discrete clustering of debris suggest formation during a single reduction event. That the debitage exhibits several colors of opalite leads us to infer the processing of multiple cores or biface blanks.

Feature 3

Feature 3 allowed us to sample a much larger reduction station. It covers 144 m^2 and contains several high density concentrations within the bounds of a moderate density surface scatter (cf. Figure 157). Surface inventory returned the only formed artifacts recovered from the feature, consisting of intermediate stage opalite bifaces, a hammerstone, and a variety of maintenance/subsistence tools (cf. Table 160). A discontinuous baseline of eight 50 cm x 50 cm surface scrapes spanned the feature, examining contexts within and between concentrations. Opalite debitage from early stage biface reduction and a few obsidian waste flakes constitute the assemblage. Densities observable on the surface do not necessarily reflect subsurface quantities of cultural material; areas *between* concentrations yielded densities comparable to those *within* them. The data suggest that the feature is a single, rather homogeneously dense scatter on and just below the surface, and that differential exposure falsely suggests multiple concentrations (cf. Botkin 1989:370-372).

Feature 8

Feature 8 consists of two moderately dense concentrations of opalite processing debris surrounded by a somewhat less dense lithic scatter over an area of 64 m^2 (Figure 157). A 1 m

x 20 cm cluster of nine opalite bifaces was noted atop the larger concentration. The feature was sampled on the assumption that it might represent a cache within a discrete workshop area.

One of a pair of 1 m x 1 m excavation units was centered on the biface cluster and the entire surrounding surface was collected in 28 scraped 1 m x 1 m units. These efforts accumulated a large and diverse assemblage of formed artifacts (cf. Table 160).

Surface scrapes recovered 13 opalite bifaces from the cluster; 20 additional specimens were recovered during subsequent excavation immediately below the scrape. Deposits below a depth of 10 cm were marked by an abrupt reduction in cultural content; these contexts returned sparse opalite waste and a single flake tool. Excavation was halted 20 cm below the surface. The cluster is more diffuse than other observed biface caches, and the loose, rodent-churned, sandy loams within the excavation units failed to clarify its depositional context. We were unable to discover if the pieces had been buried in a shallow pit or merely discarded on the surface and partially covered by natural soil processes. The scatter otherwise is a generally homogeneous, dense accumulation of opalite debitage; 61 bifaces, other reduction-related artifacts, numerous flake tools (n=11), and a pair of preforms were found as well.

Feature 8 is noteworthy on several counts. The biface assemblage is large (n=100), and represents a wide range of toolstone processing tasks (cf.Chapter 6). Most bifaces (n=86) are Stage 3 specimens; Stage 2 and Stage 4 reduction are represented only by 11 and one specimen, respectively. About half the bifaces (n=46) have been heat-treated. The opalite debitage is dominated by debris reflecting early stage biface reduction; that portion subjected to technological analysis (Chapter 10) reveals the highest incidence of heat-treatment observed in the Eastern Periphery.

Feature 12

Feature 12 is an homogeneous, 22 m^2, moderate density scatter of opalite reduction debris. It lies in the southeastern portion of the site, where a shallow loess deposit has accumulated to a depth of several centimeters (cf. Figure 157). A close-set pair of complete opalite bifaces near the center of the scatter prompted sampling in hopes that they represented a partially exposed biface cache.

The surface of the scatter was recovered by scraping a block of 18 1 m x 1 m units; a third complete biface was found immediately below the surface specimens. To explore further, a 1 m x 50 cm excavation unit was centered on the location of the three bifaces; no additional specimens were encountered, but scant quantities of opalite debitage were found to a depth of 25 cm. A second 1 m x 50 cm unit probed deposits contiguous to the original unit. One additional complete biface was recovered from the upper 2 cm of the deposit, and three more were exposed in a loose cluster immediately below. Only small quantities of opalite debitage were recovered at greater depth.

The origin and depositional context of the biface cluster remain ambiguous; it is unclear whether it constituted a cache. All seven specimens were confined to the loess deposit, and no evidence of intentional burial was observed. The pieces are, however, complete and unbroken, a condition encountered only rarely outside of caches. On the other hand, unlike caches recorded elsewhere, the bifaces in Feature 12 lay in disarray; only the three surface specimens touched one another, while the remainder were scattered both vertically and horizontally. Perhaps, as at Feature 8, the cluster represents a dispersed cache, its dispersal the product of post-depositional processes.

Aside from the biface cluster, the feature is typical of other reduction stations sampled throughout the project area. Opalite debitage makes up the bulk of the assemblage, and

displays characteristics chiefly of core reduction; heat-treated waste occurs in only minuscule amounts (cf. Chapter 10). The total biface assemblage (n=24) is dominated by Stage 3 specimens (n=18), but it includes biface blanks and incipient reduction stages as well (cf. Chapter 6). Flake tools are numerous and diverse (cf. Table 160).

Feature 14

Feature 14 lies 15 m west of Feature 12 at the southern margin of the site (cf. Figure 157). Covering only 2 m^2, it consists of a single, dense concentration of opalite waste punctuated by a single biface fragment. It was selected for sampling to represent the class of small reduction feature displaying very sparse formed artifacts. Six 1 m x 1 m surface scrape units removed the entire feature. The exercise revealed that the apparent surface extent accurately predicted its configuration in the upper 2 cm of deposit. Four units centered on the concentration returned virtually all the cultural material recovered; units beyond the concentration yielded only minor traces of debitage. The sparse surface artifact assemblage was mirrored in the units. Debitage constitutes nearly the entire return, supplemented only by the surface biface and a few flake tools (cf. Table 160). The biface (a Stage 3 specimen) and the small, sparse debitage suggest that the feature was a product of early biface reduction, perhaps a single reduction event.

Feature 19

Feature 19 occupies 39 m^2 on the northeastern quarter of the ridge top, in relative isolation from most other features (cf. Figure 157). It is defined by two dense, close-set concentrations of reduction debris, the larger (10 m^2) designated Feature 19A, the smaller (2 m^2), Feature 19B. Although the concentrations are dominated by opalite debitage, numerous formed artifacts and an abundance of obsidian is visible on the surface of each; they are particularly numerous on the surface of Feature 19A, and their prevalence in both led us to sample the feature to clarify the apparent diversity of activities represented.

Both concentrations were collected in their entirety; 12 1 m x 1 m units were scraped at Feature 19A, and four at Feature 19B. The concentrations were revealed to be confined to the upper 2 cm of deposit and the opalite debitage recovered from each reflects chiefly early stage biface production (cf. Chapter 6). The concentrations exhibit similar artifact assemblages, differing primarily in the incidence of obsidian. Feature 19A returned seven opalite bifaces, four flake tools, and two projectile points (an opalite Desert Side Notched and a non-diagnostic obsidian specimen). Obsidian waste flakes are especially abundant (n=66). Feature 19B yielded four opalite bifaces, an obsidian biface, six flake tools, and a pair of obsidian waste flakes. All the bifaces are intermediate reduction products (Stage 3).

Feature 20

Feature 20 represents a very incipient attempt at quarry pit excavation; it is the only quarry feature at 26Ek3184. Lying near a break in slope at the western margin of the site, it consists of a faint, shallow depression, ca. 5 m in diameter, fringed along its downslope edge by a weakly developed low berm (Figure 158). A moderate density scatter of quarry debris overlays and surrounds the pit, encompassing an area of 156 m^2. The surface was sampled by a cruciform of 19 1 m x 1 m surface scrape units arrayed along two baselines intersecting at

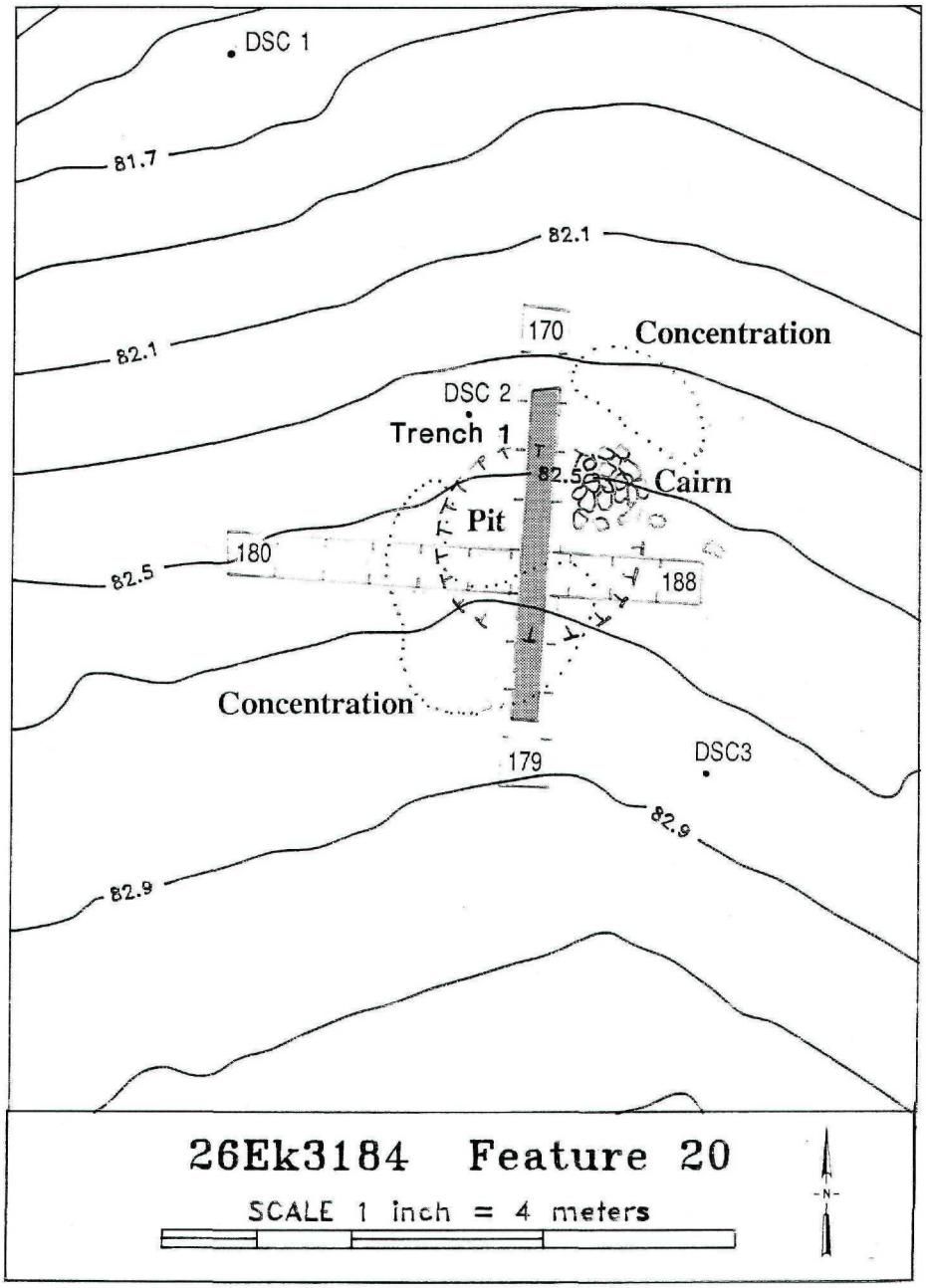


Figure 158. Feature 20 plan, 26Ek3184.

the center. Unit yields reveal a homogeneous, spatially undifferentiated deposit consisting almost exclusively of low quality opalite debitage, much of it angular shatter and waste flakes characteristic of core reduction. Formed artifacts are few; several bifaces and cores, and a single flake tool constitute the entire assemblage (cf. Table 160).

Following surface collection, the pit was bisected by a hand excavated trench (Trench 1) and the stratigraphic section revealed was drawn and described. The trench exposed a very small, shallow quarry pit with a simple stratigraphy of three units (Figure 159). The tuff bedrock contains a few pockets of opalite, but otherwise is not toolstone. Unit 3, filling the pit, contains cobbles, flakes, and cores of fine-grained bluish gray tuff; some isolated flake lenses are also present. Only Unit 3 contains quarry debris. Minor silt lenses among the coarser debris suggest possible multiple episodes of filling. The absence of Unit 3 in the western wall of the trench indicates that the center of quarrying activity was east of the trench. The hash commonly found in the bottoms of quarry pits is not present.

Unit 2 is a reddish clay paleosol washed into the pit but undisturbed outside its boundaries. Its presence at the bottom indicates that clay deposition took place before the deposition of Unit 3. Embedded in the surface of Unit 2 outside the pit are cobbles and boulders of fine grained, poorly silicified tuff. This may have invited prehistoric quarrying by promising better quality toolstone below. The clasts may represent a lag, but their origin is obscure.

Unit 1 is the typical, grayish brown silt loam that mantles much of the surface of the Tosawihi vicinity. It also contains large clasts of bluish-grey tuff.

Feature 23

Feature 23 is located at the southern edge of the site (cf. Figure 157). It covers some 63 m^2 with a moderate to high density scatter of opalite and artifacts. The latter, principally opalite bifaces, are uncommonly abundant; because of this, and a debitage accumulation reflecting a wide range of reduction stages (cortical flakes, simple interior flakes, biface thinning flakes), the feature was selected for sampling. Twenty-five 1 m x 1 m surface scrape units collected the central portion, and one scrape was continued as an excavation unit in the area of greatest artifact density.

Surface collection revealed a generally homogeneous distribution of cultural material. The excavation unit disclosed that the bulk of the feature resides in the upper 2 cm of the deposit; lower levels contain sparser cultural material, gradually diminishing with depth until bedrock is reached at ca. 30 cm. Subsurface soils are intruded heavily by rodent burrows and sage roots, and the resultant mixing probably accounts for the buried cultural deposits.

Although accompanied by numerous flake tools, the assemblage overwhelmingly reflects biface reduction (cf. Table 160). Debitage characteristic of early stage biface reduction predominates, but this emphasis is meager among the artifacts; it is represented only by two Stage 2 bifaces, a pair of cores, and a modified chunk. By contrast, most (n=33) of the 36 bifaces are intermediate stage forms (Stage 3). This discrepancy between debitage and the biface assemblage probably is a reflection of the stage at which bifaces most commonly fail during manufacture (cf. Chapter 21). The assemblage suggests that opalite arrived at Feature 23 in the form of cores (or perhaps blanks), and that these were rendered into at least early Stage 3 bifaces. Bifaces recovered by us represent unsuccessful events in this process, while specimens successfully reduced into incipient intermediate forms evidently were transported elsewhere.

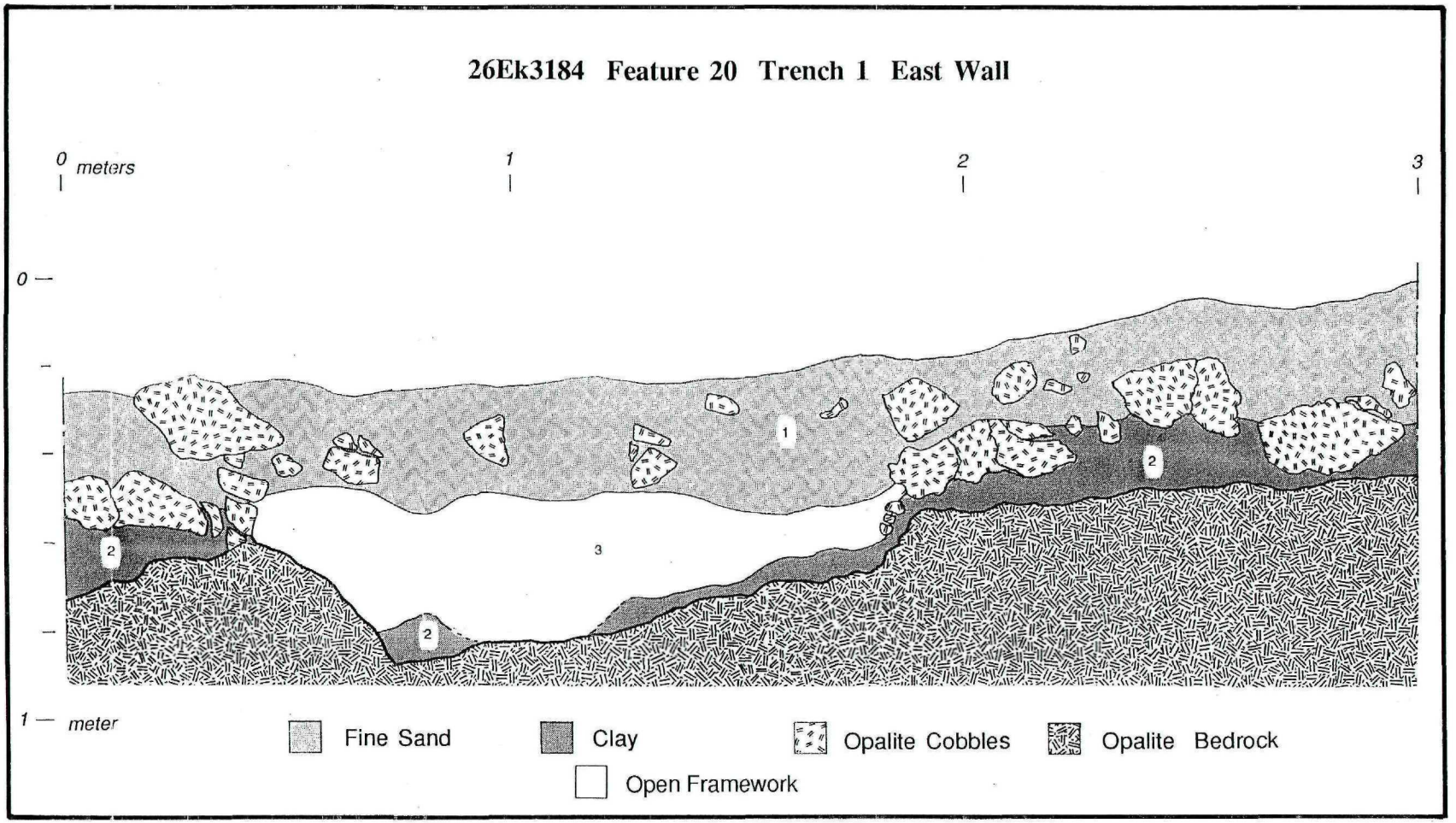


Figure 159. Description of stratigraphic units, Trench 1, 26Ek3184, Feature 20.

Figure 159. Description of stratigraphic units, Trench 1, 26Ek3184, Feature 20.

Stratum	Description
1	Light brownish gray (10YR 6/2) dry; silt loam; loose to weak granular; common opalite flakes and tuff cobbles; abundant fine and medium roots; boundary clear to gradual and irregular.
2	Dark brown (7.5 YR 4/3) slightly moist; sandy clay; strong granular, possibly reworked; common weathered opalite and tuff clasts from bedrock.
3	Moderate open framework with common bluish green tuff clasts and rare opalite flakes; common matrix of dark brown to brown (7.5 YR 4/2 to 10YR 4/3) slightly moist, less matrix in western profile indicating that the center of the pit is to the west.

Implications

The archaeological record at 26Ek3184 appears to have accrued primarily as a product of processing opalite toolstone from off-site sources. Concentrations of whole bifaces at Features 8 and 12 may reflect interim storage; as well, Feature 8 preserves a possible heat-treatment station (cf. Chapter 10). The only quarry feature within the site (Feature 20) seems to have been little used and soon abandoned; its raw material is of considerably lower quality than that found at reduction stations throughout the site. The variety of formed artifacts and the abundance of obsidian flakes recovered from reduction features imply other chores, as well.

26Ek3195

26Ek3195 is located on the southern margin of Undine Gorge, on a broad knoll at the foot of Corral Fan (cf. Figure 141). Covering 9425 m^2, it is the largest quarry site outside Ramadan Ridge. It encompasses the entire knoll top as well as its northern and western flanks, and contains four quarry pits, three outcrop quarries, and a reduction station (Figure 160). Despite its size, 26Ek3195 returned one of the Eastern Periphery's most depauperate formed artifact assemblages (Table 162).

Table 162. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3195.

		DEBITAGE[a]		FORMED ARTIFACTS			
Feature	Total Area (m^2)	n	wt. (gm)	Bifaces[b]	Flake Tools	Perc./ Cobble Tools	Total
1*	245	171	1,011.6	2	1	-	3
2*	143	452	2,972.1	12	2	2	16
3	86	-	-	3	-	1	4
4*	49	-	-	1	-	-	1
5	50	-	-	4	-	-	4
6	132	-	-	3	-	-	3
7	132	-	-	4	-	3	7
8	795	-	-	2	-	-	2
Surface Isolates	-	-	-	15	1	-	16
		623	3,983.7	46	4	6	56

*Sample Feature
[a]Does not include trench samples
[b]Includes "possible" bifaces

Nonfeature Contexts

During testing, the eight cultural features were isolated from a dense accumulation of opalite waste that literally paves the entire surface of the site. Most of the knoll outside feature boundaries appears to have served as a cobble quarry of variable quality opalite, and is strewn with hundreds of assayed cobbles, large flakes, and shatter. Underlying the amorphous scatter is a thin sandy colluvium. Low bedrock exposures of silicified tuff or sinter are extensive. Formed artifacts are rare in nonfeature contexts, consisting exclusively of early and intermediate stage opalite bifaces (cf. Table 162).

Cultural Features

Cultural features occur in all site contexts. Two shallow quarry pits (Features 3 and 4), three outcrop quarries (Features 1, 6, and 8), and Feature 5, the sole reduction station occupy the

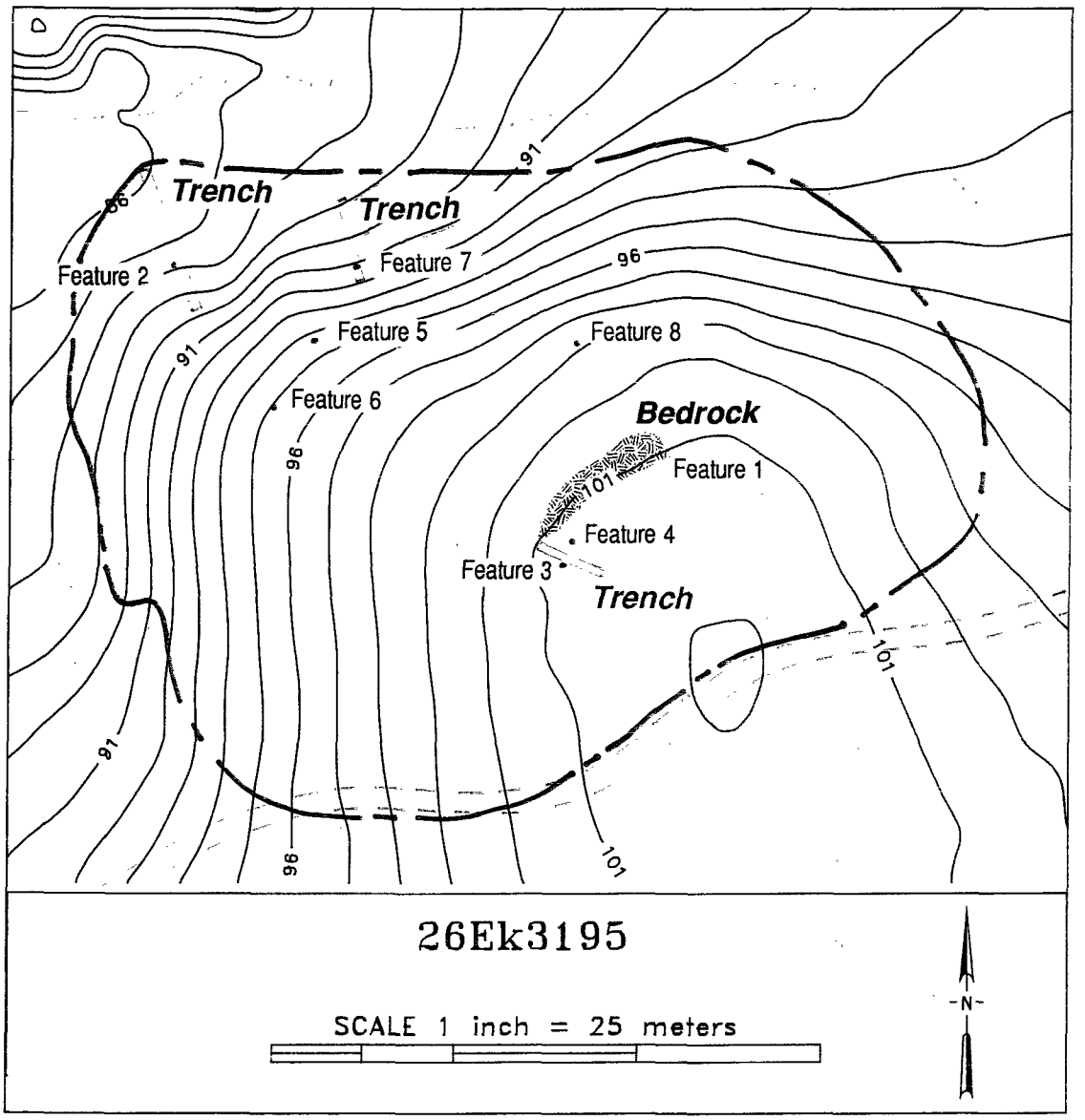


Figure 160. 26Ek3195 site map.

knoll top. Near the base of the knoll at the northern periphery of the site occur two additional quarry pits (Features 2 and 7). Both are deeper and more densely littered with quarry debris than those higher on the knoll. All features are dominated by opalite processing debris; none contains non-opalitic lithic materials, and all contain few formed reduction artifacts. Only two flake tools were encountered in Features 1 and 2 (cf. Table 162). During data recovery, work was expanded at Feature 2, and two additional quarry pits (Features 4 and 7) were trenched. Owing to its similarity to the profile of Feature 2, Feature 7 was eliminated from the analytical sample and is omitted from further discussion.

Feature 1

Feature 1 is an outcrop quarry and associated reduction area occupying 245 m^2 on a prominent opalite exposure on the knoll top (cf. Figure 160). Quarrying focused on both the outcrop and the material from the adjacent surface. Unlike the generally superior toolstone comprising the debitage, source material remaining in situ appears of inferior quality, suggesting that the better opalite was exhausted. A series of five surface units was scraped; the cultural content of the dense debris scatter surrounding the outcrop proved to be low (cf. Table 162; Botkin 1989:310-311). From the character of the debitage we infer that most of it derived from core reduction (cf. Chapter 10); the pair of bifaces recovered are early (Stage 2) reduction forms (cf. Chapter 6).

Feature 2

Feature 2, a 4 m diameter quarry pit and affiliated debris, is like many Tosawihi quarry pits; it lies at the base of a bedrock exposure, is surrounded by a berm, and has generated a downslope talus of debris (Figure 161). We sampled it because of its "typical" appearance. During testing, 13 surface scrape units bisected the feature, sampling the full complement of microtopographic surface contexts. Units returned debitage derived principally from core reduction and a formed artifact assemblage consisting of early and intermediate stage bifaces, a scraper, and a hammerstone (Table 163).

Table 163. Artifacts Recovered from Feature 2, 26Ek3195.

		DEBITAGE		FORMED ARTIFACTS			
Unit No. (Type)	Surface Scrape (m^2)	n	wt. (gm)	Bifaces	Flake Tools	Perc./ Cobble Tools	Total
1 (SF)	0.063	21	112.6	-	-	-	0
2 (SF)	0.063	4	4.3	-	-	-	0
3 (SF)	0.063	33	257.3	-	-	-	0
4 (SF)	0.063	60	472.9	-	-	-	0
5 (SF)	0.063	39	116.0	-	-	-	0
6 (SF)	0.063	33	85.1	-	-	-	0
7 (SF)	0.063	41	153.2	-	-	-	0
8 (SF)	0.063	1	0.2	2	-	-	2
9 (SF)	0.063	36	521.6	3	-	-	3
10 (SF)	0.063	180	1,247.9	-	1	-	1
11 (SF)	0.063	3	0.4	-	-	-	0
12 (SF)	0.063	-	-	-	-	-	0
13 (SF)	0.063	1	0.6	-	-	-	0
Surface Inventory	N/A	-	-	6	-	2	8
Trench Samples	N/A	44,265	38,620.6	1	1	-	2
Totals	0.819	44,717	41,592.7	12*	2	2	16

(SF) = Surface Scrape *Includes "possible" bifaces

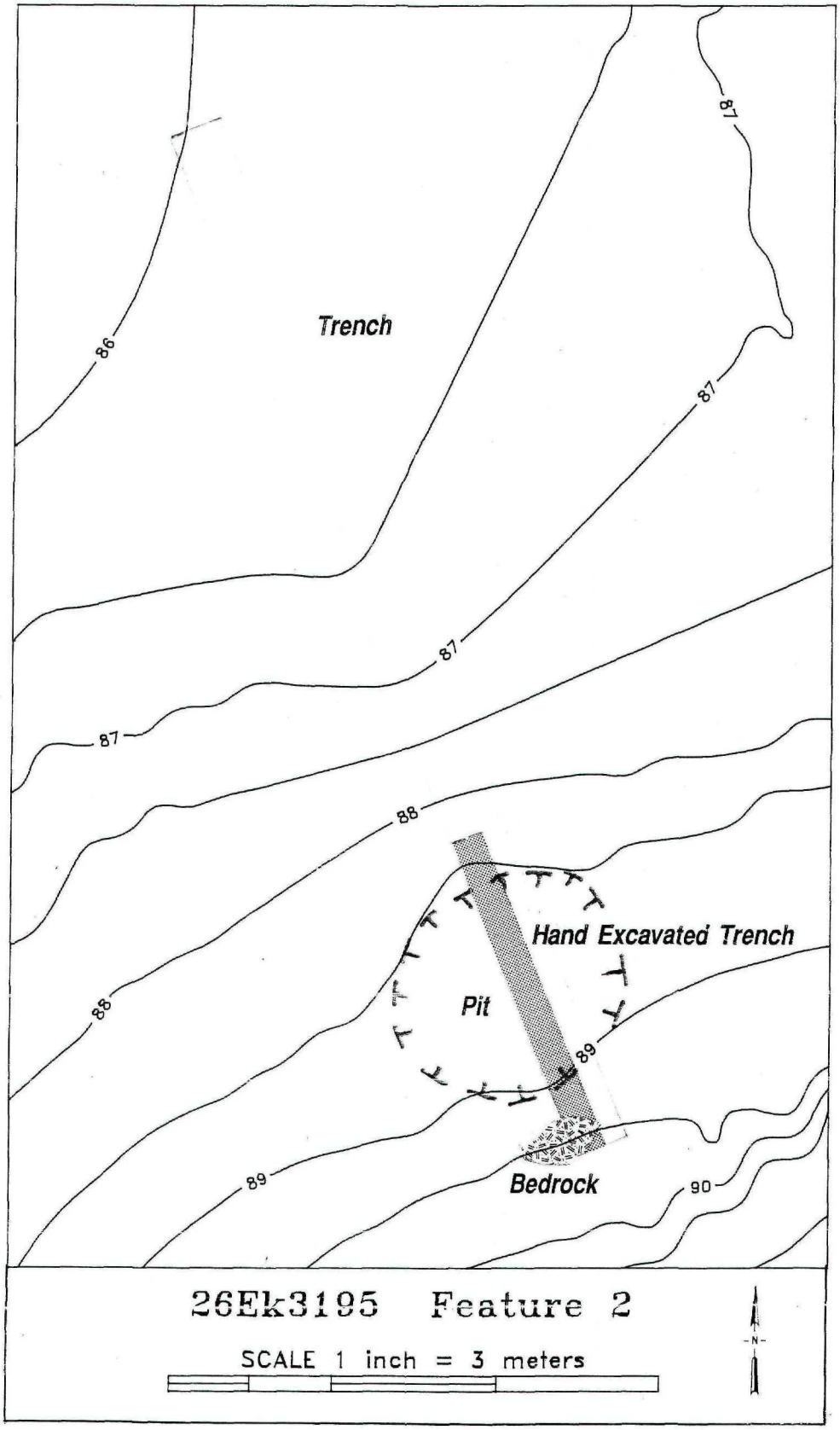


Figure 161. Feature 2 plan, 26Ek3195.

A hand-dug trench was excavated along the surface collection transect. It revealed stratified, charcoal-rich deposits to a depth of over a meter, and unearthed a prehistoric adit tunnelled into the bedrock face. However, it failed to expose the full vertical and horizontal dimension of the feature (Botkin 1989:313-315). More complete exposure was afforded during data recovery; a backhoe enlarged the original trench (Trench 1) and excavated a spur trench (Trench 2) at the base of the bedrock exposure (Figure 161).

Trench 1 exposed the underlying quarried bedrock and more of the small adit. Because of slumping and subsequent retrenching, the west wall of the enlarged Trench 1 lay approximately 20-30 cm farther west than the previous hand dug profile, and the trench was lengthened to extend downslope, into a moderately well developed soil profile. Trench 2 intersected Trench 1 along a roughly southwest-northeast axis approximately 2.0 meters northwest of the bedrock face, providing a three dimensional view of the strata. The adit at the southeast end continues along the outcrop face to the east, and almost certainly more unexposed quarried cavities lie in the bedrock. To the west, the adit ends a short distance beyond the profile face. The outcrop face probably was worked back to the south and downward to its present configuration. The horizon numbering of the original hand dug trench has been retained (Figure 162).

Horizon V is comprised mostly of Unit 43, a poorly sorted, moderately compact mixture of clayey silt loam with common pebbles and rare to common opalite chunks. It consists chiefly of colluvially derived deposit. These deposits, however, also fill a fairly large cavity quarried into the bedrock, beginning about 1.5 meters along the Trench 1 profile. Unit 48 lies on bedrock in the bottom of the pit below Unit 43, and is a poor open framework of opalite chunks composed mostly of quarry debris. Perhaps Unit 43 within the pit fill is washed material slumped into the pit from the berm.

Horizon IV also partly fills the large central pit. A charcoal accumulation at the bottom of the pit, in Unit 28, is dated to 500±80 years B.P. (Appendix L). The southern extent of Horizon IV is unclear, but a younger radiocarbon date of 320±50 years B.P. in Unit 21 of Horizon II indicates that Unit 20 perhaps is not part of Horizon IV, thus suggesting that Horizon IV ended somewhere near the middle of the central pit.

Horizon III is composed mainly of the framework Units 19, 26, and 42, and the finer Unit 25. Units 19 and 42 are probably equivalent; both directly underlie the distinct, clean silty Unit 18. Although the deposits mainly overly the central pit, they are probably associated with southward quarrying of the vertical bedrock face. A radiocarbon date of 360±60 years B.P. from charcoal in Unit 42 (Appendix L) fits well between dates from Horizons II and IV, although the degrees of error overlap.

Horizon II deposits fill the adit in the southern bedrock face with alternating moderate to typical open frameworks of medium to coarse opalite chunks and flakes, and hashy units of mixed sand, silt, and fine opalite chips. The coarse units clearly derive from quarrying. The finer units may have been formed during hammering and bashing of the bedrock during quarrying, or from slopewash mixing of soil and finer quarry refuse, or both. The Horizon II units in Trench 1 generally dip into the outcrop, while in Trench 2, they lie close to horizontal. A shaped stone disk was found in the open framework of Unit 11 of this horizon.

The poorly sorted gray brown pebbly silts and fine to medium opalite chunks of Horizon I appear colluvially derived. They extend only 2.5 meters downslope from the opalite outcrop.

Feature 4

Feature 4, located on the knoll top, consists of a single, roughly circular 4 m diameter depression ca. 10 cm deep (cf. Figure 160). Unlike most other such features, no berm could be

Figure 162. Description of stratigraphic units, Trench 1, 26Ek3195, Feature 2.

Stratum	Description
1	Grayish brown to brown (10YR 5/2 to 5/3) dry; silt loam, vesicular, loose to weak fine granular; common fine to medium subangular pebbles, sometimes in vague pebble lines; common fine roots; rare lenses of medium weathered subangular opalite chunks; boundary gradual to clear.
2	Light brownish gray (10YR 6/2) dry; silt loam; less vesicular and more compact than unit 2; weak angular blocky; abundant fine to medium pebbles and common fine opalite chunks; boundary clear and irregular.
3	Poor open framework, medium to coarse opalite chunks; common silt loam matrix as in unit 2.
4	Same as unit 2, except for a weak subangular blocky structure and more abundant pebbles and opalite chunks.
5	Same as unit 2.
6	Moderate open framework, very fine and fine opalite and tuff chunks; moderate silt loam matrix as in unit 2.
7	Moderate open framework, medium to coarse opalite and tuff chips chunks and flakes, clasts become more flake dominated to the north and more uniformly subhorizontal; moderate sandy silt matrix, brown (10YR 5/3) dry, becoming more common to the north.
8	Similar to unit 7. except for more sandy silt matrix.
9	Fine hash; grayish brown to light brownish gray (10YR 5/2 to 6/2) sandy silt; abundant fine opalite chips; notable charcoal concentration at south end of unit.
10	Moderately compact, fine poor open framework, hashy, very abundant very fine to fine opalite and tuff chips; common pulverized tuff with silt matrix, light gray (10YR 7/2) dry.
11	Typical to moderate open framework, medium to very coarse opalite chunks with medium to coarse opalite flakes; sparse matrix at coarsest center of unit becoming more common at margins, fine sand to pebbles size opalite and tuff chunks with silt, light gray (10YR 7/2) dry.
12	Fine, poor to moderate open framework, hashy, fine to medium opalite and tuff chips; common silty sand matrix, grayish brown (10YR 5/2) dry.
13	Similar to unit 12, except distinctly coarser with more medium size chips.
14	Same as unit 12.
15	Typical to moderate open framework, medium opalite chips and chunks; sparse silty sand matrix, light brownish gray (10YR 6/2) dry.
16	Fine hash of fine opalite chips with silty sand, light brownish gray to pale brown (10YR 6/2 to 6/3) dry.
17	Typical open framework, very fine to coarse opalite chips and flakes; very sparse pulverized opalite and tuff matrix; rare fine rhyolite chips.
18	Coarse hash; brown (10YR 5/3) dry; firm, compact, slightly vesicular, clayey silt; common fine to medium, angular to subangular opalite pebbles; common fine roots.
19	Typical open framework, medium to coarse opalite and tuff chunks, and medium opalite flakes; very sparse matrix as in unit 26.
20	Same as unit 18, except more abundant medium opalite chunks.
21	Typical fine hash of very fine to fine opalite chips with clayey sandy silt, grayish brown (10YR 5/2) dry.
22	Moderate open framework, fine to medium opalite chunks, chips and flakes; sparse opalite sand and silt, brown (10YR 5/2) dry.
23	Typical hash, common very fine to fine opalite chips, rare medium chips, pulverized opalite and tuff, silt, brown (10YR 5/2) dry.
24	Fine to medium chunks of tuff and some opalite in an abundant matrix as in unit 23.
25	Typical hash similar to unit 23, except for a lighter color, very pale brown (10YR 8/3) dry.
26	Typical open framework, medium to coarse opalite and tuff chunks with some medium and fine flakes; sparse hashy matrix as in unit 25.
27	Same as unit 23.
28	Typical hash, light brownish gray (10YR 6/2) dry; common charcoal.
29	Typical hash, pale brown (10YR 6/3) dry.
30	Same as unit 1.
31	Moderate open framework, coarse opalite chunks; moderate silt loam matrix as in unit 30.
32	Moderate open framework, abundant medium to coarse opalite flakes with some in lense-like orientation, rare chunks; moderate sandy silt matrix, brown (10YR 5/3) dry.
33	Moderate open framework, distinct lense of subhorizontal, fine to medium flakes of opalite, sparse matrix as in unit 32.

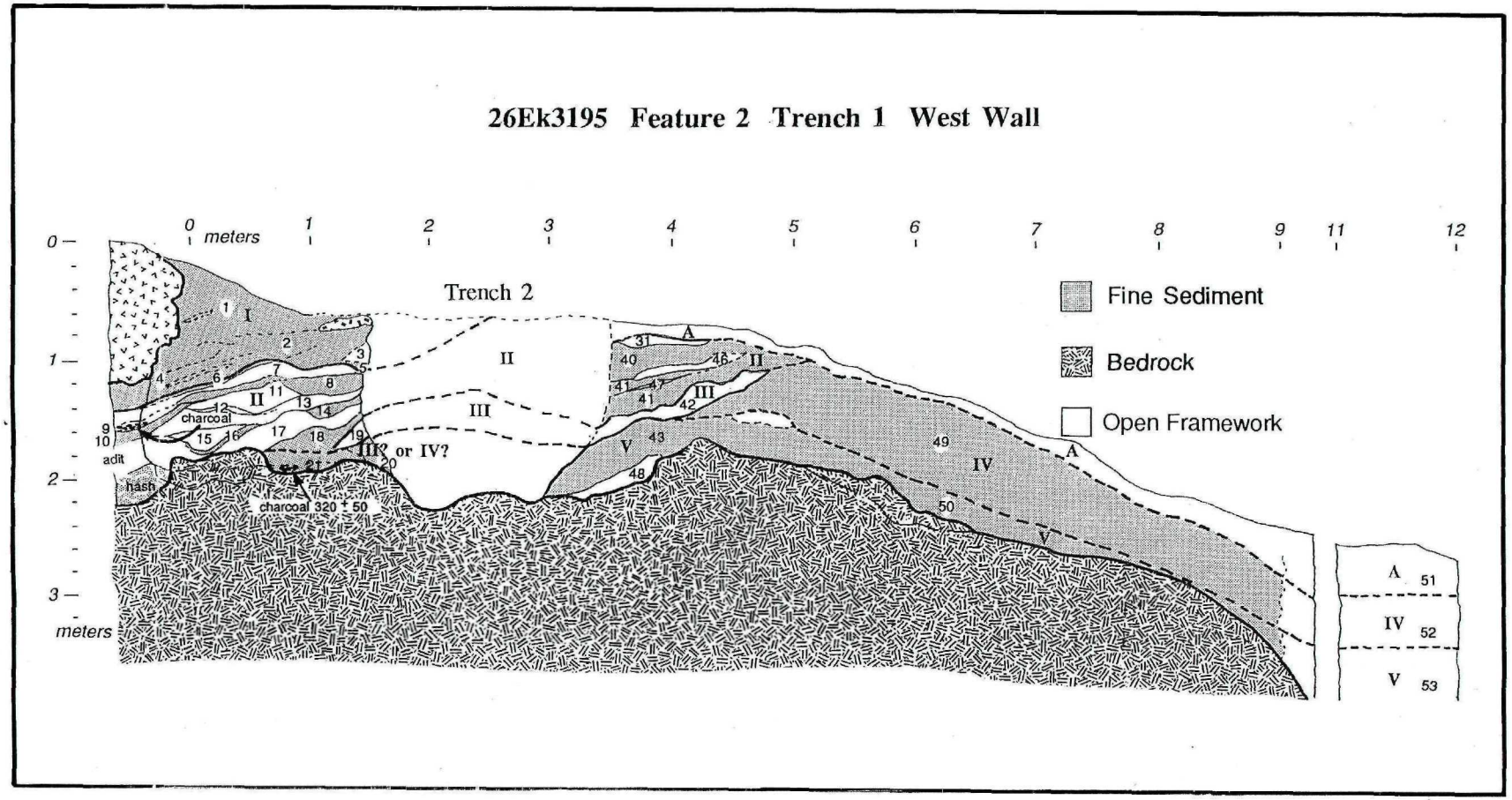


Figure 162. Description of stratigraphic units, Trench 1, 26Ek3195, Feature 2.

Figure 162, continued.

34	Brown (10YR 5/3) dry; clayey silt loam, weakly vesicular, weak fine granular, common fine roots and pores; rare to common subrounded fine pebbles.
35	Typical open framework, lense of medium to coarse opalite chunks.
36	Same as unit 34, except more common fine opalite chunks.
37	Poor open framework, fine to coarse opalite and tuff chips and chunks; moderate matrix same as in unit 36.
38	Fine open framework, very fine to medium opalite chips, chunks, and flakes, with some tuff; very sparse matrix.
39	Poor open framework, fine to coarse opalite and tuff chunks with some chips and pale brown (10YR 6/3) dry, sandy silt matrix; pink opalite is common in this unit.
40	Same as unit 39, except coarser chunks dominate, making a moderate open framework.
41	Same as unit 18, except more common opalite chips and charcoal flecks.
42	Moderate to poor open framework, very fine to very coarse opalite chips, flakes, and chunks; sparse to moderate silt loam matrix similar to unit 41; common to abundant charcoal.
43	Brown (10YR 4/3) dry; clayey silt loam; common fine angular to subrounded pebbles; rare to common opalite chunks.
44	Distinct charcoal accumulation.
45	Distinct charcoal accumulation.
46	Same as unit 35.
47	Moderate open framework, very thin fine to medium opalite flakes, moderate matrix as in unit 41.
48	Poor open framework, fine to coarse opalite chunks with some tuff; common silty sand matrix, very pale brown (10YR 7/3) dry.
49	Dark brown (10YR 3/3) slightly moist; clayey silt loam; loose to weak angular blocky; rare to common fine to medium pebbles; rare medium and coarse opalite chunks; boundary gradual and irregular.
50	Same as unit 49, except more abundant gravel and opalite chunks.
51	Dark grayish brown (10YR 4/2) dry; silt to silt loam; loose to weak granular or platy, to weak subangular blocky; abundant fine roots, common pores; boundary gradual and smooth.
52	Dark brown (10YR 3/3) slightly moist; clayey silt loam; weak medium subangular blocky; common fine to medium, subangular to subrounded pebbles; common fine roots; boundary gradual and smooth.
53	Dark yellowish brown (10YR 3/4), weakly mottled very dark brown (10YR 2/2) slightly moist; silty clay; common fine to medium subangular to subrounded pebbles; boundary gradual and smooth.
54	Dark brown (10YR 4/3) slightly moist; sandy clay, with abundant fine to coarse subangular to subrounded gravel; boundary unexposed.

identified. A light to moderate density accumulation of opalite debitage and naturally weathered opalite debris covers and encircles the pit over an area of 49 m^2, and yielded the only formed artifact found at the feature, a Stage 2 biface (cf. Table 162). A similar incipient quarry pit, Feature 3, lies immediately adjacent to the west. Numerous low bedrock exposures occur in the immediate vicinity, suggesting that activity was attracted by promise of shallow, unweathered raw material. Feature 4 was bisected by a backhoe trench (Trench 1) to investigate this minimal species of quarry pit excavation.

Trench 1 exposed a shallow profile above a near-surface opalite outcrop. At least three separate depressions may have been dug, but the natural irregularity of the bedrock surface makes it uncertain whether they are quarry pits. Since they are deepest where bedrock is softest and of the poorest quality, they perhaps are natural (Figure 163). Quarrying penetrated a brown surface loam mantling a reddish clay paleosol down to the opalite bedrock. The clays of Units 4 and 5 include sparse opalite flakes, probably either from mixing during quarrying or later bioturbation and clay swelling. The clays are fairly well consolidated and have clay skins on some ped faces. Unit 2 above the clays appears slightly ashy. If this is Mazama tephra the quarrying and redeposition of the clays could have occurred prior to 6,900 B.P., but it is more likely that Unit 2 is much younger, formed from reworked Mazama ash. Besides the limited depth of quarrying, the shallowness of the deposits may be a function of position on the crest of a small ridge, in a relatively flat area where few slopewash sediments are transported.

Implications

26Ek3195 served chiefly as a toolstone source. Quarrying efforts exploited subsurface toolstone reserves, but they extended as well to surface outcrops and colluvial supplies. The character and distribution of debitage and bifaces suggest that toolstone processing took place largely at the quarry features themselves, and that most such tasks aimed at creating early stage reduction forms. The small biface assemblage hints that most reduction products were transported away from the site for further reduction elsewhere (cf. Chapter 21).

26Ek3200

26Ek3200 is the easternmost and smallest quarry site tested in the Eastern Periphery (cf. Figure 142). Covering only 242 m^2, it lies isolated on a small bench on the mid-slope of Corral Fan (Figure 164). It occupies a region otherwise devoid of pronounced cultural accumulations, and is coincident with the only opalite outcrops occurring in this quadrant of the East.

Despite its isolation, the superior quality of opalite bedrock appears to have conditioned intensive use of the place; prehistoric quarrying intruded 80 cm of solid substrate. Results of our field efforts suggest that 26Ek3200 constitutes one of the purest expressions of unifunctional toolstone extraction observed in the Eastern Periphery (Intermountain Research 1988b:152).

Most of the site is covered by a moderate density lithic scatter dominated by large opalite waste flakes and shatter, with abundant unmodified opalite cobbles and slabs. Shallow colluvial soils are juxtaposed with low exposures of bedrock throughout. Two close-set quarry pits punctuate the general scatter and host denser concentrations of debris. Both comprise elements of Feature 1.

Feature 1

The more prominent quarry pit at Feature 1 lies on the downslope margin of the principal opalite outcrop of the site; it served as the focus of our inquiry. Its surface is defined by a roughly circular depression 4 m in diameter and ca. 35 cm deep, partially encircled by a debris-rich berm along its downslope rim. The other pit is marked by a faint, shallow, lichen-encrusted undulation of the surface approximately 3 m in diameter, that apparently represents an incipient or abandoned quarry effort initiated just north of the larger excavation (cf. Figure 164); this pit was not explored.

During testing, the surface compositions of the fill and the surrounding accumulation of tailings at the larger pit were sampled by scraping 12 25 cm x 25 cm units along a baseline parallel to the slope. The transect bisected the pit and its berm, from the outcrop ledge through the talus slope below. Subsequently, a trench was excavated by hand along the baseline to expose internal structure.

Surface artifacts are limited in abundance and variety, but they are composed almost exclusively of a visually distinctive white and pink opalite of exceptional high quality. Toolstone procurement dominates the assemblage (Table 164). Among the small number of bifaces recovered (n=12), most are early and intermediate reduction products and debitage, as typical of quarry pits observed elsewhere, chiefly from the reduction of cores (cf. Chapter 10).

Table 164. Artifacts Recovered from Feature 1, 26Ek3200.

Unit No. (Type)	Surface Scrape (m^2)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Bifaces	Flake Tools	Other/ Exotic	Total
1 (SF)	0.063	1	0.7	-	-	-	0
2 (SF)	0.063	16	32.7	-	1	-	1
3 (SF)	0.063	3	59.9	-	-	-	0
4 (SF)	0.063	2	43.7	-	-	-	0
5 (SF)	0.063	24	113.3	-	-	-	0
6 (SF)	0.063	54	182.5	-	-	-	0
7 (SF)	0.063	18	17.9	-	-	-	0
8 (SF)	0.063	42	135.9	-	-	-	0
9 (SF)	0.063	39	214.1	-	-	-	0
10 (SF)	0.063	13	45.6	-	-	-	0
11 (SF)	0.063	25	146.7	-	-	-	0
12 (SF)	0.063	3	19.1	-	-	-	0
Surface Inventory	N/A	-	-	12	-	1	13
Trench Samples	N/A	-	-	-	-	1	1
Totals	0.756	240	1,012.1	12	1	2	15

(SF) = Surface Scrape

Two quarrying tools were found, as well. One of these, a large quartzite slab with battered, step-fractured edges, lay a few meters downslope from the pit. Its tabular shape and damaged edges suggest use as a digging or hoe-like implement (cf. Chapter 11). The proximal portion of a *Bison* sp. scapula recovered from the trench sidewall in the interior of the pit (cf. Chapter 14) may have been used similarly. The broad, robust form of the original unfragmented bone could have proven useful in digging or scooping liberated debris from the pit. A similar specimen was recovered from 26Ek3208 in the Western Periphery, and others have been reported in comparable quarry contexts elsewhere (cf. Ahler 1986).

The only artifact not referable directly to toolstone procurement is a scraper, recovered from the ground surface upslope of the pit.

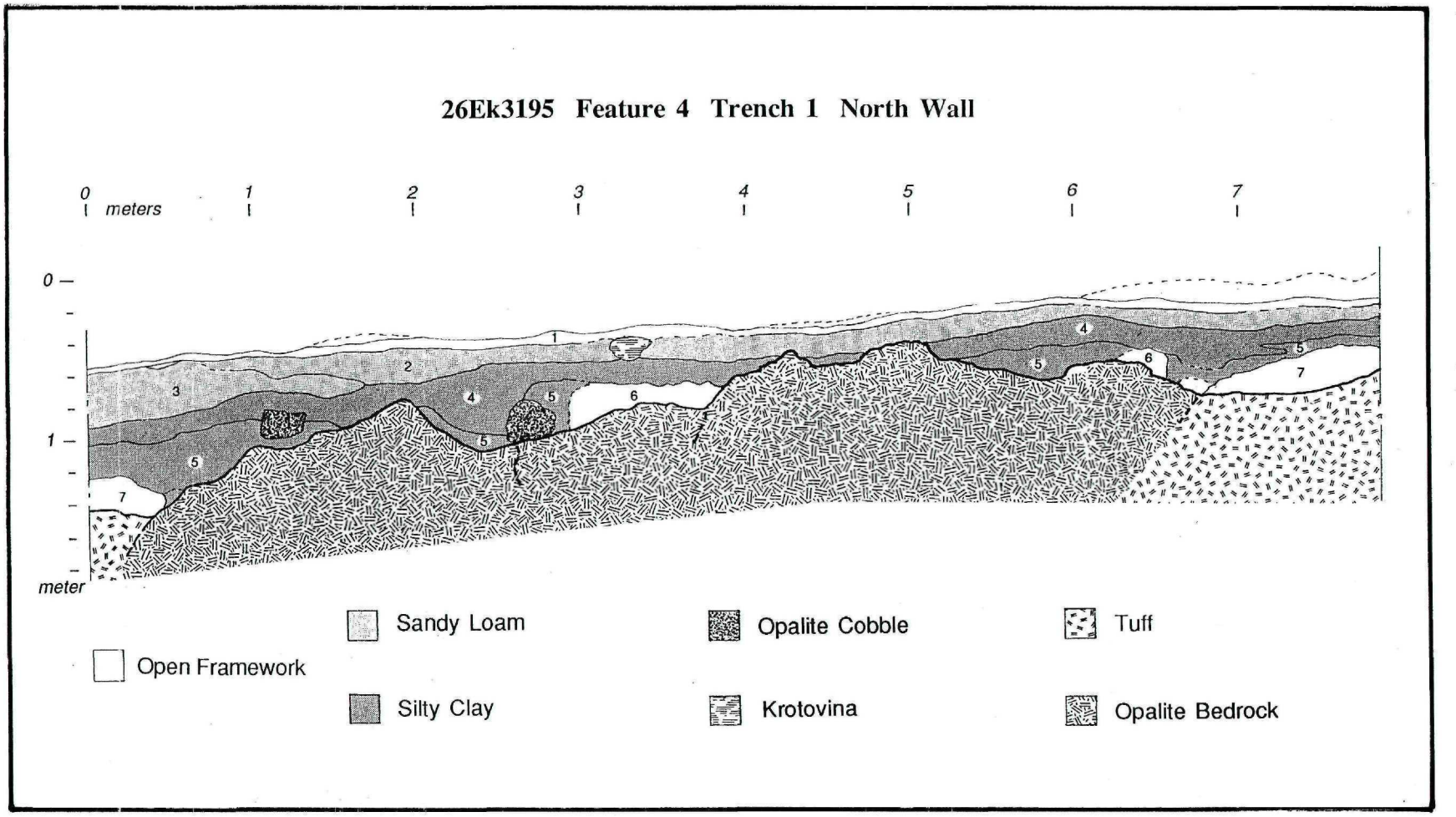


Figure 163. Description of stratigraphic units, Trench 1, 26Ek3195, Feature 4.

Figure 163. Description of stratigraphic units, Trench 1, 26Ek3195, Feature 4.

Stratum	Description
1	Brown (10YR 5/3) dry; loam; loose to weak very fine granular; common fine opalite chunks and flakes; abundant fine to medium roots; boundary clear and slightly irregular.
2	Brown to dark brown (10YR 5/3 to 4/3) dry; sandy silt loam; weak platy to moderate fine granular; common fine opalite chunks and flakes; common fine to medium roots; boundary abrupt and smooth to wavy.
3	Pale brown (10YR 6/3) dry; silt loam, possibly ashy; weak to moderate fine granular to subangular blocky; rare to common subangular opalite, tuff, and rhyolite pebbles.
4	Pale brown to yellowish brown (10YR 6/3 to 5/4) dry; clay loam; weak to moderate fine subangular blocky; abundant angular to subangular tuff and opalite clasts, rare opalite flakes; common fine roots; boundary clear and irregular.
5	Dark brown to brown (7.5 4/4 to 5/4) dry; sandy clay to sandy clay loam; moderate to strong fine subangular blocky, weak clay skins on ped faces, clay appears slightly reworked; abundant fine opalite chips, chunks, and flakes; common fine roots.
6	Dark brown to strong brown (7.5 YR 4/4 to 4/6) dry; clay; strong medium angular to prismatic, moderate clay skins on peds; common fine roots.
7	Strongly weathered tuff and opalite with some clay.

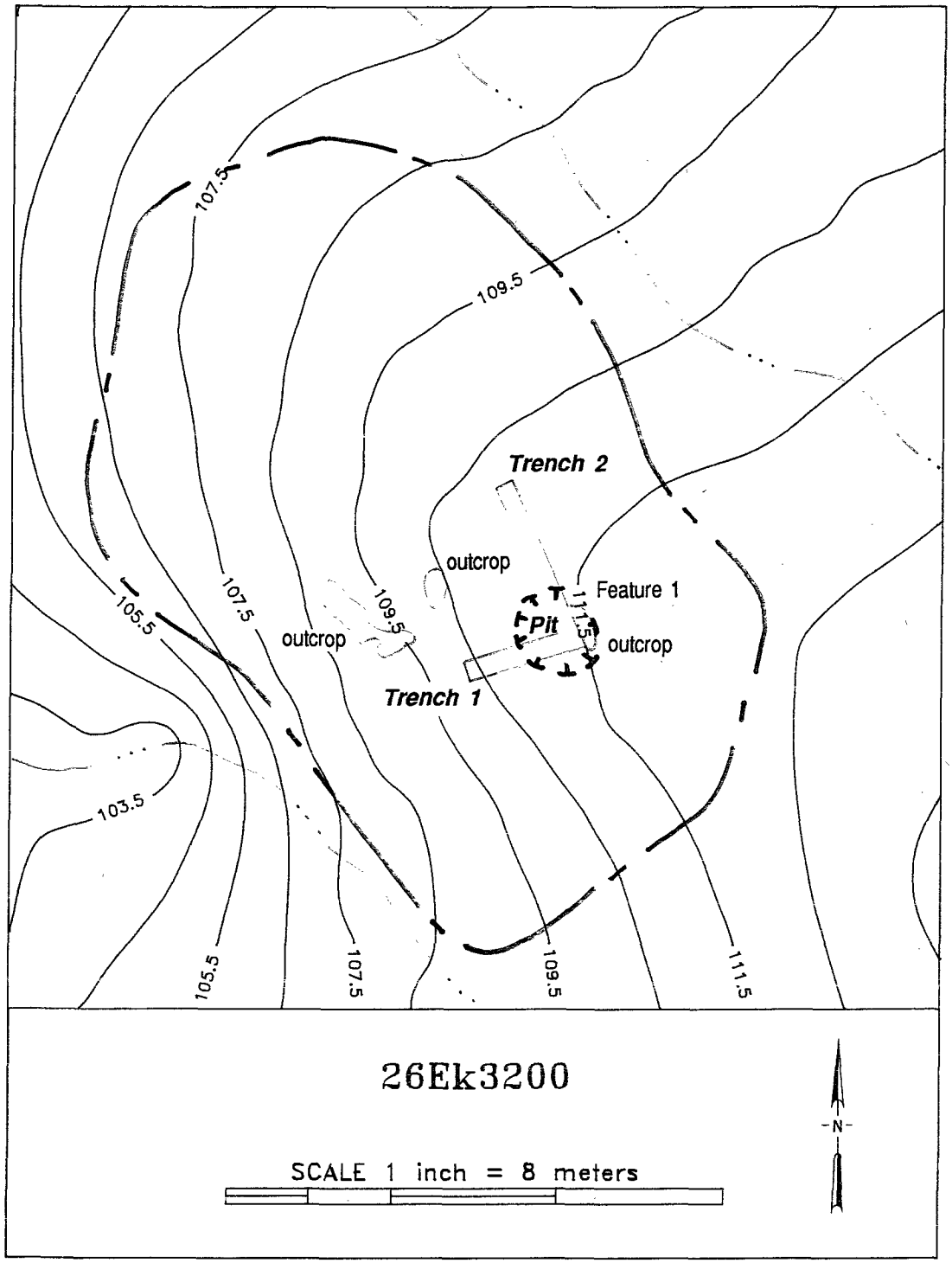


Figure 164. 26Ek3200 site map.

Stratigraphic analysis of the north trench profile pit profile was accomplished during testing. Trench expansion and excavation of an intersecting spur trench at the base of the bedrock outcrop during data recovery contributed understanding of the horizontal expression of the feature, but did not alter substantially our view of its vertical structure. The description of pit deposits presented below dates to the testing program and is borrowed from earlier documentation (Intermountain Research 1988b). The profile is depicted in Figure 162, supplemented by a planview of the pit floor in Figure 165.

> trenching exposed at least 18 distinct strata in the profile of the trench wall. These are numbered consecutively from the surface, but are not described in detail. Instead, strata are grouped into horizons and attention is devoted to the overall development of the feature.
>
> The pit was apparently excavated about 80 cm into tuff and silicified tuff bedrock. Both white and pink toolstone were extracted. The texture of strata in the pit fill alternates between fine and coarse in the manner observed in other quarry pit profiles. The sand to loamy sand fine sediments (Units 3, 5, 7, 12, 15, and 17) probably represent slopewash and eolian deposits accumulated in open pits between episodes of active quarrying. The coarser layers of angular rubble and/or cores and large flakes (Units 1, 2, 4, 6, 9, 11, 13, 14, 16, and 18) are colluvial and waste from quarrying and toolstone processing.
>
> The highly organic Unit 3, thinly mantled with a layer of flakes and angular shatter, is the present A horizon. The upslope portion appears to have been buried by mostly colluvial Units 2 and 1 in the recent past.
>
> Working upslope and into the outcrop, prehistoric quarrymen backfilled their pits as they went along. Thus, the beds are progressively younger upslope and toward the face. The pit may have been started on the fissure still present in the bottom of the oldest part of the pit.
>
> On the basis of orientation, strata can be grouped into four time-stratigraphic horizons. Horizon IV (Units 18 through 15) constitutes the oldest group. Truncated by units of Horizon II, they are short and concave upward. The outcrop face was probably near 1.4 m west of its present position. Horizon III (Units 11, 12, and 13) marks an interval when the outcrop face probably lay about 1.0 m west of its present position. These units are convex upward, preserving a portion of the pit berm. Horizon II (Units 9 through 6) marks the last intensive episode of quarrying. The profiles of these units are S-shaped, preserving both the pit floor and the berm. The outcrop face assumed its present position during Horizon II. A *Bison* sp. scapula was found in Unit 6, probably used as a digging tool. Finally, Horizon I includes the more horizontal layers subsequent to Unit 6, and suggests passive accumulations in the open pit rather than culturally generated deposits. (Intermountain Research 1988b:150-152)

Implications

26Ek3200 appears to have functioned almost exclusively as a source of high quality opalite. Lying relatively high in the landscape far removed from water or base camps, and remote from other toolstone sources, it doubtless was attractive chiefly for its extremely fine-grained and uniform quality toolstone.

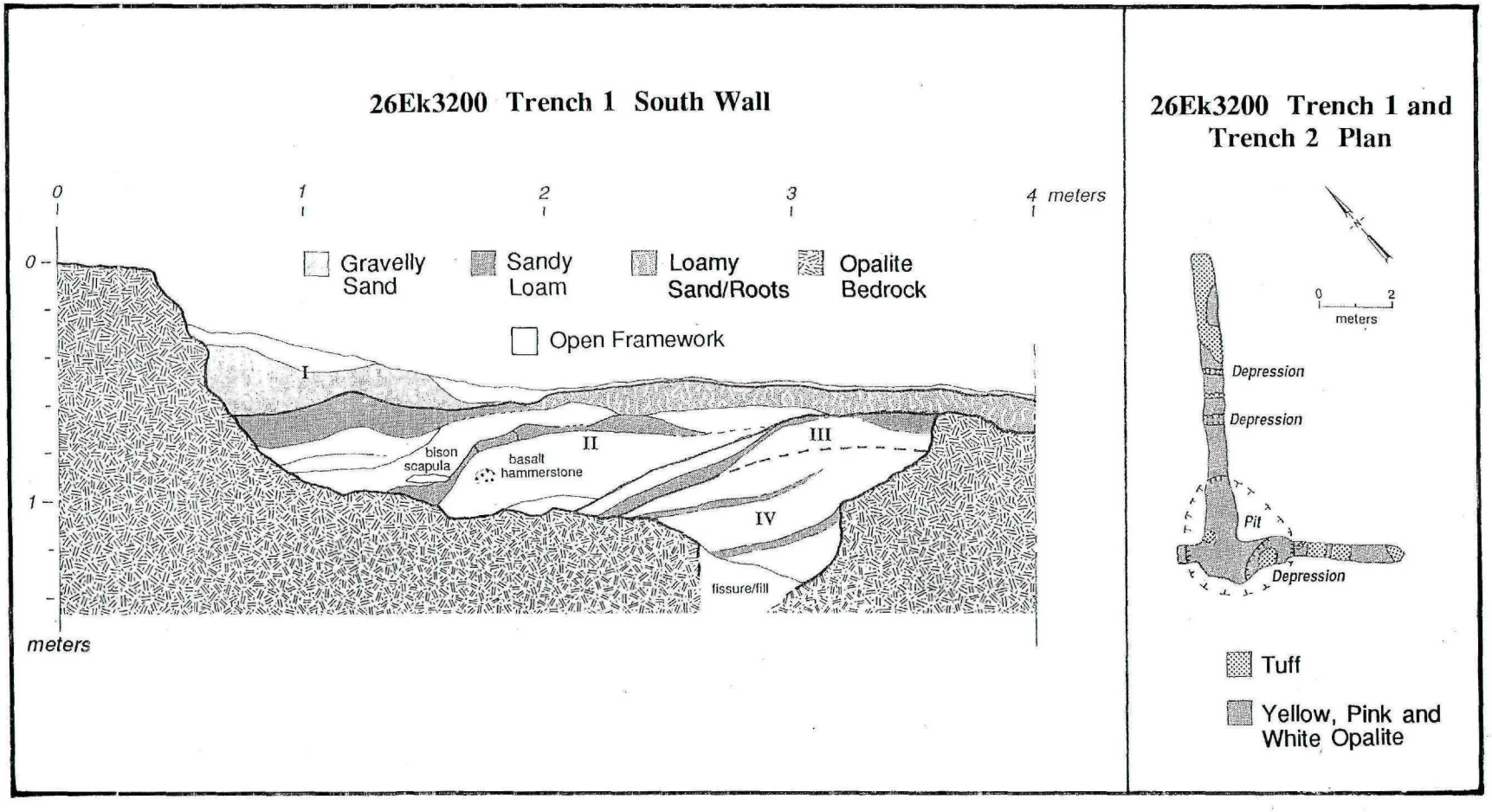


Figure 165. 26Ek3200: a. Trench 1 profile; b. Trench 1 and Trench 2 plan.

26Ek3032/Locality 19

Overlooking the middle reach of Little Antelope Creek, and some 15 m above it, Locality 19 occupies a subtle, comparatively flat bench on the otherwise steep eastern midslope of lower Holmes Ridge (cf. Figure 141). The original Tosawihi survey identified the site as a 3 m x 3 m flake scatter accompanied by a metate and, on this basis, attributed its creation to toolstone reduction and minor residential activities (Elston, Raven, and Budy 1987). Subsequent fieldwork, however, revealed the locality to be very much larger and more complex, and added a quarry pit to its attributes. Historic disturbances render the origin of the quarry pit equivocal, however.

The lithic scatter covers nearly 3000 m^2, encompassing the entire bench and extending some 50 m downslope until density falls off on the east. On the south, a minor intermittent drainage differentiates the scatter from Locality 18 (Figure 166). Site soils, like those of the surrounding area, are a clay silt loam with abundant tuff gravels; they do not appear to exceed a depth of 50 cm. A sparse open growth of low and tall sagebrush occurs sporadically across the site.

Close interval inspection revealed only one prehistoric feature in a light to moderate density background. In several places debitage densities increase subtly, possibly reflecting prior reduction episodes, but we could isolate no discrete events. Likewise, a ledge of seemingly good quality opalite at the northeastern edge of the site *appeared* battered, but equivocally so. Save a basalt metate identified in initial survey, all formed artifacts found in nonfeature contexts are products of opalite processing (Table 165).

Table 165. Artifacts Recovered from 26Ek3032, Locality 19.

		DEBITAGE		FORMED ARTIFACTS					
Unit No. (Type)	Surface Scrape (m^2)	n	wt. (gm)	Bifaces	Cores	Flake Tools	Perc./ Cobble Tools	Ground Stone	Total
Feature 1									
1-4 (SF)	4.0	11,720	24,949.8	26	2	18	-	-	46
5-8 (SF)	4.0	2,952	18,247.8	10	2	3	-	-	15
Surface Inventory	N/A	1	65.8	19	-	2	-	-	21
Nonfeature Contexts	N/A	-	-	10	1	-	2	1	14
Totals	8.0	14,673	43,263.4	65*	5	23	2	1	96

(SF) = Surface Scrape
* Includes "possible" bifaces

Feature 1

Feature 1 incorporates the small reduction scatter that initially served to identify the site. In its reconsidered form it covers ca. 500 m^2 of the central portion of the bench with a dense accumulation of lithic processing debris and other artifacts. It is distinctive in the Eastern Periphery for its mottled, multicolored pink, orange, yellow, and red opalites, and its abundance and variety of formed artifacts. The feature originally may have subsumed a quarry pit as well, but direct evidence has been obliterated by a bulldozer cut bisecting the feature (cf. Figure 166). The lithic scatter in the berm of the bladecut and surface immediately below it are the densest observed in the feature; the abundance of colorful debris and the comparatively high proportions of shatter, angular clasts, and large flakes imply primary toolstone

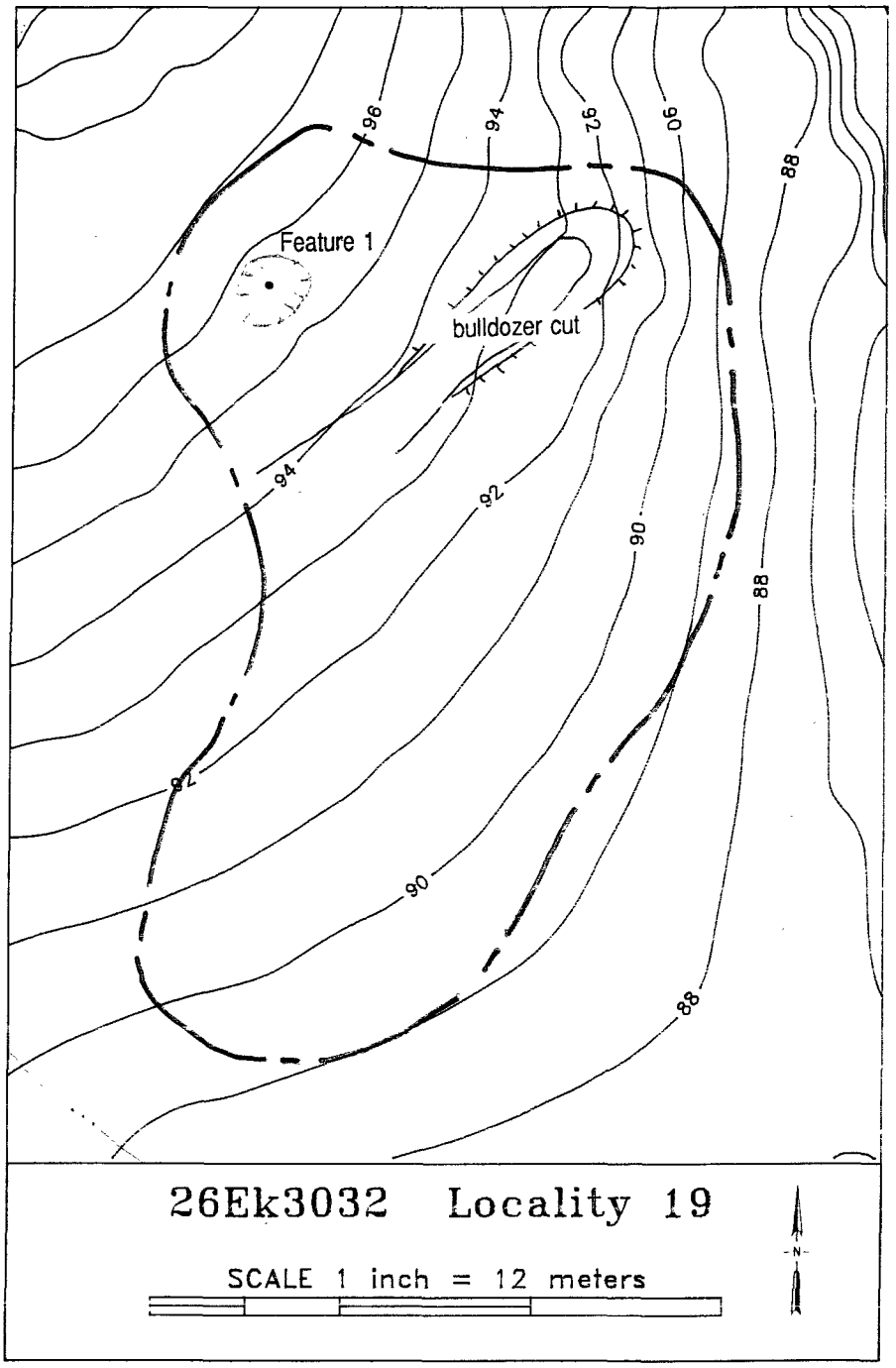


Figure 166. Locality 19 site map, 26Ek3032.

extraction. A stratigraphic profile provided by facing a segment of the cut failed to reveal clear evidence of aboriginal excavation (Figure 167). It did, however, disclose opalite bedrock just below the surface identical to the distinctive polychrome varieties dominating Feature 1. Evidence of toolstone extraction occurs as a circular, 5 m diameter depression located just above the cut; it may be a quarry pit, but its berm is nearly devoid of stone, an attribute more akin to historic prospects found in the area than to aboriginal excavations.

The remainder of fieldwork sought more to fully identify the content of the lithic scatter at Feature 1. Surface inventory recovered 19 bifaces and two flake tools from widely scattered locations. Two 16 m^2 areas were scraped, each consisting of four 1 m x 1 m units. Units 1-4 were placed immediately upslope of the bladecut; Units 5-8 sampled an area several meters below it (cf. Figure 166). The exercise revealed that the feature is confined to the surface; nowhere was it observed to intrude beneath the shovel scrapes. Unit returns were voluminous and diverse (cf. Table 165). The assemblage reflects the processing of colorful opalite presumably derived from an on-site source. Debitage chiefly is the product of core reduction, but the scores of bifaces recovered witness stages of biface production from the creation of blanks through intermediate reduction (cf. Chapters 6 and 10). Other activities are represented by twenty-one diverse flake tools were retrieved.

26Ek3197

26Ek3197 occupies 4500 m^2 of a broad peninsular shelf jutting north from the foot of Corral Fan to create a pronounced bend in the upper reach of Undine Gorge (cf. Figure 141). The shelf is bounded on the east, north, and west by the drainage; the outcrop quarry 26Ek3198 lies just upslope to the south. Extensive exposures of white and grey brecciated opalite emerge over most of its surface. Scrutiny of the site was confined to the testing phase of work.

Eleven cultural features occur; all related to opalite procurement and reduction. They are concentrated in the northwestern quadrant of the site, where toolstone extraction focused on surface and near-surface bedrock along upper and midslopes (Figure 168). Two close-set quarry pits and their associated dense lithic scatters (Features 1 and 2) share the same contour; below these, outcrop sources were exploited at Features 4 and 7. A bedrock overhang on the steep western mid-slope houses a small rockshelter (Feature 10), and a crag in the rimrock adjacent held a biface cache (Feature 5). Reduction stations (Features 6, 8, and 9) dot the gentler northern slopes and one (Feature 3) lies higher on the knoll. On the eastern flank of the shelf, an adit-like excavation (Feature 11) extends about a meter into the base of a bedrock exposure.

Site soils are undifferentiated from those of the surrounding vicinity, but they lack the pronounced loess mantle that blankets 26Ek3198 immediately upslope. Deposits at 26Ek3197 are sandy silt colluvial products containing abundant tuff and opalite gravels; the extensive on-site exposures of bedrock imply that they are generally shallow.

Nonfeature Contexts

The relatively flat, highest portion of the shelf lacks cultural features, but it is covered by a diffuse expanse of opalite debitage intermingled with a dense blanket of naturally weathered materials. Few formed artifacts lie outside feature boundaries. Inventory recovered only three opalite bifaces. Seven 1 m x 1 m surface scrape units spanned the ridge top along a common baseline, yielding sparse cultural materials (Table 166).

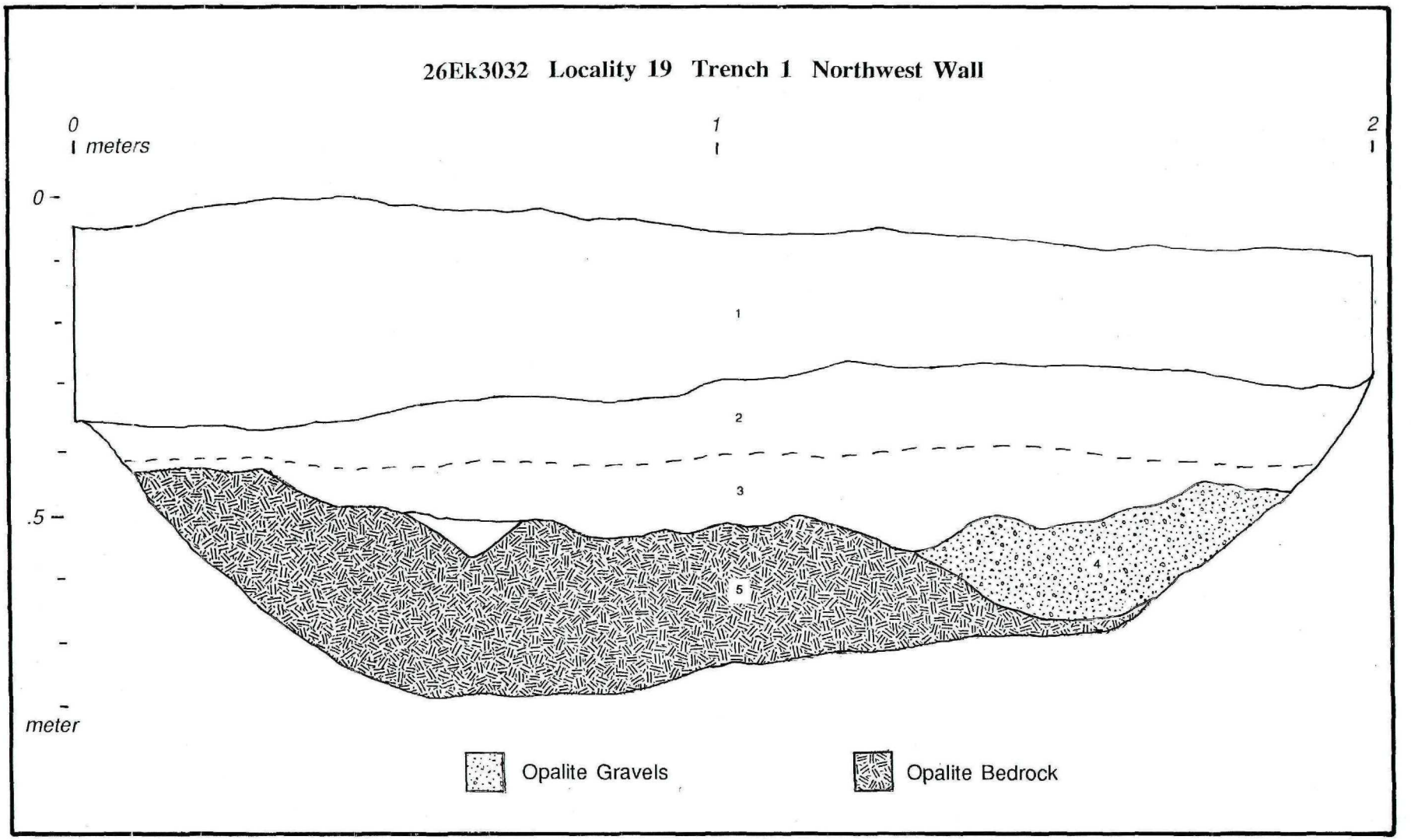


Figure 167. Description of stratigraphic units, Trench 1, 26Ek3032, Locality 19.

Figure 167. Description of stratigraphic units, Trench 1, 26Ek3032, Locality 19.

Stratum	Description
1	Brown (10YR 4/3) dry; clayey silt loam; loose to moderate fine granular; common fine to medium angular to subangular pebbles; abundant fine roots and dry organic debris; common fine to medium opalite chips and chunks, rare flakes; boundary abrupt and irregular.
2	Reddish brown (5YR 4/3) dry; sandy clay; common fine to medium angular to subangular pebbles; strong fine subangular blocky to fine prismatic; moderate clay skins on ped faces; boundary gradual and smooth.
3	Yellowish red (5YR 4/6) dry; gravely sandy clay; common fine to medium angular to subangular pebbles; strong fine to medium angular to subangular blocky; weak clay skins on ped faces; boundary gradual and irregular.
4	Angular medium to coarse clasts of weathered bedrock in clay as in unit 3.
5	White and yellow, weathered opalite and tuff bedrock with red staining and common scattered patches of gravely blue-green fine crystalline inclusions.

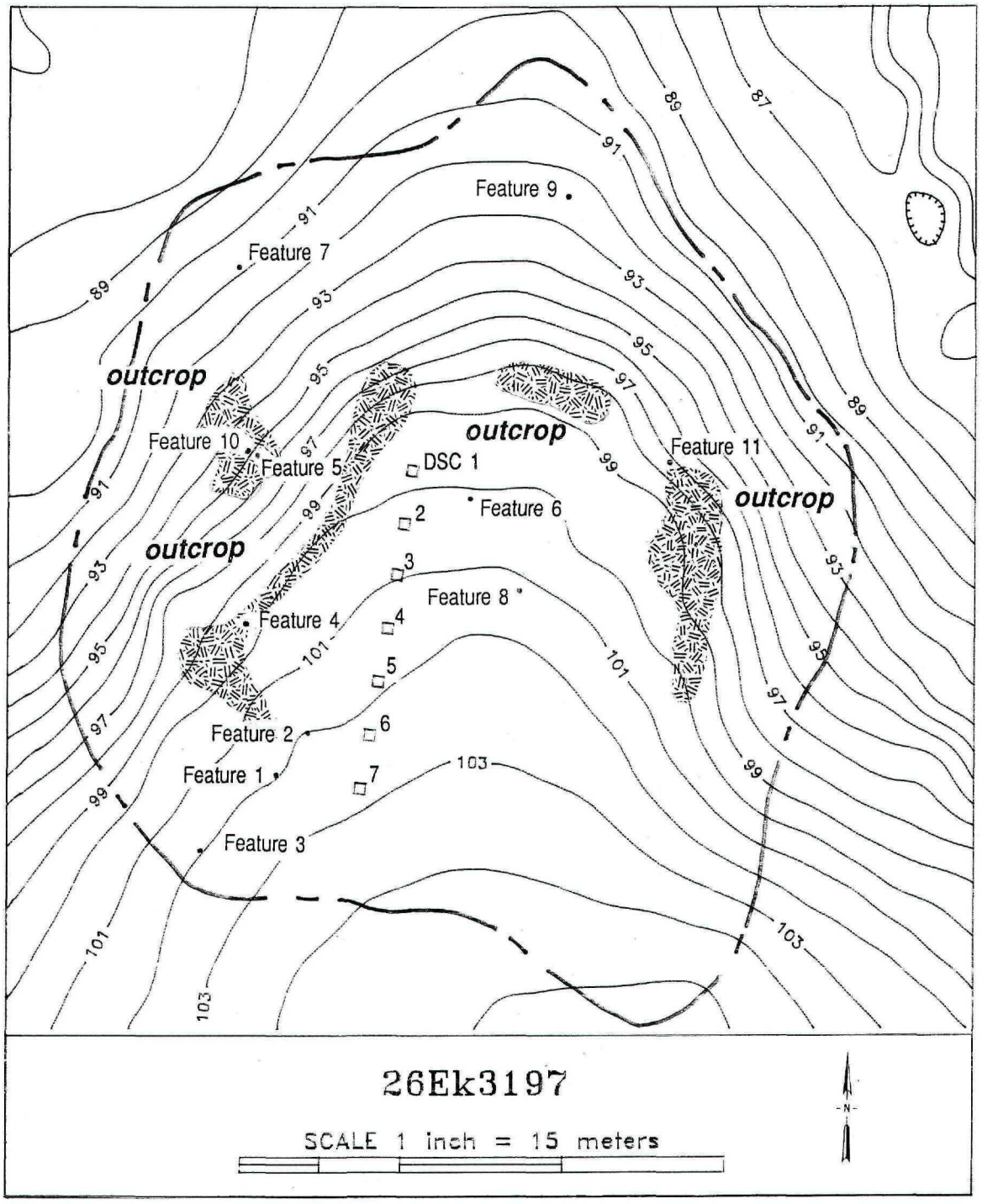


Figure 168. 26Ek3197 site map.

Table 166. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3197.

Feature	Total Area (m^2)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Bifaces	Flake Tools	Perc./ Cobble Tools	Total
1*	71	499	3,029.4	4	-	-	4
2	48	-	-	-	-	-	0
3	33	-	-	3	-	-	3
4	236	-	-	1	-	2	3
5*	49	144	1,694.4	17	1	-	18
6	88	-	-	-	-	2	2
7	17	-	-	1	-	1	2
8	154	-	-	1	-	-	1
9	37	-	-	2	-	1	3
10*	20	261	731.8	-	-	-	0
11	-	-	-	-	-	-	0
Surface Isolates	-	-	-	3	-	-	3
Other Nonfeature	-	267	1,282.4	3	-	-	3
		1,171	6,738.0	35	1	6	42

*Sample Feature

Cultural Features

Features also contain few formed artifacts (cf. Table 166). One quarry pit (Feature 1), the biface cache (Feature 5), and the rockshelter (Feature 10) were sampled.

Feature 1

Feature 1 is the larger, deeper pit. It is elliptical in plan, with diameters of 3.5 m and 2 m, and is 50 cm deep. It shares many attributes with pits examined elsewhere in the subarea, including a well developed berm along its downslope edge and a related dense lithic scatter around its perimeter. Inventory returned four biface fragments, the only formed artifacts recovered. Only the surface of the feature was scrutinized; a transect of 20 25 cm x 25 cm surface scrapes sampled a longitudinal cross-section at 1 m intervals parallel to the slope. Only opalite waste was retrieved (Botkin 1989:317-318). In contrast to the patterned variation observed in the horizontal distribution of debitage density and size at other quarry pits (cf. 26Ek3195: Feature 2; Locality 23: Feature 1), Feature 1 is homogeneous. Whether this reflects differences in manner of deposition remains unknown. We suspect, however, that post-depositional processes account for the homogeneity; greater spatial structuring may have been masked by colluvial debris from adjacent Features 2 and 3 (cf. Figure 168).

Feature 5

Feature 5 was identified by a cluster of nine opalite bifaces concentrated within 0.5 m^2 on the floor of a small sheltered crag in the rimrock (cf. Figure 168). A 1 m x 1 m excavation unit centered on the cluster revealed eight additional specimens just below the surface and just above bedrock. No stratigraphic evidence of intentional burial was observed.

Like specimens found in caches elsewhere, each of the 17 bifaces is complete. Unlike other caches, that commonly are dominated by intermediate reduction stage specimens, those of Feature 5 are chiefly Stage 2 forms (n=13); the remainder are Stage 3 (cf. Chapter 6). All are of a similar, bluish grey, coarse-grained opalite. Such material was not observed in the bedrock surrounding the cache, nor is it represented in the debitage in the vicinity. From this we infer that the cached bifaces represent a stockpile of items quarried and partially reduced elsewhere, then transported and set aside for further processing.

Feature 10

Lying 20 m west along the rim from the biface cache, Feature 10 is a small rockshelter beneath a low overhang of opalite bedrock (cf. Figure 168). Although 5 m wide, its aperture presently is only 90 cm high at the dripline; its ceiling slopes steeply downward to meet the floor just 2 m inside the outer lip. It would seem to have offered little human space; cultural remains are sparse, consisting exclusively of opalite waste (cf. Table 166).

The floor is strewn with cobbles and small roof-fall boulders, and exhibits a light, amorphous scatter of opalite debitage. Two denser accumulations of reduction debris occur on the rocky shelf just outside the overhang. A 1 m x 50 cm excavation unit straddled the dripline and was dug to bedrock (60 cm). Cultural opalite waste is scant and distributed homogeneously. The few bones recovered are of recently deceased rodents. Soils are heavily turbated, and are composed of gravelly colluvial sands dense with roof spall. They are moist, with little promise of preserved perishable remains.

Implications

Despite its size and complexity, 26Ek3197 yielded one of the smallest, least diverse collections of all sites tested in the Eastern Periphery. It appears to have attracted prehistoric use principally for its toolstone-quality opalite. Behaviors other than chert procurement and processing are little evident. The reduction of toolstone is reflected almost exclusively by quantities of opalite debitage. Bifaces (if the cache is excluded) are rare compared to their incidence at most other sites. The character of the debitage, as well as most of the biface assemblage, suggests that much of the opalite quarried on-site was reduced only to early stages, and that the vast majority then was transported elsewhere for further work.

Outcrop Quarry Sites

At six sites and at two localities of 26Ek3032, exposures of opalite bedrock constitute the sole on-site primary toolstone sources: 26Ek3191, 26Ek3193, 26Ek3196, 26Ek3198, 26Ek3201, 26Ek3203, and 26Ek3032 Localities 25 and 98. Each was tested; the results suggested that three (26Ek3198 and Localities 25 and 98) warranted revisiting for expanded sampling during data recovery. At most, outcrop quarries seem to have provided only minimal raw material; the abundant evidence of opalite reduction dominating most assemblages appears to have accrued from toolstone imported from elsewhere.

26Ek3198

26Ek3198 occupies over 12,000 m² of the crest and western slope of the principal knoll on the southern margin of Undine Gorge (Figures 169 and 141). In survey (Raven 1988) the site was designated a "Large Reduction Complex." On closer scrutiny during testing, several minor toolstone sources were discovered within its precincts, leading us to reclassify it. Still, aboriginal use appears related more to opalite reduction than to quarrying.

Shallow colluvial soils are interrupted only by several low opalite outcrops on the western rim. However, with important archaeological effect, the higher, central portion of the knoll top is mantled by an accumulation of loess.

Nonfeature Contexts

Nonfeature contexts are covered by a light to moderate density lithic scatter. Few formed artifacts occur; several bifaces and a Gatecliff projectile point were the only items found (Table 167).

Table 167. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3198.

				FORMED ARTIFACTS								
Feature	Total Area (m²)	DEBITAGE n	DEBITAGE wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Perc./ Cobble Tools	Ceramics	Other/ Exotic	Total
1*†	24	6,818	17,942.6	23	15	11	7	12	-	-	1	69
2*	0.90	598	1,939.1	-	-	1	-	1	-	-	-	2
3	22	1[a]	8.4	2	-	5	-	-	-	-	-	7
4	86	2[a]	5.2	-	-	2	-	-	-	-	-	2
5	50	2[a]	10.3	-	-	5	-	-	-	-	-	5
6	26	2[a]	7.5	-	-	5	-	-	-	-	-	5
7	123	-	-	-	-	1	-	-	-	-	-	1
8	297	3[a]	5.7	1	-	3	-	-	-	-	-	4
9*	239	107	247.2	-	-	2	-	-	-	4	-	6
10	20	1[a]	5.3	-	-	-	-	-	-	-	-	0
11	19	1[a]	1.1	-	-	1	-	-	-	-	-	1
12	4	-	-	-	-	-	-	-	-	-	-	0
13	31	1[a]	4.6	-	-	-	-	-	-	-	-	0
14*	151	707	6,140.7	-	-	8	-	-	2	-	-	10
15	33	-	-	-	-	1	-	-	-	-	-	1
16	170	1[a]	2.0	-	-	7	-	-	-	-	-	7
17	2	-	-	-	-	1	-	-	-	-	-	1
18	3	-	-	-	-	-	-	-	-	-	-	0
19	14	-	-	-	-	1	-	-	-	-	-	1
20	86	-	-	-	-	-	-	-	-	-	-	0
21	24	-	-	-	-	5	-	-	-	-	-	5
22	16	-	-	-	-	-	-	-	-	-	-	0
23	5	-	-	-	-	2	-	-	-	-	-	2
24	38	-	-	-	-	-	-	-	-	-	-	0
Surface Isolate	-	1[a]	4.9	1	-	4	-	-	-	-	-	5
Other Nonfeature	-	-	-	-	-	1	-	-	-	-	-	1
		8,245	26,324.6	27	15	66	7	13	2	4	1	135

*Sample feature
†Subsumes Feature 25 hearth
[a]Obsidian only

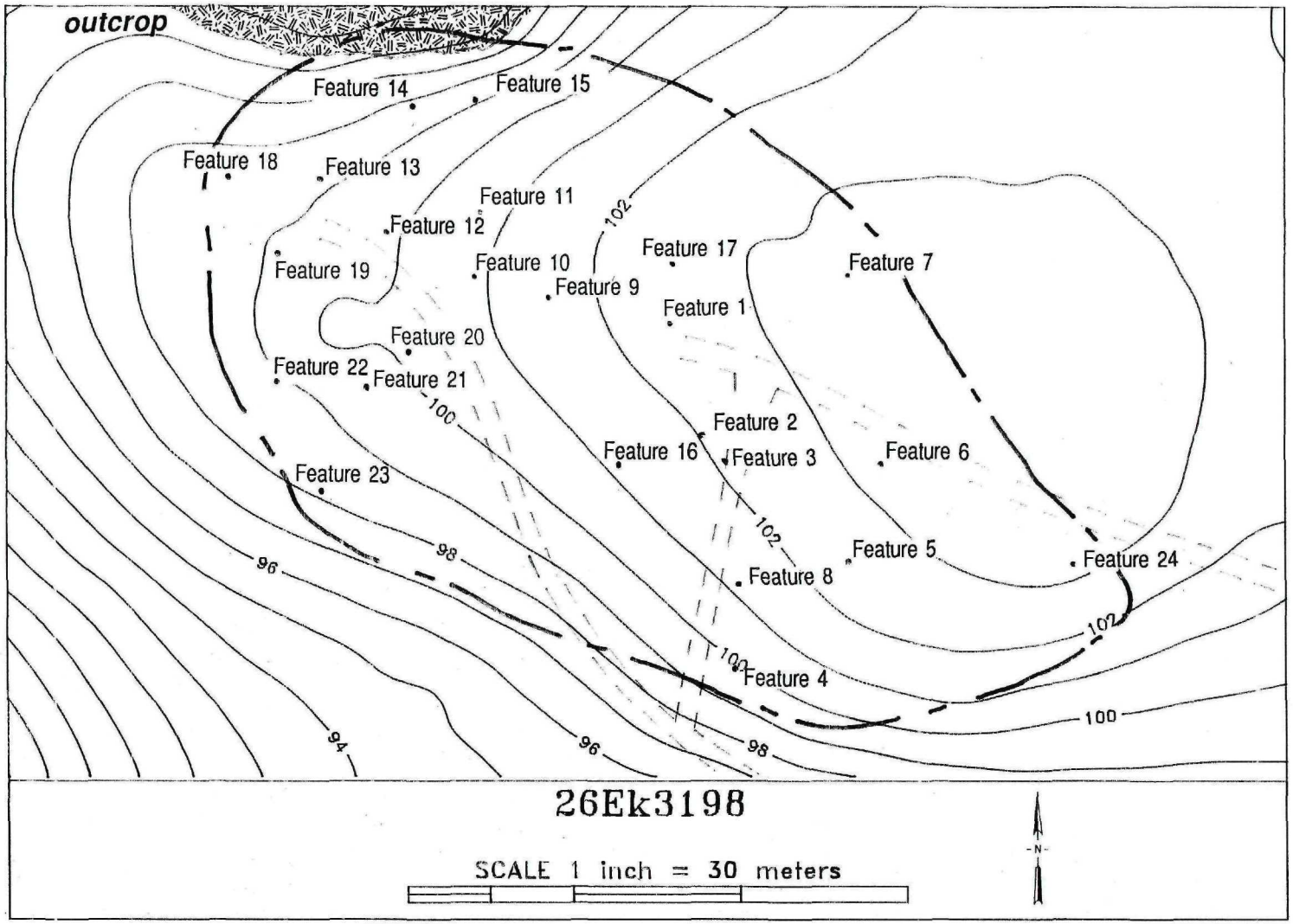


Figure 169. 26Ek3198 site map.

Cultural Features

Of 24 surface cultural features, 19 are reduction stations. Quarrying occurred at only four locations; three (Features 8, 15, and 24) reflect minor extraction efforts aimed at cobble fields while one (Feature 14) is a more extensively exploited outcrop quarry. Feature 1 stands out for its uncommon abundance of obsidian tools and debitage.

Outside Feature 1, assemblages are dominated by opalite reduction products, debitage, and bifaces; other artifacts are rare (Table 167). Several features (3-6, 8, 10, 11, 13, and 16) are augmented by scant obsidian waste. Feature 3 contained a Desert Side-notched point; another DSN and a preform were recovered from Feature 8. Several ceramic sherds dot the surface of Feature 9.

During testing, Features 1, 2, 9, and 14 were sampled; the remainder are known only from surface inventories. Results of these efforts prompted us to return to Features 1 and 14 for expanded scrutiny during data recovery. Table 167 summarizes feature contents recovered by the combined exercises.

Feature 1

Feature 1 apparently originated from activities little related to toolstone acquisition, and thus is unique among features at 26Ek3198. It is defined by two concentrations of obsidian artifacts amid an otherwise unremarkable scatter of opalite debris occupying 30 m^2 of unvegetated flat in sage on the knolltop (cf. Figure 169). We investigated it because of the large number of projectile points and other tools on the surface, and for the possibility of subsurface remains in the loess deposits.

During testing, 30 1 m x 1 m surface scrape units collected the entire visible extent of the feature; an excavation unit (Unit TS 1, Figure 170) was placed over the greatest concentration. The surface assemblage, with its abundance of projectile points, preforms, and obsidian pressure flakes, looks much like the accumulation of a hunter's small temporary camp (Table 168). Testing disclosed a deposit of comparable cultural content confined largely to the upper 10 cm (Table 169).

Table 168. Artifacts Recovered by Surface Collections from Feature 1, 26Ek3198.

Unit No.	DEBITAGE		FORMED ARTIFACTS					
(1m x 1m)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Other/ Exotic	Total
1	114	132.1	1	-	-	-	-	1
2	337	339.2	-	-	1	1	-	2
3	88	109.9	-	1	-	-	1	2
4	239	279.0	-	-	-	-	-	0
5	194	147.8	-	-	1	1	-	2
6	19	20.2	-	-	-	-	-	0
7	209	233.6	1	1	-	-	-	2
8	16	15.4	-	-	-	-	-	0
9	7	10.7	-	-	-	-	-	0
10	6	39.7	-	-	-	-	-	0
11	58	63.9	-	-	-	-	-	0
12	150	175.7	1	1	2	-	-	4
13	52	53.5	-	-	-	-	-	0
14	144	246.7	2	2	-	3	-	7
15	105	85.3	1	-	2	1	-	4
16	45	29.8	1	-	-	-	-	1
17	1,301	305.9	5	6	1	3	-	15
18	63	107.9	3	2	-	-	-	5
19	17	61.4	2	-	1	-	-	3
20	19	35.2	-	-	-	-	-	0
21	12	9.0	-	-	-	-	-	0
22	14	17.3	-	-	-	-	-	0
23	1	2.3	-	-	-	-	-	0
24	5	6.1	-	-	-	1	-	1
25	116	142.1	2	-	-	-	-	2
26	97	60.2	-	-	-	-	-	0
27	9	10.6	-	-	-	-	-	0
28	20	26.2	-	-	-	-	-	0
29	15	9.3	-	-	-	-	-	0
30	12	6.8	-	-	-	1	-	1
Totals	3,484	2,782.8	19	13	8	11	1	52

Table 169. Artifacts Recovered from Excavation Units, Feature 1, 26Ek3198.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Total
1 (TS)[a]	0.13	1,051	135.9	3	1	1	-	-	5
2 (EU)	0.18	102	468.6	-	-	1	-	-	1
3 (EU)	0.18	33	68.9	-	-	-	-	-	0
4 (EU)[b]	0.28	261	222.3	-	-	1	-	-	1
5 (EU)	0.38	160	335.5	-	-	-	-	-	0
6 (EU)	0.18	48	89.4	-	-	-	-	-	0
7 (EU)	0.18	142	316.2	1	1	-	-	-	2
8 (EU)	0.18	152	1,111.0	-	-	-	-	-	0
9 (EU)	0.18	74	130.8	-	-	-	-	-	0
10 (EU)	0.18	78	434.9	-	-	-	-	-	0
11 (EU)	0.18	168	262.6	-	-	-	-	-	0
12 (EU)	0.20	30	55.0	-	-	-	-	-	0
13 (EU)	0.20	145	387.4	-	-	-	-	-	0
14 (EU)	0.20	75	203.1	-	-	-	-	-	0
15 (EU)	0.20	51	66.8	-	-	-	-	-	0
16 (EU)[b]	0.20	86	96.7	-	-	-	-	-	0
17 (EU)	0.20	316	1,247.0	-	-	-	3	1	4
18 (EU)	0.20	121	418.0	-	-	-	-	-	0
19 (EU)	0.20	36	137.1	-	-	-	-	-	0
20 (EU)	0.20	24	74.0	-	-	-	-	-	0
21 (EU)	0.20	19	243.4	-	-	-	-	-	0
22 (EU)	0.20	47	139.3	-	-	-	-	-	0
23 (EU)	0.20	12	809.3	-	-	-	-	-	0
24 (EU)	0.20	314	1,245.9	-	-	-	-	-	0
25 (EU)	0.20	179	2,178.0	-	-	-	-	-	0
26 (EU)	0.20	118	2,686.6	-	-	-	3	-	3
27 (EU)	0.20	460	1,246.0	-	-	-	1	-	1
28 (EU)	0.08	43	487.0	-	-	-	-	-	0
Totals	5.51	4,345	15,296.7	4	2	3	7	1	17

(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Entire unit screened with 1/8 inch mesh. Unit size reduced to 1 m x 50 cm in Level 2.
[b]Includes 50 x 50 cm 1/8 inch mesh control quadrant.

Data recovery expanded exposure of the horizontal and vertical dimension of the feature; 25 additional 1 m x 1 m excavation units were dug (cf. Figure 170). Ten of these sounded randomly selected locations within the block of surface scrapes (Units EU 2 - EU 11). An additional 15 units explored random locations within a 4 m wide perimeter peripheral to the original block (Units EU 12 - EU 26).

Excavations revealed shallow deposits and contributed few additional specimens to the formed artifact assemblage (cf. Table 169). A hearth (Feature 25) was discovered in the southeastern quadrant.

Most cultural material resides in a 20 cm, upper layer of loess. Although too loose and turbated to allow preservation of krotovina, numerous active rodent burrows suggest that it has been heavily churned. Below this zone, and differentiated from it by a weak stratigraphic contact, occurs a more compact heterogeneous clayey soil, 15 cm thick, with markedly reduced cultural content. At variable depths this overlies a dense reddish clay with abundant large fragments of natural opalite capping minimally silicified tuff bedrock. In most units bedrock was encountered at or slightly below 40 cm. The reddish clays, a mixture of a paleosol and weathered bedrock, lack cultural remains save for where rodent burrows have introduced them from higher deposits (cf. comparable stratigraphy exposed at Feature 14; cf. Figure 172).

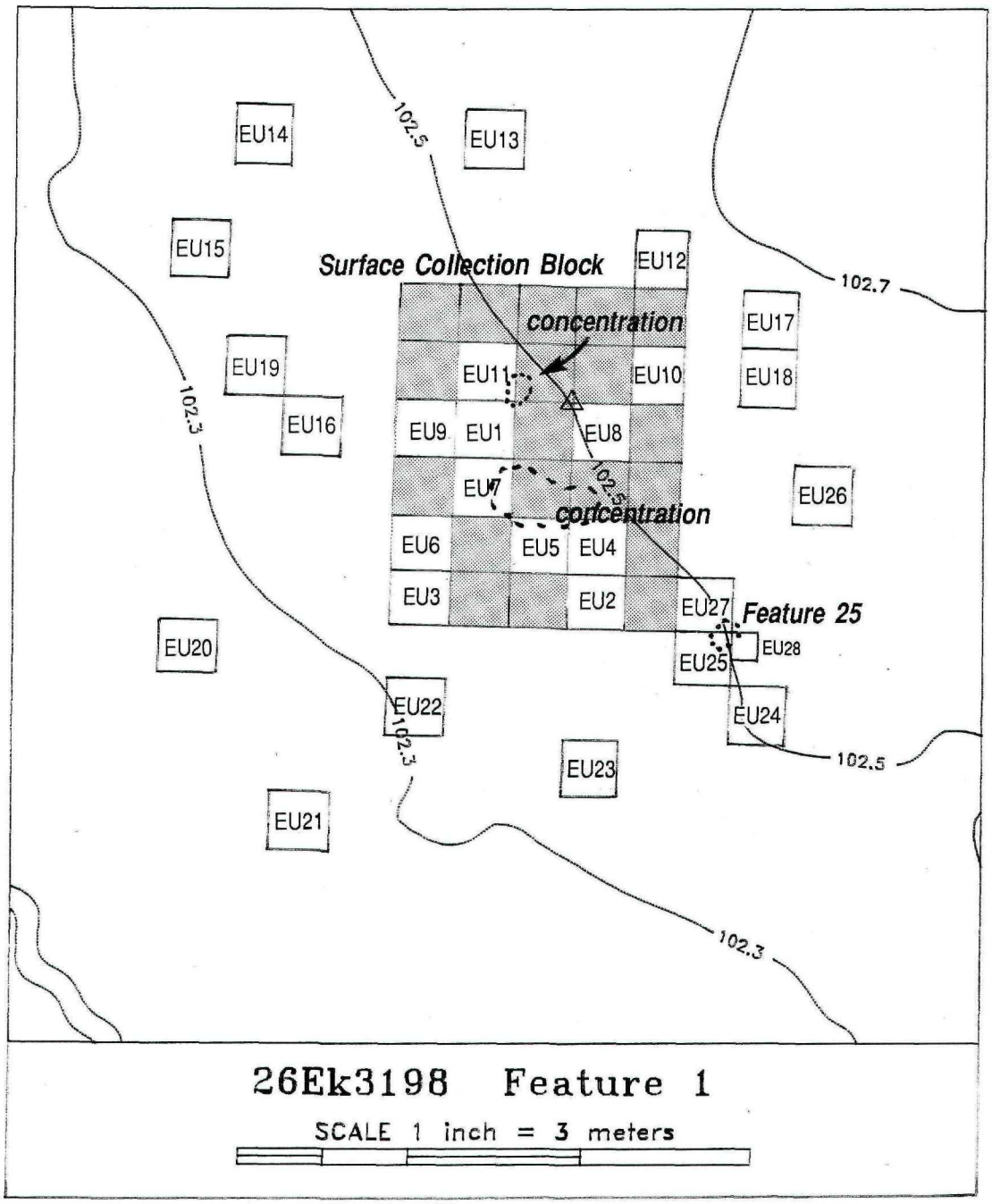


Figure 170. Feature 1 plan, 26Ek3198.

Feature 25, a hearth, was encountered in Unit 25 adjacent the southeast corner of the original block of surface scrapes (cf. Figure 170). Subsequent excavation of contiguous Units 27 and 28 resulted in its complete exposure. Lying entirely within the loess and clayey mixed deposits immediately below, the limits of the feature are clearly distinguishable from the surrounding matrix. In plan, it consists of an elliptical, 60 cm x 40 cm tightly-packed concentration of fist-sized, fire-effected tuff clasts topping and intruding a matrix of black, ashy, charcoal-rich soil. In cross-section, it is a U-shaped depression in the upper portion of the loess. The tops of the overlying rocks were encountered ca. 5 cm below surface. From ca. 10 cm below surface, the pit extends downward through the loess and the more compact soils below to intrude slightly the dense clay of the basal deposits at 25 cm. A rind of soil around the perimeter of the pit has oxidized to a bright reddish orange and deposits lining the interior are markedly more ashy than the charcoal-rich contents. Fire-cracked tuff cobbles and spalls comprise about half the volume of the pit. Radiocarbon analysis of a composite charcoal sample from the interior returned a date of 300±60 BP (Appendix L).

The function of the hearth and its relationship to other elements of the site remain unclear. Macrofossils derived from flotation disclose no use as a cooking facility (cf. Chapter 15). The position of the feature suggests affiliation with Feature 1, but no direct linkage is provided by excavations. Indirectly however, the Desert Series specimens dominating the projectile point collection from Feature 1 are congruent with the radiocarbon date obtained from the hearth.

Feature 2

Feature 2 lies 10 m south of Feature 1 and occupies the loess of the knoll top (cf. Figure 169). Its surface expression was uncommonly small (0.9 m^2), a dense scatter of opalite reduction debris. We thought the small cluster might signal a more extensive accumulation partially buried by wind-borne deposits, so we scraped three contiguous 1 m x 1 m surface units. The exercise revealed instead that the surface concentration constitutes the entire horizontal expression of the feature, confined to the upper 2 cm of deposit. A biface and a flake tool comprise the entire formed artifact assemblage; debitage chiefly reflects core functions (cf. Table 170).

Feature 9

Testing of Feature 9 was prompted by the surface occurrence of three brownware ceramic sherds that implied the possibility of diversity greater than suggested by the scatter of opalite debris. Surface scraping removed the entire feature; one additional sherd was found, together with opalite debitage indicative of early stage biface manufacture (cf. Table 170). Overall, the feature served for processing toolstone; why it contains pottery as well is unclear.

Feature 14

Feature 14 is the major opalite source within the site. Located on the northern brink of the knoll, toolstone exploitation is reflected by several dense accumulations of large fragments of opalite debris utterly blanketing the slope immediately below a series of low outcrops (Figure 171). During testing, surface scrapes sampled areas within and between concentrations; they returned formed artifacts indicative of toolstone processing (cf. Table 167) and debitage with abundant shatter and large flakes, suggestive of quarrying and initial stages of reduction (cf. Chapter 10).

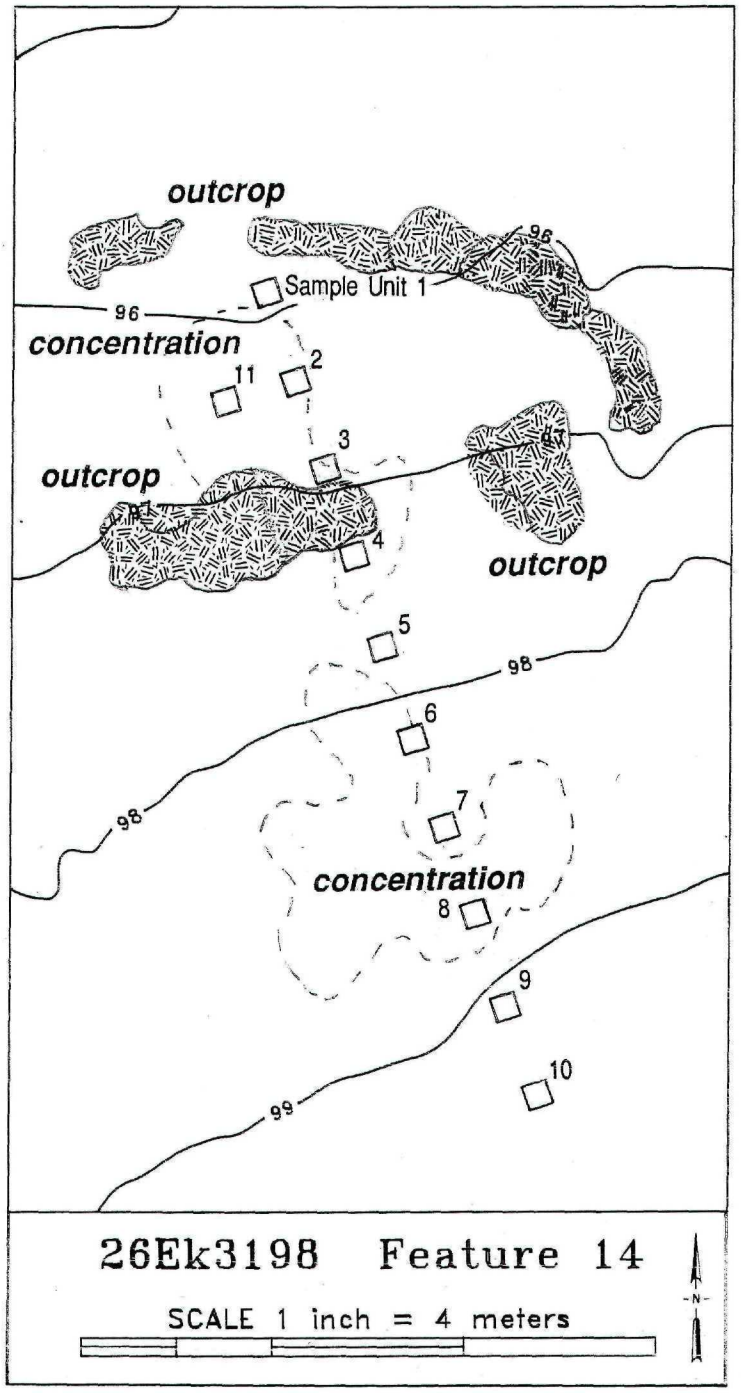


Figure 171. Feature 14 plan, 26Ek3198.

The abundance of lithic waste and the position of the debris concentrations relative to the outcrop mirror patterns observed elsewhere at quarry pits (cf. 26Ek3195; Feature 2). It seemed possible that debris might overlie and obscure quarry pits undetected during testing, or that the feature represented a very early stage of quarry formation. To explore this, a backhoe trench (Trench 1) was excavated along the surface sample transect.

The resulting profile is shallow and stratigraphically simple, with only five recognized units (Figure 172). Just above the highly irregular surface of the poorly opalized bedrock, Unit 5 consists of a reddish clay with abundant opalite and tuff fragments formed by the mixing of weathered bedrock with the overlying clay paleosol. There is no obvious cultural debris within the unit. Units 3 and 4 are clays with opalite and tuff clasts and weak to moderate prismatic soil structure. Like Unit 5, no cultural material is associated. Unit 2, a brown granular sandy loam, contains common opalite and tuff pebbles and chunks with rare opalite flakes. Unit 1, a grayish brown silt loam surface mantle, contains more opalite flakes, possibly concentrated as lag from slopewash. The clays above the bedrock indicate reworking by natural slopewash processes rather than quarrying. It appears that opalite was quarried only selectively at this feature, mostly from exposed bedrock with little (if any) digging through the soil overburden.

Implications

26Ek3198 served only minimally as an opalite source; its feature structure and artifact assemblage relate more convincingly to toolstone processing. We suspect that most opalite processed at 26Ek3198 was imported, perhaps from the neighboring, more intensively developed sources that flank it on three sides. Debitage suggests that toolstone reduced here arrived in the form of cores. From the biface collection we infer production through intermediate stages of reduction somewhat more commonly than at other quarries in the East (cf. Chapters 6 and 10).

Feature 1 appears to represent a small hunter's camp or other special purpose locus that, while not clearly associated with toolstone-orientation, nonetheless contains an assemblage of maintenance and subsistence tools perhaps reflecting tasks ancillary to, but supportive of opalite, procurement. Similar smaller and equally anomalous features occur at several other locations in the Eastern Periphery (cf. 26Ek3185, Feature 1; 26Ek3190, Feature 1; 26Ek3191, Feature 1).

26Ek3032/Locality 25

Locality 25 spans the crest of lower Holmes Ridge (cf. Figure 141). Covering 2250 m^2, it is centered on a broken rim of poor quality, reworked silicified tuffaceous sediments (Cornucopia 1987). A dense scatter of debitage and naturally fragmented opalite blankets the outcrop and its vicinity, and an anthropic talus of these materials buttresses the slopes below. Exposed bedrock dominates the surface. The sparse soils are shallow, sandy, colluvial products, dense with angular opalite cobbles; they support little tangles of low sagebrush and phlox.

Seven cultural features, all reduction stations, occur among the labyrinth of shelves, bights, and recesses in the rimrock (Figure 173). Like other outcrop quarries, exploitation of the place as a source of toolstone seems to have been minimal. Nowhere on the weathered, lichen-covered outcrop could unambiguous evidence of quarrying be found, but small quantities of locally derived debitage, distinctive for its coarse-grained, exceedingly low quality, contribute to each cultural feature as well as to the background scatter. Abundant opalite cobbles residing in the soil matrix may have provided the most commonly used on-site toolstone source.

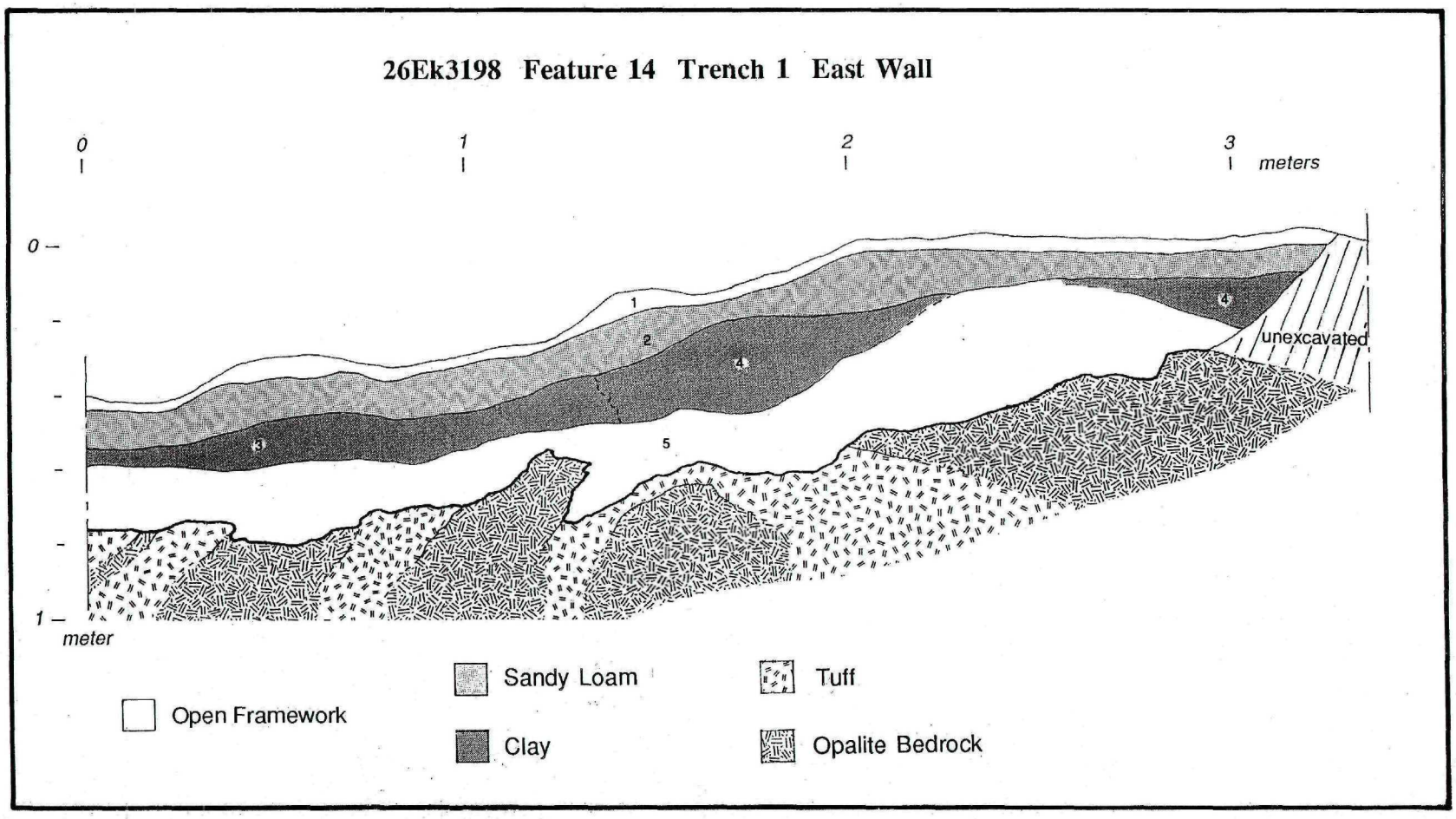


Figure 172. Description of stratigraphic units, Trench 1, 26Ek3198, Feature 14.

Figure 172. Description of stratigraphic units, Trench 1, 26Ek3198, Feature 14.

Stratum	Description
1	Grayish brown (10YR 5/2) dry; silt loam; weak fine platy; common opalite chunks; common fine roots; boundary clear and slightly irregular.
2	Brown (10YR 6/2) dry; weak fine granular; common opalite and tuff pebbles, rare opalite flakes; abundant fine roots; boundary abrupt and irregular.
3	Dark brown (7.5YR 4/4) dry; clay; moderate to strong fine angular blocky, weak clay skins; common fine subangular opalite and tuff pebbles; boundary clear and irregular.
4	Dark brown (7.5YR 4/4) dry; clay; moderate prismatic peds, moderate clay skins; rare opalite and tuff pebbles; boundary clear and irregular.
5	Strong brown (7.5YR 4/6) dry; sandy clay; weak to moderate subangular blocky; common to abundant angular to subangular fine opalite and tuff pebbles; boundary abrupt over weathered opalite and tuff bedrock.

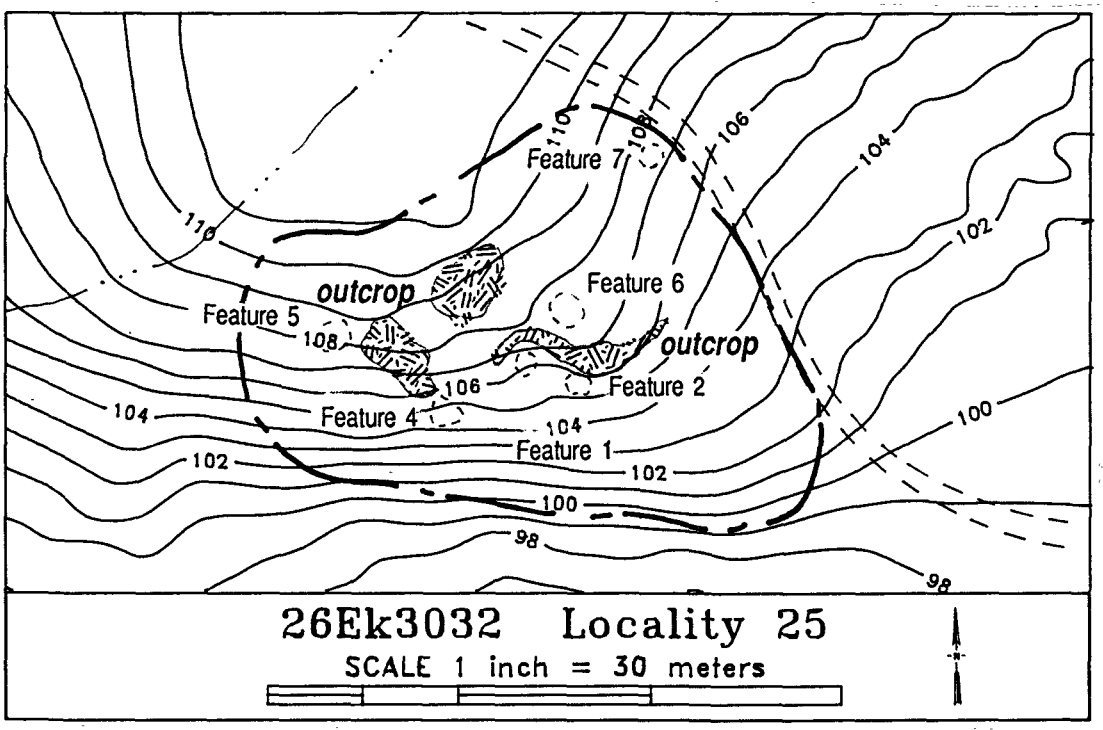


Figure 173. Locality 25 site map, 26Ek3032.

Nonfeature Contexts

Formed artifacts are scarce outside cultural features. All those found during close-interval surface inspection are direct products of opalite reduction (Table 170). Although no systematic collections of debitage were taken from nonfeature contexts, general perusal suggests that large cortical flakes and robust pieces of shatter comprise much of the waste. This, coupled with the abundance of fractured opalite cobbles and slabs, suggests that colluvial products contributed to the raw material processed at the locality.

Table 170. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3032, Locality 25.

		DEBITAGE		FORMED ARTIFACTS					
Feature	Total Area (m^2)	n	wt. (gm)	Bifaces[a]	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Total
1	7	-	-	5	-	-	-	-	5
2*	7	22,860	58,368.0	74	5	13	2	1	95
3	11	-	-	-	-	-	-	-	0
4	44	-	-	1	-	-	-	-	1
5*	23	2,856	23,011.8	13	1	-	-	1	15
6	12	-	-	-	-	-	-	-	0
7	4	-	-	-	-	-	-	-	0
Surface Isolate	-	-	-	10	-	-	-	3	13
		25,716	81,379.8	103	6	13	2	5	129

*Sample feature
[a]Includes "possible" bifaces

Cultural Features

Inventory disclosed that each of the seven reduction stations, ranging in size from 4 to 44 m^2, consists principally of concentrations of debitage and other opalite processing debris. The surfaces of most contain biface fragments; some are accompanied by cores and hammerstones (cf. Table 170). Due, perhaps, to the relatively flat surfaces and the degree to which erosion has been checked by upslope bedrock barriers, the features seem to retain high integrity. Feature 3, however, appears to have resulted from post-depositional processes; a low, neat, multi-coursed berm of large opalite waste flakes fortifies the opening of a woodrat nest at the base of a boulder. Other features are less disturbed; Features 2 and 5 were selected for sampling.

Feature 2

Feature 2 is a dense scatter of reduction debris on a pocket of sandy soil beneath a low bedrock overhang (cf. Figure 173). The 2 m high overhang could have offered shaded workspace and some wind protection; low bedrock rims upslope have virtually isolated it from erosion. Its relatively undisturbed state and the possibility of subsurface deposits led us to select it for sampling. A block of six 1 m by 1 m surface scrape units was superimposed with the aim of collecting its entire surface expression. The exercise revealed, however, that no subsurface deposit exists, the soils consisting merely of a sandy veneer over bedrock. Nevertheless, recovered artifacts include abundant opalite processing debris as well as a large and diverse assemblage of flake tools (cf. Table 170). The debitage and biface assemblages suggest that reduction tasks focused on cores and early stage bifaces (cf. Chapters 6 and 10). Numerous basalt flakes probably reflect the attrition of hammerstones (cf. Chapter 11).

Feature 5

Much larger and more open than Feature 2, Feature 5 encompasses 23 m^2 of dense reduction debris encircled by low boulders (cf. Figure 173). It was selected for sampling as a more typical representative of features at the site. Most of it lies directly on exposed bedrock, rendering standard shovel scrape techniques impossible everywhere save a small area of soil at its southern extreme. Here, a block of four 1 m x 1 m surface scrapes sampled deposits; all units revealed bedrock within 2 cm of the surface. Formed artifacts relate exclusively to opalite processing, while the debitage consists of very large waste flakes (cf. Table 170). Most of the assemblage suggests early stage reduction tasks that, as at Feature 2, involved both bifaces and cores (cf. Chapters 6 and 10).

Implications

While some on-site toolstone doubtless was exploited at Locality 25, that may not have been its principal attraction. Its ridge-top location commands a panoramic view of much of the Eastern and Western Peripheries, and it lies immediately adjacent the high quality opalite source at 26Ek3032/Locality 36. Since toolstone native to Locality 25 is inferior, the place may have served as a convenient, partially shaded reduction station.

26Ek3032/Locality 98

Locality 98 encompasses the entire 900 m^2 of a microtopographic flat on the otherwise steep eastern midslope of lower Holmes Ridge (Figure 174). It perches some 20 m above the bed of Little Antelope Creek, sharing the 5600 foot (1707 m) contour with quarry pit Locality 19 30 m south. It is separated from the reduction stations of Localities 21 and 22 on the streambank below by 50 m of 40% slope. Centered on a low opalite outcrop, Feature 1 is defined by a dense mantle of reduction by-products and naturally liberated opalite debris. This accumulation overlies soils identical to those adjacent; they are colluvial, sandy, and contain abundant unwelded tuff gravels. Although not sounded during fieldwork, site deposits seem to differ from their surroundings chiefly in the large quantity of opalite cobbles they contain and in their apparently greater depth (tall sage grows on the flat).

Cursory inspection suggested that Locality 98 was exploited for the opalite content of the low outcrop and surrounding field of cobbles. The surface of the outcrop, although weathered, appears battered as if by quarrying, and numerous split cobbles imply material assay. Fieldwork sought to clarify the relationship between the on-site toolstone source and the associated debris.

Owing, perhaps, to the abundance of material and its masking effect, close interval examination of the surface failed to discern internal differentiations in artifact densities or distribution. Several bifaces were collected from widely dispersed locations; one is heat-treated, and all are early-intermediate stage reduction products (Table 171).

The feature was bisected by ten 1 m x 1 m surface scrapes arrayed along a discontinuous baseline parallel to the slope. The exercise revealed the feature to be confined to the upper 2 cm of deposit. As anticipated by surface inspection, the sample discloses that much of the scatter consists of noncultural opalite debris and equivocal shatter. Cultural accumulations are densest in units immediately adjacent the outcrop and at the downslope

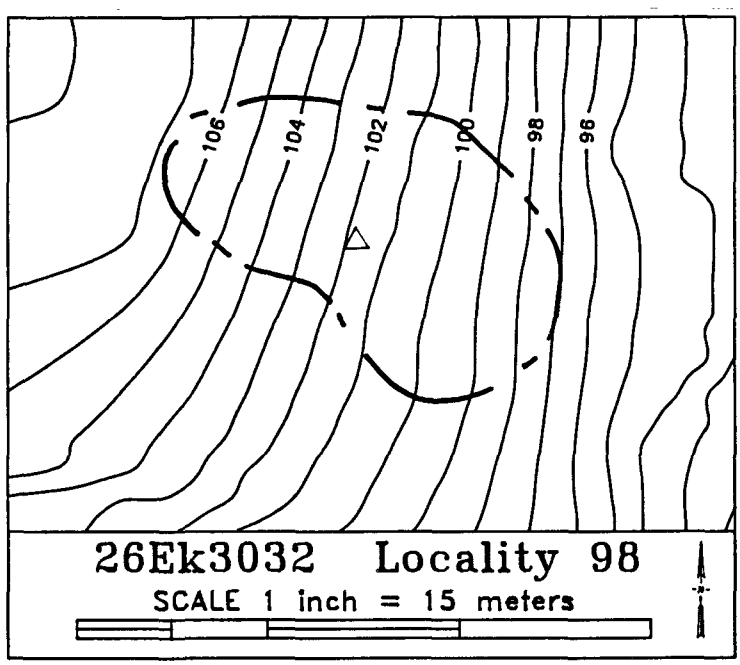


Figure 174. Locality 98 site map, 26Ek3032.

brink of the flat. Save a single flake tool and a hammerstone, the artifact content of the sample consists almost exclusively of large robust waste flakes reflecting core reduction (Table 171; cf. Chapter 10). While numerous pieces of colorful opalite, presumably of off-site origin, occur (some of this is a distinctive variety probably quarried at Locality 19), the majority of the debitage seems, from visual inspection, identical to opalite composing the outcrop and colluvial cobbles.

Table 171. Artifacts Recovered from Feature 1, 26Ek3032, Locality 98.

		DEBITAGE		FORMED ARTIFACTS			
Feature	Total Area (m^2)	n	wt. (gm)	Bifaces[a]	Flake Tools	Perc./ Cobble Tools	Total
1*	900	1,287	12,303.3	9	1	1	11

*Sample Feature
[a]Includes "possible" bifaces

The remaining outcrop quarry sites (26Ek3191, 26Ek3193, 26Ek3196, 26Ek3201, and 26Ek3203) are known only from testing. They are described briefly below, having been reported in more detail elsewhere (Botkin 1989).

26Ek3191

26Ek3191 is notable chiefly for its minimal contents. It occupies a low knoll top on the southern margin of Undine Gorge, in an area of otherwise abundant cultural remains (cf. Figure 141). Close-order reconnaissance of the 6600 m^2 comprising the site revealed one of the most sparse lithic scatters observed in the Eastern Periphery, and failed to discover any toolstone mining or processing features.

Quarrying is only weakly expressed, and lacks spatial focus. The battered appearance of the solitary low exposure of opalite on the northwestern midslope suggests that it may have provided toolstone; however, debitage is extremely sparse (<5 items/ m^2). Toolstone acquisition appears to have been directed instead toward a diffuse field of opalite cobbles weathering from colluvium on the knoll top. Some cobbles have been assayed but evidently were rejected on the spot. Sparse later stage debitage, a core, and several biface fragments recovered from widely scattered surface locations offer the only additional evidence of opalite processing (Table 172).

Feature 1, the sole feature identified, bears no clear functional relationship to opalite reduction. Isolated at the margin of the cobble field, it consists of a small cluster of obsidian artifacts scattered over 16 m^2. Surface scraping recovered its entire horizontal and vertical extent, returning an assortment of obsidian items, including an unclassifiable projectile point fragment, three flake tools, several obsidian bifaces, and numerous waste flakes. Two opalite flake tools were recovered as well, together with sparse opalite debitage (Table 172).

Table 172. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3191.

		DEBITAGE		FORMED ARTIFACTS				
Feature	Total Area (m^2)	n	wt. (gm)	Proj. Points	Bifaces	Cores	Flake Tools	Total
1*	16	23	79.3	1	7	1	5	14
Surface Isolates	-	-	-	-	4	1	-	5
		23	79.3	1	11	2	5	19

*Sample Feature

Feature 1 appears to represent a single episode of use, perhaps by hunters or others engaged in maintenance/subsistence tasks who employed imported obsidian tools and cores. Both opalite flake tools are both minimally used specimens probably selected expediently from the debris scatter.

26Ek3193

At 26Ek3193, a moderate density lithic scatter of 3610 m^2 is dotted by six reduction features and a single exploited outcrop (Figure 142). Opalite reduction, rather than extraction, appears to have engrossed most visitors. Features 1 and 4 were sampled; the contents of the remainder are known only from inventory collections (Table 173).

Table 173. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3193.

		DEBITAGE		FORMED ARTIFACTS			
Feature	Total Area (m^2)	n	wt. (gm)	Bifaces	Flake Tools	Perc./ Cobble Tools	Total
1*	226	290	1,615.3	3	-	-	3
2	112	-	-	4	-	-	4
3	14	-	-	2	-	-	2
4*	9	3,006	10,588.9	4	1	-	5
5	43	-	-	2	-	-	2
6	44	-	-	-	-	1	1
7	9	-	-	-	-	-	0
Surface Isolates	-	-	-	7	-	-	7
		3,296	12,204.2	22	1	1	24

*Sample Feature

Feature 1

A battered outcrop located on the northwestern slope suggests minimal quarrying; the outcrop and an associated dense concentration of lithic waste upslope was designated Feature 1. A discontinuous transect of surface scrapes spanned the feature, revealing its cultural content to be abundant, homogeneously distributed, and composed exclusively of opalite debitage. Individual flakes and shatter are large. The relatively high density of debris, however, probably owes not only to primary cultural deposition. The location of the feature on the midslope and the potential dam-like effect of the outcrop below it suggest that colluvial redeposition aided accumulations.

Feature 4

Feature 4, a reduction station, consists of a very dense concentration of large opalite debitage. Our initial inspection suggested it to be the product of processing cores into early stage bifaces. The moderately large debitage and the single biface fragment yielded from collection of the entire northern half of the feature seem to confirm our expectation (cf. Chapter 6).

26Ek3196

26Ek3196 occupies nearly 12,000 m² on the western extreme of the principal knoll along the upper reach of Undine Gorge (cf. Figure 142). It is isolated topographically from 26Ek3195 by a shallow intermittent drainage, and shares the knoll with numerous other sites slightly upslope and further east on the landform.

Seven cultural features define the site. Three of four outcrop quarries (Features 1, 2, and 7) lie on the relatively steep western slopes, and a smaller utilized bedrock exposure (Feature 4) occurs on more level, higher ground surrounded by Features 3, 5, and 6, all reduction stations. The two largest, most heavily used quarries, Features 1 and 2, were sampled systematically; other features were inventoried only.

As at other quarry sites, recovered assemblages reflect toolstone extraction and early stage biface manufacture, with a relatively high incidence of bifaces, cores and hammerstones. A single piece of groundstone of unidentifiable function and several flake tools reflect ancillary maintenance tasks (Table 174).

Table 174. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3196.

		DEBITAGE		FORMED ARTIFACTS					
Feature	Total Area (m²)	n	wt. (gm)	Bifaces	Flake Tools	Modif. Chunks	Cobble Tools	Perc./ Ground Stone	Total
1*	905	3,340	1,192.9	-	2	4	4	-	10
2*	2,808	1,445	9,471.5	8	1	-	4	1	14
3	35	-	-	1	-	-	-	-	1
4	16	-	-	2	-	-	-	-	2
5	75	-	-	-	-	-	-	-	0
6	31	-	-	1	-	-	-	-	1
7	528	-	-	-	-	-	-	-	0
Surface Isolate	-	-	-	5	-	-	-	-	5
		4,785	10,664.4	17	3	4	8	1	33

*Sample feature

Feature 1

Feature 1 subsumes several opalite outcrops whose battered facets testify to prehistoric exploitation. A prehistoric adit, representing a somewhat different approach to quarrying, was given special scrutiny during testing (Botkin 1989:321-324).

The adit is a small concavity gouged into bedrock at the base of a low buttress on the southern flank of the knoll. Bedrock consists of high quality opalite that apparently attracted considerable expenditure of effort. The aperture of the adit is 30 cm high and 1 m wide, and the excavation extends into the outcrop about one meter. Its floor and the ground surface immediately outside are obscured by a dense accumulation of opalite debitage and non-cultural lithic debris. The ceiling of the recess appears fire-blackened and spalled. Elsewhere on the outcrop bedrock is highly weathered, softer and grainier in texture, and of lower quality than in the immediate vicinity of the adit.

A 1 m x 1 m scrape and coterminous excavation unit sampled the area immediately outside the adit. Until bedrock was encountered at a depth of 30 cm, each level yielded opalite

debris comprising almost the entire volume of the excavated sample; soils contributed only a minor intervening matrix. Debitage is quite large, and formed artifacts relate exclusively to toolstone reduction. We infer that, once freed from the adit walls, toolstone was rendered into early stage bifaces on the spot. The products were transported elsewhere for later reduction (cf. Table 174; Botkin 1989:Table 95).

Battered bedrock exposures several meters upslope of the adit appear to reflect more typical outcrop quarrying. The dense blanket of lithic debris surrounding them was sampled by a discontinuous series of surface scrapes. The cultural content of the scatter is very diffuse, but the types of reduction artifacts comprising it are essentially identical to those at the adit.

Feature 2

Feature 2 encompasses another bedrock ledge that served as a toolstone source. Two dense scatters of reduction debris indicate that material processing occurred primarily on a relatively flat bench immediately above the outcrop. Bedrock-free gaps in the ledge have allowed quantities of debris to spill downward onto the steep slopes below; this may account for the extremely large size of the feature (ca. 2500 m^2).

A discontinuous series of surface scrapes sampled both scatters as well as a more diffuse region farther upslope. Formed artifacts and debitage are essentially identical to those obtained at Feature 1, implying similar extraction and early stage reduction functions (cf. Table 174).

26Ek3201

26Ek3201 occupies the northern flank of the principal knoll at the upper reach of Undine Gorge (cf. Figure 142). It encompasses only three reduction stations and an outcrop quarry in 2474 m^2 (Botkin 1989:Figure 79). Like 26Ek3198 just to the west, the opalite source at 26Ek3201 appears little used; aboriginal occupants seem instead to have employed the site primarily as a base for toolstone reduction convenient to other nearby sources. Nonfeature areas host a moderate density opalite lithic scatter that includes a formed artifact assemblage of very limited size and variety. Each feature was sampled; the results are summarized in Table 175.

Table 175. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3201.

		DEBITAGE		FORMED ARTIFACTS				
Feature	Total Area (m^2)	n	wt. (gm)	Bifaces[a]	Flake Tools	Perc./ Cobble Tools	Ground Stone	Total
1*	102	1,282	1,529.5	13	1	1	-	15
2*	151	2,616	2,760.0	22	-	1	1	24
3*	38	24	43.3	3	-	1	1	5
4*	679	164	1,755.9	-	-	1	-	1
Surface Isolate	-	-	-	-	-	1	-	1
		4,086	6,088.7	38	1	5	2	46

*Sample Feature
[a]Includes "possible" bifaces

Feature 1

Three dense, close-set concentrations of opalite debris, interspaced by a moderate density lithic scatter, define Feature 1. One concentration which displayed several pieces of obsidian was completely collected by a 1 m x 1 m surface scrape; a second unit sampled the inter-concentration area adjacent. Testing within the concentration yielded two dozen obsidian waste flakes as well as a large assemblage of opalite debitage and reduction forms (cf. Table 175). Markedly reduced yields (a small quantity of opalite waste) were obtained outside the visible limits of the concentration, suggesting that surface distributions accurately reflect the configuration of the feature (Botkin 1989:Table 98).

Feature 2

Save the absence of obsidian and the presence of a mano fragment, Feature 2 appeared on the surface identical to Feature 1. Sampling by means of surface scrapes within and outside debris concentrations revealed, however, that surface manifestations only weakly presage distributions of artifacts lying immediately out of view (cf. Table 175; Botkin 1989:334).

Feature 3

Feature 3, a moderate density opalite debris scatter, was sampled by a 1 m x 50 cm excavation unit to collect the dozen metate fragments observed on its surface and to probe for additional buried specimens. While the groundstone hinted that activities additional to toolstone processing occurred there, results of the exercise were equivocal.

The 20 cm of deposit overlying bedrock are heavily turbated. They yielded five additional metate fragments and a small quantity of opalite debitage (cf. Table 175). In addition, a charcoal stain of ambiguous origin was exposed; it is highly diffuse, and resembles stains of clearly modern natural origin throughout the vicinity. All seventeen metate fragments pertain to the same specimen. Some are heavily fire-affected, while others, refitted adjacent burned ones, appear pristine (cf. Chapter 12). The contrasting condition of the fragments *may* reflect reuse of some of them as cooking stones. However, given the recent and certainly long history of range fires in the region, and the shallow, churned deposits, natural burning of some fragments cannot be ruled out.

Feature 4

Feature 4 is an extensive but apparently little used outcrop quarry on a shelf of rimrock overlying the 26Ek3177 rockshelter. Surface scrapes placed within debris concentrations immediately below two battered outcrops revealed only minimal cultural contents. The sample consists almost exclusively of robust debitage; a relatively high ratio of shatter to flakes is typical of outcrop quarries elsewhere in the vicinity (cf. Table 175; Botkin 1989:Table 99).

26Ek3203

26Ek3203 occupies a narrow shelf of rimrock at the brink of Italian Mesa (cf. Figure 141). Bedrock opalite appears to have seen only minor use, even in comparison to many other meager outcrop quarries. Few formed artifacts occur, all related directly to toolstone procurement and processing (cf. Table 151). They are widely dispersed within a moderately

dense scatter of naturally liberated opalite fragments and debitage strewn over the entire 8230 m^2 of the site. Close interval surface inspection failed to isolate discrete cultural features.

A discontinuous transect of surface scrapes was placed across the entire downslope axis of the site. The large size of the debitage and the comparative abundance of shatter reflect quarrying and early stage reduction. Due to colluvial processes, or perhaps to the more commodious workspace offered by the relatively flat upper portion of the site, sample units there contain a somewhat greater abundance of small debitage.

Reduction Sites

Most sites in the Eastern Periphery lack exploited toolstone sources, and are instead defined primarily by residues of opalite reduction (cf. Table 149). All were tested save 26Ek3182, omitted from our sample after close inspection revealed the eroded and rodent-disturbed state of its sparse cultural content. Testing disclosed that 26Ek3192, and Localities 20, 21, and 22 of 26Ek3032, warranted additional examination; this was accomplished in the course of data recovery.

26Ek3192

26Ek3192 encompasses 3190 m^2 of a prominent knoll rising abruptly above Undine Gorge at the northern margin of Holeplug Ridge (cf. Figure 141). It shares the landform with outcrop quarries 26Ek3193 and 26Ek3191 to the east and west. The depositional context at 26Ek3192 contrasts strongly with these neighboring sites and with that found throughout most of the Eastern Periphery.

The surface is smooth and flat; shallow intermittent drainages have isolated it from the colluvial redeposition that has disturbed most locations in the subarea. More importantly, the site is mantled by a substantial loess deposit that in some places has accumulated to a depth of 50 cm. The loess has buried portions of two cultural features (Figure 175).

Nonfeature Contexts

Owing, perhaps, to the masking effect of wind-borne silts, nonfeature surface contexts at 26Ek3192 contain relatively few cultural residues. Surfaces outside feature boundaries reveal a light density opalite debitage scatter lightly punctuated by formed artifacts. The latter include products of toolstone processing as well as items reflecting maintenance and subsistence (Table 176).

Table 176. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3192.

		DEBITAGE		FORMED ARTIFACTS										
Feature	Total Area (m^2)	n	wt. (gm)	Proj. Points	Preforms	Bifaces[a]	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
1*	19	22,971	44,829.5	5	3	143	1	51	2	3	5	89	-	302
2*	396	16,275	24,328.0	11	1	71	3	17	2	3	1	13	1	123
3	12	-	-	-	-	1	-	-	-	-	-	-	-	1
4	64	-	-	-	-	4	-	-	-	-	-	-	-	4
5	8	1[b]	9.4	-	-	3	-	-	-	-	-	-	-	3
Surface Isolates	-	-	-	-	-	9	-	1	-	-	1	1	-	12
		39,247	69,166.9	16	4	231	4	69	4	6	7	103	1	445

*Sample feature
[a]Includes "possible" bifaces
[b]Obsidian only

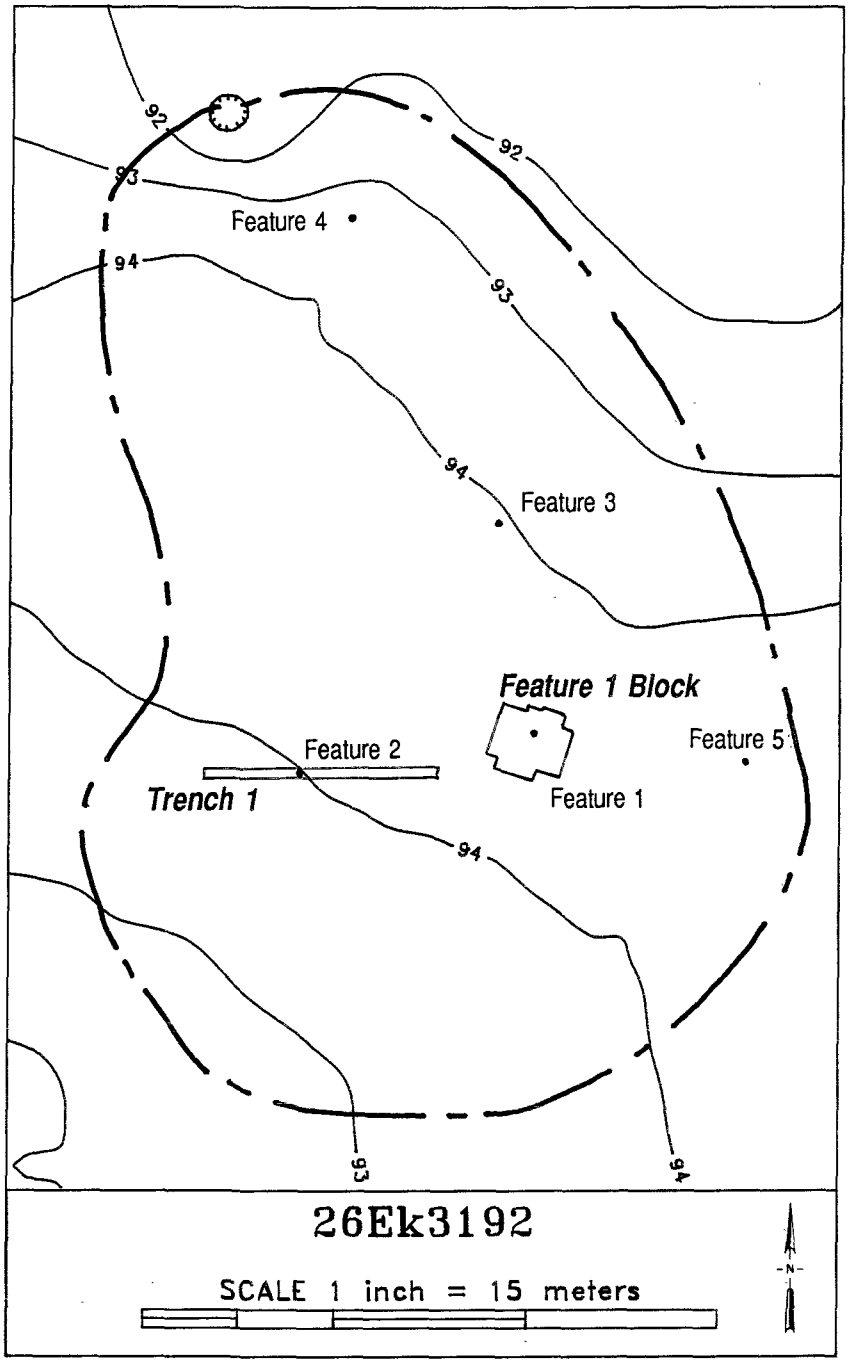


Figure 175. 26Ek3192 site map.

Cultural Features

Inventory examinations during testing suggested that three of five identified cultural features on the site periphery (Features 3, 4, and 5) are typical reduction stations. Two other features, however, contrast strikingly. Positioned just a few meters apart in the central portion of the site, Features 1 and 2 include reduction attributes but they contain as well some of the largest and most varied formed artifact assemblages encountered in the Eastern Periphery (cf. Table 176). In particular, expanded sampling during data recovery was inspired by the possibility that both features might contain buried living surfaces. Testing suggested that such surfaces might lie on the stratigraphic interface between the silty loess capping the site and an older clay horizon below.

A backhoe trench (Trench 1) was excavated through the area occupied by Features 1 and 2. The resulting profile displays the reddish clay paleosol common in the Tosawihi vicinity on both tuff and opalite lithologies (Figure 176). At 26Ek3192, the paleosol (Units 2 and 3) is developed on tuff. Unit 3 has distinct prismatic ped structure with good clay skin development; Unit 4 is a well developed calcic horizon often absent in other areas where bedrock is shallower. The strong development of the paleosol suggests a probable Pleistocene to Pliocene age.

The eolian silt loam surface mantle of Unit 1 is up to 50 cm thick. This probably is Holocene age. Large burrows, exposed at the contact between the clay of Unit 4 and the calcified tuff of Unit 5, are filled with silt of Unit 1 washed down from the above. Unit 2 is a silty clay loam with moderate to strong, granular to fine angular blocky structure with some weak clay skin development. This unit probably represents a zone of interaction between eolian Unit 1 and the underlying paleosol.

Feature 1

Feature 1 was marked on the surface by a moderate density artifact scatter covering 19 m^2 of the knoll top (Figure 177). The center of the scatter was punctuated by a tight cluster of six complete opalite bifaces, heralding what we anticipated to be a cache. Testing was begun by surface scraping the entire visible extent of the scatter in a block of 24 1 m x 1 m units. This recovered an assemblage of uncommon abundance and variety, returning, in addition to a large quantity of debitage, 37 opalite bifaces and 19 Shoshone Brownware ceramic sherds (Table 177).

A 1 m x 50 cm excavation unit centered on the biface cluster (Unit TS 1, Figure 178) confirmed our initial suspicions by returning a cache of forty-one opalite bifaces (Figure 179). The close proximity and orientation of the specimens suggests that they were placed in a basin-shaped depression ca. 50 cm in diameter and 20 cm deep. While no evidence of this pit could be detected during excavation, its presence is implied by a faint dark stain surrounding the cache visible in photographs taken through a polarizing filter. Several hundred opalite waste flakes comprise the remainder of the cultural materials occupying the loess matrix immediately around the cache (Table 178). The character of the cached bifaces is discussed in detail in Chapter 6.

Where surface scraping revealed an abundance of ceramic sherds and burned opalite flakes, a second excavation unit (Unit TS 3, Figure 178) was excavated to a depth of 10 cm to look for a hearth. Neither a hearth nor any additional ceramics were discovered, but the unit returned over 700 very small opalite waste flakes, many of them burned (Table 178).

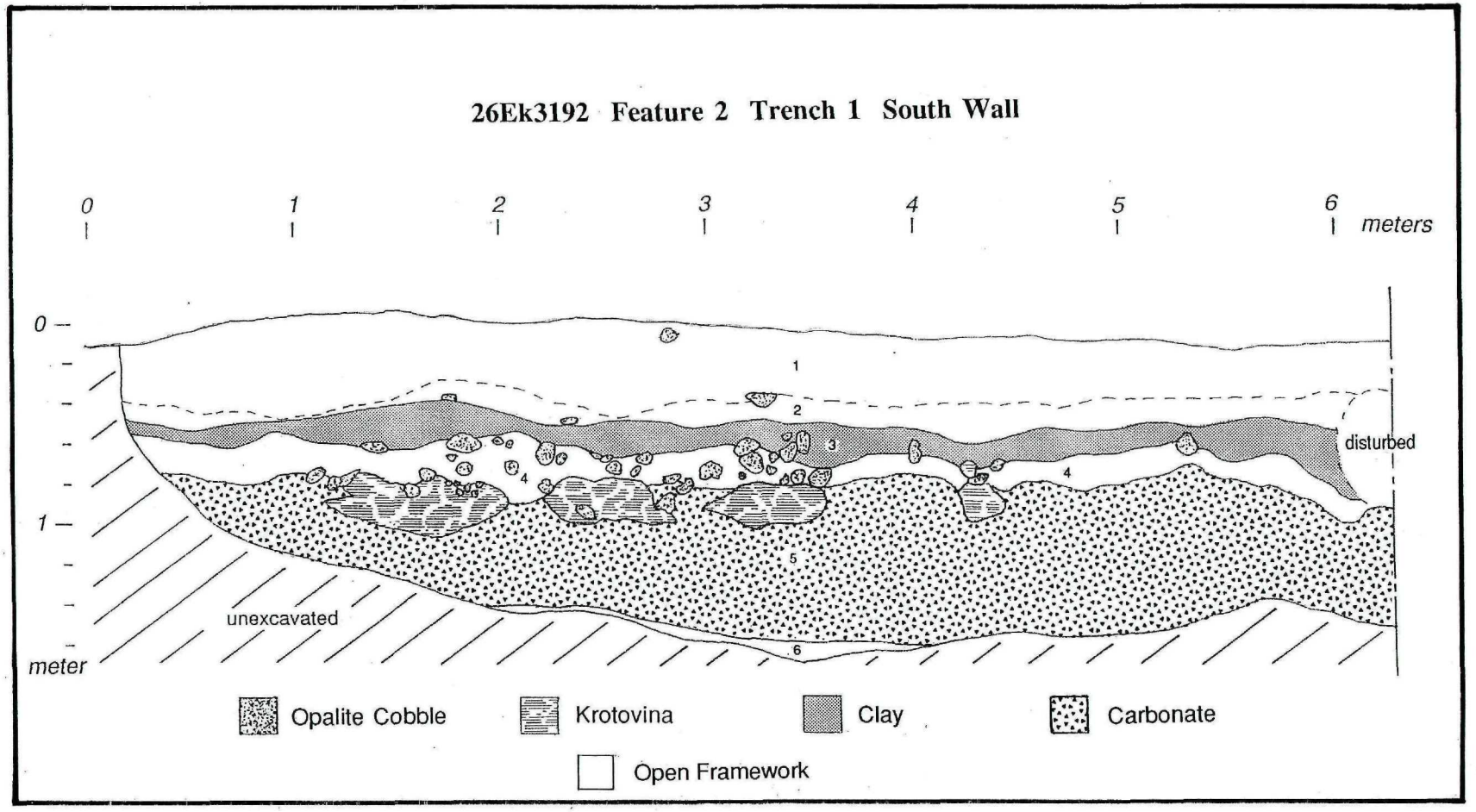


Figure 176. Description of stratigraphic units, Trench 1, 26Ek3192.

Figure 176. Description of stratigraphic units, Trench 1, 26Ek3192.

Stratum	Description
1	Light grayish brown (10YR 6/2) dry; silt loam; loose to weak granular; rare fine opalite flakes; abundant fine to medium roots; boundary gradual and irregular.
2	Brown (10YR 4/3) moist; silty clay loam; moderate to strong granular to fine angular blocky, rare clay skins on ped faces; rare angular to subangular pebbles; common fine to medium roots; boundary clear and wavy.
3	Dark brown (7.5 YR 3/4 to 4/4) moist; clay to clay loam; strong prismatic to angular blocky, abundant well developed clay skins on ped faces; rare fine subangular pebbles; common fine roots; boundary clear and irregular.
4	Strong brown (7.5 5/6 to 4/6) dry; sandy clay; abundant strongly weathered gravels and opalite cobbles; strongly calcic with incipient carbonate nodules; boundary abrupt and irregular.
5	White (10YR 8/2) dry; strongly calcified tuff, common carbonate mottling,veins, and nodules; distinct large krotovina filled with silt loam as in unit 1.
6	Dark yellowish brown (10YR 4/4) hard, non-welded tuff; minor carbonate accumulation.

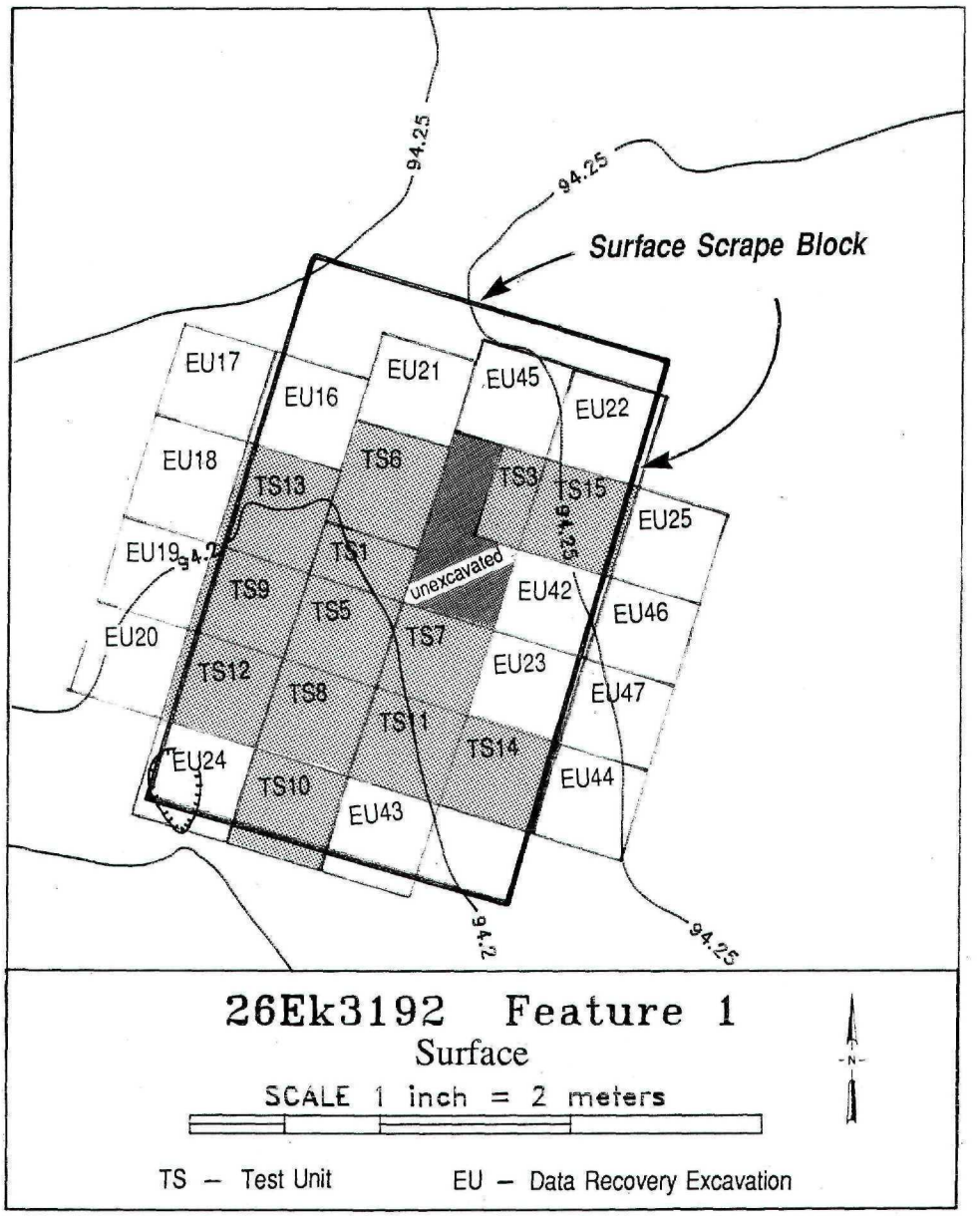


Figure 177. Feature 1 plan, 26Ek3192.

Table 177. Artifacts Recovered from Feature 1 During Test Phase Surface Collections, 26Ek3192.

Unit No. (Type)	Surface Scrape (m^2)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Preforms	Bifaces	Cores	Flake Tools	Ground Stone	Ceramics	Total
1 (SF)	1.0	48	65.6	-	-	-	-	-	-	0
2 (SF)	1.0	154	87.7	-	1	-	2	-	-	3
3 (SF)	1.0	127	147.2	-	-	-	-	-	-	0
4 (SF)	1.0	189	162.5	-	-	-	-	-	-	0
5 (SF)	1.0	348	410.6	-	1	-	1	-	4	6
6 (SF)	1.0	432	541.1	-	2	-	-	-	-	2
7 (SF)	1.0	338	373.3	-	1	-	1	-	3	5
8 (SF)	1.0	397	352.0	-	1	1	-	-	-	2
9 (SF)	1.0	342	627.1	1	4	-	-	-	-	5
10 (SF)	1.0	382	540.5	-	10	-	1	-	-	11
11 (SF)	1.0	164	263.3	-	1	-	1	-	-	2
12 (SF)	1.0	478	517.2	-	6	-	1	-	-	7
13 (SF)	1.0	439	483.4	-	-	-	-	-	-	0
14 (SF)	1.0	563	1,081.8	-	5	-	3	-	-	8
15 (SF)	1.0	722	693.1	-	2	-	5	1	-	8
16 (SF)	1.0	312	778.1	-	2	-	1	-	1	4
17 (SF)	1.0	117	168.8	-	-	-	-	-	-	0
18 (SF)	1.0	397	681.8	-	1	-	-	-	-	1
19 (SF)	1.0	94	92.4	-	-	-	-	-	-	0
20 (SF)	1.0	190	433.0	-	-	-	-	-	-	0
21 (SF)	1.0	496	783.8	-	-	-	2	-	-	2
22 (SF)	1.0	252	446.8	-	2	-	2	-	10	14
23 (SF)	1.0	66	83.6	-	-	-	1	-	-	1
24 (SF)	1.0	45	88.9	1	1	-	-	-	1	3
Totals	24.0	7,092	9,903.6	2	40*	1	21	1	19	84

(SF) = Surface Scrape

*Includes "possible" bifaces

Table 178. Artifacts Recovered from Excavation Units, Feature 1, 26Ek3192.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Total
2 (TS)[a†]	0.06	906	1,716.4	-	-	34	1	-	-	-	-	35
3 (TS)[a]	0.04	673	143.0	-	-	-	-	-	-	-	-	0
5 (TS)	0.28	745	2,135.1	-	-	5	1	-	-	-	-	6
6 (TS)	0.28	1,101	1,323.1	-	-	3	3	-	-	-	1	7
7 (TS)	0.38	1,054	3,708.7	1	-	3	6	-	1	-	-	11
8 (TS)	0.28	513	1,263.7	-	-	-	-	-	-	-	-	0
9 (TS)	0.28	254	580.8	-	-	1	1	-	-	-	-	2
10 (TS)	0.28	180	180.4	-	-	-	1	-	-	-	-	1
11 (TS)	0.28	1,147	2,123.1	1	-	6	2	-	-	-	-	9
12 (TS)	0.28	276	730.2	-	-	-	-	-	-	-	-	0
13 (TS)	0.28	516	1,109.0	-	-	2	1	1	-	-	-	4
14 (TS)	0.18	584	1,139.9	-	-	10	-	-	-	-	18	28
15 (TS)	0.23	1,177	1,949.0	-	-	9	1	-	-	-	1	11
16 (EU)	0.28	330	395.7	-	-	1	-	-	-	-	-	1
17 (EU)	0.30	254	482.0	-	-	-	-	-	-	-	-	0
18 (EU)	0.30	370	650.5	-	-	1	1	1	-	-	-	3
19 (EU)	0.30	357	640.9	-	-	-	-	-	1	-	-	1
20 (EU)	0.30	295	835.6	-	-	1	1	-	-	-	-	2
21 (EU)	0.28	661	823.1	-	-	2	1	-	-	-	-	3
22 (EU)	0.38	722	854.2	1	-	2	-	-	-	1	-	4
23 (EU)[b]	0.28	1,402	2,531.1	-	1	4	-	-	-	1	7	13
24 (EU)	0.38	377	451.2	-	-	1	-	-	-	-	-	1
25 (EU)	0.30	332	587.8	-	-	-	-	-	-	-	7	7
42 (EU)[c]	0.21	699	4,591.0	1	-	8	5	-	-	-	3	17
43 (EU)	0.28	229	476.3	-	-	1	2	-	-	-	1	4
44 (EU)	0.30	230	737.1	-	-	-	1	-	-	-	-	1
45 (EU)	0.38	250	776.5	1	-	4	1	-	-	1	-	7
46 (EU)	0.30	282	712.9	-	-	3	1	-	1	-	24	29
47 (EU)	0.30	236	1,184.9	-	-	1	-	-	-	-	8	9
Misc.[d]		-	-	-	-	1	-	-	-	1	-	2
Totals	8.00	16,152	34,833.2	5	1	103*	30	2	3	4	70	218

(TS) = Test Excavation Unit
(EU) = Excavation Unit
† Includes biface cache
*Count includes "possible" bifaces

[a]Unit size = 1 m x 50 cm; 1/8 inch mesh only
[b]Includes 50 x 50 cm 1/8 inch mesh control quadrant
[c]Unit size = 1 m x 75 cm
[d]Artifacts from rodent backdirt, Feature 1 exposure

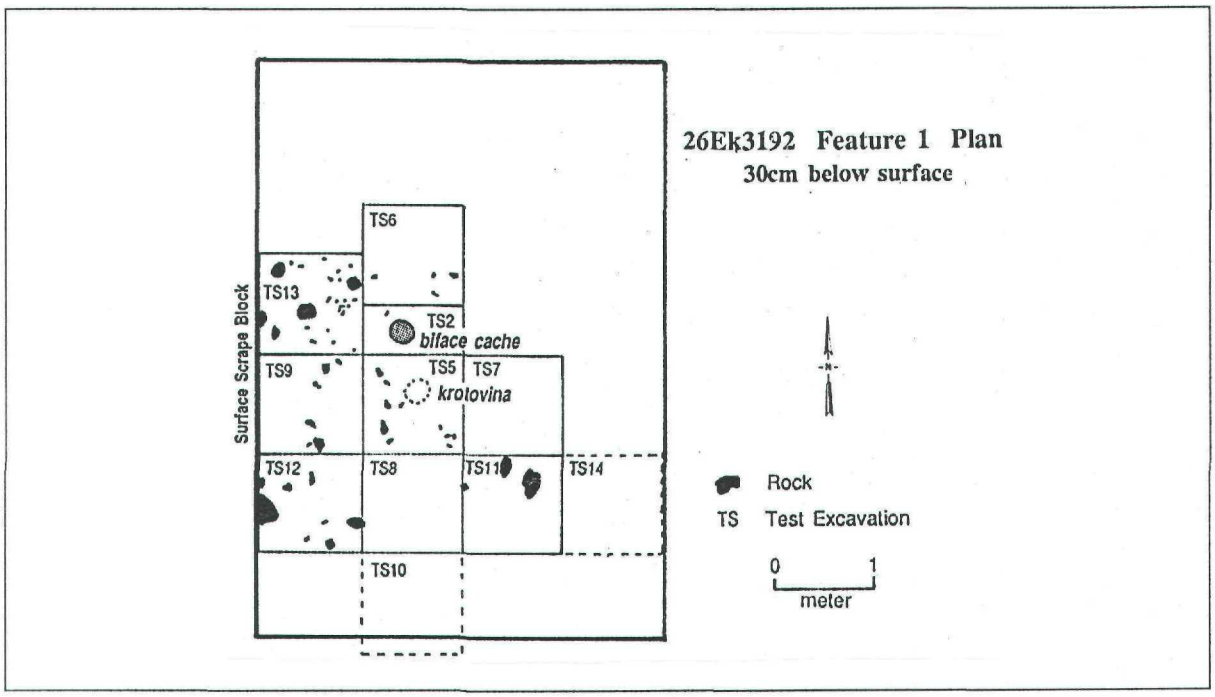


Figure 178. 26Ek3192, Feature 1 Plan. a. surface; b. subsurface.

Figure 179. Feature 1 biface cache, 26Ek3192.

Subsequent to excavation of these two units, we opened a broad, contiguous exposure around the biface cache, excavating an additional 26.5 m^2 to depths of between 20 cm and 40 cm (Figures 178a, 178b). By the close of data recovery, Feature 1 had yielded over 250 formed artifacts, including 142 opalite bifaces (41 constituting the cache), a core, a pair of hammerstones, scores of flake tools and ceramic sherds, and five projectile points including Desert Side Notched and Humboldt specimens (cf. Table 176). Opalite debitage was correspondingly abundant, accompanied by small numbers of obsidian, jasper, and basalt flakes (cf. Table 176; Table 178). The block excavation returned numerous bones as well, slightly over half of them burned; although distributed throughout the deposit, most were recovered from the silt loam matrix of Level 2 in Unit 42. The character of the faunal assemblage suggests that it represents human subsistence refuse (cf. Chapter 14).

Subsurface soils are heavily turbated and similar in structure throughout the area sampled. The profile of the north wall of Excavation Unit 22 typifies the deposit of Feature 1 (Figure 180). The exposure is approximately 35 cm deep by 110 cm wide, and exhibits three stratigraphic units. Unit 1 is a loose, brownish gray silt loam. Unit 2, also a silt loam, is slightly more yellowish and clayey. Unit 3 is very similar to Unit 2, but has very weak clay skins on blocky ped surfaces. Although the eolian origin of these silts makes separate depositional episodes within them probable, the units defined above are pedogenically distinct rather than depositional.

Most subsurface cultural materials were obtained from the upper 30 cm of the deposit, within the zone of undifferentiated mixed silts of Soil Units 1 and 2 (cf. Figure 180). However, an anomalous accumulation of lithic material occurs at the contact between these deposits and the more clayey and compact Soil Unit 3. Here, at an average depth of 26 cm, and throughout the horizontal extent of the unit, occurs a diffuse lithic scatter composed of chiefly large opalite flakes, several biface fragments, and many unmodified opalite cobbles and slabs (cf. Figure 178a). This accumulation apparently is unstructured and, lacking cultural features or other evidence for human modification of the clay surface itself, origins of the scatter remain ambiguous. The shared stratigraphic position of the material suggests perhaps its deposition

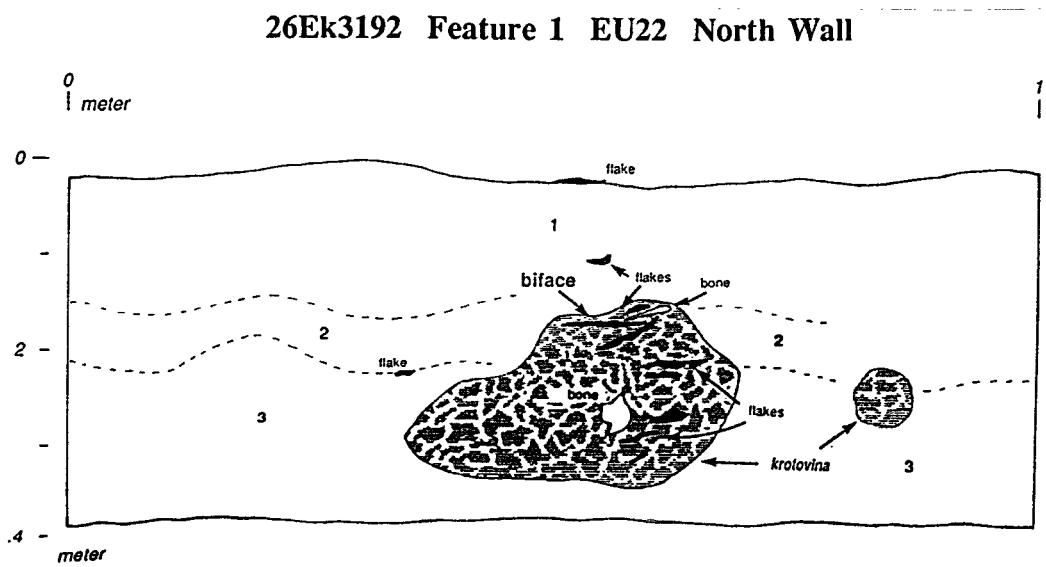


Figure 180. Feature 1 profile, 26Ek3192.

on an ancient ground surface subsequently buried by eolian silts. Alternatively, however, the comparatively large size and weight of the items, coupled with their accumulation atop soil deposits of markedly greater density than those above, suggests that foundering may account for the concentration of massive pieces.

Feature 2

Located 10 m west of Feature 1, Feature 2 is manifest on the surface by a pair of dense lithic concentrations within a more diffuse scatter covering some 12 m² (Figure 181). The artifact content of its surface resembles that of Feature 1, absent a biface cache. In addition to the dominant opalite debris, obsidian, basalt, and jasper flakes are visible within the concentrations and surrounding scatter. Surface inventory revealed numerous bifaces and flake tools, a Shoshone Brownware sherd, and an incised stone cylinder. The surface assemblage also includes a pair of steep-edged, high-domed end scrapers and a basalt Great Basin Stemmed Series projectile point (Table 179). As well, there occur several basalt biface fragments that, although too highly fragmented to be identified unequivocally, may represent an additional Stemmed Series point specimen. The presence of these scrapers and projectiles characteristic of the pre-Archaic period in the Great Basin, coupled with the possibility of buried, potentially early deposits prompted selection of Feature 2 for sampling.

Table 179. Artifacts Recovered from Feature 2, 26Ek3192.

		DEBITAGE		FORMED ARTIFACTS										
Unit No. (Type)	Surface Scrape (m²)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
1-20 (SF)	5.00	2,527	3,330.9	2	-	3	-	3	-	-	-	-	-	8
Surface Inventory	N/A	3†	11.9	3	-	23	-	3	-	-	-	1	1	31
Surface Total		3,530	3,342.8	5	-	26*	-	6	-	-	-	1	1	39
	Volume Excav. (m³)													
1 (TS)[a]	0.075	1,123	608.3	-	-	1	-	1	-	-	-	-	-	2
4 (TS)	0.80	3,756	5,068.4	5	1	16	2	3	1	2	1	-	-	31
26 (EU)[b]	0.50	1,726	3,257.4	1	-	8	-	2	-	-	-	3	-	14
27 (EU)	0.40	509	810.2	-	-	1	-	1	1	-	-	-	-	3
28 (EU)	0.40	887	1,255.6	-	-	3	-	-	-	-	-	-	-	3
29 (EU)	0.50	772	1,420.8	-	-	5	-	-	-	-	-	3	-	8
30 (EU)	0.40	366	783.3	-	-	1	-	-	-	-	-	-	-	1
31 (EU)	0.40	1,077	1,452.5	-	-	2	1	1	-	-	-	-	-	4
32 (EU)	0.40	327	488.9	-	-	1	-	1	-	1	-	-	-	3
33 (EU)	0.30	154	298.8	-	-	-	-	-	-	-	-	-	-	0
34 (EU)	0.30	412	1,188.2	-	-	2	-	1	-	-	-	-	-	3
35 (EU)	0.20	224	341.1	-	-	-	-	-	-	-	-	-	-	0
36 (EU)	0.50	473	822.8	-	-	-	-	-	-	-	-	-	-	0
37 (EU)	0.20	135	364.4	-	-	-	-	-	-	-	-	-	-	0
38 (EU)	0.30	69	89.7	-	-	-	-	1	-	-	-	-	-	1
39 (EU)	0.40	181	494.6	-	-	-	-	-	-	-	-	2	-	2
40 (EU)	0.50	1,535	2,212.8	-	-	5	-	-	-	-	-	3	-	8
41 (EU)	0.50	22	39.3	-	-	-	-	-	-	-	-	-	-	0
Subsurface Total	7.075	13,748	20,997.1	6	1	45*	3	11	2	3	1	11	-	83
Feature Total		17,278	24,339.9	11	1	71*	3	17	2	3	1	12	1	122

(SF) = Surface Scrape
(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Unit Size = 1 m x 50 cm; entirely 1/8 inch mesh
[b]Includes 50 x 50 cm 1/8 inch mesh control quadrant
†Obsidian only
*Includes "possible" bifaces

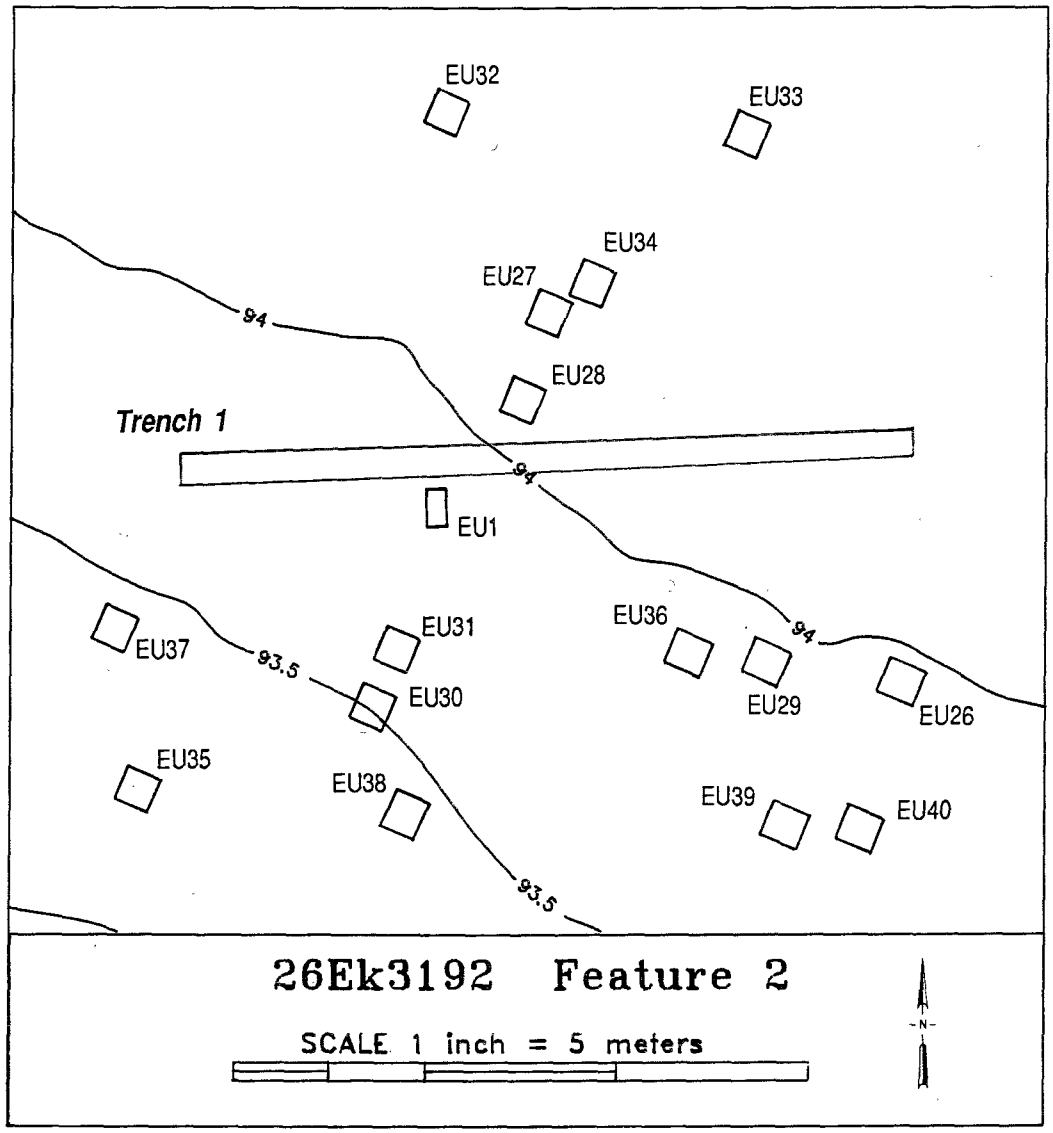


Figure 181. Feature 2 plan, 26Ek3192.

A discontinuous series of 20 50 cm x 50 cm surface scrapes was placed along a baseline bisecting the principal artifact concentration and extending into the lithic scatter beyond. The configuration of the concentration visible on the surface defines its full horizontal extent; units falling outside its visible limits yielded substantially fewer artifacts than those within it. The sample returned a large quantity of opalite waste, several obsidian flakes, and a pair of projectile point fragments (cf. Figure 181; Table 179). No additional artifacts suggesting pre-Archaic occupation were returned; both projectile fragments proved typologically non-diagnostic (cf. Chapter 8).

During testing, two excavation units explored the subsurface where debitage was found to be densest. Both revealed deposits stratigraphically comparable to those of Feature 1 and essentially identical to those of Trench 1 described above (cf. Figure 176). Unit 1 (1 m x 50 cm) was dug to a depth of 20 cm where excavation was terminated when cultural material fell off sharply and the loose silt of the upper stratum became increasingly burdened with clay.

Excavation Unit 4 (1 m x 1 m) was intended to probe the full vertical extent of the deposit; it was dug to a depth of 80 cm, well into a mixed stratum of dense clay and weathered tuff bedrock. The loose silt of the upper 10 cm proved to contain the densest cultural material, yielding abundant opalite reduction debris, a Desert Side Notched projectile point, four non-diagnostic point fragments, a mano, and several obsidian waste flakes. Subsequent levels returned diminishing numbers of artifacts. Below ca. 50 cm, roughly at the contact between the mixed upper silts and the more clayey paleosol, virtually all cultural materials were recovered from krotovina; a Cottonwood Triangular projectile point was found between 60 and 70 cm below surface (cf. Table 179).

Data recovery sought to clarify the content and structure of the subsurface deposit. As at Feature 1, work focused on exploring the relationship between cultural content of the deposits and the possible living surface at the contact between upper eolian silts and clay paleosol. This was initiated by excavation of Backhoe Trench 1, spanning the central portion of the site from the excavation unit block at Feature 1 westward across all of Feature 2 (cf. Figure 175).

Before unit excavation, the area surrounding Trench 1 was probed by a series of 88 soil core samples at 2 m intervals along seven parallel baselines spaced 5 m apart. The paleosol was encountered at depths between 21 cm and 85 cm throughout the feature; most probes hit clay between 31 cm and 40 cm below surface. The area subsequently was subdivided into six sampling strata based on depth of the paleosol. Ten 1 m x 1 m excavation units (Units 32 through 41) were distributed proportionally among the sampling strata, selected by random draw. Six additional units (Units 26 through 31) were deployed to explore more fully locations returning promising results (cf. Figure 181). In each unit digging was halted at the silt-clay interface in order to assess possible use of the ancient surface. Table 179 presents artifact recoveries on a unit by unit basis.

Unit excavation revealed subsurface deposits structured much like those exposed by Trench 1. They vary most in the depth at which paleosol (Soil Unit 4) is encountered, apparently a function of natural undulations in the bedrock substrate. Regardless of depth of the clay, the upper eolian silts (Soil Units 1 and 2) everywhere are heavily churned; krotovina and active mammal burrows abound. Cultural content of the deposit is undifferentiated horizontally, and much of its artifactual component resides in the upper 10 cm. As at Feature 1, the assemblage includes a wide range of artifact types, but it is proportionally smaller and somewhat less dense. Also, the clay contact exposed in several units in Feature 2 revealed sparse accumulations of large opalite debitage and unmodified cobbles of tuff and opalite. No subsurface features were found; in several places diffuse ash stains and charred soil reflect only burned rootballs of grasses and sage. The question of whether an ancient living surface lies beneath the silt cap remains unresolved.

Implications

The magnitude of field efforts notwithstanding, Features 1 and 2 returned assemblages among the largest and most varied of any recovered in the Eastern Periphery (cf. Chapter 23). That they also witnessed a very early occupation prior to the deposition of the loess mantle remains equivocal. Although distributed without apparent pattern, time-sensitive artifacts imply some early human presence; they reflect virtually the entire reach of Great Basin prehistory.

Antiquity and depositional context aside, the most abundant (and probably most recently accrued) remains occur on the surface as artifact concentrations relating directly to the processing of opalite and, as evidenced by the cache in Feature 1, the storage of reduced, portable products. Debitage from early stage biface reduction predominates, and bifaces reflect nearly the entire range of reduction (cf. Chapter 6). Maintenance and subsistence implements abound, suggesting activities ancillary to and supportive of toolstone processing.

26Ek3032/Locality 20

Locality 20 lies on the western flank of Ramadan Ridge, just downslope of 26Ek3170 and 6 m higher than the bank of Little Antelope Creek (cf. Figure 141). It is differentiated from its immediate surroundings by a moderate to high density lithic scatter encompassing ca. 200 m^2. Like most of the adjacent hillside, low lying, highly weathered opalite bedrock occurring throughout the site appears not to have attracted use. Intervening shallow, gravelly soils support a patchy growth of low sage, inviting little accumulation of subsurface cultural remains. Close interval surface reconnaissance revealed three small, spatially discrete concentrations of reduction debris (Figure 182). Elsewhere, extra-feature contexts were defined almost exclusively by opalite debitage (Table 180).

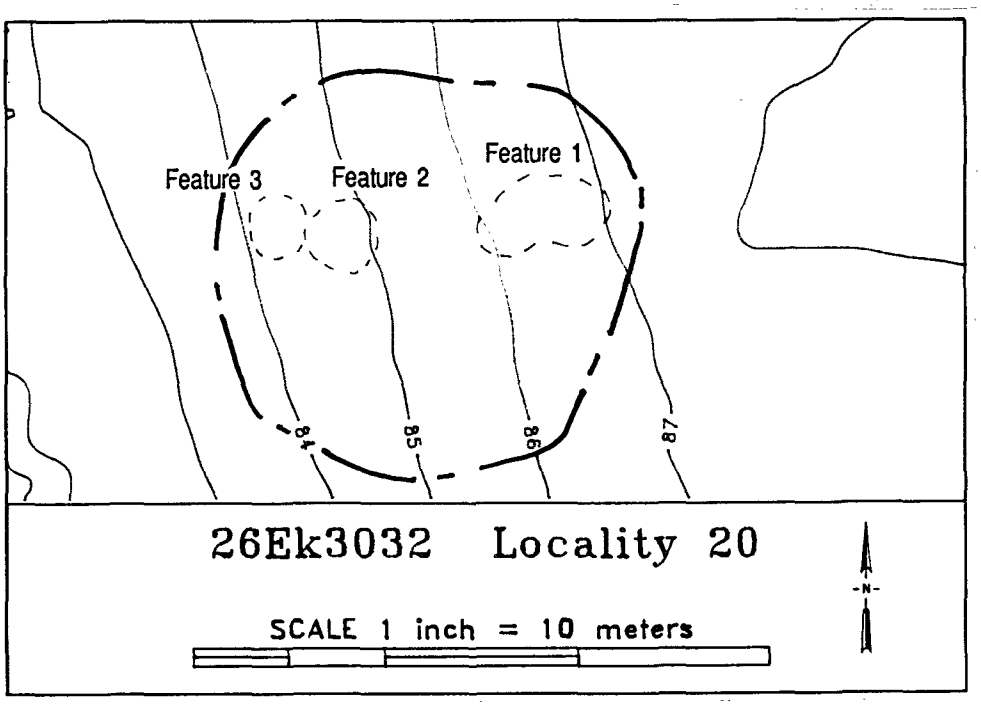


Figure 182. Locality 20 site map, 26Ek3032.

Table 180. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3032, Locality 20.

Feature	Total Area (m^2)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Bifaces[a]	Cores	Flake Tools	Total
1*	7	6,448	21,523.0	-	11	-	3	14
2*	5	1,092	4,315.1	1	2	3	3	9
3*	13	2,047	7,145.4	-	4	1	-	5
Surface Isolates	-	-	-	-	4	-	-	4
		9,587	32,983.5	1	21	4	6	32

*Sample Feature
[a]Includes "possible" bifaces

Features 1, 2, and 3 cover 7 m^2, 5 m^2, and 13 m^2, respectively. Each is a rather typical reduction station; they differ chiefly in size and density. Each was sampled by surface scrape units centered on the densest concentrations. The exercise revealed that all are confined to the upper 2 cm of deposit, and that most of their cultural contents consist of opalite reduction products (cores and bifaces) and by-products. Flake tools occur in assemblages from Features 1 and 2; the latter also yielded an Elko projectile point (cf. Table 180).

26Ek3032/Localities 21 and 22

Separated by only 30 m, Localities 21 and 22 dot the west bank of Little Antelope Creek immediately adjacent a series of boulder-lined vernal pools (cf. Figure 141). Both localities are small, ca 100 m^2 and 30 m^2, respectively, and each contains a single reduction feature. They occupy the narrow, most recent stream terrace elevated barely half a meter above the active creek bed; they are backed by the steep (40%) footslope of Holmes Ridge (Figure 183). Opalite occurs abundantly both as cobbles in the stream bed and as large, colluvially deposited clasts on the terrace. The localities were scrutinized to see whether these low quality, rarely used source types were exploited.

Close interval inspection at Locality 21 revealed few formed artifacts, all of them opalite reduction products. The sole feature (Feature 1) lies amid a cluster of low opalite boulders; it consisted of a dense, 2 m^2 accumulation of opalite debitage and numerous unmodified stream cobbles. The apparent density of the feature owes to the robustness of individual waste flakes and the co-occurrence of much non-cultural debris. The surface of the feature was collected by a pair of 1 m x 1 m surface scrape units that yielded abundant debitage, a small assemblage of formed reduction artifacts, and a flake tool (Table 181). A 1 m x 1 m excavation unit probed subsurface contexts beneath the scrape until bedrock (apparently the top of a large stream boulder) was met at a depth of 30 cm. Cultural materials occur throughout, but the unstratified sandy, alluvial matrix containing them comprises less than half excavated volume of each level. Large unmodified cobbles, angular opalite debris, and near-surface bedrock occupy most of the deposit. Artifact retrievals reflect those obtained from the surface (Table 181).

Table 181. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3032, Localities 21 and 22.

Feature	Total Area (m^2)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Bifaces[a]	Cores	Flake Tools	Modif. Chunks	Total
Locality 21								
1*	0.60	1,794	39,896.1	3	8	2	3	16
Surface Isolates	-	-	-	4	-	-	1	5
Total		1,794	39,896.1	7	8	2	4	21
Locality 22								
1*	9	2,067	13,681.6	6	2	1	-	9
Surface Isolates	-	-	-	-	1	-	-	1
Total		2,067	13,681.6	6	3	1	0	10

*Sample Feature
[a]Includes "possible" bifaces

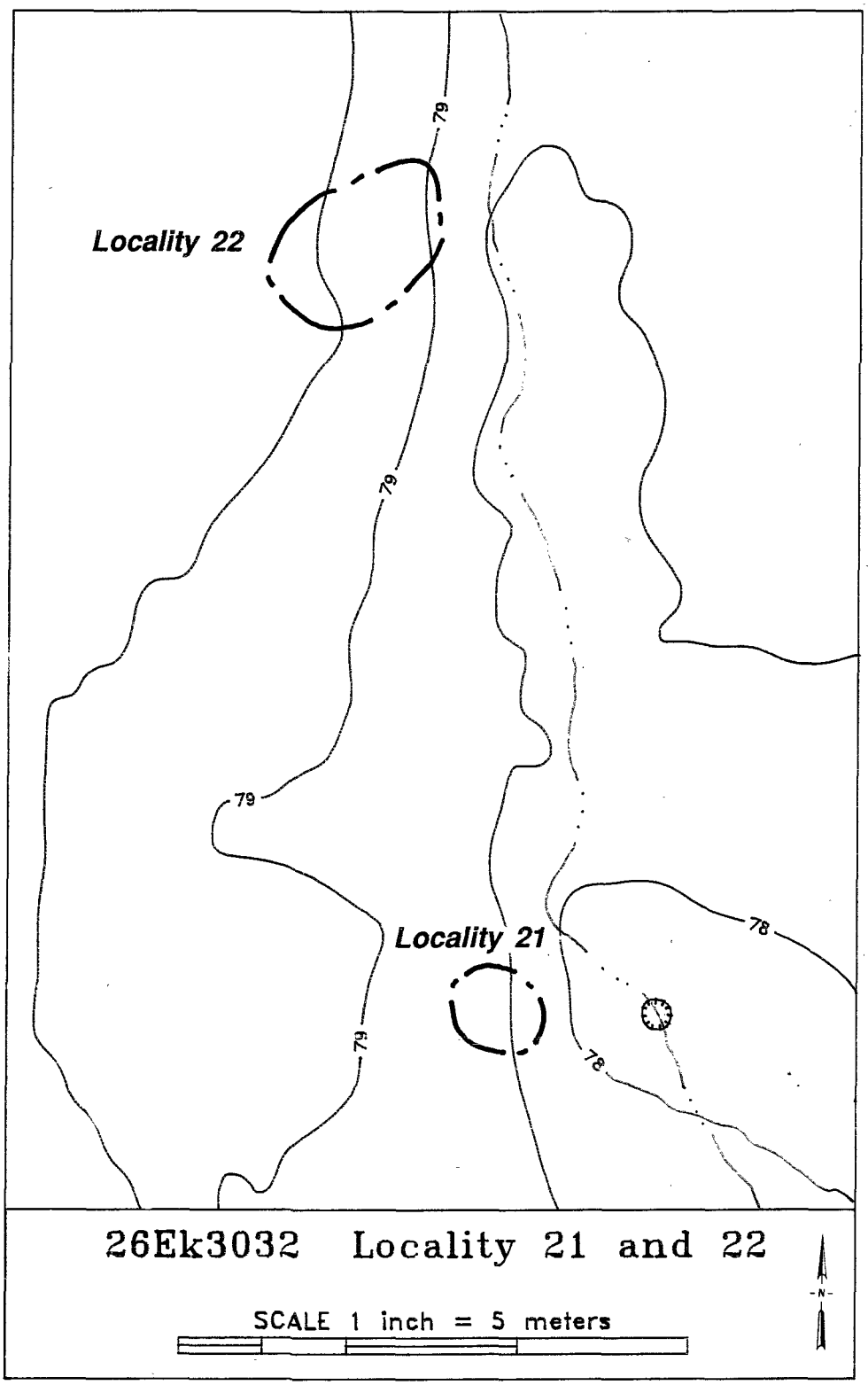


Figure 183. Localities 21 and 22 site map, 26Ek3032.

The lithic scatter at Locality 22 is less dense than that at Locality 21, but Locality 22 similarly consists of a concentration of opalite debitage and unmodified opalite debris over an area of ca. 2 m^2. Six 1 m x 1 m scrapes removed the entire surface component, and resulted in artifact recoveries comparable to those yielded by Locality 21 (cf. Table 181). In the densest zone, a 1 m x 1 m excavation unit was dug until an impenetrable stratum of stream cobbles halted work at a depth of 20 cm. Cultural material is most abundant in the upper 10 cm. Artifact returns from excavation swell the size of the collection, but add nothing new.

Analysis of the collections from Localities 21 and 22 confirm our original assumption that they represent comparatively rare instances of the use of opalite stream cobbles as sources of lithic raw material (cf. Chapters 6 and 10).

Other Reduction Sites

The balance of the reduction sites (n=16) are known only from data obtained during testing. Half of them were sampled systematically; the remainder were examined only by surface inventories (cf. Table 150).

Rarely exceeding 500 m^2 in area, and confined primarily to microtopographic flats on Ramadan and Holeplug Ridge, relatively distant from toolstone sources, these sites are defined by from one to as many as eleven culture features. Feature composition generally is equivalent to that of reduction features composing toolstone processing components at most other sites in the subarea. Remains are confined almost exclusively to surface contexts (≤ 2 cm depth) and, save exceptional features at 26Ek3185 and 26Ek3190, assemblages consist of items dominantly related to toolstone processing. For sites conforming to these generalizations, descriptions of testing procedures and results are relegated to tabular summation (cf. Tables 150 and 182) and earlier documentation (Botkin 1989). The exceptions (26Ek3185 and 26Ek3190) warrant brief separate consideration because they also exhibit non-reduction attributes.

Table 182. Artifacts Recovered from Feature and Nonfeature Contexts, Miscellaneous Eastern Periphery Reduction Sites.

			DEBITAGE		FORMED ARTIFACTS								
Site	Feature	Total Area (m^2)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Ground Stone	Ceramics	Total
26Ek3172	1*	6	1,258	1,969.9	-	-	-	-	-	-	-	-	0
	2	5	-	-	-	-	-	-	-	-	-	-	0
	3	6	-	-	-	-	-	-	-	-	-	-	0
	4	8	-	-	-	-	1	-	-	-	-	-	1
	5	14	-	-	-	-	-	-	-	-	-	-	0
	6	2	-	-	-	-	-	-	-	-	-	-	0
	Surface Isolates		2[a]	17.0	-	-	5	-	-	-	-	-	5
26Ek3173	1*	25	3,856	8,704.5	2	-	6	1	2	-	-	-	11
	2	17	-	-	-	-	-	-	-	-	-	-	0
	3	60	-	-	-	-	-	-	1	-	-	-	1
	4	24	-	-	-	-	1	-	-	-	-	-	1
	Surface Isolates		-	-	-	-	2	-	1	-	-	-	3
26Ek3174	1	82	-	-	-	-	-	-	-	-	-	-	0
	2	102	-	-	-	-	1	-	-	-	-	1	2
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3175	1	85	-	-	-	-	1	-	-	-	-	-	1
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3178	1*	44	3,737	6,463.7	2	-	13	-	-	1	-	-	16
	2	64	-	-	1	-	-	-	-	-	-	-	1
	3	10	-	-	-	-	-	-	-	-	-	-	0
	4	8	-	-	-	-	-	-	-	-	-	-	0
	Surface Isolates		-	-	-	-	1	-	-	-	-	-	1

Table 182, continued.

Site	Feature	Total Area (m²)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Ground Stone	Ceramics	Total
26Ek3179	1*	6	1,219	1,421.5	-	-	1	-	3	-	-	-	4
	2	2	-	-	-	-	-	-	-	-	-	-	0
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3180	1	12	-	-	-	-	1	-	-	-	-	-	1
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3181	1*	19	3,585	6,297.8	-	-	11	-	5	-	1	2	19
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3183	1*	8	2,175	2,454	-	-	4	-	-	-	-	-	4
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3186	1	55	-	-	-	-	-	-	-	-	-	-	0
	2	19	-	-	-	-	1	-	-	-	-	-	1
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3187	1	49	-	-	-	-	-	-	-	-	-	-	0
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3188	1	110	-	-	-	-	-	-	-	-	-	-	0
	Surface Isolates		-	-	-	-	-	-	-	-	-	-	0
26Ek3189	1	19	-	-	-	-	1	-	-	-	-	-	1
	2	49	-	-	-	-	-	-	-	-	-	-	0
	3	9	-	-	-	-	-	-	-	-	-	-	0
	4	16	-	-	-	-	-	-	-	-	-	-	0
	Surface Isolates		1[a]	4.0	-	1	1	-	-	-	-	-	2

*Sample features
[a]Obsidian only

26Ek3185 and 26Ek3190

26Ek3185 lies immediately adjacent and above 26Ek3184 on the lower slopes of Holeplug Ridge (cf. Figure 141). Occupying just over 900 m², seven reduction features and an intervening moderate density lithic scatter define the site. Each feature consists of typical, dense accumulations of opalite debitage; Feature 1 is distinguished by numerous formed reduction artifacts and a variety of maintenance/subsistence tools (projectile points, preforms, flake tools, and groundstone). Surface scrapes (20 m²) recovered its entire horizontal and vertical expression, yielding a diverse assemblage of formed artifacts and abundant reduction debris (Table 183).

Table 183. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3185.

Feature	Total Area (m²)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Perc./ Cobble Tools	Ground Stone	Total
1*	16	2,117	3,199.9	5	3	8	9	2	1	28
2	14	-	-	-	-	3	-	-	-	3
3	6	-	-	-	-	-	-	-	-	0
4	13	1[a]	1.6	-	-	1	-	1	-	2
5	26	-	-	-	-	4	-	-	-	4
6	12	-	-	-	1	1	2	-	-	4
7	5	-	-	-	-	-	-	-	-	-
Surface Isolates	-	-	-	3	-	5	2	-	-	10
		2,118	3,201.5	8	4	22	13	3	1	51

*Sample feature
[a]Obsidian only

Although more extensive (4241 m²), and containing more cultural features, 26Ek3190 is similar. Here, on the knoll top immediately east of 26Ek3184, eleven features display concentrations of opalite reduction debris (cf. Figure 142). The surface of Feature 1, however, is augmented by numerous tools and non-opalitic waste (obsidian and basalt debitage). A block of surface scrape units collected the full 28 m² expression of the feature and, where surface density proved highest, an excavation unit probed deposits to a depth of 20 cm. Toolstone processing products and by-products dominate (opalite debitage, biface fragments, etc.), but maintenance/subsistence tools are abundant (Table 184); they include several projectile points, a preform, and a dozen flake tools. They are accompanied by waste flakes of obsidian, basalt, and jasper.

Table 184. Artifacts Recovered from Feature and Nonfeature Contexts, 26Ek3190.

		DEBITAGE		FORMED ARTIFACTS							
Feature	Total Area (m²)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Ground Stone	Other/ Exotic	Total
1*	31	5,873	6,761.8	7	1	30	1	12	-	1	52
2*	9	3,002	4,467.0	-	-	13	-	2	-	-	15
3	4	-	-	-	-	-	-	-	-	-	0
4	60	1[a]	2.4	-	-	5	-	-	-	-	5
5	19	-	-	-	-	2	-	1	1	-	4
6	69	1[a]	5.8	-	-	4	-	1	-	-	5
7	14	-	-	-	1	2	-	-	-	-	3
8	12	1[a]	2.4	1	-	-	-	-	-	-	1
9	2	-	-	-	-	-	-	-	-	-	0
10	50	1[a]	9.4	1	-	-	-	-	-	-	1
11	43	-	-	-	-	1	-	-	-	-	1
Surface Isolates	-	2[a]	8.3	-	-	12	1	1	-	-	14
		8,881	11,257.1	9	2	69	2	17	1	1	101

*Sample feature
[a]Obsidian only

In artifact content and horizontal dimension both features resemble the hunters' camps or special task loci identified in Feature 1 at 26Ek3191, Features 1 and 2 at 26Ek3192, and Feature 1 at 26Ek3198. In contrast to the latter two, however, the special purpose features at 26Ek3185 and 26Ek3190 appear to lack subsurface components.

Diffuse Lithic Scatters

The remaining open sites (26Ek3176, 26Ek3194, and 26Ek3199) are diffuse lithic scatters occupying low ridge tops on the midslope of Corral Fan (cf. Figure 141). None was tested. Although covering 4240 m², 8840 m², and 1180 m² respectively, they exhibit low densities of cultural materials and discernible features (Raven 1988). Their assemblages consist exclusively of opalite reduction products.

Rockshelters

Five rockshelters occur in the northern portion of the Eastern Periphery. Most occupy low overhangs on the mid-elevation contours of Italian Mesa and one occupies a recess above the southern margin of the upper reach of Undine Gorge (cf. Figure 141). Testing was performed at 26Ek3177, 26Ek3202, and 26Ek2304; the latter was sampled further during data recovery. Testing focused on interior subsurface deposits. 26Ek3205 and 26Ek3206, exhibiting only sparse cultural materials, were not tested.

26Ek3204

The largest rockshelter, 26Ek3204, exhibits the greatest intensity of aboriginal use. Beneath a broad, overhung shelf of brecciated opalite bedrock on the south facing midslope of Italian Mesa, the site lies 23 m above the stream bed of Undine Gorge; it is accessible from it only across a steep (ca. 30%), boulder-strewn talus slope (cf. Figure 141; Figure 184).

The 18 m^2 within the drip line is flat and is covered with an unbroken pavement of opalite debitage punctuated by opalite bifaces, hammerstones, flake tools, and numerous obsidian waste flakes. In several places the bedrock walls are silicified and seem, from their gouged and hammered appearance, to have been exploited at least minimally for toolstone. Most opalite processed at the shelter, however, is of markedly higher quality than that of the surrounding outcrop. Immediately outside the dripline, the apron is littered with a similar, but less dense accumulation; cultural material and naturally weathered opalite have accrued in an extensive talus, gradually diminishing over 12 m from the mouth of the shelter.

Deposits in both the interior and exterior of the shelter appeared to hold considerable potential for buried cultural remains. Moreover, the silt loam deposits within the dripline appeared to be largely dry, although two small grassy patches near the rear wall indicated some localized collection of moisture. Seepage through roof fissures after the snowfall of June 1988 dampened these areas, but most of the interior seemed to provide dry, protected contexts likely to preserve perishable remains (Intermountain Research 1988b:151).

Testing commenced with the surface collection. Following this, subsurface deposits were probed by 2 1 m x 50 cm excavation units. Excavation Unit 1, in the interior, was dug to a depth of 60 cm. Excavation Unit 2 was placed on the upper apron outside the dripline, and excavated to 40 cm. Both units terminated where bedrock or immovable roof fall was encountered. To link stratigraphic units, a trench (Trench 1) was dug by hand from the apron to the rear wall, positioned to join and extend the excavation units (cf. Figure 184).

Excavation returned numerous formed artifacts, and an astonishing volume of debitage (Table 185); the ca. 1 m^3 sample yielded over 73,000 flakes, the vast majority of which are opalite but which include as well jasper, obsidian, basalt, and quartzite. By contrast, perishable remains are rare, and no non-lithic tools, hearths, or other facilities were encountered.

Table 185. Artifacts Recovered from Feature 1, 26Ek3204.

		DEBITAGE		FORMED ARTIFACTS								
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Total
1 (TS)[a]	0.30	71,324	31,077.4	3	1	14	-	2	-	1	-	21
2 (TS)[b]	0.20	2,370	7,070.2	-	-	8	1	3	1	-	-	13
3 (EU)[c]	0.40	50,221	35,842.4	3	3	20	-	14	1	1	-	42
Surface Inventory	N/A	-	-	-	1	42	1	1	4	5	-	54
Trench Samples	N/A	-	-	-	-	6	-	1	-	2	1	10
Totals	0.90	123,915	73,990.0	6	5	90	2	21	6	9	1	140

(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]All levels, 1/8 inch mesh
[b]Only 0-2 cm 1/8 inch control; all other levels 1/4 inch mesh
[c]All levels include 50 cm x 50 cm 1/8 inch mesh control quadrant

Also, opalite spalls derived from the exfoliation of the shelter ceiling and surrounding outcrop abound, creating deposits literally packed solid with lithic debris. Soils occupying the interstices of this matrix consist of fine silt loams, and numerous krotovina and active rodent burrows evidence prolonged and extensive mixing. Charcoal is abundant, but occurs only as minute particles scattered throughout the deposit. A composite charcoal sample derived from the 20-30 cm level in Excavation Unit 1 returned a date of 40±50 B.P. which, given ambiguities in curves for very young samples, *could* indicate an age between ca. 272 B.P. and 0 B.P. on the two sigma basis (Appendix L).

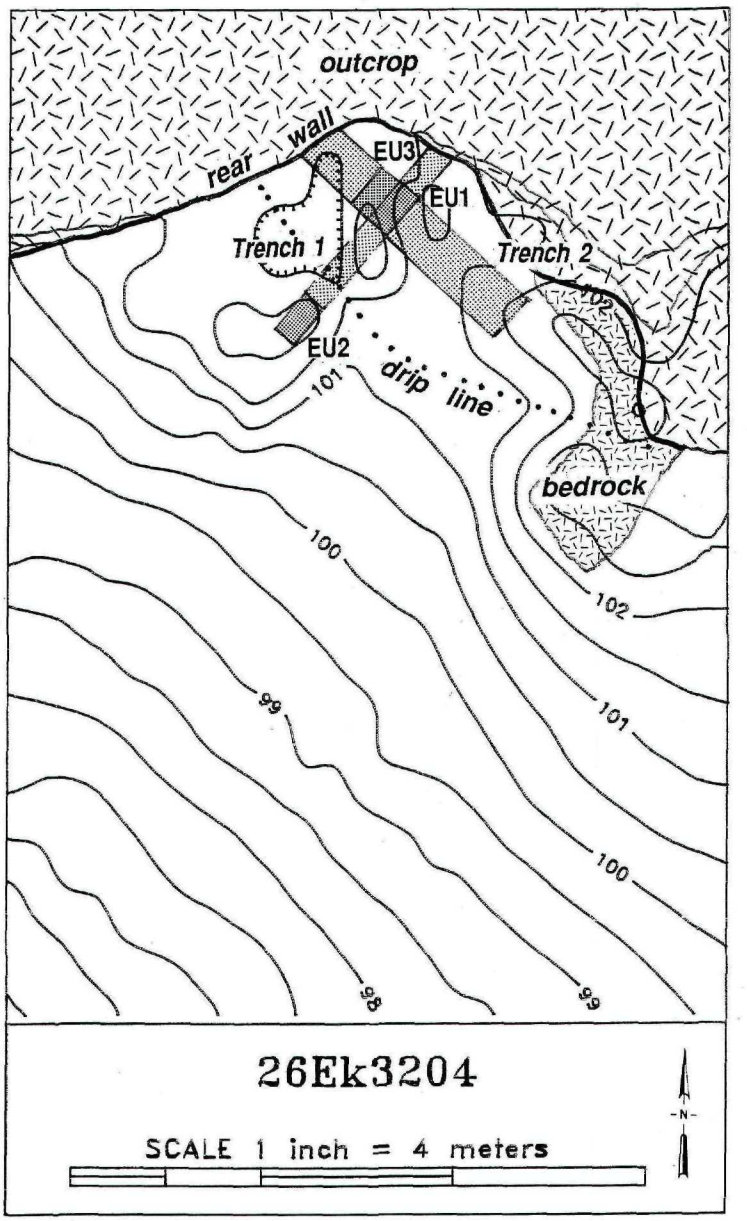


Figure 184. 26Ek3204 site map.

Data recovery expanded sampling of the interior, largely in hopes of discovering intact hearths that would allow dating discrete events of shelter use. As well, more extensive stratigraphic exposures were desired to clarify processes of site formation. An additional trench (Trench 2) was excavated perpendicular to and crossing the original trench. To obtain a controlled sample of subsurface contexts near the rear wall, a 1 m x 50 cm excavation unit (Unit 3) was extended into the northern sidewall of the new trench and dug 80 cm to bedrock (cf. 17.40).

Unit 3 returned cultural material comparable in abundance, variety, and distribution to that disclosed by Unit 1 (cf. Table 185). Neither the excavation unit nor Trench 2 revealed hearths or other subsurface cultural features.

The resulting exposures reveal only a limited depth of sediments over the bedrock surface or roof fall, which are difficult to distinguish (Figure 185). Five stratigraphic units are discernible in the profiles. Unit 5 is a slightly calcareous, yellowish brown sandy clay with common fine angular opalite spall from the shelter roof. Cultural debris is absent. Unit 4 is a brown sandy loam with common opalite gravels, some from roof spall, and some possibly washed from slopes adjacent the shelter. Cultural debris is rare. A loose brown loam with abundant opalite debris comprises Unit 3. Most of the opalite is roof spall; cultural debris is rare. Unit 2 is a dark grayish brown loam with abundant opalite roof spall and common lithic debris. Unit 1 consists of a relatively high concentration of opalite roof spall and lithic debris.

Implications

Although dominated by the debris of opalite processing, numerous flake tools and maintenance and subsistence implements suggest that 26Ek3204 may have served occasionally as shelter for small groups. Thus we sought to find hearths, perishable materials, and other data classes not commonly preserved at Tosawihi. These goals were only partially realized. Indeed, results offer no convincing evidence suggesting that non-toolstone directed activities occurred at the shelter any more than at many open-air sites in the Eastern Periphery.

Of the hundreds of bones recovered, there is little evidence for cultural origins. The assemblage consists chiefly of rodents, with a few specimens of artiodactyls, miscellaneous reptiles, and fish. Only 4% are burned, while ca. 40% exhibit diagnostic traits (e.g. pitting, rounding of fractured surfaces) marking them carnivore scat bones (Schmitt and Juell 1989). Most of the remainder appear to be recent inclusions, probably representing rodent burrow deaths (cf. Chapter 14).

The copious debris of toolstone processing, however, implies intensive use of the place as a reduction station; absent unambiguous chronological controls, the intensity of use remains unresolved. The abundance of cultural material may reflect actual relative magnitude of use or may be illusory, the product of exquisite preservation absent post-depositional colluvial processes.

The debitage assemblage, while dominated by debris of early stage opalite biface production, reflects lithic tasks ranging from core reduction to the edge maintenance of tools. Opalite bifaces, are commensurately abundant (n=81) and varied (cf. Chapter 6). As at many other sites, most specimens are intermediate stage reduction forms (Stage 3, n=49); most of the remainder are Stage 2 specimens (n=18).

Overall, most remains at 26Ek3204 suggest that it attracted use as a weather-protected workshop for the processing of imported opalite toolstone. Evidence for its use as a campsite is no more compelling than that observed at several features in open settings throughout the Eastern Periphery (cf. Chapter 24).

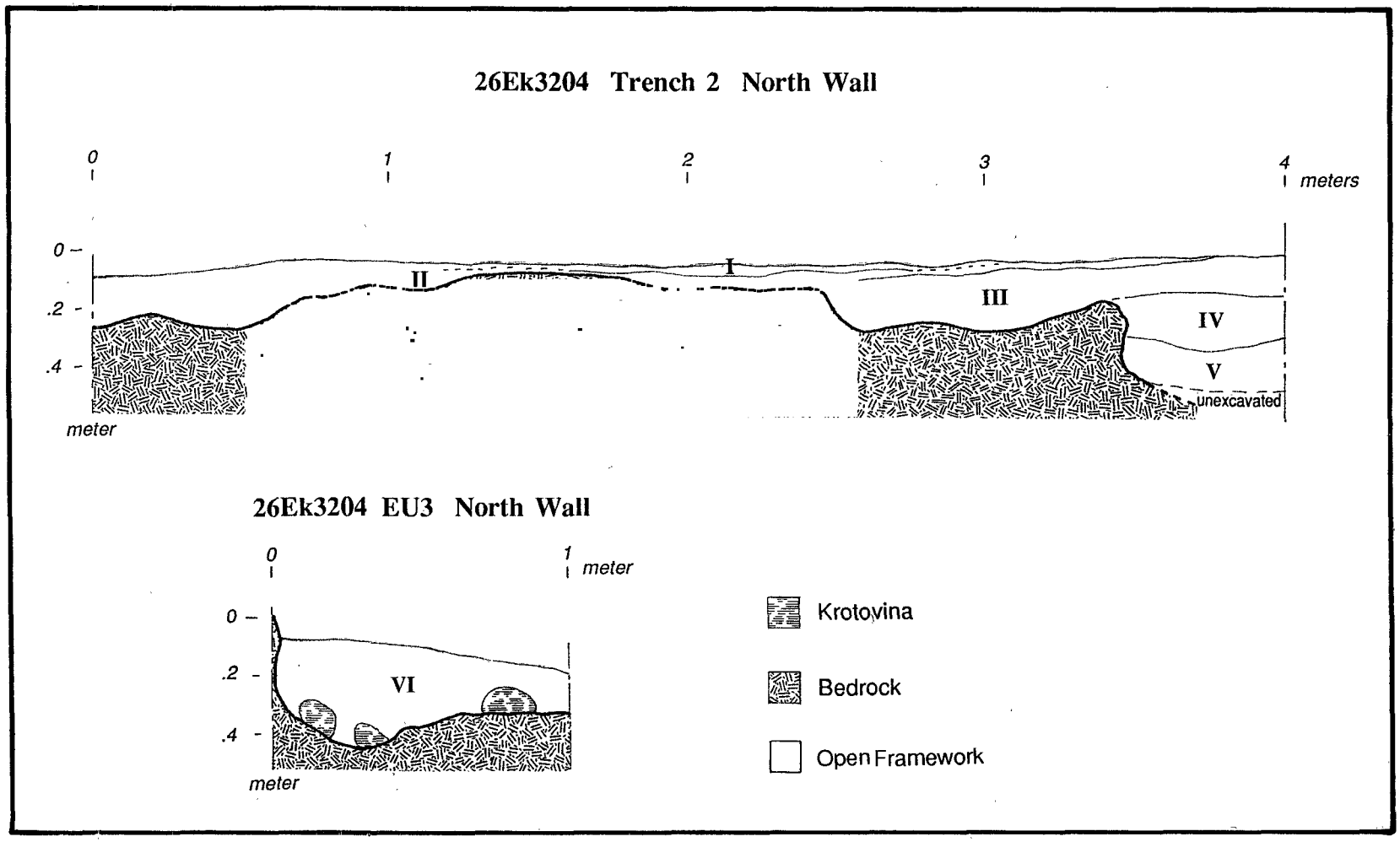


Figure 185. Description of stratigraphic units, Trench 2 and EU3, 26Ek3204.

Figure 185. Description of stratigraphic units, Trench 2 and EU 3, 26Ek3204.

Stratum	Description
1	Opalite debris and flakers from roof spall and lithic reduction, with rare to common silt matrix.
2	Dark grayish brown (10YR 4/2) dry; loam; loose to fine granular; abundant opalite roof spall and lithic reduction flakes.
3	Brown (10YR 5/3) dry; loam; loose to fine granular; common opalite roof spall and rare opalite flakes.
4	Brown (10YR 5/3) dry; sandy loam; medium subangular blocky; common opalite pebbles; very rare opalite flakes.
5	Light yellowish brown (10 YR 6/4) dry; clay with sand; strong coarse angular blocky; common fine opalite roof spall; no cultural debris; moderate dispersed carbonate.

26Ek3177 and 26Ek3202

The smallest rockshelters sampled, 26Ek3177 and 26Ek3202 enclose only 5 m^2 and 8 m^2, respectively. Both surface contexts are defined by moderate density opalite lithic scatters confined to areas within driplines and the aprons immediately outside. The battered appearance of the walls at 26Ek3177 suggests possible (but unsubstantiated) use as a toolstone source. One 1 m x 50 cm excavation unit probed subsurface contexts within the sheltered portion of each shelter. The units reached depths of 20 cm and 50 cm, respectively, when digging was halted due to opalite bedrock or large slabs of roof-fall. Deposits in both sites are essentially identical in composition and cultural content; unstratified silt loam soils are heavily turbated, lack cultural features, and are wet throughout. Most cultural materials occur in the upper 10 cm, and most artifacts were recovered by surface scrapes prior to excavation. The assemblages are exclusively of opalite, and are composed almost entirely of debitage. A pair of bifaces was retrieved from each site and these, together with a hammerstone and two unclassifiable projectile point fragments from 26Ek3177, constitute the entire formed artifact assemblages (cf. Table 151). Both appear to have seen comparatively ephemeral use as minimally sheltered reduction stations.

Chronology

By the completion of data recovery, field efforts had garnered three classes of chronological data: relative dates provided by the classification of temporally diagnostic artifact types (projectile points and ceramic sherds), radiocarbon assay of charcoal, and evaluation of obsidian hydration rim values. As elsewhere at Tosawihi, analytical results reveal a range of human use of the Eastern Periphery spanning the past 10,000 years, but the majority of the time markers reflect relatively recent prehistoric use to a somewhat greater degree than in the Western and Northern subareas (cf. Chapter 19). Figure 186 summarizes the chronological indicators recovered from the East on a site by site basis.

Projectile points are the most widely distributed time sensitive artifacts found in the East. Of 102 specimens, over half are unclassifiable with reference to Thomas's (1981) key, due to fragmentation (n=45) or deviant morphology (n=8, cf. Chapter 8).

Within the classifiable assemblage (n=49), the majority appear to have accumulated during relatively late prehistoric times; over 61% are Desert Series specimens post-dating A.D. 1300 (Desert Side-notched: n=20; Cottonwood: n=10). Similarly, although derived from only five vessels and occurring in only four sites, the bulk of the 117 ceramic sherds recovered (n=109) are Shoshone Brownware specimens, also implying occupation during Desert times (cf. Chapter 13).

Radiocarbon analyses of charcoal samples mirror and, at least indirectly, corroborate the implied stylistic chronology (cf. Appendix L). As well, unlike time sensitive artifacts, most of which are from surficial contexts linked only circumstantially to toolstone acquisition, most radiocarbon samples relate directly to quarry pit excavation. One of these is from Feature 2 at 26Ek3171, and three others date discrete episodes of pit excavation in Feature 2 at 26Ek3195 (Appendix L). Each returned readings post-dating A.D. 1300; they span the period from (roughly) A.D. 1490 to A.D. 1670. The hearth underlying, and plausibly contemporaneous with, the obsidian scatter of Feature 1 at 26Ek3198 is also attributable to post A.D. 1300, as is the ambiguously young sample derived from composite charcoal of the general matrix in 26Ek3204.

Evidence for earlier use is provided exclusively by temporally diagnostic artifacts, chiefly projectile points. Visitation ca. A.D. 700 - A.D.1300 is suggested by a pair of Rosegate Series

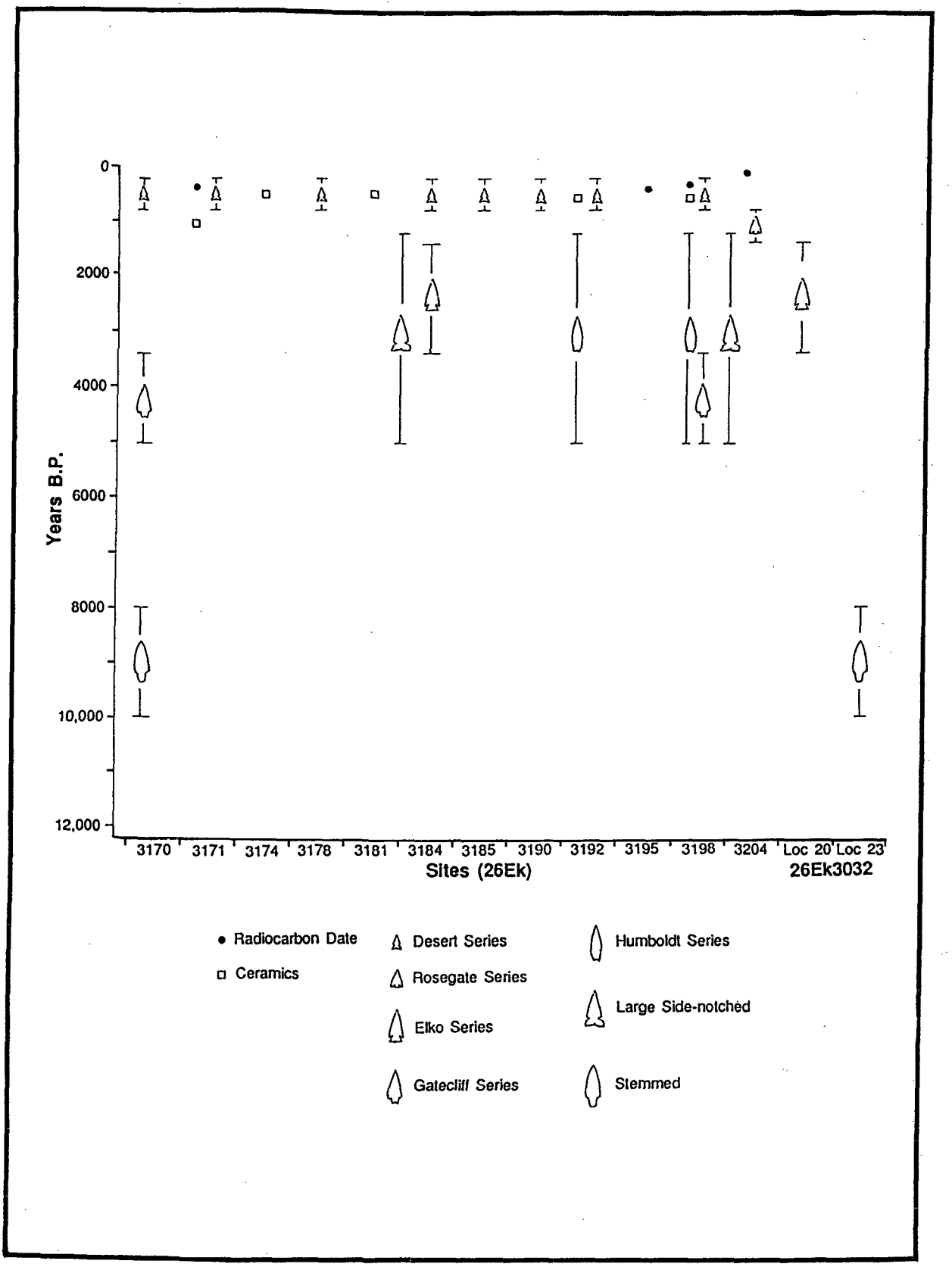


Figure 186. Chronology of the Eastern Periphery.

points from the shelter at 26Ek3204 and by eight Fremont Grayware sherds deposited at 26Ek3171 between perhaps A.D. 500 and A.D. 1300 (cf. Chapter 13). Two Large Side-notched points, ambiguous time markers in the Great Basin, could have been introduced into deposits at any time over the long period from ca. 5000 B.C. to A.D. 1300. More reliably, three Elko Series points and a pair of Gatecliff Split-stem specimens imply use between ca. 1300 B.C. - A.D. 700 and 3000 B.C. - 1300 B.C., respectively. Three Humboldt Series projectiles may have been deposited during this period as well (cf. Chapter 8).

The earliest projectile point discard, occurring perhaps between ca. 8000 B.C. - 6000 B.C., is disclosed by seven Great Basin Stemmed Series points. Stemmed specimens constitute the most populous type of classifiable point pre-dating the Desert Series in the subarea. Save a single specimen recovered from Feature 2 at 26Ek3192, all occur in sites on lower Ramadan Ridge (three within Locality 23, three at 26Ek3170). As well, two specimens occur immediately outside the boundary of the Eastern Periphery; one was found in isolation on the western flank of Ramadan ridge, and one was recovered at Locality 27 at the toe of the ridge (Leach and Botkin 1991). The distribution of stemmed points in the Eastern Periphery suggests that earliest uses of the area focused chiefly on riparian portions of the landscape (cf. Chapter 20). That toolstone may also have been of interest in early times is equivocal given the information at hand. Direct chronometric evidence and the bulk of the temporally diagnostic artifacts suggest that aboriginal focus on opalite acquisition, or at least the excavation of quarry pits, occurred considerably later.

Chapter 18

ARCHAEOLOGY OF THE NORTHERN CORRIDOR

Dave N. Schmitt and Daniel P. Dugas

The Northern Corridor occupies 6.5 km along Ivanhoe Creek, where elevations range from 5,215 ft. (1,590 m) to 5,560 ft. (1,695 m). From Willow Creek on the north, the corridor traverses a series of low stream terraces before entering Perron Canyon (Figure 187). The canyon, characterized by steep slopes containing occasional outcrops of rhyolite and welded tuff, likely served as a natural low elevation thoroughfare for access to and from the heart of the Tosawihi Quarries. Big Butte, the preeminent Tosawihi landmark, visible from some perspectives for more than 60 km, looms approximately 5 km southeast of the head of the canyon.

As the corridor continues south from the head of Perron Canyon, it enters the gently rolling terrain of Ivanhoe Creek Valley, an area is characterized by small knolls, grassy meadows, and the alluvial slopes and stream terraces flanking Ivanhoe Creek. At the south end of the corridor, where the headwaters of Ivanhoe Creek rise from numerous springs and ephemeral drainages, the topography is dominated by inset fans and craggy finger ridges along the lower slopes of Big Butte.

Local vegetation is comprised largely of big sage and low sage communities, with a sparse to dense bluebunch wheatgrass and cheatgrass understory. Big sage is most common in deeper soils, especially in alluvial sediments along stream channels, while low sage dominates shallow colluvial deposits. Both communities include rabbitbrush, Great Basin wildrye, fescue, squirreltail, and lupine. Observed fauna include marmot, ground squirrel, white-tailed and black-tailed jackrabbit, red-tailed hawk, common raven, black-billed magpie (*Pica pica*), and numerous domestic cows and sheep; faunal indicators (e.g., tracks, scatological droppings) reflect visits by coyote and deer. Aside from the road paralleling Ivanhoe Creek, historic disturbances to Northern Corridor sites have been minimal; a few bulldozer cuts and cattle trampling in Ivanhoe Creek Valley, and a recent a sheepherder camp in Perron Canyon were observed.

Centered on Ivanhoe Creek Road, a 30 m wide swath was surveyed and 14 archaeological sites identified (cf. Figure 187; Drews 1988; Schmitt 1989b). Of these sites, eight contained lithic reduction features, multifunctional toolkits, and/or light-to-moderate density lithic scatters demanding further investigation via systematic surface collection and subsurface excavation; discussions presented here focus only on these sites.

Descriptive Site Summary

Occupying a terrace above the north bank of Willow Creek (at 5,215 ft. [1,591 amsl]), 26Ek3251 represents the northernmost site in the corridor (cf. Figure 187). Initially recorded as "diffuse lithic scatter" (Drews 1988:8) with secondary and tertiary reduction debris, further scrutiny of the surface revealed ground stone, preforms, bifaces, and flake tools within and adjacent six discrete feature concentrations. Approximately 450 m south of 26Ek3251, 26Ek3234, a diffuse, undifferentiated lithic scatter, is located on a terrace riser overlooking Willow Creek and Ivanhoe Creek (cf. Figure 187). At the northern mouth of Perron Canyon, 26Ek3231 and 26Ek3232 are represented largely by diffuse lithic scatters, each containing a single lithic reduction feature (Table 186).

TOSAWIHI QUARRIES:
ARCHAEOLOGICAL INVESTIGATIONS AND ETHNOGRAPHIC STUDIES IN NEVADA

Note:

One or more pages have been removed from this part of the report due to sensitivity of specific archaeological site location information. Qualified persons may contact the Nevada Bureau of Land Management, Elko Field Office, to inquire about obtaining additional information.

Table 186. Descriptive Summary, Northern Corridor Sites.

Site No.	Type of Investigation	No. Quarry Loci	No. Non-Quarry Features	Elevation (ft.)	Site Area (sq. m)
26Ek3228	T	-	2	5,460	4,750
16Ek3229	S	-	-	5,450	100
26Ek3230	S	-	-	5,320	100
26Ek3231	T	-	1	5,320	2,100
26Ek3232	T	-	1	5,330	1,590
26Ek3233*	S	-	-	5,360	N/A
26Ek3234	T	-	-	5,262	4,200
26Ek3235*	S	-	-	5,350	N/A
26Ek3236*	S	-	-	5,390	N/A
26Ek3237	D	-	5	5,560	42,000
26Ek3238	T	-	2	5,520	22,500
26Ek3239	T	1	1	5,560	12,800
26Ek3240	S	-	-	5,480	15,000
26Ek3251	D	-	6	5,215	15,000

* isolate

Type of Investigation
S = Survey
T = Test
D = Data Recovery

The remaining four sites occupy stream terraces, ballenas, or ancient inset fans along Ivanhoe Creek in Ivanhoe Creek Valley; 26Ek3228, a small reduction complex, lies in the northern portion of the valley, and three large sites (26Ek3237, 26Ek3238, and 26Ek3239) cluster on the valley bottom near its southern reach (cf. Figure 187). Each contains at least one concentration of debitage and fragmentary bifaces surrounded by a light-to-moderate scatter of lithic debris.

Testing and Data Recovery Results

Excavations in the Northern Corridor were designed to characterize surface assemblages and to explore the extent of subsurface deposits (Table 187). When present, data were collected from feature concentrations, but, unlike surface expressions in the Eastern and Western Peripheries, discrete features are rare in the Northern Corridor; consequently, excavation often was directed toward the retrieval of tools and debitage from large, undifferentiated scatters.

Table 187. Summary of Collection Procedures, Northern Access Corridor.

	FEATURES RECORDED		FEATURE CONTEXT		NONFEATURE CONTEXT	
Site Number	Total (n)	Sampled (n)	Surface Scrape (m^2)	Subsurface Excavation (m^3)	Surface Scrape (m^2)	Subsurface Excavation (m^3)
26Ek3228	2	2	8.00	0.09	-	-
26Ek3231	1	1	4.00	-	-	-
26Ek3232	1	1	4.00	-	-	-
26Ek3234	0	0	-	-	2.00	-
26Ek3237	5	4	25.00	6.33	9.00	11.05
26Ek3238	2	1	8.00	-	2.00	0.65
26Ek3239	1	1	4.00	0.15	-	-
26Ek3251	6	3	34.00	8.22	-	2.30

Archaeological data recovered from sites in the corridor are described, with discussion of the methods and rationale motivating field investigations and, where appropriate, inferences on chronology and site function.

The six sites subject only to test excavations are presented first, followed by detailed discussions of the two larger, more complex sites revisited for extensive data recovery.

26Ek3228

Toward the northern reach of Ivanhoe Creek Valley, 26Ek3228 is situated on the western terrace of Ivanhoe Creek at an elevation of 5,460 ft. (1664 m; cf. Figure 187). Field reconnaissance in the southern portion of the site disclosed two discrete lithic concentrations (Locus A; Features 1 and 2) situated approximately 5 meters apart. The northern portion of the site is defined roughly by Locus B, a sparse lithic scatter encompassing approximately 700 m^2; although no systematic excavations were undertaken in Locus B, two small biface fragments were collected from the surface.

Features 1 and 2 were sampled by scraping a block of 4 contiguous 1 m x 1 m units in the center of each concentration (cf. Table 187). Feature 1 yielded 132 pieces of off-white opalite debitage and a metate exhibiting faint use wear (Table 188). To explore the subsurface contents of the feature, a 1 m x 50 cm unit (within a surface scrape unit) was excavated to a depth of 20 cm; the test found the feature to consist largely of a surface manifestation, as only 5 flakes were recovered from the uppermost 10 cm of excavated deposits. Overall, most of the flakes are small (mean weight/item = 0.36 gm; including a number of biface thinning flakes) suggesting that the feature served as a late stage biface reduction locus (cf. Schmitt 1989b). Similarly, the paucity of flakes in so small an area (diameter ca. 2.2 m) suggests a brief, single reduction episode.

Table 188. Artifacts Recovered from Sites in the Northern Corridor.

	DEBITAGE		FORMED ARTIFACTS										
Site Number	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Cores	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
26Ek3228	497	356.5	-	-	8	-	-	-	-	1	-	-	9
26Ek3231	254	176.6	1	1	3	-	-	-	-	-	-	-	5
26Ek3232	78	180.4	-	-	6	1	-	-	-	-	-	-	7
26Ek3234	11	3.6	-	-	2	-	-	-	-	-	-	-	2
26Ek3237	12,509	13,510.1	45	17	215	4	28	3	7	8	-	1	328
26Ek3238	3,387	2,554.2	5	-	34	1	1	-	1	1	-	-	43
26Ek3239	1,822	1,491.1	2	3	31	-	4	-	5	-	2	-	47
26Ek3251	23,270	10,606.6	45	63	169	-	38	-	3	18	2	1	339
Totals	41,828	28,879.1	98	84	468	6	71	3	16	28	4	2	780

Surface scraping in Feature 2 returned 360 pieces of opalite debitage and four fragmentary bifaces representing various reduction stages. These artifacts, together with large secondary interior flakes and small biface thinning flakes, suggest that a more diverse array of bifacial reduction/ thinning occurred at Feature 2 than at Feature 1. Like Feature 1, however, Feature 2 is a small, ovate configuration (approximately 2 m in diameter), probably representing a single, intensive reduction event.

26Ek3231 and 26Ek3232

26Ek3231 and 26Ek3232 occupy a gravelly stream terrace bordering the eastern bank of Ivanhoe Creek in Perron Canyon (elevation 5,325 ft. [1623 m]; cf. Figure 187). Each contains a single lithic reduction feature characterized by a small (ca. 2 m x 2 m), light density scatter of opalite flakes and fragmentary bifaces. To explore their contents, each feature was sampled by shovel scraping a contiguous block of four 1 m x 1 m units. Collections at 26Ek3231 yielded 254 small pieces of opalite debitage, an obsidian preform, and two biface fragments (each manufactured on high quality opalite) indicative of latter stage reduction. Conversely, early stage reduction occurred at 26Ek3232, evidenced by numerous large, secondary interior flakes (n=78; mean weight/item = 2.3 gm) and two early Stage 3 bifaces. Additional non-feature collections at these sites include biface fragments and a core (cf. Table 188), and a Rosegate Series projectile point approximately 10 m north of Feature 1 at 26Ek3231, signalling Late Archaic use of Perron Canyon.

26Ek3234

26Ek3234 consists of a sparse lithic scatter situated near the toeslope of an inset fan at an elevation of 5,262 ft. (1604 m); the site spans some 4000 m^2, overlooking Willow Creek to the north and Ivanhoe Creek to the west (cf. Figure 187). Due to the lack of discrete features and overall paucity of lithic debris, the site was investigated only via surface collections and the scraping of eight 50 cm x 50 cm units at 5 m intervals along a north-south transect (Schmitt 1989b). Although these latter investigations retrieved only 11 flakes, surface collections recovered a heat-treated, Stage 3 opalite biface fragment and an obsidian biface.

26Ek3238

Located on the west terrace of Ivanhoe Creek, 26Ek3238 is a large light-to-moderate density lithic scatter containing a cairn (Feature 2) and a dense concentration of debitage (Feature 1); both features lie in the northern portion of the site, just south of the terrace on an elevated northern toe of an inset fan. While no features were identified in the southern site area, surface reconnaissance discovered 10 biface fragments, a projectile point tip, and a mano.

At Feature 1 we skimmed two disjunct blocks of 2 m x 2 m units, retrieving 2,961 pieces of debitage and eight opalite bifaces. The wealth of debitage and debitage types (both in reduction stage and material [including basalt and jasper]), and the presence of early and late stage bifaces suggest that the feature reflects multiple reduction episodes.

Approximately 20 m west of Feature 1, Feature 2 consists of a partially collapsed rock pile covering a 1.8 m x 2.2 m area. The subangular rhyolitic cobbles (average diameter ca. 35 cm) used in its construction are locally available; their number suggests that the feature may have been five courses high. Absent associated prehistoric or historic artifacts, its age remains unknown; it may be a claim marker associated with historic mining in the Tosawihi Quarries vicinity (cf. Zeier 1987), or it may represent a prehistoric hunting feature or locational marker (cf. Pendleton and Thomas 1983).

In order to sample non-feature contexts on the terrace, eight 50 cm x 50 cm were skimmed along a baseline parallel to Ivanhoe Creek, and three 1 m x 1 m units were excavated to explore subsurface deposits; these investigations disclosed lithic tools and debitage, but found them to be relatively scarce and largely restricted to the uppermost 15 cm of the

deposits (Schmitt 1989b:131,135). Additional, non-systematic surface collections on the terrace identified a cobble tool, a core, and a host of biface fragments (cf. Table 188).

Surface collections from 26Ek3238 returned four projectile points, including a Large Side-notched and a Gatecliff Split stem, denoting an occupation sometime around 1500 B.C. Two specimens of square, edge-ground basal fragments of Great Basin Stemmed points date between 8000 and 6000 B.C.

26Ek3239

26Ek3239 occupies the top and gradual slope of a low north-trending ballena just south of Ivanhoe Creek (elevation 5,560 ft. [1695 m]; cf. Figure 187). Its western and northern boundaries are marked by an ephemeral drainage flowing into Ivanhoe Creek. On the northern toeslope of the ballena and extending down into the drainage, a cobble field (ca. 1600 m^2 in extent, designated Locus A) contains numerous reddish-brown, subangular, jasper-like nodules; the diffuseness of culturally modified lithics led us to characterize the area as a "locus" rather than a feature. Although the material is of poor quality (e.g., most cobbles contain weathering cracks and/or quartzite inclusions), a few assayed pieces, flakes, and angular pieces of shatter were observed; two hammerstones also were observed, and were mapped and collected.

We found a single lithic concentration (Feature 1) on a small flat near the crest of the ridge. The feature is a 6 m x 4.5 m, light-to-moderate density scatter of opalite debitage containing late stage bifaces (most of which display evidence of heat-treatment), preforms, and a flake tool (cf. Table 188). A four m^2 surface scrape in Feature 1 yielded 1,360 flakes and 14 additional formed artifacts, including a highly modified side-scraper.

Feature 1 was explored further by an excavation unit within the scraped area. Although the deposits are shallow, 462 flakes, three bifaces, and two pot sherds were collected. In sum, the recovered toolkit and associated fire-cracked rock suggest that the feature served as a short term camp where subsistence activities were pursued in conjunction with lithic fabrication and maintenance.

Time markers at 26Ek3239 include an Elko Corner-notched point and a Rosegate Series point; both were discovered on the surface in non-feature contexts, but their presence indicates visits between 1300 B.C. and A.D. 1300. Further, although not identified to specific type, pot sherds recovered from Feature 1 signal occupation sometime between A.D. 500 and historic contact (cf. Chapter 13).

26Ek3237

26Ek3237 is the largest site in the Northern Corridor, subsuming three discrete activity loci on the fan remnants, low ridgelines, or stream terraces bordering Ivanhoe Creek in the southern portion of Ivanhoe Creek Valley (cf. Figure 187). In the eastern portion of the site, Locus A rests on a low terrace of Ivanhoe Creek (Figure 188). Characterized by a sparse-to-light scatter of tools and debitage, the locus is bounded on the east and north by an ephemeral drainage flowing into Ivanhoe Creek, and on the west by the gentle slope of an unnamed ridgeline. Approximately 100 m west of Locus A, Locus B occupies the gradually sloping toe of an unnamed ridge (Figure 188); the area is characterized by a 720 m^2, light-to-moderate scatter containing numerous late stage bifaces. Finally, Locus C is situated on remnants of an inset fan and stream terrace in the westernmost portion of the site, bounded on the north by Ivanhoe Creek and on the east by a deep ephemeral drainage channel. Surface manifestations in Locus C include debitage and tools, including projectile points, bifaces, and simple flake tools.

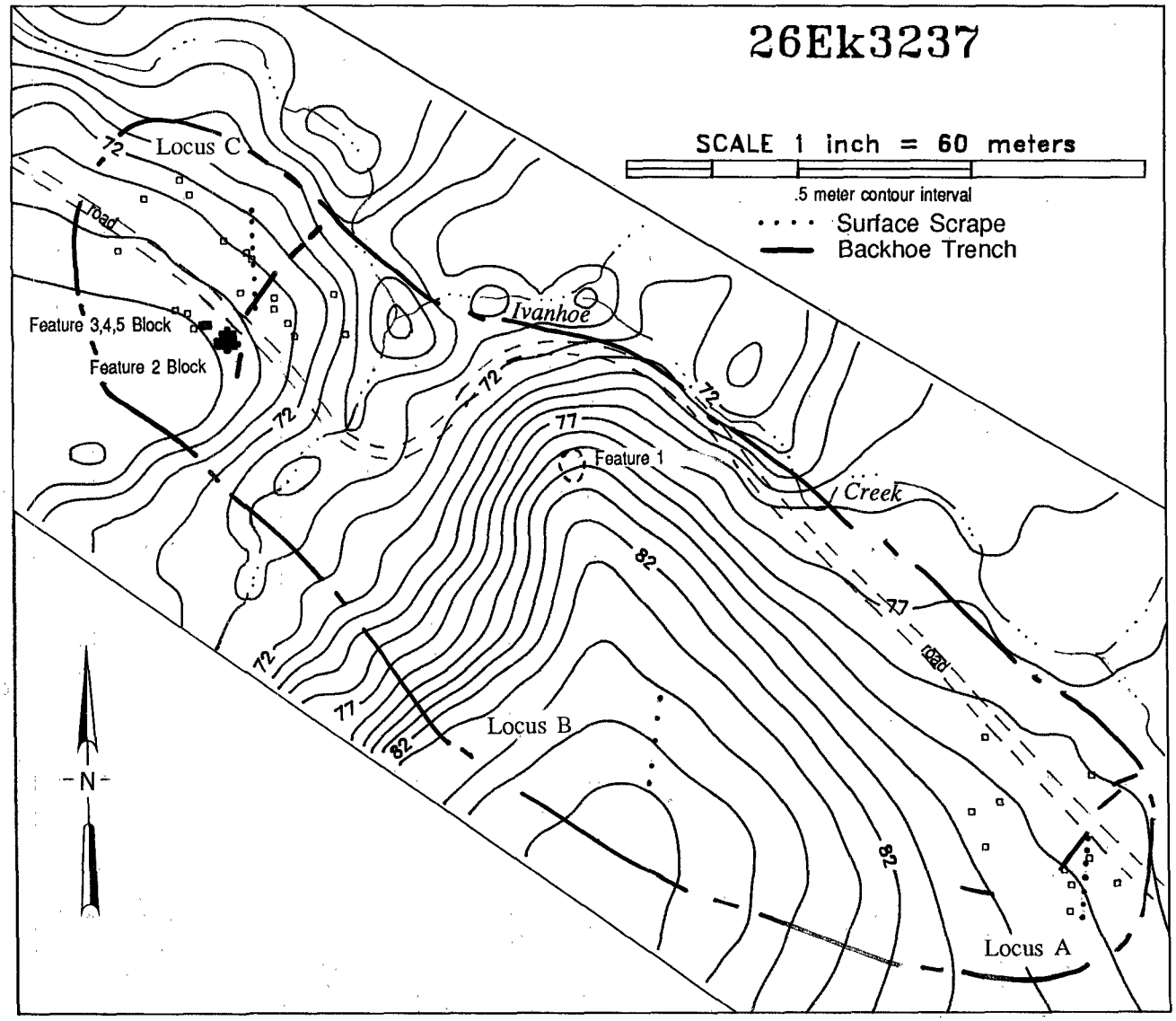


Figure 188. 26Ek3237 site map.

Geomorphic Analyses

In order to examine internal stratigraphy and investigate areas outside our excavations for buried cultural features, backhoe trenches were placed on the flanks of two low ridges adjacent ephemeral tributaries of Ivanhoe Creek (cf. Figure 188). Although no subsurface features were encountered, stratigraphic analyses of trench profiles revealed some intimate aspects of local geomorphic processes. Because soil profiles were found to be quite similar, two profiles (Trench 7, Locus A [cf. Figure 193] and Trench 1, Locus C [cf. Figure 195]) were selected for detailed description, as they serve to exemplify the stratigraphic history of the site.

Beginning with the poorly sorted sand and gravel of Unit 6 (Trench 1; Figure 189), underlain by silty clay loams in Units 5 and 4 interfingered with the sand and gravel Units 7, 8, and 9, it is apparent that this profile shows a series of interbedded coarse alluvial channel deposits with fine grained deposits of either alluvial, colluvial, or eolian origin. The minor sand and pebble component in the silty Units 2 and 3 may also be partly of alluvial origin.

Evidence for soil development in these sediments provides the best means of determining if stable surfaces previously existed here. The moderately well developed blocky soil structure and color of Units 2, 3, and 4, their relatively high degree of leaching in the iron and aluminum versus silica weathering ratios, and the increasing base content of this series (Figure 190) all suggest that soil development has occurred. The higher concentration of phosphorus in Unit 3 may indicate enrichment at the old surface level. The underlying Units 5 through 9 experienced this pedogenesis to a lesser degree, as indicated by the clay and weak soil structure in Unit 5 and the strongly weathered appearance of other gravel units. Although Unit 2 and those below appear to form a complete soil profile, it is possible that an erosional surface break may have occurred at the irregular upper boundary of Unit 4. Chronologically, Units 4 through 9 are probably pre-middle Holocene in age; the erosional surface on Unit 4 is possibly a product of middle Holocene erosion.

In a nearby cutbank of modern Ivanhoe Creek, an erosional surface directly underlying units of Mazama ash (6,800 years B.P.) may be equivalent to the Unit 4 erosional surface. Although no evidence of Mazama ash was found in Units 2 or 3, some may be mixed in with these probably middle Holocene silts. The loose, bioturbated, silty Unit 1, which overlies the soil surface on Unit 2, has only weak soil development like much of the general eolian mantle of the Tosawihi area. A series of brief stable surface episodes, no longer stratigraphically visible, may have occurred during deposition of this unit, probably in the mid-to-late Holocene.

At Locus C, Trench 1 (cf. figures 17-2 and 17-9) exhibits the most complete and detailed summary of the geomorphic history of the site; similar profiles also occur in Trenches 2, 3, and 4. Units 4 and 5 (Figure 191) are a set of olive and reddish brown, very clayey, deposits probably resulting from the in-place weathering of volcanic debris; they may be as old as middle Tertiary age. On an irregular surface overlying these clays, moderately well-sorted sands and pebbles of Unit 3 were deposited. These are similar to the sand and gravel units in Trench 7 (cf. Figure 189), and may be contemporaneous with them. The phosphorus concentrations here may have resulted from enrichment at the former surface or through later redeposition along with iron (Figure 192). On the eroded surface of Unit 3, the silt-dominated Units 2 and 1 were deposited. In texture, color, and chemistry, Units 1, 2, and 3 of Trench 1 are very similar to the same Units in Trench 7. Units 1 and 2 probably are late Holocene in age, given their associated radiocarbon dates.

Overall, evidence from trenches at Loci A and C indicate a similar history. Both of the interfluves on which they are situated are probably composed of a core of weathered Tertiary volcanic debris, as in Units 4 and 5 in Trench 1. Both, then, experienced alluvial deposition of sand and gravel, probably between the Pleistocene and middle Holocene. The overlying silts date to late to middle Holocene and younger, as suggested by the types and locations of time markers recovered from excavations.

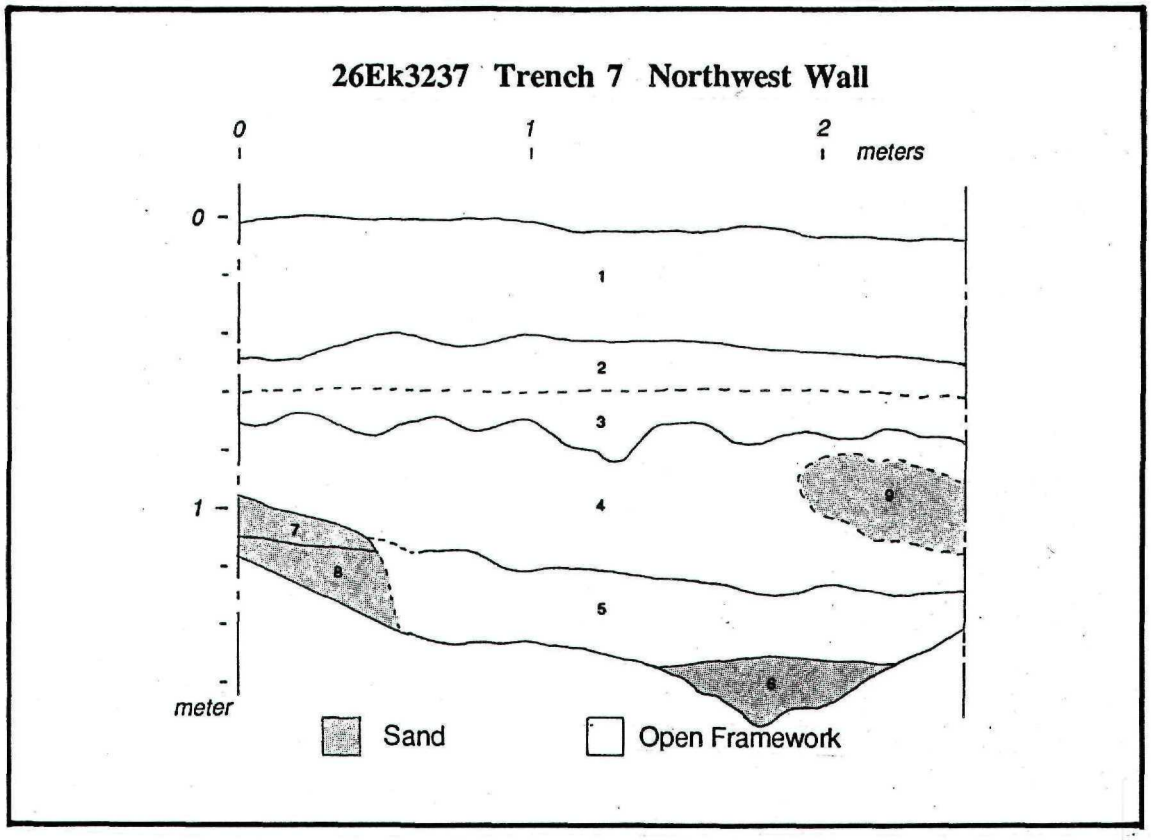
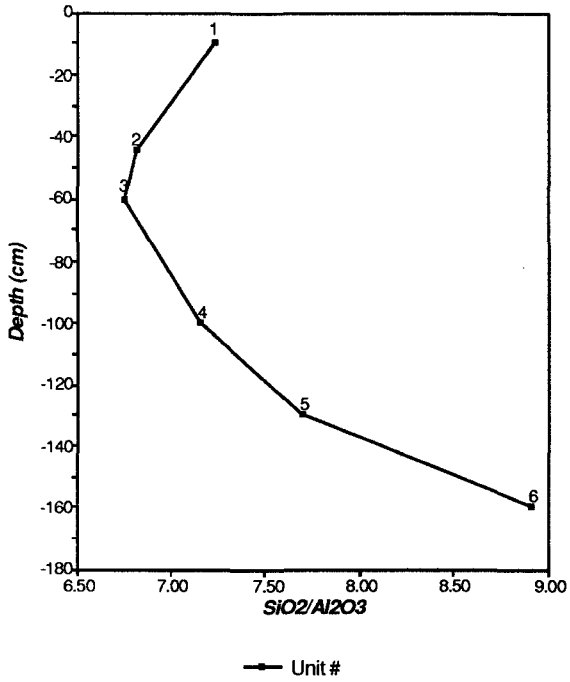
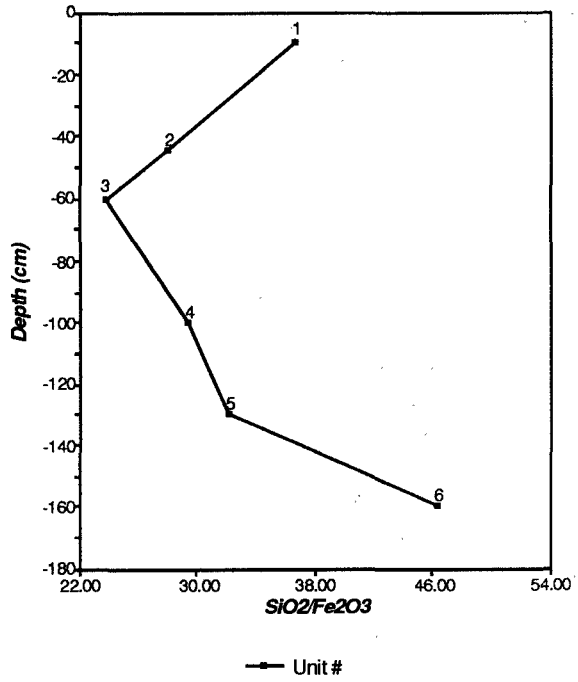


Figure 189. Stratigraphic profile of Trench 7, Northwest Wall, 26Ek3237.

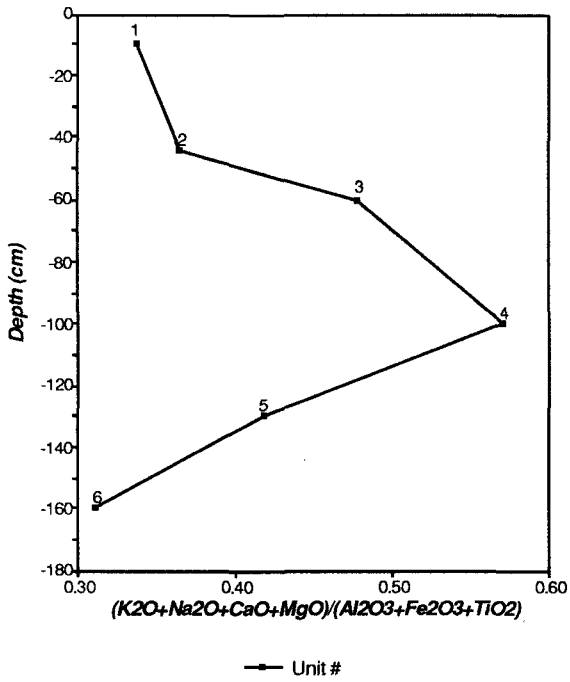
Stratum	Description
1	Dark brown (10YR 4/3) slightly moist; silt loam; loose to very weak fine platy; rare to common fine subangular to subrounded gravels; abundant fine to medium roots, rare fine pores; boundary clear and smooth to wavy.
2	Very dark brown (10YR 2/2) moist; silty clay; moderate medium angular to subangular blocky; common subangular to subrounded medium pebbles; abundant fine roots; distinct clay skins on ped surfaces; boundary gradual to clear and smooth.
3	Dark yellowish brown (10YR 4/4) moist; silty clay loam; weak to moderate, fine to medium subangular blocky; common subangular to subrounded fine sand to fine gravel; common fine roots and very fine pores; distinct clay skins on ped surfaces; boundary clear and irregular.
4	Brown (10YR 5/3) slightly moist; silty clay loam; moderate medium subangular blocky to slightly prismatic; rare to common fine subrounded pebbles; rare to common fine roots; distinct clay skins on ped surfaces; moderate to strong acid reaction on carbonate filaments grading downward to well cemented, fairly massive carbonate accumulation; boundary clear and smooth to wavy.
5	Brown (10YR 5/3) dry; silty clay loam; weak to moderate fine angular blocky; rare to slightly common subangular to subrounded pebbles; very weak acid reaction on carbonate filaments; boundary clear.
6	Poorly sorted angular to rounded, fine sand to medium gravels, some showing strong weathering boundary unexposed.
7	See description of Unit 6.
8	Moderately well sorted fine to medium subangular to subrounded sand.
9	See description of Unit 6.



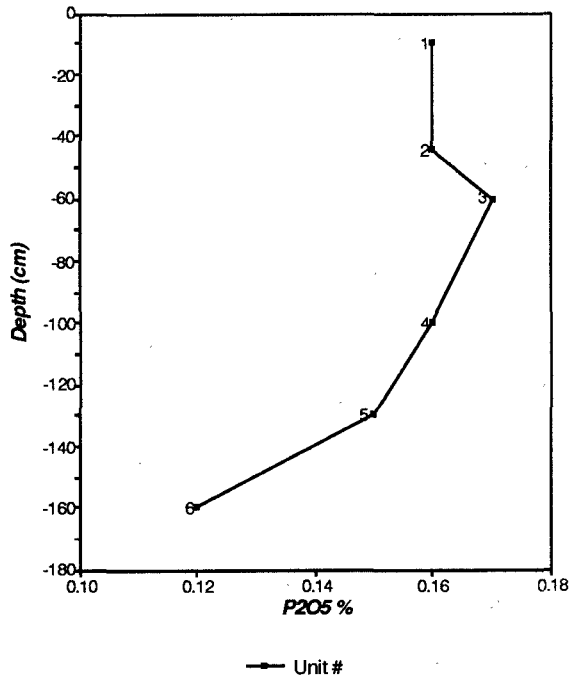
a.



b.



c.



d.

Figure 190. Molecular weathering ratios for 26Ek3237, Trench 7 profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, and (d) weight percent phosphorus.

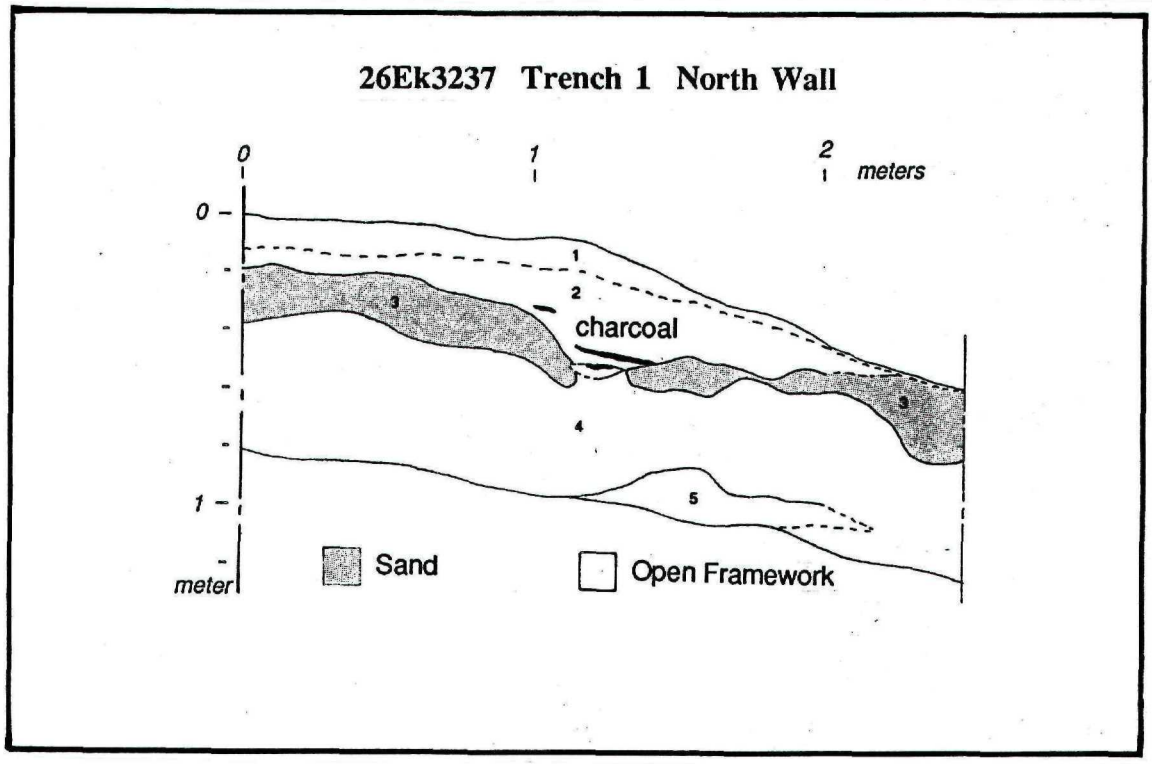
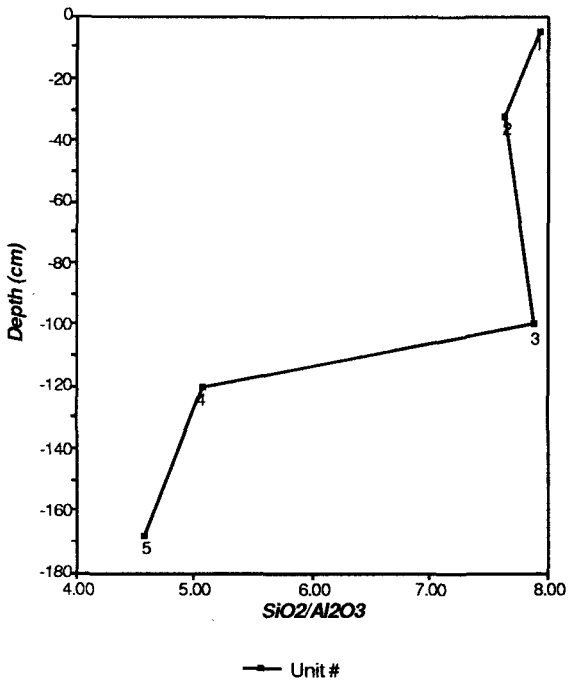
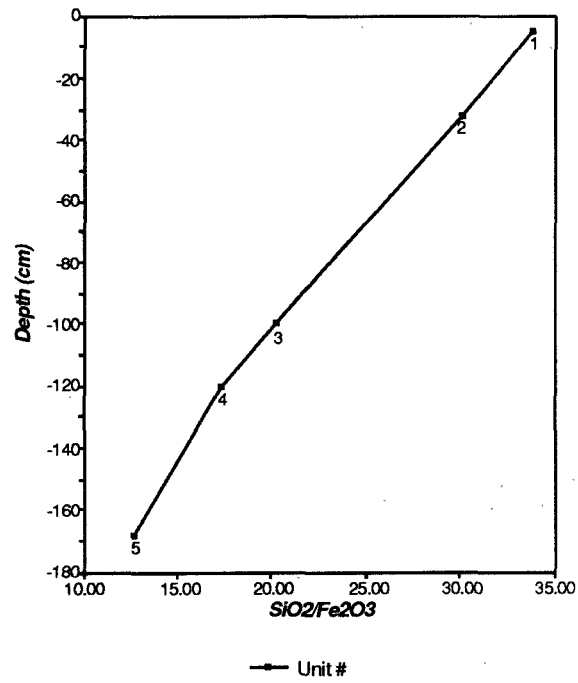


Figure 191. Stratigraphic profile of Trench 1, North wall, 26Ek3237.

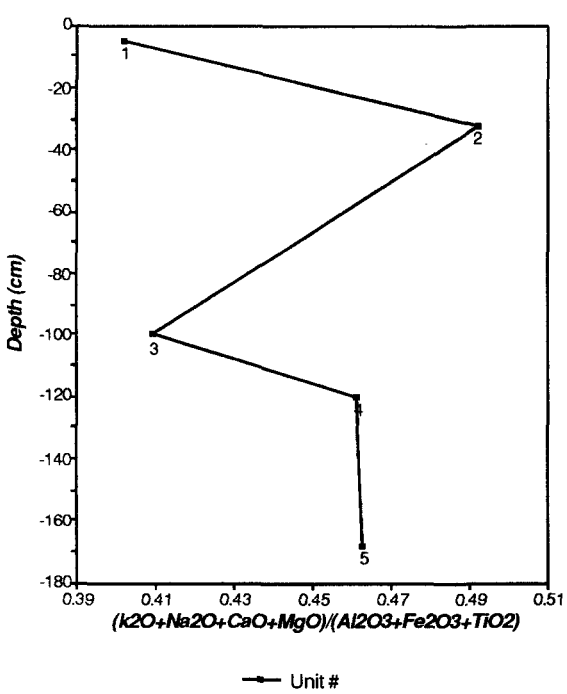
Stratum	Description
1	Dark yellowish brown (10YR 3/3) slightly moist; silty clay loam; weak medium platy to weak medium to coarse granular; rare to common fine subrounded pebbles; abundant fine to medium roots; common fine pores; boundary clear and slightly wavy.
2	Olive brown (2.5YR 4/4) slightly moist; clay loam; weak medium to coarse granular to subangular blocky; common fine roots and pores; thin clay skins on pore surfaces and some ped faces; Moderate acid reaction on abundant fine carbonate veins in lower half of unit; boundary clear and wavy.
3	Moderately well sorted, angular to subrounded, medium to coarse sands with minor clay matrix, yellowish brown (10YR 4/6) slightly moist; rare medium to coarse gravels; moderate acid reaction on fine to medium caliche veins and soft fine slightly nodular patches; boundary clear and wavy.
4	Olive brown (5YR 5/4) slightly moist; volcanic tuff, strongly weather to massive clay; faint to distinct mottling, possibly drab haloed root traces, light olive brown (5YR 4/3) slightly moist; and dark reddish brown ((5YR 3/2) slightly moist; strong acid reaction on fine to medium carbonate filaments and fine to medium nodules; boundary clear and wavy to irregular.
5	Dark reddish brown (10YR 3/30 slightly moist; volcanic tuff, strongly weathered to massive clay; faint to distinct mottling, possibly drab haloed root traces, pale olive to olive (5YR 6/3 to 5/4) slightly moist; and more patchy mottling, brownish yellow (10YR 6/8) slightly moist; carbonates as in unit 5; this unit appears to be a lens within Unit 4; boundary unexposed.
6	Poorly sorted mixture of Units 2 and 3; possibly part of a krotovina.



a.



b.



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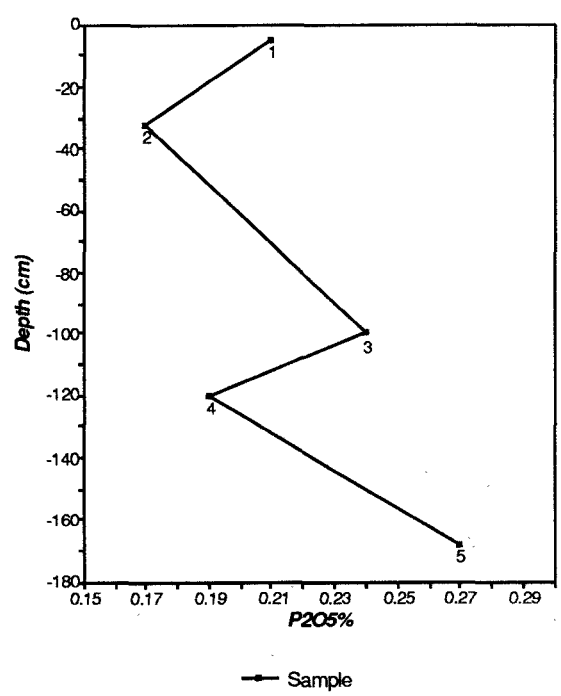


d.

Figure 192. Molecular weathering ratios for 26Ek3237, Trench 1 profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, and (d) weight percent phosphorus.

Nonfeature Contexts

Surface collections from inter-locus, nonfeature contexts of 26Ek3237 recovered 51 formed artifacts; most were recovered north of Locus B on the toeslope of a low ridge and from areas immediately adjacent Locus C. They include 37 bifaces (most are Stage 3 fragments; cf. Chapter 6), four flake tools, two cores, two preforms, two metate fragments, a chopper, and three projectile points including a Large side-notched, an obsidian Great Basin Stemmed basal fragment, and a tip.

Locus A

Initial investigations at Locus A involved surface reconnaissance in close interval transects. Although no discrete concentrations were observed, we identified a multifunctional toolkit intermixed with hundreds of waste flakes. Recovered artifact classes include a preform, a Gatecliff Split Stem projectile point, a hammerstone, a scraper, and numerous opalite bifaces (cf. Table 189). In order to sample surface materials further and to explore buried deposits on the terrace, eight disjunct 50 cm x 50 cm surface scrape units were placed along a linear baseline, and two 1 m x 1 m units were excavated. Cultural deposits are shallow, but lithics are much more abundant than expressed by surface densities. Although no additional formed artifacts were recovered, the relative wealth of debitage and the diverse toolkit collected from the surface prompted our revisit for additional collections and excavations (Intermountain Research 1988d).

Table 189. Artifacts Recovered from Locus A Nonfeature Contexts, 26Ek3237.

		DEBITAGE		FORMED ARTIFACTS							
Unit No. (Type)	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Total
1-8 (SF)[a]	0.04	119	90.7	-	-	-	-	-	-	-	0
1 (TS)2[b]	0.25	241	133.9	-	-	-	-	-	-	-	0
4 (TS)	0.30	145	125.4	-	-	-	-	-	-	-	0
46 (EU)	0.30	66	117.3	-	-	1	-	-	-	-	1
47 (EU)	0.50	196	241.6	1	-	-	1	-	-	-	2
48 (EU)	0.30	41	46.7	-	-	-	-	-	-	-	0
49 (EU)	0.40	48	53.7	-	-	-	-	-	-	-	0
50 (EU)[b]	0.20	11	22.4	-	-	-	-	-	-	-	0
51 (EU)	0.40	194	196.9	1	-	1	-	-	-	1	3
52 (EU)	0.40	163	141.6	-	-	2	-	-	-	-	2
53 (EU)	0.10	17	45.9	-	-	1	-	-	-	-	1
54 (EU)	0.40	192	220.4	-	-	-	-	-	-	-	0
55 (EU)	0.40	102	112.5	-	-	-	-	-	-	-	0
Surface	N/A	-	-	1	1	13	2	1	1	2	21
Totals	3.99	1,535	1,549.0	3	1	18*	3	1	1	3	30

(SF) = Surface Scrape
(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a] Eight 50 x 50 cm units combined
[b] Includes a 25 cm x 25 cm 1/8 inch mesh control quadrant
* Includes 2 "possible" bifaces

Supplementary data recovery at Locus A involved recordation and collection of surface artifacts and excavation of 10 randomly placed 1 m x 1 m units (Figure 193); surface survey identified additional bifaces and a retouched flake, as well as two metate fragments (cf. Table 189) adjacent a small ephemeral drainage near the northern boundary.

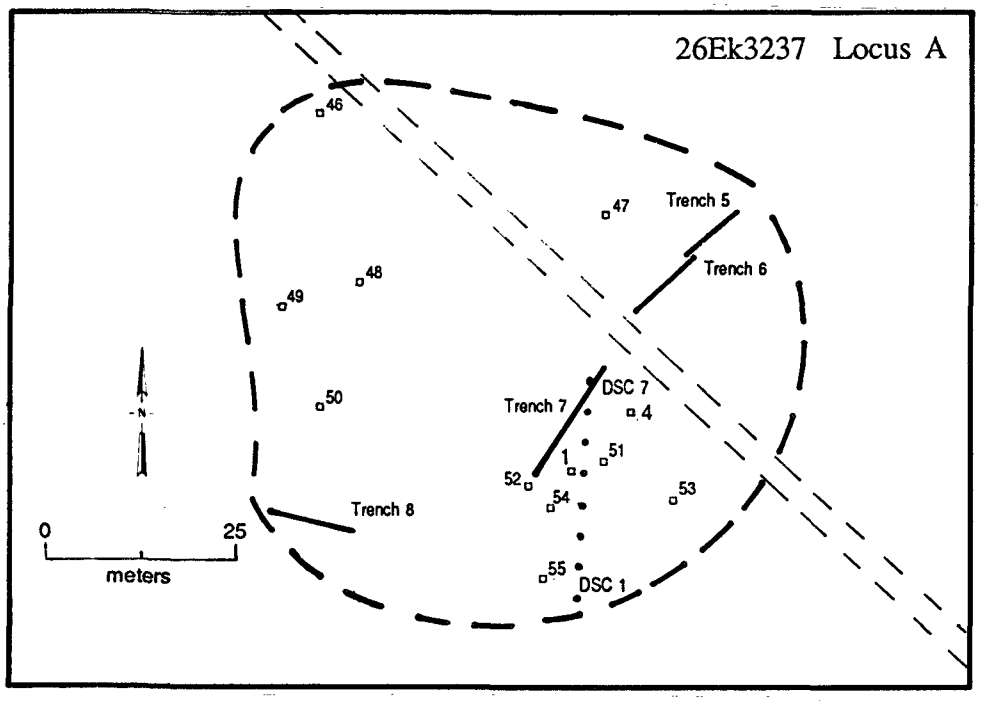


Figure 193. Location of surface and subsurface units, and backhoe trenches in Locus A, 26Ek3237.

Subsurface excavation of 10 1 m x 1 m units retrieved 1030 pieces of opalite debitage and 9 formed artifacts (Units 46-55; cf. Table 189). Debitage types are dominated by large secondary interior and biface thinning flakes (mean weight/item = 1.2 gm), suggesting early stage biface reduction was paramount; a few episodes of later stage reduction also occurred, revealed by a few small, heat-treated biface thinning flakes. Artifact densities are highest in the southern portion of the locus, especially in neighboring Units 51, 52, and 54, where a host of flakes, three bifaces, a metate fragment, and an Elko-eared projectile point were recovered (cf. Figure 193; Table 189). In the northern portion, Unit 47 also yielded high artifact returns, including a retouched flake tool and a large Gatecliff Split Stem point.

Overall, debitage types and the wealth of bifaces suggest that Locus A served primarily as a diurnal task area where early stage opalite bifaces were reduced, probably to facilitate transport to areas northwest of the quarries. The presence of flake tools and ground stone, however, reflects other uses of the area, probably as a short-term campsite where subsistence activities were undertaken in conjunction with lithic maintenance; regardless of task duration, the recovery of two Gatecliff Series points and an Elko Series point suggests these episodes occurred between 3000 B.C. and A.D. 700.

Locus B

Data recovery at Locus B involved surface collection of formed artifacts and limited surface scrapes, due, in part, to light debitage densities and shallow (colluvial) deposits (Schmitt 1989b). A total of 64 formed artifacts was recovered from the surface, including two preforms, four flake tools, two projectile points (a Rosegate Series specimen and a nondiagnostic tip), and 56 bifaces (88% of the assemblage).

Systematic surface collections involved scraping five 1 m x 1 m units at 5 m intervals along a linear transect. Four hundred sixty-one pieces of debitage were recovered, most (n=353;

77%) retrieved from the two northernmost units; Unit 4 (cf. Figure 188) yielded 243 flakes and a Rosegate Series point. The abundance of small, often heat-treated flakes (mean weight/item = 0.8 gm) associated with numerous late stage bifaces suggests the area served largely as a late stage biface reduction/manufacture locus. Two Rosegate Series points indicate visits during the Late Archaic (ca. A.D. 700 - A.D. 1300).

Locus C

Encompassing approximately 4,000 m^2, Locus C is situated atop a scoured inset alluvial fan in the easternmost portion of 26Ek3237 (elevation 5,560 ft. [1695 m]); the locus commands a vast view of Ivanhoe Creek Valley (cf. Figure 194). Although partially truncated by the Ivanhoe Creek Road (Figure 194; also cf. Figure 188), most of the locus remains undisturbed; initial surface scrutiny disclosed the presence of a light-to-moderate density debitage scatter (containing opalite, obsidian, and basalt) and several artifact classes.

Testing included scraping eight 50 cm x 50 cm units and excavating two 1 m x 1 m units placed intuitively in areas of high surface density. A total of 723 artifacts was recovered, including 718 flakes and five tools (Table 190). Surface collections retrieved 23 additional formed artifacts, including bifaces, flake tools, a core, a hammerstone, an Elko Series point, and a Humboldt point (cf. Table 190; Schmitt 1989b). Finally, a test unit was excavated adjacent the road near the southern edge of the locus to explore subsurface deposits in an area exhibiting sparse surface materials. Cultural materials are relatively few, but the unit bisected a discrete, basin shaped hearth (Feature 2) containing numerous fire-cracked rocks; contents of the feature and its vicinity as well as results of radiocarbon assay are discussed below.

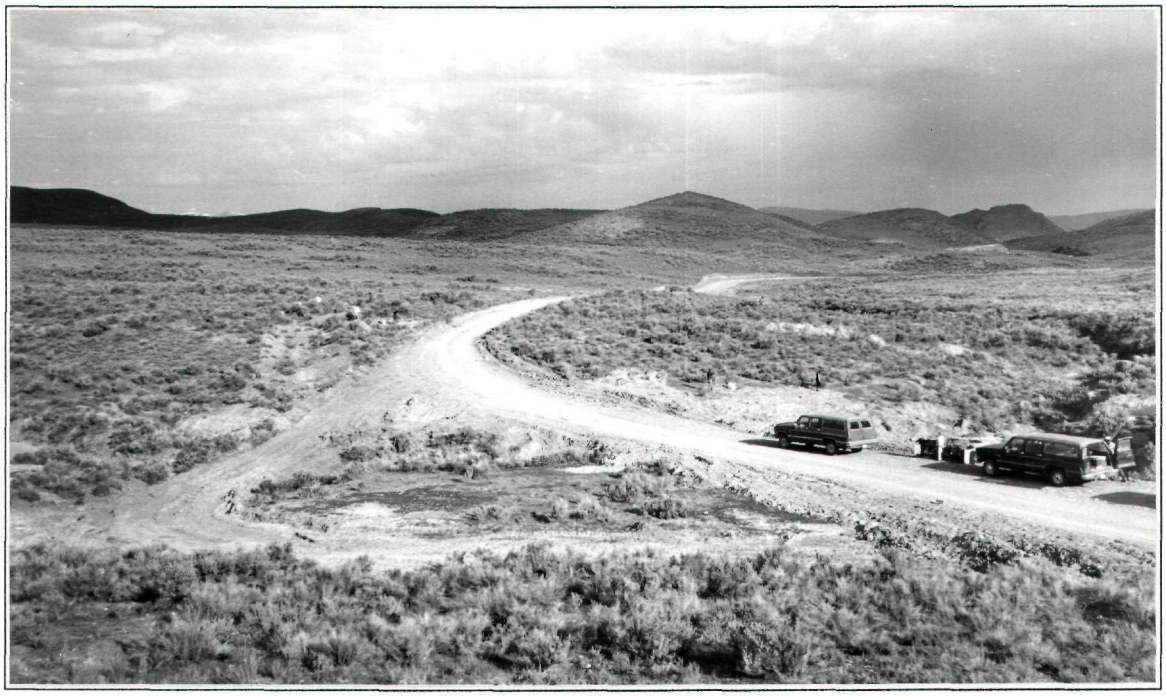


Figure 194. Overview of Locus C, 26Ek3237, looking northwest down Ivanhoe Creek Valley.

Table 190. Artifacts Recovered from Locus C Nonfeature Contexts, 26Ek3237.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	Proj. Points	FORMED ARTIFACTS Preforms	Bifaces	Cores	Flake Tools	Perc./ Cobble Tools	Ground Stone	Total
1-8 (SF)[a]	0.04	119	85.3	-	-	-	-	1	-	-	1
2 (TS)	0.20	168	121.5	-	-	1	-	-	-	-	1
3 (TS)[b]	0.25	431	275.0	1	-	2	-	-	-	-	3
31 (EU)	0.30	36	43.6	-	-	1	-	1	-	-	2
32 (EU)	0.30	44	60.3	-	-	-	-	-	-	-	0
33 (EU)	0.20	13	28.6	-	-	-	-	-	-	-	0
34 (EU)	0.60	297	358.2	1	-	1	-	-	-	-	2
35 (EU)	0.50	303	466.4	1	1	-	-	-	-	-	2
36 (EU)[b]	0.30	210	125.0	-	-	1	-	-	-	-	1
37 (EU)	0.20	57	57.3	-	-	-	-	-	-	-	0
38 (EU)	0.40	204	154.5	1	-	5	-	1	-	-	7
39 (EU)	0.30	29	46.3	-	-	-	-	-	-	-	0
40 (EU)	0.20	34	21.3	-	-	-	-	-	-	-	0
41 (EU)	0.30	100	66.4	-	-	-	-	-	-	1	1
42 (EU)	0.20	59	34.6	-	-	1	-	-	-	-	1
43 (EU)	0.10	52	48.4	-	-	-	-	-	-	-	0
44 (EU)	0.20	29	39.5	-	-	-	-	-	-	-	0
45 (EU)	0.30	51	40.6	-	1	-	-	1	-	-	2
Surface	N/A	-	-	9	-	37	2	5	2	1	56
Totals	4.89	2,236	2,072.8	13	2	49	2	9	2	2	79

(SF) = Surface Scrape
(TS) = Test Excavation Unit
(EU) = Excavation Unit

[a]Eight 50 x 50 cm units combined
[b]Includes a 25 x 25 cm 1/8 inch mesh control quadrant

Diversity of artifact classes, a hearth, and toolstone variety prompted our return to Locus C in order to investigate its contents and antiquity more fully (Intermountain Research 1988d); these supplementary investigations incorporated surface collections, 15 random 1 m x 1 m excavation units, block excavation adjacent the Feature 2 hearth, and, based on the results of these investigations, the intuitive placement of additional units. As discussed below, the latter revealed the most informative (and dramatic) artifactual remains discovered in the Northern Corridor.

Although relatively few in number, 15 random 1 m x 1 m excavation units recovered a number of functional artifact classes in association with an abundance of lithic debitage (cf. Table 190). Lithic debris is concentrated largely in the upper 20-30 cm of the deposits, but some concentrations of tools and detritus occur, probably representing partially buried activity areas; artifacts are most abundant in neighboring Units 34 and 35 (including Elko Corner-notched and Gatecliff Series points), and in Unit 38 (ca. 18 m south) where five bifaces, a notched flake, and a Humboldt point were recovered (cf. Figure 195; Table 190).

Perhaps the most striking artifact recovered from the Tosawihi vicinity is a fragmentary Clovis point preform discovered near the southern boundary of Locus C. Initially skeptical of its typological classification, due to its surface provenience and because a large portion of its base was missing, we centered a 2 m x 2 m block of excavation units over the point in the hope of finding additional pieces. These collections not only recovered the basal fragment which secured the point typology (cf. Chapter 8, Figure 53), but also disclosed a dense concentration of lithic tools and debitage in an area marked by very few surface artifacts. Further, as excavations progressed, three buried features were encountered, including two hearths and a rock pile (Features 3, 4, and 5, discussed below).

That entrenchment of Ivanhoe Creek recently has exposed sediments of pre-Mazama age bears implications regarding the Clovis preform discovered on the surface. Specifically, while the

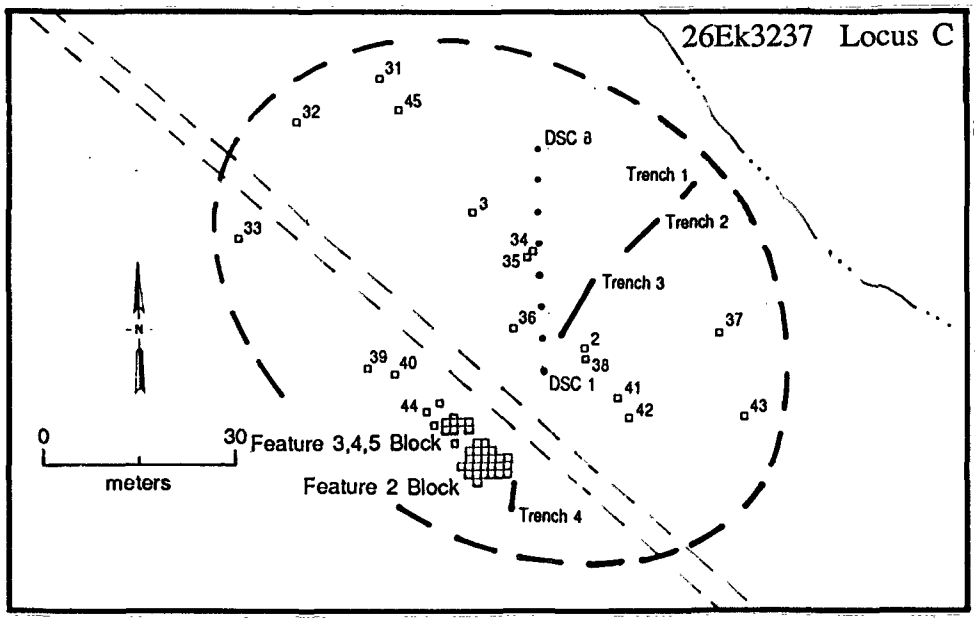


Figure 195. Location of surface and subsurface units, and backhoe trenches in Locus C, 26Ek3237.

artifact may have been collected by later peoples and transported from a distant location, it *may* have been discovered in an arroyo in the vicinity of the site; some of the stemmed points may have similar histories. If so, Late Pleistocene/Early Holocene cultural deposits may await discovery in the Tosawihi vicinity.

Feature 1

A single lithic reduction feature (Feature 1) was identified midway between Locus B and the break in slope near the base of the ridgeline (cf. Figure 188). Although no systematic collections were made, numerous large, secondary opalite flakes and angular shatter were recorded in association with three early stage biface fragments, suggesting the area served as an early stage (probably single episode) biface reduction locus.

Feature 2

A basin-shaped, rock-lined fire hearth (Feature 2) was encountered seven cm below the existing ground surface during subsurface testing in Locus C (Unit 5); associated artifacts include opalite debitage, an obsidian preform, and a ground and shaped chalcedony nodule (Table 191; cf. Schmitt 1989b:140-141). Measuring ca. 60 cm in diameter and 14 cm in depth, the hearth yielded a few flakes (some of them burned), but disclosed no direct evidence of use as a heat-treating structure; similarly, flotation analysis (cf. Chapter 15) found it devoid of subsistence residues. The hearth alone enticed our return; we were interested particularly in the deposits immediately encompassing it, since a radiocarbon date of 150 ± 60 years B.P. (Beta-28314) signaled a unique opportunity to examine regional lithic technologies associated with late prehistoric/protohistoric occupation.

Table 191. Artifacts Recovered from the Feature 2 Block, 26Ek3237.

Unit Type	No. Units	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Ground Stone	Total
TS	1[a]	0.20	106	51.0	-	1	-	-	1	2
SF	15	0.30	534	647.1	2	-	3	1	-	6
EU	10[b]	2.30	1,201	1,548.4	1	-	8	1	-	10
Surface	N/A	N/A	-	-	-	-	1	-	-	1
Totals	26	2.80	1,841	2,246.5	3	1	12	2	1	19

(TS) = Test Excavation Units
(SF) = Surface Scrapes
(EU) = Excavation Units

[a]Includes a 25 x 25 cm 1/8 inch mesh control quadrant
[b]Includes 2 units containing a 25 x 25 cm 1/8 inch mesh control quadrant

To acquire a larger data set and explore deposits surrounding the feature, a block of 25 adjoining 1 m x 1 m units (ca. 4 m N-S x 6 m E-W) was centered on the hearth; 15 units were scraped, and 10 (placed randomly throughout the block) were excavated. We recovered 1,860 artifacts, including 19 stone tools (cf. Table 191). Bifaces dominate the tool assemblage (n=12), especially Stage 3 fragments (n=10), followed by a few flake tools, projectile points, and a ground stone fragment. The debitage assemblage consists primarily of large, secondary interior flakes suggesting early stage reduction, but a diverse array of flake types and lithic materials (including small, heat-treated biface thinning flakes) indicate multiple reduction episodes.

Feature 2 probably served as a warming hearth or biface heat-treating facility; radiocarbon assay suggests use sometime during the mid-to-late Nineteenth Century. While the hearth's integrity remains largely intact, deposits in its immediate vicinity reflect repeated aboriginal site use, most occurring *prior* to hearth construction; the undulating veneer of debitage, the diversity of lithic materials and flake types, and the incidence of Elko and Large Side-notched point types suggest that most associated artifacts are products of previous occupation.

Features 3, 4, and 5

Approximately eight meters northwest of Feature 2, block excavations in Units 56-66 disclosed two hearths (Features 3 and 4) and a discrete rock pile or cairn (Feature 5) surrounded by thousands of flakes and numerous formed artifacts (Table 192). Although no discrete strata could be defined, the features are spatially distinct, allowing us to assign probable artifact-feature associations relative to arbitrary 10 cm levels (Table 192). The following discussion of feature "contents" incorporates these post hoc associations from units within and adjacent the Feature 3-5 block (Figure 196; Table 192); some analytical discussions elsewhere in this volume have presented some of these specimens as "nonfeature" artifacts (cf. Chapter 6).

Feature 3, a circular, basin-shaped fire hearth, was encountered 16 cm below surface in Units 61 and 66 (Figure 196); it measures 45 cm in diameter and 16 cm at its maximum (ca. central) depth. Interior excavations disclosed ash and dense charcoal, and approximately 25 fire-altered basalt cobbles, most lining the base. Associated artifacts include bifaces, cobble tools, flake tools, preforms (cf. Table 192), and a projectile point assemblage containing two Desert Side-notched, a Large Side-notched (found immediately adjacent the hearth), and an Elko Corner-notched. A larger projectile point aggregate was recovered *above* Feature 3 in Level 1 (cf. Table 192), where Desert Series points were most abundant (n=6).

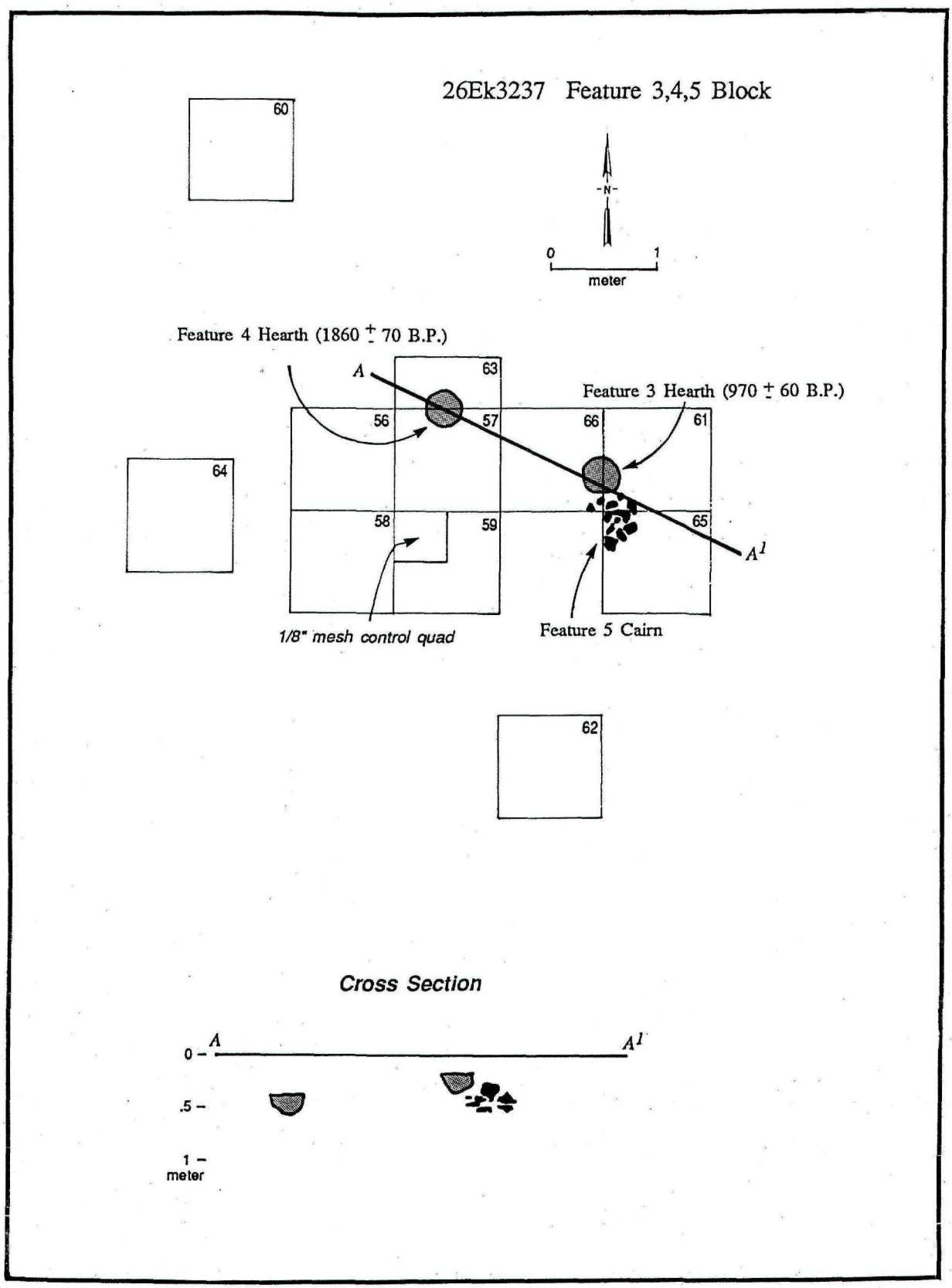


Figure 196. Feature 3, 4, and 5 block and vicinity, Locus C, 26Ek3237.

Table 192. Artifacts Recovered from the Feature 3, 4, and 5 Block and Vicinity, 26Ek3237.

Depth (cm)	Volume Excav. (m^3)	Feature(s)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Modif. Chunks	Perc./ Cobble Tools	Ground Stone	Total
0-10	1.05	-	2,829	2,580.4	9	5	13	2	-	1	1	31
10-20	1.05	3	1,140	2,040.7	4	2	9	2	1	1	-	19
20-30	1.05	3	842	934.4	1	1	7	1	-	1	-	11
30-40	1.05	4, 5	680	1,041.1	4	1	8	1	-	-	-	14
40-50	.95	4, 5	448	490.0	2	-	2	-	-	-	-	4
50-60	.45	-	352	334.7	-	-	2	-	-	-	-	2
60-70	.10	-	39	34.2	-	-	-	-	-	-	-	0
70-80	.10	-	15	9.7	-	-	-	-	-	-	-	0
Totals	5.80	-	6,345	7,465.2	20	9	41*	6	1	3	1	81

* Includes 3 "possible" bifaces

To examine the hearth's contents and assess its antiquity more fully, we extracted a soil sample for flotation and radiocarbon assay. While the former yielded no evidence of lithic heat-treatment or subsistence residues, radiocarbon analysis returned a date of 970 ± 60 years B.P. (Beta-36993), compatible with occupation of the overlying veneer during Desert times.

Approximately two meters east, a second basin-shaped, rock-lined hearth (Feature 4) was exposed between 35 and 50 cm below surface in Units 57 and 63 (Figures 196 and 197). Like Feature 3, Feature 4 is rich in ash, carbon, and oxidized soil, containing numerous fire-cracked rocks (cf. Figure 197). Radiocarbon assay and projectile point typology assign the feature a Mid-Archaic occupation; evidence includes a radiocarbon date of 1860 ± 70 years B.P. (Beta-36994) as well as two Elko Series points and a Gatecliff Split Stem. Although plant and animal macrofossils contain no unequivocal evidence of human subsistence, a few (often charred) artiodactyl bone fragments were found adjacent the hearth, *probably* representing subsistence refuse. Artifacts from these levels include 1128 flakes, 10 bifaces, and a perforator (cf. Table 192).

Figure 197. Feature 4 hearth, 26Ek3237.

An enigmatic, partially collapsed rock pile (Feature 5) was discovered in horizontal association with Feature 4 in Units 61, 65, and 66 (cf. Figure 196); it encompasses approximately 100 cobbles ranging from 10 cm to 25 cm in diameter, including a few fire-cracked specimens. Flecks of carbon occur throughout the pile, especially on the undersides of deeply buried cobbles, suggesting that the structure stood exposed for some time while precipitation leached out other carbon. The feature may consist of hearth rocks or cooking (boiling) stones deposited during use of Feature 4; too, it may have served as a "dump" for cobbles removed from task areas adjacent the hearth (e.g., sleeping areas).

The functional assessment of stacked rock features can be difficult, if not impossible. Such features are relatively common in the Great Basin, exhibiting various shapes and sizes and occurring in a variety of contexts (e.g., Budy and Elston 1986; Pendleton and Thomas 1983; Schmitt 1988c; also cf. site 26Ek3238, above). Their temporal affiliation usually must be left to speculation, but Feature 5 is an exception; its origin is associated with a dated hearth, and its apex, bracketed by another.

Excavations within the Feature 3, 4, and 5 block revealed structures and artifacts representing a palimpsest of campsite locations. Although distinct, feature-specific tool and debitage assemblages were not apparent, subjective characterization of debitage samples in the block revealed a predominance of early and late stage biface thinning flakes in the G3 size grade (cf. Chapter 10), indicating that thinning Stage 3, and possibly Stage 4 bifaces was the main lithic reduction activity performed in the vicinity, regardless of feature association. Similarly, a relatively large proportion of heat-treated bifaces and thinning flakes was recovered throughout our block excavations. Although the sporadic presence of thermally fractured opalite bifaces suggests that Features 4 and 5 may have served as heat-treatment facilities, debitage patterns (e.g., flake stages, paucity of differential luster) imply that the reduction of heat-treated bifaces occurred here after initial, post heat-treatment reduction at another location.

26Ek3251

As Willow Creek flows southeast toward its confluence with Rock Creek in the lower reaches of Squaw Valley, it passes through a wide (ca. 650 m) bottomland consisting of a complex series of stream terraces, oxbows, and ephemeral drainages. Ivanhoe Creek is a primary tributary to the system, upon the entrance to which it abruptly bends west and parallels Willow Creek for about 1 km (cf. Figure 187).

Approximately 400 m north of the bend of Ivanhoe Creek, 26Ek3251 occupies the second low stream terrace adjacent the north bank of Willow Creek (elevation 5,215 ft. [1590 m]). Present on-site vegetation is comprised exclusively of tall sagebrush with a sparse understory of cheat grass and rabbitbrush; but the host of riparian species once flourishing here has succumbed to diminished flow (owing to the construction of Willow Creek Reservoir) and to years of cattle grazing. Despite livestock trampling and the construction of Ivanhoe Creek road, most of the site remains intact, including six discrete concentrations of lithic detritus and formed tools (Figure 198).

Geomorphic Analyses

26EK3251 is situated on an oblong, northeast to southwest trending, slight topographic eminence on the alluvial plain of Willow Creek. Despite being a positive feature on the alluvial plain above the present entrenched channel of Willow Creek, this terrace has channels cut into its surface, suggesting drainage at a higher base level in the past. Seven backhoe trenches were dug at locations selected to reveal spatial differences in subsurface depositional history (cf. Figure 198); Trenches 4 and 7 were selected for detailed geomorphic description.

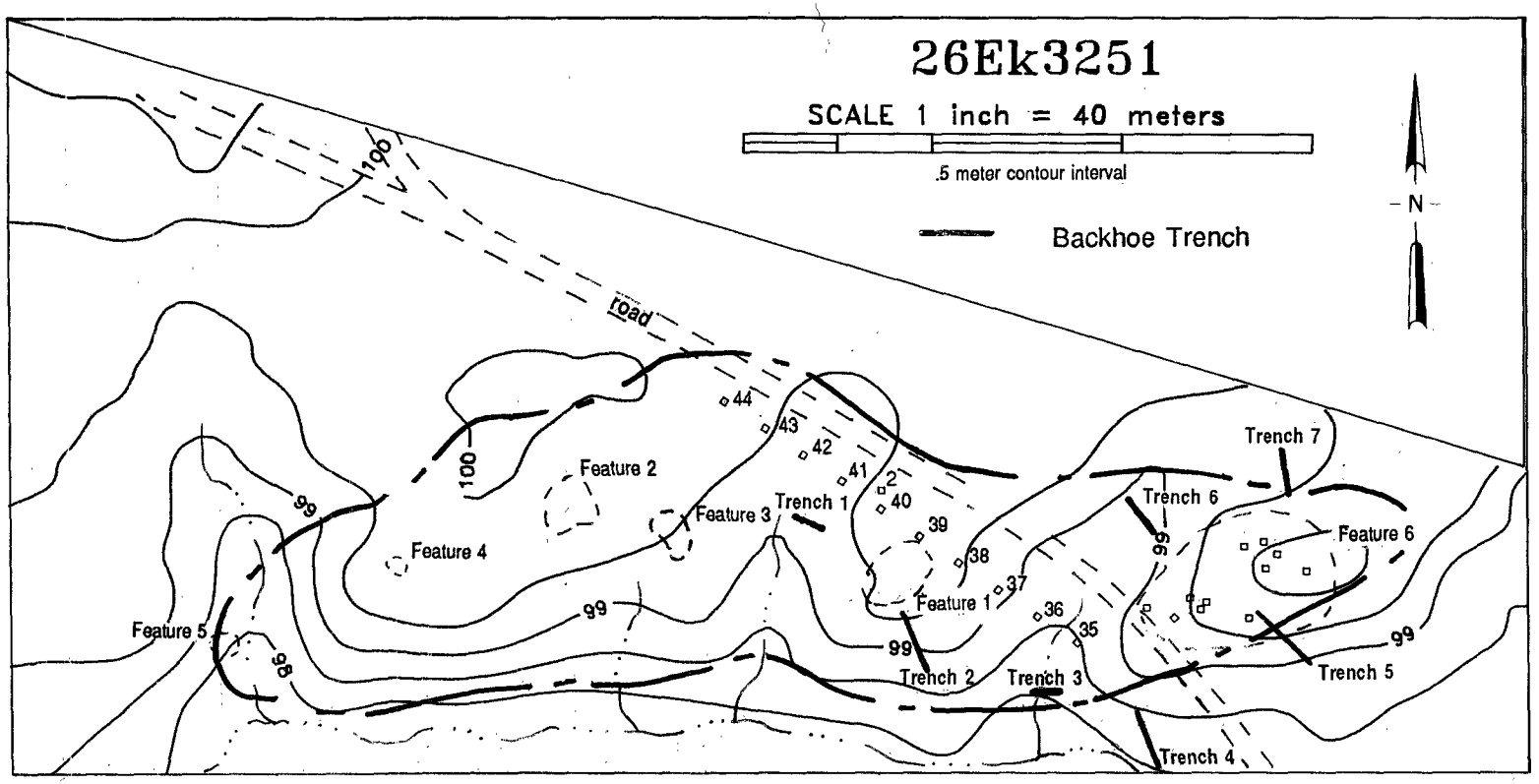


Figure 198. 26Ek3251 site map.

As displayed in the profile of Trench 4 (Figure 199), the terrace at 26EK3251 has been a fairly stable geomorphic feature during at least two past intervals separated by erosional channel cutting events. The stratigraphic sequence begins with Unit 10, a silty clay, overlain by Unit 9 and the equivalent Unit 11. At the north end of the trench, Unit 8, a silty clay loam, overlies Unit 9. These three units are well weathered and probably represent a buried soil profile; fine platy to granular soil structure in Units 8 and 9, and reddish brown root traces in Unit 10 are evidence of this. Following the soil-forming interval, the surface was eroded and much of Unit 8 was truncated where the gravel and cobbles of Unit 7 subsequently were deposited; these coarse sediments experienced channel erosion as well. Units 4, 5, and 6 (sand and gravel) later filled in part of this channel. The truncation of Units 4 through 7 indicates yet another fairly broad, later channel. Finally, sediments of Units 3, 2, and 1 progressively filled in the channel with increasingly finer materials. Unit 3 contains lenses of sand and silt representing the final alluvial stages of the terrace, whereas Units 2 and 1 are late Holocene eolian silts which typically mantle local surfaces and contain virtually all archaeological remains. Although the surface retains channel morphology, alluvial flow no longer occurs.

Molecular weathering ratios in Trench 4 (Figure 200) show a complex but systematic variation that supports the chronology presented above. For example, iron and aluminum ratios for Units 8, 9, and 10 are very low compared to overlying units. This confirms that they indeed are strongly weathered with abundant clay. Unit 9 also shows a relative increase in bases, especially carbonate, suggesting that it was the zone of carbonate accumulation in this paleosol. In the alluvial deposits of Units 4 through 7, overlying the buried soil, Unit 5 appears to be leached of silica and enriched in aluminum, iron, and bases. It is possible that this unit was modified as well during a brief period of weathering. Unusual lenticular pockets of sand found in Unit 5 may reflect either alluvial deposition or burrows filled with sediments similar to those of Unit 4. Finally, Units 1 through 3 exhibit increased weathering as a product of the accreting eolian surface.

The phosphorus plot shows enrichment at the modern soil surface in Unit 1 relative to the lower silt Unit 3. It is relatively high in Units 4, 5, 6, 7, and 10, probably reflecting changing oxidation rates in the coarser sediments or the unweathered state of the sands and gravel. Finally, in Unit 8, the high percentage of phosphorus probably results from organic enrichment when it was part of the soil surface.

In Trench 7 (Figure 201), deposition was dominated by fine sediments in Units 8, 9, and 10, similar to Units 1, 2, and 3 in Trench 4. At the bottom, the profile revealed Unit 6, a deposit of alluvial gravel and cobbles. This is immediately overlain by Unit 8, a thin, intermittent, grayish brown volcanic ash, very similar in appearance and texture to Mazama ash (6,800 years B.P.) seen in profiles along the modern Willow Creek channel (Figure 202); Unit 5 in Trench 5 probably is the same ash. This suggests that units above these ashes are younger than late middle Holocene, as supported by time sensitive artifacts recovered in excavation (cf. below).

Above the ash in Trench 7, Unit 5 is a fairly massive calcareous silt loam. It appears eolian in origin but may be fine alluvium. In the equivalent Unit 4 of Trench 5 (Figure 198), there were isolated pockets of moderately hard, white vitreous material. Although they exhibited little acid reaction for carbonate, chemical analysis revealed them to be calcium and magnesium rich; their origin remains unclear. Another notable characteristic of Unit 5 in Trench 7 and Unit 4 in Trench 5 is an extremely irregular yet distinct upper contact. Two possible origins seem likely: either it is a severely irregular erosional surface or an artifact of bioturbation and disturbance of the unit's structure. Evidence for extensive bioturbation was noted in the overlying loose silty Unit 3 where several burrows were identified. Unit 3 simply may be a bioturbated zone of the underlying unit. Some of this mixing also may owe to rooting by larger vegetation. Units 1 and 2 were typical of eolian silts mantling the surface at the site.

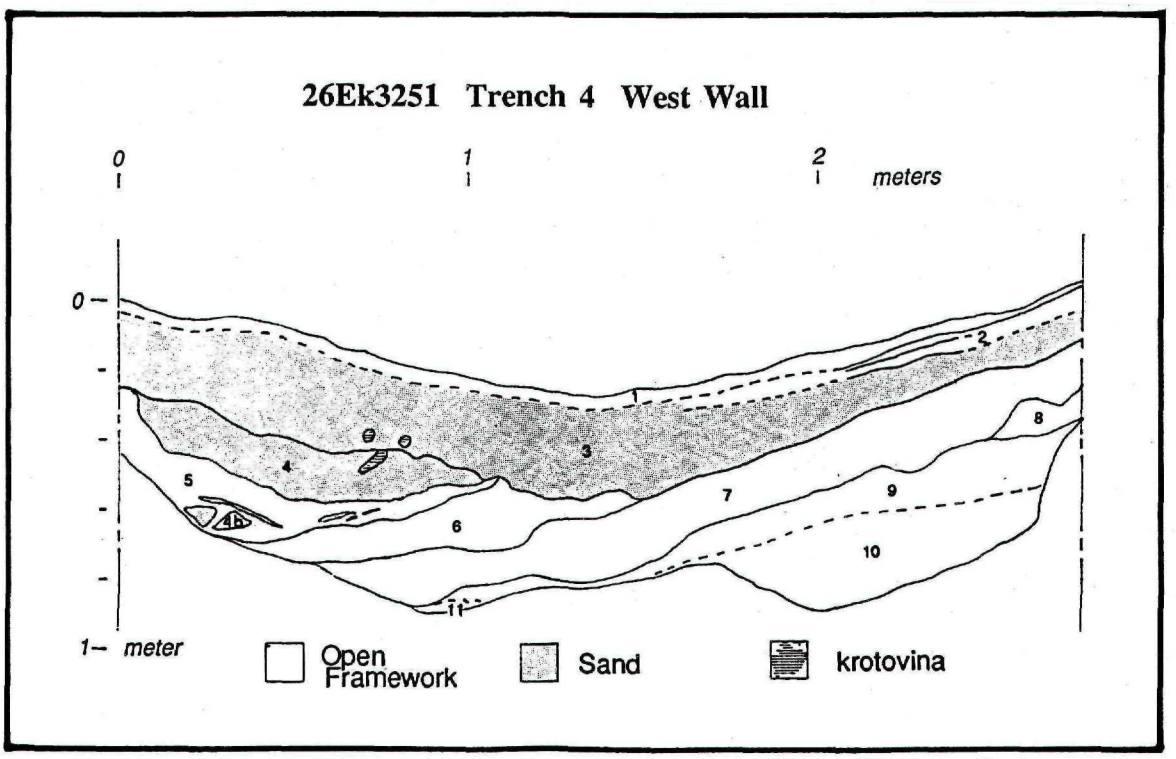
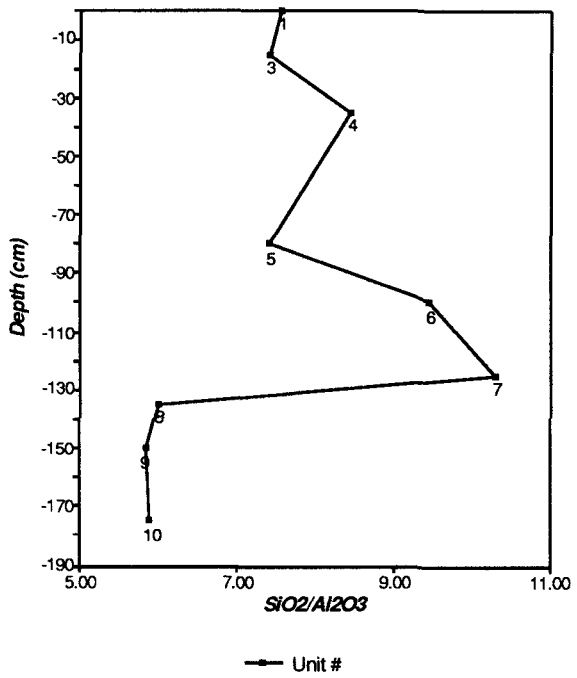
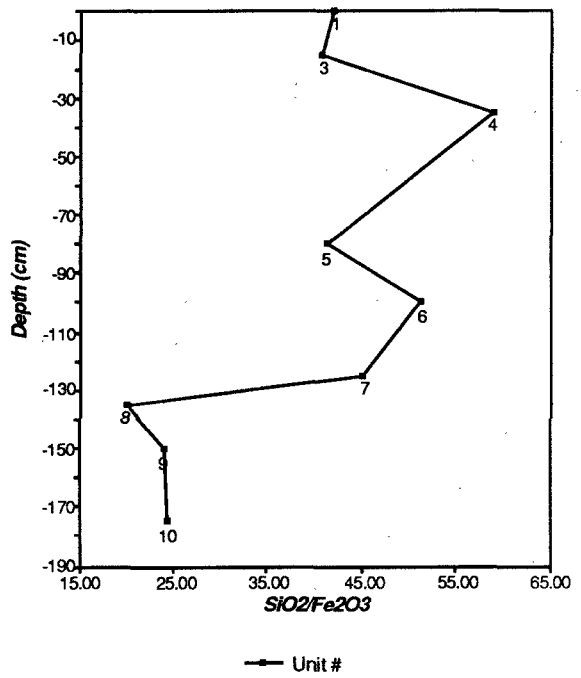


Figure 199. Stratigraphic profile of Trench 4, West wall, 26Ek3251.

Stratum	Description
1	Dark brown (10YR 4/3) dry; silt loam; weak medium to coarse granular; rare fine to medium subangular to subrounded pebbles; abundant fine to medium roots; boundary abrupt and broken.
2	Light grayish brown (10YR 6/2) dry; silt loam; weak medium platy to moderate medium subangular blocky; rare fine to medium subangular to subrounded pebbles; abundant fine to medium roots; boundary abrupt and smooth to wavy.
3	Dark grayish brown (2.5Y 4/2) dry; loamy medium to coarse sand to loam, distributed as discontinuous lenses; weak fine platy to weak medium subangular blocky; rare subrounded to rounded fine pebbles to fine cobbles; common fine to medium roots; rare krotovina; boundary abrupt and wavy to irregular.
4	Dark grayish brown (2.5Y 4/2) dry; fine to coarse, subrounded to rounded sand, generally coarsening downward, showing cross-bedding, with intermittent silty sand lenses; rare coarse roots; boundary abrupt and wavy.
4b	See description of Unit 4, occurring as isolated pockets in Unit 5.
5	Pale brown (10YR 6/3) dry; sandy loam, with fine to medium subrounded sand lenses; rare medium roots; boundary abrupt and wavy.
6	See description of Unit 4, with the exception that sands are generally coarser with fine to medium subrounded medium to coarse gravels; boundary clear and irregular.
7	Pale brown (10YR 6/3) dry; matrix and clast supported, poorly sorted, subrounded coarse gravel to medium subrounded cobbles; gradual and irregular.
8	Dark yellowish brown (10YR 4/4) dry; silty clay loam; moderate fine platy to coarse granular; rare medium roots; boundary gradual.
9	Yellowish brown (10YR 5/6) dry; strong mottling very pale brown (10YR 8/3), yellowish red (5YR 5/6) and dark reddish brown (5YR 3/3) silt loam; moderate fine platy; rare very fine roots; boundary diffuse and slightly wavy.
10	Yellowish brown (10YR 5/8) dry; silty clay; strong mottling, possibly root traces, yellowish red (5YR 5/6) and dark reddish brown (5YR 3/3); fairly massive; boundary unexposed.
11	Brown (10YR 5/3) dry; sandy loam; no structure apparent; boundary abrupt.



a.



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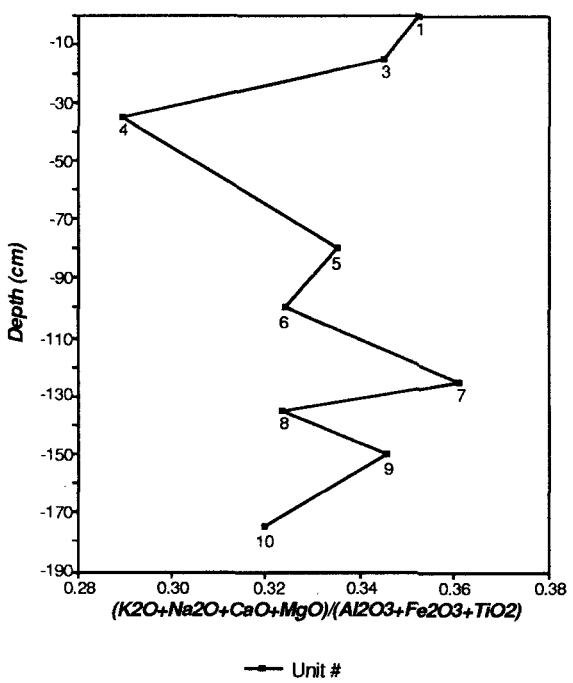

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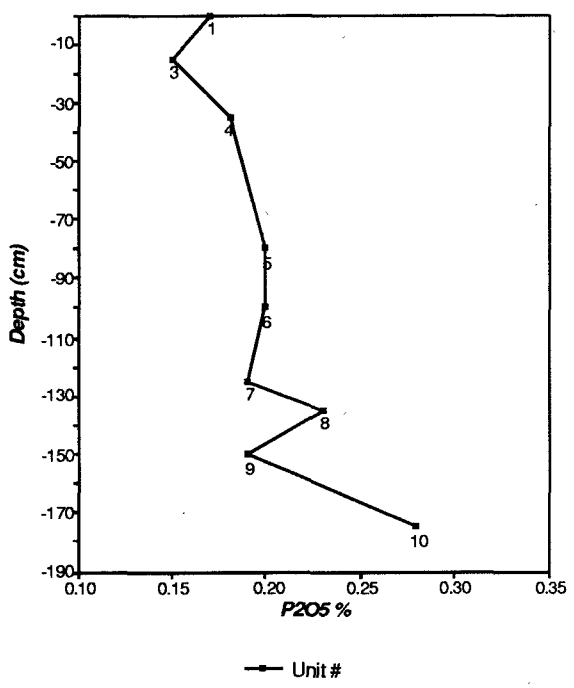


d.

Figure 200. Molecular weathering ratios for 26Ek3251, Trench 4 profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, and (d) weight percent phosphorus.

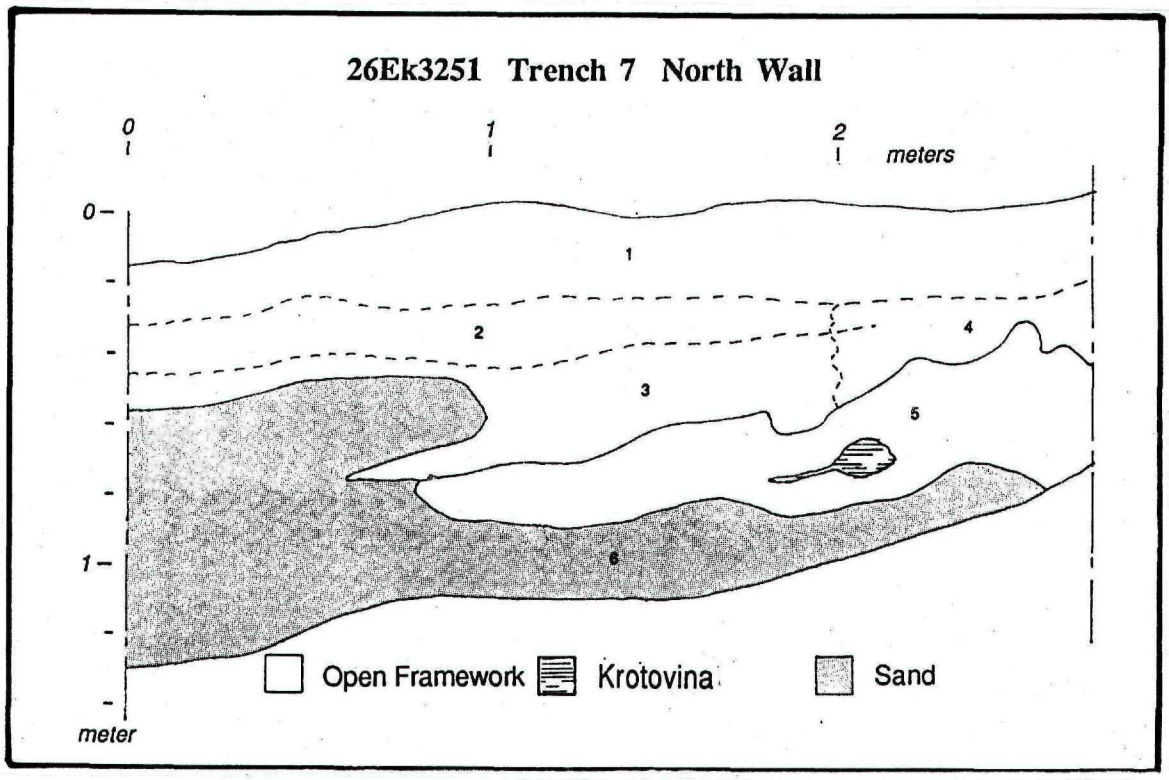


Figure 201. Stratigraphic profile of Trench 7, North wall, 26Ek3251.

Stratum	Description
1	Pale brown (10YR 6/3) dry; silt loam; weak medium to coarse granular to weak fine subangular blocky; rare fine to medium subangular pebbles; abundant fine to medium roots, rare to common fine pores; boundary clear and smooth.
2	Dark brown (10YR 4/3) moist; clay loam; weak to moderate medium angular to subangular blocky; rare fine to medium subangular pebbles; common fine to medium roots, rare fine pores; boundary clear and smooth.
3	Dark yellowish brown (10YR 4/4) moist; silt loam; weak to moderate medium angular to subangular blocky; rare fine to medium angular to subangular pebbles; common fine roots and pores; boundary abrupt and very irregular.
4	Light yellowish brown (10YR 6/4) dry; silt loam; moderate medium angular to subangular blocky; rare fine to medium angular to subangular pebbles; common roots and pores; strong acid reaction on carbonate filaments and weak nodules; boundary abrupt and irregular.
5	Brown (10YR 5/3) dry; sandy loam to silt loam; fairly massive; rare fine to medium subrounded pebbles; rare fine roots; strong reaction on carbonate filaments and mottling, very pale brown (10YR 8/3) dry; boundary abrupt and irregular.
6	Fine to medium sand matrix, dark reddish brown (5YR 3/3) supporting medium to coarse subrounded gravels, cross-bedded; grading downward to clast-supported coarse subrounded cobbles; possible iron staining in sands; strong acid reaction on carbonate lenses up to 4 cm thick; boundary unexposed.

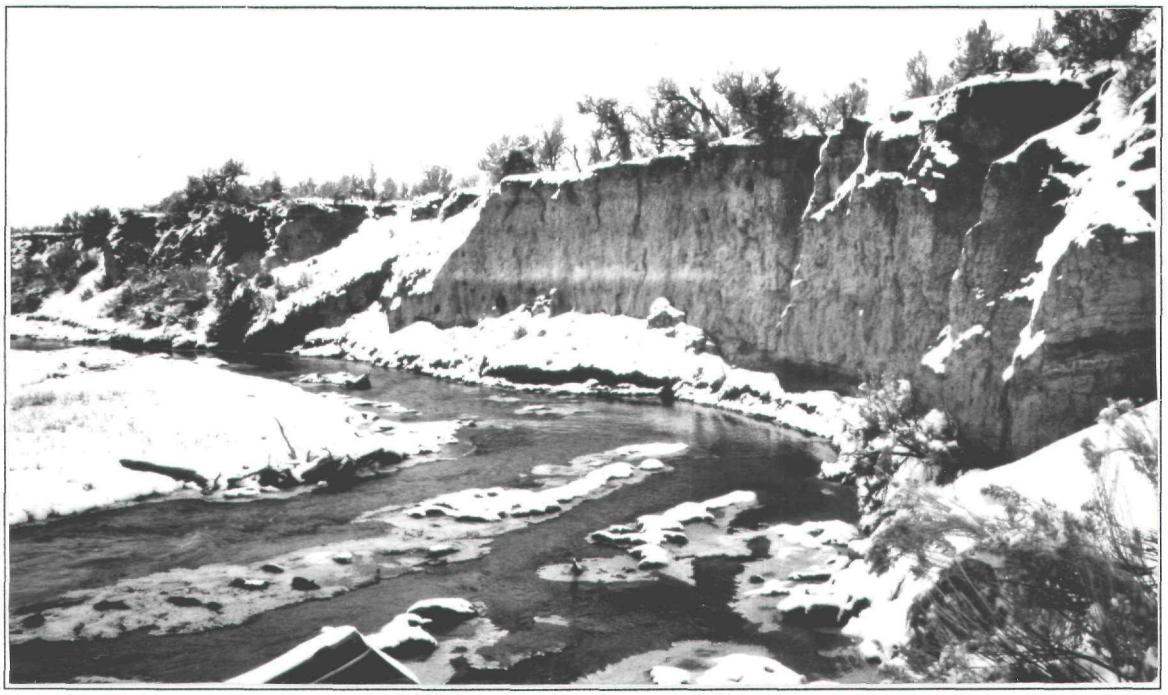


Figure 202. Mazama ash stratum exposed in Willow Creek cutbank south of 26Ek3251 (photograph taken in November, 1988).

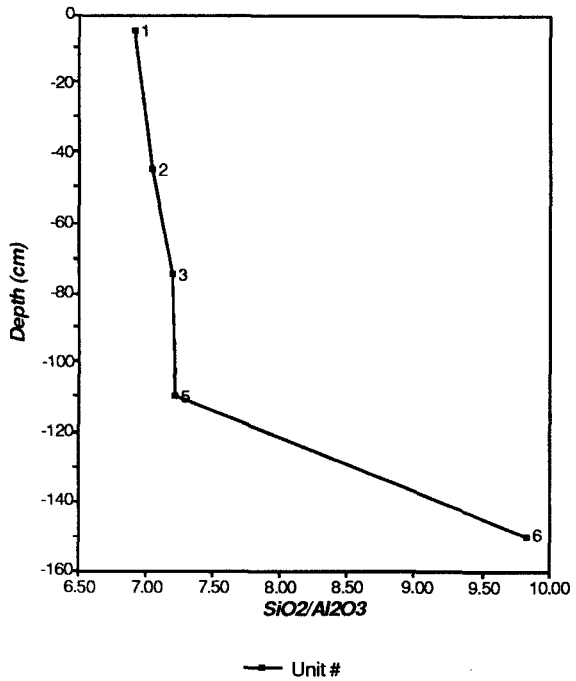
The weathering ratio plots for Trench 7 (Figure 203) show greatest weathering at the surface, decreasing downward to Unit 3. Unit 5 appears weathered in terms of relative iron accumulation, yet there is a decrease in aluminum, reflecting the clay-poor texture of the unit. A relative increase in calcium and magnesium oxide and a small increase in phosphorus suggests that this is part of a former weathered surface.

Excavation Units 28 and 34 (cf. Figure 205), which exposed profiles of the uppermost silt deposits seen in the backhoe trenches, also underwent detailed field description and chemical analysis. These excavations had simple profiles which showed the strongest leaching of sediments at about 30-40 cm depth. This suggests that silts shallower than 30 cm have not experienced as much weathering and therefore may be relatively new eolian deposits accreted onto former stable surfaces.

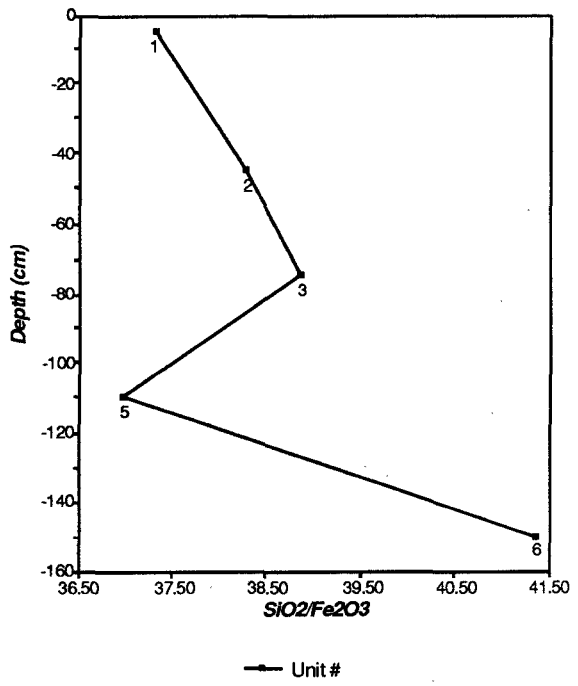
In conclusion, geomorphic evidence from surface morphology and the stratigraphy in a series of backhoe trenches disclose the following general structure and history of the alluvial terrace at 26EK3251. First, a core of older land surface, best represented by the buried paleosol in Trench 4, was apparently developed in older alluvial sediments. Following this interval, there was a period of channel migration, erosion, and deposition on the terrace surface. This produced the alluvial Units 7, 6, 5, and 4 of Trench 4, and Units 6 and 5 of Trench 7. Finally, after a major, possible mid-Holocene channel cutting event that truncated sediment units from the previous depositional interval and which may account for some of the irregular erosional relief, fine channel filling and eolian mantling occurred during the latter half of the Holocene. Some stratigraphic breaks suggesting stable surfaces may also be present in the upper silts (e.g., increased leaching of the silts around 30-40 cm depth). As we observe below, evidence of human occupation has accumulated only on the surface and in the upper few centimeters of this stack of sediments.

Nonfeature Contexts

Nonfeature investigations at 26Ek3251 involved the collection of surface artifacts and subsurface excavation of 1 m x 1 m units. Surface collections retrieved preforms, bifaces, flake tools



a.



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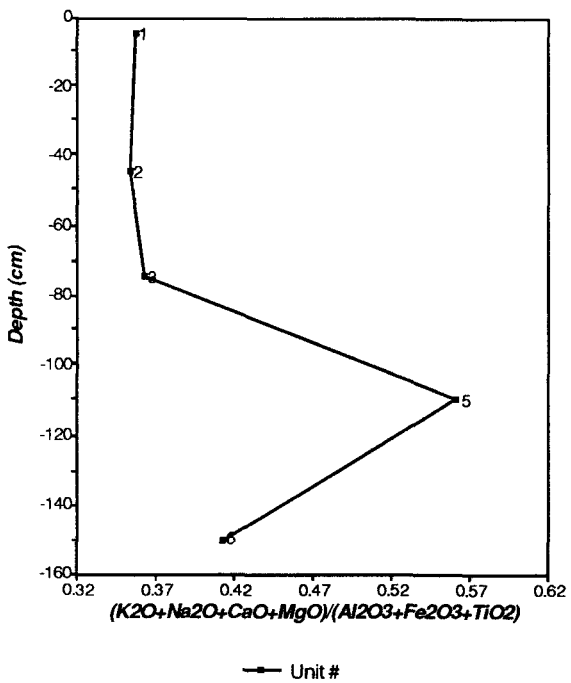

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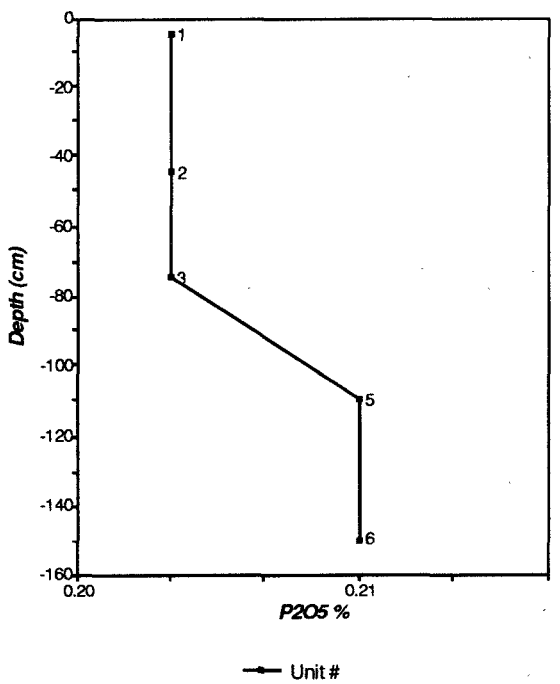


d.

Figure 203. Molecular weathering ratios for 26Ek3251, Trench 7 profile displaying relative oxide enrichment of (a) alumina, (b) iron, (c) bases, and (d) weight percent phosphorus.

(including highly modified end scrapers and a drill/perforator), metates, a single mano, and abundant debitage (Table 193). Seven projectile points were recovered as well, including Humboldt, Rosegate, and Desert Side-notched specimens.

Table 193. Artifacts Recovered from Nonfeature Contexts, 26Ek3251.

		DEBITAGE		FORMED ARTIFACTS				Perc./		
Unit No.	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Cobble Tools	Ground Stone	Total
(2)	0.10	13	4.0	-	-	-	-	-	-	0
35	0.20	16	11.3	-	1	-	-	-	-	1
36	0.20	35	21.8	-	-	-	-	-	-	0
37	0.30	108	108.0	-	-	3	-	-	-	3
38	0.30	57	34.9	-	-	5	-	-	-	5
39	0.20	28	17.6	-	-	-	-	-	-	0
40	0.20	31	20.1	-	-	-	1	-	-	1
41	0.20	13	11.1	-	-	-	-	-	-	0
42	0.20	7	9.4	-	-	-	-	-	-	0
43	0.20	14	14.4	-	-	-	-	-	-	0
44	0.20	8	3.7	-	1	-	-	-	-	1
Surface	N/A	-	-	7	6	17	4	1	7	42
Totals	2.30	330	256.3	7	8	25*	5	1	7	53

( ) = Test Excavation Unit

* Includes 1 "possible" biface

During testing, a 1 m x 1 m unit was excavated adjacent Ivanhoe Creek Road (Unit 2; cf. Figure 198) in an area of sparse surface lithics. Although subsurface materials were scant (cf. Table 193), our revisit deployed 10 additional 1 m x 1 m units along a baseline in similar, nonfeature contexts; our intent was twofold: to examine the various, subtle topographic features and to examine loess deposits systematically for buried features. These excavations disclosed a small concentration of flakes and bifaces in Units 37 and 38 (cf. Figure 198; Table 193), but exposed no features and, overall, found very little buried lithic debris.

Feature 1

Located on an elevated flat near the center of the site, Feature 1 is a dense scatter (11 m x 7.5 m) of heat-treated opalite debitage containing several flake tools, ground stone fragments, and fire-cracked rocks. Testing involved scraping a 2 m x 6 m block of 1 m x 1 m units (Units 1-12) and limited subsurface excavation (Figure 204). Numerous bifaces, projectile points, and preforms recovered from these initial investigations (Table 194) prompted our return to expand surface and subsurface investigations with the hope of identifying heat-treatment facilities or structural remains (Intermountain Research 1988d).

Supplementary data recovery employed 10 1 m x 1 m surface scrapes adjacent the existing block (Units 13-22), and judgmental placement of 10 excavation units subsequent to scraping (cf. Figure 204). As presented in Table 194, these investigations recovered thousands of pieces of debitage (dominated by small, heat-treated opalite flakes, but also including obsidian, jasper, and basalt), ground stone, flake and cobble tools, projectile points, preforms, and bifaces; artifacts were especially abundant in the southern and eastern excavations (e.g., Units 14, 15, and 18; cf. Figure 204 and Table 194).

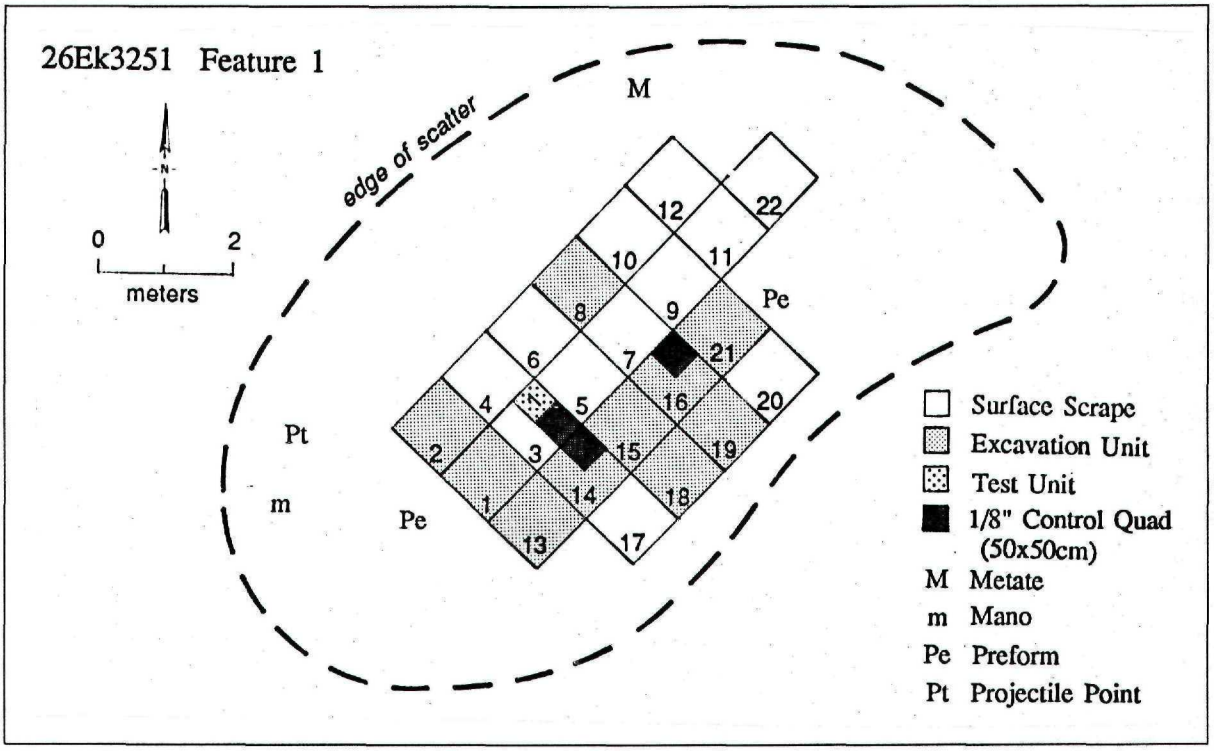


Figure 204. Plan view of Feature 1, 26Ek3251.

Table 194. Artifacts Recovered from Feature 1, 26Ek3251.

Unit No. (Type)	Volume Excav. (m^3)	DEBITAGE n	DEBITAGE wt. (gm)	FORMED ARTIFACTS Proj. Points	Preforms	Bifaces	Flake Tools	Perc./ Cobble Tools	Ground Stone	Total
1 (TS)[a]	0.125	1,566	393.0	1	1	9	1	-	-	12
1 (EU)	0.40	484	193.9	-	1	3	3	-	-	7
2 (EU)	0.30	489	236.8	-	2	2	-	-	-	4
3 (SF)	0.01	262	121.4	1	-	6	-	-	-	7
4 (SF)	0.02	124	50.0	2	1	3	1	-	-	7
5 (SF)	0.02	336	119.4	-	2	1	-	-	-	3
6 (SF)	0.02	165	68.0	-	1	3	-	-	1	5
7 (SF)	0.02	177	67.8	-	1	1	-	-	-	2
8 (EU)	0.30	222	98.6	-	-	2	2	-	-	4
9 (SF)	0.02	80	34.6	-	1	3	-	1	-	5
10 (SF)	0.02	50	28.8	1	-	1	-	-	-	2
11 (SF)	0.02	63	22.9	-	-	-	-	-	-	0
12 (SF)	0.02	43	18.5	-	-	-	-	-	-	0
13 (EU)	0.30	599	316.0	1	4	6	1	-	-	12
14 (EU)[a]	0.30	2,015	757.0	3	4	7	6	-	-	20
15 (EU)	0.30	1,043	391.9	2	3	12	1	-	1	19
16 (EU)[a]	0.30	748	263.2	1	-	6	-	-	2	9
17 (SF)	0.02	239	152.0	1	2	3	2	-	-	8
18 (EU)	0.30	543	257.1	2	3	4	1	-	-	10
19 (EU)	0.30	282	140.4	-	2	1	-	-	-	3
20 (SF)	0.02	191	109.5	1	-	2	2	-	-	5
21 (EU)	0.30	541	292.7	1	1	8	2	-	-	12
22 (SF)	0.02	39	26.0	-	-	1	-	-	-	1
Surface	N/A	-	-	1	2	-	-	-	2	5
Totals	3.455	10,301	4,159.5	18	31	84*	22	1	6	162

The wealth and variety of artifacts retrieved from Feature 1 suggest that the area served as a campsite. While neither hearths nor structural remains were identified, fire-altered rocks and charcoal flecks were encountered throughout our excavations; a hearth subsequently eroded and dispersed, may have once been present. Debitage and heat-treated bifaces (n=73, commonly middle-to-late stage) indicate frequent biface reduction, but the abundance of flake tools (scrapers, drills, knives, and retouched flakes) and the presence of grinding stones suggest an array of subsistence and fabrication tasks as well.

The most salient aspect of the assemblage is the abundance of small, heat-treated preforms and projectile points reflecting manufacture and maintenance of hunting equipment. Projectile points were encountered throughout excavation, represented largely by fragments, chiefly tangs, margins, and midsections; three of four classifiable points (three Rosegate Series and a Cottonwood Triangular) are fragmentary, including two specimens displaying impact fractures. Preforms, both complete and fragmented during manufacture, also were recovered (cf. Table 194), and represent the largest aggregate of this artifact class recovered from the Tosawihi vicinity. Clearly, Feature 1 commonly was used by hunters to "gear-up" for hunting forays around Willow Creek, and points were manufactured there to replace specimens broken in previous ventures; three identified Rosegate Series points suggest these episodes occurred most frequently between A.D. 700 and A.D. 1300.

Feature 2

Feature 2 (cf. Figure 198) is a 11 m x 7 m ovate lithic scatter encompassing four debitage concentrations. We scraped a 2 m x 6 m contiguous block of 1 m x 1 m units in the westernmost concentration; 7,174 flakes and 30 formed artifacts were recovered. The observed toolkit includes 20 bifaces, four preforms, and six projectile points, including an identified Rosegate specimen. Additionally, we excavated a 1 m x 1 m unit within the scrape; a biface fragment, and 1,015 flakes were recovered, most of which (89%) were retrieved from the uppermost 20 cm of excavations (Schmitt 1989b).

Most of the debitage consists of heat-treated opalite flakes produced during mid-to-late biface reduction. The bifaces, exhibiting manufacture failures, reflect similar stage reduction (most are mid-to-late stage 3 heat-treated fragments), suggesting that the feature served chiefly for biface reduction and manufacture.

Features 3, 4, and 5

Three lithic reduction features (Features 3, 4, and 5; cf. Figure 198) were recorded in the field, but were not subjected to further scrutiny; characterization involved recordation of debitage types and abundances, and the collection of formed artifacts. Each assemblage is dominated by biface reduction debris, but a projectile point fragment, a preform, and a scraper at Feature 3 signal more diverse tasks. Surface collections at Feature 4 returned a single heat-treated opalite biface fragment, and at Feature 5, a biface and a Humboldt point.

Feature 6

Feature 6, the largest feature in the corridor, consists of a lithic scatter ca. 35 m x 15 m adjacent the eastern site boundary (cf. Figure 198); initial surface reconnaissance

identified two metate fragments, two bifaces, and a preform. Generally, light debitage density appeared higher in deflated and eroded areas, suggesting that subsurface deposits might be present (Schmitt 1989b:145); accordingly, to explore subsurface deposits, we placed a 1 m x 1 m test unit central to a small debitage concentration. Excavation (to 50 cm) returned four formed artifacts (Table 195), 907 flakes (including obsidian tertiary flakes from our 1/8 in. mesh control quadrant), and fragmentary faunal remains.

Table 195. Artifacts Recovered from Feature 6, 26Ek3251.

		DEBITAGE		FORMED ARTIFACTS								
Unit No.	Volume Excav. (m^3)	n	wt. (gm)	Proj. Points	Preforms	Bifaces	Flake Tools	Perc./ Cobble Tools	Ground Stone	Ceramics	Other/ Exotic	Total
(3)[a]	0.50	907	376.3	1	-	2	1	-	-	-	-	4
25	0.40	254	124.3	1	1	2	-	-	-	-	-	4
26	0.30	146	89.3	1	-	-	-	-	-	-	-	1
27	0.40	381	240.9	1	3	2	1	-	-	-	-	7
28[a]	0.60	922	304.7	-	3	7	-	1	-	-	-	11
29	0.30	229	134.5	1	-	3	-	-	-	-	-	4
30	0.40	448	244.4	-	-	2	2	-	-	-	-	4
31	0.50	522	293.3	3	8	9	3	-	-	-	1	24
32	0.40	503	362.8	1	-	1	1	-	-	-	-	3
33	0.30	189	101.8	-	-	1	-	-	-	-	-	1
34	0.60	163	92.6	-	1	3	1	-	-	-	-	5
Surface	N/A	-	-	3	3	5	1	-	5	2	-	19
Totals	4.70	4,664	2,364.9	12	19	37*	10	1	5	2	1	87

( ) = Test Excavation Unit
[a] Includes a 25 x 25 cm 1/8 inch mesh control quadrant

* Includes 1 "possible" biface

We returned to Feature 6 the following season to collect additional artifacts from the surface and to examine its subsurface contents through further excavation of 10 randomly placed 1 m x 1 m units (Figure 205; cf. Intermountain Research 1988d). Although we found flakes and artifacts restricted largely to the uppermost 30 cm of the deposits, artifacts are abundant across the feature, and include various material types and functional classes (cf. Table 195). Supplementary surface collections inflated artifact diversity with an edge faceted cobble and two Brownware sherds; the surface also yielded the only two diagnostic projectile points at Feature 6 (Desert Side-notched and a Gatecliff Split Stem specimens).

Level 3 (20-30 cm B.S.) of Units 28 and 32 disclosed scatters of fire-cracked rock and charcoal flecks probably reflecting dispersed hearths. Flotation of a sediment sample from Unit 32 returned very little carbon, but plant macrofossil analysis identified charred seeds, strengthening our initial assumption. Not surprisingly, all identified specimens are riparian species native to regional wetland environments (see Chapter 15).

An increase in tool and debitage counts was noted in associated (contiguous) unit/levels, including the *in situ* recovery of a number of flake tools and bifaces. Artifacts were especially abundant in Unit 28 (although partially enhanced by a 1/8 in. mesh control quadrant; cf. Table 195), but relatively sparse in Unit 32. Neighboring Unit 31 (cf. Figure 205), however, *may* represent an activity area associated with an inferred hearth; excavations yielded an unprecedented 24 artifacts (including flake tools and a bone awl fragment) associated with fragmentary large mammal remains.

In sum, Feature 6 yielded an abundant and functionally diverse artifact assemblage. Like Feature 1, it served periodically as a campsite where resource acquisition and processing as well as artifact fabrication and maintenance were performed. The presence of Brownware pottery and a Desert Series point signal occupation after A.D. 1300, and a Gatecliff Split Stem point suggests a much earlier visit sometime during the mid-Archaic.

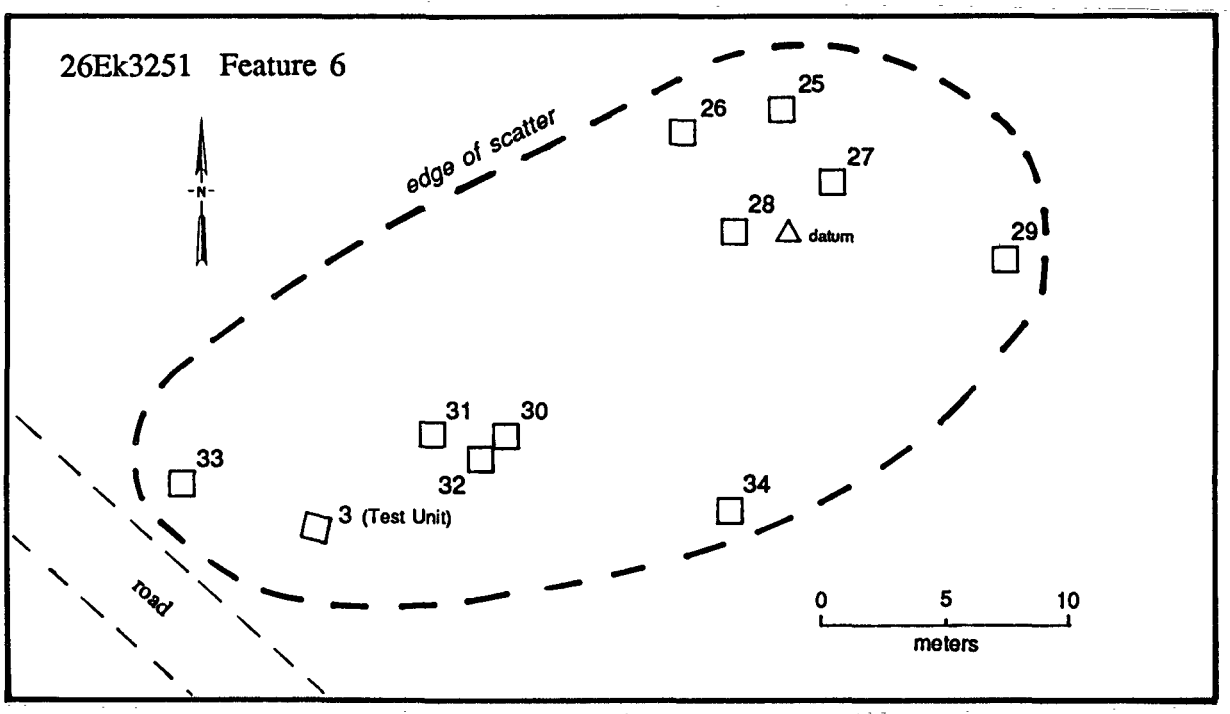


Figure 205. Unit location map, Feature 6, 26Ek3251.

Chronology

Relative and absolute time markers were recovered from five of eight sites investigated in the Northern Corridor (Figure 206). A single Gatecliff Split Stem point and two Humboldt points from 26Ek3251 indicate occupation perhaps as early as 3000 B.C., but the remaining specimens (six Rosegate Series and three Desert Series), as well as Shoshone Brownware sherds, suggest more frequent occupations during Late Archaic times; a single Rosegate point from 26Ek3231 also indicates Late Archaic use of Perron Canyon.

Several time sensitive artifacts were recovered from Ivanhoe Creek Valley; they reflect thousands of years of visits (also cf. Chapters 8 and 19). Testing at 26Ek3238 returned Large Side-notched and Gatecliff types, as well as a Stemmed point indicating occupation between ca. 8000 and 6000 B.C. (Figure 206). At 26Ek3239, an Elko Corner-notched point and a Rosegate Series specimen denote occupation between 850 B.C. and A.D. 1300. Two small, non-diagnostic ceramic sherds recovered from the site also have chronological significance; regardless of typological identification, they signal occupation sometime between A.D. 500 and historic contact (cf. Chapter 13).

Surface collections and excavations at 26Ek3237 returned both temporally diagnostic artifacts and radiocarbon dates (cf. Figure 206); of particular interest, the site yielded the entire Great Basin projectile point sequence, spanning some 10 millennia (i.e., Clovis to Desert Series). Although our single Clovis point doubtless was scavenged and redeposited by later peoples, the presence of the entire Desert West projectile point sequence has few precedents in the Great Basin.

Locus C of 26Ek3237 also returned several chronological markers, including three hearth features which fix separate occupations between 1860 years B.P. and the mid-Nineteenth Century. While Loci A and B probably experienced multiple occupations as well, associated projectile points

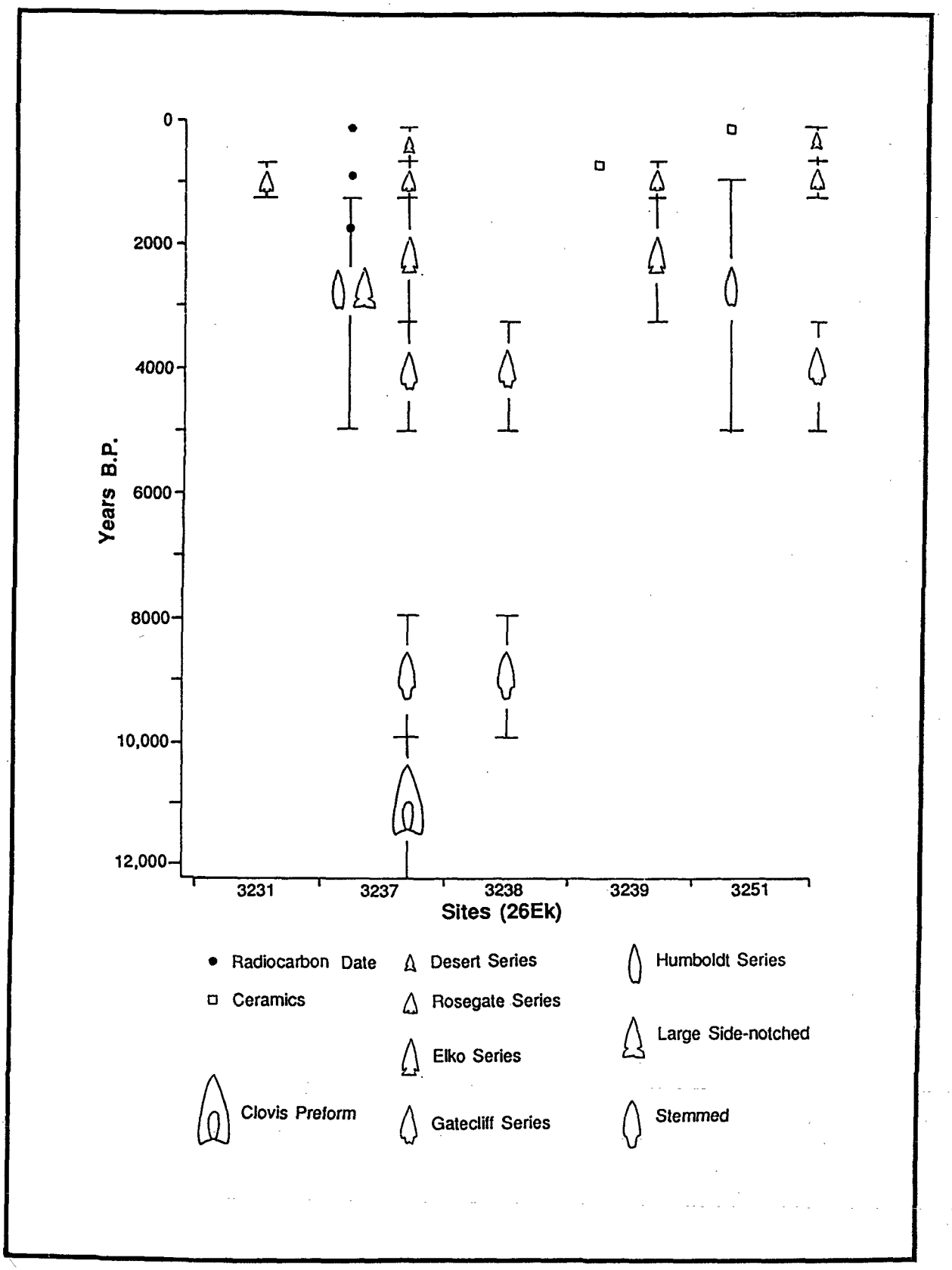


Figure 206. Chronological indicators, Northern Corridor.

reflect more temporally restricted use; two Rosegate Series points reflect visits to Locus B only during the Late Archaic, and two Gatecliff Spilt Stem points and an Elko Eared specimen bracket occupations of Locus A between 3000 B.C. and A.D. 700.

All excavations in the Northern Corridor found cultural remains restricted to the veneer of Middle to Late Holocene eolian silts that blanket the region. While most time sensitive artifacts and all of the radiocarbon dates clearly concur, a Clovis preform and numerous Great Basin Stemmed points also occupy these later deposits, suggesting that cultural remains predating known sites by as many as 6,000 years *may* exist in the Tosawihi vicinity; they may lie beyond our present realm of inquiry.

Summary

With the exception of a small, inferior quality opalitic cobble field at 26Ek3239, archaeological sites in the Northern Corridor are dominated by non-quarry attributes. Nearby opalite sources (e.g., isolated outcrops, stream cobbles) peripheral to the Tosawihi Quarries may have been exploited, but the archaeological paucity of early stage reduction (i.e., cores and Stage 1-2 bifaces), the low frequency of cortex and angular shatter, and the high frequency of heat-treated tools and detritus suggest that most toolstone in these sites was acquired at and transported from the heart of the quarries. However, based on their contents and proximity to the quarries, some "reduction" sites in the corridor (e.g., 26Ek3238 and 26Ek3228) may represent diurnal task sites where toolstone was further reduced, probably to facilitate transport.

Although data recovered from the Northern Corridor reveal little about how toolstone was *procured*, they offer a unique laboratory for exploring the economics of toolstone *transport*. Because stone is dense and heavy, transportable quantities are defined by human limits of effort that doubtless inspired much of the extensive initial processing and caching of products (e.g., bifaces) at or near the quarries (cf. Chapter 4). To examine overall fall-off rates in toolstone packages along the corridor as a function of distance from source, mean weight per debitage item was calculated for each site assemblage containing more than 200 flakes. Figure 207 plots the results, revealing the expected, gradual inverse relationship; flake sizes diminish with increased distance from the quarries.

In sum, the Northern Corridor is dominated by biface reduction debris, but tool fabrication and subsistence tasks were pursued there as well. Toolkits and subsistence residues from 26Ek3237, 26Ek3251, and, to a lesser extent, 26Ek3239, reflect streamside campsites offering access to a broader suite of biotic resources than available in the quarries; riparian plants and permanent water must have drawn attention, as did the mammalian resources they attract.

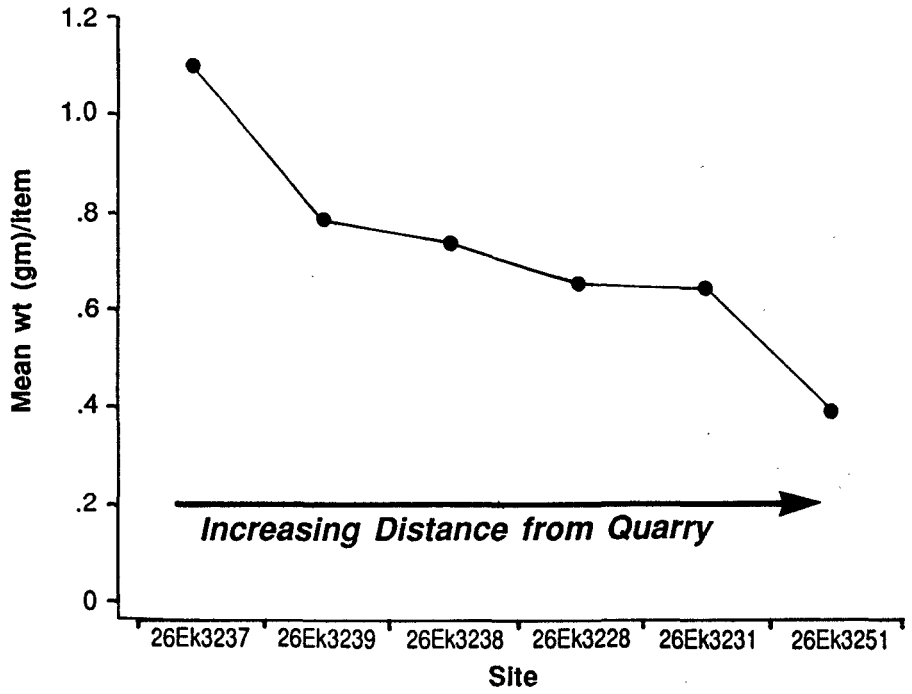


Figure 207. Mean debitage weight/item at selected Northern Corridor sites.

PART IV. DISCUSSIONS

Chapter 19

CULTURAL CHRONOLOGY

Robert G. Elston and Michael P. Drews

Cultural chronologies describe the dates and sequence of phases in the culture history of a locality or region, providing frameworks for the study of change through time. Data used to construct them include relative stratigraphic positions, dates derived from radiocarbon and obsidian hydration, and distributions of time-diagnostic artifacts such as projectile points and pottery. Patterning in these data may themselves suggest cultural change. Cultural phase boundaries mark changes in sets of cultural attributes sufficient to discriminate archaeological units (Willey and Phillips 1958:22). The prehistoric past can be divided at several different levels of generality; in the western Great Basin, the inclusiveness of phase discrimination ranges from shifts in adaptive strategy (Elston 1986a) to changes in projectile point styles (Thomas and Bettinger 1976; Thomas 1981). Chronological data for the Middle and Upper Humboldt regions are summarized in Figure 208 and compared to the Monitor Valley sequence (Thomas 1981, 1983b) and Elston's (1982, 1986a) adaptive chronology for the western Great Basin.

Adaptive Strategies in the Western Great Basin

As a means of organizing discussion of temporal variability in the western Great Basin, Elston (1982; 1986a) partitioned the prehistory of the region on the basis of broad changes in adaptive strategy (Figure 208). The resulting intervals are relatively long, with indistinct temporal boundaries, and local and regional variations in the ways different adaptive strategies were played out.

The earliest period of human occupation is poorly known (Willig and Aikens 1988). The terminal Pleistocene, or Twocreekan interval (10,500 to 9,050 B.C.; J.O. Davis 1978b, 1982:63), was a time of deglaciation and erosion during which the Humboldt River discharged about ten times its current flow. Archaeological remains radiocarbon dated between 10,000 - 9,000 B.C. have been recovered from a few, widely scattered caves, including Cougar Mountain Cave 2 and Connley Cave 4B, Oregon; Danger Cave, Utah, and Fishbone Cave, Nevada (Bedwell 1973; Jennings 1957; Orr 1956, 1974; Thompson et al. 1987). Clovis points in the far West are associated with radiocarbon dates between 10,000 and 9,250 B.C. (Willig and Aikens 1988:Table 2a).

In the Great Basin, the only fluted point from a dated context (9,503-8320 B.C.) lay in the lowest levels of Danger Cave (Jennings 1957; Holmer 1986), but the specimen is morphologically atypical as Clovis. Surface finds of Clovis points are more common (Basgall 1988; Campbell and Campbell 1940; E.L. Davis 1978a; Kelly 1978; Tadlock 1966; Tuohy 1968, 1969; Warren and Phagan 1988). A cache of Clovis points was discovered recently in East Wenatchee, Washington (Mehringer 1988), and dated geochemically to slightly later than 9,300 B.C. (the fall of Glacier Peak tephra; Mehringer and Foit 1990). As described in Chapter 8, the Clovis preform recovered from site 26Ek3237 on Ivanhoe Creek during the present project is very similar in size, morphology, and technology to points in the Wenatchee cache.

Other basally thinned, concave based points occasionally occur in early assemblages associated with ancient lake shores. Pendleton (1979) includes them in the Great Basin Concave Base Series, which includes *Tonopah* and *Triple-T* variants. Thomas (1981) placed the basal date of the Triple T variant at about 3,500 B.C. The Tonopah variant, so far lacking stratigraphic context, may be much earlier.

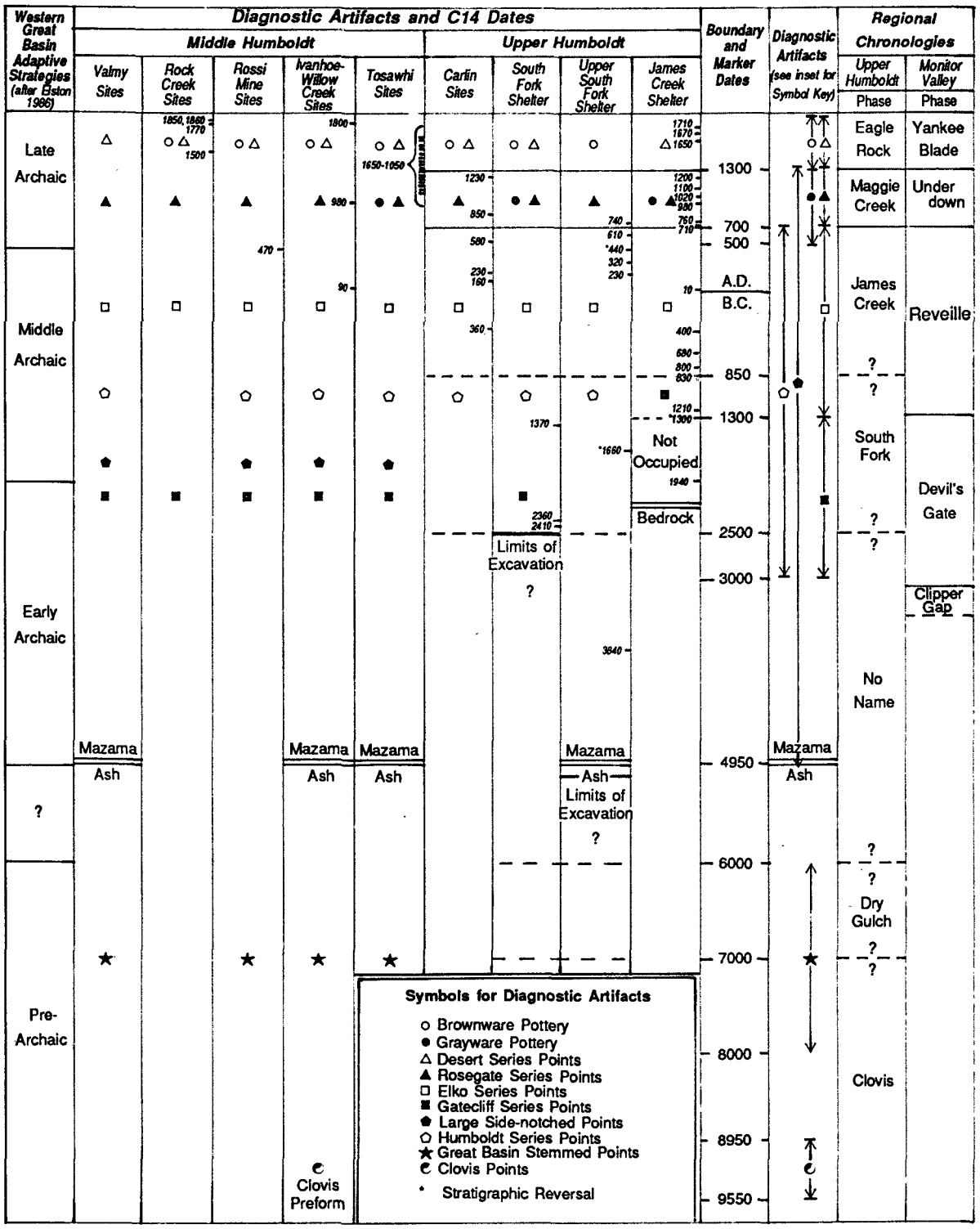


Figure 208. Middle and Upper Humboldt regional chronology.

The Early Holocene, between 9,050 and 4950 B.C., saw the final transition to a fully interglacial climate and ecology (Davis 1982:63-65). Early in the period, the Great Basin was occupied by people who used Great Basin Stemmed Series (GBSS) projectile points (Tuohy and Layton 1977). Surface finds of GBSS points are much more common than finds of Clovis points; they occur both in isolation and in large assemblages (cf. Willig and Aikens 1988). Too, they are found more frequently in buried contexts with associated radiocarbon dates. The extreme range of radiocarbon dates for GBSS points in the Great Basin (Willig, Aikens, and Fagan 1988:Table 3) is 8650 B.C. (Connley Cave 5B; Bedwell 1973) to 5480 B.C. (Hogup Cave; Aikens 1970), but most dates fall between 8,000 B.C. and 6,000 B.C.

The cultural manifestations discussed above are usefully referred to as Western Clovis and Western Stemmed complexes (Willig and Aikens 1988:1). In Elston's (1982, 1986a) scheme of Great Basin adaptive strategies, both are lumped as *Pre-Archaic*, temporarily deferring the question, until more evidence accrues, of whether either or both represent variants of Paleoindian adaptation, early Archaic adaptations, or something else entirely. They seem sufficiently different, however, to be distinguished from variants of the better-known Archaic adaptive strategy. While the pre-Archaic strategy probably involved sparse populations, high residential mobility, and non-intensive plant food processing and storage (reflecting a relatively narrow diet breadth), the Archaic strategy entailed a decrease in overall mobility, increased land-use diversity, broadened diet breadth, and intensified resource procurement.

Shifting strategies and broad-based foraging are characteristic of the Archaic. Basic technologies change very little, but, on a large scale, there seem to be long term, additive trends in strategies forming the basis for a tripart division. Characteristics include introduction of intensive seed processing technology (mano and metate) in the Early Archaic (ca. 5000-2000 B.C.), lowered mobility and increased reoccupation of residential and cache sites in the Middle Archaic (ca. 2000 B.C.-A.D. 500), and introduction of bow and arrow and additional plant processing equipment (suggesting further increase in diet breadth and resource intensification) in the Late Archaic (ca. A.D. 500-Present). Temporal ranges of projectile point styles associated with these strategies are summarized in Figure 208.

Regional Chronologies

Cultural chronologies have been synthesized for most of central and eastern Nevada (Thomas 1983b, 1988; James 1981; Rusco 1982; Smith et al. 1983; Elston and Budy 1990), with regional cultural sequences divided into phases developed only for Monitor Valley (Thomas 1983b) and the Upper Humboldt region (Elston and Budy 1990). However, phase boundaries in the two regions do not necessarily match owing to differences in phase definition (Figure 208).

Monitor Valley and Upper Humboldt Regions Compared

Thomas (1981, 1983b) defined the phases of the Monitor Valley sequence as purely temporal units bounded by changes in projectile point style manifest in the well stratified, radiocarbon-dated deposits of Gatecliff Shelter. He then used the phase units to monitor archaeological variability and change in mostly surface assemblages throughout the Monitor Valley region (Thomas 1983b, 1988). In contrast, the Upper Humboldt sequence is pieced together from several excavated rockshelters and open sites the archaeological records of which vary in stratigraphic resolution and completeness (Elston and Budy 1990). Since the number of archaeological observations is limited, phase content and boundaries are provisional. Prior to about 1300 B.C., Upper Humboldt radiocarbon dates are scarce, and phase boundaries are distinguished by little more than changes in projectile point style; later phases are thought to mark shifts in settlement patterns and variable intensity of site use.

Cultural Chronology of the Upper Humboldt Region

The Upper Humboldt River extends from Beowawe east to the headwaters; the Upper Humboldt Region is comprised of the country tributary to the Upper Humboldt River east of the Tuscarora Mountains. The Middle Humboldt River is the reach between Golconda and Beowawe; the Middle Humboldt Region includes the tributary area between the Osgood and the Tuscarora Mountains. By this definition, the Tosawihi Quarries lie in the Middle Humboldt, although, as discussed in earlier chapters, there is much to suggest that they served as a major lithic resource to both the Middle and Upper Humboldt regions. The degree to which the Upper Humboldt cultural sequence is applicable to the prehistory of the Middle Humboldt region is a question explored in this report.

The archaeological record of the Upper Humboldt region, while not wholly invisible, is difficult to see before 2500 B.C. The South Fork shelters (Heizer et al. 1968; Spencer et al. 1987) and James Creek Shelter (Elston and Budy 1990) provide the only long stratigraphic records in the region. Variability in proportions of local toolstone and Tosawihi chert in James Creek Shelter reflects toolstone economics at the site during periods of greater or less intense occupation. The only radiocarbon date older than 2500 B.C. in the Upper Humboldt (3840 B.C.) comes from Upper South Fork Shelter, where sparse debitage was found below Mazama Ash dating to 4950 B.C. (Spencer et al. 1987). No Clovis sites are known in the Upper Humboldt. Diagnostic GBSS points of the earliest Upper Humboldt phase (Dry Gulch: 7,000-6000 B.C.) occur as isolated artifacts or in small assemblages of lithic tools and debitage; these frequently occur with flaked stone crescents in other regions, but, not so far, in the Upper Humboldt. GBSS points also are found in palimpsest surface assemblages with later components which, in some cases, may be products of scavenging. There are no reliable dates for terminal use of GBSS points. The temporal boundaries and content of the Dry Gulch Phase thus remain unclear.

The No Name Phase (5000-2500 B.C) *should* represent the first local expression of the Early Archaic as characterized above, but it is an interval less well-known archaeologically than the preceding period. A major environmental change during this interval was the invasion of single-leaf pinyon (*Pinus monophylla*) into the western and central Great Basin between 4000 and 2000 B.C. (Thompson 1984a), reaching its northern limit just south of the Humboldt River by about 1500 B.C. (Thompson 1984b). Few archaeological sites referable to the No Name Phase have been observed on the Upper Humboldt (Elston and Budy 1990), although it is possible that the right places have not yet been searched. The 3040 B.C. radiocarbon date from Upper South Fork Shelter relates to a hearth, but associated cultural materials are sparse, suggesting use of the shelter as a short-term field camp (Spencer et al. 1987). If the lack of sites of this age throughout the Upper Humboldt region is not due simply to sampling error, the data suggest that population levels were relatively low.

The last 500 years of the No Name Phase coincide with part of the temporal range of Gatecliff Series projectile points (3000-1300 B.C.: Thomas 1981, 1983b), but there are no reliable diagnostic artifacts for the interval between about 6,000 and 3,000 B.C. (Figure 208). At one time, Humboldt points were thought to date between 4000 and 1000 B.C. (Heizer and Hester 1973). Thomas (1981) later suggested that Humboldt points occur throughout the Archaic and thus are not good time markers; certainly their stratigraphic position in Gatecliff Shelter is ambiguous (Thomas 1983b). Large Side-Notched points apparently were used as early as 5,000 B.C., but their chronological range is great and they, too, are poor time markers (Figure 208).

The South Fork Phase (2500-850 B.C.) spans the boundary between the Early Archaic (2500-1500 B.C.) and the Middle Archaic (1500 B.C.-A.D. 500), but the archaeological visibility of its early portion is slight in the Upper Humboldt Region. Moreover, both upper and lower boundaries of the South Fork Phase differ from the otherwise congruent Devil's Gate Phase (3000-1300 B.C) of central Nevada, for which Gatecliff points are diagnostic (Figure 208). The

earliest radiocarbon date from South Fork Shelter (Heizer et al. 1968) is 2410 B.C.; a Gatecliff point and two Humboldt points were produced from deposits dated between 2410 B.C. and 1370 B.C. Occupation began in James Creek Shelter sometime before 1250 B.C., and a Gatecliff point was recovered from deposits there dating between 1250 B.C. and 850 B.C. (Drews 1990). The terminal date of 850 B.C. for the South Fork Phase, based on the end date for the South Fork component of James Creek Shelter, is about 400 years later than the end of the Devil's Gate Phase in Monitor Valley (Thomas 1983b).

Relatively little is known of prehistoric lifeways on the Upper Humboldt during the South Fork Phase. Although in central and western Nevada, more intensive use of upland areas and particular sites after about 1500 B.C. is thought to signal increased population (Elston 1982; Thomas 1982). Remains from James Creek Shelter (Elston and Budy 1990) and the South Fork Shelters (Heizer et al. 1968; Spencer et al. 1987) suggest occasional use by individuals or small groups, probably during hunting forays. Various toolstones were exploited at James Creek Shelter during the South Fork Phase; 66% of the debitage consists of locally available Maggie Creek chert, 22%, of Tosawihi chert, 4%, of obsidian, and 13%, of other toolstone. Although the sample is small, Paradise Valley obsidian is more abundant than Brown's Bench obsidian at James Creek Shelter (Hughes 1990).

The temporal boundaries of the James Creek Phase (850 B.C.-A.D. 700) are defined on the basis of radiocarbon dated stratigraphy from James Creek Shelter (Elston and Budy 1990). The lower boundary date of 850 B.C. falls 450 years later than the Reveille-Devil's-Gate boundary in Monitor Valley (Figure 208). During the first part of the phase, occupation of James Creek Shelter and the South Fork Shelters intensified, although all these sites continued to be used as overnight stops or short term logistical bases for individuals or small groups of hunters (Spencer et al. 1987; Elston and Budy 1990). After about A.D. 1, use of James Creek Shelter intensified further, with the occasional construction of shallow, saucer-shaped, grass lined features which probably served as beds. The proportion of Tosawihi chert declined to 11% and obsidian to 1%, while local Maggie Creek chert increased to 82%. Similar features and increased activity also occurred at Upper South Fork Shelter, but possibly somewhat later. Elko Series projectile points are diagnostic of the James Creek Phase, and their wide distribution across the landscape indicates the exploitation of an broader range of settings and a more eclectic use of the environment than previously obtained (Rusco, Davis, and Jensen 1979; Armentrout and Hanes 1987). This trend mirrors more intensive use of uplands and particular sites after about 1,500 B.C. in western and central Nevada; it may reflect increased population (Elston 1982; Thomas 1982).

The Maggie Creek Phase (A.D. 700-1300) was accompanied by a vast increase in the intensity and frequency of occupation at James Creek Shelter, including the construction of residential structures such as pits with brush wind breaks and level floors with multiple hearths (Elston and Budy 1990). Absolute numbers of artifacts increased at the site. Local Maggie Creek chert comprised 89% of the debitage, while Tosawihi chert declined to 7% and obsidian nearly disappeared. Large amounts of bison bone occur in Maggie Creek deposits at James Creek Shelter, as does a wide variety of plant remains; these suggest use of the site during several seasons, and the procurement of several different resource sets. Level floors perhaps represent summer foraging base camps, while pits with brush structures may have been used in late fall or winter by hunters. However, construction within the shelter declines in late Maggie Creek times between A.D. 1200 and A.D. 1300. A similar intensification in use of Upper South Fork Shelter occurred during the same time (Spencer et al. 1987); the record there (Heizer et al. 1968) is less clear, however, possibly reflecting a change in target resources rather than a change in intensity of use. Rosegate Series projectile points and Salt Lake Grayware ceramics (Madsen 1986) are diagnostic.

The Eagle Rock Phase (A.D. 1300 through protohistoric times) apparently represents the archaeological record of the Numic speaking Shoshoni peoples who occupied the region at historic contact. Along the Upper Humboldt, the phase is marked by Desert Series projectile points (Desert Side-notched and Cottonwood), and by Shoshone Brownware ceramics (Elston

and Budy 1990). In James Creek Shelter, occupational intensity sufficient to create discrete use areas did not resume until about A.D. 1600. The proportion of local Maggie Creek chert in the debitage falls to its lowest value (61%), while that of Tosawihi chert is highest (32%); obsidian accounts for less than 1%, suggesting a return of toolstone economy similar to that prevailing during the James Creek Phase. A comparable hiatus is suggested at South Fork Shelter by a layer of decomposed pack rat nesting material 18 in. below the surface; all the Desert Series points and Brownware pottery lay either in this layer or above it. Only James Creek Shelter has produced radiocarbon dates in the range of the Eagle Rock Phase; judging by projectile point frequency, the intensity of occupation diminishes throughout the Upper Humboldt during the Eagle Rock Phase.

Cultural Chronology of the Middle Humboldt Region

The cultural chronology of the Middle Humboldt Region is known only from archaeological work at Valmy (Treaty Hill) on the plain of the Humboldt River in Pumpernickel Valley (Davis et al. 1976; Elston et al. 1981; Rusco and Davis 1979), Rossi Mine in the Tuscarora Mountains (Rusco et al. 1982), and the Rock Creek sites in the Sheep Creek Range (Clay and Hemphill 1986). In all these areas, the proportion of Tosawihi chert or opalite in debitage ranges between 70% and 100%. The record of the Middle Humboldt is slender, however, with only four radiocarbon dates; few other data suggest cultural variation over time.

Rusco et al. (1982) investigated five archaeological sites in the Rossi Mine area about 15 km from the Tosawihi Quarries, two of which (26Ek2304 and 26Ek2305) contained temporally diagnostic artifacts. The full range of Archaic point types, Brownware pottery, and pre-Archaic Great Basin Stemmed Series points were recovered from 26Ek2304; a hearth at this site yielded a radiocarbon date of A.D. 1480. In contrast, 26Ek2305 produced only Late Archaic Rosegate and Desert Series points. Assemblages from all the Rossi Mine sites are similar (considering sample size), including bifaces, cores, flaked stone, and ground stone tools; the faunal assemblage from 26Ek2304 includes antelope and bison.

Archaeological study of the Rock Creek sites, located between 50 and 30 km from the Tosawihi Quarries, involved limited surface collections and testing (Clay and Hemphill 1986). The Rock Creek sites produced the full range of Archaic projectile points with the exception of the poorly diagnostic Large Side-Notched type; in addition, Brownware pottery was recovered from 26La1950. The projectile point sample at each site, however, consists of fewer than ten items. Three radiocarbon dates were obtained from Rock Creek; the earliest (from 26La1902) is A.D. 1770 (Figure 208).

Studies conducted during evaluation of power plant siting at Valmy (Davis et al. 1976; Elston et al. 1981; Rusco and Davis 1979) involved survey of over two sq mi. and the recording of 79 archaeological sites, ranging from isolated finds to large scatters of artifacts. These were interpreted variously as Archaic long term (winter) residential base camps, short term seed gathering and processing camps as well as ambush and processing sites for large game, and short term hunting and game processing locations. In addition, several sites contain isolated artifacts or small assemblages of Pre-Archaic Great Basin Stemmed points (and in one case, a crescent), as well as a couple of Great Basin Concave Base points. No radiocarbon dates were recovered from any sites in the Valmy area.

The question of the age of the Humboldt Series is of importance at Valmy; they account for 61% of the total Valmy projectile point assemblage (Table 196). On the basis of the chronological range for Humboldt points given by Heizer and Hester (1973), and in the absence of radiocarbon dates, there seems to be evidence for a mid-Holocene intensification in use of the Valmy area between 4000 B.C. and 1000 B.C. (Davis et al. 1976; Rusco and Davis 1979; Elston et. al 1981). If Thomas (1981) is correct in his assessment of the performance of the

Humboldt Series as time markers, their presence at Valmy is just noise. If, on the other hand, Humboldt points in this context are coeval with Gatecliff points (as they are in Hidden Cave) and in upland intercept hunting sites in Monitor Valley (cf. Thomas 1985, 1988), their abundance in the Valmy area suggests greatly intensified use of the marshy Humboldt River flood plain in the Early Archaic, coincident with the late No Name Phase and South Fork phases of the Upper Humboldt. Calculating the average loss rate for Humboldt points (series duration divided by number of points) further elucidates the Early Archaic intensification in the Middle Humboldt region; assuming that the 3700 year range for the Humboldt Series is correct (Thomas 1981), the points were dropped at an average rate of one every 77.08 years, while loss rates for pre-Archaic and later Archaic types range from one/285 years (Stemmed Series) to one/200 years (Desert Series). However, since this plethora of Humboldt points is unparalleled elsewhere, and is unsupported by radiocarbon dates, interpretation is difficult.

Even if Humboldt points are removed from consideration, Table 196 still suggests anomalous (compared to the Upper Humboldt) variation in the intensity of use of the Valmy area throughout prehistory. For one thing, there are as many Great Basin Stemmed points as there are Gatecliff points. For another, post-Elko (James Creek Phase) projectile point frequencies decrease. We must conclude with the old saw that additional work is needed in Pumpernickel Valley and elsewhere on the Middle Humboldt in order to clarify chronological ambiguities.

Table 196. Frequencies of Projectile Points by Series at Valmy

Series	N	%
Desert	3	4
Rosegate	2	3
Elko	9	11
Gatecliff/Pinto	7	9
Humboldt	48	61
Large Side-notched	3	4
Stemmed	7	9
Total	79	

Cultural Chronology at Tosawihi Quarries and Vicinity

Chronological data from the Tosawihi Quarries and sites on Ivanhoe Creek and Willow Creek is provided by radiocarbon dates, time-diagnostic artifacts, and, in some places, the presence of Mazama tephra (Figure 208). Obsidian hydration measurements provide independent dating.

Radiocarbon Dates

Radiocarbon dates were presented by site in Chapters 16-18; here (Table 197) they are grouped by project area. While such dates are relatively abundant at Tosawihi compared to other archaeological study areas in the region; they were obtained from relatively few sites, most of them from quarry pit features with complex stratigraphy where inverted dates are common. Plotted in chronological (not stratigraphic) order by area in Figure 209, these dates form convincing patterns that should be viewed with a certain caution. Nevertheless, the reality of these patterns, as we shall see, is supported by other, independent chronological indicators.

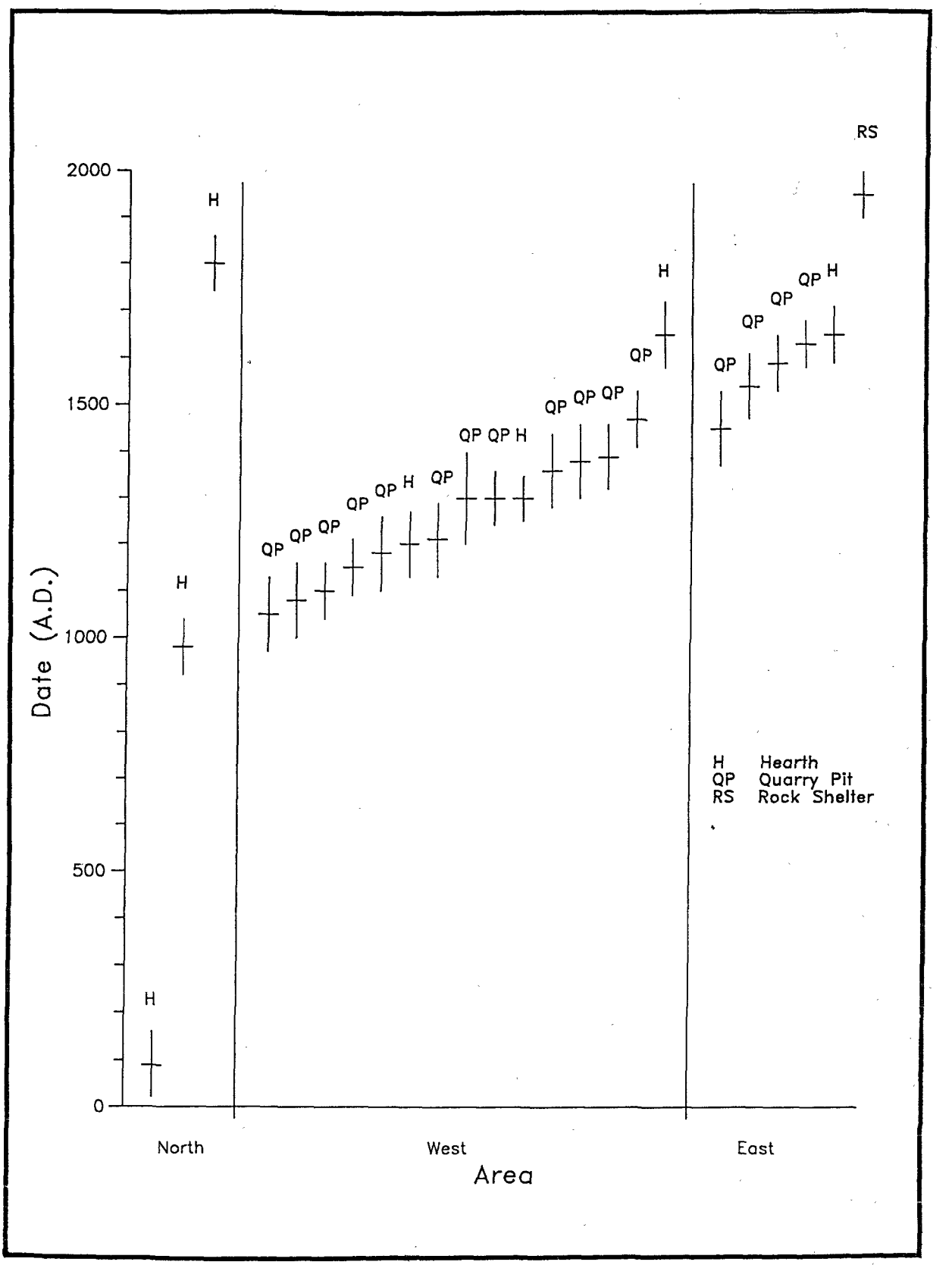


Figure 209. Radiocarbon dates for Tosawihi and vicinity.

Three dates from the Northern Corridor (all from 26Ek3237) are spread evenly over the past 2,000 years or so, as are the dates from open sites at Carlin depicted in Figure 208. Dates from the Western Periphery, however, cluster around a mean of A.D. 1275±162. There are only six radiocarbon dates from the Eastern Periphery and, with the exception of the anomalous date of A.D. 1950 from rockshelter 26Ek3204, these dates also cluster, with a mean of A.D. 1553±78. These data suggest intensive quarrying at Western Periphery site 26Ek3208, and associated hearth building at near-by residential and processing sites, over the period A.D.1050-1650. In contrast, radiocarbon dates associated with quarrying and hearth building in the Eastern Periphery fall within a 200 year period between A.D. 1450 and 1650.

Table 197. Radiocarbon Dates From Tosawihi Quarries and Vicinity

Study Area	Site Number	Reference Number	Laboratory Number	Feature Type	Date (Radiocarbon Years B.P.)	Date
Northern Corridor	26Ek3237	2141	Beta-28314	Hearth	150±60	A.D. 1800
	26Ek3237	8802-4	Beta-36993	Hearth	970±60	A.D. 980
	26Ek3237	8845-1	Beta-36994	Hearth	1860±70	A.D. 90
Western Periphery	26Ek3092	8584-5	Beta-36976	Hearth	750±70	A.D. 1200
	26Ek3092	8645-1	Beta-36977	Hearth	650±50	A.D. 1300
	26Ek3106	2021-1	Beta-26827	Hearth	300±70	A.D. 1650
	26Ek3208	2500-2	Beta-26754	Quarry Pit	800±60	A.D. 1150
	26Ek3208	2500-4	Beta-26755	Quarry Pit	650±60	A.D. 1300
	26Ek3208	2599-15	Beta-36383	Quarry Pit	900±80	A.D. 1050
	26Ek3208	2599-21	Beta-36984	Quarry Pit	870±80	A.D. 1080
	26Ek3208	2599-22	Beta-36985	Quarry Pit	650±100	A.D. 1300
	26Ek3208	2599-23	Beta-36986	Quarry Pit	570±80	A.D. 1380
	26Ek3208	2599-24	Beta-36987	Quarry Pit	480±60	A.D. 1470
	26Ek3208	2599-25	Beta-36988	Quarry Pit	840±60	A.D. 1100
	26Ek3208	2599-28	Beta-36989	Quarry Pit	560±70	A.D. 1390
	26Ek3208	2599-31	Beta-36990	Quarry Pit	770±80	A.D. 1180
	26Ek3208	2599-33	Beta-36991	Quarry Pit	740±80	A.D. 1210
	26Ek3208	2599-36	Beta-36992	Quarry Pit	590±80	A.D. 1360
Eastern Periphery	26Ek3171	2599-5	Beta-36978	Quarry Pit	410±70	A.D. 1540
	26Ek3195	2599-129	Beta-36979	Quarry Pit	320±50	A.D. 1630
	26Ek3195	2599-130	Beta-36980	Quarry Pit	500±80	A.D. 1450
	26Ek3195	2599-131	Beta-36981	Quarry Pit	360±60	A.D. 1590
	26Ek3204	2003-13	Beta-26828	Rockshelter	40±50	A.D. 1950
	26Ek3198	8462-6	Beta-36982	Hearth	300±60	A.D. 1650

Ceramics

Pottery was found at nine sites. All Grayware discovered so far is Salt Lake Gray, thought to date between A.D. 700 and A.D. 1300; Shoshone Brownware is dated less securely, but probably ranges between A.D. 1300 and about A.D. 1850 (Madsen 1986). Unclassifiable sherds are assumed to range somewhere between A.D. 500 to historic times. The time ranges represented by ceramics at Tosawihi are graphed in Figure 210. The number of sites with pottery in each study area is small, but more sites in the Eastern Periphery contain pottery than in the north or west, and a higher proportion of eastern sites contain only the relatively late Brownware.

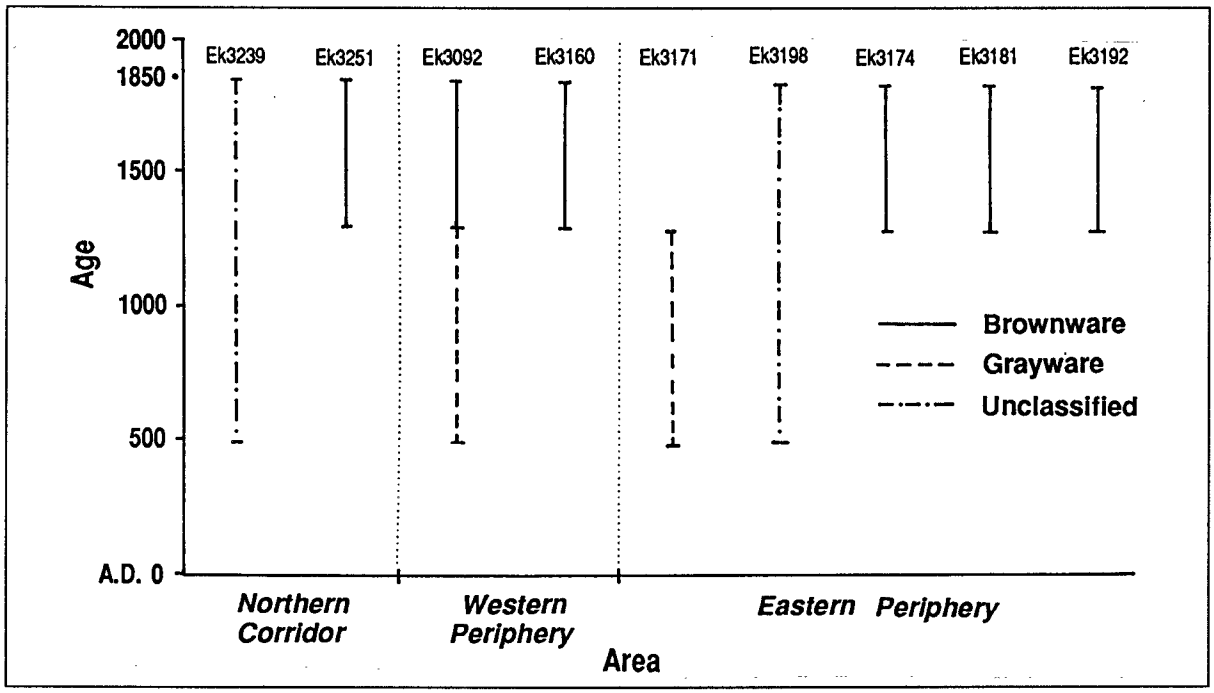


Figure 210. Chronological ranges of ceramics at Tosawihi and vicinity.

Projectile Points

The full chronological range of Great Basin projectile points has been observed in sites at Tosawihi and vicinity. The occurrence of a Clovis point preform fragment at 26Ek3237 suggests that people were in the Tosawihi uplands during the Pleistocene-Holocene transition as early as 10,000 B.C.; Great Basin Stemmed Series, Gatecliff Series, Elko Series, Rosegate Series, and Desert Series points document the presence of prehistoric hunters and gatherers at Tosawihi throughout the Holocene, including the Pre-Archaic - Archaic transition, and all the stages of the Archaic (cf. Figure 208).

Projectile points are numerous and their distribution reveals several patterns suggesting changing use of the Tosawihi landscape through time. Arranged in chronological order and plotted by cumulative frequencies, each assemblage exhibits a characteristic "temporal curve" (Thomas 1983b; 1988). Projectile point loss-discard rates may be influenced by variation in technology, lithic terrane, site function, frequency of occupation, and other factors; heuristically, the curves allow the graphic observation and comparison of this variability. Differing rates among areas or time periods in the same site may signal functional, technological, and spatial variability that can be investigated further.

Figure 211 shows the cumulative frequency curve of projectile points in the Tosawihi assemblage compared with similar ogives from various other upland assemblages in central and northeastern Nevada. In the Tosawihi curve, frequencies of points increase steadily through time, but the rate of increase is greater for Elko Series points with the greatest gain exhibited by Desert Series types. This produces a J-shaped curve, concave to the left. In contrast, point frequency curves for upland sites suggest the greatest increase in frequencies for the Elko Series, and lower frequencies among Late Archaic point series (Rosegate and Desert); thus, the non-Tosawihi curves are all S-shaped.

Thomas (1988) has observed that cumulative ogives sometimes suggest statistically insignificant similarities or differences among frequency distributions. These differences may be

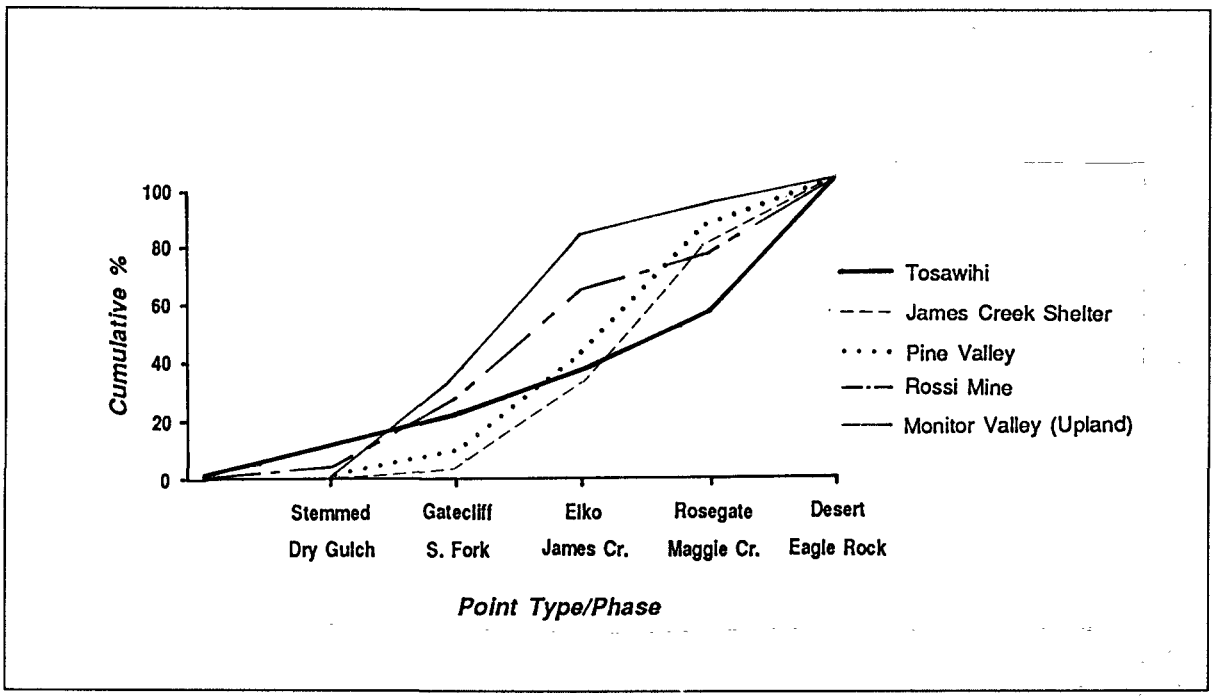


Figure 211. Cumulative frequency curve of Tosawihi assemblage and other upland assemblages.

assessed more adequately by employing the Kolmogorov-Smirnov (KS) two-sample test (Blalock 1979), wherein frequency distributions are considered significantly different only if observed differences in cumulative frequencies exceed a predetermined critical value at the 0.05 level. Table 198 shows that the critical values are exceeded in all cases; thus, we conclude that the Tosawihi distribution is distinctly different from other upland distributions.

Table 198. Maximum Observed and Critical Values Between Tosawihi and Upland Profiles.

	Sample Size n1	n1	Critical Value (0.05)	Max. Observed Value
Tosawihi/Rossi Mine	191	41	.230	.263
Tosawihi/Pine Valley	191	80	.181	.299
Tosawihi/James Creek	191	80	.181	.238
Tosawihi/Monitor Upland	191	62	.199	.451

The temporal curves for each Tosawihi geographic study area are plotted in Figure 212. The curve for the Tosawihi Quarries is most unique. The Northern Corridor and Western Periphery appear similar, while curves for the quarries and the Eastern Periphery contrast the most. Point frequencies in the Northern Corridor and Western Periphery uniformly increase through time, describing a nearly flat line in the case of the North and a slightly J-shaped line for the West. Frequencies in the Eastern Periphery are relatively low through the Rosegate Series, and increase sharply for Desert Series points, producing an even more strongly J-shaped curve. Conversely, the profile for the Tosawihi Quarries exhibits a high frequency of early Great Basin Stemmed Series points, with decreasing trends thereafter, producing a C-shaped curve. A KS test of frequency distributions (Table 199) confirms the statistical significance of the graphic differences among these curves at the 0.05 level. Only the Western Periphery and Northern Corridor distributions and the curves they describe could have been drawn from the same population.

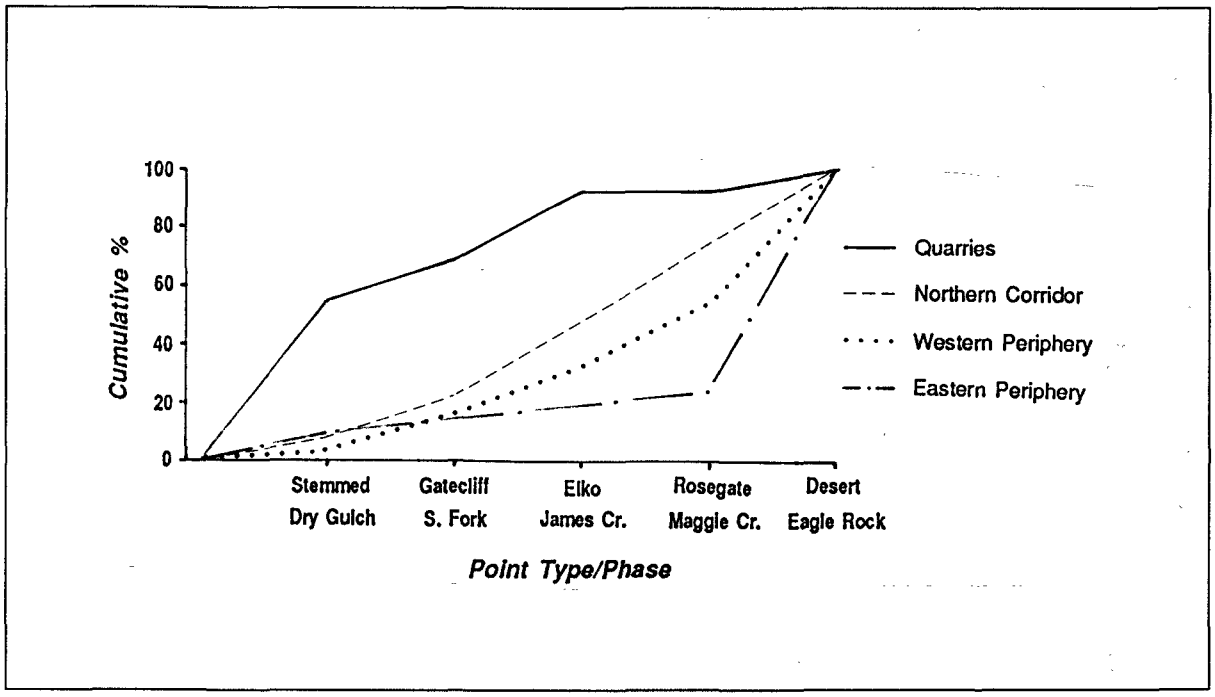


Figure 212. Cumulative frequencies of Tosawihi point assemblage by study area.

Table 199. Maximum Observed and Critical Values Between Tosawihi Geographic Area Profiles.

	Sample Size n1	n1	Critical Value (0.05)	Max. Observed Value
East/West	40	95	.256	.290
East/North	40	43	.299	.500
East/Quarry	40	13	.434	.720
West/North	95	43	.250	.210
West/Quarry	95	13	.402	.600
Quarry/North	13	43	.430	.460

Since the Northern Corridor sites are most distant from the quarry proper, we might expect projectile point frequencies to be somewhat similar to non-Tosawihi upland assemblages, and, in fact, Northern Corridor frequencies are not significantly different from the frequency curves of the pooled upland point assemblage. This probably is due to the relative flatness of both the upland and Northern Corridor curves. The more variable frequency distributions of the three project areas are significantly different, however, from the pooled upland assemblages.

Details of the differences between projectile point curves for different project areas at Tosawihi are illuminated by plots of projectile points across the landscape and by frequency seriation. Figure 213 plots total projectile point frequency by site. It is apparent that many sites are limited to the occurrence of a single point, and that certain sites contain more points than others. Frequency seriation by site presented in Figure 214 reveals that the sites in which projectile points are most abundant have sustained recurring occupation from the Early Archaic (and in the case of 26Ek3237, from the Pre-Archaic). Such sites all lie in the Western Periphery and Northern Corridor. Although some sites in the Eastern Periphery have small accumulations of projectile points, they never are as large as those in the West; moreover, 60% of all points in the Eastern Periphery assemblage are of the Late Archaic Desert Series. The

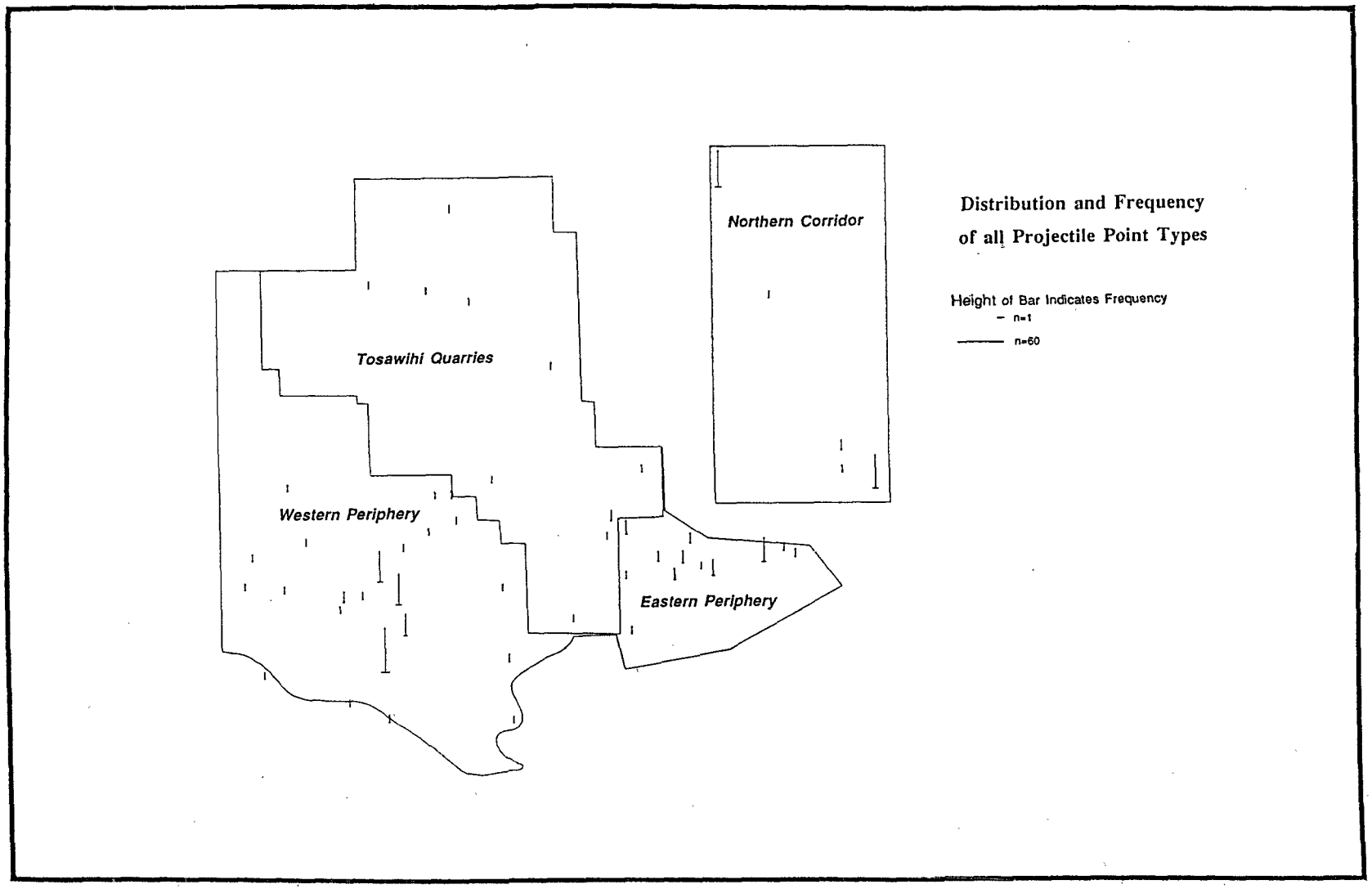


Figure 213. Distribution and frequency of all projectile point types.

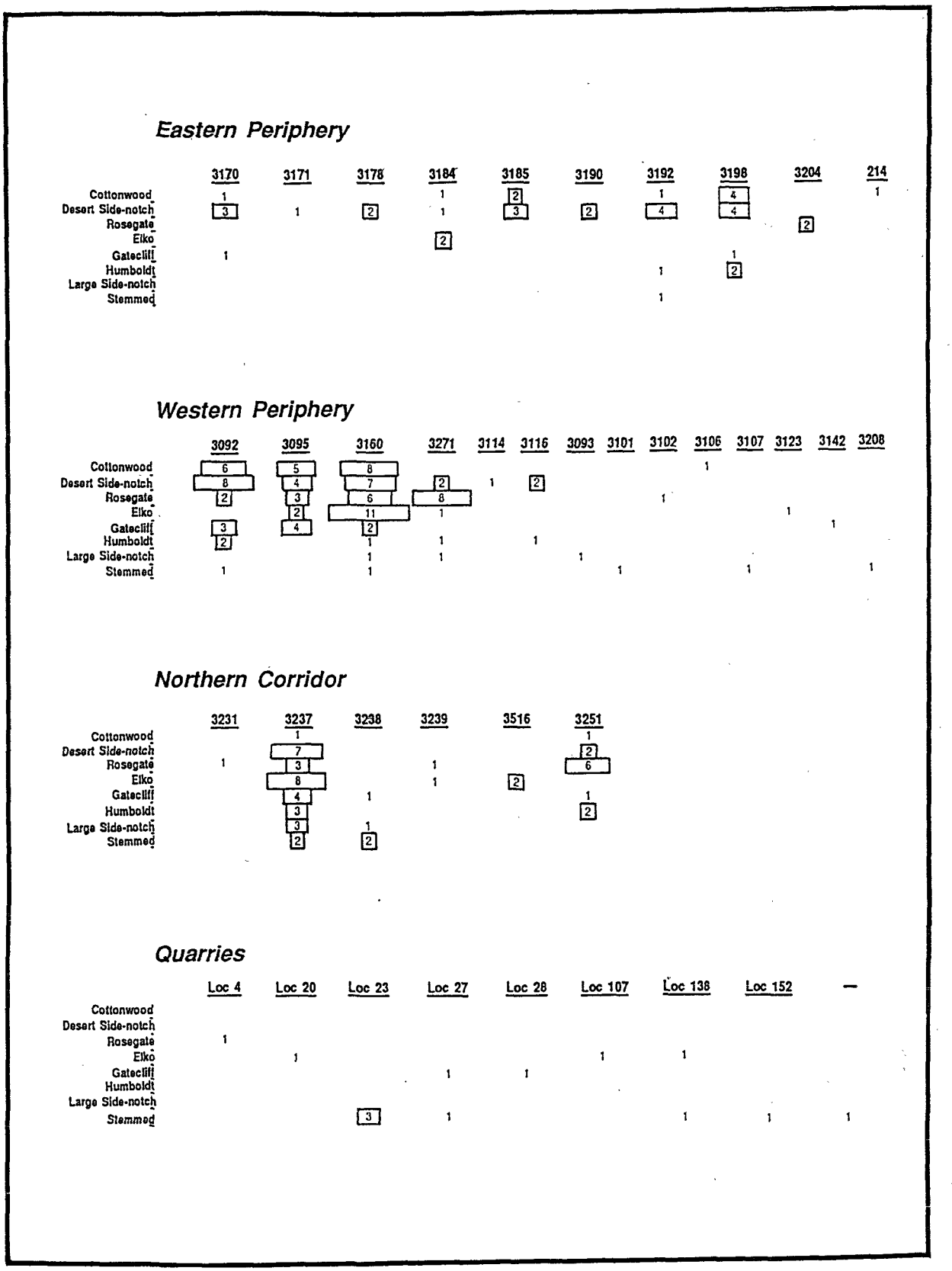


Figure 214. Frequency seriation of Tosawihi projectile points.

Tosawihi Quarries (26Ek3032) exhibit yet a different pattern, with one small accumulation at Locality 23 and only isolated points elsewhere. In the Quarries, only one projectile point is Late Archaic; all others are Middle Archaic to Pre-Archaic.

As shown in the rose diagram of Figure 215, the contrast is striking between the distribution of Pre-Archaic and Early Archaic points on the one hand, and Middle to Late Archaic points on the other. The former are scattered across the landscape as if particular location were unimportant. By the middle Archaic, however, certain places begin to be favored for occupation and are used over and over again. In the very Late Archaic, the same sites are used as in the Middle Archaic, but projectile points begin to accumulate at new places in the Eastern Periphery, an area heretofore visited infrequently.

Average loss rates reiterate the Late Archaic intensification at Tosawihi (Table 200); they are consistently higher in the Western Periphery than in other areas, a pattern most likely linked to continued reoccupation and subsequent retooling at a few favored "residential" localities in that area. While raw frequencies suggest that the Eastern Periphery was the focus of activity during the final phase of the Late Archaic, loss rates suggest concurrent intensification of activity in the West. For Tosawihi as whole, Late Archaic types are deposited at rates nearly three times higher than their Middle and Early Archaic counterparts.

Table 200. Average Loss Rates for the Tosawihi Projectile Point Assemblage.

	Duration	North		West		East		Quarry	
	years	n	rate	n	rate	n	rate	n	rate
Desert	600	11	54.55	44	13.63	30	20.00	1	600.00
Rosegate	600	11	54.55	20	30.00	2	300.00	-	
Elko	2000	11	181.82	15	133.33	2	1000.00	3	1000.00
Gatecliff	1700	6	283.33	10	170.00	2	850.00	2	850.00
Humboldt	3700	5	740.00	5	740.00	3	1233.00	-	
LSN	6300	6	1050.00	3	2100.00	-	-		
Stemmed	2000	4	500.00	5	400.00	4	400.00	7	285.71

It is this Late Archaic increase in projectile point frequencies that gives Tosawihi its unique temporal signature; it may imply changes in mobility and procurement strategies, and probably reflects an intensification of quarrying activity. Something of this sort is suggested by the distribution of projectile point series in feature and non-feature contexts (Table 201). The tendency for Desert Series points to be located within discrete features appears to be directly related to the tendency for Middle Archaic, Early Archaic, and Pre-Archaic points (Elko, Gatecliff, and GBSS) to be found in non-feature contexts. This suggests several possibilities. One is that the creation of discrete features was less frequent in earlier times than later. In turn, fewer features might indicate fewer visits, shorter time of residence, or less intensive processing of toolstone (most discrete features are concentrations of debitage), or a combination of all three. On the other hand, geological and taphonomic processes may have biased the archaeological record in favor of late features by progressive deterioration. These possibilities are examined further in Chapter 22.

Table 201. Proportions of Projectile Points by Series in Feature and Non-Feature Contexts.

	FEATURE			NON-FEATURE		
Series	N	Col %	Row %	N	Col %	Row %
Desert	55	64.0	64.0	31	29.5	36.1
Rosegate	15	17.4	44.1	19	18.1	55.9
Elko	7	8.1	22.6	24	22.9	77.4
Gatecliff	4	4.7	20.0	16	15.2	80.0
Stemmed	5	5.8	25.0	15	14.3	75.0
Total	86			105		

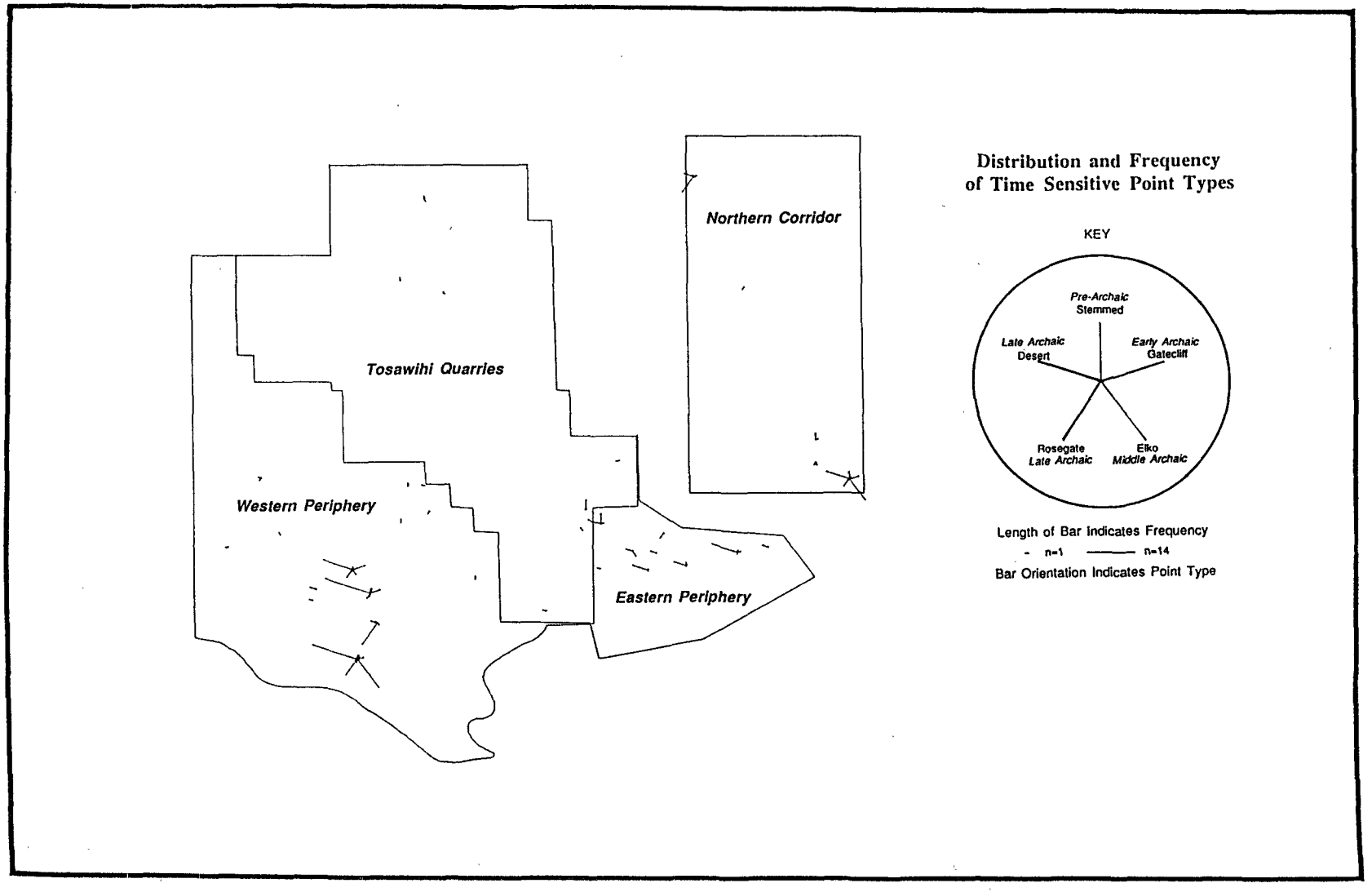


Figure 215. Distribution and frequency of time sensitive point types.

Obsidian Sourcing and Hydration

Chemical composition and source identification is a necessary precursor to obsidian hydration analysis because glass chemistry varies from source to source, and hydration rates vary with glass chemistry. In addition, the distance and direction to source informs on such problems as overall mobility and trade. One hundred forty-seven obsidian artifacts from Tosawihi and vicinity were subjected to nondestructive energy dispersive X-Ray florescence analysis (Appendix N) in order to determine their chemical composition. The composition of specimens then was matched to reference specimens from known sources.

Each of the 147 specimens sourced by X-ray florescence subsequently was subjected to hydration analysis (Appendix M). Most specimens were cut only once, but six sustained additional cuts in order to check for multiple or variable hydration rinds that might suggest scavenging and reuse. Hydration rims were absent from eight artifacts, however, so the total number of hydration values (153) differs from the total number of obsidian artifacts observed.

X-Ray florescence studies reveal 14 to 16 sources of obsidian used at Tosawihi Quarries (Table 202 and Appendix N). The identification of the Fox Mountain source is less than certain and four specimens may have come from either Double H Mountains or Pinto Peak. Several sources of unknown location have been identified in previous studies (Unknown A-F), and nine specimens derived from a previously unrecognized source of unknown location. Six of the known sources (Bordwell Spring, Fox Mountain, Double H Mountains, Majuba Mountain, Pinto Peak, and Paradise Valley) lie to the west (Figure 216). Three others (Brown's Bench, Malad, and Timber Butte) lie to the north. The Paradise Valley source, located some 90 km northwest, provided nearly half of all sourced obsidian from Tosawihi.

Box plots of hydration values by source are given in Figure 217; Table 202 presents hydration value statistics. Obsidian from the Brown's Bench source exhibits the widest range of values, followed by Paradise Valley, the unrecognized source, Pinto Peak, and Unknown D.

Table 202. Mean Obsidian Hydration Values by Source.

Source	n	%	No. of Readings	Missing Rinds	Mean Hydration Thickness	Standard Deviation
Browns Bench	37	25.34	38	4	3.338	2.431
Bordwell Spring	1	.68	1	-	4.200	-
Fox Mountain	1	.68	1	-	2.600	-
Double H Mountain	1	.68	1	-	3.500	-
Malad, Idaho	3	2.05	3	-	1.733	.155
Majuba Mountain	1	.68	1	1	-	-
Pinto Peak/Double H Mtn.	4	2.74	4	-	3.000	2.166
Paradise Valley	71	48.63	74	1	3.403	2.056
Timber Butte, Idaho	1	.68	1	-	1.500	-
Unrecognized Source	9	6.16	12	-	3.317	2.091
Unknown A	4	2.74	4	-	1.325	.0287
Unknown B	2	1.37	1	1	4.800	-
Unknown C	2	1.37	2	1	1.100	-
Unknown D	6	4.11	6	-	1.450	-
Unknown E	1	.68	1	-	7.500	-
Unknown F	2	1.37	2	-	1.700	-
	146	100.00	152	8		

Arranging hydration values of Paradise Valley obsidian (for which sample size is sufficient) by projectile point series in chronological order shows values to vary systematically

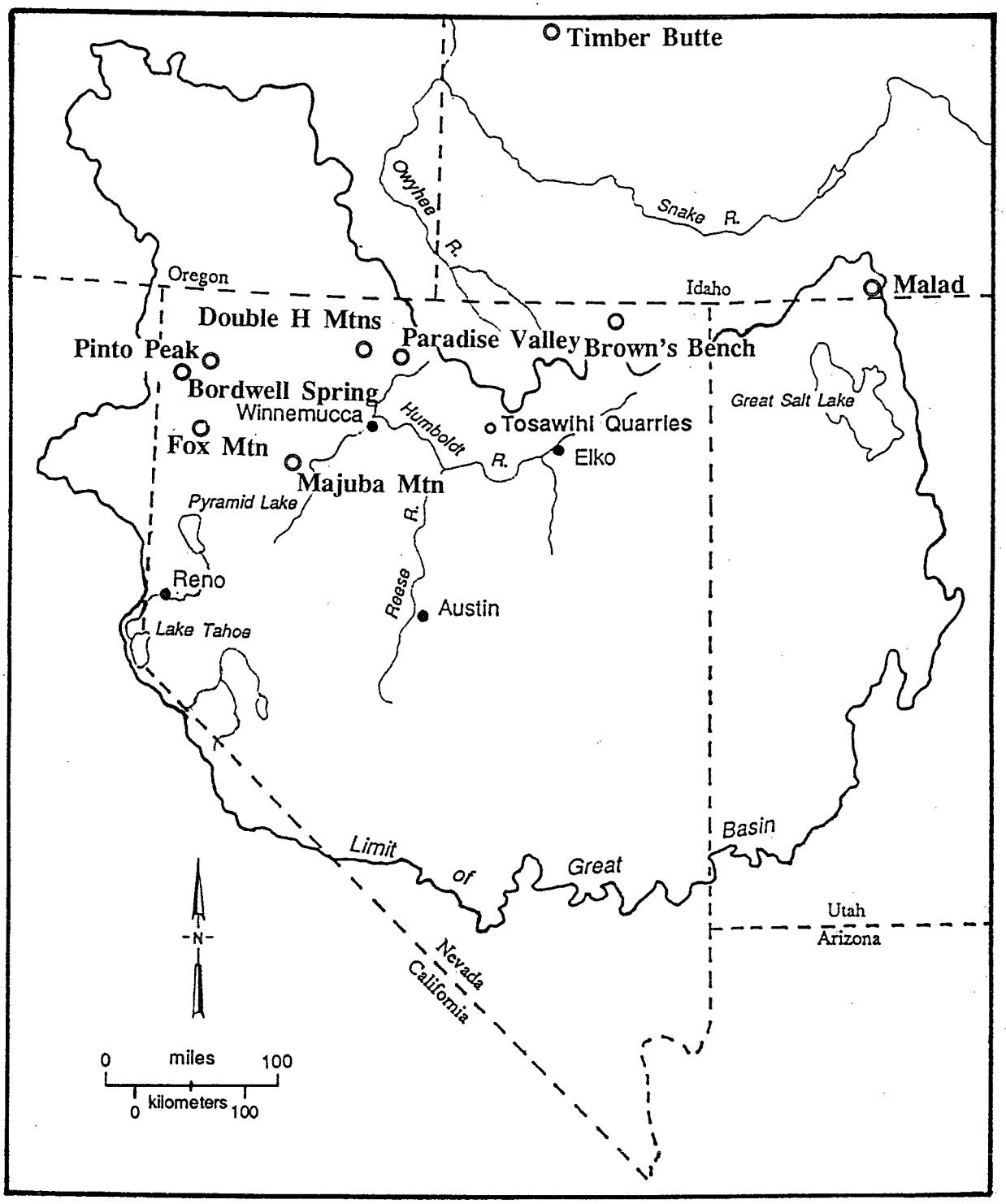


Figure 216. Obsidian source locations.

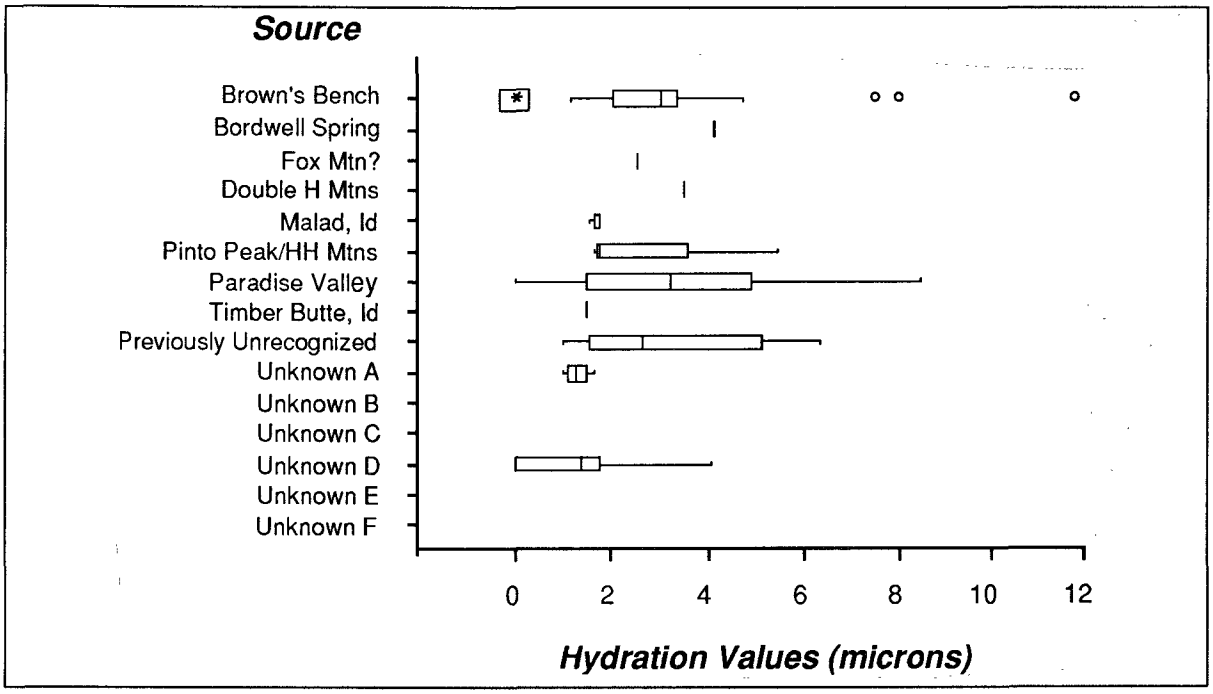


Figure 217. Mean hydration values by source.

as expected (Figure 218a), although there is considerable overlap between series. The very large spread for Large Side Notched, although only based on three values, is as expected for this poorly time sensitive series. The very large value for the single Humboldt Series point is greater than expected but not interpretable with only a single datum. The larger than expected outliers for Cottonwood points in the Desert Series, as well as Rosegate, Elko, and Gatecliff Series suggest the possibility that some points were misclassified. For example, a few specimens keyed as Cottonwood points may actually be Rosegate preforms. Similarly, some of the Rosegate points may have been reworked from older points, and extreme measurement from an Elko point was taken from a re-worked margin.

The box plots in Figure 218a-b show these relationships in a different way. The much greater range of hydration values for artifacts classified as Cottonwood points is clear for the Paradise Valley and Brown's Bench sources. The box plots and the simple plot of values from various other sources (Figure 218c) suggest a generally late range for artifacts morphologically outside the parameters of the Thomas (1981) key, and a large range of values for points unclassifiable due to fragmentation. Together, these suggest that the Paradise Valley source was used more or less throughout prehistory, while use of the remaining sources was restricted to the Late Archaic and Pre-Archaic. Figure 218b does not reflect two Great Basin Stemmed points made of Brown's Bench obsidian on which hydration rinds could not be observed; the distribution of Brown's Bench obsidian thus appears to be part of a larger pattern in which there is greater variability in obsidian sources during Pre-Archaic and Late Archaic times. It is interesting to note that Brown's Bench obsidian was present throughout the record at James Creek Shelter (Hughes 1990), although Paradise Valley obsidian always was more abundant.

As touched on previously, there are two common explanations for increased variability in toolstone sources. One involves greater mobility which makes more sources accessible to individuals; the larger number of Pre-Archaic sources thus fits well with our interpretation of a highly mobile Pre-Archaic subsistence and settlement strategy. The other explanation involves trade and redistribution in a less mobile settlement pattern, such as we have proposed for the Late Archaic; this fits with the Middle Archaic collector - Late Archaic traveller pattern proposed by Bettinger and Baumhoff (1982). Of course, confirmation of this will require additional sourcing and hydration data from sites outside Tosawihi.

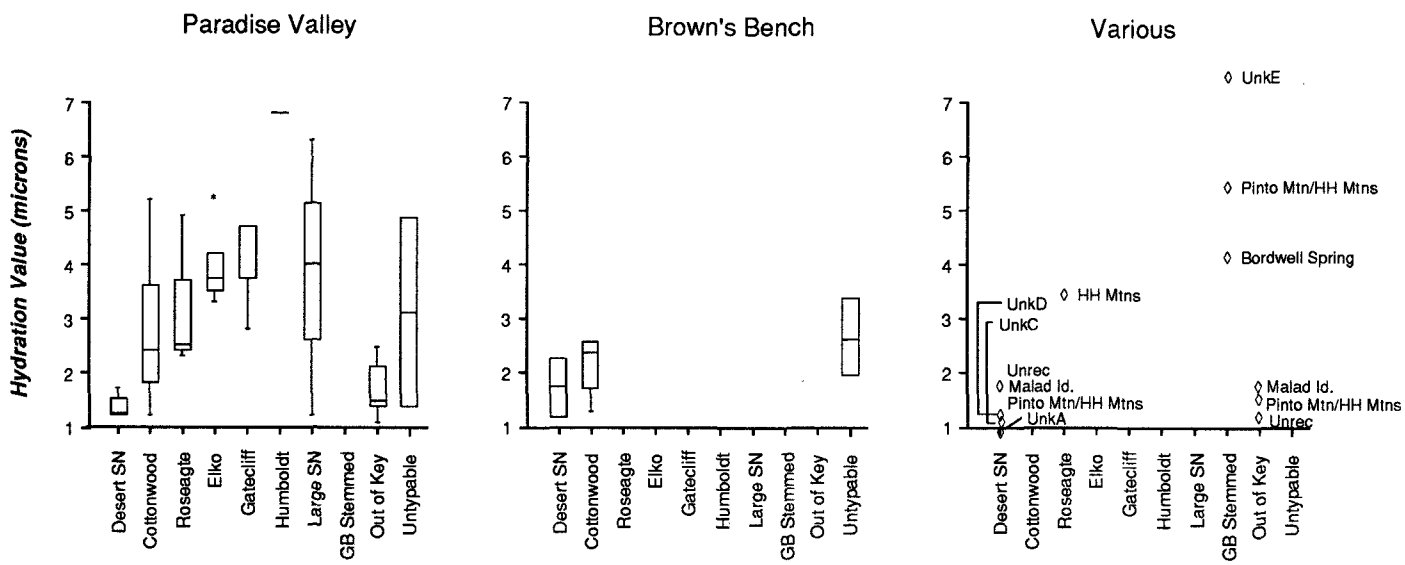


Figure 218. Mean hydration values by source and projectile point type.

Although the distribution of projectile points suggests a strong temporal contrast between feature and non-feature contexts, the relationship is expressed less robustly by the obsidian hydration data. The mean hydration values for all obsidian artifacts are given by source in Table 203. Although the mean hydration values for non-feature obsidian are greater in each case, the t-test shows no significant differences at the 0.05 level.

Table 203. Mean Obsidian Hydration Values by Source, Feature and Non-Feature Contexts.

	FEATURE			NON-FEATURE		
Source	n	Mean	SD	n	Mean	SD
Brown's Bench	20	3.29	1.76	6	3.50	4.21
Paradise Valley	30	3.20	2.10	38	3.55	2.04
All	73	2.90	1.95	62	3.50	2.24

Box plots of obsidian hydration values for major tool categories by source are presented in Figure 219. These plots show that the range of values for small bifaces and debitage is similar to the range for projectile points. This suggests that some small obsidian bifaces have considerable antiquity, and, in fact, may be fragments of preforms for GBSS points. In addition, obsidian debitage has been produced over a long period. Were subsequent research to establish absolute hydration rates for different sources, obsidian debitage could become a useful temporal marker for the region.

Tephrochronology

Mazama ash is present in deposits exposed in Willow Creek at 26Ek3251, and on Ivanhoe Creek just upstream of 26Ek3237 (Elston, ed. 1989), but not in any sites in the Eastern and Western Peripheries. The chances are, therefore, that all sites described in this report are younger than 7,000 B.P., since Mazama ash is either far below cultural deposits, if present, or is absent altogether. For a while, we thought that Mazama ash was absent from the vicinity of the Quarries, perhaps scoured away during the mid-Holocene. In the summer of 1989, however, we observed the ash in colluvium cut by an ephemeral stream at the southern base of Big Butte and in colluvial deposits at the north end of Velvet Canyon. Artifacts are present below Mazama ash in alluvial and colluvial sediments recently exposed during testing of Localities 26 and 27 in 26Ek3032 (Leach and Botkin 1991). The presence of Mazama ash in the Tosawihi uplands will allow correlations with other Mazama localities in the Upper Humboldt region, including Valmy on the Humboldt River (Elston et al. 1981), in the James Creek drainage (Elston and Budy 1990), at Upper South Fork Shelter (Spencer et al. 1987) and on Mahala Creek in North Fork Valley (Madsen 1985).

Summary and Conclusions

Compared to adjacent regions, the temporal record for Tosawihi is complete, but it suffers similar chronological ambiguities for the Pre-Archaic and Early Archaic, lacking reliably dated, buried cultural deposits or absolute hydration rates for the major obsidian sources that could be applied to surface materials. The number of radiocarbon dates is relatively large, but they are concentrated in the Late Archaic and subject to the caveats discussed above.

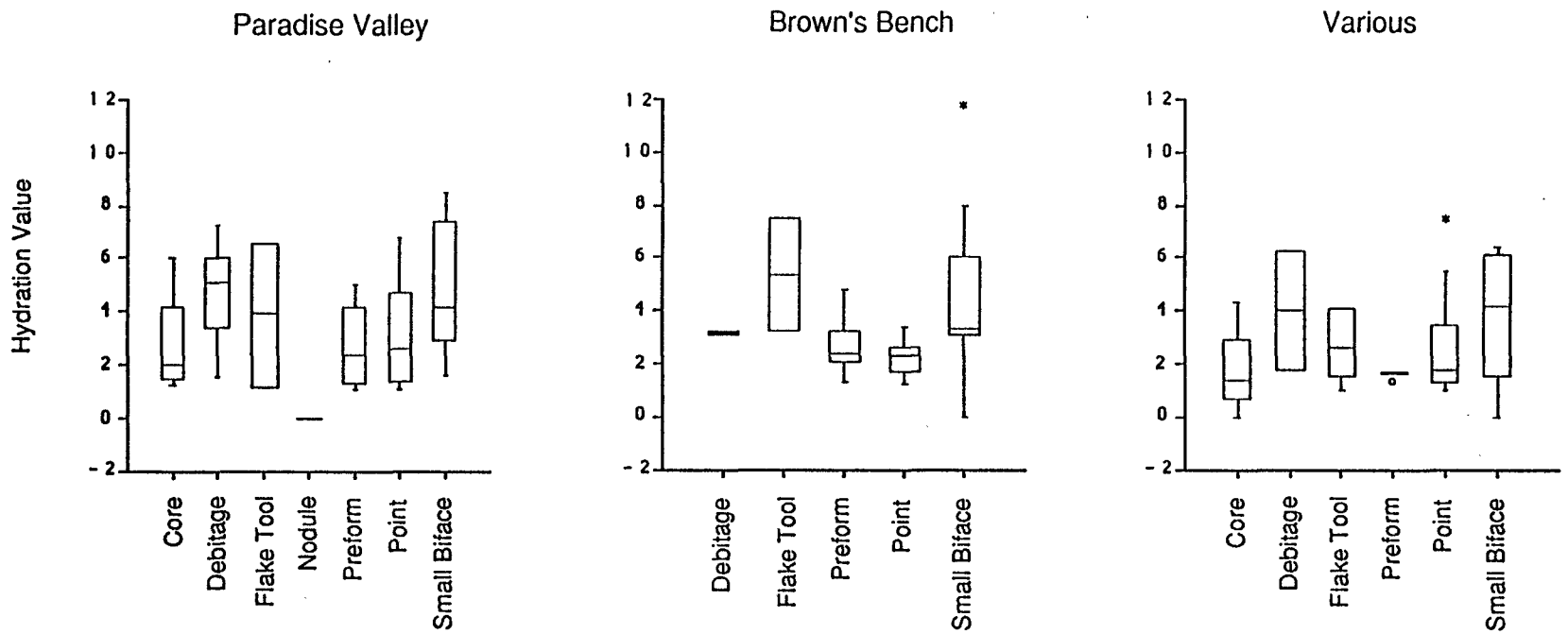


Figure 219. Mean hydration values and sources for major tool categories.

The Middle Humboldt chronology remains too ambiguous for meaningful comparisons with Tosawihi, but matching Tosawihi and the Upper Humboldt provides some interesting contrasts. In the Upper Humboldt, sites are occupied intermittently and for short periods, from earliest times through most of the Middle Archaic James Creek Phase. At James Creek Shelter and the South Fork shelters, intensity of occupation began to increase during the late James Creek Phase, accelerated in the Late Archaic Maggie Creek Phase, then abruptly fell off in the Eagle Rock Phase. Similar trends are observed elsewhere in the region. An analogous pattern of short term, intermittent use, not tied to a particular place, is seen at Tosawihi through the Pre-Archaic, although the "sweet spot" of 26Ek3237 was used regularly from earliest times. The relatively large number of obsidian sources suggests high mobility and large annual range. In the Early Archaic, a few sites in the Western Periphery (26EK3092, 26Ek3095, and 26Ek3160) were visited frequently enough for artifacts to accumulate, a trend that increased throughout the remainder of the sequence. At the same time, the number of obsidian sources shrinks to one, at Paradise Valley, 90 km west. This could have resulted from lower mobility and contraction of annual range. In the latter part of the Late Archaic, congruent with the Eagle Rock Phase of the Upper Humboldt, favored sites at Tosawihi continued to be occupied together with new sites in the Eastern Periphery, while quarrying appears to have intensified. These trends were accompanied by an increase in the number of obsidian sources to nine. One possible explanation is that further increases in population, still lower mobility, and yet smaller annual range made trade in lithics increasingly important, along with use of smaller, perhaps lower-quality sources that previously were ignored.

While it looks as if something very different is going on at the Tosawihi Quarries during the Late Archaic compared to other areas in the Middle and Upper Humboldt regions, events in both areas are likely connected, parts of system-wide changes that we presently do not see clearly. It is safe to say that people have visited Tosawihi Quarries from the earliest prehistoric times, and that the archaeological record there probably spans 10,000 years. The distributions of time sensitive artifacts, obsidian hydration values, and radiocarbon dates suggest differences in the way people used Tosawihi through time.

Chapter 20

SUBSISTENCE

Dave N. Schmitt, Eric Ingbar, and Christopher Raven

We proposed in Chapter 2 that the Tosawihi countryside was neither homogenous nor very generous in the resources it offered prehistoric foragers. Toolstone was its chief immutable attraction over most of the millennia it was visited, and to get that and bring it home in usable packages, aboriginal groups had to calculate with fairly nice precision how to feed themselves during quarrying ventures. In the present chapter we look at some of the exigencies of making a living at Tosawihi, paying particular attention to the roster of locally available foodstuffs, the energetic implications of exploiting them, and the slender archaeological evidence for any of them ever actually having come into play. Our intent is to synthesize current understanding of basic subsistence strategies at the quarries, in the interest of informing later discussions (Chapter 28) about the role they may have played in economic decision-making.

First, we identify categorically what we believe to have been the principal subsistence opportunities available to prehistoric visitors to the quarries, addressing, where we control the necessary data, both spatial and seasonal incongruities in the distribution of resources. Next, we attempt to relate the resource landscape to the specific foraging values of individual classes of species within it, relying on empirical generalizations and a few assumptions drawn from optimal foraging theory; our intent here is to sketch the determinants of a feasible diet breadth for Tosawihi foragers, to evaluate local foodstuffs in light of some of the forfeitures of other opportunities that visits to the uplands must have entailed, and to anticipate what the archaeological record should look like if our assumptions are correct. Too, we confront some of the ways in which critical elements of the effective foraging environment may have changed over the hundred centuries of the Holocene.

Subsequent discussions relate how the things we have collected from the archaeological record bear directly on these issues—how organic residues and subsistence-related artifacts testify to the content of prehistoric meals and past strategies of food-getting —and we explore the limited degree to which the distributions of these data classes in time and space inform us about the gastric organization of work at Tosawihi. In later chapters, we consider how our best current understanding of the material, spatial, temporal, and energetic aspects of reconstructible Tosawihi subsistence strategies sheds light on prehistoric strategies of lithic procurement.

Subsistence Opportunities and Constraints

Even under the most provident past ecological regime, the resource landscape of the Tosawihi uplands is likely to have differed significantly from that of the surrounding low country; the bottomlands of Willow Creek, Rock Creek, Boulder Creek, and the Humboldt River almost certainly always were lusher than the craggy, poorly watered, thinly mantled knolls and slopes of the quarry and its hinterlands. In most seasons, and under most imaginable regimes, the high country simply was less hospitable than the valley floors, owing to a chain of three ecological contingencies.

In the first place, Tosawihi lies very near the crest of the local watershed, with the result that perennial groundwaters are limited to the eruptions of a few shallow aquifers; only half a dozen springs and seeps rise early in the year, and only two of them are reliable past August under the current regime. Streams are even more fugitive; only Willow Creek and,

less exuberantly, Ivanhoe Creek, flow past June. This means that the availability of water must have constrained freedom of movement in and around the quarries whenever climate approximated the present circumstance, and that the activities of prehistoric foragers must have been tethered in time and space to a relatively small number of water sources. In contrast, we have observed fairly abundant, reliable waters in nearby, comparably upland settings (e.g., the Snowstorm Mountains, the Tuscarora Range, and the Owyhee Bluffs), suggesting that the relative dryness of the Tosawihi landscape is a local phenomenon, necessarily typical of neither the latitude nor the elevation at which it rests.

In the second place, absent many spring plots and riparian corridors, vegetation seldom flourishes with the moisture-loving communities that elsewhere comprise the Great Basin's richest foraging patches. The shallow, quickly-drained soils of most of the landscape, in fact, are dominated today by inedible or non-nutritious shrubs (big sage, low sage, rabbitbrush, and phlox), interspersed with a mundane assortment of perennial grasses. The deep gorges of a few now-seasonal drainages retain small pockets of more complex (and, from a foraging perspective, more favorable) associations, and we must assume that prior to the inception of domestic livestock grazing the grasslands were more productive than they are today. Neither setting, however, offers much browse or cover for herbivorous animals, and neither offers many plants of economic interest to human foragers. Without a significant modification of the effective moisture regime, (e.g., as a product of increased precipitation, the onset of cooler conditions, or a shift in the seasonal dominance of rainfall), no forager *ever* should have left the lowlands to go to Tosawihi solely to collect plant foods.

And in the third place, the poverty of water and plants impoverishes the abundance and distribution of wildlife. Lacking diverse or particularly favorable habitats, few native animals larger than Size Class IV (cf. Chapter 13) dwell in the countryside. In this respect, too, Tosawihi differs from surrounding upland settings; absent the extensive riparian zones or well-developed mountain shrub communities (bitterbrush, serviceberry, mountain mahogany) that characterize many mid-elevation patches within 20 km of the quarries, deer and mountain sheep are likely to have visited only seasonally. Except for brief (but sometimes tightly clustered) congregations in the spring, few deer and antelope were observed over our four seasons of fieldwork; we suspect that, even before the attrition of habitat induced by livestock grazing, mining, and fire-suppression, there would have been few resources to attract large herds. Too, while smaller mammals (especially rodents and lagomorphs) thrive in several microhabitats, and in peak seasons (chiefly, spring) doubtless compose a rich and unignorable biomass, we doubt that the populations of their largely insular colonies bulk large enough to sustain prolonged or intensive human predation.

This reading suggests, of course, that the Tosawihi environment as it presently is composed could offer foragers few opportunities to hunt and fewer to gather in most seasons of most years; even a drink of water can be hard to get away from a few scattered points on the map. Consequently, we can posit few reasons why, outside a probably narrow window in late spring or early summer, foragers should have abandoned the well-watered, fish-rich, grassy, herd-strewn valley bottoms lying on every side to come up to this unforgiving landscape (as it presently is composed) unless they were motivated by reasons *other* than feeding themselves well. Almost every upland in every direction is likely to have offered better foraging opportunities and is more likely to have been included in an annual foraging range. But the archaeological record discloses that people came to Tosawihi time and again, in great numbers or over a long span of time, to get toolstone. We are interested, then, in understanding *how* quarriers may have compromised their opportunities for better or easier meals in the interest of acquiring stone, and in measuring the degree to which the quest for toolstone may have supplanted the quest for cheap food. Some observations on the probable balance of costs and benefits follow.

Credits and Debits of Foraging at Tosawihi

None of the resources presently available at Tosawihi rewards its capture very favorably; measured calorically, the best foraging returns should come from hunting deer and antelope (mammals of Size Class V), while other classes of quarry generally should return fewer calories for greater expenditures of effort (Table 204).

Table 204. Caloric Returns from Hunting Various Size Classes of Mammal (after Simms 1987:47; cf. Thomas 1969)

Size Class		Return Rate (Cal/hr)
I	Mice, Voles	2,837 - 3,593
II	Ground Squirrels, Wood Rats	5,390 - 10,780
III	Rabbits, Hares, Marmot	8,983 - 15,400
IV	Coyote, Badger	(12,354 - 23,425)*
V	Deer, Pronghorn, Sheep	15,725 - 31,450
VI	Bison, Wapiti, Cow	Untested

*Interpolated estimate; caloric returns from hunting Class IV mammals were not tested in Simms' foraging experiments.

These experimentally-derived return rates suggest that efficient Tosawihi foragers always should have pursued animals of higher size class, since the reward of the larger meat "packages" gained far outweighs the greater costs of search, pursuit, and handling entailed in their capture and processing as food. Such a strategy could be invoked, however, only when and where the target prey was available, and we have little reason to believe that Tosawihi often hosted deer and antelope in abundance. Only along the courses of Willow Creek and Ivanhoe Creek (the Northern Corridor), along Undine Gorge (the Eastern Periphery), and perhaps in Basalt Canyon and on the slopes of Rodent Valley (the Western Periphery), do circumstances of water, vegetation, and landform conspire to invite big herbivores. Elsewhere, although they may have passed by occasionally (and on which occasions they *always* should have been taken by prudent foragers), deer and antelope, as well as their meatier precursors (elk and bison), seldom are likely to have congregated in the area and only in spring are likely to have contributed to the composition of reliable foraging patches.

Smaller animals are another matter; we saw them abound at the margins of almost every site we visited, and we found lots of them comfortably at home along Ivanhoe Creek, in Rodent Valley, and along the southern flank of Undine Gorge. Their cumulative biomass doubtless is relatively high, although it is prone to fluctuate dramatically from year to year (Janetski 1979). Efficient capture techniques (such as snare-trapping) can enhance the foraging value of Class II and III animals as game (Janetski 1979; Simms 1987:70-71), and at Tosawihi such animals are likely to have comprised the upper end of the diet breadth whenever larger game was unavailable or inconvenient to pursue (cf. below). Consequently, we should expect to see them represented more frequently in the archaeological record than the bony parts of bigger game. Because, however, irrespective of capture techniques, rabbits, rats, and mice are costlier to exploit, they make up a more expensive diet than big game hunters customarily enjoy, and other enterprises (such as toolstone acquisition) that rely on such a diet necessarily must have adopted a posture of temporary impoverishment.

Of plant foods at Tosawihi we almost cannot say too little; they are scattered, sparse, and they offer meager benefits. The richest foraging returns from species we have observed in the field should come from bitterroot (Simms 1987:181), presently confined to a relatively small zone in the Western Periphery (i.e., Bitterroot Ridge, subsuming 26Ek3095, 26Ek3160, and 26Ek3165). Elsewhere, save a few ragged patches where roses and currants struggle at the bottoms of deep gorges, there are no plants better to eat than grass. Grasses, however, are among the costliest foods Great Basin peoples are known to have pursued, and their caloric returns reflect how hard it is likely to have been for foragers to rely on plant foods at the quarries (Table 205).

Table 205. Caloric Returns from Collecting Various Plant Species (after Simms 1987:47)

Species	Return Rate (Cal/hr)
Bitterroot	921 - 1,238
Bluegrass	266 - 473
Great Basin Wildrye	301 - 392
Bluebunch Wheatgrass	ca. 250*
Sedge	202
Squirreltail	91

*Interpolated estimate; caloric returns from bluebunch wheatgrass were not tested in Simms' foraging experiments.

So, when foragers went to Tosawihi (for whatever reason), planning to live off the land, they had to plan also to eat lean, and to burn a lot of energy assembling, for the most part, scrappy meals. Only in late spring or early summer could the hunter reliably expect to bring home an antelope or a deer; more often, he or his party could count at best only on returning marmots, rabbits, and rodents. Gathering, inevitably, was even less rewarding; aside from bitterroot (the richest locally available food plant, but less than half as productive as the poorest animal quarry), only wretchedly costly grasses were at hand. For human groups living at other times of the year lower on the landscape, where resources were richer and their capture more assured, trips to Tosawihi must have comprised a considerable forfeiture of other, less risk-prone opportunities, a tacit willingness to embrace a broader diet breadth, and a measured assessment of resource costs and values that judged toolstone acquisition an affordable (that is, profitable) pursuit.

We have few bases from which to speculate about *how* profitable such ventures ultimately may have been, but we can begin to understand something of the economic decision-making they entailed by measuring the subsistence costs they are likely to have exacted. If we assume, for instance, that a young adult male will burn on the order of 600 Cal/hr while quarrying in pits (a very rough approximation based on our own actualistic quarrying experiments [cf. Chapter 4] as well as on interpolations from estimates for various athletic activities demanding comparable levels of effort; cf. World Almanac 1991:205), we observe that subsistence reliance on most locally available plant foods would require preposterous outlays of time to fuel the work. A quarrier *could* live on a diet of squirreltail grass, but only if he or his cohort were willing to invest about seven hours in seed collection and processing for every hour spent quarrying. Even bitterroot, the most favorable plant resource available in the local biotic assemblage, should require about .5 person-hours of post-encounter handling time to support every person-hour of quarrying. Hunting, on the other hand, could support quarrying more easily, the expected ratio of subsistence time to quarrying time ranging from about 5:1 to more than 50:1. Clearly, quarriers at Tosawihi always should have relied chiefly on a diet of meat, supplemented by high ranked plant foods only where an otherwise unoccupied, non-hunting labor force was available to carry out the necessary collection and processing.

These considerations contribute to modeling some of the scenarios under which subsistence may have been pursued at Tosawihi, and to sketching some of the ways in which other work there may have been organized to accommodate the need to eat. If we assume, for instance, that quarrying ventures most likely were staged in late spring or early summer in the interest of capitalizing reduced opportunity costs, then pursuit of big game must have been part of the enabling strategy. Regardless of group composition, however, this means that the efforts of at least some potential quarriers necessarily were deflected sometimes to get food. If quarrying parties were composed of small groups of males, this could have been accomplished either through task specialization or rotation of tasks; in either case, both hunting *and* quarrying must have required forfeiture of time spent in the other pursuit, and each, in consequence, must have been rendered more costly. Alternately, if mixed gender parties visited the uplands during the same season, women (and perhaps children) could have foraged for lower-ranked but still energetically enabling resources (small mammals, bitterroot) while men quarried. It even is conceivable that, in the interest of maximizing efficiency, women may have relieved men from certain quarrying tasks to support occasional hunting forays. Implicit in this, of course, and untestable archaeologically, is the assumption of a sexual division of labor in which men usually pursue more mobile subsistence resources (i.e., big game) while women usually collect more static ones (which happen, incidentally, to fall lower along the optimal diet curve; cf. Figure 220). Too, we assume that women did not constitute the primary quarrying work force, although this might be challenged by the proposition that, physical strength allowing, the most profitable blend of effort should assign big game hunting as men's first priority in support of the quarrying party, however composed.

Past early summer, with the retreat of deer and antelope from the area, foragers would have to shift their attention to lower-ranked resources, and time spent at the quarries should grow progressively more expensive. We have observed, for instance, that small mammal colonies

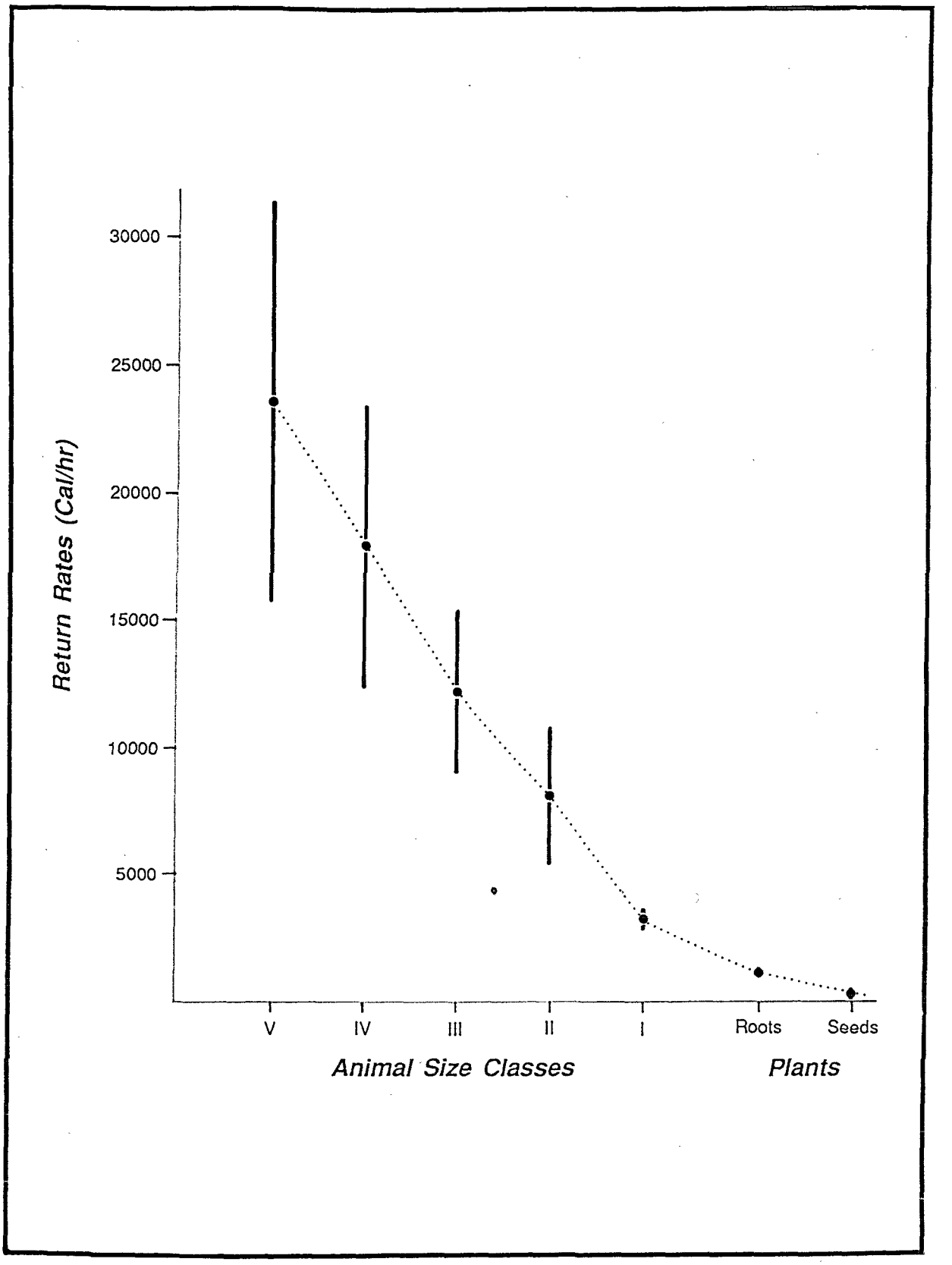


Figure 220. Categorical Optimal Diet curve for presently available Tsosawihi resources (return rates after Simms 1987).

constitute probably favorable (but finite) foraging patches throughout the summer of most years, but that other resources decline, sometimes critically. By the end of summer there remain few plant foods to bolster the diet; grasses have dropped their seeds, and the starch reserves of roots have been depleted to foster new growth. We suspect that even the most robust colonies of small mammals at Tosawihi could tolerate to only a limited degree the intensification of predation that a late summer foraging focus would impose, since at that time they would constitute virtually the whole of the diet; if not depleted utterly, their populations easily could be stressed, with severe consequences for out-year foraging in the same patches.

Too, of course, water sources outside the Northern Corridor are unreliable late in the warm season, with the result that in many years (under the current regime) quarrying forays would be taxed by the additional costs of travel or water transport. The unreliability of local water prevails throughout the fall of most years, posing a formidable limiting factor on human presence in the quarries, and is relieved only with the onset of winter snowfall, itself a major constraint inflating the costs of both foraging and quarrying.

We suspect, then, that amelioration of the opportunity costs of quarrying (cf. Chapter 3) could be achieved effectively only in late spring or early summer, when big game, rodents, roots, and water all were available, relatively plentiful and predictable, and cheaper to exploit than in any other season. The possibility remains, however, that quarrying ventures sometimes (i.e., in unfavorable seasons or years) were provisioned from resource patches lying outside the immediate Tosawihi vicinity; since better habitats for upland game lie only moderate distances north and east of the quarries, better lowland habitats to the west and south, and even a salmon fishery is (was) within reach (cf. Chapter 2), it might have repaid quarriers to bring food with them. Unless the remains of species exotic to the quarries (e.g., salmon) were detected, we do not expect to be able to discern such practice in the archaeological record. We observe, however, that such a strategy necessarily would entail added transport costs diminishing, by variable degrees, the value of the support resources (Madsen and Jones 1987) and inflating the cost of off-season quarrying.

If our various assumptions about the value and distribution of resources at Tosawihi are correct, what should we expect to see in the archaeological record by way of subsistence-related artifacts and residues? In the first place, hunting implements (particularly, projectile points) should be more abundant and more broadly distributed than plant processing equipment, but we should not expect their absolute frequency to approach that of neighboring upland regions in which hunting is likely to have been a more central enterprise. Moreover, they should not be distributed homogenously across the landscape, but rather should tend to cluster in vicinities likely to have attracted larger (and hence more valuable) game; the immediate margins of Ivanhoe Creek, Willow Creek, Little Antelope Creek, and the seeps of Basalt Canyon are the most probable arenas for the aggregation of high-ranked game, and it is in those locations (together with Tosawihi Spring in Big Butte Valley, outside our present theater of interest) that we should expect to find the most abundant incidence of projectile points.

Milling stones, on the other hand, reflect the expenditure of much harder work for lower returns, and we should expect to find them only coincident with patches of relatively high-ranked plant resources (such as Bitterroot Ridge) or at locations that, owing to other attributes (e.g., the availability of water), invited residential stays; stream banks and spring meadows should encompass nearly the entire assemblage of plant-processing equipment. *All* classes of subsistence-related artifact, of course, should occur in habitation sites, with which the occurrence of permanent or semi-permanent sources of water should be the most overt environmental correlate.

We expect organic subsistence residues to be bound almost exclusively to habitation sites (cf. Chapter 26), because it is only in those settings that we anticipate *virtually* all butchering of animals and *all* processing of plants to have been carried out. Since few of the reconstructibly available food species save deer and antelope demand remarkable transport costs, we should expect small game and plant residues to be found only in hearthside contexts. Large game residues (reflecting occasional field butchering) may be distributed more widely, but their spatial patterning (particularly, their coincidence with probable foraging patches) is likely to be undetectable without massive areal sampling.

Finally, we control very few data on how the Tosawihi environment is likely to have changed over the course of the Holocene, but most changes, irrespective of their nature, probably influenced the timing, geography, and energetics of foraging opportunities. A slightly moister regime than prevails at present, for instance, predictably would support the proliferation of grasses and forbs, while a cooler one could have invited the colonization of more robust tap-rooted species (inducing a semi-woodland setting?) than occur today. In the former instance, we should expect small mammals to flourish; in either, large herbivores are likely to have benefitted. Were we to model *conceptually* (absent empirical evidence that they ever actually occurred) the effects of some categorical changes in the local environment – if, for instance, we were to subscribe to Antevs' (1948) "neothermal" model of climatic change throughout the Great Basin, and were to assume that a post-Pleistocene "anathermal" episode, roughly coincident with the Late Pre-Archaic archaeological period (Elston 1986a), wrapped most of the countryside in a cooler, moister regime than we currently enjoy—then we should expect that during that episode Tosawihi and similar settings were better places for foragers to visit than they are now. In fact, the Tosawihi uplands should not under those circumstances have constituted an *un*favorable foraging patch, but should have rewarded foragers with big packages of meat (e.g., bison and elk, neither of which reside in the vicinity today) and plant resources vastly easier (and more profitable) to collect. And given such an assumption, how should the archaeological record of such different, early times look? Probably, we should find in the Early Archaic (or *whenever* climate supported richer habitats) that people may have been attracted to the uplands for reasons additional to or *besides* the acquisition of toolstone, that the distribution of their activities over the landscape should be less dependent on the distribution of outcrops and deposits of opalite, and that subsistence residues and subsistence-related artifacts should be more plentiful.

In the following pages we discuss how the observed archaeological record comments on these assumptions. We focus particularly on organic residues and various artifact classes believed to have functioned in the procurement or processing of food, giving special attention to the areal and temporal distributions of the subject data classes.

Archaeological Data

Most artifact classes used by foragers contribute to subsistence; even cores yield flakes that may be used to produce projectile points and meat cutting implements, and in this way assume at least indirectly a subsistence relationship. The following discussions, however, consider only artifact classes which, based on morphology, use traces, or strong warranting arguments from ethnographic observations, were used in the food quest and food processing; we are concerned with projectile points, ground stone, ceramics, and cutting tools, and archaeologically recovered floral and faunal remains. Our focus here is on data offering direct evidence of subsistence related tasks, and on how the distribution of these tools and residues reflect prehistoric subsistence patterns at Tosawihi.

Organic Evidence: Faunal Remains

Faunal remains are scarce at Tosawihi, and, when they are present, they are represented largely by small mammals. Above, we outline our expectation that faunal evidence should occur preferentially in areas most attractive as habitation sites. Although rodents probably were exploited as food (at least on an encounter basis), the small mammal assemblage offers little indication of such activities; most elements are complete, or they evidence partial digestion by non-human predators. Consequently, our discussions here address only the fragmentary, burned, and/or butchered remains of larger mammals (i.e., jack rabbit-sized and larger; cf. Table 206, Figure 221). Clearly, the scant occurrence and wide distribution of bones with cut marks offers few insights into subsistence practices (e.g., carcass transport and butchery; cf. Binford 1981a; Lupo 1990; Lyman 1985; O'Connell, Hawkes, and Jones 1990), but rather afford only brief glimpses of where subsistence activities occurred in the Tosawihi Quarries vicinity.

Table 206. Summary of Organic and Artifactual Subsistence Evidence by Site.

Site	Faunal Remains[1]	Plant Macrofossils[1]	Ground Stone (n)	Pottery[2] (n)	Projectile Points[3] (n)	Edged Tools[4] (n)	Total # of Classes Present
26Ek3032,L.4	-	-	0	0	1	0	1
26Ek3032,L.19	-	-	1	0	0	1	2
26Ek3032,L.20	-	-	0	0	1	1	2
26Ek3032,L.23	-	-	0	0	6	0	1
26Ek3032,L.28	-	-	0	0	1	0	1
26Ek3032,L.40	-	-	0	0	1	0	1
26Ek3032,L.72	-	-	0	0	1	0	1
26Ek3032,L.93	-	-	1	0	0	0	1
26Ek3032,L.107	-	-	0	0	1	0	1
26Ek3032,l.138	-	-	0	0	2	0	1
26Ek3032,L.152	-	-	0	0	1	0	1
26Ek3032,L.158	-	-	0	0	1	0	1
26Ek3075	-	-	0	0	1	0	1
26Ek3092	+	+	8	4	37	9	6
26Ek3093	-	-	0	0	2	1	2
26Ek3095	+	-	13	0	36	15	4
26Ek3096	-	-	1	0	0	0	1
26Ek3099	-	-	0	0	1	0	1
26Ek3101	-	-	0	0	1	0	1
26Ek3102	-	-	0	0	1	1	2
26Ek3106	-	-	1	0	2	1	3
26Ek3107	-	-	0	0	1	0	1
26Ek3110	-	-	0	0	0	1	1
26Ek3114	-	-	0	0	1	1	2
26Ek3116	-	-	0	0	6	0	1
26Ek3123	-	-	0	0	1	0	1
26Ek3125	-	-	0	0	1	0	1
26Ek3142	-	-	0	0	1	0	1
26Ek3144	-	-	0	0	1	0	1
26Ek3148	-	-	0	0	1	0	1
26Ek3149	-	-	2	0	3	0	2
26Ek3154	-	-	0	0	1	0	1
26Ek3160	-	-	18	1	57	16	4
26Ek3162	-	-	0	0	1	0	1
26Ek3165	-	-	4	0	3	5	3
26Ek3170	-	-	2	0	11	4	3
26Ek3171	-	-	1	1	2	0	3
26Ek3173	-	-	0	0	2	0	1
26Ek3174	-	-	0	1	0	0	1
26Ek3177	-	-	0	0	2	0	1
26Ek3178	-	-	0	0	3	0	1
26Ek3179	-	-	0	0	0	1	1
26Ek3181	-	-	1	1	0	2	3
26Ek3184	+	-	1	0	6	2	4
26Ek3185	-	-	1	0	8	1	3
26Ek3190	-	-	1	0	9	2	3
26Ek3191	-	-	0	0	1	0	1
26Ek3192	+	-	7	1	15	5	5
26Ek3196	-	-	1	0	0	0	1
26Ek3198	-	+	0	1	27	4	4
26Ek3201	-	-	2	0	0	0	1
26Ek3202	-	-	0	0	0	1	1
26Ek3204	-	-	1	0	6	2	3
26Ek3208	-	-	0	0	1	0	1
26Ek3228	-	-	1	0	0	1	2
26Ek3231	-	-	0	0	1	0	1
26Ek3237	+	+	8	0	40	6	5
26Ek3238	-	-	1	0	5	1	3
26Ek3239	-	-	0	1	2	1	3
26Ek3251	+	+	17	1	45	4	6
26Ek3271	-	-	6	0	23	5	3

Notes: [1]Denoted here as present/absent (±).
[2]Estimated number of vessels (cf. Chapter 12).
[3]Includes non-classifiable fragments and specimens. Excludes points broken in manufacture.
[4]Includes pressure retouched Stage 4 and Stage 5 bifaces, and flake tools with soft to medium edge damage and polish traces.

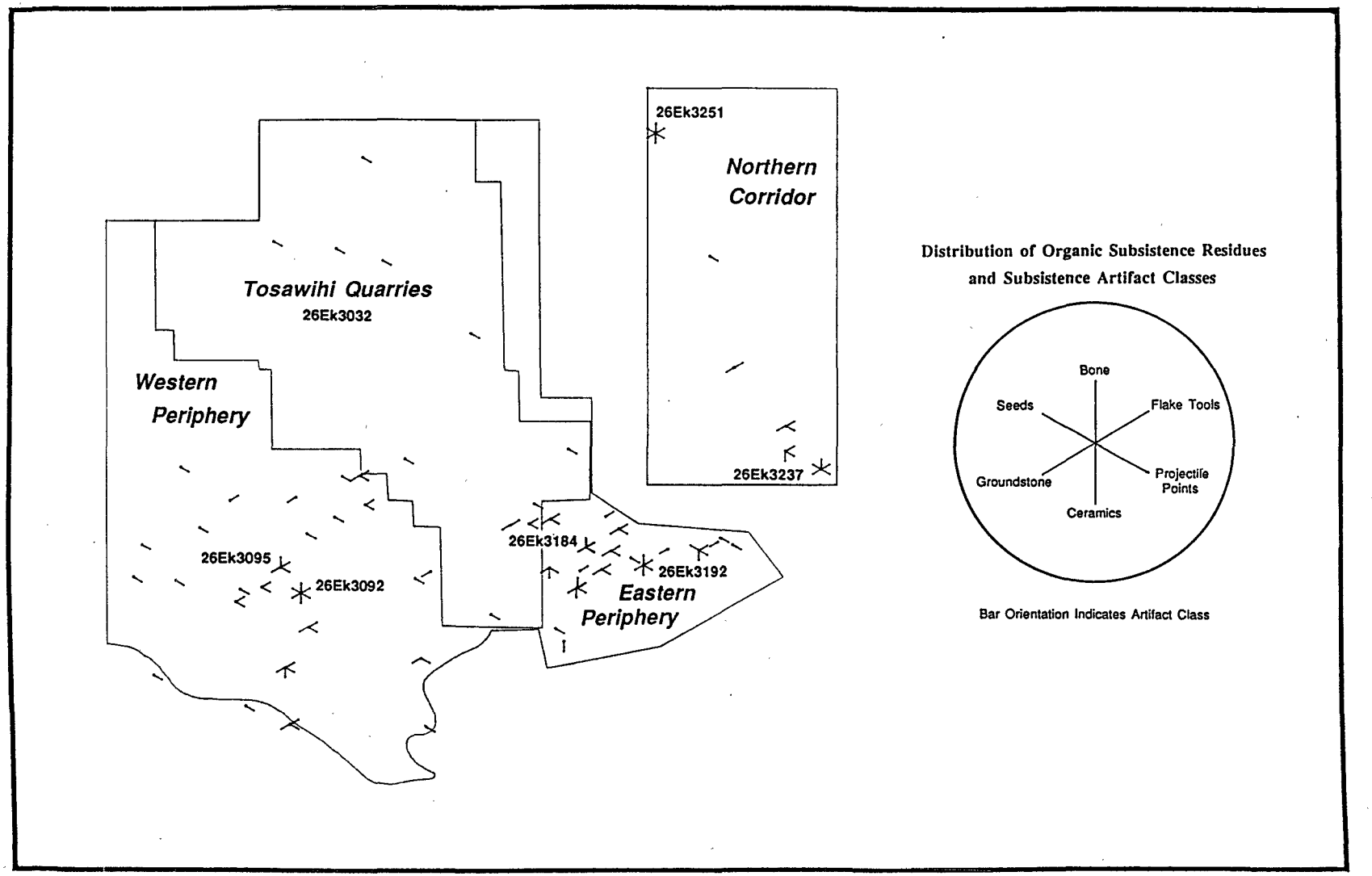


Figure 221. Presence/absence distribution of organic subsistence residues and subsistence artifact classes.

Two sites adjacent Ivanhoe and Willow Creeks in the Northern Corridor returned fragmentary (often burned) large mammal bones, most of them adjacent hearths (i.e., Features 3 and 4 at 26Ek3237) or dispersed hearth-like features (Feature 6 at 26Ek3251), in association with ground stone and flake and cobble tools. 26Ek3092 and 26Ek3095 in the Western Periphery also yielded subsistence-related faunal remains, including five specimens from 26Ek3092 which display butchering marks characteristic of dismemberment, marrow extraction, and possibly filleting (cf. Table 107).

Aside from elements displaying cut marks or flake scars, the least equivocal evidence of cultural bone refuse at Tosawihi is a cluster of fragmented and burned marmot remains recovered from Feature 1 at 26Ek3192; all came from a single unit/level aggregate in association with ground stone, flake tools, projectile points, and a fragmentary ceramic vessel (cf. Chapter 15). Only a few isolated faunal items were retrieved elsewhere in the site.

Not surprisingly, cut, fragmented, and/or burned large mammal remains were found almost exclusively in areas utilized as campsites, signaled by the presence of hearths and the recovery of multifunctional toolkits. Conversely, two quarry pits yielded bison and elk remains used as quarrying implements (cf. Chapter 13). These artifacts most likely were brought to the quarries as tools, rather than as food elements, and probably are not (Tosawihi) subsistence indicators. Although the occurrence of "food bone" attests to subsistence activities performed at these sites, the overall rarity of faunal remains must be attributed to post-depositional attrition, as most Tosawihi sites occupy the shallow, commonly bioturbated aeolian silts blanketing the region; the recovered faunas probably are only a small portion of what was deposited originally.

Organic Evidence: Plant Macrofossils

Like archaeofaunal remains, we expected plant macrofossils to be present chiefly in places used for human habitation, but they, too, are scarce. This is attributable in part to sampling techniques, but the overall scarcity of plant macrofossils seems also a product of post-depositional organic degradation; our samples were taken from areas where floral subsistence debris should be anticipated in the archaeological record (e.g., in and adjacent hearths), but analysis found many sediment samples virtually devoid of such remains (cf. Chapter 14). The dearth of plant macrofossils may be a product of poor preservation, infrequent use, or both.

Of the 37 sediment samples from four sites (26Ek3092, 26Ek3198, 26Ek3237, and 26Ek3251; cf. Table 206; Figure 221), charred seeds are most abundant (but still relatively few) in a "dispersed hearth" adjacent Willow Creek at 26Ek3251; the association includes riparian plant species presently absent from the Willow Creek bottomlands (cf. Chapters 14 and 17). Charred seeds in hearth features at the remaining sites probably represent subsistence refuse, but they are sparse and they reflect only meager caloric returns.

Artifacts: Ground Stone

The use of manos, metates, mortars, and pestles in the processing of plant and animal resources is well documented in Great Basin ethnographies (e.g., Downs 1966; Steward 1941; also cf. Fowler 1986). Macroscopic observations of morphology and surface use wear commonly segregate these artifacts as food processing tools. As discussed above, we expect ground stone to be present in habitation sites and in association with patches of relatively high-ranked plant resources.

Ground stone artifacts occur at numerous Tosawihi sites, and are particularly abundant in the Western Periphery (cf. Table 206; Figure 221). In the Bitterroot Ridge vicinity, milling

equipment (especially metates) abounds at 26Ek3095 and 26Ek3160 (cf. Chapter 11), both of which occupy areas within or adjacent patches of bitterroot, grasses, and onion. Similarly, 26Ek3251, situated in the riparian bottomlands of Willow Creek, yielded a large assemblage of milling stones, including fragments of at least nine individual metates.

Ground stone was collected from several sites in the Eastern Periphery, but, with the exception of two manos and five metates recovered from 26Ek3192, most assemblages consist of single specimens (cf. Chapter 11). Compared with ground stone frequencies in the Western Periphery, milling equipment in the Eastern Periphery suggests that certain subsistence tasks were undertaken less frequently there. This may be the case, but chronological markers recovered from the Western Periphery indicate occupation over a much longer span of time, and the higher frequency of ground stone may be simply a product of longer use. Further, the abundance of milling equipment in the Western Periphery could owe to patterns of expedient use and discard; most metates are manufactured on the tabular basalt (cf. Chapter 11) occurring throughout the area in exfoliated outcrops, colluvial flows, and stream cobbles, and, being close at hand, required little investment of search time.

Artifacts: Ceramics

Ceramic vessels can serve as food storage containers and cooking pots, and probably usually reflect subsistence activities; they are expected to occur most frequently in places used for habitation. Ceramic analyses found some interior surfaces to exhibit noncarbonaceous blackened residues (cf. Chapter 12), suggesting that many vessels were employed in the preparation and storage of food (cf. Steward 1941:232). These artifacts signal subsistence tasks performed after A.D. 500.

Excavations and surface collections yielded fragments of 12 vessels from nine sites; 26Ek3092 returned pieces of 4 pots (including Fremont Grayware) in association with hearths, ground stone, and faunal remains; the remaining eight sites contained one each (cf. Chapter 12). Interestingly, fragments of five vessels were recovered from sites in the Eastern Periphery, lending support to our model of Late Archaic intensification of use of this area (cf. projectile point discussions, below).

Artifacts: Projectile Points

In the ensuing discussion, we consider the general distribution of projectile points across the Tosawihi landscape as indirect evidence of subsistence practices, recognizing that their presence can owe to multiple factors; those specimens lost in hunting or left with untransported animal parts should reflect areas exploited for game, while those broken during maintenance or transported in prey away from kill locations will not necessarily reflect the same geography. Unfortunately, we cannot distinguish these various contexts. Instead, we are interested in the spatial and temporal distribution of points, since patterns of discard or loss reflect how landscape use was organized. Projectile points do not necessarily mark hunting areas, but they can indicate group organization; insofar as different organizational patterns correspond to different subsistence practices, projectile point distributions are indirect subsistence indicators.

The distribution of projectile points of all types, including unclassifiable fragments and specimens (cf. Chapter 8) is summarized in Figure 213 (cf. Chapter 19). We exclude from consideration the nine points broken in manufacture, since these never became part of a subsistence tool kit. Far more projectile points were recovered from the Western and Northern areas than from the Eastern Periphery and localities within 26Ek3032. The Bitterroot Ridge

area of the Western periphery exhibits a particularly high frequency of points, as do sites 26Ek3237 and 26Ek3251 in the Northern Corridor. Topographically, locations with high point frequencies tend to lie within one to two hundred meters of larger drainages. Since larger drainages support richer forage and more diverse resources, they undoubtedly were more attractive as habitation locales, and attracted more abundant wildlife.

Time-sensitive projectile point series further elucidate the pattern observed in the overall distribution of projectile points (cf. Figure 215). The Bitterroot Ridge sites (26Ek3092, 26Ek3095, 26Ek3160, 26Ek3271) together with two Northern Corridor sites (26Ek3237 and 26Ek3251), have the widest temporal spreads. These locations were used over the longest periods and perhaps, in consequence, they accumulated the largest projectile point assemblages.

The distribution of time sensitive point series reflect changes perhaps related to general changes in subsistence strategies through time. Great Basin Stemmed points often occur as isolates. Gatecliff points are infrequent, but when present they tend to occur with other, later point types. Elko and Rosegate Series points are relatively frequent (cf. Chapter 9), but the majority of them come from the Bitterroot Ridge sites listed above. Desert series points (Cottonwood and Desert Side-notched) also are common there, but they also frequently occur in the Northern Corridor and in the Eastern Periphery, where they are the most common projectile point series.

Three distributions of time-sensitive projectile points are apparent. The oldest series (Great Basin Stemmed) shows no obvious clustering; this may indicate dispersed use, with little revisitation of particular locales. Tentatively, hunting at Tosawihi during this time period may not have been organized from particular places on the landscape, being staged rather on a sporadic, *ad hoc* basis. Elko and Rosegate Series points clearly cluster in space, suggesting repetitive use of certain places, particularly those in the Bitterroot Ridge area and in the Northern Corridor; within this time period, hunting may have been organized from a few recurrently used places, often within a short distance of drainages. A marked change in distribution is evident among Desert Series points; they occur in many new locations, including the Eastern Periphery and several smaller sites in the Northern Corridor. The tendency of Desert Series points to cluster, rather than to occur as isolates, again suggests organized hunting from a few repetitively used places, but with many "new" places being visited.

Artifacts: Edged Tools

Morphological attributes of bifaces and flake tools are discussed in Chapters 7 and 8; the classes are considered together here because both provide edges useful for subsistence tasks, irrespective of morphological class. Only flake tools with edge damage or wear polish consistent with the cutting of soft to medium texture materials are considered to be subsistence tools (cf. Chapter 8). Similarly, pressure-retouched Stage 4 and Stage 5 bifaces are incorporated in our discussion because most of those examined for use wear were used for cutting (cf. Chapter 6, Table 10).

Edged tools are present at many sites (cf. Figure 221; Table 206); their presence generally is associated with other kinds of subsistence tools; they rarely are the sole subsistence related artifacts in an assemblage. They are particularly prevalent on Bitterroot Ridge in the Western Periphery and in the larger sites of the Eastern Periphery. Too, they are abundant in the Northern Corridor; five of the six sites in this area contain either used flakes or pressure retouched bifaces.

The occurrence of edged tools may have more to do with the locations at which things were processed for consumption than with the places at which resources were harvested. That they tend to occur predominantly in locations having at least one (and usually more) subsistence residue or artifact class present underscores this possibility.

Cooccurrence and Variation in Subsistence Indicators

Artifacts and residues associated with subsistence cooccur at sites on Bitterroot Ridge in the Western Periphery, at 26Ek3237 and 26Ek3251 in the Northern Corridor, and at several sites in the Eastern Periphery (cf. Figure 221; Table 206). In part, this pattern is undoubtedly attributable to the data recovery activities themselves: more extensively excavated sites have a better chance of yielding rarer classes of subsistence evidence. Some patterns of cooccurrence, however, are too strong to account for in this fashion, and instead may represent recurring prehistoric subsistence activities undertaken in conjunction with each other. We examine such patterns here, in order to elucidate what activities they may reflect. We also examine the evidence presented above in a composite fashion, comparing geographic areas in terms of the numbers of subsistence-related data classes present in each.

Groundstone presence/absence and edged tool presence/absence are closely correlated (chi square = 5.5, df=1 $p<.05$). Since cutting tools are useless in processing many food items that would have been ground, beaten, or mashed, this association suggests that many places were used for multiple resource procurement. In other words, a tentative interpretation of sites where groundstone and edged tools occur together is that they served as broad spectrum acquisition/processing localities.

Also, the numbers of tool classes present vary within geographic areas. We have discussed above the relatively abundant evidence of subsistence activities in the Western Periphery and a few sites in the Eastern Periphery and the Northern Corridor. When the number of classes of evidence for all sites (excluding quarry locations and isolated artifacts) are summed for each area (Table 206), Northern Corridor sites generally exhibit a greater variety of subsistence indicators; the Western and Eastern Peripheries exhibit less variety (Table 207). Subsistence-related artifacts reflect this pattern. Furthermore, sites with economic faunal remains (i.e., food bones) also exhibit more subsistence-related artifacts and more subsistence-related data classes than does any single geographic area (cf. Table 207).

Table 207. Frequency of Occurrence of Subsistence-related Data Classes by Geographic Area.

	North n	West n	East n	Sites w/ Economic Fauna
Total sites, excluding isolated finds	6	16	17	6
Total number of subsistence classes present	20	38	38	30
Mean number of classes/site	3.33	2.38	2.24	5.00
Total number of subsistence artifacts	135	287	138	280
Mean number of artifacts/site	22.50	17.94	8.12	46.67

Discussion

Unequivocal archaeological remains from prehistoric subsistence practices are scant at Tosawihi. Poor preservation no doubt has taken a toll of direct organic indicators of subsistence, but the degree of fossil attrition is unmeasurable. However, since the likelihood of encountering

organic remains in excavation is proportional to their original abundance, organic remains indicate (albeit skeletally) *where* subsistence activities are likely to have occurred. Upon examination, their occurrence corresponds well with expected locations of prehistoric subsistence activities.

Further support for our expectations is provided by indirect indicators of subsistence (i.e., ground stone, ceramics, projectile points, and edged tools). Although widely scattered, these artifact classes tend to follow the model of subsistence at Tosawihi presented above. Ground stone, for example, is most abundant adjacent potential water sources in the Western Periphery and perennial sources in the Northern Corridor.

The distribution of subsistence indicators varies. Ground stone is rare in the Eastern Periphery and in the main body of the quarries, probably because the Western Periphery hosts more abundant plant resources. As well, the Western Periphery appears to have had a long tenure of use, as indicated by projectile points and radiocarbon assays (cf. Chapter 19, Figure 209). The late, sporadic, occurrence of ground stone in the Eastern Periphery may owe to intensification of use of the quarries; the plant resources in this area are relatively poor, but exploitation may have been necessary during the Late Archaic (cf. Chapter 18).

Projectile points track a general pattern of change in how the Tosawihi landscape was used. The earliest time-sensitive series (Great Basin Stemmed) reflects little repetitive use of specific places; points of this series are widely distributed, commonly found on the surface with no other associations. In a few favored locations, where the scant subsistence resources of Tosawihi cooccur (e.g., Bitterroot Ridge and the Northern Corridor), a pattern of repeated use emerged during the mid-Archaic. The Eastern Periphery saw little use during the time represented by Elko and Rosegate Series points. Repetitive use of favored places became widespread during Desert times. Desert Series points and ceramics are the predominant subsistence and temporal indicators on sites in the Eastern Periphery, and many sites there appear to have been established and visited recurrently during the period. This pattern of land use, which we believe to have been related to subsistence practices, began in the Mid-Archaic and expanded during Desert times.

The pattern of change is provocative; while we cannot rule out the importation of food by prehistoric quarriers, subsistence appears always to have been an important determinant of how prehistoric groups organized visits to Tosawihi. If prehistoric groups provisioned forays in advance (cf. Binford 1978b:84), then some of our direct indicators of subsistence may consist of imported food packages. Under this scenario, subsistence resource acquisition at Tosawihi only supplemented extrinsic resources. Alternatively, if forays were self-supporting (living off the landscape while in it), then recovered subsistence residues evidence primary subsistence practices.

In either case, the observed patterns appear to reflect changes in how hunter-gatherers organized their use of the landscape. Whether social environment, natural environment, or both were the ultimate causes of change remains unclear. We can speculate that changes extrinsic to the quarries may have caused the archaeological record at Tosawihi itself to change; in that case, changes should be evident both at and away from the quarries. Alternatively, exploitation of the quarries may have changed absent extrinsic factors. In this case, there should be no contemporaneous change in the archaeological record away from the quarries.

Clearly, the resolution of such large questions requires a more regional perspective; since subsistence information is scarce throughout the northern Great Basin, however, it often will be similar to the evidence discussed above. In consequence, identifying and understanding changes in Great Basin land-use requires that *all* potential evidence be brought to bear in subsistence studies. This is why we have incorporated tools used to procure and to process food as evidence of subsistence along with direct indicators of subsistence such as floral and faunal remains. One advantage to this approach is that it skirts the problem of differential organic preservation. A second advantage is that it permits comparison with other studies, including surface surveys (cf. Thomas 1988). Through such comparisons, we eventually may address why hunter-gatherer subsistence patterns change through time.

Chapter 21

OPALITE REDUCTION TRAJECTORIES

Kathryn Ataman and William W. Bloomer

Lithic technological systems are comprised of one or more trajectories, that is, regular sequences of transformations resulting in final lithic products. The dominant patterns created by these sequences are dendritic trajectories, their nodes constituting stages along the reduction continuum. Nodes are visible where changes in reduction technique or approach occur. In large part, the patterns we observe probably resulted from repeated responses to recurrent situations arising within a specific technology during the reduction of a particular artifact class.

The trajectory concept is used here to examine strategies in the production of certain artifact classes; we inquire as well into the organization of work and the standardization of production. Various trajectories within a technological system may be interrelated, and in some cases they are quite complex. For example, flakes (by-products of the production of a particular artifact class) fall out of one trajectory at the point they are produced; if selected for further processing, they become incorporated into a separate trajectory. Breakage in manufacture, reworking, and resharpening also are elements of the trajectory, of which the end point is the broken or discarded tool.

In recent years studies of lithic technology have contributed insights toward understanding broad issues such as forager mobility strategies and technological responses to raw material availability. The trajectory concept increasingly has served some of these questions (Sampson 1985; Amick 1985; Bamforth 1986; Zeier and Elston 1986; Kelly 1988). Some analytic schemes are highly formalized (e.g., Elston 1986c) while others are extremely generalized (e.g., Muto 1971b). The notion of trajectory commonly has been used to contrast coexisting technologies using raw materials differentially, especially where, for example, exotic materials are used more intensively than local toolstone. Our concerns at Tosawihi differ from many of these studies, since primarily *one* type of raw material is present and there appears to be little constraint on its use (judging by the vast amounts of discarded debitage). We have opted for a scheme which follows an artifact from blank to finished or discarded item and notes where by-products leave the primary trajectory to be discarded, exported, or incorporated into a secondary trajectory.

At Tosawihi, bifaces are the primary focus of lithic production; almost all biface reduction can be subsumed by a single trajectory, although blank type, stage of heat-treatment, and stage of export vary. A wider variety of other tools was produced through other trajectories. The various trajectories are not completely discrete, however; the production of biface blanks may partake of the same processes used for flake tool blank production, and both forms may be obtained as by-products of biface manufacture.

As noted above, trajectories often vary with raw material; this is true at Tosawihi. Obsidian and basalt trajectories vary considerably from that of opalite, not so much due to material flaking qualities as to the raw form of the material and the intended final product.

Because Tosawihi is a production site and artifacts usually were exported in unfinished form, steps involved in finishing (in addition to much of the reworking and resharpening undertaken throughout the use-life of an artifact) often are not visible. Evaluation of Tosawihi materials produced expectations regarding the form of export and general use of the toolstone after it left the quarries. Various production stages have been defined in light of these expectations, but trajectories cannot be reconstructed completely without reference to the use of Tosawihi opalite outside the quarry area. As noted above, evidence concerning the ultimate fate of artifacts leaving Tosawihi is indirect. The trajectories into which we assume bifaces passed after leaving the quarries are discussed in the concluding section of this chapter.

We have observed two primary trajectories, reflecting biface reduction and flake core reduction. Secondary trajectories, initiated on primary by-products, also are present; most often, the end products of these trajectories are flake tools or projectile points. The relevant evidence is discussed below.

The Reconstruction of Trajectories

Lithic trajectories can be observed through examination of bifaces, flake tools and points, and debitage (as well as their distributions) across the project area, and through the incidence and nature of heat-treatment at sites within and beyond the quarry vicinity. Several categories of observation are discussed below.

Blank Production

Blank procurement is the first step in any kind of reduction. While blanks are removed from areas where they are produced, debitage characteristic of their production is found at quarries. Where flake blanks are produced from quarried chunks or blocks, this debitage consists of irregular flakes of various sizes, shatter, and fragments of matrix waste material. Blanks can be produced directly from bedrock outcrops as well, or from bedrock faces in quarry pits, leaving only negative scars as evidence of their production. Alluvial or colluvial cobbles also can serve as blanks, and can be reduced as blocks or used as cores for the production of flake blanks. The reduction of cobble blanks is signalled by flakes with cobble cortex while the use of flake blanks is signalled by flake blank characteristics on the ventral surfaces of early stage bifaces, by the presence of bulb removal flakes in the debitage, or by significant numbers of flake cores in association with biface thinning flakes. The use of block blanks can be inferred in cases of early biface reduction when cobble and flake blank evidence is absent.

Blank Morphology

Early stages of artifact production largely are dependent upon initial blank form. Blank form frequently can be determined on early stage, less reduced bifaces, but only infrequently on middle or late stage bifaces. In contrast to bifaces and projectile points, flake tools seldom are reduced extensively after obtaining the blank (unless made on biface fragments); consequently, blank form can be determined more frequently than on bifaces. Blanks used for the production of projectile points often are difficult to recognize; their form is observed more easily on points made on thin flakes reduced entirely by pressure flaking, since some portion of both surfaces may be left unflaked. In contrast, larger points tend to be made on percussion flaked bifacial preforms; evidence of blank form generally has been obscured. The lengths of blanks made on biface thinning flakes, provide indices of original biface size and stage of detachment, reflecting the points at which artifacts left the biface trajectory to enter a secondary trajectory.

Biface Staging

Like other lithic artifact forms, bifaces progress through successive reduction stages; they are reduced more extensively than many tool forms, however, and the stages through

which they pass are more numerous and easier to define. Many biface technologies are generalized over much of their reduction sequence, and a common analytical scheme (e.g., that of Callahan 1979) suffices to describe them. The scheme we have used is based on Callahan's but has been modified slightly (cf. Chapter 6). Although not every biface fragment can be placed within the staging framework (since our approach is based primarily on extent of reduction rather than metric attributes), we usually can assign any biface to a *general* stage (blank or edge preparation, primary thinning, secondary thinning, or finishing) and often can be more precise (e.g., early or late primary thinning). In most cases, the bifaces observed represent failures; many are broken, and some are badly proportioned. Cache bifaces, which we assume were prepared and stored at the quarries for recovery and perhaps additional processing at a later date, are an exception (cf. Chapter 6). Caches contain most of the unbroken bifaces recovered from Tosawihi. Characteristics such as blank type, size and proportion at different stages, as well as standard techniques of manufacture, can be understood more easily by examining complete (and, we assume, non-discarded) specimens. The proportions of different stages and the incidence and stage of heat-treatment in cache samples also can be compared to those in the assemblage as a whole to assess the form in which bifaces left the quarries, but many are reduced further along the reduction sequence than cache bifaces. Cache bifaces, then, may have been left at Tosawihi for later recovery, but they probably were processed further prior to export.

Debitage is also used to characterize stages of reduction and to reconstruct the operative trajectories. Presumably many bifaces were removed from the quarry vicinity, and because they do not break in equal frequency at all stages of reduction, the stages of exported bifaces are unlikely to be the same as those represented in the assemblage. It may be that debitage is a more accurate index of stage production than of stage at moment of export. Mass analysis and a typological technological analysis were used to characterize the debitage recovered from features, and this information also has been incorporated in our reconstruction. However, mass analysis does not allow fine-grained determinations of stage. Since only a small sample of material could be analyzed with more detailed analytical techniques, much of the analysis is based on examination of bifaces rather than debitage.

Reduction Techniques

Several categories of debitage are characteristic of different types and stages of reduction. These distinctions are discussed in detail in Chapter 10. In general, biface reduction can be recognized by the presence of significant frequencies of edge preparation flakes and biface thinning flakes.

Flaking mode, or the technique by which flakes are detached, is another category of evidence useful in reconstructing trajectories. This bears most significantly on questions about the standardization of production; hard hammer percussion may be used throughout the trajectory, or, at some point, may be replaced with soft hammer percussion or pressure flaking.

The distinction between hard hammer (usually hard stone) and soft hammer (antler, bone, wood, or soft stone) percussion flaking is difficult to recognize on the surfaces of bifaces or other tools, but its diagnostic attributes are more apparent in debitage. Unlipped platforms and prominent points and bulbs of percussion (indicative of hard hammer flaking), as opposed to lipped platforms, diffuse bulbs and vague points of percussion (soft hammer flaking) seem to be good separating criteria (Newcomer 1970; Ohnuma and Bergman 1982; Hayden and Hutchings 1989). Although unquantified in our study, soft hammer flaking probably was relatively common in biface reduction at Tosawihi. Supporting this view is the recovery of what appear to be two antler hammers (cf. Chapter 14; Schmitt and Carroll 1992), both from quarry pit contexts.

Pressure flaking may be recognized either from negative flake scars or from the presence of pressure flakes in the debitage, generally recovered only in 1/8 in. screened samples. Few bifaces in the assemblage appear to have been pressure flaked (all are Stage 4 or 5); most pressure flakes probably resulted from preform and projectile point manufacture. An antler pressure flaker was recovered.

Heat-treatment

Heat-treatment of opalite was a common practice at Tosawihi. Heat-treatment of silicious toolstone improves its flakeability, and changes its appearance. It is most useful for biface thinning and pressure flaking because less force is required to detach flakes and better control is possible. Patterns of heat-treatment provide evidence about the standardization of tool production, and more indirectly, about the intended use of the final product. The frequency of heat-treatment in the production of various artifact classes and the stage at which it was undertaken is compared, between sites within the quarry area and others farther away where artifacts, the production of which began at Tosawihi, were reduced further or were used. These data allow us to address the form of export and ultimate use of bifaces made at Tosawihi.

The incidence and stage at which heat-treatment was conducted can be recognized by differential luster on lithic surfaces, generally allowing us to distinguish among pieces heat-treated while still attached to a core, as blanks, or during the course of reduction. When a core is heat-treated and a flake then is detached from it, the entire ventral surface of the flake appears lustrous. However, when a flake is heat-treated, only negative flake scars produced *after* heat-treatment are lustrous. If heat-treatment has interrupted reduction, both lustrous and dull scars are present. When all flaked surfaces appear lustrous, such as in the case of late stage bifaces or finished or nearly finished projectile points, the necessarily earlier stage at which heat-treatment was undertaken cannot be determined.

Primary Trajectories

Biface Reduction

Most bifaces at Tosawihi went through a similar production sequence and appear to be products of a somewhat standardized technological system. However, variability in the shape of blanks required different approaches. Variability among individual knappers, using different tools and raw materials, also can affect the details of reduction but probably less so than blank form. So, although most Tosawihi bifaces were reduced at least part way through the following sequence of stages, the vast majority never reached Stage 5 and only 15% reached Stage 4, as they usually were removed from the quarry prior to finishing (Figure 222).

Stage 1 Blank Procurement/Production
Stage 2 Blank/Edge Preparation
Stage 3 Primary Thinning
Stage 4 Secondary Thinning
Stage 5 Finishing

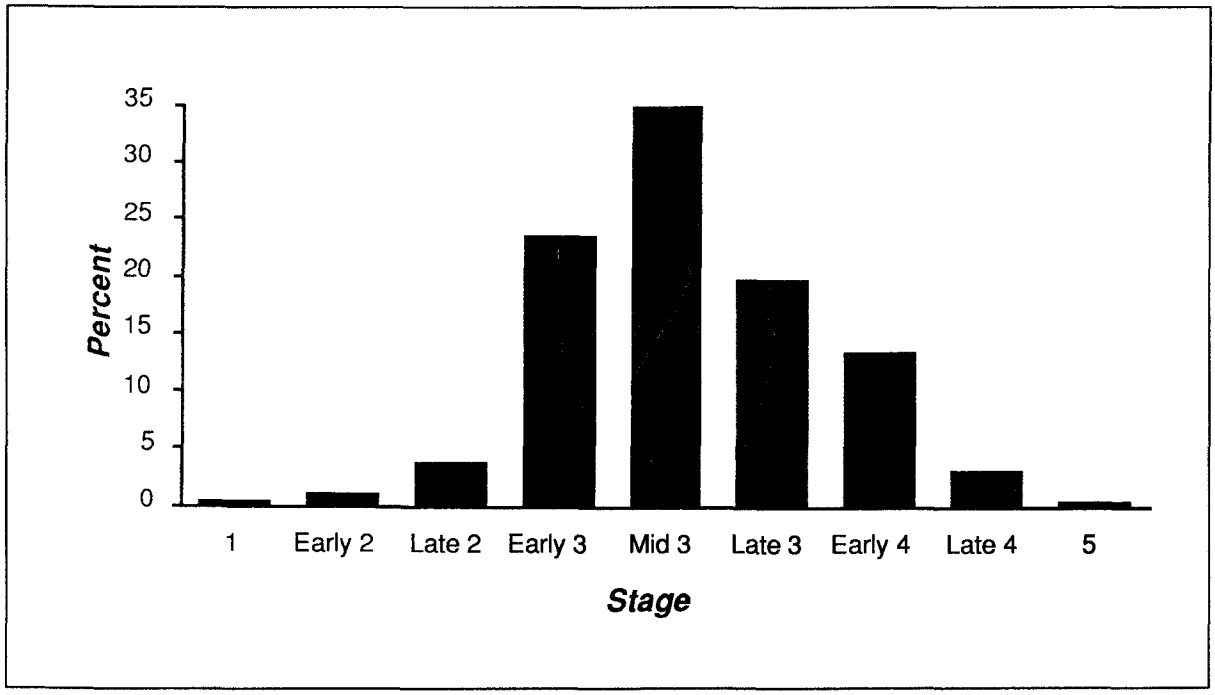


Figure 222. Proportions of bifaces by stage in opalite assemblage (indeterminate stages not included).

Figure 223 outlines the reconstructed Tosawihi biface reduction trajectory. Blank procurement consists of the process of obtaining blanks in the form of cobbles, blocks, or flake blanks. Flake blanks may be produced directly from bedrock or detached from cores, while cobbles may be collected from drainages or colluvial deposits; blocks usually must be extracted from a bedrock matrix. Blank type was recorded for only about half of the biface assemblage. Of these, 33% could be identified as flake blanks, and only 1% as cobble blanks. As noted above, blocks are recognizable primarily from an absence of contradictory data, but we assume they sometimes served as blanks. Also, there are few cores in the assemblage and it seems unlikely that they were the primary source for flake blanks unless further reduced into bifaces. Artifacts of this stage are difficult to recognize and cannot be distinguished from discarded, unselected quarry debris. Therefore, we have declined to identify bifaces from this stage in settings near toolstone sources. If removed from the immediate source, pieces suitable for biface production are assumed to have been selected from the quarry debris and are designated Stage 1 bifaces, although reduction has not been initiated.

In Stage 2, the blank is prepared for thinning with the intent of producing a bifacial edge on which strong platforms can be prepared. At Tosawihi, the processing of Stage 2 bifaces is quite variable, and is largely dependent on the original blank form; flake blanks require less preparation while cobbles and blocks require more. Thin, wide flake blanks can be edged for primary thinning with a minimum of effort, but blocks with thick edges need more extensive preparation. Blocks vary in shape from slab-like to very blocky and this variation also affects the process of reduction; slab-like pieces are reduced in a fashion similar to flake blanks. In this stage the flaking mode is primarily hard hammer percussion. Its by-products consist of characteristic edge preparation flakes and non-diagnostic flakes, some of which are large enough to be selected for inclusion in other trajectories. This stage was divided into early and late substages, which comprise 1.1% and 3.7% of the total classifiable assemblage. It is possible that some bifaces were exported at this stage.

Stage 3 reduction consists of primary thinning. The intention is to thin the biface without significantly reducing its width. In this stage, flake scars only infrequently extend beyond

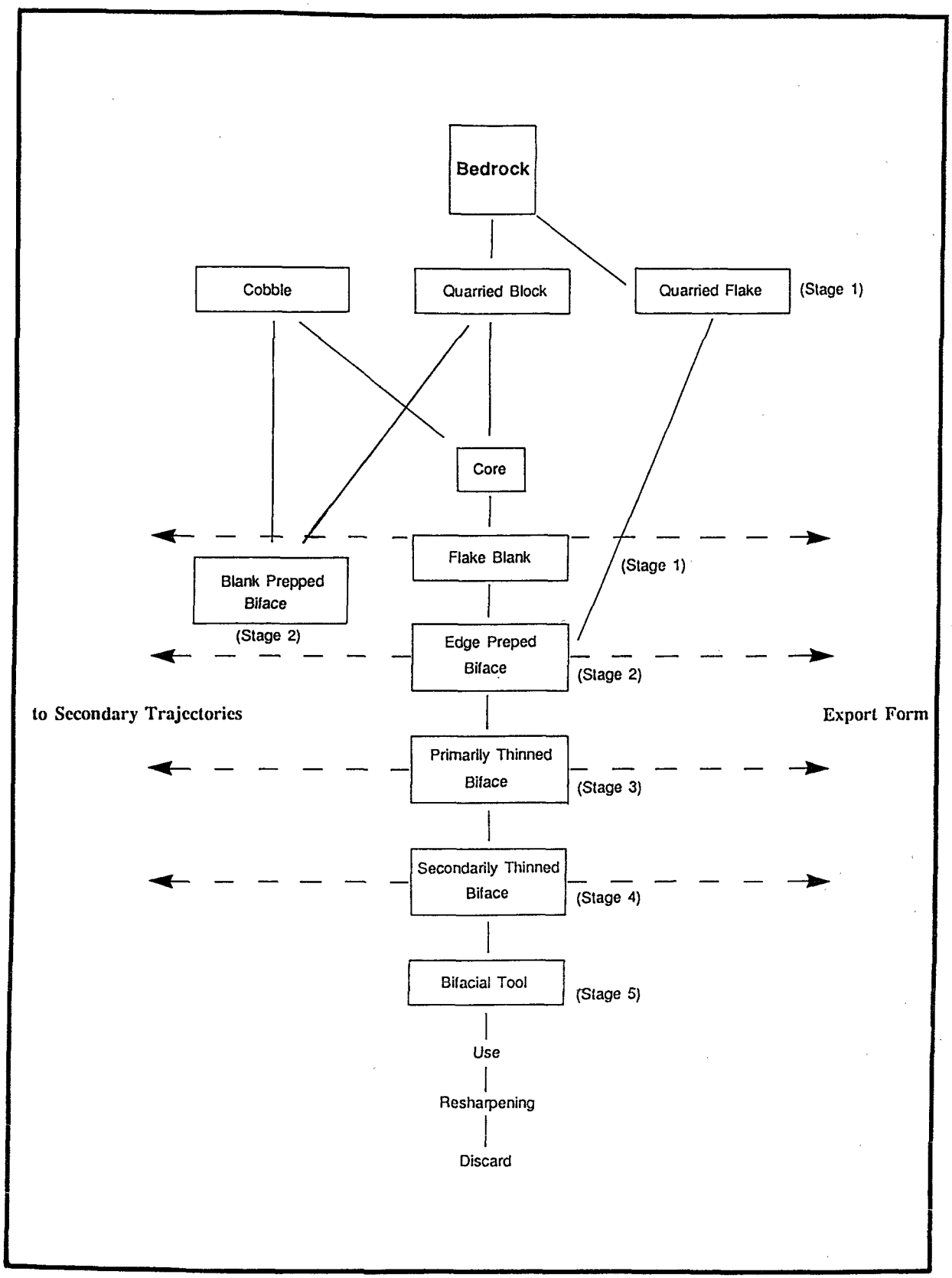


Figure 223. Biface reduction trajectory.

the mid-line of the piece and the general cross-section approaches a lenticular form. Flaking may be by hard hammer percussion, soft hammer percussion, or both. The primary diagnostic by-products of this reduction stage are biface thinning flakes, some of which are large enough for use as blanks for other tools, but not for bifaces. Some bifaces of this stage may have been exported from the quarries. This is the primary stage of reduction represented at Tosawihi, comprising 78% of the biface assemblage; it was divided into early (23.6%), middle (35.2%) and late (19.3%) substages.

In Stage 4 the biface is thinned further. The flake scars usually are smaller and may be produced with hard hammer percussion, soft hammer percussion, or both. These scars frequently extend across the midline of the biface and the cross-section is lenticular or flattened/lenticular. The by-products are primarily small biface thinning flakes suitable for the production of small tools or projectile points. This stage has been divided into early and late substages, representing 13.3% and 2.9% of the assemblage respectively. Some bifaces were almost certainly exported in this form.

Stage 5 involves regularizing the edge, preparing hafting elements, or further shaping and thinning, sometimes employing pressure flaking; a finished bifacial tool is the final product. At this point our staging scheme deviates from that of Callahan, which contains additional stages originally intended to describe the production of Clovis points. Only 11 Stage 5 bifaces were recovered at Tosawihi, testimony that few bifaces were exported from the quarries as finished tools.

If the primary reason for visits to Tosawihi was procurement and processing of toolstone, it is unlikely that many bifaces produced there reached the end of their use lives at the quarries. A sample of bifaces was selected from the most apparently finished specimens and examined for use wear traces. A small proportion evidently were used as cutting tools, but most recovered Tosawihi bifaces were broken in manufacture and discarded before becoming bifacial tools.

Many bifaces broke and were discarded (falling out of the trajectory) during the course of manufacture. If broken fragments were large enough, they were repaired and reduction continued. Thus, the frequency of breakage at a particular stage is not reflected accurately by the number of biface fragments; experimental replication is required to estimate the true frequency. Our replication experiments and examination of the incidence of breakage suggest that bifaces do not break often during edging (Stage 2), and that heat-treated bifaces are more likely to break at *any* stage (except perhaps, during pressure flaking) than are non-heat-treated ones. So, although most bifaces recovered from Tosawihi are classified as middle Stage 3 (35% of those that can be placed within the staging framework), this stage may not represent the primary form exported from the quarries.

Heat-treatment

At Tosawihi, some bifaces of every stage were heat-treated, the proportion increasing through the reduction sequence. Seven percent of Stage 1 bifaces were heat-treated, rising to 72% in Stage 5 (Figure 224). Heat-treatment appears to have been a standard step in the reduction continuum, intended to facilitate biface thinning and to increase knapping control. Our heat-treatment experiments show that while the failure rate due to overheating is low (it is more difficult to *reach* the required temperature than to exceed it), the incidence of breakage increases after heat-treatment. Thus, risk involved in heat-treatment is low while risk in thinning after heat-treatment is relatively high. Heat-treatment occasionally was initiated early in Stage 2, but more often undertaken during Stage 3.

Some variation in the incidence of heat-treatment by stage may be related (as are many other characteristics of biface production) to the shape of the original blank. If heat-treatment

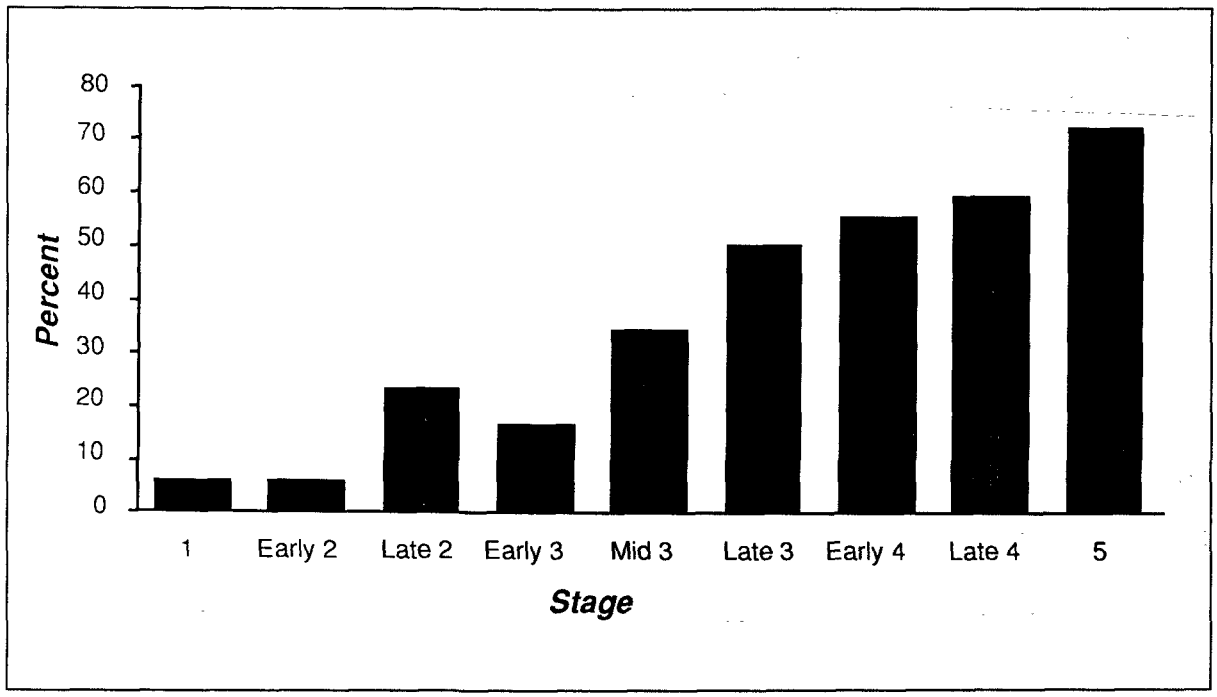


Figure 224. Heat-treatment of opalite bifaces by stage.

was initiated primarily to facilitate secondary thinning, relatively thin Stage 2 bifaces may have been heat-treated earlier in the reduction sequence than thicker but more reduced Stage 3 pieces. From another perspective, heat-treatment may have been undertaken at the point of the change in flaking mode (hard hammer to soft hammer percussion) which allows more controlled thinning.

In sites along the Northern Corridor, the size of early and middle Stage 3 bifaces is very similar, as is the incidence of heat-treatment in the two substages; in the assemblage as a whole, as well as within both of the other subareas, later stage bifaces are smaller and more frequently heat-treated. The pattern in the North suggests that small flake blanks, as well as partially reduced bifaces, were reduced at those sites.

Flake Core Reduction

Core reduction represents an independent trajectory when it involves the production of flake blanks for tools other than bifaces, but when used for the production of biface flake blanks it is part of the biface trajectory. A diagram of the reduction process involved in the flake core trajectory is presented in Figure 225. Cores can be produced either from cobbles or from quarried blocks, and early stage bifaces also may serve as cores. Considerably more cores than bifaces were made on cobbles. We assume that the production of flakes from cores for the production of bifaces and other tools was not common at Tosawihi. This assumption is based on recovery of few cores (137 cores as opposed to nearly 4500 bifaces); too, they are small relative to bifaces. If cores were reduced further (or transformed into bifaces) however, they may not be recognizable; in this case, the incidence of core reduction for the production of flake blanks may have been somewhat more common than is apparent. Although platform preparation may have occurred, cores at Tosawihi generally received little preparation other than rough shaping before flakes were detached. The types and sizes of cores vary widely, and

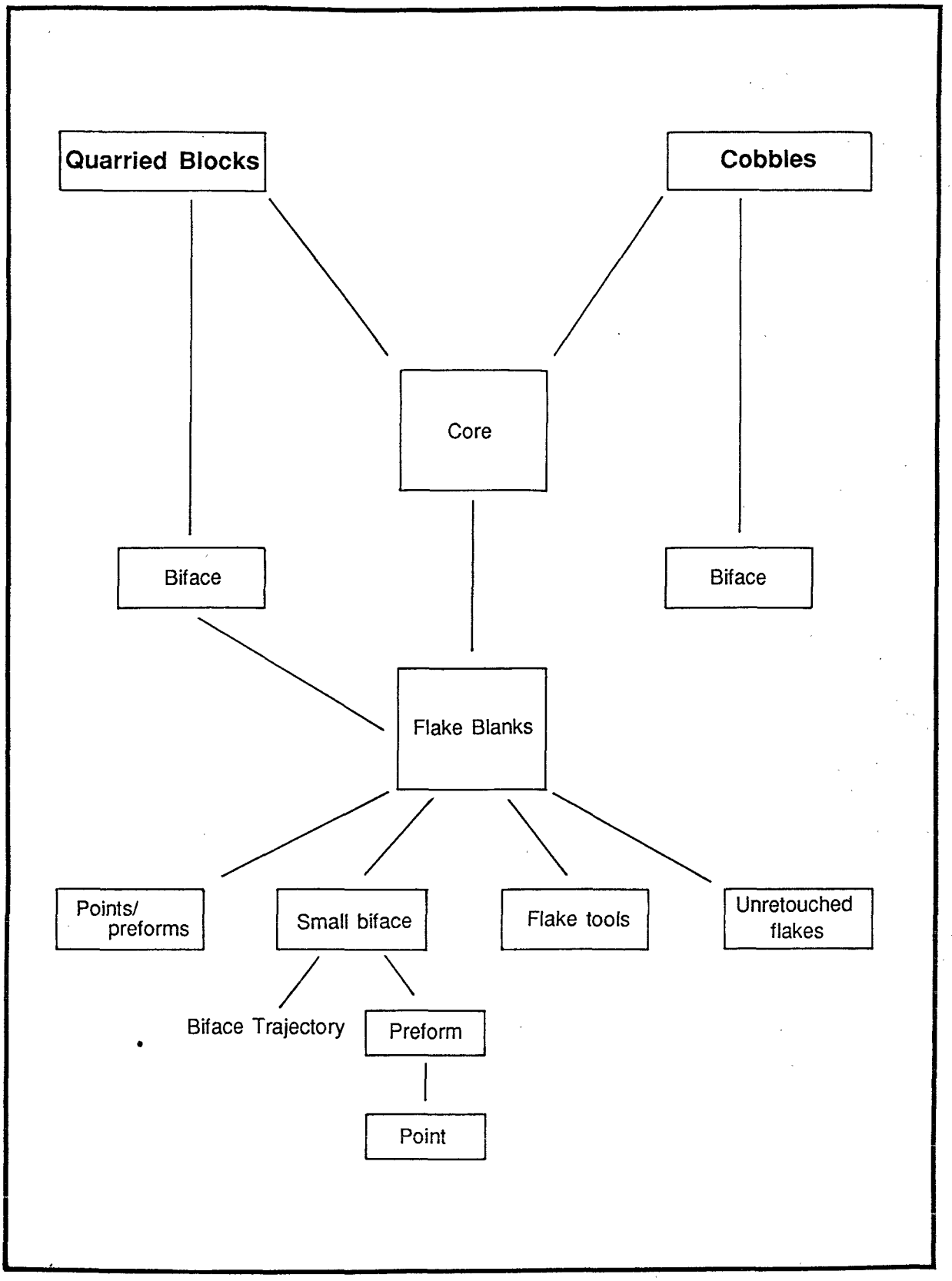


Figure 225. Core/flake reduction trajectories.

most are rather irregular; flakes produced from them could have been made into very small bifaces, flake tools, or projectile points. Hard hammer percussion probably was the flaking mode employed; its by-products would be non-diagnostic flakes.

Secondary Trajectories

Secondary trajectories represent sequences of reduction using blanks obtained as by-products of a primary trajectory. At Tosawihi, the primary trajectory providing blanks for secondary ones is the biface trajectory, although exhausted cores conceivably could be recycled into bifaces. Figure 226 reconstructs these secondary trajectories.

At several points along the biface trajectory, flakes suitable for the production of other tool categories are produced, usually during blank production, primary thinning, and secondary thinning; their size dictates the forms into which they subsequently are reduced. Flakes produced during blank preparation or primary thinning can be quite large, and could have been used for the production of almost any category of flake tool, point, or small biface; those produced during secondary thinning probably were used primarily to produce preforms for small projectile points. Since many of the blanks used in the production of flake tools, preforms, and points were made on biface thinning flakes and, we assume, because few flake cores have been recovered, biface reduction was the primary route by which blanks for flake tools, preforms, and points were obtained.

It is difficult to segregate flake tools broken in manufacture from those broken during use. Likewise, reworking is difficult to recognize on tools made on flake fragments. Projectile points and preforms have more standardized forms, and thus are easier to recognize than flake tools when broken in manufacture. Preforms are broken throughout the reduction sequence but very few were broken fatally during final finishing (at least, not during notching). Points commonly break in both manufacture and use, and the fractures produced by each kind of failure often are indistinguishable. Reworking of points is easier to recognize than in other tool classes; at Tosawihi 9% of the projectile points show evidence of reworking.

Use wear on flake tools reflects a wide range of functions at many of the larger sites. Many of these tools exhibit intensive wear but no evidence of use in multiple actions, indicating that they were made for specific purposes. While projectile points were manufactured, used, and reworked *in situ*, some points could have been imported in finished form. Projectile points were made in three ways: small points (arrowpoints) were made directly on thin flakes, while larger points (dart or spear points) sometimes were made on percussion flaked bifacial preforms with later pressure flaking; stemmed points were percussion flaked and edge ground, without pressure flaking finishing.

There are one third as many flake tools, preforms, and projectile points as bifaces in the assemblage. Our use wear studies indicate that only a small number of late stage bifaces were used *at* Tosawihi. Although only a sample of bifaces was examined, it is clear that most were exported unused and unfinished. This contrasts with the flake tool and projectile point assemblages, which almost certainly were produced primarily for *in situ* use.

Heat-Treatment of Flake Tools and Points

As with bifaces, the heat-treatment of flake tools and projectile points can be undertaken before the flake blank is detached from the core (or biface), as a blank, or during the process of reduction. About 20% of flake tools were heat-treated; this is a lower proportion

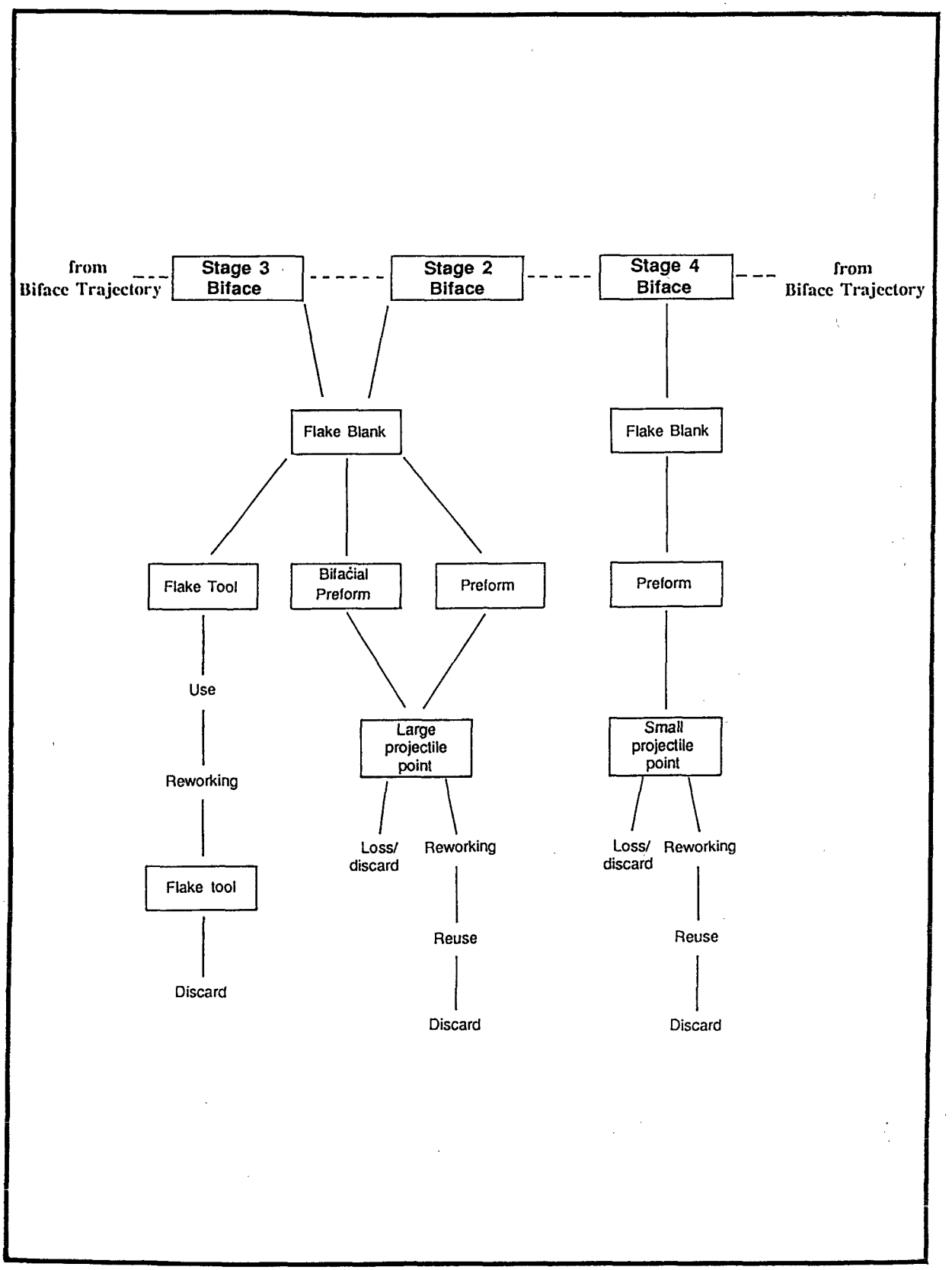


Figure 226. Secondary reduction trajectories.

than that for bifaces as a whole, while that for preforms and projectile points is quite high (60-80%). In these categories, heat-treatment appears to have been intended to facilitate pressure flaking.

Discussion

Length of Trajectories Represented in Various Subareas

It has been suggested that the length of trajectories present at particular sites may reflect the general function of those sites (Johnson 1989). The assumption is that tools are roughed out but not finished at quarry or short term extraction sites, and that a smaller segment of a particular trajectory may be present there than at maintenance activity sites where tools are finished, used, or resharpened. While this model generally may be true, it does not apply in all circumstances and varies with raw material and cultural system. For example, Gramly (1980) has described a quarry location where toolstone was quarried, tools were manufactured and finished, and exhausted tools were discarded; it contains the entire range of reduction stages.

Whether or not this concept can be used strictly to infer functional variation at Tosawihi, it is useful for comparing the portions of the reduction sequence present within the various subareas and contrasting these with the assemblages of sites outside the Tosawihi vicinity. Our four subareas exhibit distinctly different biface and tool assemblages. The Quarry subarea consists primarily of extraction sites where some processing and other activities took place. The Eastern Periphery contains some material sources but consists primarily of reduction stations, with limited residential activity. Sites in the Western Periphery and the Northern Corridor consist primarily of reduction stations or reduction stations with a residential component.

Figure 227 plots the segment of the opalite biface trajectory represented in each area. Two lines have been drawn for each subarea; that on the left marks the full extent of the trajectory present while that to the right signals only those stages represented by more than 1% of the local assemblage. Only the Quarry is represented by less than the full length of the trajectory. The more abbreviated lines are of similar lengths in all the subareas, but different portions of the trajectory are represented; the areas nearer the Quarry are earlier in the trajectory and those farther away are later. The line representing the trajectory fraction present at the sites we examined outside the Tosawihi vicinity is shorter, representing only the latest stages in the trajectory.

Consequently, while the bifaces from the Northern Corridor are more greatly reduced than those from the other subareas, the pattern still is more similar to that found at other sites within the Tosawihi vicinity than to those outside it. This suggests that all Tosawihi sites fall in a zone in which toolstone processing was the primary focus of activity.

Form of Export

We have inquired of the form in which bifaces and other tools were exported from the Tosawihi vicinity using data collected from both within and outside the immediate area. As noted in Chapter 6, cache bifaces, if stored for quick retrieval during short visits and intended for export without further reduction, should reflect the form in which bifaces were exported. They are, however, less reduced and less frequently heat-treated than the majority of bifaces

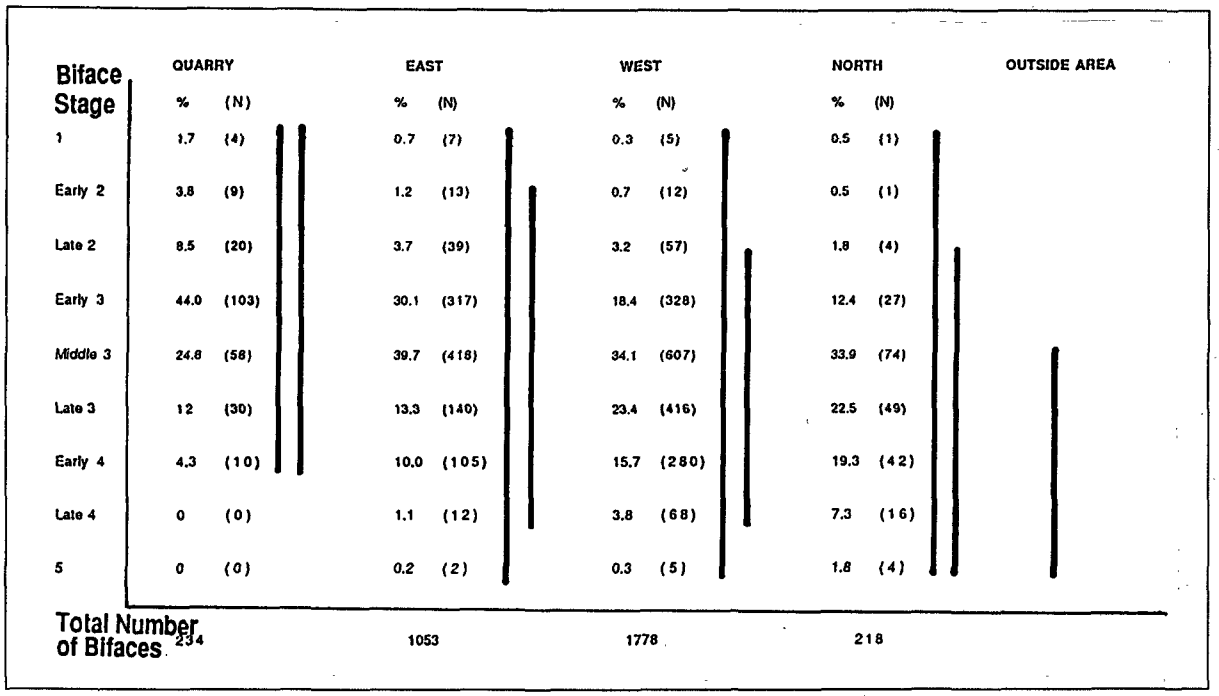


Figure 227. Length of biface trajectory represented in the subareas and outside the project area. Left bold line indicates full extent of trajectory present. Right bold line greater than 10% of trajectory present.

in the assemblage as a whole. Of 84 bifaces recovered from caches, the majority (77.4%) are early or middle Stage 3 and only two are heat-treated. It seems likely that these pieces probably would have been reduced further and heat-treated before export. As they clearly are not rejected products (in contrast to the majority of bifaces recovered), we have excluded them from the counts used in reconstructing the stage of export from fragmentary bifaces.

When subareas are compared, both stage of reduction and proportion of heat-treatment increase with distance from the quarry proper. This suggests that bifaces were exported from the quarry area at different stages, reflecting the distance of campsites from the quarry proper, and that bifaces were reduced progressively at campsites as the quarriers left the area.

As noted above, in order to investigate this further we also briefly examined material recovered at sites ranging from 12 to 60 km from the center of the quarry area. While Stage 1 and Stage 2 bifaces occur occasionally, almost all bifaces made of Tosawihi material at these sites are late Stage 3 or Stage 4 heat-treated specimens. This indicates either that bifaces were exported in a form later than early Stage 3 or that further reduction took place as they were transported. In addition, biface production debitage found at these sites almost exclusively is heat-treated, implying that most bifaces were heat-treated before export, or heat-treated before reduction was continued. It is unlikely that they were exported directly from the Quarry subarea because bifaces found there clearly are of earlier stage than those in the other subareas.

Most bifaces recovered at Tosawihi are middle Stage 3 (35.3%), and an equal proportion were reduced past that stage (cf. Figure 222). Most are broken, so we cannot assume that the proportions of stages present in our assemblage correspond directly to the proportions of each stage exported. Unequal breakage would affect the proportions of discarded pieces, and, in fact, replicative and archaeological studies (Amick 1985) as well as our own biface breakage data have shown that bifaces tend to break more frequently later in reduction. The difference in stage proportions of complete and broken bifaces in our assemblage can be seen in Figure 228.

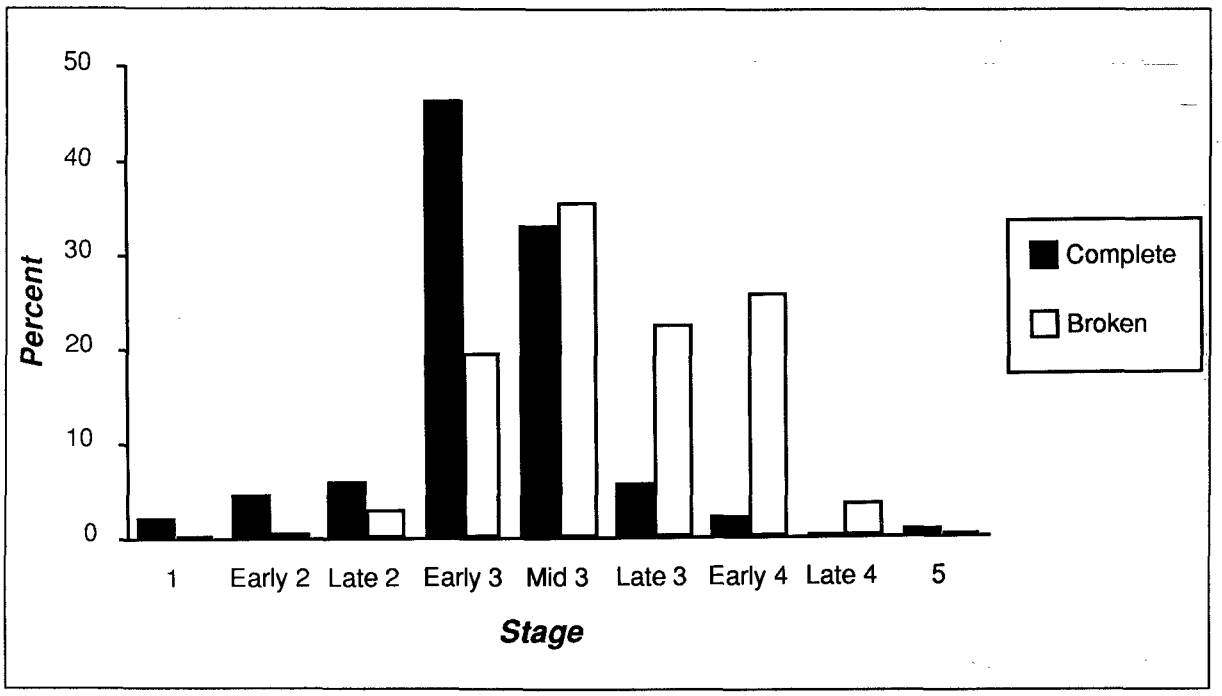


Figure 228. Proportions of complete and broken bifaces by stage.

When the differences between the samples of complete and broken specimens are compared, we see that breakage increases in middle Stage 3; broken pieces are significantly more frequent in late Stage 3. The proportion of broken pieces remains high in Stage 4, but the breakage rate may decrease somewhat toward the end of the reduction sequence. The point (late Stage 3) at which the steepest increase takes place probably reflects the point at which heat-treatment becomes common (Figure 229) and soft hammer billets may have come into play.

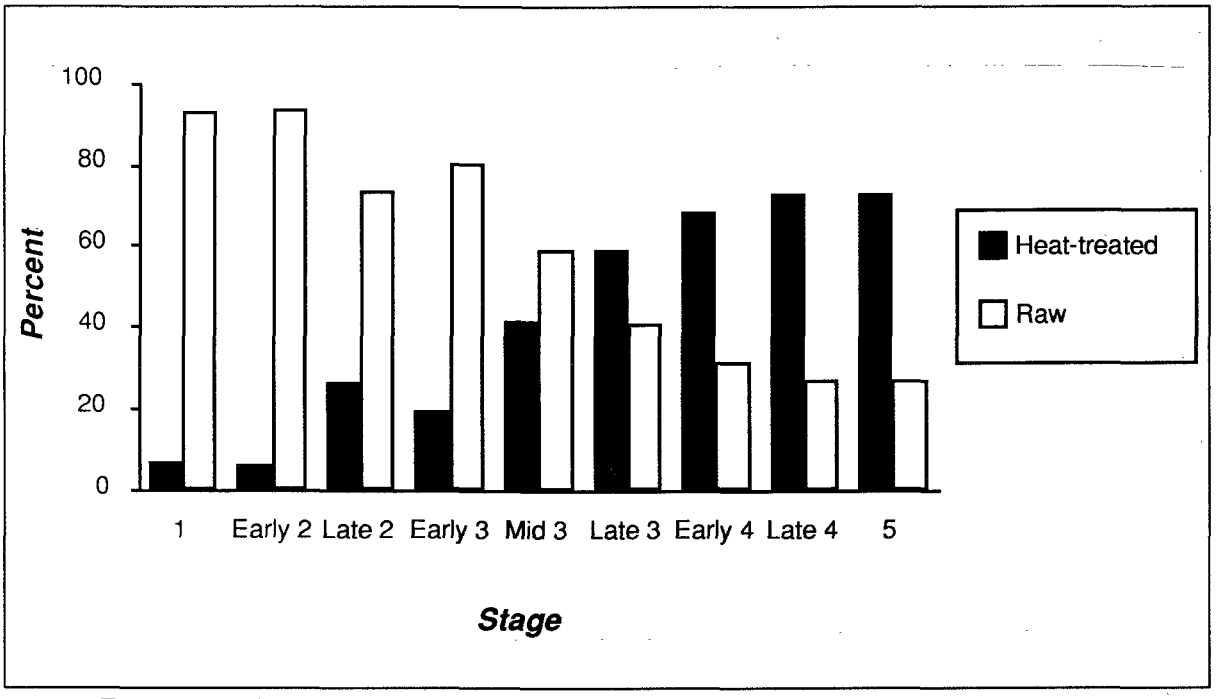


Figure 229. Heat-treatment of bifaces by stage.

Determination of the form of export is, thus, quite complex. In fact, it is easier to say what was not exported than what *was*. We already have rejected that most bifaces were exported in a form represented by cache bifaces and, likewise, we must reject the possibility that all bifaces were exported as middle Stage 3 forms, since 40% of those in our sample were broken during manufacture at a later stage. Few, if any, were exported as Stage 1, Stage 2, or early Stage 3 forms; these stages are rare in biface and debitage assemblages at sites away from the processing areas, and few are heat-treated.

This leaves a wide range of possibilities for export form, but the proportions of bifaces distributed among the stages in the assemblage represent failures; they were created by differential breakage rates increasing through the first half of the reduction sequence, rising most steeply between middle and late Stage 3 and leveling off subsequently. If no export is postulated until middle Stage 3, the breakage rates in each prior stage until that point should remain constant under various export scenarios. We already have determined that breakage increases from Stage 1 to at least Stage 4, and that all bifaces were exported at middle Stage 3 or later. Assuming a successful biface manufacture rate of 70% (Sassaman 1988) and a sample of 100 bifaces, patterns of export can be modeled and the derived breakage rates used to evaluate various scenarios.

Two rejectable possibilities are that no middle Stage 3 bifaces were exported, or that only Stage 5 bifaces were exported (i.e., that all bifaces were reduced to finished form). The darkened curve on Figure 230 illustrates the breakage rates which would have occurred in each stage under a scenario of no export until Stage 5. Neither possibility is acceptable because, irrespective of success rate, the large proportion of Stage 3 bifaces in the assemblage means that, while breakage rates should increase from Stage 1 to middle Stage 3, they necessarily would decrease after that point, which contradicts our observations. Therefore, at least some middle Stage 3 forms must have been exported, and we must conclude that the material leaving Tosawihi consisted of a *range* of forms, that is, middle Stage 3 bifaces and later stage forms. Most were heat-treated.

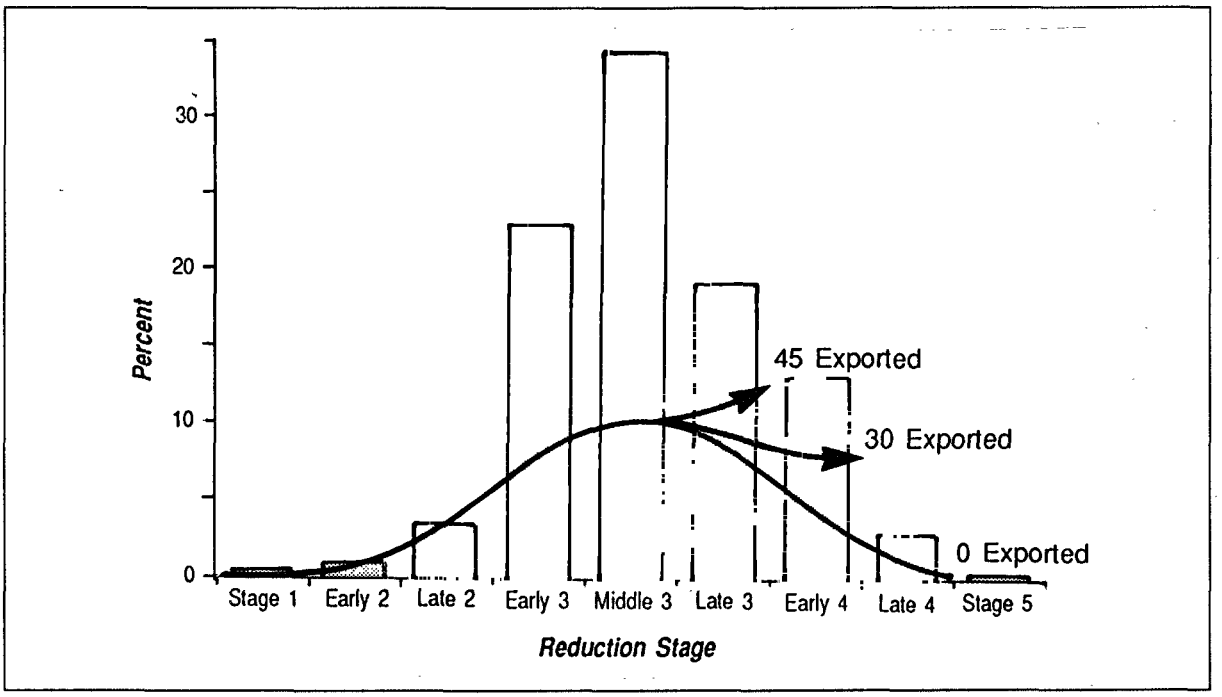


Figure 230. Estimated breakage rates with varying export in Middle Stage 3.

But can we be more precise about the mix of biface forms leaving the Tosawihi vicinity? If we spin out the same arguments, we can model various acceptable scenarios. Again assuming a 70% success rate, we modeled export of various frequencies and found constraints suggesting that 50-60% of the bifaces were exported at middle Stage 3, 15-20% in late Stage 3, and 15-20% in Stage 4. If 30 of the 100 sample bifaces were exported at middle Stage 3 (given the assumed success rate of 70%), the breakage rate in late Stage 3 would still be lower than in middle Stage 3 and, therefore, the number exported must be higher. If 45 of the 100 sample bifaces were exported at middle Stage 3, then the breakage rate increases dramatically between middle and late Stage 3. Thus, in order to effect an increase in the breakage rate between middle and late Stage 3, at least 50% of the bifaces exported must have left the system at middle Stage 3; if then, the proportion of remaining bifaces exported in late Stage 3 is greater than 50%, Stage 4 breakage becomes inordinately high, so we postulate approximately equal numbers of late Stage 3 and Stage 4 bifaces exported. Figure 231 illustrates possible export form bifaces.

Our conclusions concerning the export proportions are tentative; simulation programs could help explore the possibilities, by allowing us more easily to vary assumptions and to contrast the material exported from various subareas, but the conclusion that a mixture of stages was exported, with the highest proportion being middle Stage 3, seems secure. Whether this mixture should be ascribed to temporal changes in export form, varying preferences by different contemporary groups, or other reasons, cannot be addressed without better temporal control than presently available.

The export form of other artifact classes is even more difficult to determine. It seems likely, however, that, as noted above, tools other than bifaces were made primarily for *in situ* use.

General Function

Bifaces frequently are assumed to be cores (Kelly 1988), used away from quarry areas as sources for flake blanks for projectile points and other tools. Alternatively, they may serve as preforms for bifacial tools or knives. Since Tosawihi bifaces were exported in "unfinished" form, bifaces and debitage recovered from the project area can be used only indirectly to inform ultimate function. Heat-treatment provides one line of evidence; heat-treatment is an integral part of the Tosawihi reduction sequence, that by late Stage 3, (the principal stage at which bifaces were exported) more than half of the pieces were heat-treated. The size of flake tools and larger projectile points indicates that most were made on biface thinning flakes removed during early stage biface reduction. The size of preforms and arrowpoints shows that the blanks on which they were made could have been removed at any stage of reduction. The form in which they were heat-treated, however, indicates that they were not detached from heat-treated bifaces, and that most probably were made on early stage biface thinning flakes.

Almost all bifaces and debitage of Tosawihi opalite from sites away from the quarries were heat-treated, but projectile points were not made on flakes detached from heat-treated bifaces. This suggests not only that some number of raw flake blanks were exported in addition to bifaces, but also that at these sites bifaces did not often function as cores. Therefore, their reduction probably was in aid of the production of bifacial tools. Without further and more detailed examination of additional collections we can only suggest that most Tosawihi bifaces were intended to be knives; whether they were traded, and to what destinations, are questions awaiting further research.

Standardization of Production

The patterns observed in lithic reduction trajectories at Tosawihi indicate that, while the location of some elements vary, the sequence through which bifaces were reduced was quite formal.

Although we lack good chronological control for most samples, the quarry area clearly was exploited over a long period of time, and the patterns of toolstone procurement and processing observable there probably persisted for long periods. The quarries *could* have been exploited simultaneously by a number of groups, but, those groups must have shared approaches to the reduction of bifaces and may have shared a persistent technological tradition as well.

Whether specialist quarriers and knappers were the primary quarry users is impossible to address without more precise chronological control. As noted in Chapter 6, several special reduction techniques common to cache bifaces and in the assemblage as a whole may be peculiar to Tosawihi, and their presence may signal the presence of specialists. Other collections from production sites need to be examined to determine whether similar techniques are operating when future work at Tosawihi yields material with good chronological control, such questions can be examined more fully.

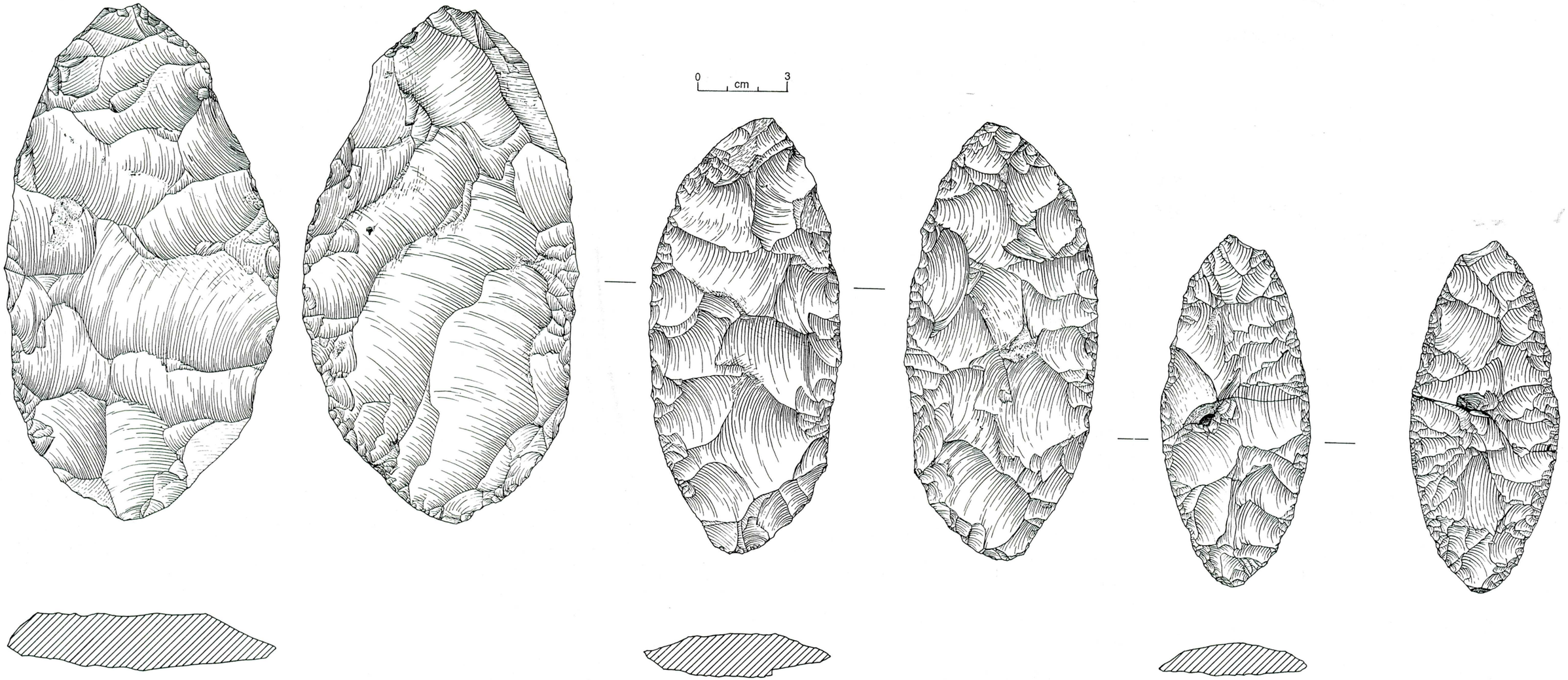


Figure 231. Possible export form bifaces. a. Late Stage 3; b. Stage 4; c. Stage 5.

Chapter 22

CREATION AND TRANSFORMATION OF TOOLSTONE EXTRACTION AND PROCESSING FEATURES

Robert G. Elston and Daniel P. Dugas

Among the many aspects of site creation and transformation, we focus here on the creation, development, and abandonment of quarry pits and associated toolstone processing features; we touch other domains peripherally.

According to Schiffer, archaeological inference is not simply a matter of assuming that past human behaviors were "the sole determinants of the present-day properties of the archaeological record" (1987:5), nor does one need only apply a set of correlates relating behavioral phenomena to their archaeological consequences in order to make reliable inferences. Schiffer (1987:7) cautions against taking the archaeological record at face value, as well as attempting to read behavior from it directly.

We suggested in Chapter 3 that, while Tosawihi is no Pompeii (Binford 1981b), its lithic deposits (and perhaps those of other quarries) are relatively unaffected by many processes that transform other kinds of artifacts and features in other contexts. We generally agree with Schiffer's admonition against taking the archaeological record at face value, but we are reasonably confident of our ability to define the archaeological consequences of lithic quarrying and processing from ethnographic analogy (Binford and O'Connell 1984; Binford 1986; Hayden 1979a; Jones and White 1988), and our own quarrying experiments (Carambelas and Raven 1991; Chapter 26, this report), and to recognize those consequences in the archaeological record. Surprises are possible, but we expect the range of residue-producing and deposit-disturbing prehistoric behaviors at quarries to be limited.

The interaction of cultural and natural processes creates the archaeological record. Our concepts of cultural and natural transformations are similar to Schiffer's (1976; 1987) C-transforms and N-transforms, but we are less interested in whether or not one set of processes has distorted the products of the other than we are in recognizing and separating their effects. Distinguishing human modification of cultural deposits from disturbance by natural agents is essential to interpret quarry pit stratigraphy correctly and account for the displacement or inversion of datable materials. Identification of natural agents and processes also helps avoid confusing certain natural features of site structure, such as root balls and depressed root zones, with cultural features.

Cultural and natural processes, moreover, act at different temporal and spatial scales. Natural processes operate more or less continuously, but are slowly incremental and tend to be overwhelmed when human agents are actively at work; cultural processes generate large volumes of material over relatively short periods of time. Thus, the ability to distinguish the products of natural and cultural processes allows one to estimate the volumes of material extracted and processed during a given interval, as well as to identify episodes of quarry pit abandonment. The extent of pedogenic modification to natural and cultural deposits also provides a clue to the relative time deposits have remained undisturbed by human agency.

Finally, if we are to understand why a particular quarry location was selected for exploitation, and understand the natural constraints on prospecting and mining it, we must understand the original extent of the outcrop as well as its degree of exposure, depth of colluvium, soil type, and other natural conditions prior to human disturbance.

In this chapter, we more fully develop models of site formation and transformation previously sketched (Elston 1988a 18-26; 1988b:32-39). Here, we describe the creation of

toolstone extraction and associated processing features based on ethnographic analogy and some results of our experimental quarrying, creating a general model of quarry site formation and cultural transformation of quarry site deposits. Drawing on our understanding of geomorphic processes and pedogenisis, we consider natural agents and processes that transform features created by humans. We describe the influence of bedrock morphology on quarrying strategies, and, finally, summarize the transformations to quarry sites expected after abandonment. Taken together, cultural and natural processes generate a model that accounts for the regular occurrence of certain types of surface and subsurface deposits in and adjacent quarries, and allows us to address such problems as the presence of inverted radiocarbon dates in some quarry deposits. Further support for this approach is provided by Wilke and Schroth (1989), who recently advanced a model of toolstone prospecting that closely parallels one of ours.

Creation of Toolstone Extraction and Processing Features

The ethnoarchaeological literature, particularly that of Australia, provides significant insights into the structure and content of lithic extraction and processing features (Jones and White 1988; Binford and O'Connell 1984; Binford 1986; Gould 1977, 1980:124-125; Hayden 1979a:51; O'Connell 1974, n.d.; Tindale 1965:140). When we apply these insights to the Tosawihi lithic terrane, we can make some quite specific predictions about the archaeological record. While the acquisition of toolstone is a continuum (like many other cultural processes), it can be divided for heuristic purposes into different activities corresponding to various aspects of search (including preparation and prospecting) and handling (including extraction and processing), as outlined in Chapter 3.

Procuring and Transporting Quarrying Tools

Fully embedded, encounter toolstone procurement of the type Binford (1979) attributes to the Nunamiut Eskimo requires no special preparation beyond ordinary outfitting to prepare for various contingencies of hunting and gathering. Intensive exploitation of toolstone at a quarry, however, might require some special preparation involving the procurement and transport of special tools needed for quarrying, lithic processing, and self maintenance. The acquisition of such tools involves costs and benefits distinct from the quarrying forays in which the tools eventually are employed, but it influences the costs and benefits of quarrying nonetheless. Tool transport increases travel costs (a component of search costs), but these may be balanced by decreased time and effort needed to procure tools at the quarry.

The benefits of transporting exotic tools depends on the availability of suitable local materials. For instance, Yolngu Aborigines procured quartzite hammerstones from a traditional named source some 60 kilometers from the Ngilpitji quarries and transported them to the quarries (Jones and White 1988:58). Although nicely rounded quartzite cobbles suitable for hammerstones and grinding tools are available in gravel bars along Willow Creek, none appears to have been transported the 12 km to Tosawihi. Aside from small obsidian artifacts, the most lengthy portage documented so far is a vitrophere metate carried 3 km to 26Ek3095 from its source to the east; the metate is not a quarrying tool, however, and may have been on its way elsewhere when it broke at Tosawihi.

Some transport of hammerstones occurred, but mainly involved more local materials moved over much shorter distances (cf. Chapter 11). Large basalt boulders obtained from Basalt Canyon were carried as far as 1.6 km to quarry pits on Butterscotch Ridge and Bordes Ridge. Smaller quartzite hammerstones obtained from Little Antelope Creek were used throughout the quarries, mostly for processing. This suggests that most quarrying, lithic

processing, and plant processing tasks were accomplished with tools made from local materials, without costly imports, and that people had time to collect them at the quarry, as well. Bison bone and elk antler tools recovered from quarry pits also might have been procured from kills at or near the quarries, but probably are personal gear procured prior to quarrying forays.

Prospecting

All toolstone is derived from bedrock, but weathering, erosion, and agents of turbation create and distribute rock fragments in soil and stream deposits as well. Thus toolstone may occur in massive bedrock surface outcrops, in beds buried by colluvium or alluvium, or as clasts in colluvium or alluvium. In lithically rich terranes such as Tosawihi, one may be confronted with lithic raw material in all its forms; in other places, only clasts may be present. *Prospecting* is the active search for lithic raw material; our usage of the term is somewhat broader than that of Wilke and Schroth (1989).

Encounter Assay

It is not unreasonable to assume that prehistoric people always were on the lookout for lithic raw materials, prospecting more or less continuously. We also assume that prehistoric people assayed likely rocks whenever time and opportunity provided by the lithic terrane allowed, following a "catchem up" strategy similar to that of the Nunamiut Eskimo (Binford 1979:258). Since it takes relatively little effort to scoop up a rock and detach a flake with another local stone, we might imagine such *encounter assay* occurring at frequent intervals as people moved through the landscape on their way to and from other business. Even were it impossible to stop and procure good stone, its location would be remembered, and the lithic terrane of the entire range would become mentally mapped in some detail. The greater time available, of course, the more reduction could be performed at the find locality.

Locating Toolstone at the Quarry

Once in the vicinity of a toolstone source, the first step in acquisition is to find a location where toolstone can be extracted. If a quarry already has been established, this may be fairly easy, since the surest alternative is to work in an existing exposure where the presence and quality of toolstone is known and the effort of extraction can be estimated closely. If previously exploited sources have been depleted, however, or the area is unknown, prospecting for new material must take place. Wilke and Schroth define "places where potentially flakable stone was assayed or tested for quality" as *lithic raw material prospects* (1989:146).

Upon arrival at the quarry, the first observed activity of both Yolngu Aborigines of Arnhem Land (Jones and White 1988) and Alyawara Aborigines of Central Australia (Binford and O'Connell 1984) was to wander over the area, looking at material exposed on the surface, and testing or assaying likely pieces by breaking them open and striking flakes from them. The Aborigines were not really interested in the surface material (which was too weathered to be useful), *per se* (Tindale 1965:140), but in what it indicated about the quality of subsurface rocks. The Yolngu paid special attention to places where previous lithic reduction had occurred, and members of both groups were interested particularly in partially buried boulders (Jones and White 1988:59; Binford and O'Connell 1984:411-412). The Alyawara used chunks of

toolstone as assaying hammers, while Yolngu apparently used the quartzite hammers they brought with them. The prospectors in both groups continually passed material back and forth, conferring on its quality.

Finally, at quarries the initial examination of surface material eventually is augmented by subsurface exploration, to which we extend the term "prospecting." Yolngu prospectors pushed over old trees in order to bring up subsurface clasts in their roots; both Yolngu and Alyawara excavated shallow pits, and expanded those that exposed good material. Small, shallow, exploratory pits abandoned without subsequent toolstone extraction are expected to fill in quite rapidly, and may be difficult or impossible to detect in the archaeological record.

Extraction and Processing

Whether or not to use surface material or expend time and energy to retrieve buried material appears to depend on the type of rock present in both surface and subsurface contexts, the task(s) for which stone tools are intended, and the time available for procurement (Gould 1980:124-125; Hayden 1979a; Torrence 1983).

Quarry pitting occurs when the payoffs in getting subsurface toolstone are higher than those of surface material. Gould (1977:163-164, 1980:124-125) observed the use of ubiquitous, medium to low quality surface rocks for expedient tasks, and their subsequent abandonment at the place of use (defined as *ephemeral stone acquisition and use sites* by Wilke and Schroth 1989:148). Nonetheless, Aborigines excavated one or two feet below the surface at sources of high quality white chert for unweathered, buried toolstone. While Hayden (1979a:51) saw no evidence of quarry pits at any of the Papuna opal sources he visited, one of his Walbiri informants recalled that people used to dig deeply for chunks of toolstone up to 50 cm in diameter (Hayden 1979a:51). Binford and O'Connell (1984) report excavation as an extraction technique for high quality material; Jones and White (1988) observed pits as deep as 55 cm.

Organization of Ethnographic Quarrying and Processing

Toolstone extraction and processing generates distinctive kinds of features and debris, including quarry pits and berms, adits, cobble concentrations, and dense flake scatters. The following description might well be of the Tosawihi Quarries, were we to substitute sagebrush for trees and opalite for quartzite:

> Between each rock exposure and clump of trees was a dense scatter of flaked and modified stone...Undulating depressions encircled by high densities of flake debris alternated with clusters of large blocks from which only a few flakes had been struck. Away from these clusters of 'big stuff', scattered on the sandier slopes or tucked under the edges of vegetation, were small, half-moon scatters of large flakes and a few chunks and blocks (Binford and O'Connell 1984:409).

Quarrying by Australian Aborigines was observed by Binford and O'Connell (1984) and Jones and White (1988). Although there is a logical order to assaying, extraction, and processing, these activities do not form stages in the strict sense. In both ethnographic examples and experimental quarrying, all three activities often occurred simultaneously, with some people prospecting and extracting while others processed extracted toolstone.

In all cases, a likely spot for quarrying was found by prospecting, as described above. Both Aborigine quarries contained quartzite clasts in a sandy soil matrix. The clasts seem to have been much larger in the Alyawara quarry than they were at Ngilpitji. At the Alyawara quarry, once a partially buried boulder was located, minimal excavation was conducted with digging sticks and hands to expose enough of the subsurface rock for assay (Binford and O'Connell 1984). This created a small, shallow pit around the buried rock, a slight berm of soil and waste rock (tailings) along the edge of the pit, and primary and secondary debitage, mostly in the bottom of the pit. Photographs provided by O'Connell (personal communication) show the first deposits of soil arrayed in fan shaped piles around the pit. When assaying returned satisfactory results, further excavation exposed and removed the buried rock, or, if the rock was too large, the "pit" came to comprise a trench around it. At the Alyawara quarry, larger boulders were moved with wooden levers, and were broken up using block-on-block and fire setting techniques; chunks of rock too large to move remained in the pit. According to Binford and O'Connell's map (1984:Figure 5), the three pits excavated at the Alyawara quarry were elongate and less regular in shape than those at Ngilpitji, ranging in maximum dimension from 150 to 225 cm; pit depths are not reported.

At the Alyawara quarry, pits were concentrated around a large surface boulder; distances between them varied only from 50 to 75 cm (Binford and O'Connell 1984:Figure 5). A large core separated from a boulder by fire was moved with a lever about 1 m to the pit margin. Unable to manipulate this block easily, the knapper worked around and around it, leaving a ring of debitage encircling the partially reduced core. Other, smaller cores (ca. 45 lb) were transported from 1 to 6 m from their pits of origin. The distance between individual processing locations varied from 3 to 5.5 m. At each processing location, the knapper sat on the ground with the core in front of him, striking platform facing to the right. Trailing away from the core to the right was an arcuate scatter of debitage with a radius of about 1 m, in which items appeared to grow smaller with distance from the core. Larger items, however, accumulated along the margin of the scatter away from the knapper, where they perhaps were tossed in order to keep the area around the core clear. The area to the left of the core was mostly free of debris. Items selected by the knapper for further reduction or later use were placed by his right knee. The total area in which the three Alyawara performed extraction and processing was approximately 72 m^2 or 24 m^2 per person in the three man work party.

Work at Ngilpitji quarry was divided into two sessions. During the first, pits were excavated, stones assayed, and one of the older men, Dhulutarrama, manufactured blades and flakes. In the second session more blades were produced by Diltjima, and blades were reduced to points by the younger Roger Yilarama. At Ngilpitji, most clasts were cobble to small boulder in size. Using a metal bar as a digging stick, one man excavated five roughly circular pits ranging from 30 to 120 cm in maximum diameter and from 20 to 55 cm in depth. Fire setting was known to the Yolngu Aborigine quarrymen observed by Jones and White (1988), but was not used during the particular foray described, apparently because there was no need for it in the extraction of relatively small clasts from their sandy soil matrix. Working into a face cut into the downslope side of the pit, the quarryman extracted small boulders of quartzite and piled them in berms along the sides of the pit as he worked, mostly in the uphill and downhill quadrants. The berms of boulders, soil, and coarse flakes appear from the map presented by Jones and White (1988:Figure 3) to range from 20 to 50 cm in width. The boulders were examined, likely ones assayed, and some selected for further reduction as cores.

At Ngilpitji, the distance between quarry pits ranged from 1.5 to 13 m. Cores were reduced by the two more experienced older men, Diltjima sitting about 1 m from the pit margin, and his assistant, Yilarama, 1 m to 2 m away from him. Dhulutarrama reduced cores about 7 m from the pit, where a fallen log provided a work surface. The total area occupied by quarry pits and reduction locations was 230 m^2, or 46 m^2 per person in the work party.

Diltjima placed cores in a shallow pit on a grass pad on his left side as he sat on the ground. The hammerstone was swung across the front of the body. Diltjima piled some of the primary flakes adjacent to the core on the side about 50 cm away from him; later, he inspected

each flake and placed it in a pile behind him, where they were culled by Yilarama for suitable point and tool blanks; the unused flakes formed an elongated elliptical scatter about 50 x 200 cm extending behind Diltjima. Small flake debris was swept away to the side with the primary flakes. While Diltjima reduced cores, suitable flakes were made into points by Yilarama employing direct percussion with the blank resting flat on an anvil stone, using another large flake as a hammer. In one case, small flake debris were dropped in a semicircle around him, in another, in a pile on his right. A pile of unretouched flake blanks was left here as well. Yilarama carried the finished points to a place about 9 m east, where other men had gathered to gossip, and some additional retouching was done there. This was only about 5 m east of the location at the fallen tree where Dhulutarrama had reduced several cores.

Experimental Quarry Pits

In experimental quarrying at Tosawihi, three quarry pits were excavated, comparable in size to the ethnographic examples described above (Carambelas and Raven 1991; Chapter 26, this report). Tools included hammerstones, a digging stick, cow scapula scoops, and a metal dish pan used as a "basket". All the experimental pits attempted to expose beds of opalite more or less parallel to the ground surface. The first was excavated blindly though soil and into unsilicified tuff in the vicinity of a prehistoric quarry pit, but toolstone never was encountered. Upon abandonment, this pit was roughly oval, 66 x 99 cm in plan and 75 cm deep, with a berm over 100 cm wide. A second pit was excavated at Locality 36 of 26Ek3032, where a backhoe trench had revealed a horizonal bed of opalite underlying about 50 cm of soil; moreover, a system of cracks in the opalite appeared to offer ingress into the rock. Extraction began in the bottom of the backhoe trench using hammerstones with wooden and antler wedges, but was extended into the undisturbed soil and bedrock on the upslope side, where a digging stick was employed as well. Upon abandonment, the pit was approximately oval in plan, about 140 by 90 cm, and 65 cm deep. An arcuate berm comprised of soil and waste rock about 110 cm wide lay around the downslope quadrant; this berm, however, had shifted position several times during excavation as the direction of work changed to take advantage of opportunities offered by cracks in the bedrock. A third pit was excavated through the center of a filled prehistoric quarry pit. The experimental pit was roughly circular in plan, about 120 cm in diameter and 70 cm deep, with a berm of soil and old quarry debris about 50 cm wide around the east quadrant. Bedrock was encountered at the bottom, but little was removed. The quarriers noted that while the pits were shallow, it was easy to remove loose soil and fine clasts by scrabbling it with bare hands or scooping it with scapulas. Only in pits deeper than 20 cm was it more efficient to fill the dish pan with soil and dump it.

Quarry Pit Anatomy

Neither the ethnographic nor experimental quarry pits described above are very complex features, but they share several attributes we assume will appear in any quarry pit created with similar technology; three components should be invariable. First is the pit itself, a cavity, circular or oval in plan, from which soil and rock have been removed. Second are deposits of soil and rock removed from the pit; tossed, scraped, scooped, or scrabbled, these tend to accumulate in a convex berm around pit margins; the inner slope usually is steeper than the outer, and deeper pits exhibit higher and wider berms. Third are deposits that fill the pit after abandonment. Together, the pit and berm contain several surfaces with different gradients, each influencing deposition and forming unique contexts for human activity. The surfaces include the pit bottom, inner slope, berm top, outer slope, and exterior (Figure 232).

Abandoned quarry pits eventually fill with material slumped, washed, or blown in; as discussed in Chapters 15 and 16, most pits at Tosawihi were visited several times, "migrating"

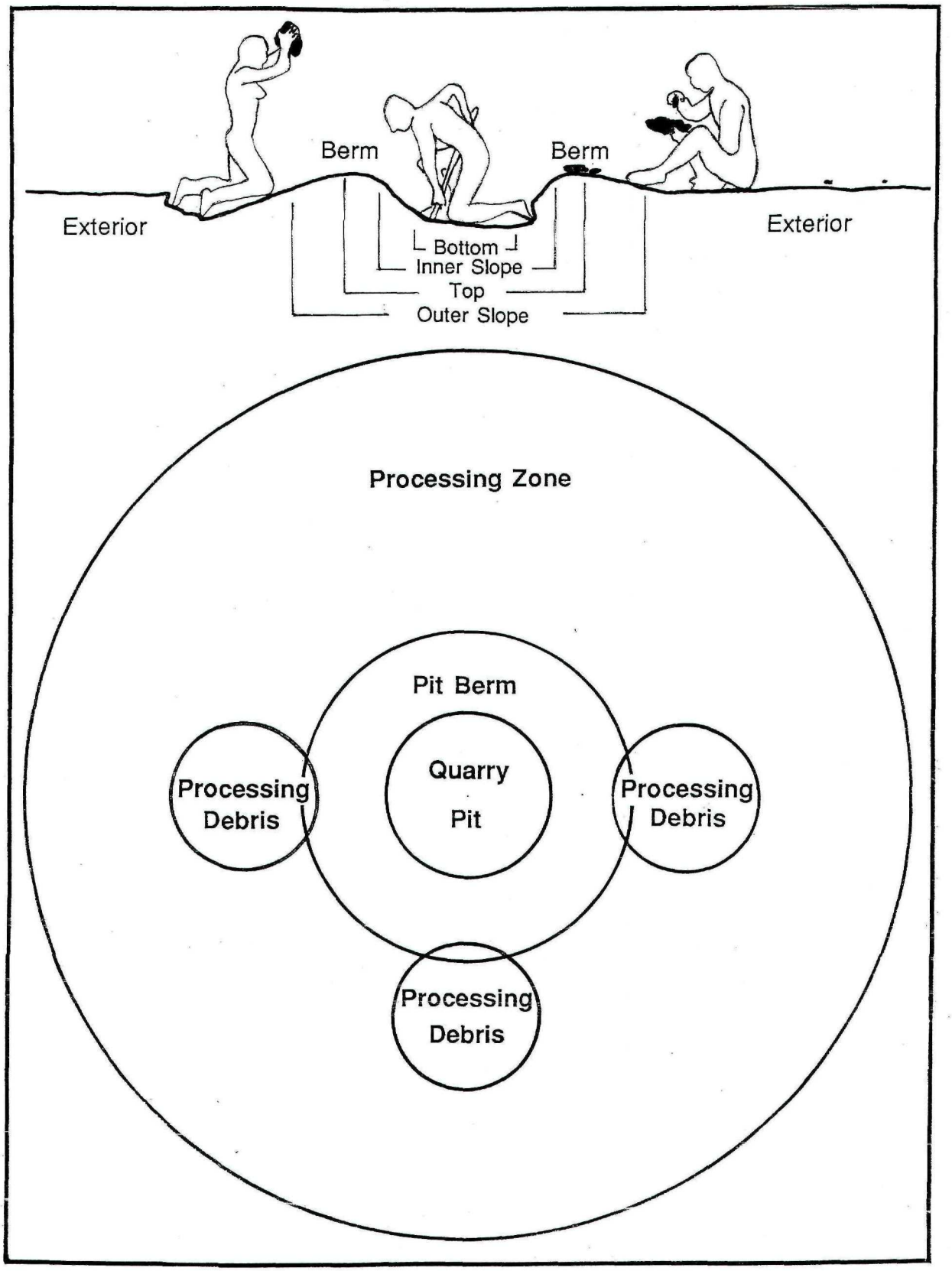


Figure 232. Quarry pit schematic model.

as new raw material was sought. The major strategies called into play involved working back and forth along the strike of a buried opalite layer or the face of an outcrop; where pits were sunk on opalite layers more or less parallel to the surface, work proceeded into the slope. Both strategies filled vacated portions of pits with the debris from current workings.

The mean plan dimensions of ethnographic and experimental quarry pits were 116 cm x 90 cm, with berms ranging between 30 cm and 110 cm wide. The pits were large enough to accommodate a single worker, but did not offer sufficient level space or proper substrate for toolstone processing; in fact, all ethnographic observed processing took place outside the pits. The mean distance of the processing knapper from the pit margin is quite similar in each case (Table 208). Of the nine ethnographic processing episodes, four occurred at 1 m, one at 2 m, and one at 2.5 m from the edge of the pit, so we might suppose that processing toolstone from a particular pit is most likely to occur in a zone about 2.5 meters from it. Since the arc of processing debris around each knapper is about 1 m in diameter, the processing debris from knappers closest to the pit overlaps the berm. In the real world, quarry pits and processing zones are rarely symmetrical and they vary in size. Nevertheless, the relationships shown schematically in Figure 232 serve as a general model.

Table 208. Distance of Ethnographic Toolstone Processing From Pit Margins*.

	Alyawara Quarry	Ngilpitji Quarry
	1.0	1.0
	1.0	1.0
	6.0	2.0
	5.5	2.5
		13.0
Mean	3.38	3.90
SD	2.75	5.13

*distances measured from maps presented by Binford and O'Connell (1984:Figure 5) and Jones and White (1988:Figure 3)

Quarry Assemblages and Deposits

The schematic model, based on experimental and ethnographic data, suggests that different processing activities are more likely to occur in certain places than others, and should produce variation in the spatial distribution of artifacts and types of deposits within and adjacent quarry pits. Types of deposits also should reflect the method used to extract toolstone and the type of deposit excavated. In the ethnographic examples above, the target resource is toolstone clasts in a soil matrix. The Knife River Flint quarries (clasts in outwash buried by loess) and the Potomac quarries (gravel bar clasts in alluvium) are soil matrix quarries (Ahler 1986; Holmes 1897, 1919). All of the Tosawihi quarries studied to date are bedrock quarries, more similar to the Flint Ridge, Ohio or Spanish Diggings, Wyoming quarries described by Holmes (1919); insight into deposits produced from quarrying bedrock was obtained only from experimental quarrying at Tosawihi.

Assay, Extraction, and Processing Assemblages

Ethnographic accounts suggest that assay generates quantities of primary flakes and assayed stones. Encounter assay and core reduction of isolated stones probably account for

many of the small, enigmatic flake scatters dotting most landscapes in the Great Basin. Many more of these scatters undoubtedly have disappeared, particularly those in streambeds and on geologically active surfaces. Assemblages derived from assay have been observed archaeologically by Wilke and Schroth (1989) in the Mojave Desert, and near Lake Mead, Nevada where they are defined as *Pattern I* assemblages (Kamp and Whittaker 1986:385-386). *Pattern II* assemblages result from largely unsuccessful reduction beyond assaying, and contain cores and the primary and secondary flakes removed from them. *Pattern III* assemblages result from successful core reduction, containing debitage from which desirable pieces have been removed selectively. *Pattern IV* assemblages are similar to Pattern III save that cores have been removed while flakes remain. Pattern III and IV assemblages are likely to be abundant at quarries, although all four patterns should be present. For convenience we refer to these assemblage types subsequently in this chapter, but the scheme is not used elsewhere.

Cobble Quarries

Where marginal quality toolstone occurs in abundant surface clasts or outcrops, assay alone, even on an encounter basis, might generate relatively dense scatters of debitage over generations. Such places should exhibit distinctive debitage profiles, with high proportions of primary and secondary decortication flakes; mass analysis should characterize the debitage as core reduction. Assayed cobbles and cores should be present, hammerstones, cores, and bifaces rare, and quarry pits absent. The scatter of surface artifacts should lack structure, but may be aggregated around bedrock outcrops or on stable surfaces (cf. Kamp and Whittaker 1986:384). This model parallels the lithic raw material prospect model of Wilke and Schroth (1989).

Although several such "cobble quarries" were recorded during surveys of Tosawihi and vicinity (Budy 1988, Elston, Raven, and Budy 1987, Raven 1988), only one was sampled during testing (Intermountain Research 1988b), a "nonfeature" portion of 26Ek3197 (cf. Table 166). Its debitage was not subjected to technological analysis, but mass analysis classified it as core reduction (distinguished mainly by relatively few, but large and heavy, items in the largest size class) with weights and counts close to the means for all core reduction assemblages. The formed artifact assemblage shares several, but not all features, with the model. Other kinds of activities were performed on the site, so we probably can assume some overprinting; with only one example it is difficult to interpret deviations.

An unexpected feature is the lack of assayed cobbles. Cores also are absent, but, as we have seen elsewhere, biface production at Tosawihi did not involve cores to any great extent; neither cores nor assayed cobbles are abundant in any assemblage. The model predicts the absence of bifaces and hammerstones; however, three bifaces constituted the only formed artifacts from this area of the site. Perhaps, in the absence of a core technology, bifaces are created during assaying, or perhaps the production of bifaces is not spatially bound. Bifaces are common in other parts of the site. No hammerstones were present in the cobble quarry area, but hammerstones occurred elsewhere on the site in discrete features.

Outcrop Quarries

Where surface materials of sufficient quality occur, testing may pass seamlessly into extraction without the excavation of quarry pits. In this situation, assemblages should be similar to those from quarry pit sites, containing the hammerstones, cores, and later stage bifaces that are absent from accumulations of assaying debris described above. This was tested

at Tosawihi through surface scrapes in several sites field classified as "Outcrop Quarries", where surface outcrops were exploited without quarry pitting. The assemblages of these sites, shown in Table 209, are predicted fairly well by the model. Bifaces dominate and hammerstones are plentiful. Cores and core-like modified chunks are rare, as in most places investigated to date at Tosawihi. Sixty-three percent of bifaces are stage 3, thirty four percent, stage 2; only two are heat-treated. The presence of flake tools is enigmatic; perhaps they were employed in maintenance of extraction tools. Debitage assemblages were not subjected to technological analysis, but all were classified by mass analysis as core reduction.

Table 209. Debitage and Tool Assemblages from Outcrop Quarry Sites.

Site	Feature Wt.	Ave. Deb.	Bifaces	Flake Tools	Percuss. Tools	Modif. Chunks	Cores
26Ek3032, L98	1	9.5	9	1	1	-	-
26Ek3193	1	5.6	3	-	-	-	-
26Ek3195	1	5.9	2	1	-	-	-
26Ek3196	1	0.7	8	1	4	1	1
26Ek3198	14	8.7	8	-	2	-	-
26Ek3201	4	1.2	13	1	1	-	-
26Ek3203	-	1.4	6	-	-	2	-

Pit Quarries

Irrespective of the nature of toolstone deposit, surface prospecting and assaying should produce a background of overlapping, relatively diffuse, Pattern I assemblages (Kamp and Whittaker 1986) over the entire quarry site. Pattern I assemblages also may occur within the quarry pit if raw material is assayed as it is encountered, or on the berm if raw material is stockpiled there to be tested, as at Ngilpitji. Breaking down large clasts to remove them from the pit results in debris comprised of large primary and secondary flakes and chunks superficially resembling Pattern II assemblages. Use of fire adds thermal spalls, chunks, charcoal, and smoke-stained rock. Similar assemblages are produced by quarrying bedrock, but particles tend to be larger and more abundant. Extraction assemblages are likely to contain hammerstone spalls and broken hammerstones, particularly in bedrock quarries; in rare cases, perishable quarrying tools of bone or antler may be present. Whether any of this material remains in the pit or is removed to the berm or beyond depends on where in the quarrying cycle it is created, and whether the pit migrates in search of new material. Quarrying debris created toward the beginning of a quarrying episode is more likely to be removed than material created at its conclusion. Material excavated as a pit migrates is likely to end up as backfill in older portions of the pit.

Processing Assemblages

In the ethnographic examples, all toolstone processing (reduction of cores, preparation of blanks, and initial stages of manufacture) were performed on the pit margin and beyond.

Reduction of massive cores in the processing zone can create large quantities of coarse debitage superficially resembling quarry debris, but such processing produces Pattern II (unsuccessful core and all flakes), Pattern III (exhausted core and incomplete flakes), and Pattern IV (core removed, all flakes remaining) assemblages. All these assemblages were produced in the ethnographic examples.

Deposits of Soil Matrix Quarries

All quarrying for buried toolstone begins with the removal of soil and colluvium covering beds of bedrock or enclosing bedrock clasts (Figure 233a-d). Larger clasts are likely to be separated as encountered; if tossed out into the exterior zone, they may be dispersed. If, however, clasts are tossed to the top or outer slope of the berm, they can roll down and accumulate at the foot of the outer slope where they subsequently may be buried (the closer quarry pits are to each other, the more likely it is that material removed from one pit will fill another). If clasts are placed on the pit berm, particularly if stacked along the pit margins (as at Ngilpitji quarry), they form, in part, coarse deposits comprising the berm (Figure 233a). The soil matrix and finer clasts are likely to be scrabbled out with the bare hands or moved with scoops or in baskets, forming lenses of fine material. Since it is removed first, topsoil may be found unconformably atop undisturbed soil under the berm at the pit margin, but also may be found overlying coarser deposits, particularly if the pit has been extended into fresh areas during excavation. Fire setting to break up larger clasts produces thermal spalls, smoke blackened rocks, and charcoal (Figure 233b). Thus, as shown schematically in Figure 233a-d, deposits produced by quarrying clasts in soil matrix are likely to be restricted to fine grained sediment, coarse accumulations of culled clasts, and fine to coarse debris from toolstone assaying and processing if fire setting has been employed.

Deposits of Bedrock Quarries

All the deposits produced by soil matrix quarrying also are produced in bedrock quarrying when soil overburden must be removed from bedrock (Figure 233c). If, however, clasts in the soil matrix are not the object of quarrying, there may be less tendency to stack them on pit margins, and debitage from assaying and processing is likely to be less abundant in fine grained deposits. If quarrying begins in or at the foot of a bedrock outcrop, the removed overburden may consist of angular colluvium with little or no fine grained soil.

Bedrock quarrying at Tosawihi generated certain types of deposit to which we attached special terms in Chapters 15 and 16. *Chunks* and *shatter* are angular opalite or tuff clasts of various sizes, not considered flakes or cores. *Chips* are fine opalite fragments (2 mm—3 cm) that tend to be thin and sharp but lack flake morphology and probably are products of battering. *Flakes* are the recognizable product of conchoidal fracture with platforms and diagnostic features of dorsal and ventral surfaces.

Hash refers to very fine opalite chips mixed with clay, silt, and pulverized tuff, created by battering tuff and opalite bedrock with hammerstones. Hash is not likely to be present in a soil matrix quarry, but it almost always occurs within deposits filling bedrock quarry pits, rather than in berms, and often is the first deposit in the pit fill, directly overlying bedrock. Although much hash may lie on the quarry floor in primary position (Figure 233c), more undoubtedly is washed there. Bedrock quarrying at Tosawihi is a dusty business; the fine components of hash (pulverized tuff and opalite, silt, clay) coat everything, ready to be washed into the pit bottom by the first rain. Exactly this sequence of events occurred on completion of the first quarrying experiment described above.

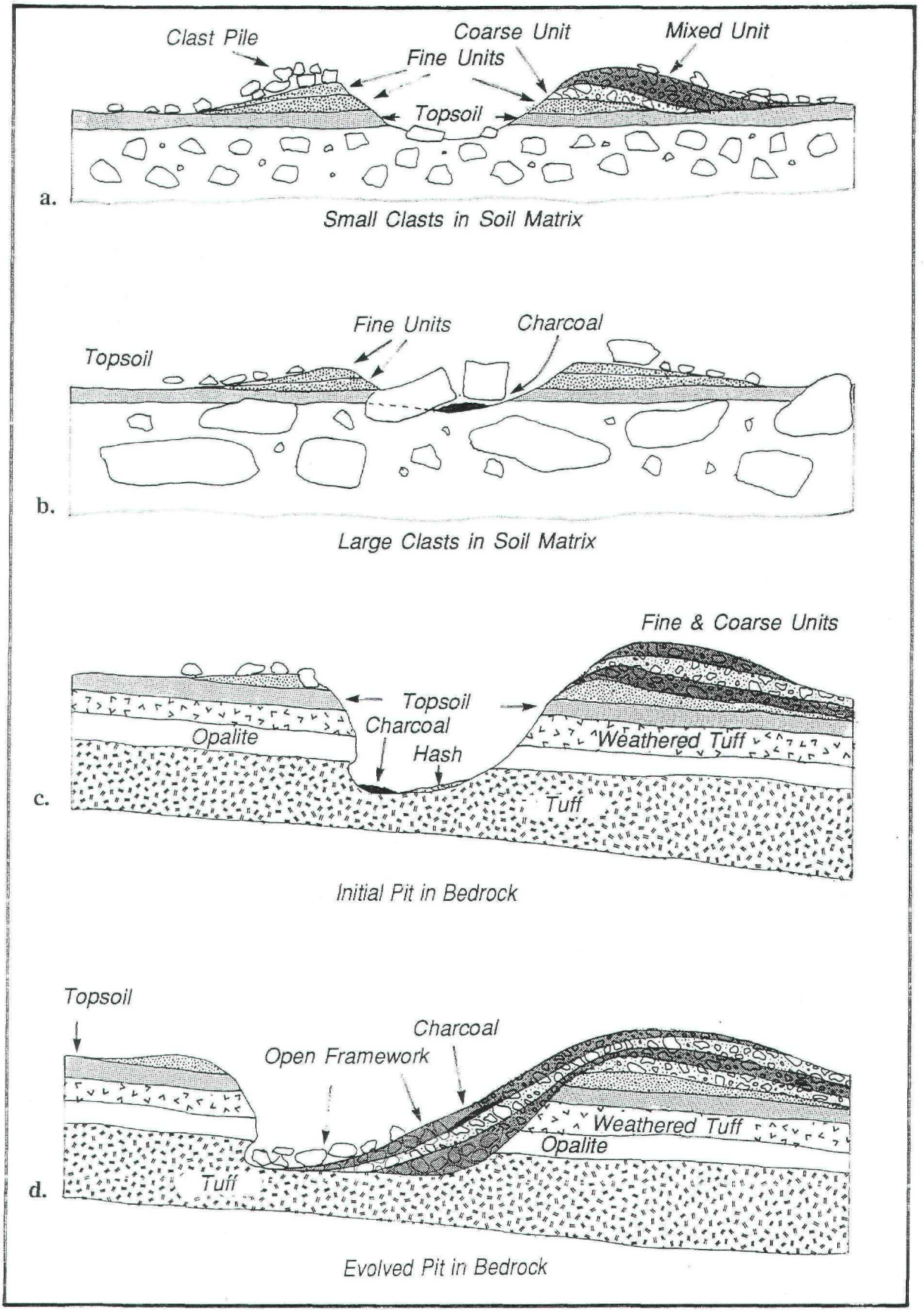


Figure 233. Schematic cross-sections of quarry pits.

Experimental bedrock quarrying produced coarse chunks of opalite and tuff, mixed with large opalite flakes and pieces of shatter; experimental firing produced thermal spalls and smoke blackened stones, as well as deposits of charcoal. Coarse material also was created by initial reduction of extracted toolstone. Battering with hammerstones produced hammerstone spalls and fragments, and these often are components of coarse deposits. Coarse material commonly occurs in prehistoric deposits at Tosawihi; in Chapters 15 and 16, stratigraphic descriptions refer to layers and lenses of coarse to medium *open framework*, or *clast-supported* deposits, in which pieces of rock lie against or upon one another with abundant spaces between them (Figure 233d). When open frameworks are deposited, larger flakes and chunks tend to fall to the bottom and sides of the pit in subhorizontal layers, and coarse units and open frameworks are more common in prehistoric quarries at bedrock outcrops than in pits excavated to horizontal beds of toolstone. Typically, this coarser material is accompanied by a sparse matrix of fine sediment, probably incorporated into the deposit by infiltration. When the matrix is so abundant that larger pieces do not rest on one another, the deposit is described as *matrix-supported.*

Deposits produced during major hiatuses in quarrying derive mostly from colluvial slopewash and eolian deposition. Colluvial slopewash constitutes the downslope movement of sediments, caused by periodic rains and/or gravity, that commonly are dominated by silty matrix, with matrix-supported pebbles, opalite chunks, chips, flakes, and tuff chunks. Later stage reduction debris is present as lenses in some pit fill, particularly in units near the surface. This probably results from periodic episodes of toolstone reduction in areas peripheral to the center of the active quarry pit; a partially filled pit makes a better work space than one newly excavated. It also is probable that, like disturbed open framework strata, some finer pit fill units have been redeposited. Such redeposition is suggested by jumbled units in which most opalite flakes are matrix-supported, with random, non-horizontal orientations. These, however are difficult to distinguish from undisturbed slopewash units.

If open framework deposits are pushed back or scraped away during later quarrying (as previously modeled in the interpretation of inverted radiocarbon dates at 26Ek3208), a randomly piled, jumbled mass of clast-supported materials results. Mixtures of various proportions of tuff and opalite chunks, chips, soil from pit margins, and charcoal are produced easily when berms shift or pits are excavated through older quarry debris (cf. Figure 233d).

Homogenization of Quarry Assemblages

Since size sorting of extraction and processing debris occurs commonly as products of both human and natural agents, it is not unreasonable to assume similar variation in the distribution of artifacts associated with quarry features. Our model of quarry site formation suggests that extraction and processing tasks are likely to be horizontally segmented, which should result in patterned variability in the distribution of artifacts. We believe this to be the case. Further consideration of the model, however, also suggests that processing assemblages from the berm and processing zone around the quarry pit are likely to overlap and become mixed with extraction debris cleaned from the pit. Occasionally, when pits are sufficiently large, processing may take place within the pit itself; this can occur any time during extraction or after abandonment, as the pit fills with natural and cultural debris. Thus, we should see a high degree of homogenization in and adjacent quarry pits, with more discrete features and assemblages at increasing distances.

We examined this proposition with data provided by the technological analysis of debitage from stratigraphic samples taken from trenched quarry deposits (cf. Chapter 5). In each sample, technological analysis flagged the presence of products of one or more of four reduction stages: core reduction, blank preparation, Stage 2 biface reduction, and Stage 3 biface reduction. Some samples contained no diagnostic debitage and were not included in

analysis. The location of each sample was obtained from profile drawings, reflecting pit interiors, inner slopes, berms, outer slopes, and exteriors. Cross-tabulation of reduction stage and quarry pit context produced a matrix of data (Table 210) remarkable for its symmetry on any axis; all four reduction stages have virtually the same proportions in each context. A χ^2 test fails to reject the null hypothesis (no significant difference in the locations of reduction stages in quarry pit samples). While our sample obviously is biased (most samples are from pit interiors), it is difficult to escape the conclusion that assemblages and deposits of quarry pits are highly homogenized. This does not mean that one cannot find individual lenses of unmixed extraction and processing debris, but they are difficult to recognize in the field; further investigation of the problem will require more systematic sampling of contexts.

Table 210. Cross-Tabulations, Quarry Pit Context by Reduction Type.

		Core	Blank	Biface 2	Biface 3
Interior	*Count*	59	28	31	5
	Row %	48	22.5	25.4	4.1
	Col. %	60.6	56.1	59	50
Inner Slope	*Count*	24	12	12	3
	Row %	47.5	23.2	23.2	6.1
	Col. %	24.4	23.5	21.9	30
Berm	*Count*	11	8	7	1
	Row %	40.4	28.8	26.9	3.8
	Col. %	10.9	15.3	13.3	10
Outer Slope	*Count*	3	3	2	0
	Row %	40	33.3	3.8	0
	Col. %	1.4	5.1	3.8	0
Exterior	*Count*	1	0	1	1
	Row %	33.3	0	33.3	33.3
	Col. %	0.5	0	0.5	0.5

Formation and Transformation Processes

Geological and biological processes begin to transform archaeological sites as soon as they are created. Discerning natural and human agents of modification in and around a site is perhaps the most challenging problem in studying site formation processes. Natural agents of deposition include the disintegration of surface outcrops by frost wedging, frost heaving, soil creep, rooting, clay shrinking and swelling, silt infiltration under clasts, and slopewash. For instance, it sometimes is difficult to distinguish whether accumulations of cobble-sized objects in pit fill and on pit margins resulted from of human collection and sorting or from natural agents (such as frost heaving) acting on otherwise undifferentiated quarry waste.

All these processes may cycle opalite fragments to the surface from buried surfaces. Other than the morphology of opalite debris, which may signal its human or natural origin, the redeposition of such material at the surface may be difficult to distinguish from initial deposition by human agents. In addition, we note that prehistoric prospectors must have been aided in their search for toolstone by natural cycling of opalite clasts to the surface from buried bedrock.

The notable agencies of non-cultural site transformation at Tosawihi are slope movement, eolian and alluvial deposition, and bioturbation by burrowing animals. Most slopes

exhibit soil movement through solifluction and slopewash; discrete lithic scatters on slopes typically are fan-shaped, with the apex of the fan upslope. Eolian and alluvial deposition has buried archaeological deposits, now visible on the surface only in tailings of animal burrows. Some open sites have been churned thoroughly by burrowing animals. Coverage of site surfaces by annual tailings where burrowing animals are active appears to range from five to twenty percent per annum, suggesting complete redistribution every decade or so.

Since the distinction between human and natural processes and their consequences is important to our analysis, we define them in the following section and discuss means by which they may be distinguished. It is useful to think of formation processes in terms of four types of effects: deposition, dispersion, aggregation, and degradation; each can be produced by both human and natural agents.

The distinctive nature, stratigraphic position, and morphology of most material resulting from the human utilization of a quarry or lithic processing site allow ready identification of its artificial nature. Identification of some quarry materials, however, is problematic due to overprinting of natural surface processes and the intrusion of naturally derived sediments. Difficult interpretive situations also can arise in the identification of bedrock surfaces modified by natural weathering as opposed to quarrying. The recognition of natural or human processes acting to move artifacts or natural materials around sites, especially on surfaces outside quarry pits, also can be difficult.

Recognizing Quarried Bedrock Surfaces

Several lines of evidence help identify quarried bedrock surfaces. First, natural weathering tends to follow natural plains of weakness along more easily weathered tuff contacts or stringers of tuff internal to masses of opalite; weathered depressions that form in opalite or tuff are irregular in shape and depth. Quarried surfaces, on the other hand, exhibit distinctive morphology resulting from the removal of opalite. Typically, quarried surfaces exhibit oval or round pit shapes, usually with relatively smooth bottoms, particularly when exhausted (cf. Feature 7, 26Ek3171; Feature 3, 26Ek3208). These excavations often crosscut the structure and banding of opalite and tuff bedrock. Tosawihi quarriers utilized naturally weak zones in the bedding, and pits eventually cross-cut the natural bedrock structure. In comparison to undisturbed bedrock, quarried surfaces commonly are more massive, often showing signs of battering (myriad intersecting ring cracks and shatter marks) and conchoidal fracture, reflecting direct percussion rather than natural fracturing.

Additionally, one of the best indicators of absence of quarrying is found in the soil overlying the bedrock surface. As noted elsewhere, red clay paleosol develops on bedrock within a meter or two of the surface (virtually everywhere at Tosawihi). The presence of intact and well developed soil structure in the red clay covering bedrock surfaces indicates that no quarrying has occurred. An abrupt clear contact between the clays and overlying gray silts also indicates lack of disturbance. Subsurface weathering of opalite or tuff bedrock in association with the clay soil also results in a reddish iron oxidization or kaolinization of the tuff, and in the gradual infiltration of expandable clays into cracks, facilitating further fracturing. These signs of weathering are not present on quarried surfaces.

In certain contexts, however, caution is advised in using soil as a reflection of human activity, where slope wash and soil creep have created disturbance, or where the shrink and swell activity of clays in the red paleosol may have re-established soil structure and weathering after disturbance. These cases are more common on steeper slopes or in the earliest quarry deposits. In either case, other evidence (such as site morphology and the appearance of abundant quarried opalite debris) considered in relation to soil conditions make the identification of quarried bedrock more reliable.

Processes of Degradation

Degradation is the deterioration of materials and objects through biochemical or mechanical processes, including mechanical and chemical weathering (patination, hydration, thermal stress, etc.) and organic decay. While the vast majority of artifacts at Tosawihi are of relatively immutable stone, the forces of organic decay effectively have removed most artifacts of hide, textile, fiber, wood, and bone. Bone and antler quarrying and processing tools are preserved only in coarse open work quarry pit deposits that do not retain water to foster a decay-inducing moist environment.

Organized conchoidal fracture isolates culturally produced opalite debris. Alternatively, naturally derived opalite debris often has undergone processes of both surface and subsurface weathering that leave identifiable evidence. Opalite can be degraded and fractured naturally by hydration, frost wedging, thermal expansion and contraction, salt weathering, plant rooting, chemical weathering by lichens, and impaction from rockfall or stream cobble transport. These processes are slow, and their products clearly discernible as multiple surficial and internal fracturing (making the material unsuitable for toolstone production) by a yellowish oxidized weathering patina typical of degraded surface materials in the Tosawihi area, and by a tendency to be more rounded than quarried materials.

Degradation by natural impact generally can be discounted because most quarry localities are not near areas where these processes occur; this may prove more problematic in quarries perched on the margins of Velvet Canyon, each with its own talus of quarry debris. In minor rockfalls associated with quarry features, however (such as at 26Ek3208, Features 2 and 3), large-scale mass wasting was limited and is unlikely to have produced impacted natural debris mistakable for cultural products. In the case of fractures produced during stream transport, broken clasts fresh enough to retain angularity should be accompanied by many more rounded pieces typical of stream beds. Thus far we have far observed no extensive natural opalite cobble or fragment accumulations mistakable for quarry deposits or human refuse.

Processes of Deposition

Deposition frequently is created by human discard or loss; natural agents include wind (eolian accumulation of loess and sand), gravity (colluvial deposition), and water (alluvial deposition). Natural deposition at Tosawihi occurs as loessial silts, colluvium, or alluvium. Loessial silt typically is grayish brown and well sorted, although it occasionally contains common to abundant pebbles and gravel (reflecting the addition of fine colluvium by slopewash and bioturbation). These silts mantle nearly all surfaces at Tosawihi save steeper slopes and bare bedrock outcrops. In areas with soil cover, silts typically contact the underlying red clay paleosol abruptly. Only minor evidence suggests pedogenic horizonation in the silts, although it may be that extensive rooting by sagebrush, grasses, other vegetation, and animal bioturbation has contributed to soil homogeneity.

Generally, the silt mantle is thickest on the northwestern and western sides of hill slopes, leeward of prevailing winds, and thinner on the southeast sides. This is similar to conditions observed by Chadwick and Davis (1990) for loessial silt accumulations on shoreline terraces of the Lahontan Basin west of Tosawihi. It is possible that Tosawihi silts derive from a similar source, probably the eolian deflation of lowland basin floors (particularly the Humboldt River Basin and Carson Sink; cf. Eckert et al. 1989). Some silt may be of local derivation from the weathering of volcanic tuffs.

In addition to the windward control of eolian deposition, the silt mantle at Tosawihi often is thicker on ridge crests, perhaps owing to reduced slopewash. Silt accumulation is

thicker at the toes of slopes in stream drainages as well, where it apparently has accumulated by slopewash from above and because of the higher density of dust-trapping vegetation; conversely, vegetation generally is thickest in areas of thick silts. We suspect this causality to be reciprocal.

Within quarry pits, loessial silts are difficult to distinguish from those introduced by slopewash because they infiltrate readily into void spaces and mix with quarry debris. We found a few examples of depositional units in quarry pits (e.g., 26Ek3195, Feature 2, Unit 18, and 26Ek3208, Trench 2, Unit 44) where well sorted silts with little or no sand or fine gravel indicate eolian deposition. Such deposits may have been enhanced by establishment of vegetation such as grasses which trapped fine silts blown into the pit. The abundant silts in the area also may have effected aggregative processes in the area (see discussion below).

Colluvium is derived from bedrock scarp erosion, from surface weathering, and from soil processes acting on buried bedrock especially from active clays in the paleosol—bioturbation and the erosion by slopewash of unconsolidated Pleistocene terrace sediments. Debris from quarrying activities join the colluvium. Mixing of colluvium with fine soil materials occurs by bioturbation, clay shrinking and swelling, silt infiltration, frost heaving, solifluction, and gravity creep.

The most prevalent means of colluvial addition probably is by slopewash during rainfall and perhaps by gravity; the poorly sorted nature of some quarry filling units (cf. Trench 3, 26Ek3208) with common rounded pebbles and silt suggest their derivation by wash from adjacent pit walls. It is difficult, however, to discern the relative natural vs. human agency in several of these depositional unit types because fine quarrying debris can be mixed so readily with naturally derived materials.

Alluvium occurs as both remnants, now perched high in the landscape, of ancient (Pliocene and Pleistocene) stream activity, and in the beds and low terraces of currently active streams. While the most recent stream deposits bear little on prehistoric quarry activity, except for providing hammerstones, their relationship to non-quarry sites can be important; 26Ek3092 is an example.

Processes of Dispersion

Dispersion is the movement of material from its place of deposition, either as individual particles or artifacts, or as masses or groups of these. Common human agents of dispersion are excavation, cleaning, scavenging and transport; common natural agents include bioturbation, slope movement (frost heaving, solifluction, slope wash), and the erosional activity of water and wind. Trampling by both humans and animals may contribute to dispersion under certain circumstances of slope and substrate.

While subsurface bioturbation in quarry debris can include both faunal or floral agents, the dispersive activity of plants at Tosawihi is much more pronounced than that of animals. The roots typically found in quarry debris are very fine, although occasional coarse sagebrush tap roots are present. Rooting depth ranges from a thin near-surface veneer to a meter or more, sometimes reaching bedrock. Mechanical dispersion and destruction of stratigraphic relationships by rooting leads to homogenization of deposits. Rooting mixes materials of different sizes and thus obscures some of the size sorting created by human agents. It also blurs or distorts the boundaries between stratigraphic units. Dispersive activity was most pronounced in debris units with abundant silty fine matrix, such as in Trench 1 at Locality 36, 26Ek3032 (IMR, in progress), as opposed to deposits dominated by coarser opalite debris, such as Features 2 and 3 at 26Ek3208.

Another aspect of plant rooting, perhaps more a depositional agent than a dispersive one, is its role in the accumulation of infiltrating fines in quarry debris. Although fine grained sediments, washed or blown onto coarse pit deposits with abundant void space, tend to infiltrate downward, evidence of a trapping mechanism responsible for inhibiting infiltration often can be seen in matrix-rich, fine grained depositional units overlying coarse open framework units of angular opalite cobbles and flakes. This may owe to growth of a root mat accompanied by gradual deposition of fine sediments. Roots trap and stabilize sediments, while the fine grained matrix enhances the water holding capacity of debris, promoting the further growth of vegetation and rooting. Of course, roots may grow into the fines after their establishment as a capping unit by some other mechanism. It may be that fine units overlying coarser ones arise by the gradual mechanical accumulation of fines which eventually form 'bridges' across voids and between clasts, similar to the accumulation of clays or carbonates in some soils; examples, however, usually occur in much finer grained material in natural soil settings. Such root structures were observed, for example, at 26Ek3195 (Unit 18 of Trench 1, Feature 2).

As noted previously, animal disturbance is less prevalent. Angular quarry debris is unsuitable for digging or construction of dens, and there is little evidence of burrowing by small animals. Some ant activity was noted in association with quarry debris but typically was limited and shallow in extent. Animal trampling does not appear significant (except, possibly, by cattle). Animal burrowing *is* extensive in non-quarry areas (cf. profiles of 26Ek3092).

Slope movement as a dispersive agent comes about variously; mechanisms include frost heaving, solifluction and soil creep, slopewash, and rain drop impact. Frost heaving occurs when frost under clasts or artifacts, where moisture tends to accumulate, forces them and other soil material upward perpendicular to the slope. When frost thaws, objects drop. Objects thus are moved progressively downslope, dispersed from their initial resting place. Solifluction is similar, occuring where soils creep in the presence of water.

Slopewash may be an especially strong dispersing agent where moderate slope and poor infiltration combine to enhance the movement of sheets of water across the surface. Depending on the amount and velocity of water, even gravel size objects may be moved. It is also possible that, given massive deluge, debris flows can be created by the mixing of fine and coarse grained sediments into dense fluid slurries. Evidence for such flows, however, are very limited at Tosawihi, perhaps restricted to certain units in Trench 3 at 26Ek3208.

A final mechanism that may be of importance is raindrop impact which can move objects not only mechanically, but also by washing sediments away from objects, creating pedestals; the resulting pedestals eventually collapse downslope, moving objects with them.

Processes of Aggregation

Aggregation is the collection or concentration of objects and materials. Humans frequently aggregate materials during collection and in storage. Extracted clasts were aggregated at Ngilpitji Quarry by stacking them around pit margins; pit berms are created by the aggregating process of least effort disposal of quarry debris. Most non-quarry lithic features at Tosawihi are aggregations of artifacts created by performing repetitive processing tasks in the same place. The Tosawihi biface caches are aggregations of stored goods. Natural agents of aggregation include gravity accumulation, foundering, and lag concentration.

Aggregation of artifacts or quarry debris can result in either selectively size sorted or poorly sorted deposits. Accumulation by gravity fall and mass movement may account for much of the size sorting that occurs in pit fill not otherwise attributable to the selective

production of debris of a certain size. Gravity acts easily on piles of unconsolidated quarry and processing debris, particularly on masses of thin, slippery flakes. It is difficult in many cases, however, to discern the mechanisms of sorting; large opalite cobbles, for example, may be tossed selectively to a certain area at the bottom of the trench during quarrying, while gravity may sort coarse opalite debris naturally. Larger clasts are less likely to be trapped in cavities and tend to travel farther down the slope because their volume, mass, and momentum increase as the cube of their diameter, while surface area, and therefore friction, increase only as the square (Young 1972).

Slumping of over-steepened pit walls appears to have been a natural mechanism depositing poorly sorted debris. This is recognized most easily where re-excavation and truncation of older units has taken place and a small talus of debris can be seen clearly to have slumped into the pit.

Additionally, lag concentration can take place in or outside the pit. Within the pit, it involves the infiltration of fine materials through courser debris leaving behind the coarser materials. Although this undoubtedly takes place, it may be difficult to distinguish from gravity sorting or primary production of coarse debris as described above. Beyond the pit berm, lag accumulation of artifacts and other debris can occur either by the removal or addition of accompanying fine sediments. In the case of removal, coarser artifacts and debris are left behind while slopewash removes finer materials mechanically transportable as functions of rainfall abundance, intensity, and slope.

The *addition* of fines can create a lag of objects wherein coarser objects, previously buried, are raised to the surface and concentrated, or founder, sinking slowly, finally to form a layer of clasts that appears to be in primary position. When a soil dries after rainfall, for instance, the particles surrounding a coarse object shrink and pull away from it. When this occurs, finer grained materials such as eolian silts and silty material fall into the voids, especially beneath the object. The net result is progressively more soil deposition under the object and its progressive rise to the surface (McFadden et al. 1987). This also can occur with the slight lifting of clasts by frost heaving and the subsequent infiltration of fines. With sufficient time, coarse objects may cover the surface, giving the appearance of a lag of materials similar to desert pavement. Although a true desert pavement with an armoring gravel cover is not present in the Tosawihi area, this process appears to have taken place, as attested by the amount of eolian silts.

Bedrock Morphology and Quarrying Strategies

Although quarry pits themselves are strong modifiers of site condition, altering subsequent site formation processes, it is useful to examine the preexisting conditions promoting or inhibited initial selection and subsequent formation of quarry features. Assessing the original nature of the outcrop is essential for understanding later site formation processes, both natural and human.

Bedrock geology around Tosawihi is described in Chapters 2 and 5. Modification of surface morphology has occurred by isolated faulting, stream channel incision and terracing, and slope retreat. Bedding typically has a dip of 15° to 30°o to the southeast. The hydrothermal emplacement of opalite was controlled to a large degree by pre-existing bedding in airfall and ashflow tuffs. The relative quantity of opalite or tuff ranges from minor tuff lenses interspersed with massive opalite, to massive tuff with isolated opalite bands, to evenly bedded occurrences of both rock types. It appears that a combination of both was most ideal for extraction of opalite; tuff lenses or bands allowed adits to be created along the softer tuffs, thus allowing isolation of opalite overhangs where larger blocks of potential toolstone could be exploited. Where opalite was too massive, it may have been difficult to extract large blocks without

damaging their internal homogeneity, since battering often introduces fractures and stress. Outcrops *too* tuff rich, on the other hand, may have been uneconomical to quarry.

Assessment of bedrock morphology and its degree of exposure time prior to utilization sometimes is equivocal, owing to modification of the outcrop by quarrying as well as to movement of soil and colluvium, which may have covered or uncovered opalite surfaces. With these constraints in mind, the configuration of opalite bedrock exploited by prehistoric quarriers at Tosawihi falls into three morphological types (cf. Chapter 5): above surface ledges or outcrops, subsurface bedrock with bedding intersected by the surface slope, and subsurface bedrock with bedding parallel to the surface. The development of quarries in each situation presents different sets of problems and advantages that we characterize in terms of three quarry types (Figure 234) described below. Quarry features investigated during the present study are classified in Table 211.

Table 211. Quarry Types at Tosawihi Quarries.

Site No.	Type 1	Type 2	Type 3	SOIL/COLLUVIUM*
26Ek3084-F1-T2		+		
26Ek3085-T1	+	+	+	+
26Ek3032-L19	+			
26Ek3032-L23-T1		+	+	
26Ek3032-L26-T1		+?	+	
26Ek3170-F1-T2			+	+
26Ek3171-F2-T2		+	+	+
26Ek3171-F7-T3		+	+	+
26Ek3184-F20-T1		+	+	
26Ek3195-F2-T1,2	+	+?		+
26Ek3195-F4-T1		+?	+	
26Ek3198-F4		+		
26Ek3198-F14		+		
26Ek3200	+			
26Ek3208-F2,3	+			

*indicates presence of substantial soil and alluvium cover

Type 1 Quarries

Type 1 Quarries exploit a surface ledge or outcrop, typically on moderate to steep slopes of fault scarps (26Ek3208, Features 2 and 3) or in stream cuts (26Ek3195, Feature 2) where bedding intersects the eroded slope (Figure 234a-c). Other sites of this type include 26Ek3085, 26Ek3032 (Localities 19 and 26), 26Ek3195 (Feature 2), and 26Ek3200 (Table 211). The steep slope and enhanced slopewash and mass wasting in these areas assured easy access to the outcrop by keeping it generally free from soils and colluvial cover. This provided opportunities for easy initial assessment of the quality and potential quantity of the opalite source, while imposing constraints on the freshness of the source due to surface weathering.

Surface ledge sites typically are accompanied by talus cones of both natural and quarry debris. The internal morphology of the talus consists of bedded depositional units which, when nearest the bedrock face, slope into the outcrop. Farther from the outcrop face, deposits tend to slope more naturally, parallel to the hillslope; ideal examples are deposits at 26Ek3208 (Features 2 and 3), and 26Ek3195 (Feature 2).

On steeper Type 1 sites, less soil matrixes incorporated into the quarry debris, generally because the steeper slopes have a higher ratio of angular colluvium to soil and because working

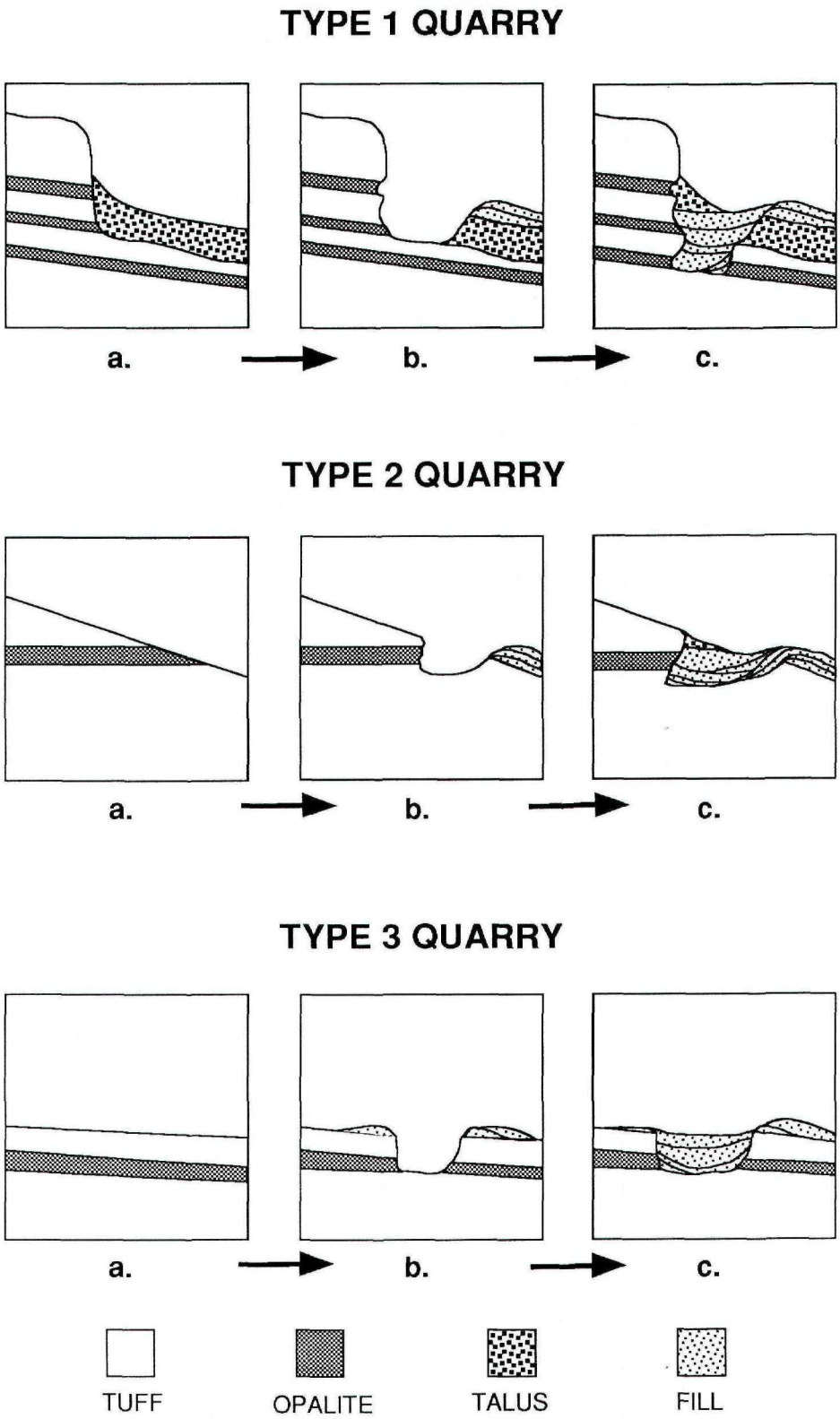


Figure 234. Tosawihi quarry types.

of the opalite face involved less disturbance of the surrounding soil. Also, the thinness of soils on steeper slopes results in less vegetation, and therefore less opportunity for bioturbation and soil mixing. Alternatively, steeper slopes may enhance slopewash and soil creep, thus actively introducing upslope sediments into pit features.

The final quarrying phases at Type 1 sites might have been caused by the exhaustion of opalite deposits; alternatively, outcrops may have been quarried far enough into the hillside that the effort of removing debris from the working face became too great. These probably are the two main causes of abandonment in nearly all quarrying situations.

Type 2 Quarries

The second type of opalite source consists of subsurface toolstone strata whose bedding is intersected by the slope in which they occur (Figure 234c-d). Although several such outcrops are known, the circumstance is commonest on gently-sloped crests of ridges where the predominant dip of geologic beds allows greatest intersection of bedding and surface. Sites of this type include 26Ek3084 (Feature 1), 26Ek3085, 26Ek3032 (Locality 23), and 26Ek3198 (Feature 14). Other bedding intersections may occur along stream banks as well, as in the case of bedrock near Feature 2 of 26Ek3195.

Type 2 sites are related to Type 1 sites, in that the latter, also, are typically formed by the intersection of opalite beds with slope surfaces. They usually differ, however, in the angle of slope and, as a consequence, in the amount of soil (owing to reduced surface erosion on gentler slopes). In such cases, more soil often fills quarry pits than at Type 1 sites. This promotes greater bioturbation both by plants and animals. That toolstone beds are less exposed at the surface and dip into the slope may increase the difficulty of toolstone extraction, resulting in the earlier abandonment of Type 2 quarries.

Type 3 Quarries

Type 3 sites occur where bedrock is covered by soil and colluvium and the toolstone stratum lies parallel to the surface; the surface slopes gently, either on the dipping side of fault blocks or on remnant erosional alluvial terraces Figure 234g-i). Opalite typically is exposed as a massive floor of bedrock at the bottom of quarry pits. Soil constitutes more of the pit fill than at other site types. Much less slope erosion occurs, natural soil is thicker and more abundant, and natural coarse colluvium is a only minor component. 26Ek3171 is an ideal example of this bedrock type. Other sites include 26Ek3170 (Feature 1), 26Ek3184 (Feature 20), and 26Ek3195 (Feature 4).

This kind of setting is the most problematic in terms of understanding how initial prospecting was done. Although soil activity and bioturbation may bring bedrock pieces to the surface, there may be surface little evidence to indicate exactly where good subsurface deposits occur. Exploratory excavation through the silt soil and clay paleosol beneath would be quite risky (as our experimental quarrier Carambelas discovered), but might be the only way to determine the potential of a location accurately. Once a suitable source is found, the opalite is relatively easy to follow. Such bedrock should not have suffered surface weathering, and therefore might be fresher and less fractured than at other kinds of sources. On the other hand, the relative difficulty of quarrying at Type 3 sites also is influenced by the massiveness of the bedrock. Bedrock with few cracks is hard to penetrate with hammerstone technology. Once a Type 3 quarry pit was started, quarriers may have taken pains not to allow the working face to become too smooth and convex for detachment of blocks and flakes. The

smooth, bowl-like floor of Feature 7 quarry pit in 26Ek3171 is a case in point. This pit was completely emptied in order to estimate the total volume of toolstone removed from it (about 24 m^3), and experimental quarrying attempted subsequently. The smoothness and massiveness of the stone, however, defeated our attempts.

Site Abandonment

Considering that pit features are modifications of several previously existing conditions, they clearly become part of the geomorphic environment and affect the processes taking place within it. Excavation of quarry pits disturbs the soil and removes vegetation, allowing more effective surface runoff and more sediment movement around sites. The pit itself becomes an ideal catchment for some of this material if its berm does not impair influx. Within the pit, especially on its marginal walls, sediment wash, infiltration of sediments into void space both by water flow and by eolian influx, slope failure, and slumping of debris are common. Later, as vegetation is reestablished on the quarry debris, root turbation occurs.

Upon abandonment, it is likely that the processes most dominant prior to quarrying resume, although changed by the new morphology of the site. On steep slopes characteristic of Type 1 sites, for example, colluvial activity is still be an important element of geomorphic processes operating there; at the large quarry on Red Hill (26Ek3208), extremely large pits were filled almost completely with colluvium. Where soil originally was abundant, such as more gently-sloped Type 2 or 3 sites, relatively large amounts of soil will be incorporated into pit fill, acting as a substrate for pedogenic processes so that plant communities and soil development are likely to be re-established.

Chapter 23

ASSEMBLAGE DIVERSITY AND COMPOSITION

Eric E. Ingbar

Why stone tool assemblages differ in composition is a question central to many archaeological studies. The debates between Francois Bordes and Lewis and Sally Binford in the 1960s sharpened awareness of just how crucial this question is to interpretation of the archaeological record. The focus of argument during this exchange was how best to *interpret* differences in assemblage composition. That there actually *were* differences in the composition of the assemblages was never in question.

In this chapter, differences in assemblage content are *not* taken as self-evident. Instead, determining differences is the focus of inquiry. How different are the tool assemblages recovered from different parts of the Tosawihi vicinity? In what ways do they differ? Are there distinctive patterns in the composition of Tosawihi tool assemblages? Our proximate goal is pattern recognition in a variety of measures of diversity and assemblage composition. Because Tosawihi is a major toolstone source, tool assemblages obviously should differ from those found in areas lacking toolstone. How different are the Tosawihi tool assemblages from those found in other parts of the Great Basin? And in what ways do they differ?

Ultimately, the patterns examined here must be interpreted. Some patterns are products of sample size; others are not explicable in this light, and most likely result from how different places in the Tosawihi landscape were used. While this chapter does not attempt to interpret all patterns of assemblage composition (cf. Chapters 24 and 25), distinguishing the effects of sample size on assemblage composition allows some untangling of the complicated relationships among tool assemblages. Our goal is to distinguish patterning that *may* be due to prehistoric use of the landscape. Patterns of assemblage composition are sought as indicators of dimensions of variation in assemblage composition. As subsequent chapters reveal, differences in assemblage content resonate through interpretation of activities undertaken in the Tosawihi landscape (cf. Chapter 24) and interpretation of how they were placed on the landscape (cf. Chapter 25). Thus, pattern recognition and the elimination of spurious patterns resulting from sampling properties set the stage for more concise discussions of prehistoric behavior at Tosawihi.

Pattern recognition is approached in two ways here. Various measures of assemblage diversity are examined first. *Diversity* has no precise numerical meaning, since it consists of three different families of measures: richness, evenness, and heterogeneity (Bobrowsky and Ball 1989). Only the first two measures are examined here. Also, we examine and compare the contents of assemblages aside from overall diversity measures. This approach builds on patterns of assemblage richness and evenness. Assemblage composition analyses in theory are independent of diversity patterns, since assemblages that differ in composition may have the same diversity values. Thus, compositional analyses provide insights into diversity patterns and additional patterns exclusive to this approach.

Tosawihi Tool Assemblages

Recent research has shown that sampling effects have a pervasive influence on interassemblage comparisons using both intuitive and statistical models (Bobrowsky and Ball 1989; Grayson 1981, 1985; Leonard and Jones 1989; Jones et al. 1983, 1989; Thomas 1988). The logic underlying these difficulties is simple: larger samples tend to have more rare

members of a population. Hence, the number of types, classes, species, etc., present in a sample tends to correlate with sample size. Since almost all measures of sample diversity employ in some form the number of classes present, sample size has far-reaching effects on intuitive and explicit measures of diversity.

Classification itself plays a pivotal role in forming the relationship between diversity and assemblage size. For example, in a classificatory scheme with an infinite potential number of classes, *sample richness* (the number of classes or types actually present) can increase without bounds. Yet, for any finite number of classes (as in most archaeological classification schemes) a point is reached where all classes have constituent members, so richness ceases to increase. This *saturation* point, and the resulting richness value, is determined by many factors; to compare richness values across assemblages requires that all assemblages be classified in the same fashion.

For the purposes of this chapter, an assemblage (i.e., a sample) consists of the tools from discrete site areas. When possible, a subarea within a site (designated as a locus) was considered a distinct sample (cf. Chapters 16, 17, 18). The results of artifact analyses (cf. Chapters 6 to 13) were used to classify tools into 47 *types* (Table 212). Debitage was not included. Some types are combinations of specific analytical categories (e.g., scrapers of all forms are considered a single type here). A useful reduction of these data collapses types into six functional *classes* (Table 212), following Thomas (1988).

Table 212. Tool Classes and Tool Types.

Class	Types	n	%	Class Total	Class %
WEAPONS	(Projectile Points)			392	7.1
	Cottonwood	31	0.56		
	Desert Side-notched	54	0.98		
	Rosegate Series	34	0.62		
	Elko Series	29	0.53		
	Gatecliff Series	19	0.35		
	Humboldt Series	13	0.24		
	Large Side-notched	9	0.17		
	Stemmed	18	0.33		
	Clovis	1	0.02		
	Out of key	27	0.49		
	Fragmentary points	157	2.86		
FABRICATING/PROCESSING BYPRODUCTS				2009	36.6
	Cores (all types)	123	2.24		
	Preforms (all stages)	252	4.59		
	Modified Chunks	67	1.22		
	Bifaces, Stages 1 to 3.4	1567	28.50		
QUARRYING EQUIPMENT				6	0.11
	Bone scoops	1	0.02		
	Bone, antler wedges	1	0.02		
	Large quarry hammerstones	4	0.07		
FABRICATING/PROCESSING TOOLS				374	6.80
	Scrapers (Types 1 to 3)	178	3.24		
	Pointed tools (Types 4 to 7)	103	1.83		
	Notch/denticulate	61	1.11		
	Microdenticulate	6	0.11		
	Abrader, shaft abrader (Types 5 and 6)	9	0.16		
	Scratched stone	14	0.25		
	Bone awls	2	0.04		
	Bone flakers	1	0.02		

Table 212, continued.

Class	Types	n	%	Class Total	Class %
GENERAL UTILITY TOOLS				2583	47.00
	Bifacial flake tool (Types 9 to 11)	21	0.38		
	Misc. ret'd. flake (Types 14 to 16)	298	5.42		
	Fragments of tool (Types 21 and 22)	117	2.13		
	Crudely retouched flake	13	0.24		
	Discoidal tool	10	0.18		
	Flake chopper/hammer	12	0.22		
	Other flake tool	5	0.09		
	Choppers, scraper/planes, hammer/choppers (Types 2, 5, 6)	41	0.75		
	Shovel	3	0.05		
	Bifaces, Stages 3.5 to 5	1946	35.40		
	Hammerstone	116	2.11		
	Expedient bone tool	1	0.02		
DOMESTIC EQUIPMENT				132	2.40
	Mano	23	0.42		
	Metate	66	1.20		
	Mortar	6	0.11		
	Pestle	4	0.07		
	Brownware[a]	8	0.15		
	Grayware[a]	3	0.05		
	Indeterminate ware[a]	2	0.04		
	Bead, bead preform, pipe, misc. exotica (Types 7 to 10)	18	0.33		
	Bone beads	2	0.04		
	GRAND TOTAL	**5496**			

[a]Minimum number of vessels (cf. Chapter 13).

Five of these classes were defined by Thomas for analysis of tool assemblages from Monitor Valley (1988); their constituents are used here for comparison between Tosawihi and Monitor Valley. In addition to adding a new class to Thomas's scheme (Quarrying Equipment) and dropping another (Ornamental), there are some differences between our class definitions and those used by Thomas. Our *General Utility* tools probably differ from Thomas's original conception of tools with multiple uses. At Tosawihi, hammerstones probably are related more closely to the fabrication of stone tools than to other uses. Likewise, discoidal tools probably are large quarry hammerstones. Stage 3.5 and later stage bifaces, while generally useful, may be also products of toolstone processing (but not toolstone procurement) rather than general utility tools. Nonetheless, these three tool types *potentially* are of general use, regardless of their probable roles functions. Hence, they are retained in the General Utility tool class.

In addition, for some analyses two simple environmental variables, water and toolstone (cf. Chapter 2), were encoded for each site. Assemblages were given values for their distances from these resources according to distance classes of less than 250m, 250-500m, and more than 500m.

One hundred three assemblages are considered here (Appendix O). Discretionary test units in the Eastern Periphery and sites not systematically collected are excluded from the dataset, referred to below as the *pooled Tosawihi assemblage sample*. Many of the following

analyses of the pooled Tosawihi assemblage sample, or portions of it, required logarithmic transformation of both sample (assemblage) size and the dependent variable under investigation to create an approximately normal distribution with linear properties (Velleman and Hoaglin 1981).

Assemblage Richness and Evenness

Ecologists and statisticians usefully distinguish three information measures to characterize data in discrete categories. *Richness* is the number of classes present in a sample, regardless of how many variates (tools, in this study) occupy each class. The theoretical richness maxima for type and class data are 47 and 6, respectively (we recognized 47 types of things, assignable for 6 classes). Measures of *evenness* examine the equitability of variate distributions across categories. An assemblage of 100 tools in only two classes is less even than an assemblage of 100 tools equally frequent in 10 classes. Pielou's J statistic is used here as a measure of evenness (cf. Kintigh 1989; Brobowsky and Ball 1989), although it, too, is correlated with sample size. Lastly, measures of *heterogeneity*, such as the Shannon-Weaver index (Shannon and Weaver 1949), attempt to summarize the joint characteristics of sample evenness and sample richness. Heterogeneity measures are appealing because they evoke an intuitive definition of diversity as related to both richness and evenness. However, Peet (1974, 1975) has shown that the Shannon-Weaver index and other similar measures are sample size dependent. Furthermore, Brobowsky and Ball (1989:7-8) contend that heterogeneity measures present inherent difficulties, since they combine two different sample properties (richness and evenness). For these reasons, no heterogeneity measures are used in this study.

Both type and class richness are calculated easily by counting the non-null classes. Evenness was studied using Pielou's J statistic (Pielou 1975) and rank-order correlations (Whittaker 1972).

Type and Class Richness

Richness is a simple measure. Its utility has been questioned due to its correlation with sample size, but several profitable ideas on how the richness: size relationship can be useful have been advanced. Kelly (1985) and Thomas (1988) have argued that different patterns of hunter-gatherer land use should generate archaeological assemblages with differing slopes of the richness:size curve (Figure 235). Places where a limited number of tool types or classes were discarded repetitively should exhibit a low richness: size slope coefficient. Assemblage size increases at a relatively rapid rate relative to the variety of tool classes because the same tool classes are discarded redundantly. Activities such as gathering plant foods within the diurnal foraging range may create such assemblages. More diverse tool discard patterns, perhaps associated with longer-term use of places, has a somewhat steeper slope, since the number of tool classes discarded increases more rapidly relative to assemblage size. Still longer-term place use produces an even wider variety of tool-discarding activities, and so yields the steepest richness: size slope coefficient. This idealized scheme of slope values expected under various patterns of place use ignores multiple uses of the same place. Consequently, it is not expected that a group of archaeological assemblages always will fit these patterns. Nor does finding such patterns necessarily indicate that the pattern of place use conformed to the idealization suggested by Thomas. Nonetheless, comparison of regression slopes, when calculated over subdomains of an entire set of assemblages, can provide useful insights into how a landscape as a whole may have been used. For example, Thomas (1988:383, Figure 144) suggests that from lowest to highest, slope coefficients of the richness: size regression equation may equate with diurnal, logistical, and residential use of places.

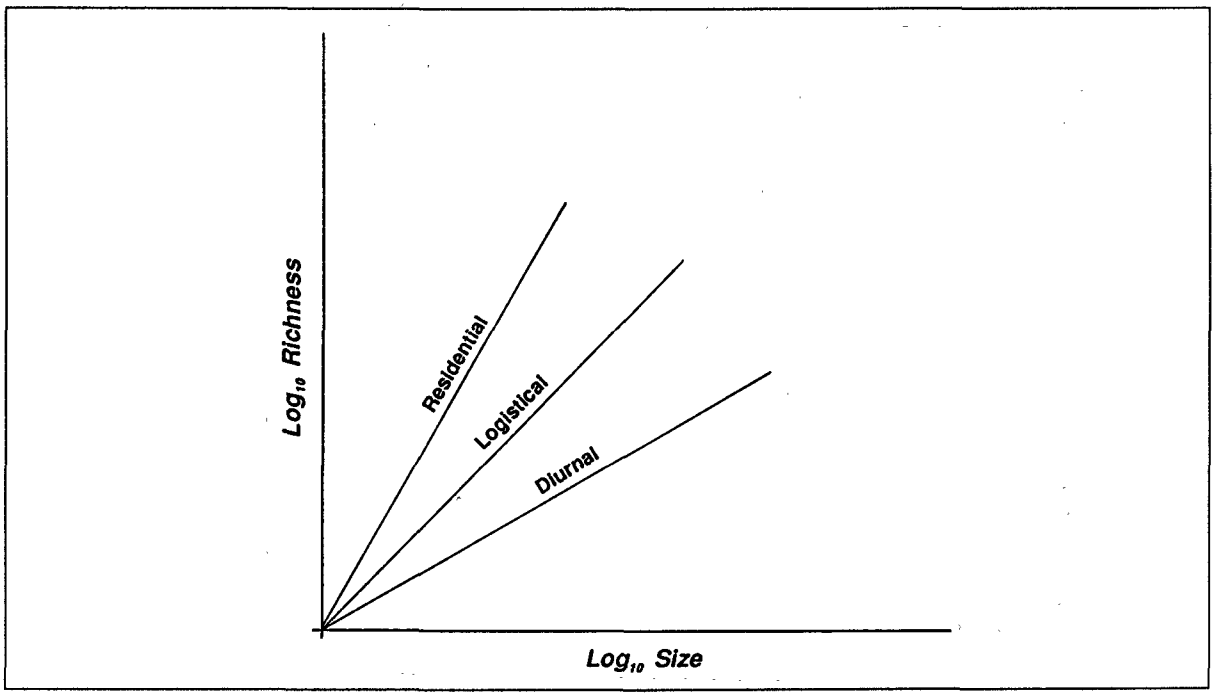


Figure 235. Expectations of richness: size relationship.

Tosawihi offers no obvious environmental strata akin to those used by Thomas (1988) in his Monitor Valley study. However, because water and toolstone are critical resources, the assemblages were stratified by proximity to each in three strata (within 250m, 250m to 500m, greater than 500m). Regression coefficients were calculated for each stratum and significant ($p<.05$) regressions compared. T-tests between regression slope coefficients showed no significant difference between any pairs of significant correlation coefficients.

Examination of variety values for individual cases can be done in two ways. One technique examines outliers to the richness: size relationship. These reside in the confidence limits of the regression equation. A second technique simulates the expected variety values for assemblages of different sizes, given overall class frequencies for a particular group of assemblages (or, better still, some *a priori* expectation of the proportions of classes; cf. Kintigh 1984, 1989); outliers to the richness: size relationship then are highlighted for further examination.

The relationship between artifact type richness and sample size is depicted in Figure 236 for all Tosawihi assemblages containing more than one tool type. The 81 assemblages follow the expected trend of increasing richness of types and increasing sample size (r-squared=0.94, $p<.001$). Although the relationship between assemblage size and class richness is similar (Figure 237), and also is significant (r-squared=0.61, $p<.001$), the point swarm has a greater spread because the number of classes is more variable at a given level of sample size.

Since assemblage richness and size are highly correlated, outliers to this regression must differ somehow from cases within the expected range of richness. For this analysis, only assemblages with at least ten tools were employed, since below this the empirical slope of the richness: size relationship is steeper (cf. Figure 236). A regression line and 99% confidence intervals were calculated, and outlier assemblages determined by inspection (Figure 238; Table 213). Due to the wide variation in assemblage size associated with different values of class richness, this approach was not employed with the class data.

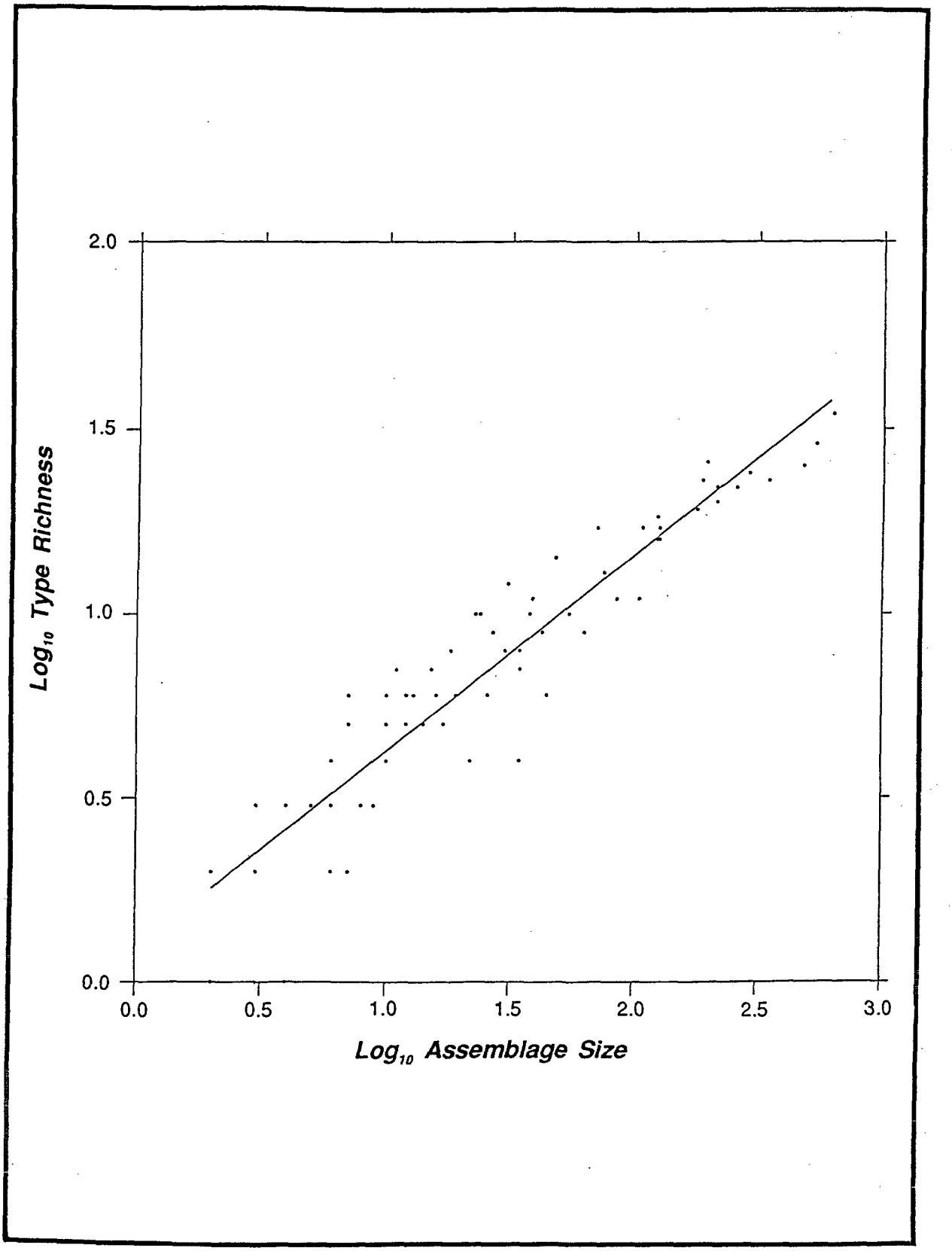


Figure 236. Type richness vs. sample size.

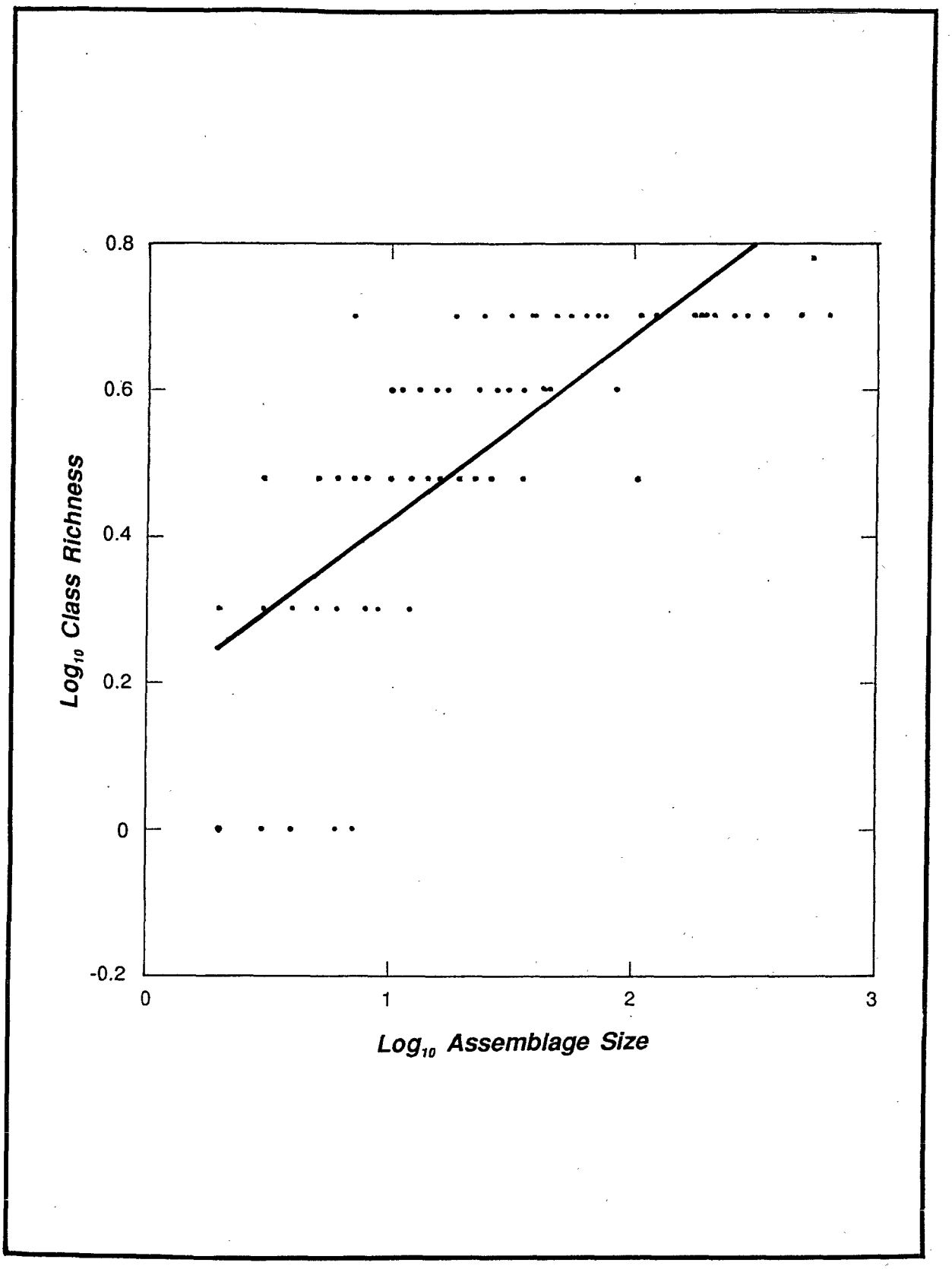


Figure 237. Class richness vs. sample size.

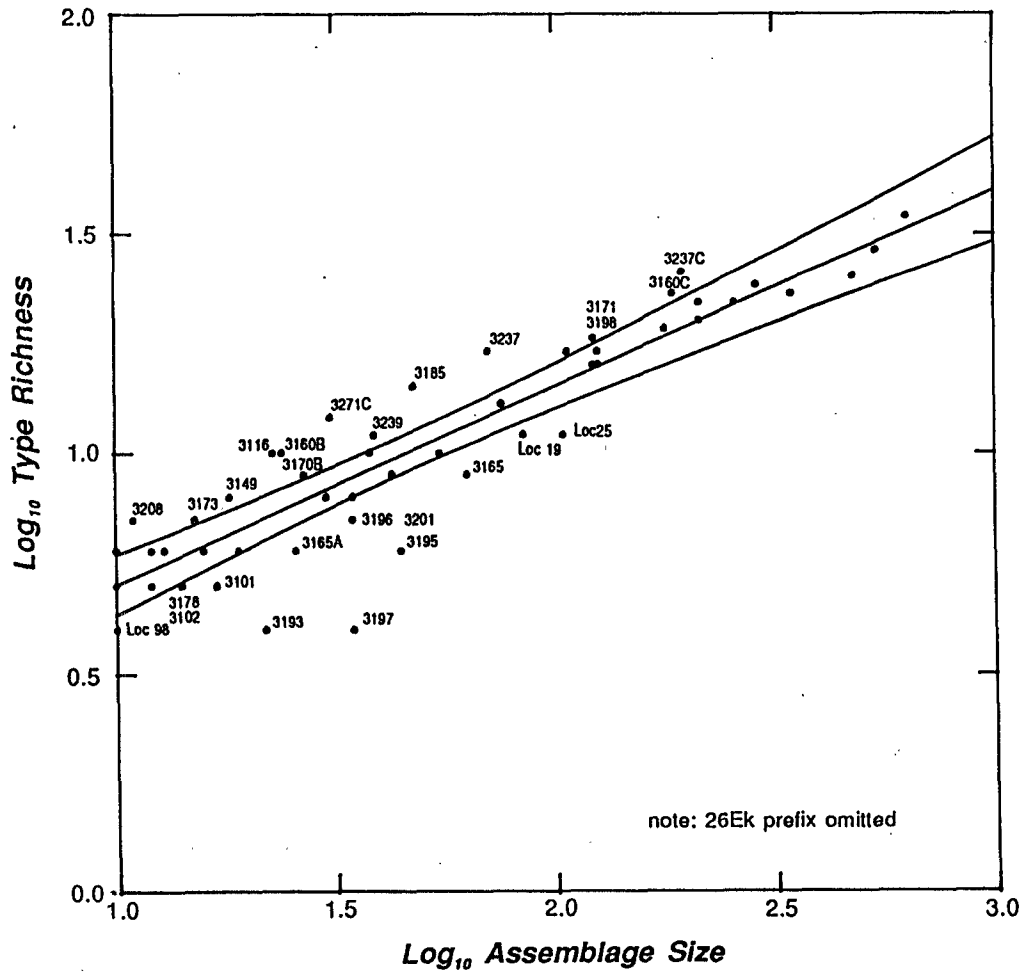


Figure 238. Type richness vs. assemblage size with 99% confidence intervals.

Table 213. Outliers to Type and Class Richness Relationships to Assemblage Size.

Site (locus)	Outlier to 99% confidence limits, regression of type richness on assemblage size	Outlier to 2 standard error boundary of simulated type richness	Outlier to 2 standard error boundary of simulated class richness
3032/19	-1	-1	-1
3032/25	-1	-1	-1
3032/98	-1	0	0
3101	-1	0	0
3102	-1	0	0
3116	1	0	0
3149	1	0	0
3160	1	0	0
3160B	1	0	0
3165	-1	-1	0
3165A	-1	0	0
3170B	1	0	0
3171	1	0	0
3173	1	0	0
3178	-1	0	0
3184	-1	-1	0
3185	1	0	0
3193	-1	-1	0
3195	-1	-1	0
3196	-1	-1	0
3197	-1	-1	-1
3198	1	0	0
3201	-1	-1	0
3208	1	0	0
3237	1	0	0
3237C	1	0	0
3239	1	0	0
3271C	1	0	0

1 = above expected values
-1 = below expected values
0 = within expected values

The detection of outliers can be extended using a technique developed by Kintigh (1984, 1989) in which expected richness values are determined from a Monte Carlo simulation. In this technique, simulated assemblages of specified sizes are generated by random selection of class members. The simulation model is constructed so that the probability of choosing any given class or type is dictated by its proportion in the pooled sample of all assemblages, or some other *a priori* expectation. For the Tosawihi data, the overall proportions of types and classes were employed as the mean probabilities (cf. Table 212). Two datasets were generated, one based on class proportions, the other on type proportions; each consisted of 50 simulated assemblages at eight sample sizes (n = 10, 20, 40, 80, 150, 300, 600, 1000). Means and standard errors for richness were calculated, transformed to logarithms, and the assemblage data for assemblages of 10 tools or more were plotted against two standard error boundaries (an approximate 95% confidence interval) of the simulated data.

The type richness data contain only outliers less rich than expected (Figure 239). Eight of the ten outlier assemblages also are outliers to the regression relationship (only 26Ek3184 and 26Ek3160 are not; cf. Table 213). The class richness data contain three outliers to the simulated boundaries (Figure 240; Table 213), all below the expected richness values and also outlying both regression and simulated boundaries of type richness.

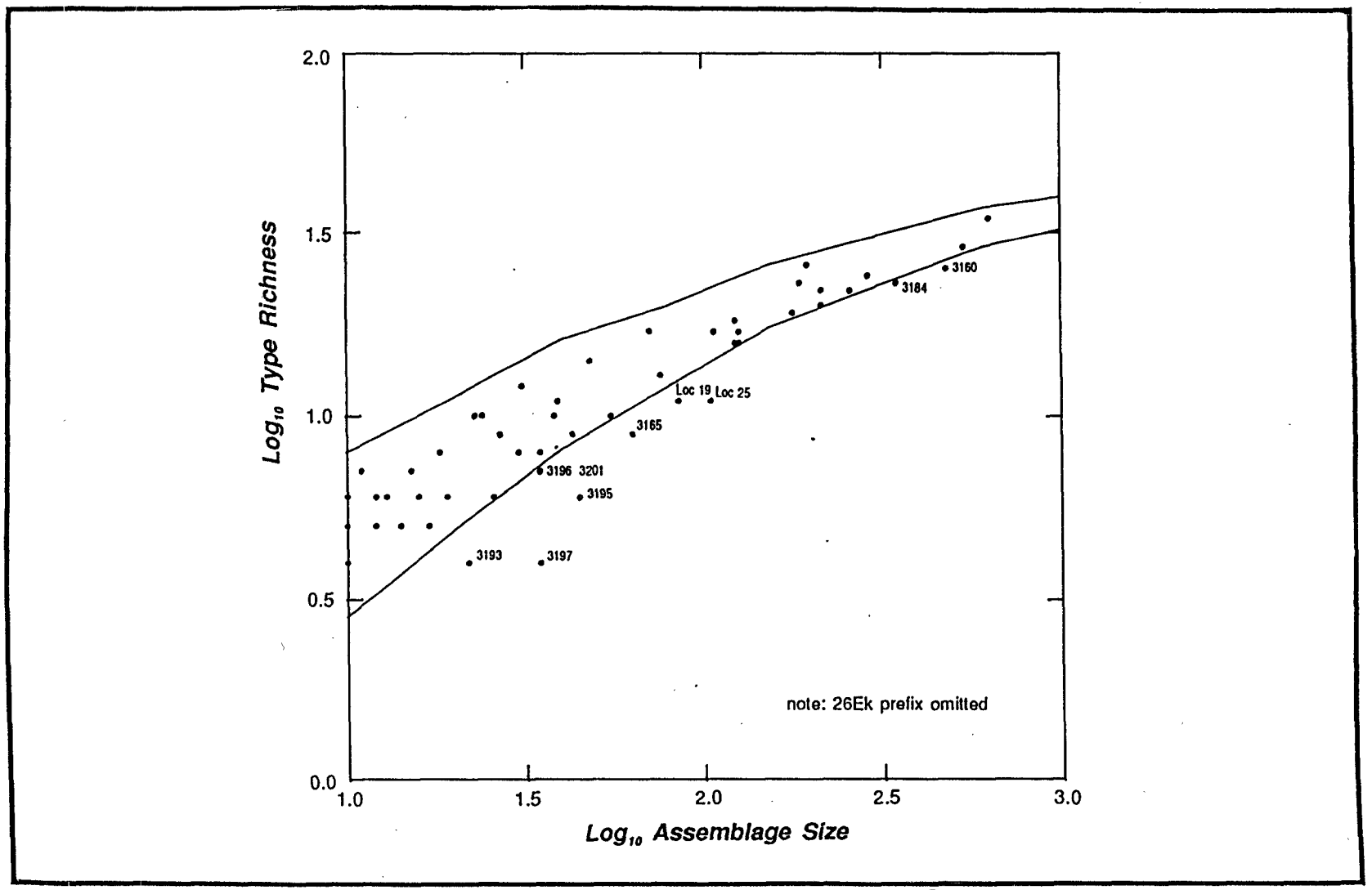


Figure 239. Type richness vs. assemblage size with upper and lower boundaries of 2 standard deviations around mean of simulated data and outlier assemblages.

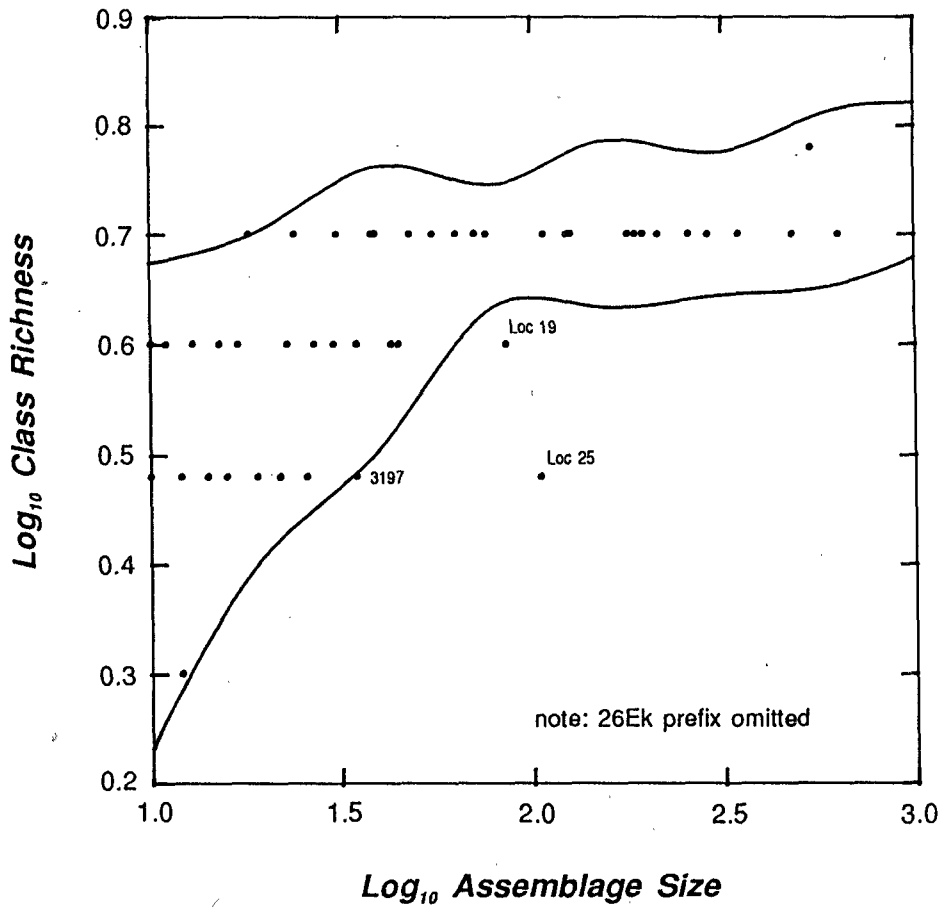


Figure 240. Class richness vs. assemblage size with upper and lower boundaries of 2 standard deviations around mean of simulated data and outlier assemblages.

Overall, type and class richness values are both dependent upon sample size. Type richness is more responsive to sample size than class richness, probably because with a reduced number of classes the variance in assemblage size at a given level of class richness is much greater. Patterns are distinguishable in richness values; ten assemblages lie outside the confidence limits of the richness: size regression, and eight are also outside the two standard error boundaries of simulated richness data for tool type assemblages. Thus, no matter how one constructs the "expected" boundaries of richness for assemblages of tool types, eight assemblages fall outside of it. Outliers to expected values of richness simulated for assemblages of tool classes also were found in this fashion.

Type and Class Evenness

Evenness measures the relative frequency of type or class constituents. Evenness was studied at Tosawihi in two ways: through rank order correlation coefficients and with Pielou's *J statistic. Calculation of Pielou's J statistic is done by calculating the Shannon-Weaver index (a* heterogeneity measure) for each sample and dividing it by the logarithm of the maximum number of types or classes (cf. Kintigh 1989). Here, the denominators are log (47) and log (6) for types and classes, respectively. Calculation of rank order correlation coefficients was undertaken using the proportion of classes as one set of values, and calculating Spearman's r for each assemblage compared to the proportion of classes in the pooled Tosawihi assemblage sample. Assemblages not significantly correlated with the overall rank ordering differ in evenness from the pooled Tosawihi sample. The reason for poor correlation of any single assemblage lies in its composition, but here we seek aberrant assemblages as indices of evenness (cf. Whittaker 1972).

Pielou's J statistic is partly dependent on sample size (Brobowsky and Ball 1989; Kintigh 1989). Consequently, examination of evenness using this statistic follows the same logic as the examination of outliers above: J statistics were calculated for simulated assemblages (both type and class) and two standard errors. Tool type evenness (Figure 241) is correlated only weakly with sample size ($r=.21$, $p>0.1$). Over half the assemblages ($n=56$) lie outside the simulated boundaries. Thirty-three assemblages are less even, and one more even, than expected (Table 214). The simulated boundaries for class data (Figure 242) have fewer outliers (9 less even, 4 more even, than expected; cf. Table 214), probably due to the large standard deviation of the simulated J values (illustrating why J values cannot be compared across different typologies; cf. Kintigh 1989:35-36).

Table 214. Outliers to Type and Class Evenness Relationships to Assemblage Size.

Site (locus)	Outlier to 2 standard error boundary of simulated type richness	Outlier to 2 standard error boundary of simulated class richness
3032/19	-1	0
3032/21	-1	-1
3032/23	-1	0
3032/25	-1	-1
3032/98	-1	0
3092	-1	0
3093	0	-1
3095	-1	0
3101	-1	0
3102	-1	0
3104	-1	0
3106	-1	0
3107	-1	0
3149	0	1
3160	-1	-1
3160A	-1	0
3160C	-1	-1

Table 214, continued.

Site (locus)	Outlier to 2 standard error boundary of simulated type richness	Outlier to 2 standard error boundary of simulated class richness
3165	-1	0
3165A	-1	-1
3171	-1	-1
3178	-1	0
3184	-1	-1
3185	0	1
3192	-1	0
3193	-1	0
3195	-1	0
3196	-1	0
3197	-1	-1
3204	-1	0
3208	1	0
3237	-1	0
3237C	0	1
3238	-1	0
3251	0	1
3271	-1	0
3271A	-1	0
3271B	-1	-1

1 = above expected values
-1 = below expected values
0 = within expected values

Spearman rank order correlation coefficients were calculated for all tool class assemblages, but not tool *type* assemblages, since the many infrequently occurring tool types would have yielded spurious correlations. Outlier assemblages have a Spearman's r not significant at the $p=0.05$ probability level (i.e, Spearman's $r < 0.829$ and $r > -0.829$, since n is fixed at 6). Assemblages not correlated with the overall tool class proportions are less even *relative* to the pooled assemblage sample: they differ in the proportions of tools in classes and consequently have a different ranking.

Sample size plays an important role in determining the membership of this group (Figure 243). Small assemblages (often single artifacts) are much more common in this group than in the sample as a whole. Because the curve of the point swarm flattens after sample size equals ten, assemblages having more than ten tools probably are true outliers independent of sample size (Table 215). The compositional differences between these assemblages and the pooled Tosawihi tool assemblage sample are discussed below.

Examination of evenness in the Tosawihi assemblages is dominated by the effects of assemblage size. Both measures of evenness employed are subject to sample size dependency. Isolating outliers to expected values of Pielou's J statistic showed that approximately half the tool assemblages, when examined as types, are less even than expected. A smaller percentage are lower than expected when the same statistic is calculated for assemblages of tool classes. This suggests that many of the assemblages are dominated by tool types or tool classes having higher frequencies than the pooled proportions indicate. The same pattern is evident in the rank order correlation examination of evenness, but in the rank order examination, a non-significant result can be achieved by having a higher proportion of a *particular* tool class than the pooled assemblage.

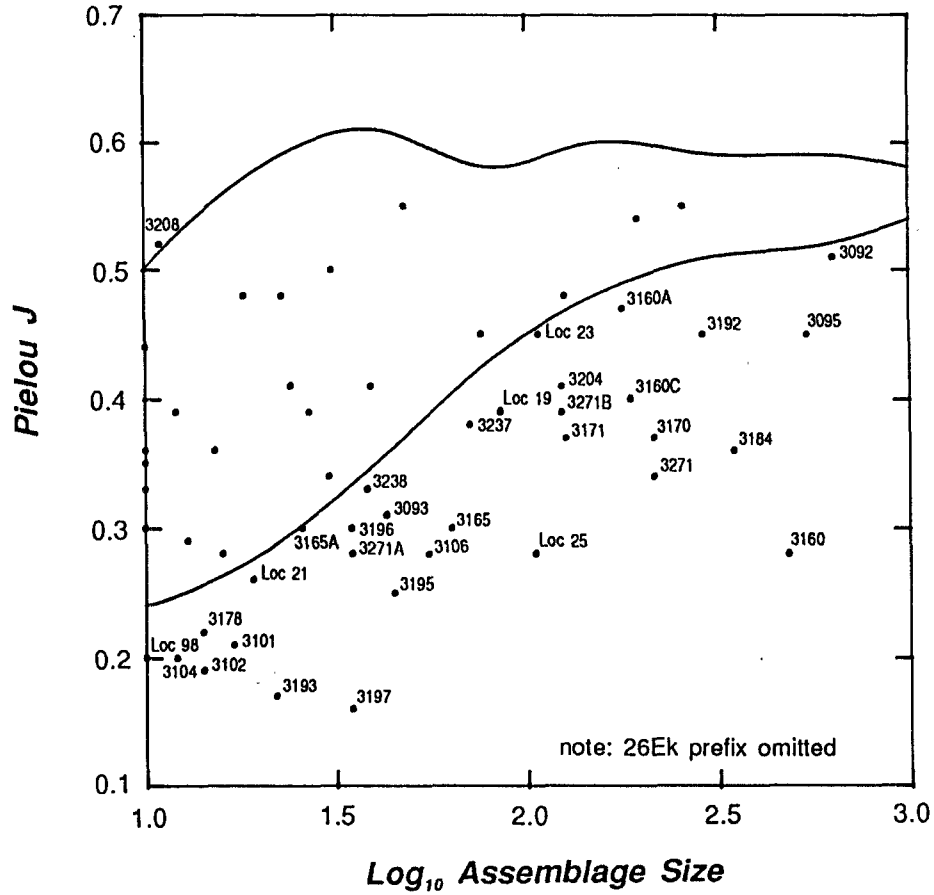


Figure 241. Type evenness vs. assemblage size with upper and lower boundaries of 2 standard deviations around mean of simulated type evenness and outlier assemblages.

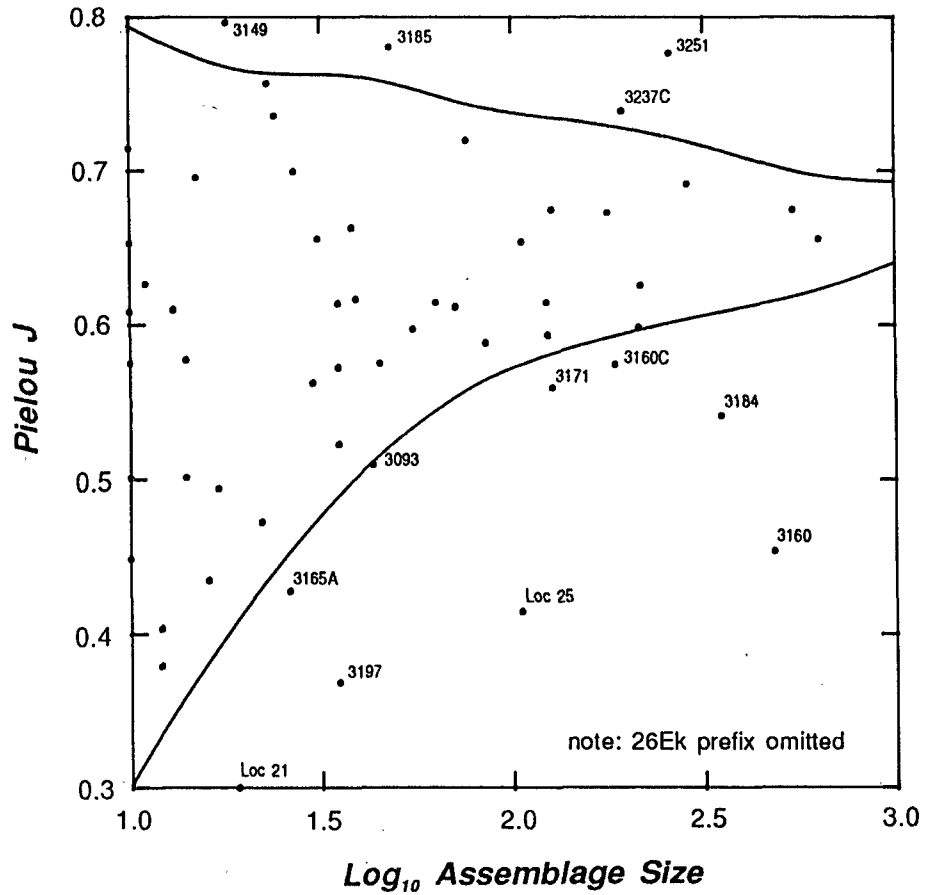


Figure 242. Class evenness vs. assemblage size with upper and lower boundaries of 2 standard deviations around means of simulated class evenness and outlier assemblages.

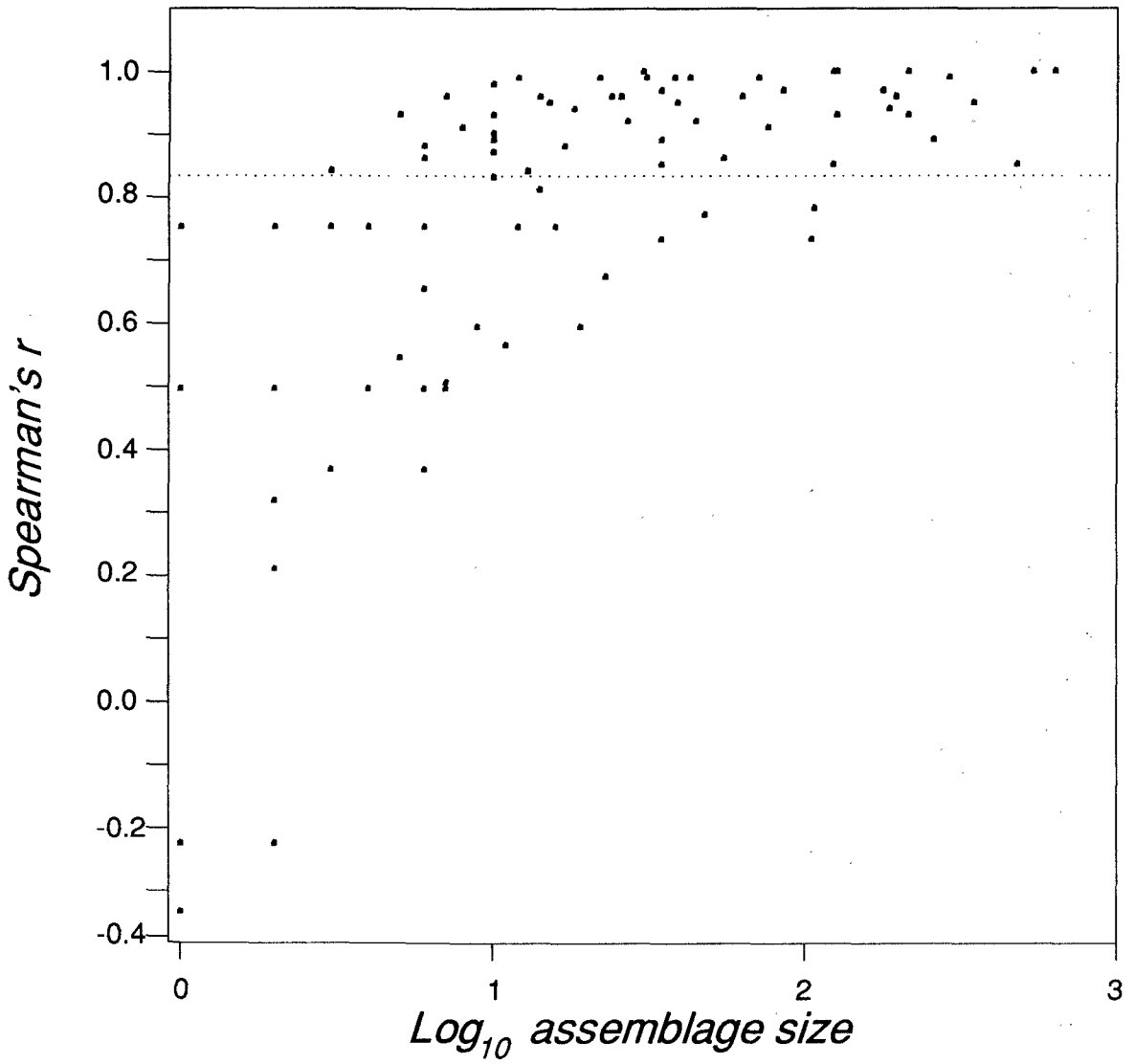


Figure 243. Spearman's r vs. assemblage size. Assemblages with rho<0.829 are not significant.

Table 215. Assemblages Having Insignificant Rank Order Correlations with the Pooled Assemblage Sample, based on Tool Class Proportions.

	TOOL CLASS							
Site/Locality	Quarry	Weapons	Fabricating/Processing Byproducts	Tools	General Utility	Domestic Equipment	N	Spearman's Rho
26Ek3032/093	0	0	0	0	0	1	1.00	-0.351
26Ek3144	0	1	0	0	0	0	1.00	-0.235
26Ek3032/028	0	1	0	0	0	0	1.00	-0.235
26Ek3125	0	1	0	0	0	0	1.00	-0.235
26Ek3142	0	1	0	0	0	0	1.00	-0.235
26Ek3032/107	0	1	0	0	0	0	1.00	-0.235
26Ek3032/072	0	1	0	0	0	0	1.00	-0.235
26Ek3032/004	0	1	0	0	0	0	1.00	-0.235
26Ek3032/040	0	1	0	0	0	0	1.00	-0.235
26Ek3032/158	0	1	0	0	0	0	1.00	-0.235
26Ek3123	0	1	0	0	0	0	1.00	-0.235
26Ek3075	0	1	0	0	0	0	1.00	-0.235
26Ek3032/152	0	1	0	0	0	0	1.00	-0.235
26Ek3154	0	1	0	0	0	0	1.00	-0.235
26Ek3162	0	1	0	0	0	0	1.00	-0.235
26Ek3148	0	1	0	0	0	0	1.00	-0.235
26Ek3032/024	0	0	1	0	0	0	1.00	0.489
26Ek3100	0	0	1	0	0	0	1.00	0.489
26Ek3155	0	0	1	0	0	0	1.00	0.489
26Ek3262	0	0	1	0	0	0	1.00	0.489
26Ek3110	0	0	0	0	1	0	1.00	0.746
26Ek3186	0	0	0	0	1	0	1.00	0.746
26Ek3032/138	0	2	0	0	0	0	2.00	-0.235
26Ek3237B	0	1	1	0	0	0	2.00	0.201
26Ek3174	0	0	0	0	1	1	2.00	0.313
26Ek3234	0	0	2	0	0	0	2.00	0.489
26Ek3189	0	0	2	0	0	0	2.00	0.489
26Ek3085	0	0	0	0	2	0	2.00	0.746
26Ek3088	0	0	2	1	0	0	3.00	0.359
26Ek3183	0	0	0	0	3	0	3.00	0.746
26Ek3231	0	1	1	0	1	0	3.00	0.746
26Ek3087	0	0	4	0	0	0	4.00	0.489
26Ek3091	0	0	3	0	1	0	4.00	0.747
26Ek3179	0	0	0	2	3	0	5.00	0.539
26Ek3086	0	0	4	2	0	0	6.00	0.359
26Ek3232	0	0	6	0	0	0	6.00	0.489
26Ek3032/026	0	0	5	0	1	0	6.00	0.652
26Ek3177	0	2	2	0	2	0	6.00	0.746
26Ek3203	0	0	7	0	0	0	7.00	0.489
26Ek3237A	0	2	1	1	2	1	7.00	0.499
26Ek3032/022	0	0	8	0	1	0	9.00	0.593
26Ek3208	0	1	0	3	6	1	11.00	0.558
26Ek3181	0	0	1	0	9	2	12.00	0.754
26Ek3178	0	3	7	0	4	0	14.00	0.81
26Ek3096	0	0	11	0	4	1	16.00	0.75
26Ek3032/021	0	0	16	1	2	0	19.00	0.585
26Ek3116	0	6	4	5	8	0	23.00	0.667
26Ek3197	0	0	26	1	8	0	35.00	0.727
26Ek3185	0	8	19	9	11	1	48.00	0.765
26Ek3032/025	0	0	75	6	24	0	105.00	0.732
26Ek3032/023	1	6	57	16	26	0	106.00	0.784

Assemblage Composition

The examinations of richness and evenness relative to assemblage size presented above clearly indicate that sample size is an important contributor to the diversity (in its inexact sense) of Tosawihi tool assemblages. In the diversity inquiry the potential importance of specific constituent tool types or classes within a sample, i.e., assemblage composition, was largely ignored. In theory, the actual classes or types present in a sample are not *necessarily* conditioned by sample size, but in practice the presence of rare tool classes must be conditioned by the size of the sample. Indeed, this is the rationale for Monte Carlo simulations of richness and evenness values using type or class proportions (Kintigh 1989; Rhode 1988). Thus, outliers to measures of diversity are likely to differ in composition from non-outliers of the same sample size.

Another important aspect of the richness and evenness calculation is that individual tool types or tool classes are all given equal weight. For example, it is immaterial whether an outlier assemblage to the type richness: size regression contains five tool types from the same tool class, or five tool classes represented by one tool type each. So, patterns in assemblage composition based on contrasts of outlier and non-outlier samples *could* indicate assemblage types or profiles but they need not do so. Rather, it is far more likely that such contrasts indicate the *dimensions* along which assemblage composition varies and not different global patterns of assemblage composition. Differences in assemblage composition are *not* used in this study to construct a higher order classification of assemblages. The dimensions found in this fashion need not accord with site function, landscape position, etc., because the contrast still presumes equal importance of each tool class or tool type. In the real world of archaeological things, however, we rarely presume equal importance of different kinds of artifacts. Debitage types, for instance, rarely are considered significant evidence of subsistence actions (although they might be). *Weighting* values for different tool types or classes would of course vary according to the needs of a particular analysis.

The research question guiding the initial inquiry into assemblage composition is: what are the axes of variation in assemblage composition? Only the tool class data are used in examining assemblage composition, to promote replicability between regional samples by avoiding overdependence on the Tosawihi typology, even though General Utility tools may have a somewhat different meaning in the Tosawihi context (cf. above). First, outliers to the boundaries of the richness: size regression, richness: size simulations, and evenness:size simulations are compared to the composition of the assemblages that are not outliers. Next, assemblages that are outliers to the evenness comparison made using Spearman rank order correlation coefficients are contrasted with assemblages correlating with the tool class proportions of the pooled Tosawihi assemblage sample. In all of these analyses, tool classes are not differentially *weighted*, since the aim is to discover what the most variable tool classes are and how they are related to each other. Nor are individual assemblages of particular interest, for the same reason.

The second part of this inquiry examines individual assemblages in comparison to the pooled Tosawihi sample and weights their attributes. Individual outlier assemblages are found through differences in the frequencies of particular tool classes by comparing tool class proportions of each assemblage to the tool class proportions of the pooled Tosawihi assemblage sample. A differential weighting of one tool class is examined next. Assemblages with Domestic Equipment class artifacts are segregated and pooled (hence they are given a different weighting) for contrast with all other assemblages. Finally, attributes of assemblages extrinsic to their composition are examined by giving analytical weight to the distance of an assemblage from water and toolstone sources.

The methods of comparison used are similar to those employed by Thomas (1988). Since all of the contrasts are a comparison of the frequencies of tool classes for a single assemblage or pooled totals for groups of outlier assemblages vs. pooled non-outlier assemblages, a matrix

of two by six cells contains the basic data. Chi-square tests of independence of this matrix and Kolmogorov-Smirnov two sample tests of cumulative proportional differences were employed to assess compositional variation. The former test seeks to reject the null hypothesis of independence of tool class distribution relative to outlier status. The latter test seeks to reject the null hypothesis of equal proportional frequency of tool classes between the two pooled groups.

If both tests rejected their respective null hypotheses at a level of significance of $p=0.05$, further examination of the two samples was undertaken to examine *how* they differ in composition. Details of compositional differences were examined using adjusted standardized residuals, which yield an estimate of the deviation of each cell from its expected value under a model of independence (Everitt 1977). Deviations from expected chi-square values having a probability of less than 0.05 (adjusted residuals greater than 1.96 or less than -1.96) are considered indicators of important departures from independence. Residuals for each pooled outlier sample are illustrated graphically (cf. Figure 244). Since adjusted residuals in a 2 by *n* matrix are always equal for adjacent cell pairs, the residual pattern for the nonoutlier group always mirrors the residual pattern of the outlier sample or group.

Assemblage Composition of Outliers to Type and Class Richness

Assemblages below, within, and above the 99% confidence limits of the type richness: size regression (Table 213, Figure 238) were compiled into three pooled samples. Assemblages above the limits are richer than the overall Tosawihi assemblages, those below, less rich than expected. Tests of the similarity of tool class composition were performed between the less rich (i.e., below the 99% confidence interval limits) and the within limits groups, and the more rich and the within limits group.

The 13 less rich assemblages differ in composition from the 62 assemblages that fall within the limits (chi-square=46.168, $p<0.001$; Dmax=.055, Dcrit=.052 at $p=0.05$, $n1=855$, $n2=3394$). Assemblages less rich than expected tend to have fewer artifacts in the Weapons and Domestic Equipment classes, and more tools of the General Utility class (Figure 244a). (The same pattern is present in the outliers to *simulated* type richness relative to size, since the same assemblages compose this group.) The four assemblages richer than expected are also different in tool class composition (chi-square=89.166, $p<0.001$; Dmax=.113, Dcrit=.045 at $p=0.05$, $n1=1235$, $n2=3394$; Figure 244b), having less than expected frequencies of Fabricating/Processing byproducts and greater than expected frequencies of artifacts in the Weapons and General Utility classes.

The same examination was undertaken using the boundaries of two standard deviations around the mean simulated class richness values. The three outliers to the simulation of class richness values (all lower than expected values; cf. Table 213, Figure 240) form a sparse matrix with 30% of its cells having counts below five. The statistical results therefore are not ideally reliable, although they are significant (chi-square=67.205, $p<0.001$; Dmax=.183, Dcrit=.093 at $p=0.05$, $n1=225$; $n2=5259$). The residuals show lower than expected frequencies of tools in the Domestic, General Utility, and Weapons classes, and higher than expected frequencies of Fabricating/Processing Byproducts (Figure 245).

In general, all of the less rich outliers (whether calculated from regression on type richness or simulation of class and type richness values) show lower than expected values of the Weapons and Domestic tool classes. Fabricating/Processing Tools and Quarry Equipment are not highly variable in frequency from less rich to average richness assemblages. General Utility and Fabricating/Processing Byproduct tool classes vary in their relationships to the average richness sample, depending upon the particular contrast employed, although in both type and class simulation contrasts, Fabricating/Processing Byproducts are higher than in the

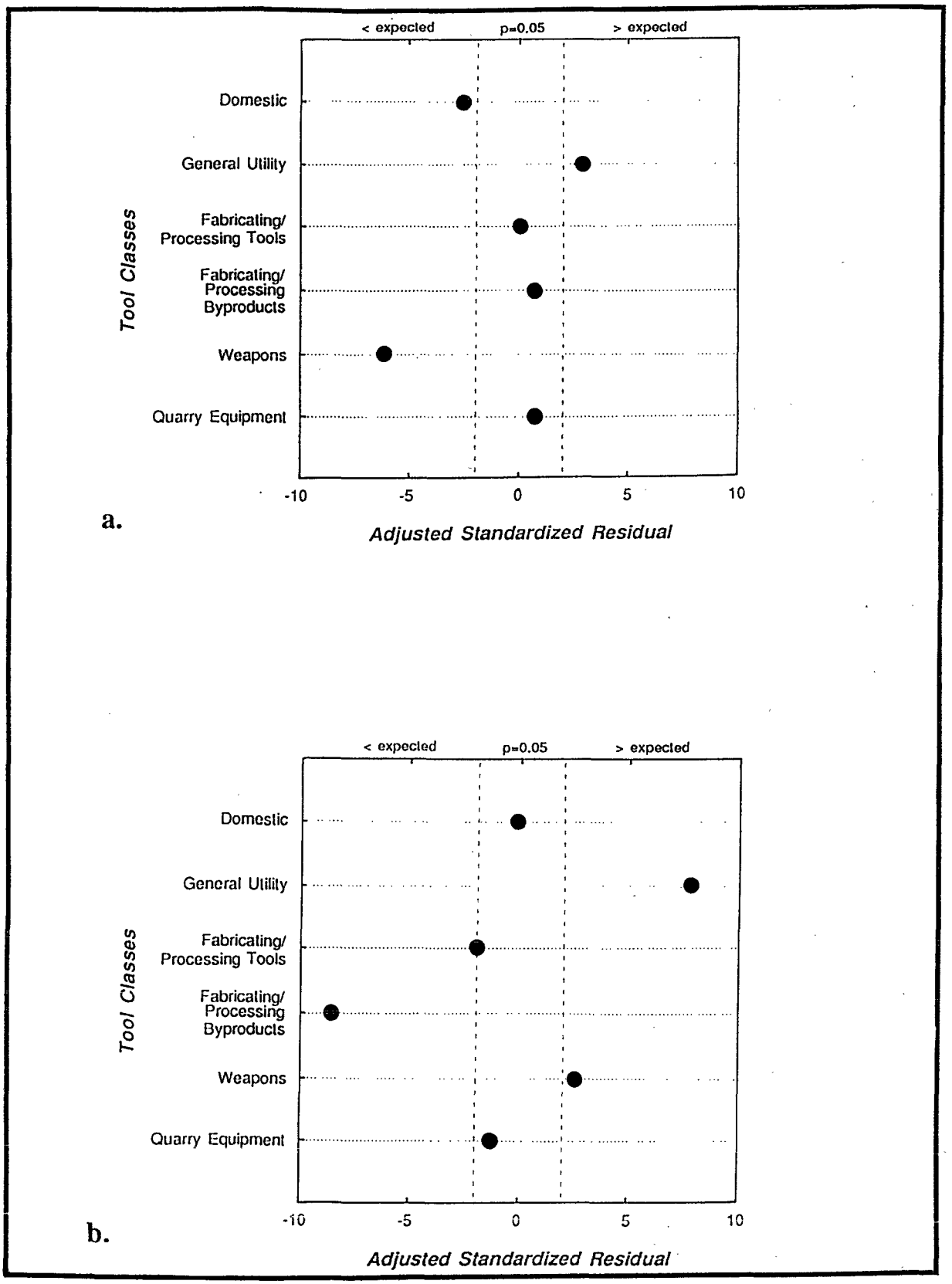


Figure 244. Adjusted standardized residuals for (a) assemblages less rich and (b) more rich than the type richness:sample size regression.

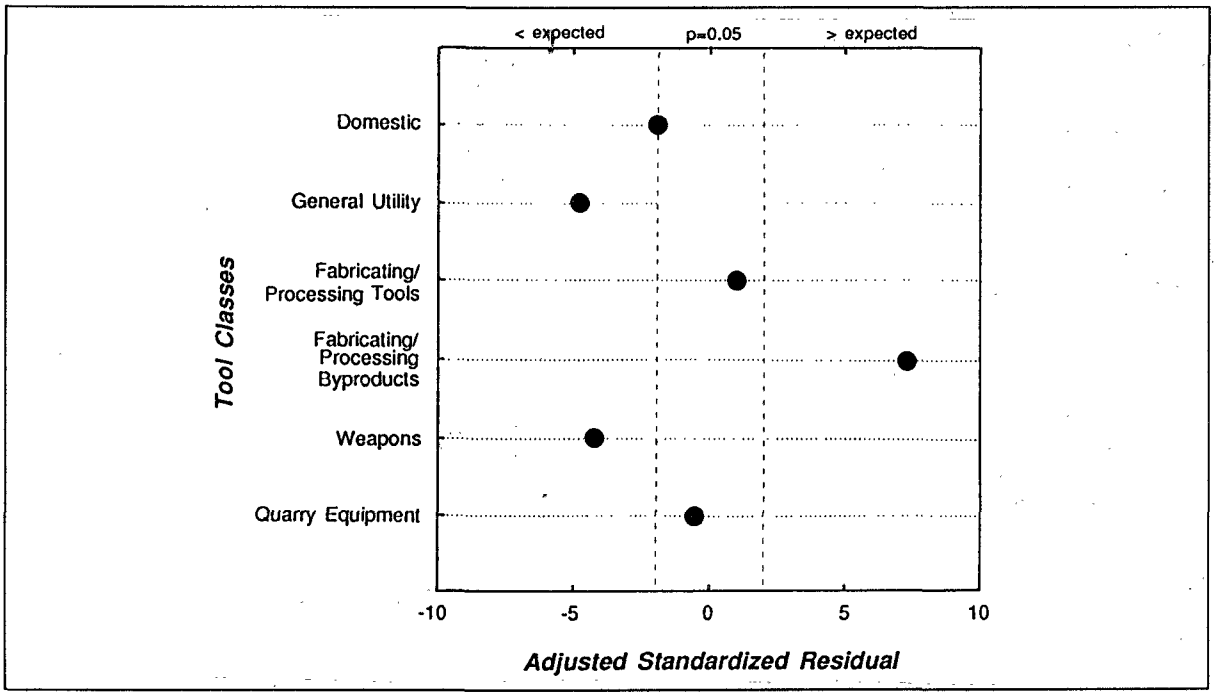


Figure 245. Adjusted standardized residuals for assemblages of tool classes less rich than two standard errors around the mean of simulated richness.

average samples. In sum, the low richness assemblages are consistent in their lack of Weapons and Domestic Equipment. The high richness assemblages (Figure 244b) show a partial reversal of this pattern: high frequencies of Weapons and low frequencies of Fabricating/Processing Byproducts.

Assemblage Composition of Outliers to Type and Class Evenness

Comparison of the thirty-one assemblages less even than the boundaries of simulated evenness values based on types (Figure 241, Table 214) shows that less even assemblages have higher frequencies of General Utility tools and lower frequencies of tools in the Domestic, Fabricating/Processing Byproduct, and Weapon tool classes (chi-square=112.152, $p<0.001$; Dmax=.113, Dcrit=.042 at $p=0.05$, $n1=4051$; $n2=1422$; Figure 246). The single assemblage lying above the two standard error boundary of type evenness is not significantly different from the average sample group.

The ten assemblages below the simulated tool class evenness boundaries (Figure 242, Table 214) differ significantly from the 76 assemblages in the average sample group (chi-square=124.477, $p<0.001$; Dmax=.155, Dcrit=.042 at $p=0.05$, $n1=1493$; $n2=3473$). The less even tool class assemblages mirror the composition of the less even tool type assemblages, with the exception that Fabricating/Processing Tools occur in approximately the expected frequency (Figure 247a). The four assemblages with higher than average evenness values (Figure 242, Table 214) relative to the simulated class evenness distribution also differ significantly from the average group (chi-square=86.560, $p<0.001$; Dmax=.103, Dcrit=.064 at $p=0.05$, $n1=518$; $n2=3473$). Three of the four assemblages (26Ek3149, 26Ek3185, 26Ek3237 Locus C) also are higher than the average group in richness (based on regression limits), so it is not surprising that they mirror this group in composition (cf. Figure 244b and Figure 247b).

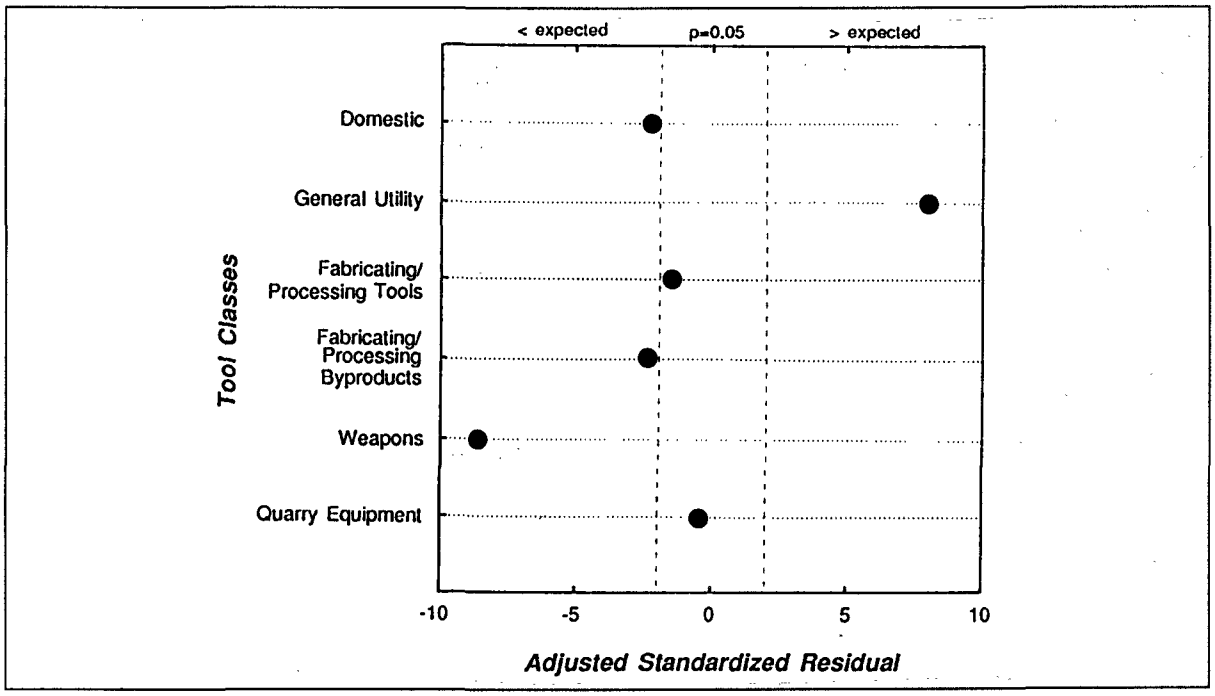


Figure 246. Adjusted standardized residuals for assemblages of tool types less even than two standard errors around the mean of simulated richness.

In fact, many of the same assemblages are recurrent outliers (cf Table 214, 215), so outliers to the richness relationship are also likely outliers to evenness values. There is no reason why evenness of tool classes should be correlated with richness of tool types, since the number of types present is not necessarily related to how they are distributed among classes or how class frequencies are related. However, the same assemblages appear as outliers in different kinds of analyses, indicating that there really must be something different about them in comparison to all other tool assemblages. Hence, differences in composition probably are real, that is, they are not merely artifacts of the analytical techniques employed.

Assemblage Composition of Outliers to the Rank Correlation Relationship

The Spearman's *r* examination undertaken above to assess assemblage evenness provides a starting point for the analysis of assemblage composition. Figure 243 and Table 215 show that some assemblages are not correlated with the pooled tool class proportions of the Tosawihi assemblages. These assemblages have a composition different from the overall Tosawihi sample, since tool classes occur in a different order of frequency. In the pooled Tosawihi tool class assemblage, the order of tool class occurrence is: General Utility implements (47%); Fabricating/Processing Byproducts (36.6%); Weapons (7.1%); Fabricating/Processing tools (6.8%); Domestic Equipment (2.4%); and Quarry Equipment (0.1%). A closer examination of why the ten assemblages with more than ten tools (Table 215) are not correlated with the pooled sample reveals a pattern in seven of the ten assemblages. These seven assemblages (26Ek3178, 26Ek3096, 26Ek3197, 26Ek3185, and 26Ek3032 Localities 21, 23, and 25) all have Fabricating/Processing Byproducts as their most frequent tool class, and General Utility tools rank second. Activities that generated Fabricating/Processing Byproducts appear to have been more common than the norm on these sites. The most frequent tools in this class at Tosawihi are early stage bifaces (earlier than Stage 3.5; cf. Chapter 6), and it is perhaps no surprise that all seven of the assemblages cited above are at most a few hundred meters from toolstone sources; many actually *are* toolstone sources.

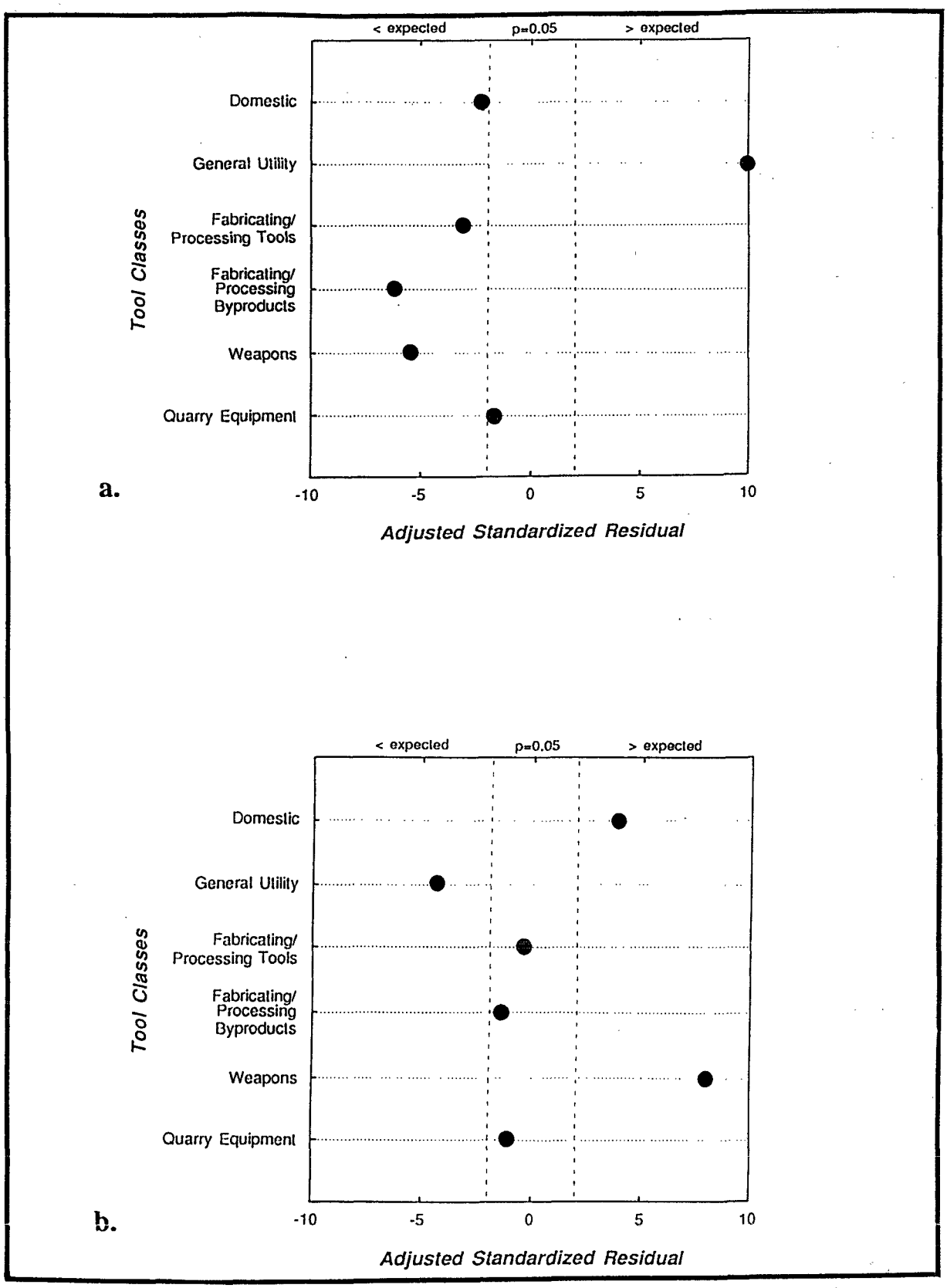


Figure 247. Adjusted standardized residuals for assemblages of tool classes (a) less even than two standard errors around the mean of simulated richness and (b) more even than two times the standard error around the mean.

Assemblage Composition of Outliers to Tool Class Proportional Frequency

The comparisons above are phrased in terms of *groups*: assemblages that shared a particular outcome in the analysis of richness and evenness. The method of contrasts employed can be extended to contrast single assemblages with all other assemblages. No contrast of richness or evenness precedes assemblage selection, although only assemblages with more than ten tools were examined in this analysis. Each assemblage was contrasted with the pooled Tosawihi assemblage sample (subtracting the assemblage of interest) using a Kolmogorov-Smirnov two-sample test (Thomas 1976). Like the Spearman's rank order correlation coefficient study, constructing the contrast in this way compares tool class *proportions* and not frequencies, so it is independent of sample size. Tool class assemblages different at the $p = 0.05$ level and containing more than ten tools are considered outliers to the tool class proportional frequency.

Seventeen assemblages are outliers with regard to tool class proportional frequency (Table 216). Compared to the pooled sample to which they were compared, they fall into three distinct groups: those with high proportions of Fabricating/Processing Byproducts and low proportions of General Utility tools (Group 1 assemblages), those with low proportions of Fabricating/Processing Byproducts and high proportions of General Utility tools (Group 2), and those with high proportions of Weapons (Figure 248). Some minor differences between the three groups and the pooled assemblage class proportions are also evident in Figure 248. For example, Group 3 assemblages have not only proportionally more tools in the Weapons class, but also have fewer General Utility tools and more Domestic Equipment than the pooled assemblage. Group 1 has more Fabricating/Processing Tools as well as more Fabricating/Processing Byproducts. Thus, the comparison of individual assemblages to the pooled sample tool class proportions appears to isolate consistent differences in some assemblages.

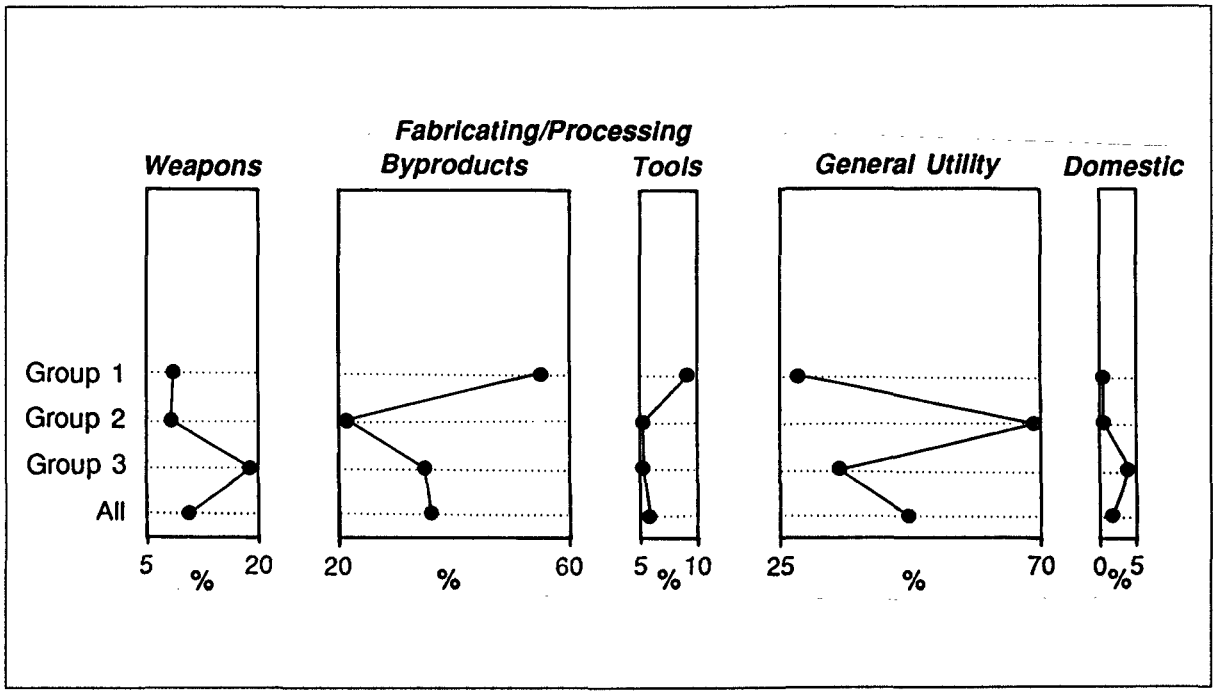


Figure 248. Proportional frequency of tool classes (excluding Quarry Equipment) for pooled Tosawihi assemblages and three Kolmogorov-Smirnov analytical result groups.

Table 216. Kolmogorov-Smirnov Test Outliers ($p<0.05$) to Pooled Tool Class Proportional Frequency.

Figures shown are percentage difference between class proportion in assemblage and class proportion in pooled Tosawihi assemblages without assemblage. *Only assemblages with more than ten tools are shown.*

Site (locus)	Quarry	Weapons	Fabricating/Processing Byproducts	Fabricating/Processing Tools	General Utility	Domestic	Analytical Group
3032/21	-0.11	-7.16	47.93	-1.57	-36.66	-2.42	1
3032/23	0.85	-1.51	17.67	8.42	-22.98	-2.46	1
3032/25	-0.11	-7.28	35.66	-1.14	-24.68	-2.46	1
3170	-0.11	-3.54	15.07	0.67	-10.56	-1.54	1
3185	-0.11	9.61	3.17	12.02	-24.36	-0.33	1
3190	-0.11	4.77	7.07	5.08	-15.70	-1.11	1
3197	-0.11	-7.19	38.08	-4.00	-24.36	-2.43	1
3203	-0.11	-7.15	63.64	-6.84	-47.12	-2.41	1
3204	-0.11	-2.31	19.27	2.99	-18.20	-1.63	1
3232	-0.11	-7.15	63.62	-6.84	-47.12	-2.41	1
3160	-0.12	-2.80	-23.72	-4.97	31.51	0.10	2
3160C	-0.11	-2.35	-12.54	-0.36	16.18	-0.82	2
3181	-0.11	-7.16	-28.17	-6.85	28.00	14.29	2
3184	-0.12	-5.48	-10.15	1.88	15.83	-1.96	2
3198	-0.11	14.45	-3.45	-3.77	-5.46	-1.66	3
3237C	-0.11	11.30	-4.65	-1.20	-6.57	1.24	3
3251	-0.11	10.81	3.24	-0.66	-18.06	4.79	3

Analytical Group:

(1) Fabricating/Processing Byproducts greater than in pooled assemblage. General Utility Tools less than in pooled assemblage.

(2) Fabricating/Processing Byproducts less than in pooled assemblage. General Utility Tools greater than in pooled assemblage.

(3) Weapons greater than pooled assemblage.

Axes of Variation, Analytical Weighting, and Controlling Assemblage Composition

Outliers to the unsurprising relationship between measures of diversity and measures of evenness indicate that the composition of Tosawihi assemblages can be modeled as an arrangement of tool frequency along two compositional dimensions or axes. The clearest axis is defined by Domestic Equipment and Weapons. These tool classes are closely related to each other; when the frequency of one is high, so is the other (cf. Chapter 20). The two are either both higher than expected or both lower than expected in all but one of the six chi-square contrasts in which they are included (Figure 244b).

A second axis of variation is defined by three tool classes. Fabricating/Processing Byproducts and Fabricating/Processing tools share the same outlier status (i.e., significantly higher or lower than expected) in four of the six contrasts presented above. The linkage between these two classes is less strong than that between Weapons and Domestic Equipment. General Utility tools are at the other end of the Fabricating/Processing axis of variation. This tool class is always either more or less frequent than expected in the six contrasts. There is good reason to suspect that many of the General Utility tool types at Tosawihi are more related to chipped stone production (since later stage bifaces and hammerstones are part of this class) than to the performance of multiple tasks. So, frequencies of General Utility tools might be expected to covary positively with the Fabricating/Processing compositional dimension. In fact,

they do not. Fabricating/Processing classes and General Utility tools are residuals in the same direction (both more than expected or both less than expected) in only one of the five contrasts containing significant Fabricating/Processing residuals. Thus, General Utility tools may be the other end of the fabricating/processing compositional dimension. This is clearly seen in the results of the Kolmogorov-Smirnov comparisons of individual assemblages to the pooled Tosawihi sample (Table 216).

The Domestic Equipment-Weapons and Fabricating/Processing-General Utility dimensions are mutually independent. Any given assemblage then, consists of some mixture of these two compositional dimensions (Figure 249). The Tosawihi assemblages are complicated mixtures of both axes, so no clear assemblage patterns emerge (hence no higher order typology of "assemblage types" is generated by this study). Yet, if one axis of this variation is given more analytical weight than the other, compositional differences may become apparent and perhaps even interpretable.

Variation in Assemblages with Domestic Equipment

Domestic Equipment is infrequent, comprising only 2% of the pooled Tosawihi tool assemblage (Table 212). Although several tool types comprise the Domestic Equipment class, many have fairly specific functions related to food processing (cf. Chapters 12, 13, 20). Are other tool classes positively or negatively associated with these (inferred) behavioral indicators (cf. Chapter 20)? To evaluate this, assemblages with and without Domestic Equipment were compared to each other, thus giving analytical weight to this particular tool class. Since the previous analyses showed that Weapons covary with Domestic Equipment, Weapons should associate positively with Domestic Equipment.

Tool class composition differences were assessed with chi-square and Kolmogorov-Smirnov tests contrasting the frequencies of the other four tool classes excluding Quarry Equipment. As in

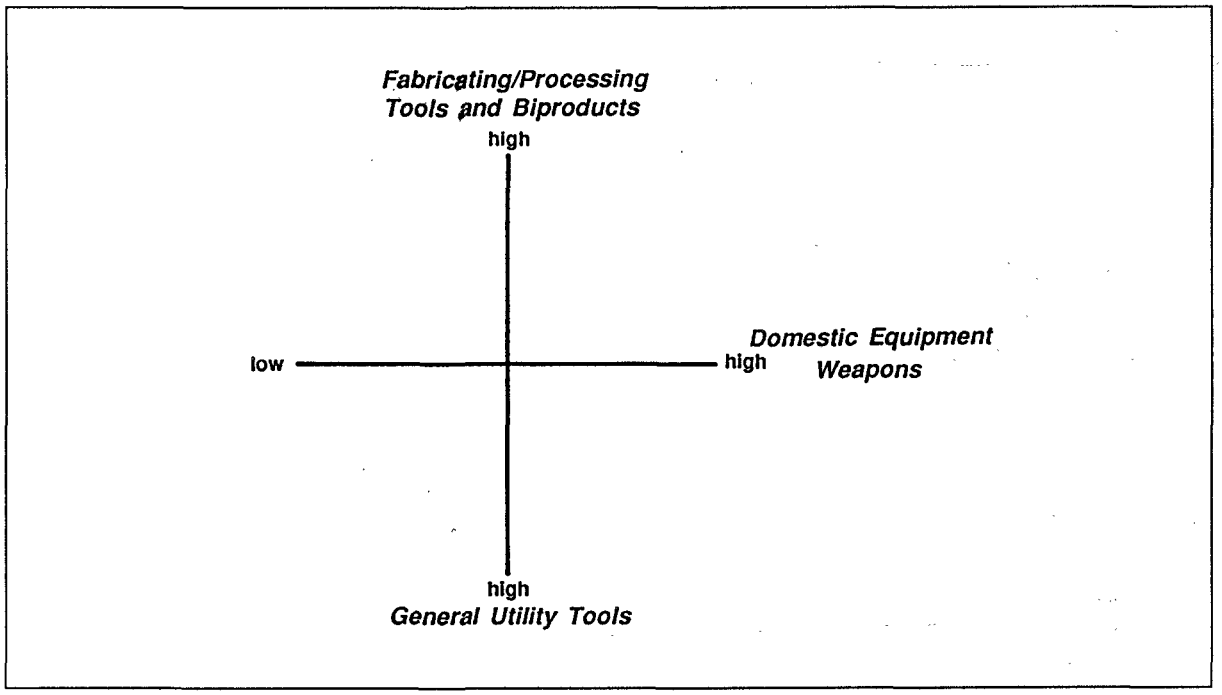


Figure 249. Axes of variation in the Tosawihi tool assemblages.

all previous compositional analyses, only assemblages with more than ten tools were included in the contrast. There are, indeed, differences between assemblages with Domestic Equipment (n=32) and those without (n=17; chi-square=67.86, df=3, $p<0.01$, Dmax=.151, Dcrit=.060 at $p=0.01$). The compositional differences can be examined readily using adjusted standardized residuals (Everitt 1977) shown in Figure 250. Assemblages containing Domestic Equipment tend to have significantly higher frequencies of Weapons (as expected) and General Utility tools. Fabricating/Processing Byproducts are significantly less frequent than expected under a chi-square model of independence between the two groups.

If, as suggested above, we consider assemblages containing Domestic Equipment and Weapons as at least partially reflecting maintenance activities, the "production" axis of assemblage variation is split when presence of Domestic Equipment is given analytical weight (Figure 251a). The results suggest that the discard of food processing equipment was segregated from discard of Fabricating/Processing equipment and byproducts. Whether this represents differences in locations of activities is addressed below.

Variation in Assemblages using Environmental Variables

As shown above, different axes of variation can be separated in the Tosawihi assemblages, and their separation may be useful in interpreting prehistoric activities. The analytical weighting used above is internal, since Domestic Equipment is a part of the assemblages themselves. Analytical weight was therefore given to an *intrinsic* part of the assemblages, by presuming it to be more meaningful than others. Analytical weight also can be given to *extrinsic* factors. Two of the most important at Tosawihi are proximity to toolstone and proximity to water (cf. Chapter 2). How do the Tosawihi assemblages fit along the dimensions of assemblage composition controlling for these factors?

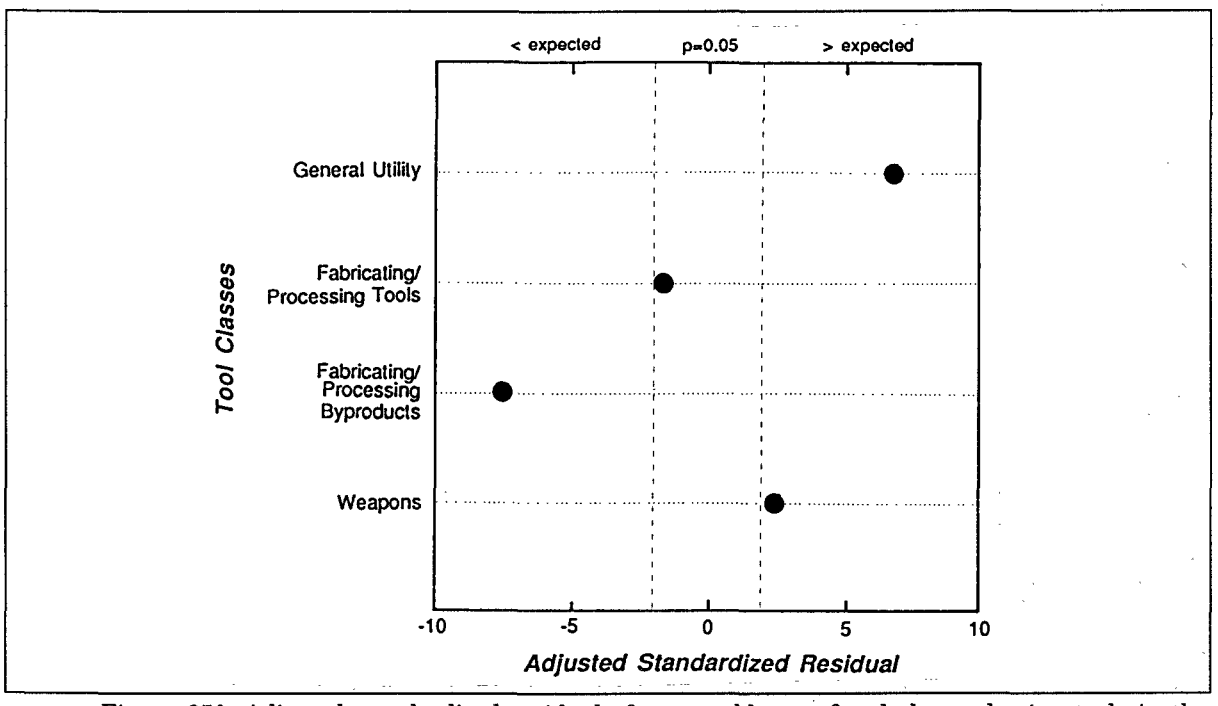


Figure 250. Adjusted standardized residuals for assemblages of tool classes having tools in the Domestic Equipment tool class.

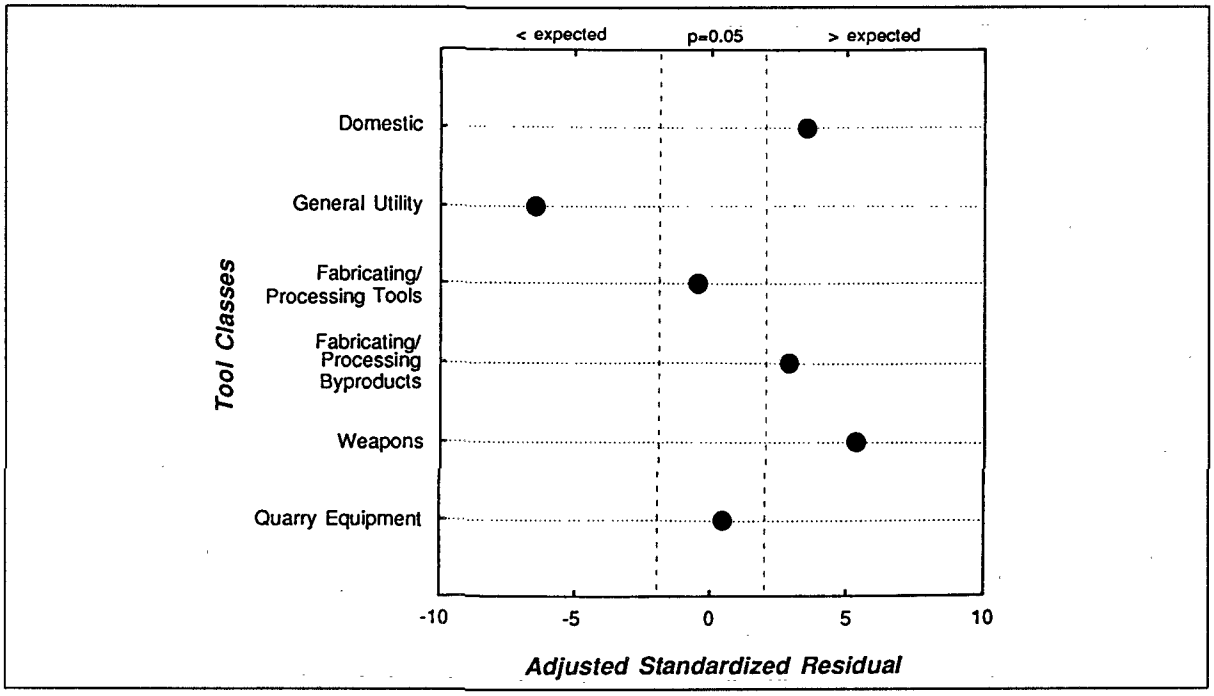


Figure 251. Adjusted standardized residuals for assemblages of tool classes within 250m of water sources.

Using the same techniques described above, assemblages within 250m of water and within 250m of toolstone were segregated from all others, and contrasted with them. Both contrasts (water<250m vs. water>250m; toolstone<250m vs. toolstone>250m) are highly significant. Assemblages near potential water sources differ in composition from those away from water sources (chi-square=66.329, p<0.001; *D*max=.076, *D*crit=.037 at $p=0.05$, $n1=3243$; $n2=2241$) by having lower than expected frequencies of General Utility tools and higher than expected frequencies of Domestic Equipment and Fabricating/Processing Byproducts (Figure 252). Scaling the results along the axes of compositional variation (Figure 251b), the pattern clearly differs from the results of weighting Domestic Equipment assemblages. Assemblages within 250m of toolstone sources also differ from other assemblages (chi-square=123.696, p<0.001; *D*max=.152, *D*crit=.038 at $p=0.05$, $n1=3439$; $n2=2045$). Assemblages close to toolstone (Figure 253) have higher than expected proportions of Fabricating/Processing Tools and Byproducts, and lower than expected General Utility tools and Domestic Equipment. Scaled along the two axes of compositional variation (Figure 251c) the two groups form a pattern similar to that for sites with Domestic Equipment vs. sites without Domestic Equipment. Insofar as activities are indicated by the axes of compositional variation, these analyses jointly show that activities followed a regular pattern in relation to landscape properties.

Discussion

A series of arguments was advanced in Chapter 4, suggesting that variation in the tools discarded in a location should reflect many facets of human behavior. For example, places used for long term visits to Tosawihi are expected to contain discarded tools associated with the maintenance of human groups, especially tools used directly in procurement and processing of food (cf. Chapter 20).

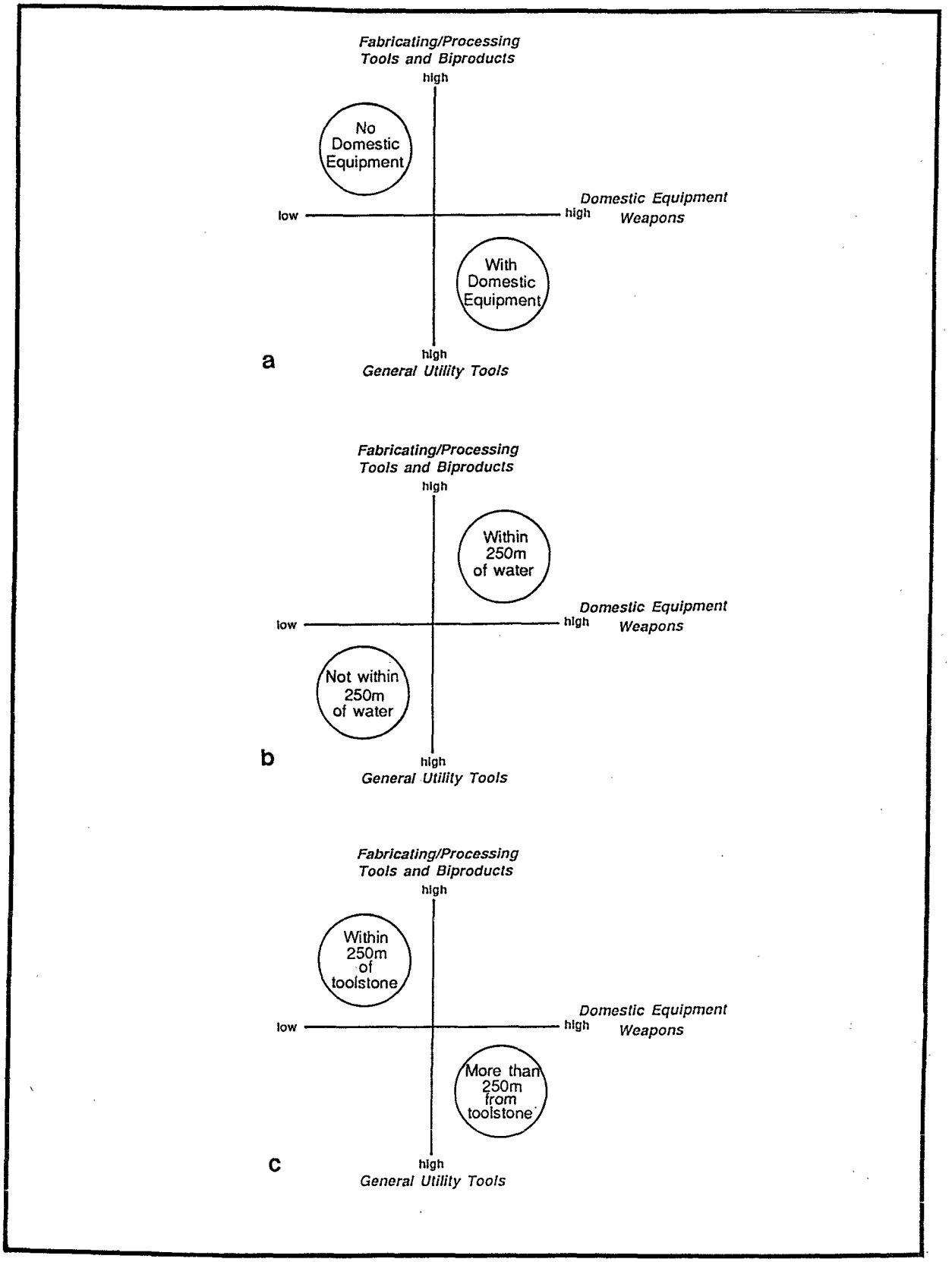


Figure 252. Tool composition patterns scaled along axes of variation in the Tosawihi tool assemblages.

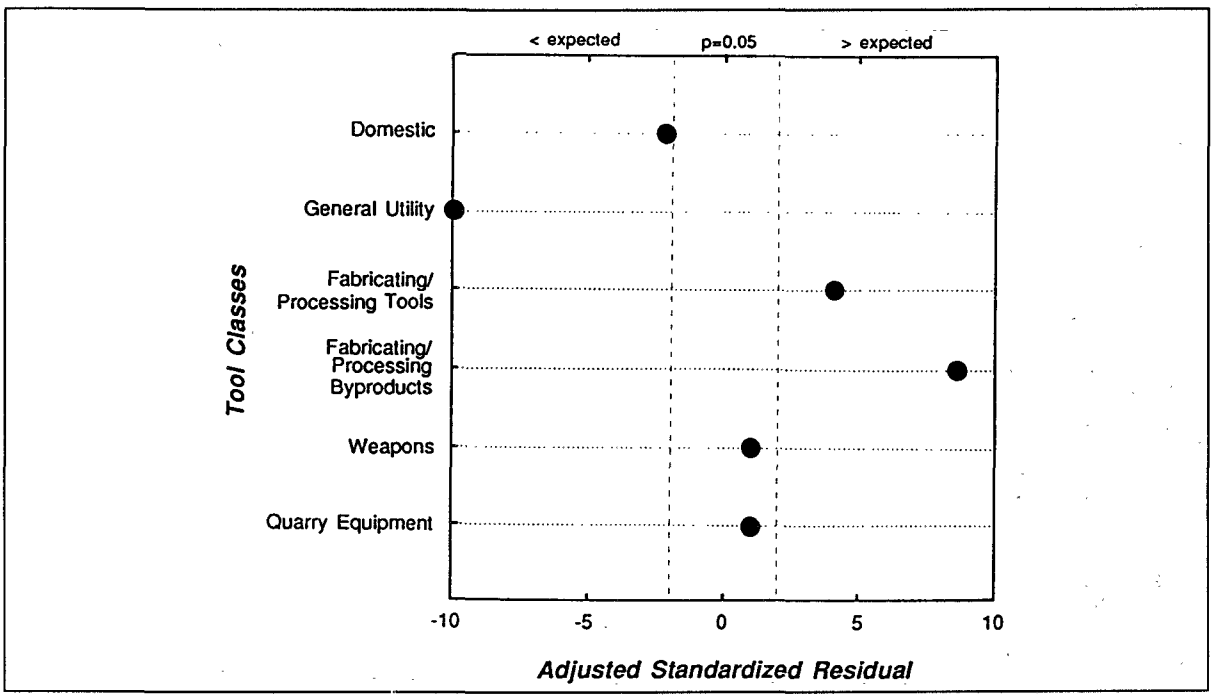


Figure 253. Adjusted standardized residuals for assemblages of tool classes within 250m of toolstone sources.

Assemblages of discarded and lost tools can contain direct testimony to human actions, such as tools discarded at the location(s) of their use. Tool assemblages also can contain tools discarded at locations different from their places of use. Worn projectile points, for example, may be discarded where idle time permits refurbishing of a toolkit. Assemblages also can contain evidence of longer term behavior in support of a particular technological organization: the production (or overproduction) of tools for future (rather than immediate) use. Thus, while assemblages can testify directly to actions undertaken where tools are found, they also can contain tools that are shades of events past, events present, and events in the future.

The strong relationships between assemblage size and various measures of assemblage richness and evenness are artifacts of sampling, and thus are wholly expectable. The strength of these relationships clearly restricts interpretation of the Tosawihi tool assemblages based only on intuitive expectations of greater and lesser diversity.

Assemblages that do not fit the expected relationship between size and diversity measures have consistent differences in composition from their non-outlier counterparts. Because the relationship between sample richness and sample size is so expectable, little could be learned by examining assemblage composition without somehow controlling for the effects of sample size. The technique used here was to examine the composition of outlier assemblages. In effect, the contrasts employing outliers break apart the monolithic relationship between sample size and assemblage richness, allowing more fruitful direct comparisons. The desired goals were not simply numerical contrasts or the creation of assemblage types. As stated at the outset of the chapter, the aim was to define general patterns in assemblage composition to serve as a basis for further studies of particular assemblages or sites (Table 217).

Table 217. Summary of Diversity and Composition Results for Each Assemblage.

Site	A	B	C	D	E	F	G	H	I	J
26Ek3032/004	0	0	0	0	0	0	0	0	<250	<250
26Ek3032/019	-1	-1	-1	-1	0	0	0	1	<500	<250
26Ek3032/020	0	0	0	0	0	0	0	0	<500	<250
26Ek3032/021	0	0	0	-1	-1	1	1	0	<500	<250
26Ek3032/022	0	0	0	0	0	0	0	0	<500	<250
26Ek3032/023	0	0	0	-1	0	1	1	0	<500	<250
26Ek3032/025	-1	-1	-1	-1	-1	1	1	0	<500	<250
26Ek3032/026	0	0	0	0	0	0	0	0	<250	<250
26Ek3032/028	0	0	0	0	0	0	0	0	<250	<250
26Ek3032/040	0	0	0	0	0	0	0	0	500+	<250
26Ek3032/072	0	0	0	0	0	0	0	0	<250	<250
26Ek3032/098	-1	0	0	-1	0	0	0	0	<500	<250
26Ek3032/107	0	0	0	0	0	0	0	0	<500	<250
26Ek3032/138	0	0	0	0	0	0	0	0	<250	<250
26Ek3032/158	0	0	0	0	0	0	0	0	500+	<250
26Ek3084	0	0	0	0	0	0	0	0	<250	<250
26Ek3085	0	0	0	0	0	0	0	0	<250	<250
26Ek3086	0	0	0	0	0	0	0	0	<250	<500
26Ek3087	0	0	0	0	0	0	0	0	<250	<250
26Ek3088	0	0	0	0	0	0	0	0	<250	<250
26Ek3090	0	0	0	0	0	0	0	0	<250	<250
26Ek3091	0	0	0	0	0	0	0	0	<250	<250
26Ek3092	0	0	0	-1	0	0	0	1	<250	<250
26Ek3093	0	0	0	0	-1	0	0	0	<250	<500
26Ek3095	0	0	0	-1	0	0	0	1	<250	<500
26Ek3096	0	0	0	0	0	1	0	1	<250	<500
26Ek3099	0	0	0	0	0	0	0	0	<250	<250
26Ek3100	0	0	0	0	0	0	0	0	500+	<250
26Ek3101	-1	0	0	-1	0	0	0	0	<500	<250
26Ek3101/1	0	0	0	0	0	0	0	0	<500	<250
26Ek3102	-1	0	0	-1	0	0	0	0	<500	<250
26Ek3104	0	0	0	-1	0	0	0	0	500+	<250
26Ek3106	0	0	0	-1	0	0	0	1	500+	<250
26Ek3107	0	0	0	-1	0	0	0	0	<500	<250
26Ek3110	0	0	0	0	0	0	0	0	<500	<500
26Ek3114	0	0	0	0	0	0	0	0	<500	500+
26Ek3115	0	0	0	0	0	0	0	0	<500	<500
26Ek3116	1	0	0	0	0	1	0	0	<500	<500
26Ek3149	1	0	0	0	1	0	0	1	<250	<500
26Ek3160	1	0	0	-1	-1	0	2	1	<500	<500
26Ek3160A	0	0	0	-1	0	0	0	1	<500	<500
26Ek3160B	1	0	0	0	0	0	0	1	<500	500+
26Ek3160C	0	0	0	-1	-1	0	2	1	<500	<500
26Ek3165	-1	-1	0	-1	0	0	0	1	500+	500+
26Ek3165A	-1	0	0	-1	-1	0	0	1	500+	500+
26Ek3170	0	0	0	0	0	0	1	1	<500	<250
26Ek3170A	0	0	0	0	0	0	0	0	<500	<250
26Ek3170B	1	0	0	0	0	0	0	0	<500	<250
26Ek3171	1	0	0	-1	-1	0	0	1	<250	<250
26Ek3172	0	0	0	0	0	0	0	0	<250	<250
26Ek3173	1	0	0	0	0	0	0	0	<250	<500
26Ek3174	0	0	0	0	0	0	0	1	<500	<500
26Ek3177	0	0	0	0	0	0	0	0	<250	<250
26Ek3178	-1	0	0	-1	0	1	0	0	<250	<250
26Ek3179	0	0	0	0	0	0	0	0	<250	<250
26Ek3181	0	0	0	0	0	1	2	1	<500	<250
26Ek3183	0	0	0	0	0	0	0	0	<500	<250
26Ek3184	-1	-1	0	-1	-1	0	2	1	<500	<250
26Ek3185	1	0	0	0	1	1	1	1	<250	<250

Table 217, continued.

Site	A	B	C	D	E	F	G	H	I	J
26Ek3186	0	0	0	0	0	0	0	0	<250	<250
26Ek3189	0	0	0	0	0	0	0	0	<250	<250
26Ek3190	0	0	0	0	0	0	1	1	<250	<250
26Ek3191	0	0	0	0	0	0	0	0	<250	<250
26Ek3192	0	0	0	-1	0	0	0	1	<250	<250
26Ek3193	-1	-1	0	-1	0	0	0	0	<250	<250
26Ek3195	-1	-1	0	-1	0	0	0	0	<250	<250
26Ek3196	-1	-1	0	-1	0	0	0	1	<250	<250
26Ek3197	-1	-1	-1	-1	-1	1	1	0	<250	<250
26Ek3198	1	0	0	0	0	0	3	1	<250	<250
26Ek3200	0	0	0	0	0	0	0	0	<500	<250
26Ek3201	-1	-1	0	0	0	0	0	1	<250	<250
26Ek3202	0	0	0	0	0	0	0	0	<500	<250
26Ek3203	0	0	0	0	0	0	1	0	<500	<250
26Ek3204	0	0	0	-1	0	0	1	1	<500	<250
26Ek3208	1	0	0	1	0	1	0	1	<250	<250
26Ek3228	0	0	0	0	0	0	0	1	<250	<250
26Ek3231	0	0	0	0	0	0	0	0	<250	<250
26Ek3232	0	0	0	0	0	0	1	0	<250	<250
26Ek3234	0	0	0	0	0	0	0	0	<250	<250
26Ek3237	1	0	0	-1	0	0	0	1	<250	<250
26Ek3237A	0	0	0	0	0	0	0	1	<250	<250
26Ek3237B	0	0	0	0	0	0	0	0	<250	<250
26Ek3237C	1	0	0	0	1	0	3	1	<250	<250
26Ek3238	0	0	0	-1	0	0	0	1	<250	<250
26Ek3239	1	0	0	0	0	0	0	1	<250	<250
26Ek3251	0	0	0	0	1	0	3	1	<250	<250
26Ek3271	0	0	0	-1	0	0	0	1	<250	<500
26Ek3271A	0	0	0	-1	0	0	0	0	<250	<500
26Ek3271B	0	0	0	-1	-1	0	0	1	<250	<500
26Ek3271C	1	0	0	0	0	0	0	1	<250	<500

Key:
A. Outlier to regression of type richness on sample size.
B. Outlier to regression of simulated type richness on sample size.
C. Outlier to regression of simulated class richness on sample size.
D. Outlier to simulation of type evenness on sample size.
E. Outlier to simulation of class evenness on sample size.
F. Non-significant Spearman's rho correlation with pooled assemblage sample.
G. Kolmogorov-Smirnov test outlier.
H. Assemblage has Domestic Equipment.
I. Distance to water.
J. Distance to toolstone.

The results of these analyses show that tool assemblages at Tosawihi can be roughly scaled along two orthogonal axes of variation, one defined by Domestic Equipment and Weapons, the other by Fabricating/Processing Tools and Byproducts at one end and General Utility tools at the opposite. These two axes can be linked reasonably to two different dimensions of human action at Tosawihi. Domestic Equipment-Weapons are tool classes used to support or *maintain* people directly by providing food (cf. Chapter 20). The other axis is more closely related to *production*, creating a surplus in excess of local needs through the quarrying and processing of toolstone and the production of bifaces. The inverse relationship of early stage bifaces (which dominate the Fabricating/Processing Byproducts class) and later stage bifaces (which dominate the General Utility class) further suggest that the discard of failures (cf. Chapter 6) in biface production occur in distinct locations, perhaps indicating that the action of biface reduction was similarly segregated. Since biface breakage rates increase in

later stages of reduction (cf. Chapter 6), this pattern probably is even stronger than it appears in these results. Later stage bifaces (i.e., bifaces that fall into the General Utility class) should be more ubiquitous since they break more frequently. If they were commoner in the Tosawihi pooled assemblage sample, then they would not pattern differently from the Fabricating/Processing Byproducts.

At first glance, this outcome seems obvious. People have to feed themselves, and in the process of getting food, processing it, and consuming it, the equipment of human maintenance is discarded. At the same time, only the most profligate stone tool using hunter-gatherers would pass up the toolstone of Tosawihi. So, finding that Tosawihi tool assemblage composition can be interpreted as a mixture of maintenance and production residues is not startling.

What *is* worthy of notice is how closely the two axes are intertwined. Lithic procurement and production (especially on the scale of opalite exploitation at Tosawihi) need not occur in the same places as human maintenance activities. Spatial segregation of the two is easily visualized, for example as a result of exploitation of the quarries solely by logistical forays which leave little trace of human maintenance (cf. Chapter 4). Under this scenario, Tosawihi sites should exhibit assemblages dominated by fabricating and processing, little domestic equipment, and few weapons and general utility tools. If, on the other hand, the Tosawihi uplands were exploited chiefly as a foraging patch, assemblage composition should exhibit more residues of maintenance and relatively few by-products of lithic production. The assemblages expected from these alternate poses can be represented graphically in nearly diametric opposition (Figure 254).

No clear segregation of compositional axes is apparent in the Tosawihi assemblages. When different assemblage attributes are given unequal analytical weights, patterns emerge which indicate how these two dimensions of behavior were integrated. The next logical step is to examine how they cooccur. This involves analysis of site function to discover which activities went together and how frequently they did so (cf. Chapter 24). How these prehistoric actions were integrated with broader strictures on behavior imposed by the distribution of resources and the limitations of human energy then can be examined through looking at where prehistoric actions happened on the landscape (cf. Chapter 25).

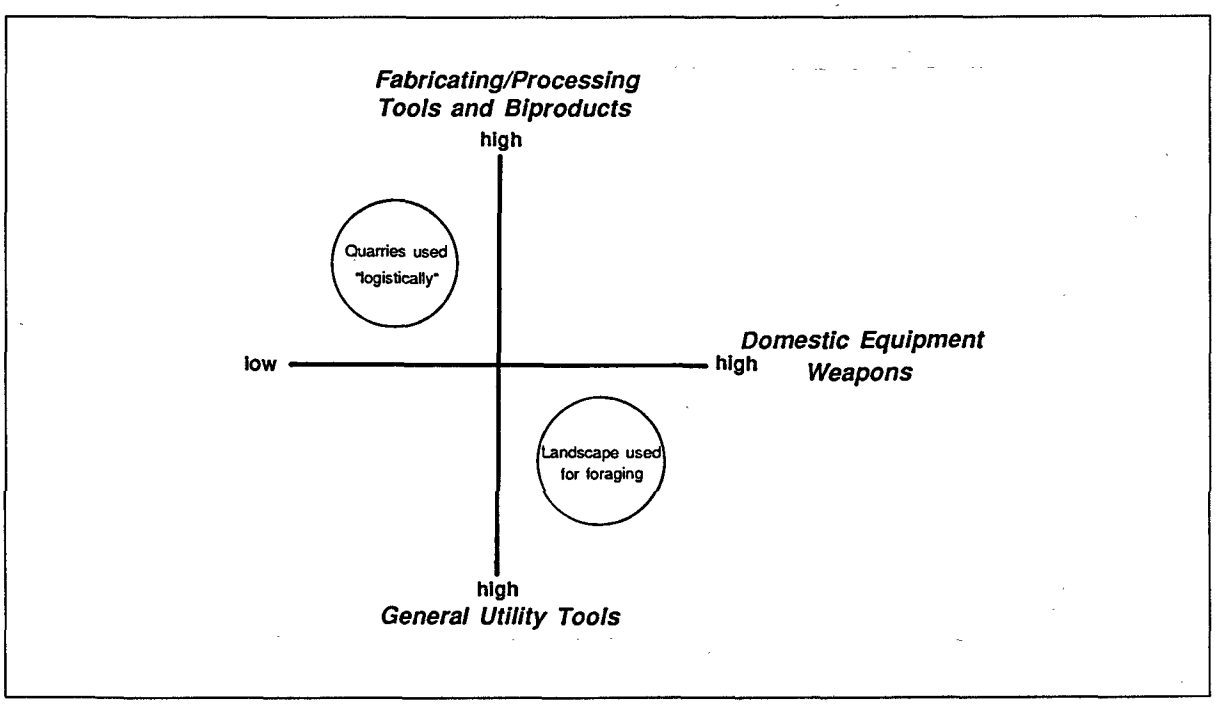


Figure 254. Hypothetical assemblage coordinates on the axes of variations in Tosawihi tool assemblages.

Chapter 24

SITE FUNCTION AND RESIDENTIALITY

Melinda Leach

We have suggested in Chapters 3 and 4 that alternative lithic procurement strategies employed by prehistoric Great Basin hunter-gatherers were conditioned by attributes of the lithic terrane, seasonal scheduling constraints, labor availability, regional toolstone demand, and other factors. The mix of strategies used was tied closely to settlement and subsistence, often involving shifts in mobility and residential patterns as means to alleviate transport, extraction, and opportunity costs of toolstone.

Herein, we examine variability in archaeological patterning as a function of cost-minimizing economic behavior. One way in which toolstone acquisition costs can be minimized is to alter the locations of activities on the landscape, and consequent variations in site structure, assemblage composition, and site function should be apparent. Variability is *presumed*, then, and the goal of this chapter is not to investigate whether or not functionally different kinds of sites occur, but to examine how variation is distributed among several apparent site classes. Special attention is given variability in the nature and location of domestic behavior (residentiality), since residential sites can inform about the structure and organization of groups using the quarries.

Several methods for examining differences in assemblage composition across predetermined site classes are employed to advance arguments about functional variability and to assess whether various residential modes appear to correspond with different modes of lithic procurement.

Organizational and Archaeological Attributes of Alternative Residential/Mobility Strategies

Chapter 3 proposed that alternative toolstone procurement techniques (encounter procurement, surface collection, quarrying, and retrieval) were accompanied by both variable return rates and variable opportunity costs, and that certain organizational strategies might be employed to affect these favorably. Such strategies include shifting mobility and residential options and altering labor organization. Several mobility and procurement options are available to toolstone collectors (cf. Chapter 4, especially Figure 19). They may gather toolstone during regular foraging activities (an encounter pattern); they may collect toolstone from within the diurnal range of an existing residential base (a diurnal pattern); they may move the residence to the toolstone source for a short-term toolstone collecting foray (a short-term residential pattern); they may move the residence to the vicinity of toolstone, convenient to other non-toolstone resources, for an extended stay (a longer-term residential pattern); or they may dispatch special-task groups to toolstone sources some distance from the residence (a logistical pattern). Quarriers may, in fact, integrate several of these options when conditions warrant.

These procurement strategies suggest specific archaeological expectations about the nature and locations of residences or of associated residential activity (cf. Chapter 4). These alternative scenarios are depicted in Figure 255 and are reviewed in Table 218.

Recognizing and ascribing such hypothetically differentiated site assemblages to any one of these scenarios is problematic. Given the time depth of the archaeological record at Tosawihi, these strategies may not appear distinct, but we expect that traces of at least the more visible scenarios (logistical, short-term, and longer-term residential use) may be detected. *Observed* variability is examined below.

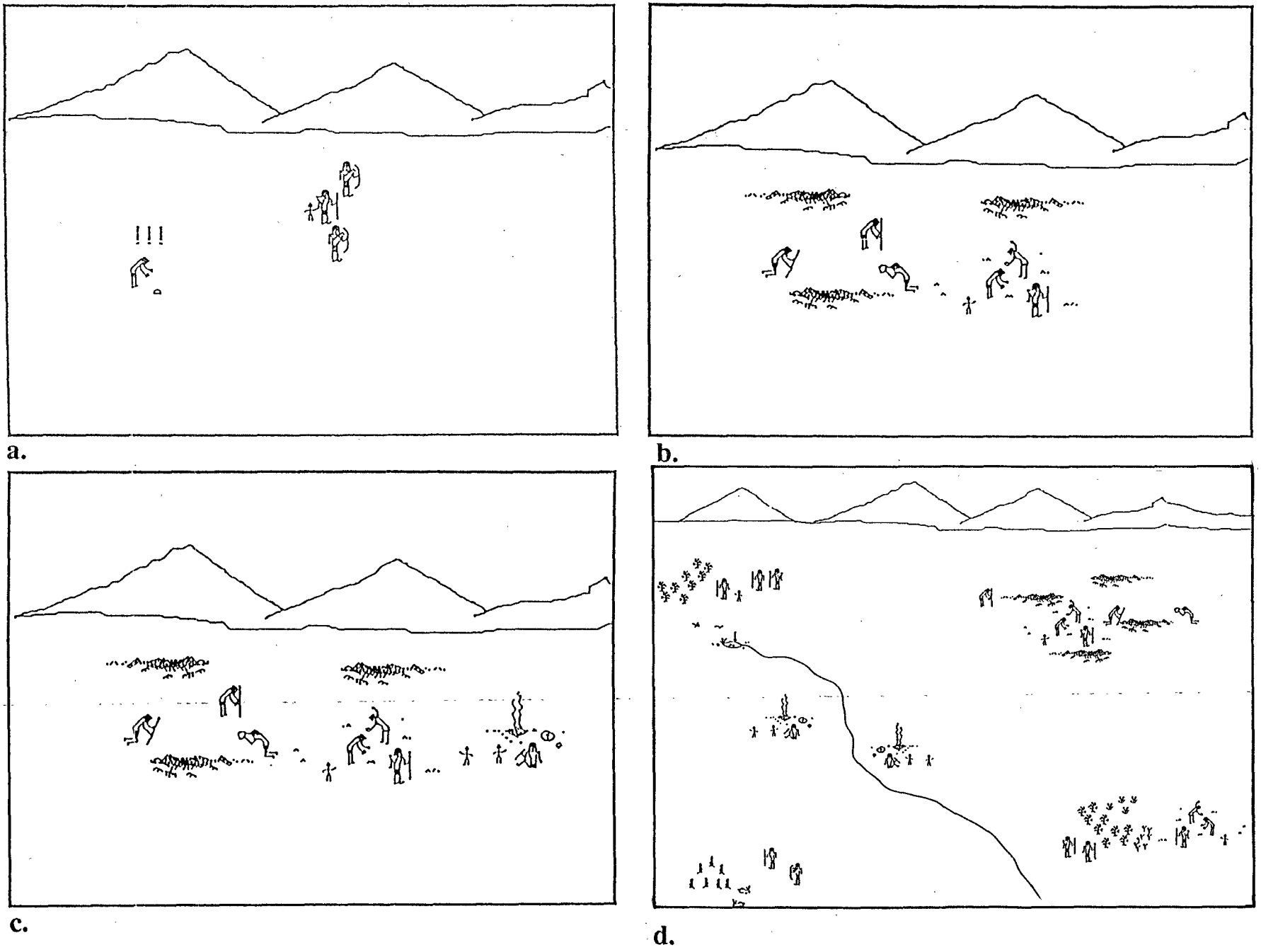


Figure 255. a. Encounter procurement of raw materials during the course of foraging; b. diurnal quarrying from off-quarry residence; c. short-term residential or logistical use of a quarry locale; d. long-term residential use of the quarries—quarrying activities and resource procurement are segregated from residence location. (Cartoons courtesy of R.G. Elston).

Table 218. Alternative Tosawihi Lithic Procurement Strategies and Hypothesized Organizational Attributes.

Lithic Procurement Strategy	Relative Opportunity Costs	Relative Mobility Level	Group Size/Composition	Location of Domestic Activities	Intensity of Domestic Behavior	Relative Assemblage Diversity Expected
Encounter	low	high	small family foraging group	off-quarry	--	low
Diurnal	moderate	moderate	small family or task groups	off-quarry	--	low
Short-term Residential	low	moderate-high	small family foraging group	at or very near quarry	ephemeral	low
Long-term Residential	low-high depending on season of residential move	low-moderate	single or multiple families and small task groups	near quarry: primarily convenient to water and a mix of food patches; secondarily to toolstone	moderate-high	moderate-high
Logistical	low-high depending on season	low-moderate	small task groups	at or very near quarry	ephemeral	low

Site Typology

In the previous chapter, differences in site assemblage variety were evaluated relative to sample size, and a pervasive relationship between the two variables was demonstrated. Still, there remained unexplained that variability ascribable to functional differences in the way humans behaved on the landscape. To review, two axes of assemblage variation were defined relating to domestic maintenance and lithic extraction and production (cf. Chapter 23, especially Figure 252). This framework requires closer examination; it will be used here to evaluate differences in sites and how they are integrated into a system of maintenance and quarrying/tool production.

The seventy-six sites (excluding 26Ek3032, Locality 93, an isolated millingstone) investigated by testing and data recovery are segregated by a simple typology that discriminates sites and assemblages containing on-site lithic sources and quarrying features, reduction debris or features, and domestic equipment (this and other tool classes are defined in Chapter 23). The resulting site classes include quarrying locales, reduction locales, and residential locales (reduction or quarrying complexes that also contain domestic equipment, designated domestic reduction sites and domestic quarries, respectively; cf. Table 219).

Table 219. Definition of Principal Site Classes.

Site Classes	Reduction Debris	Quarrying Features/ Lithic Source	Plant Processing Equipment
Reduction Locales	+		
Quarrying Locales	+	+	
Residential Locales			
Domestic Reduction Sites	+		+
Domestic Quarries	+	+	+

+ Indicates presence of assemblage item or feature

The distribution of site classes across Tosawihi subareas is conditioned largely by toolstone availability, topography (particularly broad, flat places suitable for extended stays), and reliable water sources. The Eastern Periphery contains almost twice as many outcrop quarries and four times as many quarry pit sites as the Western Periphery, and encompasses all rockshelters and isolated milling stations. Lithic reduction scatters and reduction complexes are nearly evenly split between the Eastern and the Western Peripheries, and *only* such scatters and complexes are found in the Northern Corridor.

The East, with its broadly distributed toolstone sources, contains 56% of the quarrying locales and 100% of the domestic quarries (Table 220; Figure 256). Forty-two percent of the domestic reduction sites lie in the West, compared to 32% in the East and 26% in the Northern Corridor. In addition to being more abundant in the West, domestic reduction sites are considerably more extensive there, revealing complex site structures that signal repeated, long-term occupations.

Table 220. Distribution of Site Classes Across Tosawihi Subareas.

	Northern Corridor (row %)	Eastern Periphery (row %)	Western Periphery (row %)	Total
Domestic Quarries	-	7 (100%)	-	7
Domestic Reduction Sites	5 (25%)	6 (32%)	8 (42%)	19
Quarrying Locales	-	9 (56%)	7 (44%)	16
Reduction Locales	3 (9%)	16 (47%)	15 (44%)	34
Total	8	38	30	76

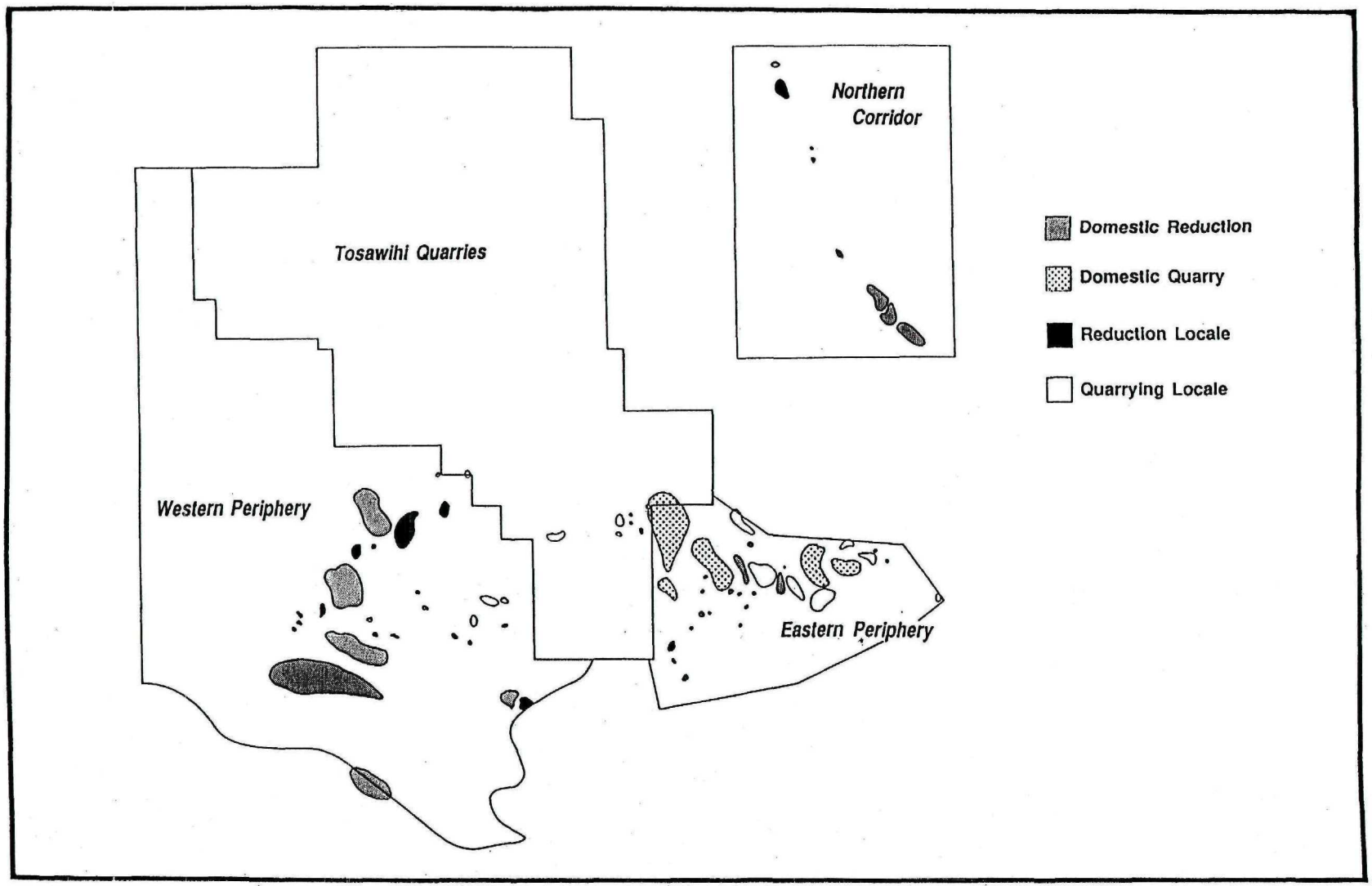


Figure 256. Distribution of principal site classes across Tosawihi Subareas.

Quarrying Locales (n=16)

Locations of natural toolstone deposits and lithic extraction—including cobble deposits, outcrop quarries (Figure 257), and quarry pits—range in scale from the massive, 4-meter deep deposits of opalite quarrying debris at 26Ek3208 (Figure 258a) to shallow depressions found elsewhere. These sites contain quarrying tools such as boulder-sized hammerstones and, where preservation is excellent, perishable quarrying implements like bone or antler wedges and scapula scoops (Figure 258b). Ash and charcoal lenses from bedrock fires are common, as are primary fabricating/processing by-products (e.g., cores, modified chunks, and early stage bifaces) from blocks, slabs, and flake blanks. Most debitage at quarrying locales consists of early stage reduction, since blanks, cores, and bifaces usually are reduced in bulk at the quarries for transport to other locales. The distribution of functional tool classes across quarrying locales is shown in Table 221.

Table 221. Assemblage Composition of Quarrying Locales.

Site No.	Site Type	Area (m^2)	Features (n)	Quarrying Equipment	Weapons	Fabricating/ Processing By-products	Fabricating/ Processing Tools	General Utility Tools	Domestic Equipment	Volume Excav. (m^3)
Subarea: East										
26Ek3032/23	QP	30	1	1	6	57	16	26	-	0.060
26Ek3032/25	OQ	2,250	7	-	-	75	6	24	-	0.240
26Ek3032/98	OQ	900	1	-	-	6	1	3	-	0.200
26Ek3191	OQ	6,600	1	-	1	3	1	5	-	0.080
26Ek3193	OQ	3,610	7	-	-	10	1	11	-	0.140
26Ek3195	QP	9,425	8	2	-	23	3	17	-	0.023
26Ek3197	QP	4,556	11	-	-	26	1	8	-	0.665
26Ek3200	QP	242	1	1	-	7	1	4	-	0.015
26Ek3203	OQ	8,230	-	-	-	7	-	-	-	0.075
Subarea: West										
26Ek3082	OQ	300	3	-	-	-	-	-	-	0.000
26Ek3083	OQ	2,000	-	-	-	-	-	-	-	0.000
26Ek3084	OQ	4,250	2	1	-	2	1	6	-	0.010
26Ek3085	QP	1,178	8	-	-	-	-	2	-	0.000
26Ek3104	OQ	600	-	-	-	5	-	7	-	0.025
26Ek3207	OQ	1,200	-	-	-	-	-	-	-	0.000
26Ek3208	QP	10,367	10	-	1	-	3	6	1[a]	0.000[b]

QP = Quarry Pit
OQ = Outcrop Quarry

[a]Ornamental bone beads only
[b]Backhoe Trenches only

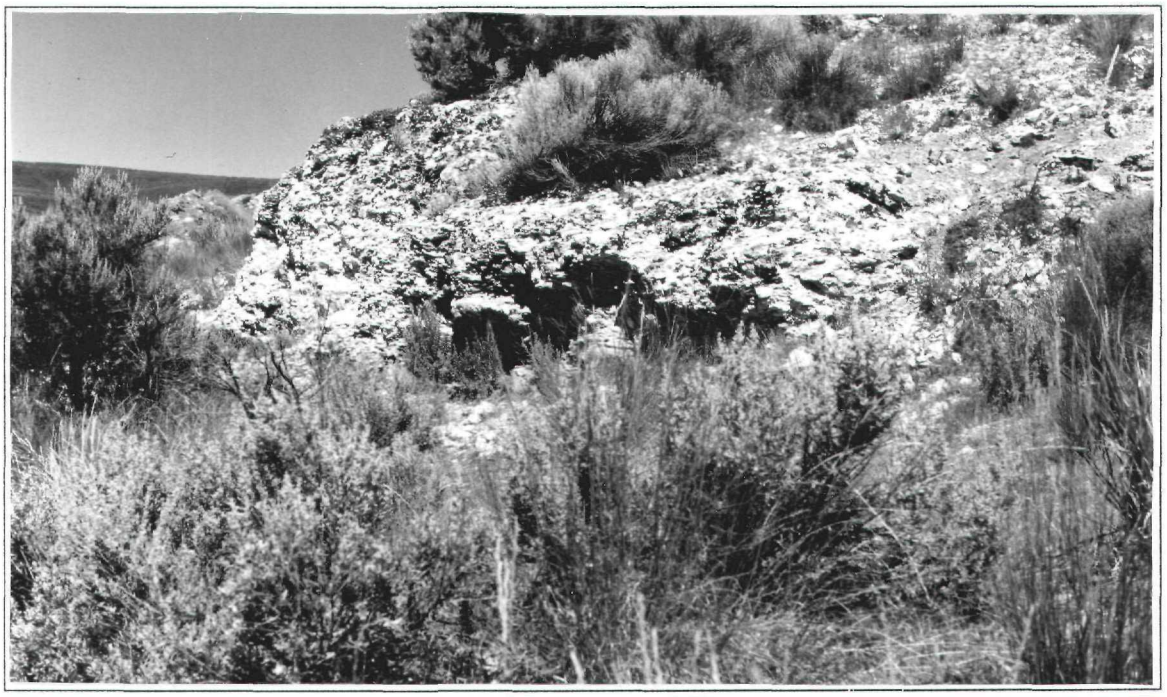


Figure 257. Opalite outcrop used as toolstone source.

Figure 258. a. Backhoe trench at 26Ek3208, revealing deep deposit of opalite quarrying debris; b. bison scapula scoop, located under photo (scale) in deposit of quarry debris.

Reduction Locales (n=34)

Reduction locales are the archaeological remains of lithic (usually biface) reduction episodes. They range from small, discrete, shallow scatters of debitage (Figure 259) representing single reduction events to large, multi-feature complexes (Table 222). Two such locales (26Ek3177 and 26Ek3202) lie within Eastern Periphery rockshelters. Reduction assemblages tend to be dominated by the by-products of fabricating and lithic processing (especially debitage and shatter), with bifaces and cores predominating. The occurrence, however, of weapons (projectile points) and certain general utility tools (particularly various flake tool forms) suggests a broader diversity of processing activities at some reduction stations (cf. discussion below). Analyses presented elsewhere in this volume have demonstrated that when these locales fall relatively near the heart of the quarries, early stages of toolstone reduction and biface forms are typical; farther from the quarries, late stage bifaces and debris are more common (cf. Chapters 6, 10, and 25).

Table 222. Assemblage Composition of Reduction Locales.

Site No.	Area (m^2)	Features (n)	Hearths	Weapons	Fabricating/ Processing By-products	Fabricating/ Processing Tools	General Utility Tools	Volume Excav. (m^3)
Subarea: East								
26Ek3032/20	200	3	-	1	12	2	15	0.140
26Ek3032/21	100	1	-	-	16	1	2	0.270
26Ek3032/22	5	1	-	-	8	-	1	0.300
26Ek3172	2420	6	-	-	1	-	5	0.160
26Ek3173	530	4	-	2	4	2	7	0.865
26Ek3175	90	1	-	-	-	-	-	0.000
26Ek3177	70	1	-	2	2	-	2	0.100
26Ek3178	910	4	-	3	7	-	4	0.100
26Ek3179	110	2	-	-	-	2	3	0.260
26Ek3180	12	1	-	-	-	-	-	0.000
26Ek3183	90	1	-	-	-	-	3	0.300
26Ek3186	185	2	-	-	-	-	1	0.000
26Ek3187	40	1	-	-	-	-	-	0.000
26Ek3188	95	1	-	-	-	-	-	0.000
26Ek3189	1,320	4	-	-	2	-	-	0.000
26Ek3202	8	1	-	-	2	-	1	0.250
Subarea: West								
26Ek3086	1,100	-	-	-	4	2	-	0.000
26Ek3087	300	-	-	-	4	-	-	0.000
26Ek3088	650	-	-	-	2	1	-	0.000
26Ek3090	150	-	-	-	2	1	2	0.450
26Ek3091	400	-	-	-	3	-	1	0.000
26Ek3093	1,875	6	+	2	15	1	25	1.070
26Ek3097	500	-	-	-	-	-	-	0.000
26Ek3099	750	4	-	1	2	-	7	0.000
26Ek3100	5,850	2	-	-	1	-	-	0.040
26Ek3101	11,250	-	-	1	6	2	15	0.740
26Ek3102	2,400	5	-	1	7	-	6	0.160
26Ek3107	6,750	5	-	1	3	-	2	0.092
26Ek3114	100	1	-	1	4	2	3	0.200
26Ek3115	100	1	-	-	3	2	5	0.200
26Ek3116	200	1	-	6	4	5	8	0.240
Subarea: North								
26Ek3231	2,100	1	-	1	1	-	1	0.080
26Ek3232	1,590	1	-	-	6	-	-	0.080
26Ek3234	4,200	-	-	-	2	-	-	0.040

+Hearth present

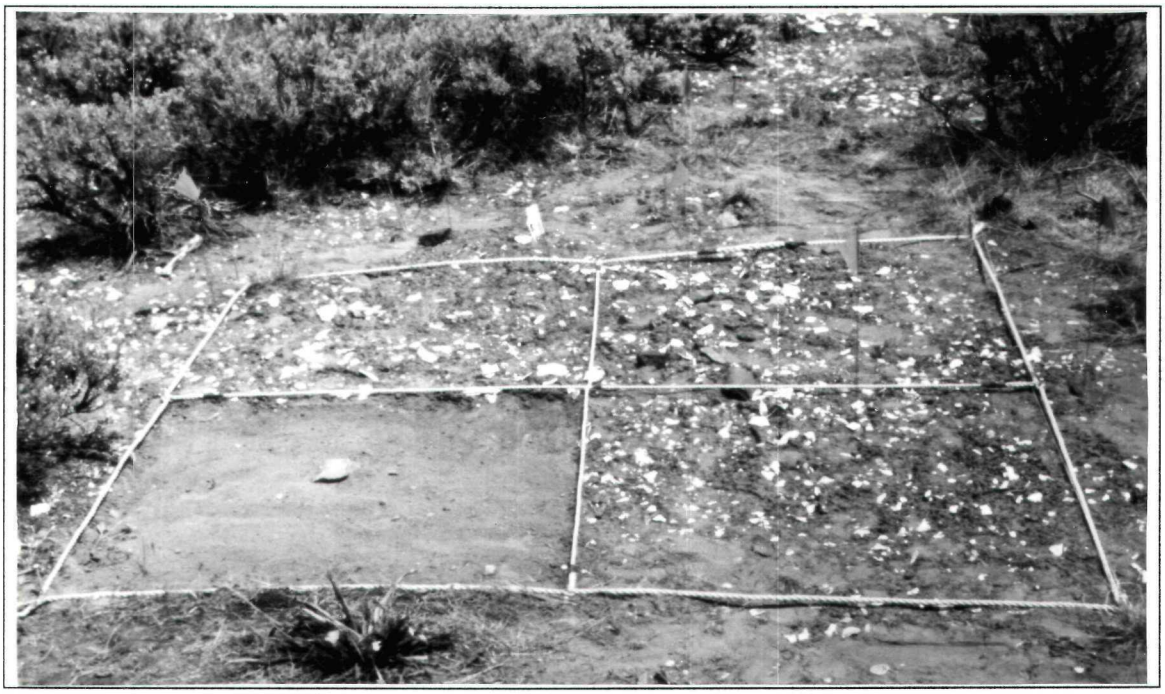


Figure 259. Shallow reduction scatter. Lower left quadrant has been scraped to two cm.

Residential Locales (n=26)

In hunter-gatherer settlement systems, "residences" typically are the places where a variety of economic and domestic pursuits come together, and where a variety of by-products reflect the residues of multiple maintenance and processing activities (Binford 1980:9; Thomas 1988:381). The assemblages at Tosawihi residential locales are distinguished by the residues of tool production, tool maintenance, and food processing (Table 223), discarded in varying degrees of intensity. And there is often a high incidence of lithic heat-treatment, a relatively time-intensive process that can be engineered easily during down-time in camp (cf. Chapters 6 and 10).

The presence of millingstones in any quantity guarantees membership in this site category. At Tosawihi, millingstones occur overwhelmingly in the context of other things—in clusters of multi-purpose features and tools reflecting functions beyond field food processing. In such contexts, then, plant processing signifies a commitment to time and place, a convening of equipment at a particular location, task differentiation, and very probably a relatively extended stay. The convergence of these phenomena defines "residentiality" in the Tosawihi environment.

Residential locales may exhibit the structured use of domestic space. 26Ek3092, for example, hosts a central boulder (cf. Figure 114a) that served as a long-term focal point for various activities, resulting in some 24 overlapping features, and 26Ek3095 contains multiple, functionally-differentiated surface features (cf. Chapter 16). Too, sites reoccupied over many episodes may exhibit complex aggregates of seemingly unrelated debris, as camp maintenance activities and the displacement of work areas over time contributed to vertical and horizontal reorganization of debris.

Biface caches are most common in, though not exclusive to, residential sites, which also often contain hearths (Figure 260) or ashy concentrations, multiple tool maintenance and reduction features, preserved subsistence remains, occasional evidence of ceramic vessel use, and sometimes relatively large numbers of millingstones.

Table 223. Assemblage Composition of Residential Locales.

Site No.	Area (m^2)	Features (n)	Hearths	Biface Caches	Quarrying Equipment	Weapons	Fabricating/ Processing By-products	Fabricating/ Processing Tools	General Utility Tools	Domestic Equipment	Volume Excav. (m^3)
Subarea: East											
26Ek3032/19	10	1	-	-	-	-	33	12	39	1	0.160
26Ek3170	31,000	14	-	+	-	11	119	23	96	2	8.500
26Ek3171	7,540	8	-	-	-	2	52	7	64	2	7.560
26Ek3174	590	2	-	-	-	-	-	-	1	1	0.000
26Ek3181	235	1	-	-	-	-	1	-	9	2	0.520
26Ek3184	11,309	26	-	+	-	7	94	30	216	2	4.880
26Ek3185	910	7	-	-	-	8	19	9	11	1	0.440
26Ek3190	4,241	11	-	-	-	9	33	9	24	1	0.865
26Ek3192	3190	5	-	+	-	16	98	32	132	9	15.840
26Ek3196	11,800	7	-	-	-	-	21	2	11	1	0.400
26Ek3198	12,724	26	+	-	-	27	42	4	53	1	7.010
26Ek3201	2,474	4	-	-	-	-	19	2	12	2	0.310
26Ek3204	60	1	-	-	-	6	68	12	36	1	0.900
Subarea: West											
26Ek3092	4,800	24	+	-	-	37	245	48	286	14	26.560
26Ek3095	15,000	25	-	+	1	36	190	26	260	27	12.396
26Ek3096	14,250	7	-	-	-	-	11	-	4	1	0.080
26Ek3106	5,175	7	+	-	-	2	31	4	17	1	1.100
26Ek3149	2,500	3	-	-	-	3	5	1	7	2	0.330
26Ek3160	46,000	25	+	-	-	58	175	35	578	20	15.130
26Ek3165	4,500	2	-	-	-	3	25	3	54	4	5.550
26Ek3271	19,500	22	-	-	-	23	160	24	193	6	1.940
Subarea: North											
26Ek3228	4,750	2	-	-	-	-	2	-	5	1	0.250
26Ek3237	42,000	5	+	-	-	45	88	14	118	9	18.250
26Ek3238	22,500	2	-	-	-	5	14	1	17	1	0.850
26Ek3239	12,800	1	-	-	-	2	10	3	23	1	0.210
26Ek3251	15,000	6	-	-	-	45	102	16	77	18	11.075

+Hearth or biface cache present

Residential assemblages are more likely to contain exotic raw materials: 92% manifest multiple raw materials (including obsidian, basalt, and other materials), compared to only 36% of the non-residential assemblages. Even more striking is the distribution of obsidian across residential and non-residential locales (Table 224). Imported to the quarries from substantial distances, obsidian arrived from a broad territory well beyond the boundaries of the Tosawihi vicinity (cf. Chapter 19). Residential sites yield obsidian assemblages in far greater proportions than non-residential locales (Figure 261), and contain, as well, a wider representation of distant obsidian sources in their reduction debris (cf. Appendix N).

Table 224. Obsidian Sources Represented in Tosawihi Assemblages.

Residential Locales	Non-Residential Locales
•Bordwell Spring, Nevada	•Brown's Bench, Nevada
•Brown's Bench, Nevada	•Paradise Valley, Nevada
•Double H Mtns., Nevada	•Pinto Peak, Nevada
•Fox Mtn., Nevada	•Unknown Source A
•Majuba Mtn., Nevada	
•Pinto Peak, Nevada	
•Paradise Valley, Nevada	
•Malad, Idaho	
•Timber Butte, Idaho	
•Unrecognized Source	
•Unknown Source A	
•Unknown Source B	
•Unknown Source C	
•Unknown Source D	
•Unknown Source E	
•Unknown Source F	

Figure 260. Hearth at 26Ek3092.

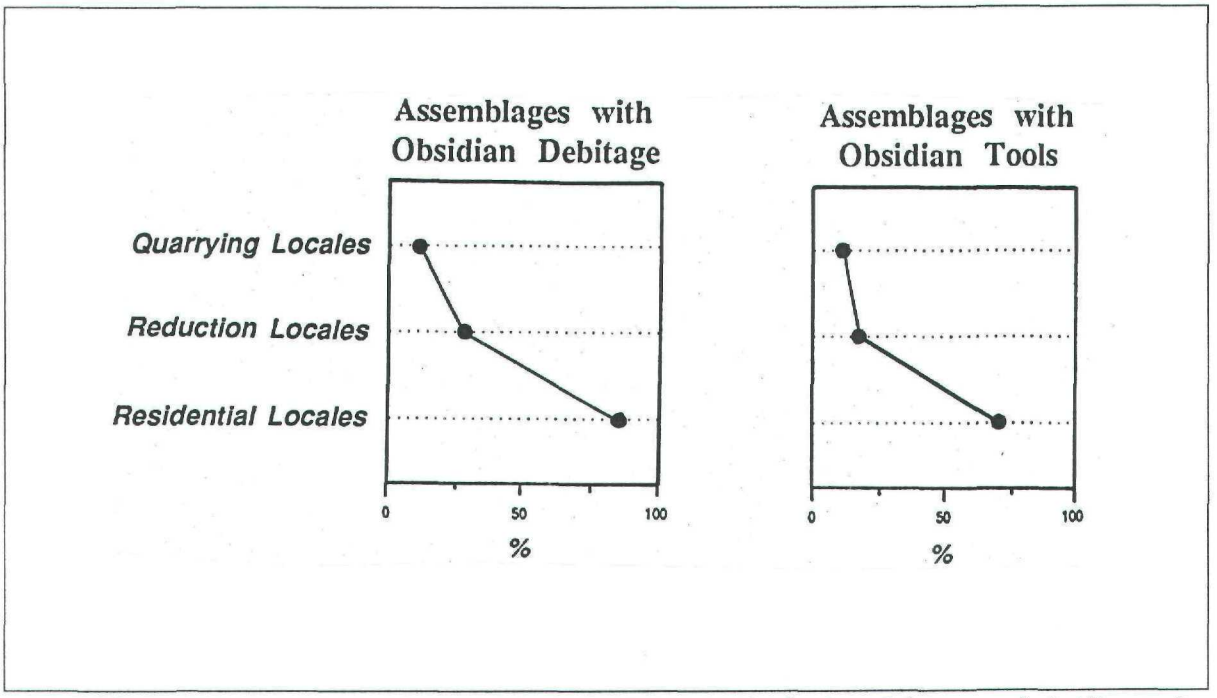


Figure 261. Proportions of sites, within site classes, with obsidian debitage and obsidian tools.

Domestic Reduction Sites and Domestic Quarries as Residential Subclasses

Turning now to how residentiality intersects with quarrying behavior, the chief economic pursuit at Tosawihi, some of the internal variability witnessed among residential localities must be highlighted. Recall that sites with domestic equipment were segregated further on the basis of quarrying features; those with quarrying debris were designated domestic quarries, those without, domestic reduction sites. Domestic reduction sites exhibit the most overt signs of residentiality (chiefly, relatively large numbers of millingstones, ceramics, and functionally-diverse features; cf. Table 225). Domestic quarries maintain high tool diversity and density reflecting a variety of activities, yet they reveal far more ephemeral domestic use; domestic equipment, such as groundstone and ceramics, appears only in isolated occurrences, in only one or two features, or in non-feature contexts.

Table 225. Assemblage Composition of Residential Locales, by Subclass.

Type	Site No.	Subarea	Domestic Equipment	General Utility Tools	Fabricating/ Processing Tools	Fabricating/ Processing By-products	Weapons	Quarrying Equipment
Domestic Reduction Sites								
	26Ek3092	West	14	286	48	245	37	-
	26Ek3095	West	27	260	26	190	36	1
	26Ek3096	West	1	4	-	11	-	-
	26Ek3106	West	1	17	4	31	2	-
	26Ek3149	West	2	7	1	5	3	-
	26Ek3160	West	20	578	35	175	58	-
	26Ek3165	West	4	54	3	25	3	-
	26Ek3174	East	1	1	-	-	-	-
	26Ek3181	East	2	9	-	1	-	-
	26Ek3185	East	1	11	9	19	8	-
	26Ek3190	East	1	24	9	33	9	-
	26Ek3192	East	9	132	32	98	16	-
	26Ek3204	East	1	36	12	68	6	-
	26Ek3228	North	1	5	-	2	-	-
	26Ek3237	North	9	118	14	88	45	-
	26Ek3238	North	1	17	1	14	5	-
	26Ek3239	North	1	23	3	10	2	-
	26Ek3251	North	18	77	16	102	45	-
	26Ek3271	West	6	193	24	160	23	-
Domestic Quarries								
	26Ek3032/19	East	1	39	12	33	-	-
	26Ek3170	East	2	96	23	119	11	-
	26Ek3171	East	2	64	7	52	2	-
	26Ek3184	East	2	216	30	94	7	-
	26Ek3196	East	1	11	2	21	-	-
	26Ek3198	East	1	53	4	42	27	-
	26Ek3201	East	2	12	2	19	-	-

The marked visibility of domestic equipment at domestic reduction sites (compared to its relatively low densities at domestic quarry sites) is accounted for largely by multiple and prolonged reoccupations of favorable locations (cf. Conclusions, below). These sites are usually close to a significant water source, and this feature in a relatively dry upland was, no doubt, a seductive attractor for the location of sustained residential activities. As well, several economic advantages often converge in these locations—comfortable resting spots for toolstone reduction, reliable sources of hammerstones, predictable root crops, access to game watering areas—so the repeated use of these locations is expected (cf. Binford 1980:9; Thomas 1983b:427).

Evaluation of Site Class Variability

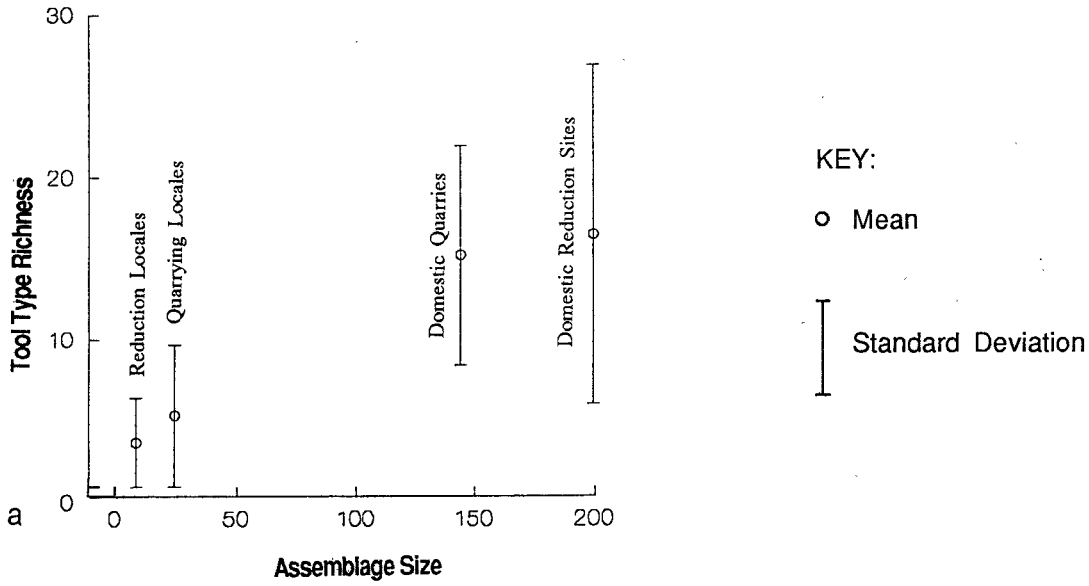
The basic typology of sites for the Tosawihi system has been defined; below, we explore how well the principal site classes hold up under scrutiny, and investigate some of the variability within and among them. In the previous chapter, the effects of sample size on assemblage variety were explored in some detail. The relationship between tool type richness and assemblage size bears brief reiteration here, as the recognition of assemblage diversity is critical to discussions of site function. Typically, small assemblages with low richness are interpreted as diurnal use locales; moderately sized and moderately diverse assemblages as short-term, logistical field camps; and larger, more diverse assemblages as residential bases (Thomas 1988:381).

When we examine the relationship between tool type and tool class richness (cf. Chapter 23), several patterns emerge (Figure 262). First, the four principal site classes (reduction locales, quarry locales, domestic quarries, and domestic reduction sites) are segregated cleanly by mean assemblage sizes. Thus, it appears that they are distinct from each other, at least in terms of size. However, this pattern is a function both of the intensity with which tools were discarded across site types (a behavioral phenomenon) and of our own collection strategies; we excavated significantly more volume, and thus retrieved more rare items, on residential sites than on other kinds of sites.

Second, the power of assemblage size to predict richness is revealed; as assemblage size increases, so do tool type and class richness. Assemblages of reduction and specialized quarry locales are considerably smaller and contain fewer classes of tools. Standard deviations around mean assemblage size for these sites are rather large, indicating considerable internal variability in the numbers of tool classes they contain; this also suggests some internal functional differentiation, explored below. Assemblages of domestic quarries and domestic reduction sites reveal higher mean tool type and class richness, restricted variability in the number of tool classes, and considerably more internal variability in tool types. That is, though individual tool types are variable, they are merely repetitive members of a few functional tool classes.

The linear relationship between tool type and tool class richness across site classes confirmed by Figure 262 suggests that absolute assemblage variety is not a particularly good measure of site complexity. Analyses that investigate *relative* assemblage variety and assemblage *composition* are more informative of site class variability. Thomas (1988:381) and others have posited that the relative degree of variety revealed between site classes within a single settlement system may inform importantly about site function. Different functional uses of the landscape may produce groups of assemblages with variable slopes (slope coefficients of the richness:size regression (cf. Chapter 23 and Figure 235).

We can use these relationships to model expectations about Tosawihi. Diurnal use areas (equivalent to Tosawihi quarrying and reduction locales) typically were targeted at limited tasks, and should produce relatively homogeneous assemblages resulting from a limited number of tool types being discarded repetitively. Such assemblages will be depicted by a low richness:size slope coefficient. Logistical base camps, though short-term, encompass more diverse activities and therefore more diverse discard patterns, and should reveal a steeper richness:size slope. The steepest slope coefficient should characterize those places used longest and witnessing the widest variety of activities and tool discard patterns (residential sites; cf. Chapters 4 and 23; Thomas 1988:381). Tosawihi assemblages might be expected to follow similar patterns, given specific expectations about assemblage composition and breadth of tool classes (Table 226).



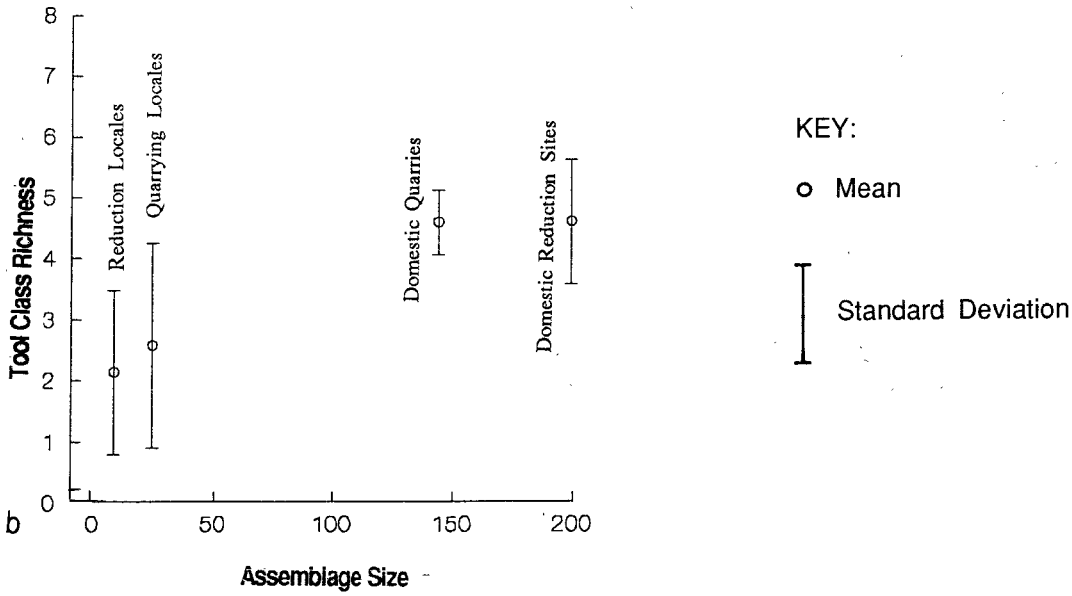


Figure 262. Mean tool type richness:assemblage size; b. mean tool class richness:assemblage size.

Table 226. Expected Site Class Assemblage Components.

	Domestic Equipment	Weapons	General Utility Tools	Quarrying Equipment	Fabricating/ Processing Tools	Fabricating/ Processing By-products
Domestic Quarries	+	+	+	+	+	+
Domestic Reduction Sites	+	+	+		+	+
Quarrying Locales				+	+	+
Reduction Locales			+		+	+

Domestic quarries should reveal the steepest slope (and the highest regression coefficient) since they are expected to contain the broadest number of tool classes, comprised of debris of disparate residential activities (domestic equipment) as well as reduction tools and debris and quarrying equipment. Domestic reduction sites should be somewhat less diverse (since they lack quarrying activities), reflecting a somewhat flatter, yet still quite steep slope. Reduction stations should reveal a significantly flatter slope still, and finally, quarry locales should have the flattest of all (they should contain the least diverse assemblages, reflecting redundant extraction and processing activities).

The Tosawihi regression slope lines for log tool type richness:log assemblage size (Figure 263) reveal a substantial (and expected) disparity in assemblage variability across site classes, but show a surprising lack of congruence with the expected pattern detailed above (Table 227 provides regression coefficients for principal Tosawihi site classes).

Table 227. Regression Coefficients for Tosawihi Site Class Assemblages (log Tool Type Richness: log Assemblage Size).

Site Class Assemblage (n)[a]	Slope *b*	Correlation *r*
Domestic Quarries (n=7)	.56	.98[b]
Domestic Reduction (n=19)	.47	.99[b]
Reduction Locales (n=29)	.66	.89[b]
Quarry Locales (n=13)	.42	.78[c]

[a]some cases excluded due to missing data
[b]significantly different from zero (at $p<.001$)
[c]significantly different from zero (at $p<.01$)

The steepest slope is represented by reduction locale assemblages, indicating the greatest relative variety of all site classes. Domestic quarries and domestic reduction sites are intermediate in slope, and, as predicted, quarrying locales are the least diverse. Reduction stations, rather than representing single-purpose, homogeneous assemblages, are characterized by considerable assemblage variability. As their assemblages increase in size, assemblage variety increases more rapidly than for all other site classes.

This reduction locale pattern has several behavioral implications: (1) multiple, functionally-differentiated uses of single locations may have increased the average (overall) mean tool type richness, (2) multiple reoccupations of single loci, though each may have consisted of special-purpose activity sets, appear diverse in the aggregate, (3) resources exploited, group composition, or artifact byproduct histories may have been highly variable over

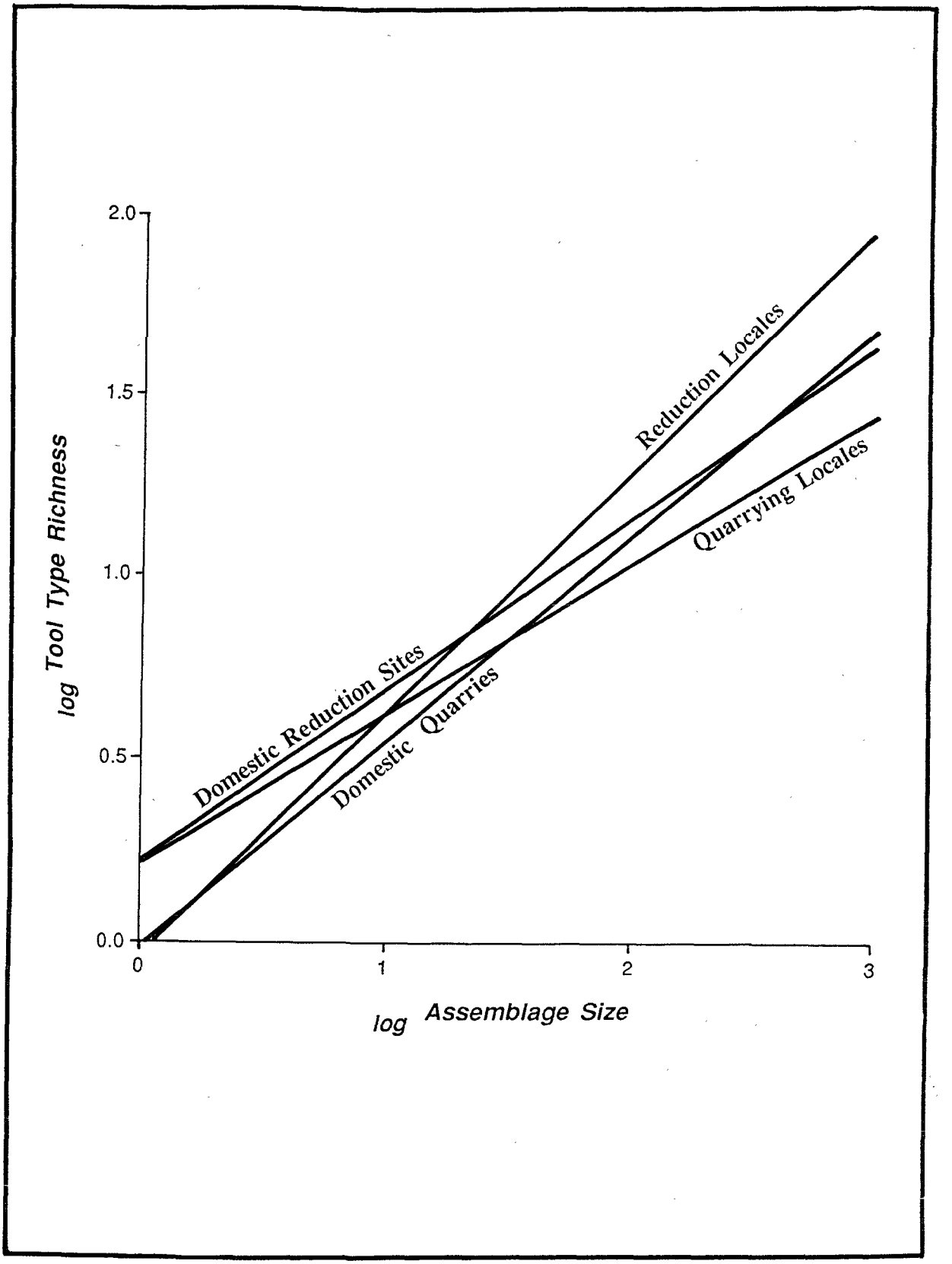


Figure 263. Regression of log tool type richness to log assemblage size, all site classes.

time (Thomas 1988), producing a class of highly differentiated sites, and (4) some reduction sites actually may represent scenes of short-term domestic activities, not recognized archaeologically because they lack groundstone. Without intensive analysis of feature-level data and good internal chronological control, the first three possibilities are impossible to address. However, the potential of some reduction sites to represent unrecognized domestic sites is a testable proposition.

Two aspects of assemblage composition within reduction locales (functional tool class frequencies and biface stage frequencies across subareas) were examined more closely for spatial/functional variability. The intent was to discover whether proximity to quarries (sites falling in the Eastern Periphery) or proximity to large domestic sites (sites falling in the Western Periphery and the Northern Corridor) affect assemblage characteristics.

In the first analysis, summed frequencies of weapons, fabricating/processing by-products (cores, preforms, and early stages of bifaces), fabricating/processing tools, and general utility tools (tools used in a wide variety of activities, including varieties of flake tools, late stage bifaces, and bone tools) were cross-tabulated by subarea (Figure 264). Low expected frequencies of tools in the Northern Corridor reduction locale assemblages (33% of the cells contained expected frequencies of fewer than 5) made application of the chi-square test inappropriate. We then combined frequencies of tools into groups shown in Chapter 23 to co-vary commonly (i.e., weapons were combined with general utility tools and fabricating/processing by-products with fabricating/processing tools). A chi-square result of 5.83 (with 2 degrees of freedom) did not exceed the critical chi-square value of 5.99 (at .05), thus no significant association could be demonstrated between tool groupings and geographical subareas. Analysis of adjusted standardized residuals (Everitt 1977; cf. Chapter 10) is not strictly appropriate given this chi-square result, but the analysis suggested a pattern of unexpectedly low weapon/general utility tool frequencies and unexpectedly high fabricating/processing tool and byproduct frequencies in the Northern Corridor.

This suggestive pattern was born out by a Kolmogorov-Smirnov Two-Sample Test conducted between pairs of subarea assemblage aggregates (Figure 265). Only one pair of

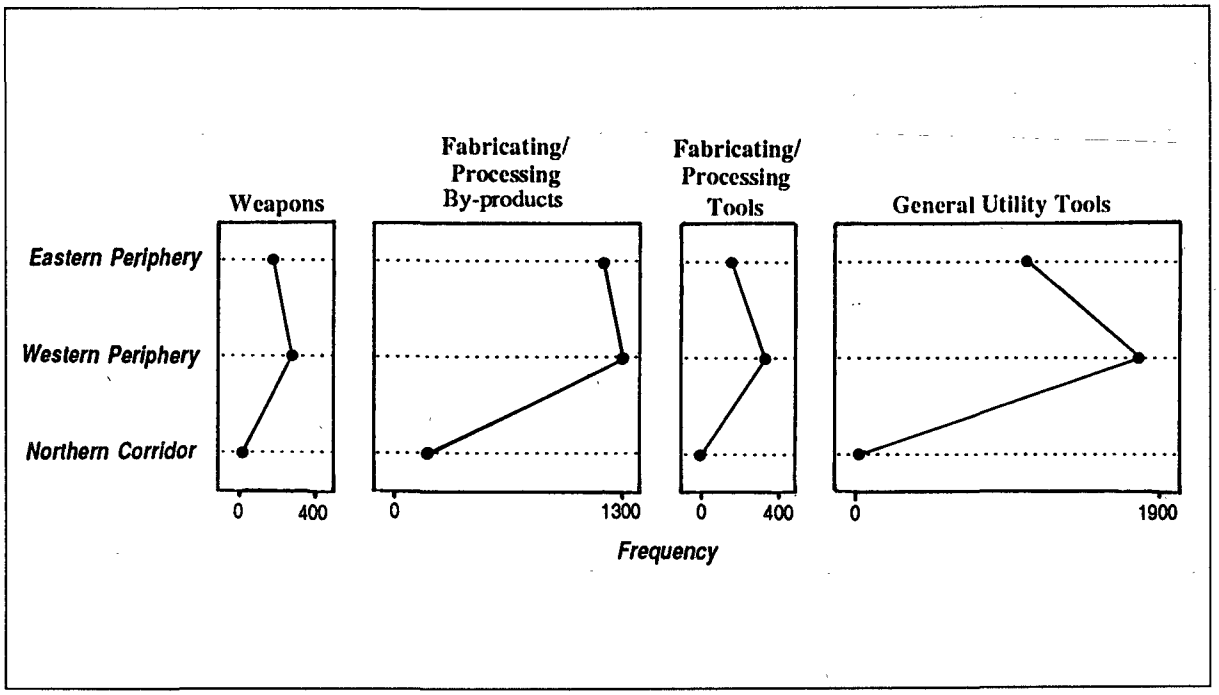


Figure 264. Frequencies of functional tool classes, across Tosawihi Subareas, reduction locale assemblages (n=34).

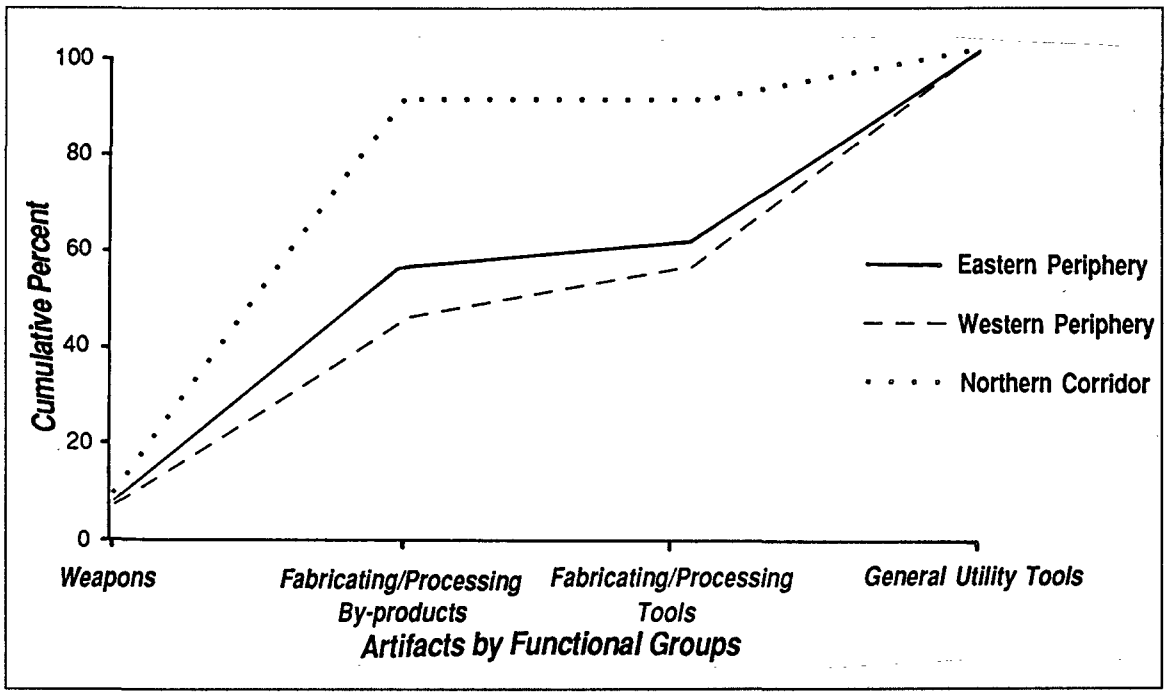
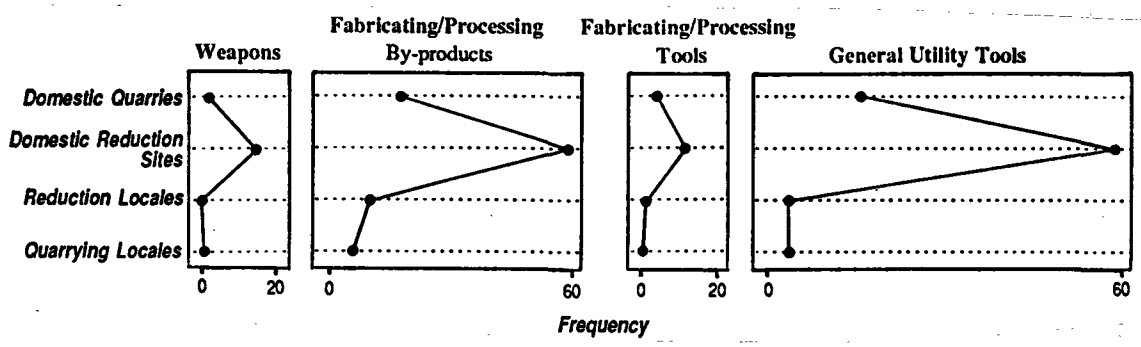


Figure 265. Cumulative proportions of functional tool classes, across Tosawihi Subareas, reduction locale assemblages (n=34).

combined assemblages, the Northern Corridor and Western Periphery residential locales, revealed a significant (Dmax=.46, Dcrit=.43, at p=0.05, n1=11, n2=163) difference in the proportions of functional tool classes. This result at first is surprising, since domestic reduction sites lie close to reduction locales in both these areas. Yet Northern reduction locales have relatively more fabricating/processing by-products and relatively fewer general utility tools and appear to be somewhat more specialized, with less evidence of other processing/maintenance activities. Reduction activities in the Northern Corridor may be integrated with other activities (as when they are components of multi-function domestic sites) *or* they may be spatially segregated, with reduction occurring away from multi-function sites. The Eastern and Western reduction locale assemblages look very similar, reflecting comparable trajectories of lithic production (substantial quantities of processing by-products), as well as maintenance activities (revealed by significant proportions of general utility tools and weapons) *co-occurring* with reduction episodes. The comparison of fabricating/processing bifaces (Stage 3.4 and earlier) and general utility bifaces (Stage 3.5 and later) from reduction locales failed to reveal significant patterning across subareas (chi-square = 5.923, $.05 < p < .10$).

A cluster analysis performed on *non-reduction* locales incorporating major tool types and flake tool sub-types failed to reveal any striking *within*-class site clusters. This suggests that there is more variation across site classes than within them, and that our pre-defined site classes segregate well and are relatively consistent internally.

An analysis of differences in functional tool class composition among principal site classes was undertaken next (Figure 266). Excluding domestic equipment (primarily millingstones, the most obvious domestic signal) and quarrying equipment (our rarest tool class) enabled us to evaluate how different the remaining assemblages really are. A chi-square test result of 113.93 (with 9 degrees of freedom; $p < .001$) revealed a significant association between tool classes and site classes. That is, they are not independent phenomena. Analysis of adjusted standardized residuals (Everitt 1977; results shown in parentheses) showed several classes of data to co-occur more frequently than expected under conditions of random association: weapons



Figue 266. Frequencies of functional tool classes across site classes (n=76).

(4.65) and general utility tools (4.62) at domestic reduction sites, and fabricating/processing by-products (8.51) at quarrying locales. These results are entirely expected; domestic reduction sites (arguably occupied longer than specialize quarrying locales) are an appropriate functional context for the deposition of tools used in a variety of food processing and maintenance tasks (cf. Chapters 20 and 23). Quarrying locales, on the other hand, the scenes of primary toolstone extraction, are likely repositories for the debris from early stage stone tool production. Other tool classes are less common than expected within site classes: weapons at domestic quarries (-3.19) and quarrying locales (-3.92), fabricating/processing tools (-2.32) and by-products (-6.0) at domestic reduction sites, and general utility tools at quarrying (-7.1) and reduction locales (-2.42).

All possible pairs of site classes were evaluated by K-S test for significant differences in proportions of tool classes (weapons, fabricating/processing by-products, fabricating/ processing tools, and general utility tools) (Figure 267). Significant differences in the proportions of tool classes within summed assemblages were revealed between domestic quarries and quarrying locales (Dmax=.18, Dcrit=.08, at p=0.05, n1=998, n2=382), domestic reduction sites and quarrying locales (Dmax=.19, Dcrit=.07, at p=0.05, n1=3664, n2=382), and domestic reduction sites and reduction locales (Dmax=.09, Dcrit=.08, at p=0.05, n1=3664, n2=287).

This analysis allows the important observation that a differential (probably residential) "effect" is pervasive in other tool classes, *even when millingstones are removed from the assemblages*. Domestic reduction sites differ from reduction locales and domestic quarries differ from quarrying locales not just because they contain milling equipment, but because the suites of activities producing the assemblages were distinctive.

It is interesting, as well, that the proportions of remaining functional tool classes are not significantly different between the two kinds of residential sites. Though these site classes occur in quite different settings (cf. Figure 256; Chapter 25), and generally offer quite different facilities and resources, apparently the variety of production and maintenance activities that took place upon them varied only slightly.

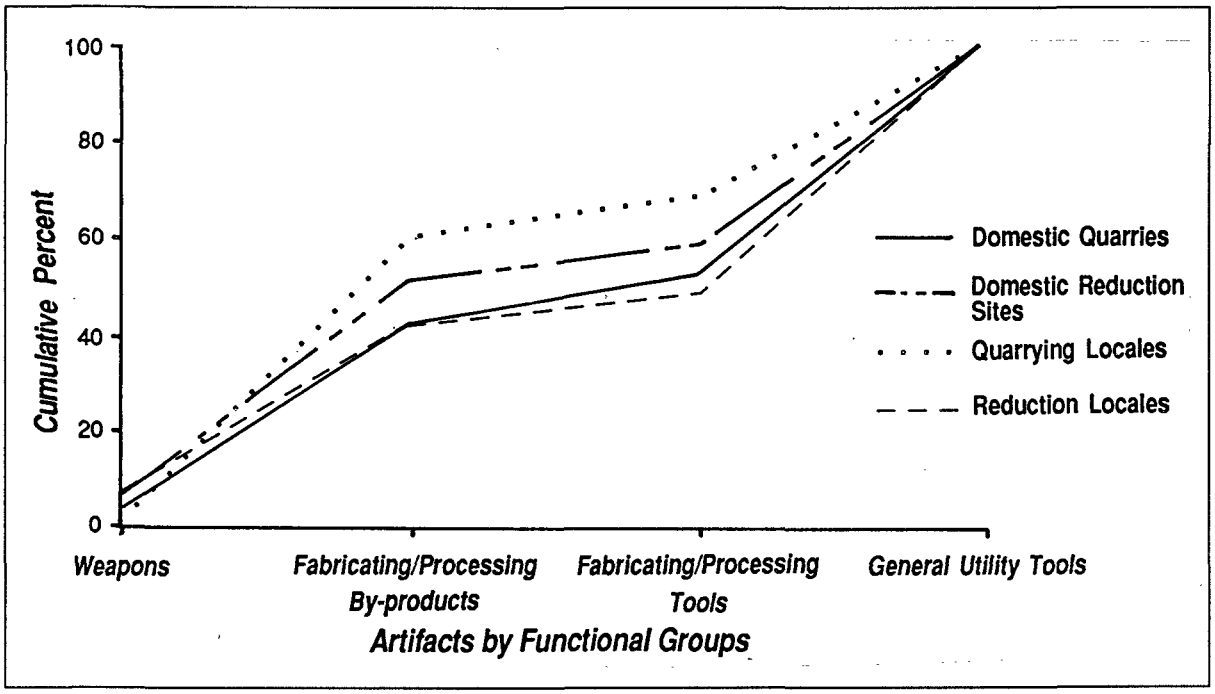


Figure 267. Cumulative proportions of functional tool classes across site classes (n=76).

Confirming the results of the standardized adjusted residuals analysis presented above, residential sites were shown to contain somewhat more general utility tools, more weapons, and slightly fewer fabricating/processing by-products than do quarry and reduction locales. The lower frequencies of these by-products at residences indicate emphasis on later stages of toolstone reduction. A closer examination of biface assemblages confirms this pattern (Figure 268). There is a significant difference in the proportions of fabricating (early stage) bifaces (Stages 1 to 3.4) and general utility (late stage) bifaces (Stages 3.5 to 5) across several site categories (domestic quarries and quarrying locales--*D*max=.31, *D*crit=.10, at p=0.05, n1=663, n2=251; domestic reduction sites and quarrying locales--*D*max=.35, *D*crit=.09, at p=0.05, n1=2421, n2=251; quarrying locales and reduction locales--*D*max=.29, *D*crit=.13, at p=0.05, n1=251, n2=177). Residential sites contain more late stage bifaces than early ones, while quarrying locales, where fabrication and initial lithic reduction are primary activities, reveal substantially more early stage bifaces. In the aggregate (across the entire study area), reduction locales contain almost equivalent proportions of early and late stage bifaces. It has been shown elsewhere in this volume, however, that when analyzed in smaller subsets (e.g., across Tosawihi subareas) reduction locales contain internal biface stage variability accounted for by distance from the central quarries (cf. Chapters 4, 6, and 25).

Additional exercises were undertaken to evaluate the validity of the primary site typology and to identify between-class differences, including a stepwise discriminant analysis to investigate both how well our site typology was replicated by multivariate analysis and to discover if any tool types are particularly powerful discriminators among site classes. For the discriminant analysis, artifact frequencies were converted to presence/absence data to ameliorate the persistent problem of differential sampling and large assemblage size variation. Several patterns were particularly informative:

(1) When millingstones and ceramics, our chief domestic indicators, were removed from the analysis and flake tool subtypes substituted as discriminating variables, sites still were correctly identified more than 76% of the time. Sixty-three percent of the domestic reduction sites and 86% of the domestic quarries were identified correctly, suggesting that, with the addition

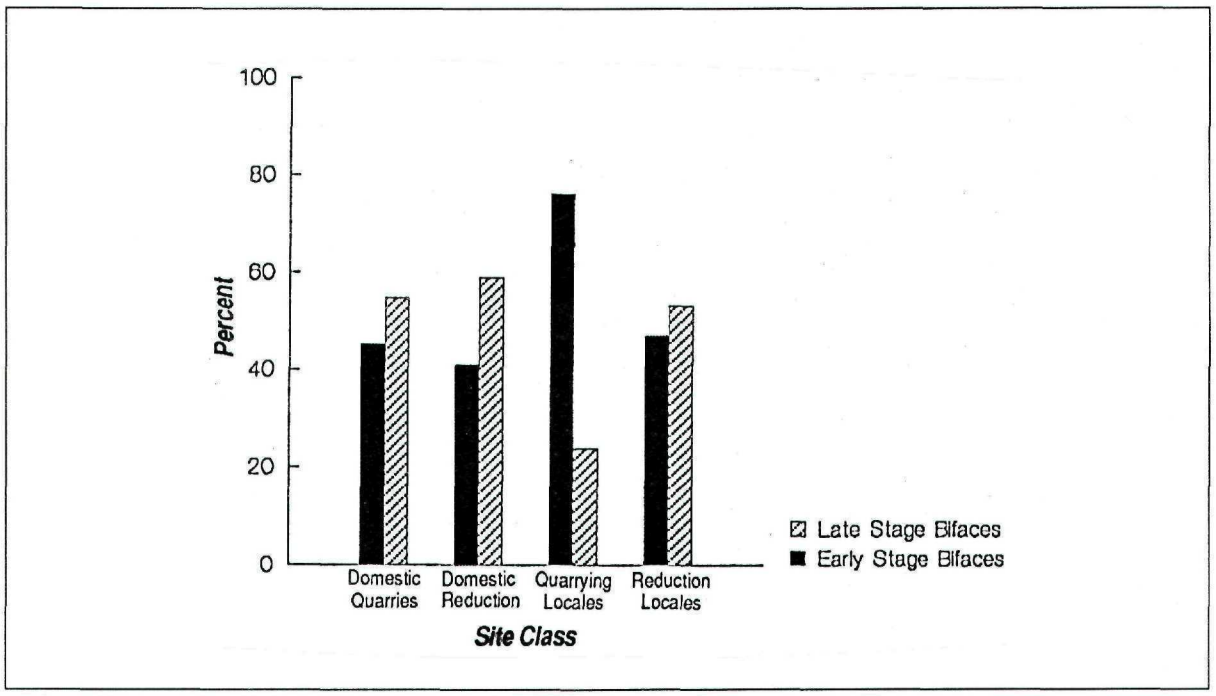


Figure 268. Relative proportions of fabricating (early stage) bifaces and general utility (late stage) bifaces across site classes.

of flake tool subtypes, discriminating power is substantial. Ninety-one percent of the reduction locales were classified correctly, signalling a higher internal consistency than previous analyses have indicated, and confirming the functional distinction between domestic reduction sites and reduction locales. Quarries, however, were segregated poorly.

(2) Removing flake tool subtypes caused classificatory accuracy to plunge for domestic reduction sites (to 36.8%) and quarrying locales (to 25%). Relatively rare flake tool subtypes, then, are very sensitive indicators of domestic site variability. However, 100% of all domestic quarries were correctly assigned to class, emphasizing the differentiation between domestic quarries and quarrying locales.

(3) Particularly powerful discriminators include percussion/cobble tools, preforms, points, crudely retouched flakes, microdenticulates, bone tools, notched denticulates, general utility bifaces, and miscellaneous retouched flakes. To explore this result further, we undertook a K-S test of the proportional contribution of these selected tool types to site classes, ordered by their entry into the discriminant functions. Domestic quarries are significantly different from domestic reduction sites (Dmax=.08, Dcrit=.06, at p=0.05, n1=552, n2=2292), chiefly in the higher relative proportion of projectile points on the latter. Domestic quarries and quarrying locales (Dmax=.21, Dcrit=.13, at p=0.05, n1=552, n2=139), domestic reduction sites and quarrying locales (Dmax=.21, Dcrit=.12, at p=0.05, n1=2292, n2=139), and quarrying locales and reduction locales (Dmax=.21, Dcrit=.16, at p=0.05, n1=139, n2=149) also vary significantly in their tool type proportions.

The graphed relative proportions of these tool types, compared across site classes, provide singular profiles (Figure 269). Quarrying locales are particularly distinctive, with higher proportions of bone tools (though these are still quite rare), notched denticulates, percussion/cobble tools, and miscellaneous retouched flakes, suggesting a suite of tools functionally related to toolstone extraction. Also notable is the lack of preforms, projectile points, and general utility (later stage) bifaces; domestic quarries and domestic reduction sites,

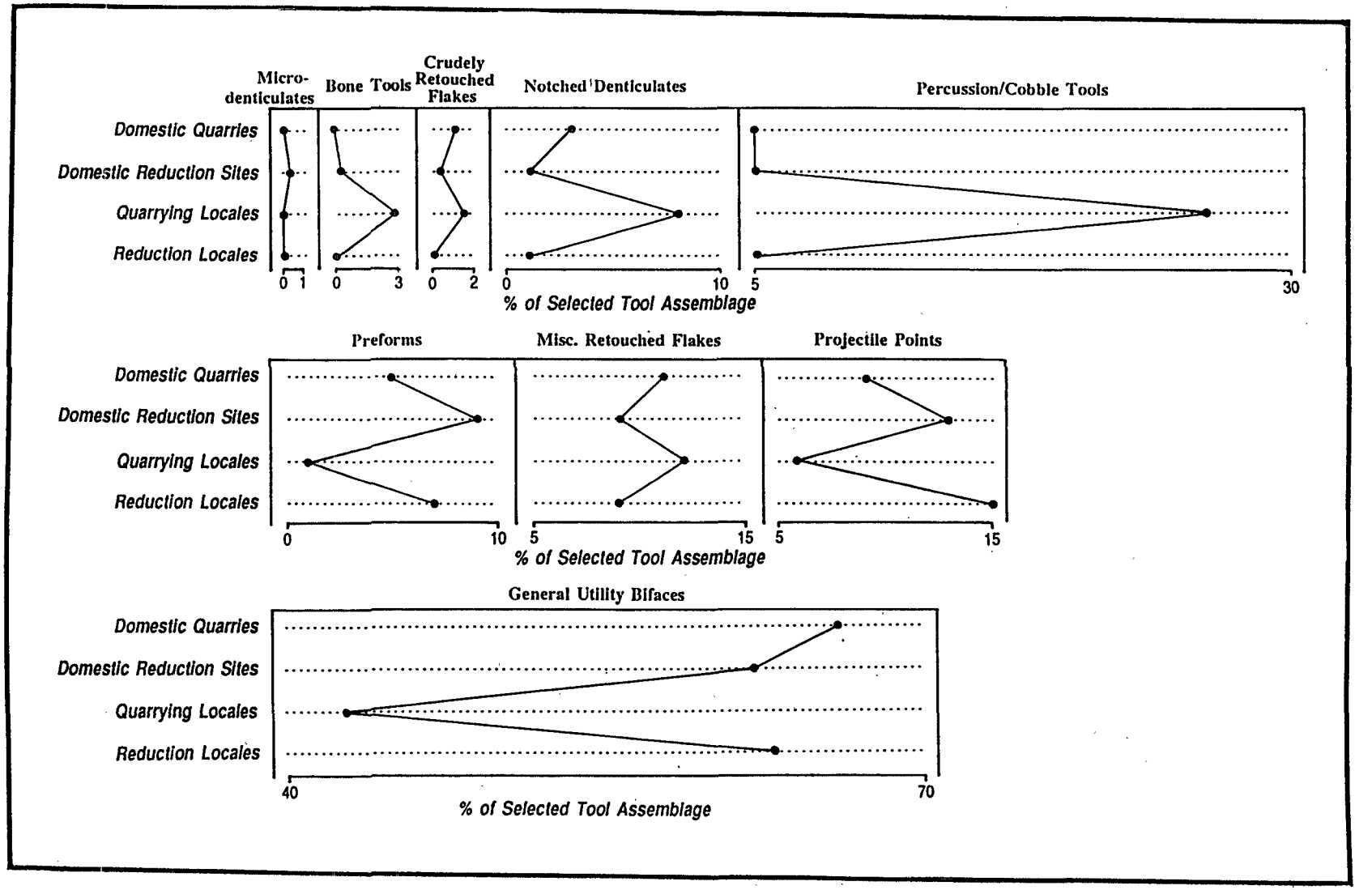


Figure 269. Relative proportions of discriminating tool types across site classes.

on the other hand, are repositories for these tool types. Weapons and late stage bifaces, then, were not discarded commonly where people conducted relatively narrow activities (e.g., at quarrying locales). However, as domestic exercises (indicated by millingstones and ceramics) were added to the repertoire of other activities, and as more time was spent, several classes of tool types such as preforms, projectile points, and general utility bifaces were added.

As presented in Chapter 7, flake tool variety and sample size are related linearly. Because we invested considerably more time in the excavation of potential residential sites than in special-purpose locales, and retrieved comparatively larger assemblages, it is not surprising that we recovered a higher diversity of flake tools from them. Nonetheless, when we examine the relative proportions of flake tools *within* assemblages, and compare these *across* site types, we see a marked, sample-size independent, difference in assemblage components. In particular, comparatively high proportions of flake tools make up assemblages at domestic locales. Figure 270 plots the graphic proportional contributions of flake tools to the total assemblages of each site class.

Figure 271 depicts the contribution of specific flake tool types to entire flake tool assemblages. Specifically, domestic sites have a higher mean proportion of pointed tools and retouched flakes in their assemblages than do reduction and quarrying locales. Because such tools are used for a wide range of perforating, boring, drilling, grooving, cutting and scraping functions (cf. Chapter 7), it is not surprising that these activities should be carried out more often in the context of multiple domestic routines.

Discussion and Conclusions

An understanding of site function is critical for understanding regional settlement study patterns. Variability in the archaeological record implies variability in behavior, and if we are attempting to define organizational strategies and long-term changes in them, we must be able to sort out variable poses on the landscape that resulted from these organizational modes.

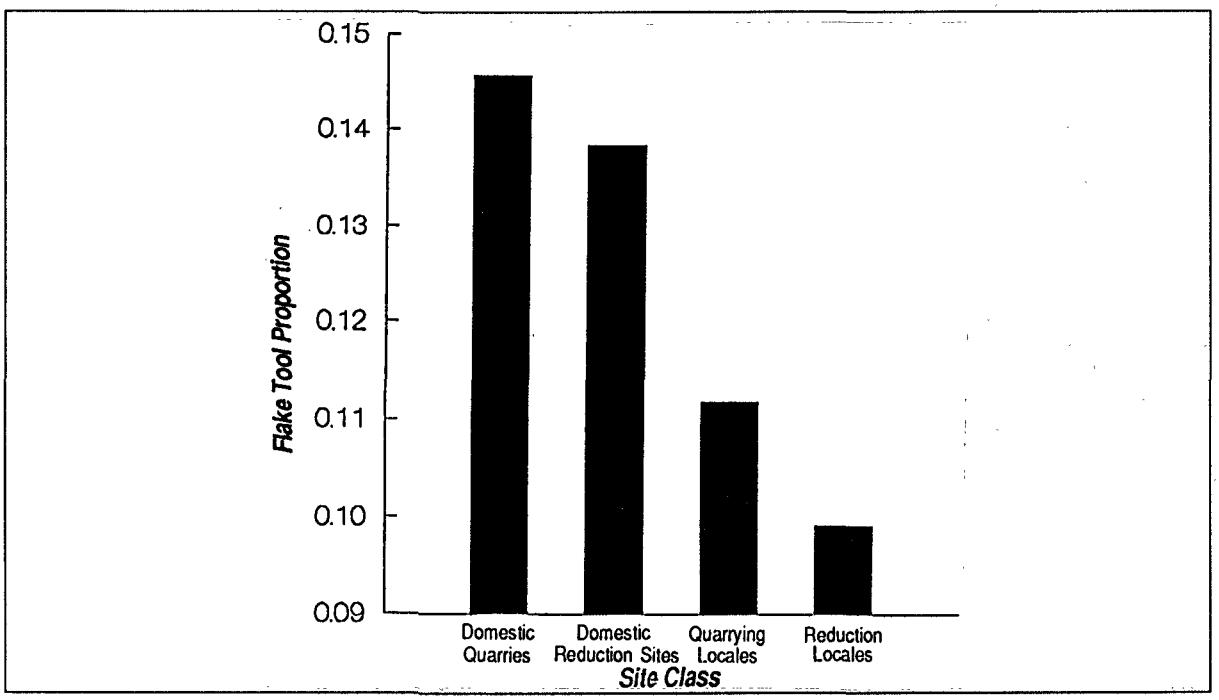


Figure 270. Proportional contribution of flake tools to total assemblages across site classes.

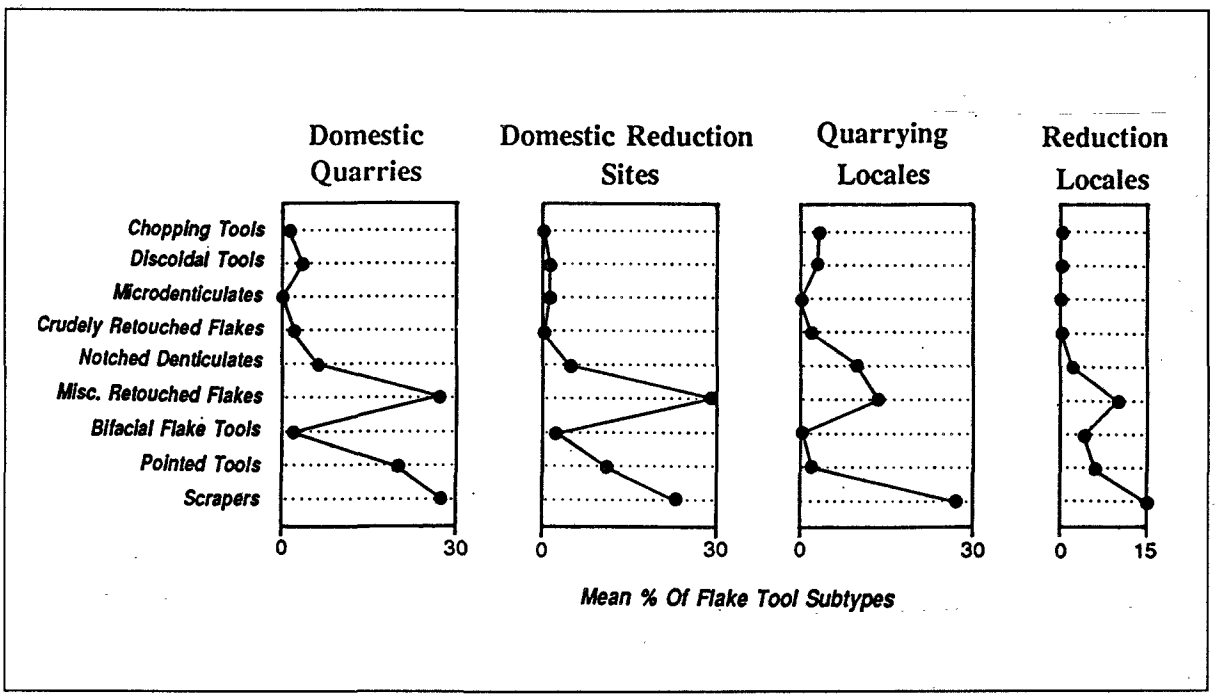


Figure 271. Mean proportions of flake tool types comprising flake tool assemblages across site classes.

In Chapter 4, we argued that opportunity costs incurred during toolstone procurement can be reduced in several ways, including positioning activities so that travel costs are minimized, and segmenting the organization of labor, so that only a few individuals or task groups are removed from foraging opportunities. How were these alternative strategies realized at Tosawihi? We have recognized two dimensions of residentiality at Tosawihi, the ephemeral domestic behavior at or near toolstone sources (domestic quarries) and the more visible reoccupations of off-quarry locales favorably located near water and food resource patches (domestic reduction sites). Each pose represents efforts to accommodate cost-minimizing strategies.

In the case of domestic quarries, transport costs are minimized (the camp is established directly on the toolstone source) and bifaces are prepared for transport. Placing a short-term residence or a logistical camp on a toolstone source represents a highly efficient spatial strategy when time spent at the quarries can be minimized. Food resources at Tosawihi are poor enough, even in the most productive seasons, that if group size and time at Tosawihi *can* be limited, they *should* be. Because time at the quarries is short, it is not necessary to place residences convenient to any particular food resources; small food supplies can be packed in and groups need not invest substantial time maintaining themselves while there. Activities are located near toolstone sources, and little time or energy is expended in travel or transport.

For longer-term stays at the quarries, however, such a strategy is exceedingly risky and costly, given the spatial structure of food resources. Opportunity costs while camping on a toolstone source increase significantly the longer the stay, since one may be isolated from other life-supporting resources.

When energy and time spent at Tosawihi are extended, then, possibly by high toolstone demand, decreased access to other toolstone sources, or constrained territorial movements, it pays to adopt a different residential strategy, involving residential groups moving into the vicinity of the quarries during food-rich seasons and establishing longer-term residential bases

off-quarry. A relocated residential group engages in intensive toolstone extraction as one activity among numerous other domestic routines (cf. Figure 255d). Quarrying is undertaken diurnally by part of the residential group, while others are foraging for food to support an extended stay. Concerns for propinquity to water and food resources, as well as to toolstone sources, dictate the placement of the residence. Diurnal collecting trips requiring no encampment at the quarries would, of course, leave no significant domestic signature on toolstone sources.

Representing this strategy, most domestic reduction sites are relatively far from toolstone sources, their location being conditioned more by the distribution of water and food resources. Lithic cores and bifaces are transported to them where they subsequently are prepared for further transport.

To summarize, where residential assemblages co-occur with toolstone sources, we suggest we are seeing evidence either of logistically-organized task-group or short-term residential group exploitation of the quarries (these alternative modes are indistinguishable in the archaeological record). The second residential strategy (heavily represented in the Western Periphery and Northern Corridor) is illustrated by domestic reduction sites, which reveal very different locations and organization. An extended residential stay in the Tosawihi vicinity and the disjunct nature of support resources required strategic positioning of residence and task groups with regard to *both* food and toolstone patches.

Thus, the enactment of longer-term residential use (with bases located convenient to multiple resources) vs. logistical or short-term residential use (with bases located only to ease toolstone access) is conditioned by external phenomena which may have dictated the need to acquire other resources concurrently with toolstone procurement.

Adoption of a longer-term residential lithic procurement strategy may have been an appropriate response to various external conditions, including an increased need to intensify toolstone collection (e.g., because of trade demands or regional constraints on movements to other toolstone sources). Evidence for the intensification of quarrying activity at Tosawihi has been presented in Chapter 19, and some confirmation of the phenomenon can be provided here (Figure 272). Although the attractive locations of domestic reduction sites have been favored from Pre-

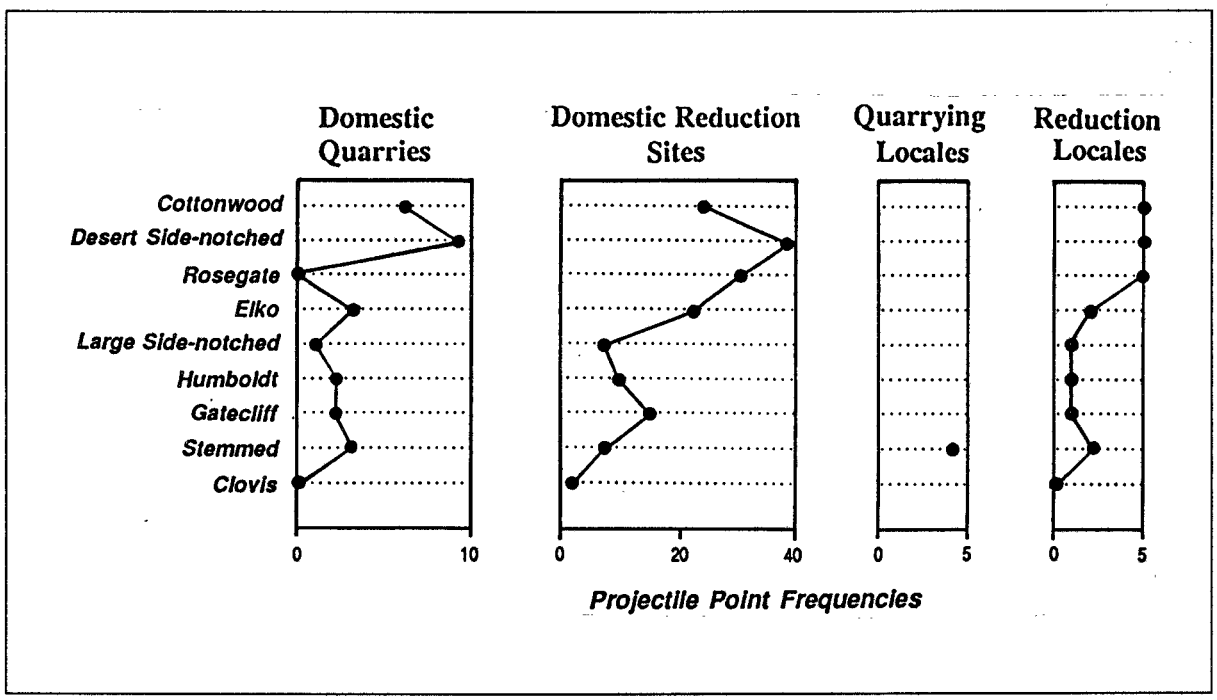


Figure 272. Frequencies of projectile points by site class.

Archaic times through the Late Archaic, over 70% of the time-markers at these "sweet spots" began to be deposited about 3250 BP, suggesting intensified use of the locations of domestic reduction sites after Elko series points were introduced.

Intensification of activity at the quarries has important implications for residential and mobility strategies. Once intensification began, cost-minimization concerns motivated quarriers to establish more centrally-located residential camps, enabling convenient access to plants and game in support of longer forays. The availability of water, game, and root crops on the West and in the North may account for the frequently reoccupied, aggregate sites we see in several of the later domestic reduction sites.

Chapter 25

SPATIAL RELATIONSHIPS

Christopher Raven

I placed a jar in Tennessee,
And round it was, upon a hill.
It made the slovenly wilderness
Surround that hill.
—Wallace Stevens

We assume that spatial structures observable in the archaeological record bear patterned relationships to the behavior that produced them. This assumption has fostered a burgeoning literature, largely ethnoarchaeological, of investigations of "site structure" (Binford 1978a, 1978b, 1982, 1983a; Gould 1980; Kent 1984; O'Connell 1987; O'Connell, Hawkes, and Blurton Jones 1991; Simms 1988; Yellen 1977a). The message of much of this literature has been cautionary, adumbrating *why* most such inquiry is conducted in ethnoarchaeological contexts; quite simply, it is vastly easier to understand spatial patterns of which the causal behavior has been witnessed than to infer causality from a sometimes taciturn archaeological record. The interpretive hazards conferred by the repeated use of places, by the mounting of multiple and often unrelated activities from a single hearth, by activities that intentionally reorganize spatial distributions (such as scavenging and the cleaning of living surfaces), and by the storm of taphonomic processes that begins to descend the moment after deposition all inhibit simple linear inferences about why things lie where they do.

At Tosawihi we have seen all these hazards at play, but we believe there remains an important residue of patterning within aggregations of things that can inform us usefully about the spatial organization of prehistoric behavior at the quarries. We are concerned here particularly with patterns discernible in *sites*, since those are the principal spatial frames of reference within which virtually all our data were collected, and with some of the behavioral events that contributed to their placement on the landscape.

Assumptions and Analytical Conventions

Events are constituted always, and only, of interplays of matter, energy, space, and time (Raven 1985); observation of these properties suffices to describe any event, and no event transpires absent the coincidence of all of them. *Behavior*, consisting of patterned sequences of events, is measurable with reference to each. Archaeology reconstructs events that transpired in time past, during which some quantity of energy acted on some circumstance of matter in some context of space. And because often we are more concerned with behavior than with the events of which it is composed, we ask the archaeological record to disclose recurrences in the ways that matter, energy, space, and time came into play.

But archaeological data consist chiefly of packages of matter deposited in spatial contexts, from the study of which we infer the temporal and energetic histories effecting their conditions and locations. In the present report we dwell at length on circumstances of *matter* (the physical data classes of the archaeological record) in Part II, on circumstances of *space* (the distributions and locations of pieces of the record) in Part III, and on inferences of the systematics of *time* and *energy* (how and when things got to be where they are, in the conditions they exhibit) in Part IV; in the chapter at hand, we are concerned particularly with synthesizing our archaeological observations on regularities of spatial patterning at Tosawihi, and with relating our observations to what we believe to have been some of the circumstances causing them to occur.

The various models discussed in Chapter 3 take as their common point of departure the economic assumption that successful expenditures of effort tend to be organized in ways that yield favorable ratios of benefit to cost. In the abstract, this can be accomplished severally; productivity can be enhanced by efficient strategies of procurement, processing, and redistribution of resources, while costs can be reduced by adjusting how time and energy are expended, how matter is manipulated, and how space is occupied. In real world situations, the possibilities are likely to be vastly more diverse, owing to the interplay of numerous subtly weighted variables. Too, we assume that in any system of work several strategies of economizing are likely to operate concurrently.

To approach the problem of understanding how effort may have been organized at Tosawihi, particularly with reference to the procurement, production, and transport of useful (beneficial) packages of toolstone, we formalized in Chapter 4 some expectations about how the archaeological record should look if various imaginable behavioral scenarios were played out. Among these are several explicit expectations about spatial relationships, all based on the principal of distance minimization as one among many viable economic strategies for reducing costs or enhancing productivity. Below, we examine our archaeological observations to test the reliability of these expectations, adopting for purposes of discussion some simple analytical conventions and definitions.

Location and Distribution

Spatial patterns are either intrinsic or non-intrinsic, i.e., they do or they do not have anything to do with variables of the field or environment in which they occur. Non-intrinsic patterns are independent of landscape attributes, and usually are defined by spatial relationships among members of a single class of phenomenon (e.g., bifaces, reduction stations, residential complexes) or among phenomena witnessed at the same scale of observation (e.g., artifacts, features, sites); we refer to such patterns as *distributions*. Distributions can be described with reference to distance and direction between equivalent members of the class, relative densities of members by area, and tendencies toward patterning in the arrangement of members. *Interpretation* of distributions, however, may require that we also invoke observations of dimension and make inferences about their hierarchical organization.

Intrinsic spatial patterns, on the other hand, are conditioned by various qualities of their environment, and their description requires identification of the environmental attributes on which they depend; we refer to them as patterns of *location*. Locational patterns come about when some aspect of the environment attracts or repels the placement of an activity; the occurrence of toolstone, water, and economically useful plants and animals are all likely to have served at Tosawihi as locational attractors of certain classes of activity, while various limiting factors (steepness of slope, barrenness of resources) may have repelled use of certain tracts. Additionally, however, other classes of cultural place-making (e.g., the placement of campsites, caches, permanent facilities, or prior episodes of quarrying) may have affected later locational decisions, and the explanation of observed patterns may require consideration of both natural and cultural attributes of the immediate environment.

Units of Analysis

We looked at spatial patterns in the Tosawihi record on two principal levels of abstraction. In the first place, we inquired how *sites* are distributed relative to one another and how the locations of various functional categories of site may have been influenced by intrinsic attributes of the cultural and natural landscape. We were concerned especially with

trying to determine the degree to which the geographies of various categories of work may have interdepended. In the second place, we wanted to look at the internal structure of those clusters we identified as "sites" in order to evaluate the degree to which activities within them were patterned discriminately, so we paid particular attention to the distribution and location of *features*; an intentional by-product of this inquiry was to test the utility of site boundaries for segregating meaningful aggregates in the archaeological record.

In all these inquiries we have adopted the geographer's convention of representing our data classes as spatially discrete points within a field, a concession to the utility of point pattern analysis for signalling patterned spatial relationships (Boots and Getis 1988). In certain cases (for instance, in treating hierarchical arrangements of sites and features) we have considered factors such as dimension (e.g., area) as well, but these have served to *qualify* points in our array rather than to modify their position or relationship to other points.

Distributions and Locations of Aggregates

From Tosawihi we collected some 1,337,000 cultural items, recording the provenience of each within .1 m^3 of archaeological deposit. In the preponderance of cases, these items occurred in visually discernible clusters that we designated "sites" or, where we observed clustering of clusters, or other patterns of apparent interrelationship, as "features" of sites. During testing and data recovery we investigated 363 features at 67 sites (cf. Chapters 16, 17, and 18), and from study of their form and content have drawn inferences about their function (cf. Chapter 24). In the following discussion we address some salient spatial relationships among the principal functional classes (residences, quarries, reduction stations) to which they can be assigned. We concentrate particularly on patterns observed in the Eastern and Western Peripheries, since only there do we control sufficiently detailed *areal* data to confront most issues of spatial patterning; the *linear* data available relative to distributions and locations in the Northern Corridor will be examined, but they cannot lead to comparable conclusions. (n.b.: In the ensuing analyses we have regularized somewhat the boundaries of the Eastern and Western Peripheries to eliminate narrow projections that would compromise calculations of distribution and areal density; the same conventions have been adopted for all maps and computations involving surface area throughout the chapter).

Residences

Five sites in the Eastern Periphery (26Ek3170, 26Ek3171, 26Ek3184, 26Ek3192, and 26Ek3198), five in the Western Periphery (26Ek3092, 26Ek3095, 26Ek3160, 26Ek3165, and 26Ek3271), and two along the Northern Corridor (26Ek3237 and 26Ek3251) exhibit attributes suggesting that at various times and to varying degrees of intensity they functioned as residences (cf. Chapter 24). Details of their distribution indicate the operation of similar criteria of site placement for all but the two northernmost sites, and they allow us to examine some of the expectations regarding residential location advanced in Chapter 4.

Residences in the Western Periphery are strongly clustered in the central southern portion of the subarea; the smallest polygon enclosing all of them occupies no more than 14% (314,036 m^2) of the entire subarea (Figure 273). The four northern sites of the group (26Ek3092, 26Ek3095, 26Ek3160, and 26Ek3271), in fact, cluster so tightly that their average size is larger than the distances separating any adjacent pair. This argues that their evident discreteness (suggested by discontinuities in the scatter of cultural materials between them) may owe more to intrinsic qualities of the landscape than to actual segmentation of residence; we note, for instance, that they occupy the *only* flat ground in their immediate vicinity (26Ek3092 on a terrace at the base

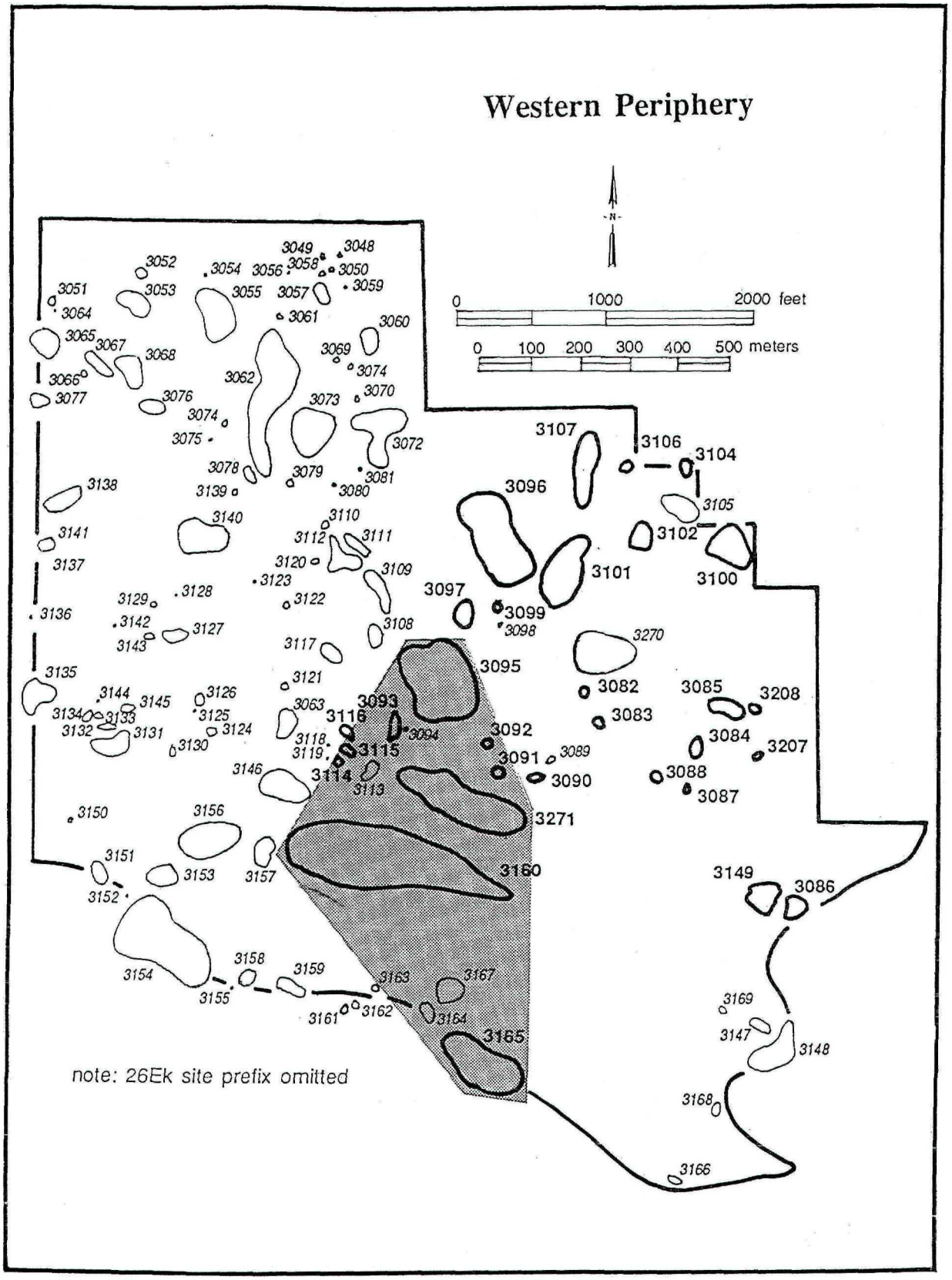


Figure 273. Residential zone of the Western Periphery.

of Basalt Canyon, 26Ek3095 on a broad bench above it, and 26Ek3160 and 26Ek3271 on wide ridgecrests to the south), with much steeper slopes intervening. They thus may reflect related, functionally overlapping, task-specific work and habitation areas exploited sometimes even by the same population, the selection of specific work and living areas dictated by microtopographic variation. 26Ek3165 occupies a saddle of the next ridgecrest south from the group; although something of an outlier, it lies barely more than 400 m from its nearest residential neighbor in the larger aggregation, suggesting that its location was selected on largely similar criteria.

If the five clustered sites discussed here truly define the "residential zone" of the Western Periphery, we are struck by how relatively little diverse is the habitat in which they occur, and how relatively uniform the suite of resources to which they gave access. In light of the expectations regarding environmental correlates of residential locations discussed in Chapter 4, the placement of this zone is remarkably favorable. The only surface water presently available within the entire subarea, for instance, lies just downslope from 26Ek3095 and only about 200 m up-drainage from 26Ek3092. Runoff from this source (a minor seep) is channeled, when flowing, along the Basalt Canyon drainage through the northern reach of the residential zone, passing no more than 50 m from the margin of 26Ek3271 and less than 150 m from 26Ek3160. The flow has been seasonal in recent years, but we note that subsurface waters can be tapped fairly easily along its course; in late June of 1989 (the third year of a drought beginning in 1987), when no flow remained and the up-drainage seeps were declining, channel-bank excavation units at 26Ek3092 had to be terminated when water was encountered at a depth of ca. 1 m. 26Ek3165, the most remote site within the residential zone, is more problematic; it lies nearly 600 m from the nearest approach of the Basalt Canyon drainage, and under the current climatic regime appears high and far from water. A major channel passes some 250 m north of the ridge on which it rests, however, and it may be that, as in Basalt Canyon, subsurface waters could be tapped easily along its course.

The sites lie at an average distance of 470 m from the nearest major sources of toolstone (26Ek3084 and 26Ek3270); 26Ek3092 and 26Ek3095 are the closest (335 m), while 26Ek3165, the most remote, is about twice as far. Since only three major opalite sources occur within the Western Periphery, and since only the very steep slopes of Red Hill intervene between them and the residential zone, it would appear that residences were placed largely to optimize proximity to water (as first priority) and toolstone, constrained only by the requirement for flat ground.

Biotic factors doubtless reinforced this site selection, however, and lent added attractiveness to the residential zone. Bitterroot (the most favorable plant food available in the entire Tosawihi vicinity) achieves its densest stands within and immediately adjacent the subject sites, helping explain the relatively high frequency of ground stone artifacts in their assemblages. Too, the transit of Basalt Canyon (one of the few relatively favorable deer habitats in the subarea) and the adjacency of Rodent Valley (an extremely favorable small mammal habitat) render the residential zone and its immediate hinterlands the richest foraging patch in the Western Periphery; sites within it, then, enjoyed superior access to virtually all the resources we expect to have influenced residential location at Tosawihi, and the zone constitutes a convincing example of the central place solution to managing resource propinquity (cf. Chapter 4).

Sites with residential attributes in the Eastern Periphery pattern somewhat differently from those in the west. An eastern residential zone can be defined (Figure 274) within which most residential sites cluster more tightly than their western counterparts (they can be enclosed by a polygon bounding ca. 198,300 m^2), but the zone is more diffuse relative to the entire surface area of the eastern tract (the polygon encloses 31% of the subarea). Since subarea boundaries were defined arbitrarily, however, we tentatively accept that residences are more nucleated in the Eastern Periphery than in the west, although for the most part they appear to have been inhabited less intensively. Only the sites along Ramadan Ridge (26Ek3170 and 26Ek3171) and 26Ek3192, along Undine Gorge, exhibit a complexity and depth of deposit

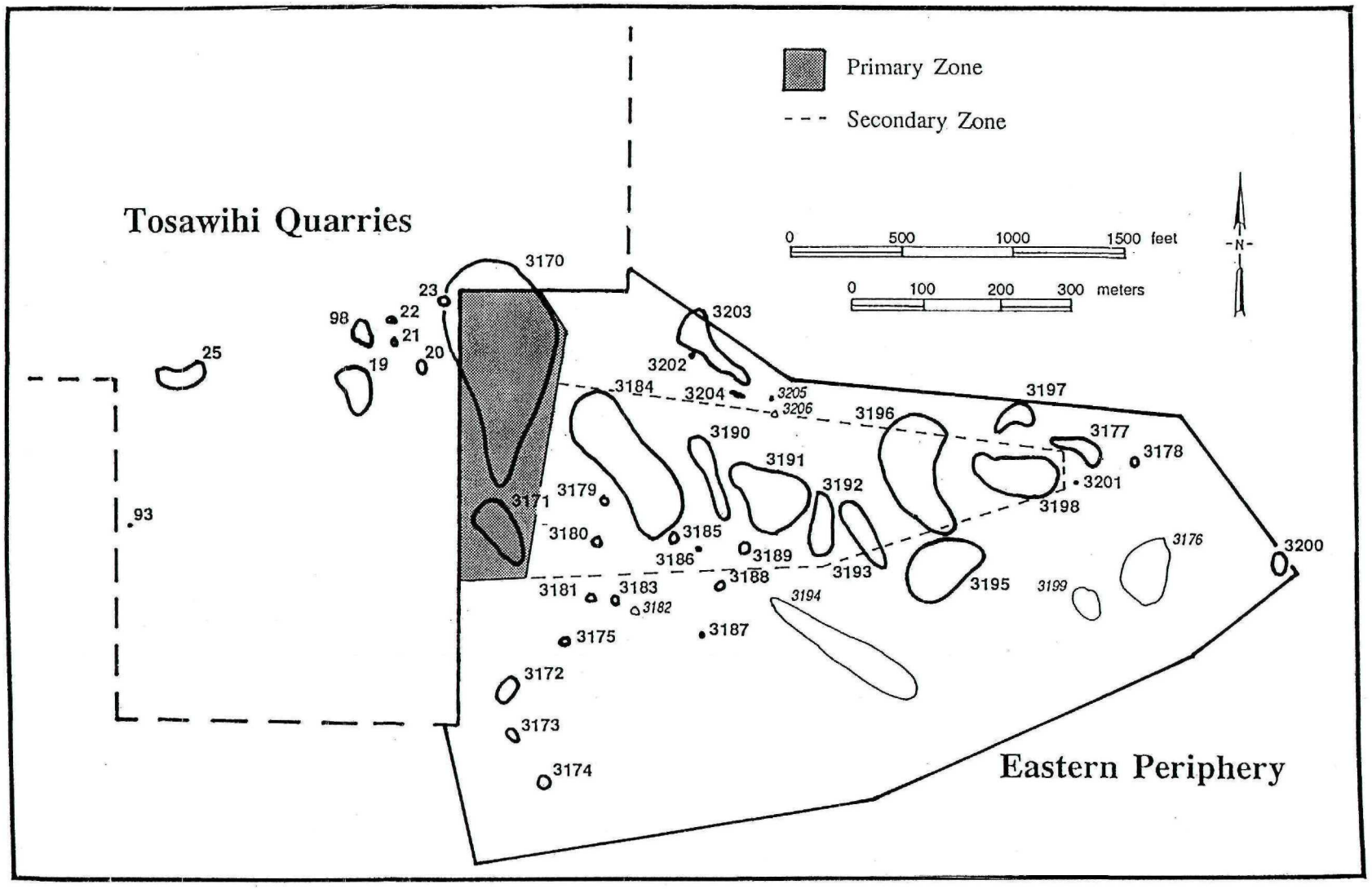


Figure 274. Residential zone of the Eastern Periphery.

suggesting continued revisits, while most of the more easterly places are sparser, shallower, and probably reflect much shorter-term or less frequent occupations. We note that the Ramadan Ridge/Undine Gorge residential zone is continuous with a linear, rather uniformly-spaced array of habitations extending north into 26Ek3032 (Localities 27 and 28, not considered in the present report).

As in the Western Periphery, the discontinuity between adjacent residential sites on Ramadan Ridge probably is a function of a minor break in slope between their precincts. Likewise, slope and a minor drainage channel may account for the apparent separateness of 26Ek3170 and 26Ek3184, the latter a large complex of reduction stations the assemblages of some of which exhibit various residential attributes (cf. Chapter 24). In this view, Ramadan Ridge, rather than the sites lying along and adjacent it, constitutes the residential center of the subarea, and issues of both propinquity and convenience resulted in a somewhat discontinuous distribution of artifacts and features that are components of essentially a single habitation sphere.

Locationally, the heart of the principal residential zone of the Eastern Periphery lies within a 200 m radius of a small but reliable seep at the confluence of Velvet Canyon and Little Antelope Creek, the only relatively permanent water source in the subarea. Other, lesser residences lie along the southern margin of Undine Gorge, now a seasonal drainage in the channel of which ponds collect after early summer rains.

All eastern residences suggest placement largely influenced by the incidence of toolstone sources. Major quarry features occur within the precincts of the larger residences (26Ek3170 and 26Ek3171), while minor sources occur within more diffuse or smaller ones (e.g., 26Ek3184 and 26Ek3198). No residence, however, lies more than 180 m from a major, intensely exploited source of opalite, and we assume that the somewhat diffuse distribution of lesser residences owes in part to the widespread distribution of high quality opalite throughout the subarea.

We have few bases from which to infer that foraging values played a very great role in conditioning residential locations in the Eastern Periphery. Virtually no favorable plant resources grow in the area today, and certainly not in densities likely to constitute profitable foraging patches. Small mammals are relatively abundant in meadows at the northern toe of Ramadan Ridge and on the soft, gradually undulating soils south of Undine Gorge, and the depths of the gorge probably are visited sometimes by deer, although we have observed none over four seasons of fieldwork. The location of 26Ek3198, however, atop a knoll allowing monitoring of a considerable stretch (nearly 1 km) of the deepest part of the gorge, should constitute a favorable hunting stand; the site's assemblage suggests a short-term hunter's camp, and deer passing along the gorge may well have been the attraction.

Major residential locations in the Northern Corridor (26Ek3237 and 26Ek3251) appear to have been conditioned chiefly by reliable water (both lie at major drainage confluences) and chances of game (riparian zones and bifurcating corridors invite both small mammals and deer). We have not observed abundances of particularly valuable plant foods, but both vicinities are grazed heavily under the current regime and are likely to have been more productive before the introduction of domestic livestock. Both sites are far from the nearest known sources of toolstone (although we control no areal survey data in their vicinities), and we assume that their placement had nothing directly to do with the distribution of opalite. Their assemblages, however, indicate that the *use* of opalite, and perhaps its transport, came importantly into play at both places.

Quarries

The location and distribution of quarrying sites are, of course, constrained absolutely by the distribution of toolstone sources, but it is not the case that all potential sources are

likely to have been exploited; quality of material and favorability of location (e.g., proximity to water and residential bases) also must have contributed to the initial selection of a source and to the intensity of its subsequent exploitation (cf. Chapter 4). In fact, however, the distribution of suitable opalite is not homogeneous throughout the Tosawihi vicinity, and its relative abundance affected significantly the volume, content, and location of the resulting archaeological record; much of the character of the various subareas under consideration here was induced by their geographic relationship to available toolstone.

The eastern and western subareas are designated "peripheral" precisely because the intensity of quarrying activity there so evidently was secondary to that conducted within 26Ek3032 (the Tosawihi Quarries proper). Within 26Ek3032, quarry pit localities occur at the density of .21/10,000 m^2, implying that, on average, no place within the quarry lies more than about 300 m from an exploited source of stone. Moreover, two-thirds of the quarry pit localities recorded during initial survey consist of quarry pit *complexes* composed of from two to as many as 55 individual pits (Elston, Raven, and Budy 1987), swelling by a considerable degree the actual intensity of toolstone extraction reflected. This contrasts strikingly with the pattern in the Eastern Periphery, in which quarry pit localities occur at a density of only .079/10,000 m^2, or at an average distance of slightly more than 500 m from any point on the landscape. The distribution is even sparser in the Western Periphery; quarry pit localities occur at a density of .013/10,000 m^2, meaning that any point within the subarea is likely to lie on average somewhat more than 1200 m from the nearest exploited stone source. In neither subarea do quarry pit complexes contain more than a half-dozen pits, further emphasizing that toolstone procurement within them was marginal compared to the intensity of effort expended in 26Ek3032. No quarry pit localities occur along the Northern Corridor, the nearest such site (26Ek3250) lying some 4100 m southeast of the southernmost site (26Ek3237).

Within the eastern and western subareas the incidence of toolstone tends to be clustered. Opalite occurs in the Eastern Periphery only on lower Ramadan Ridge, along the cliffs above Undine Gorge, and in an isolated pocket at the far eastern extreme of the subarea (26Ek3200), with the result that a contiguous block comprising ca. 75% of the surface offers no toolstone whatsoever. In the Western Periphery, virtually all exposed or near-surface opalite (and *all* intensively exploited sources) falls on the crest and slopes of Red Hill; in effect, almost all toolstone extracted within the subarea came from a single zone occupying less than 10% of the surface.

As will be detailed in subsequent discussions, different patterns of exploitation and transport are likely to have characterized the two subareas; in the East, owing to the greater dispersal of principal sources, most opalite is likely to have been extracted locally (i.e., within the subarea), while in the West, owing to its more tightly nucleated exposures, opalite is likely either to have been obtained from sources outside the subarea (sources within 26Ek3032) or transported over considerably greater distances than in the East. The locational relationships of reduction stations to quarries help clarify the archaeological implications of these probable patterns.

Reduction Stations

Reduction stations constitute the most populous class of archaeological place encountered in our investigations of the Tosawihi peripheries, and we expect them to be our most informative source about how space was organized around the quarries (cf. Chapter 4). Their distributions and locations test several of our assumptions about the role of propinquity in conditioning where activities are likely to be carried out (especially in relation to toolstone sources and residential loci), and their compositions define the degree to which convenience governed the reorganization of things in space. We looked at some of the critical spatial relationships of 333 reduction stations (135 in the Eastern Periphery and 198 in the Western

Periphery), limiting our inquiry to those areas in which we control detailed areal data on surface patterns and assemblage compositions.

Based on the principal of distance minimization as a strategy for diminishing the expenditure of effort, we advanced in Chapter 4 a general model of how reduction stations should be located relative to toolstone sources and residences. The model is represented graphically in Figure 275 where, reduced to its simplest elements, we see that the frequency of reduction stations should be high in the immediate vicinity of their parent quarry and in the vicinity of the residence from which the work force was dispatched; between those poles, frequency should decline. Moreover, reduction stations near quarries should be characterized by a high incidence of early stage reduction debitage, while the incidence of later stage debitage should increase as the residence is approached. Deviations from the ideal model are anticipated, of course, as a consequence of numerous real-world contingencies (e.g., multiplicity of quarries, variations in toolstone quality, intervening opportunities or hazards), but we expect observed patterns to *trend* toward the ideal. Deferring for the moment issues of their content, we consider our population of reduction stations only as points in a field in order to inquire how their locations are related spatially to the locations of quarries and residences.

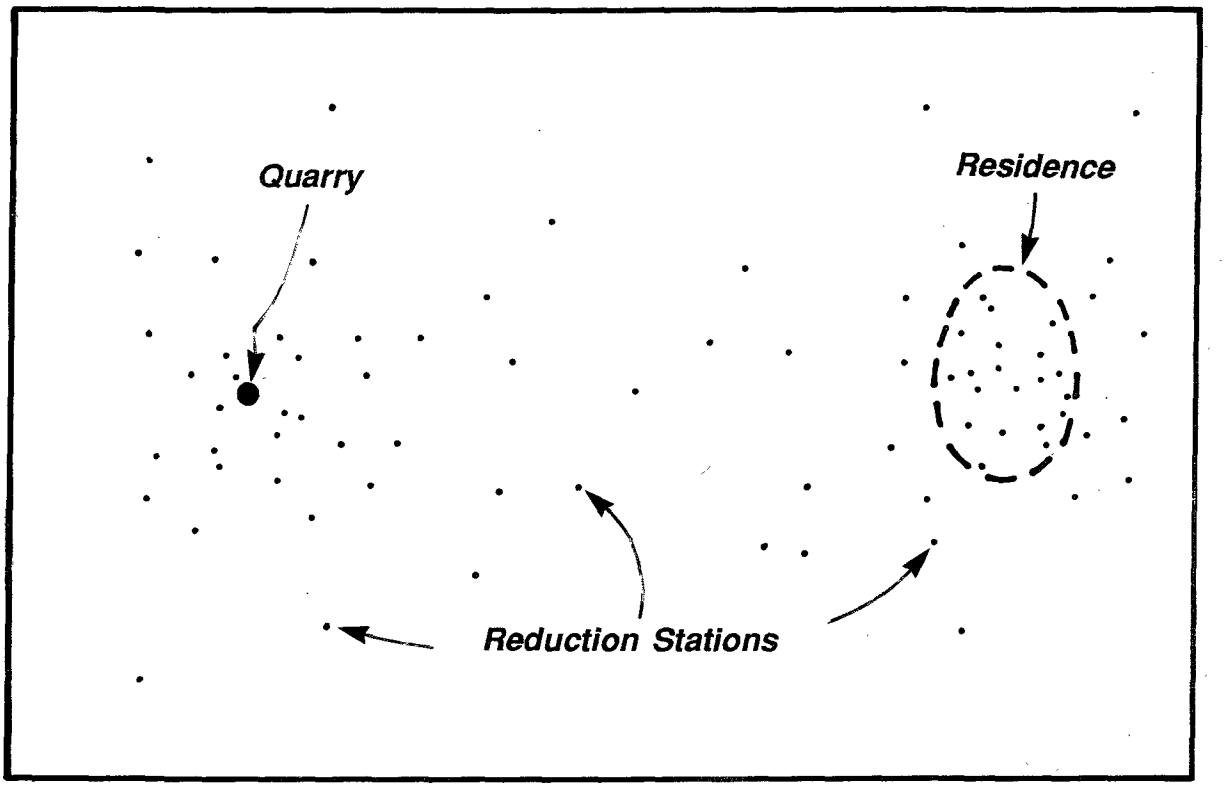
Reduction Stations and Quarries

In the Eastern Periphery we have identified five locations (26Ek3032/23, 26Ek3171, 26Ek3195, 26Ek3197, and 26Ek3200) at which major efforts of toolstone extraction were undertaken. Several other locations occur within the subarea at which very minor procurement efforts have left sparse traces; these consist chiefly of little-used cobble quarries and occasionally battered outcrops. In no instance, however, do we have reason to believe that the volumes of toolstone removed from such places approached by an order of magnitude that taken from our five principal quarries, and they are dismissed from the present analysis.

Major quarries in the Western Periphery are limited to three sites on Red Hill (26Ek3084, 26Ek3208, and 26Ek3270). Numerous localities within 26Ek3032, however, lie close to the northern margin of the subarea and doubtless contributed opalite to the local archaeological record; we have included, therefore, the locations of Localities 36, 39, 42, 43, 182, 193, 199, 201, and 204 in our spatial analysis of toolstone accessibility in the west, even though we have not examined their contents beyond initial reconnaissance.

The 333 reduction stations of our sample lie at an average distance of 373 m from the nearest quarry, although the two subareas differ notably; the average distance from reduction station to nearest quarry is 525 m in the Western Periphery, in the Eastern Periphery, only 152 m. Figure 276 graphs the actual frequency by distance in both areas, from which it is evident not only that absolute distances are considerably greater in the West, but that all articulations within the distance/frequency profile are pitched much higher there. For instance, the highest incidence of reduction stations occurs in the East between 100 - 200 m from the nearest quarry, while in the West it lies between 400 - 500 m. This would appear to contradict our expectation that a high frequency of reduction stations should lie in the immediate vicinity of quarries, but we note that the steep slopes of Red Hill probably constrained much use of the surface. In this case, it may have been considered an acceptable trade-off either to reduce raw material directly within the quarry precinct or to transport it to the nearest level ground for reduction rather than to risk rolling down hill.

In order to relate these general, area-wide frequencies to zones probably served by individual toolstone sources, we subdivided both subareas on the basis of proximity to specific quarries. In Figures 277 and 278 the Eastern and Western Peripheries have been segmented into Thiessen polygons (or Dirichlet domains; cf. Boots and Getis 1988:71), space-exhaustive zones that enclose all the space within a field closer to a single point than to any other (Hodder



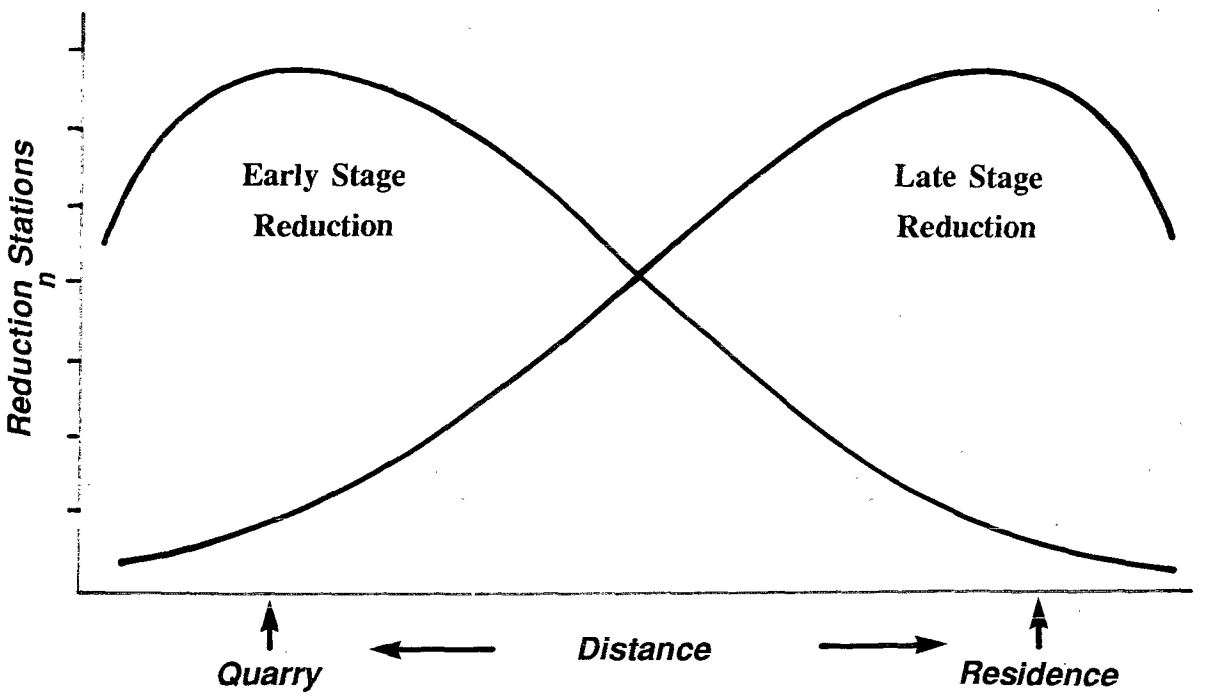


Figure 275. Expected distribution of Reduction Stations as a function of distance from Quarry and Residence.

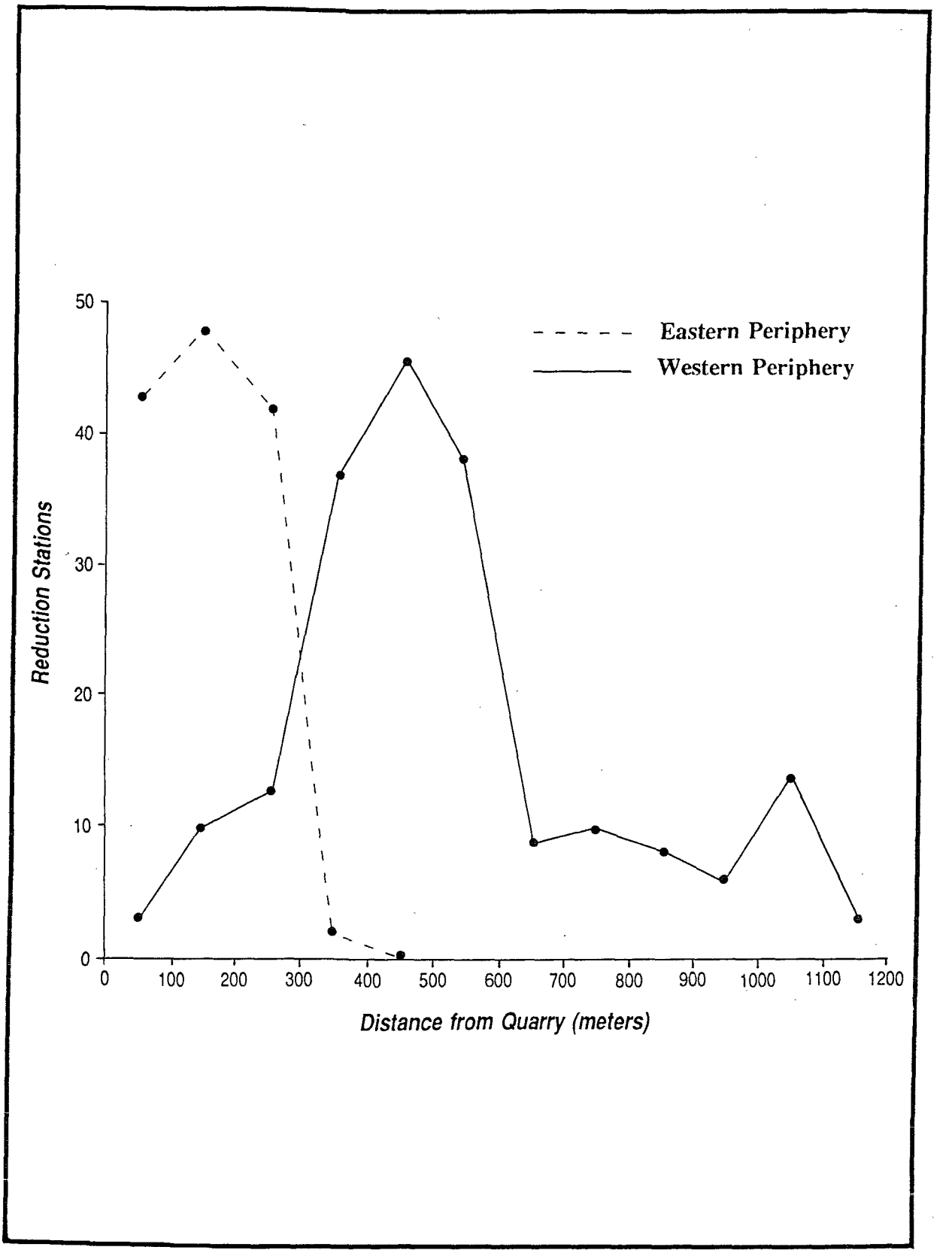


Figure 276. Distance of 333 Reduction Stations from nearest quarry, Eastern and Western Peripheries.

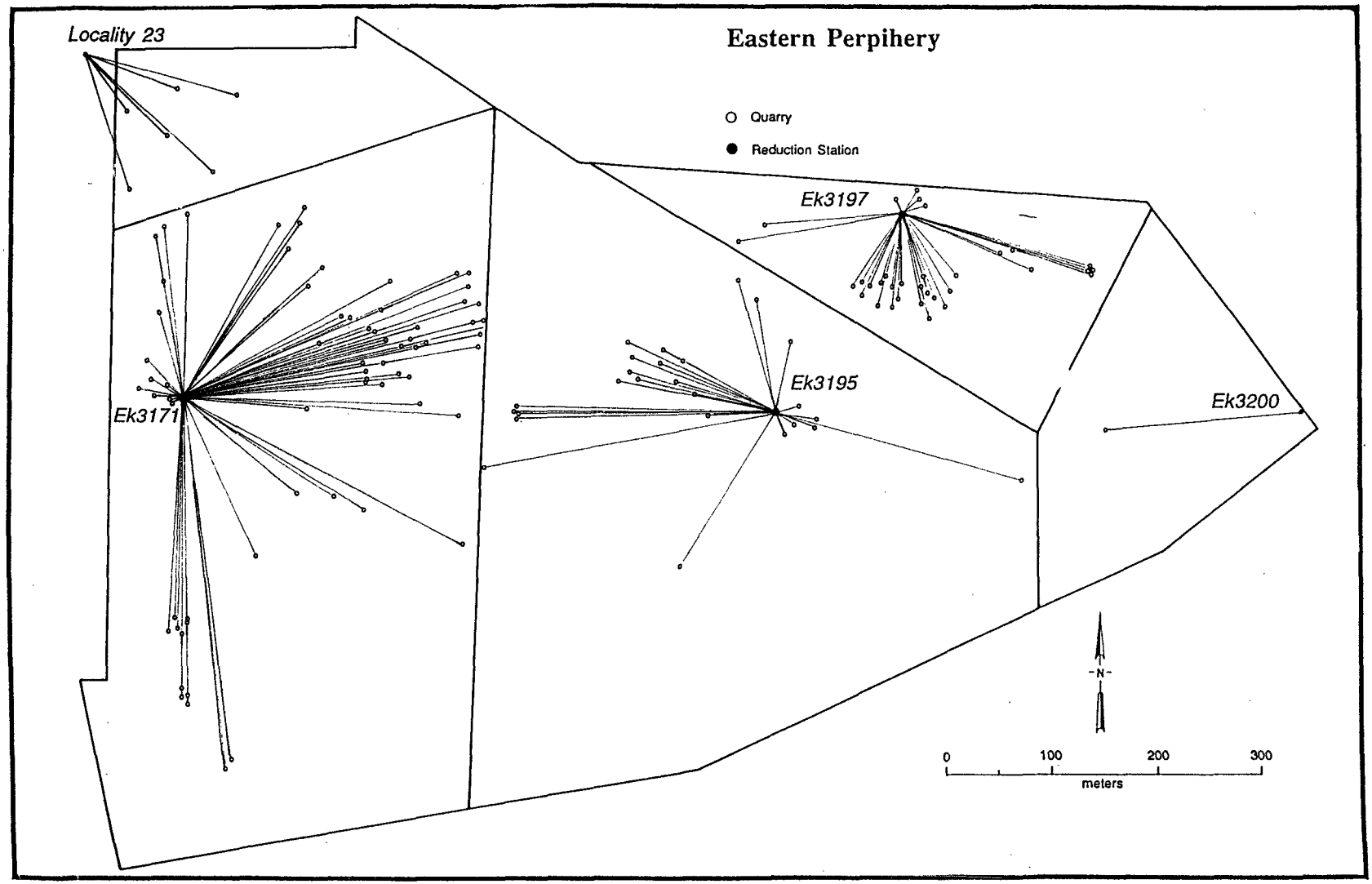


Figure 277. Quarry zones defined by Thiessen Polygons around major quarries, Eastern Periphery; Reduction Stations linked to nearest quarry.

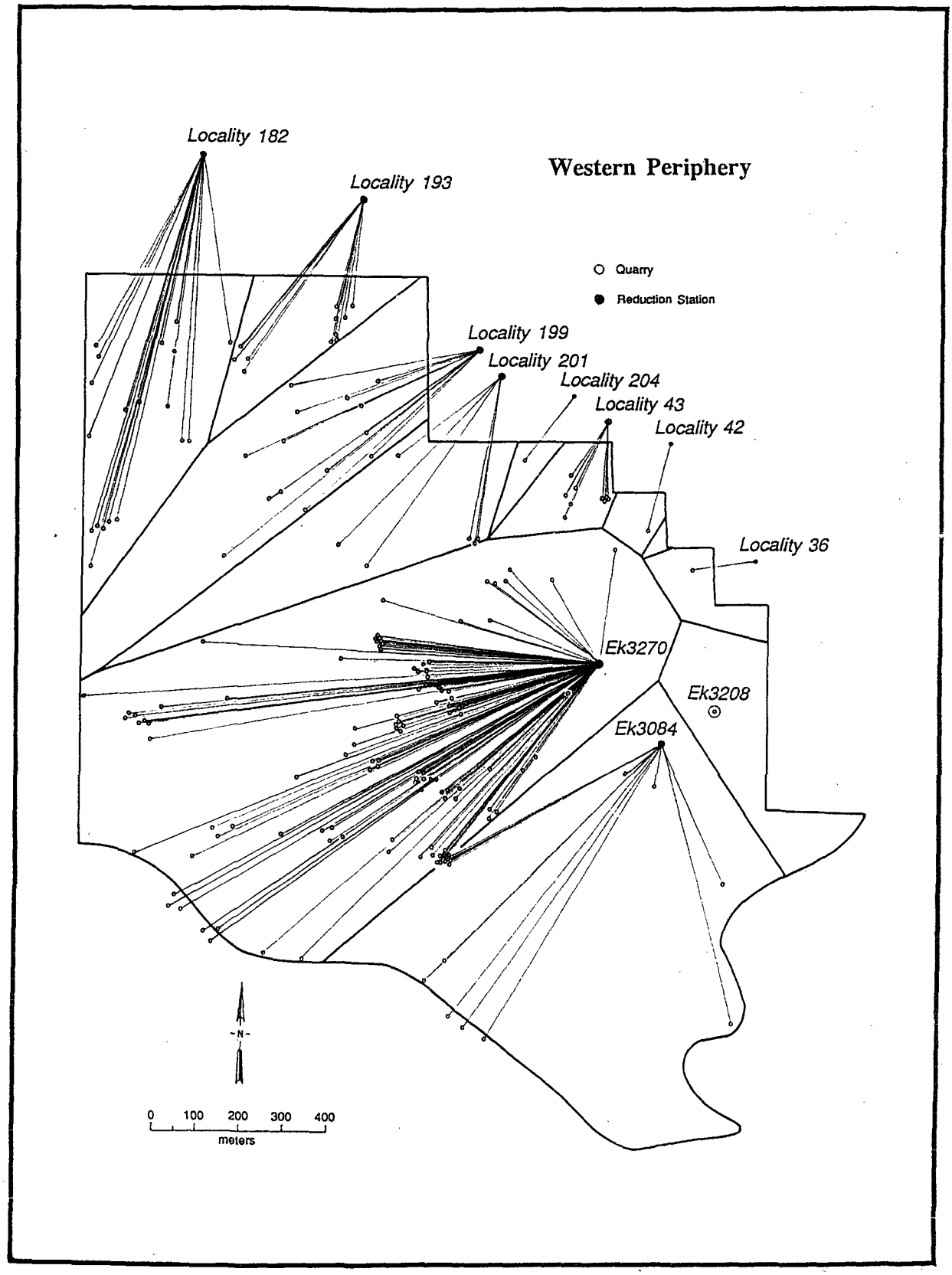


Figure 278. Quarry zones defined by Thiessen Polygons around major quarries, Western Periphery; Reduction Stations linked to nearest quarry.

and Orton 1976:59-60; Taylor 1977:306-307); we centered our polygons on the five major quarries in the East and the three in the West. In the ensuing discussions, we refer to the areas enclosed by these polygons as "quarry zones," designated by the principal toolstone source within each. They segregate populations of reduction stations lying nearer one major quarry than any other (indicated by fine-line radials on Figures 277 and 278), and are purely theoretical constructs for organizing the array of quarries and reduction stations by distance minimization.

Immediately evident in comparison of the two patterns is how the location of reduction stations relates to the distribution of quarries. In the Eastern Periphery, all quarries save 26Ek3032/23 are internal to the subarea, and most capture multidimensional reduction station targets within their proximal zones. In the Western Periphery, only two quarries (26Ek3084 and 26Ek3270) within the subarea lie closer to any reduction stations there than do the various localities of 26Ek3032 external to it on the north, with the result that nine of the twelve quarry zones are attenuated.

The quarry zones clearly group reduction stations on a principal very different from that which groups them into sites, and the resulting groups exhibit both absolute and relative differences among them. One way of looking at these differences is expressed in Table 228, in which overall densities of reduction stations are calculated for each quarry zone.

Table 228. Areal Frequency of Reduction Stations by Quarry Zone, Eastern and Western Peripheries.

Quarry Zone	Area (m^2)	Reduction Stations n	Reduction Stations/ 10,000 m^2
Eastern Periphery			
26Ek3197	64,375	32	4.97
26Ek3195	238,750	26	1.09
26Ek3032/23	40,000	6	1.50
26Ek3171	231,875	70	3.02
26Ek3200	55,000	1	.18
Total	630,000	135	2.14
Western Periphery			
26Ek3032/182	192,500	19	.99
26Ek3032/193	67,500	11	1.63
26Ek3032/199	240,000	14	.58
26Ek3032/201	165,000	6	.36
26Ek3032/204	15,000	1	.67
26Ek3032/43	35,000	10	2.86
26Ek3032/42	17,500	1	.57
26Ek3032/36	30,000	1	.33
26Ek3032/39	2,500	0	-
26Ek3208	82,500	1	.12
26Ek3270	840,000	121	1.44
26Ek3084	560,000	13	.23
Total	2,247,500	198	.88

We note particularly that average densities are very much higher in the Eastern Periphery, suggesting that in that subarea quarries tend to be related spatially to more reduction stations within a smaller area. This does not mean, however, that we should expect eastern quarries to have been exploited more intensively than those in the West, since western

quarry zones in some cases are very much larger (e.g., the zone surrounding 26Ek3270 is larger than the entire Eastern Periphery, and subsumes nearly as many reduction stations). Too, some very high densities in the west (e.g., Localities 43, 182, and 193 of 26Ek3032), as well as some very low ones (Localities 36, 39, and 201) are products of zones attenuated by the northern study area boundary and are of questionable comparability.

More informative than comparison of simple *densities* of quarry zones is comparison of the *distance structures* they display, since these allow more direct inquiry into the degree to which distance from quarry actually may have contributed to the location of reduction stations around it. Table 229, for instance, assigns numbers of reduction stations in terms of hundred meter increments of distance from the quarry in each zone, and calculates reduction station density for each distance domain.

Table 229. Areal Frequency of Reduction Stations by Distance from Nearest Quarry, Eastern Periphery.

Quarry Zone	Radial Distance from Quarry (m)	Area (m^2)	Reduction Stations n	Reduction Stations/ 10,000 m^2
26Ek3171	0 - 100	30,000	8	2.67
	100 - 200	58,750	24	4.08
	200 - 300	68,125	36	5.28
	300 - 400	50,625	2	.39
	400 - 500	24,375	0	-
26Ek3197	0 - 100	22,500	23	10.22
	100 - 200	33,750	9	2.67
	200 - 300	8,125	0	-
26Ek3195	0 - 100	31,875	10	3.14
	100 - 200	73,125	10	1.37
	200 - 300	91,250	6	.66
	300 - 400	42,500	0	-
26Ek3032/23	0 - 100	5,625	2	3.55
	100 - 200	18,125	4	2.21
	200 - 300	16,250	0	-
26Ek3200	0 - 100	10,625	0	-
	100 - 200	26,250	1	.38
	200 - 300	18,125	0	-

With the exception of the quarry zone around 26Ek3171, there is a general fall-off in density as a function of distance from the quarry. The relationship is depicted graphically in Figure 279, in which actual similarities and anomalies become especially evident. 26Ek3197, 26Ek3032/23, and 26Ek3195 all exhibit the trend anticipated by the model. The quarry at 26Ek3200 constitutes a minor anomaly owing to the uniquely sparse use made of its quarry zone. This perhaps is a function of its remoteness from the principal residential zone, since exploitation of its toolstone necessarily would have been somewhat more expensive in terms of travel and transport costs than any other quarry in the Eastern Periphery. Relative to this, we note that it appears to have been the least exploited of the major quarries of the East in terms of probable volume of material removed.

The quarry at 26Ek3171 is anomalous in a different respect; it exhibits a high degree of exploitation, and its quarry zone encloses the highest numbers of reduction stations in the subarea. While reduction stations occur in substantial densities within distances of 100 and 200

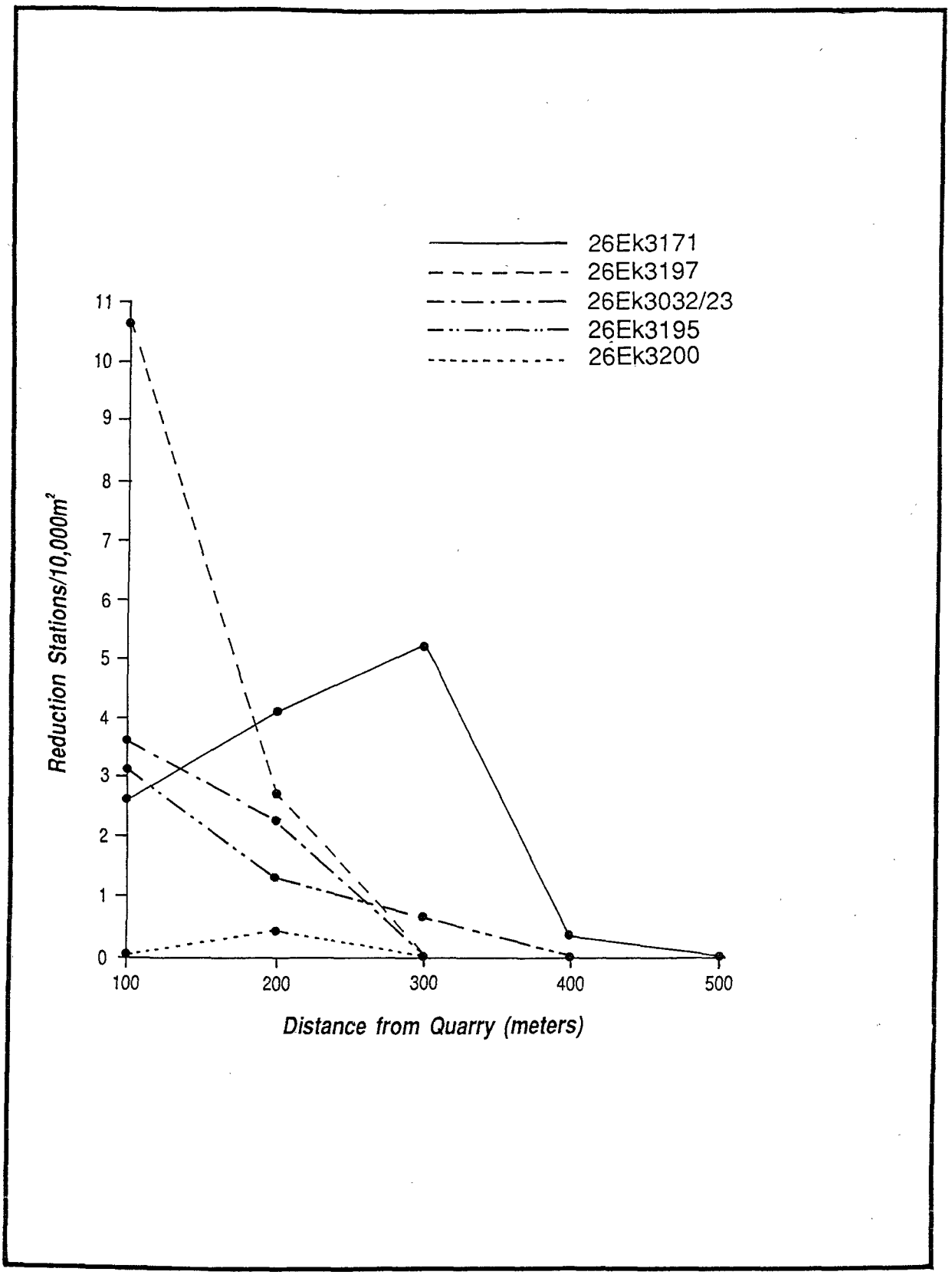


Figure 279. Areal frequency of Reduction Stations by distance from nearest quarry, Eastern Periphery.

m from the quarry, density peaks between 200 and 300 m distance, beyond which it falls off abruptly. Several factors may have contributed to this result. In the first place, 26Ek3171 occurs directly within the principal residential zone of the Eastern Periphery. While both 26Ek3170 and 26Ek3171 exhibit discrete reduction stations within their precincts, both also are characterized by large, amorphous expanses of scattered debitage and tools that probably represent blurred palimpsests of numerous originally discrete depositional components (cf. Chapter 17). In several instances, in fact, discrete reduction stations can be discerned in surface contexts *superimposed upon* the churned and apparently disorganized deposits. This suggests that the incidence of reduction *episodes* actually may have been quite high in areas 100 and 200 m distant from the quarry, but that their archaeological visibility (in the form of reduction stations) has been impinged by disaggregation owing to concentrated use and trampling of the surface. Only reduction stations representing the latest such episodes remain to be counted.

In the second place, over 70% of the reduction stations lying between 200 and 300 m from 26Ek3171 occupy the cluster designated 26Ek3184. We have discussed above the possibility that this site may constitute a related outlier of the Ramadan Ridge residential zone, separated from it chiefly by landform anomalies. If this is the case, the apparently high density of reduction stations at this distance may reflect a workshop of the residential zone that actually received *less* use than the heart of the Ramadan Ridge sites despite its greater frequency of visible reduction stations; excavation found deposits at 26Ek3184 generally not to exceed 10 cm in depth, while those of 26Ek3170 and 3171 frequently attain depths of 40 - 50 cm.

Density patterns in quarry zones of the Western Periphery are more variable, in part as a function of the attenuation of nine of them by the northern study area boundary. Table 230 arrays numbers of reduction stations by distance from quarry in each quarry zone and presents density as a function of distance.

Table 230. Areal Frequency of Reduction Stations by Distance from Nearest Quarry, Western Periphery.

Quarry Zone	Radial Distance from Quarry (m)	Area (m^2)	Reduction Stations n	Reduction Stations/ 10,000 m^2
26Ek3032/182	300 - 400	32,500	1	.31
	400 - 500	37,500	3	.80
	500 - 600	32,500	5	1.54
	600 - 700	32,500	4	1.23
	700 - 800	25,000	0	-
	800 - 900	17,500	5	2.86
	900 - 1000	10,000	1	1.00
	1000 - 1100	5,000	0	-
26Ek3032/193	200 - 300	22,500	4	1.78
	300 - 400	20,000	3	1.50
	400 - 500	15,000	4	2.67
	500 - 600	10,000	0	-
26Ek3032/199	100 - 200	25,000	0	-
	200 - 300	30,000	1	.33
	300 - 400	25,000	4	1.60
	400 - 500	25,000	4	1.60
	500 - 600	27,500	4	1.45
	600 - 700	25,000	0	-
	700 - 800	25,000	1	.40
	800 - 900	20,000	0	-
	900 - 1000	17,500	0	-
	1000 - 1100	15,000	0	-
	1100 - 1200	5,000	0	-

Table 230, continued.

Quarry Zone	Radial Distance from Quarry (m)	Area (m^2)	Reduction Stations n	Reduction Stations/ 10,000 m^2
26Ek3032/201	100 - 200	7,500	0	-
	200 - 300	25,000	0	-
	300 - 400	35,000	4	1.14
	400 - 500	22,500	0	-
	500 - 600	20,000	2	1.00
	600 - 700	17,500	0	-
	700 - 800	15,000	0	-
	800 - 900	10,000	0	-
	900 - 1000	7,500	0	-
	1000 - 1100	5,000	0	-
26Ek3032/204	100 - 200	7,500	1	1.33
	200 - 300	7,500	0	-
26Ek3032/43	0 - 100	2,500	0	-
	100 - 200	15,000	8	5.33
	200 - 300	15,000	2	1.33
	300 - 400	2,500	0	-
26Ek3032/42	100 - 200	12,500	1	.80
	200 - 300	5,000	0	-
26Ek3032/39	200 - 300	2,500	0	-
26Ek3032/36	100 - 200	25,000	1	.40
	200 - 300	5,000	0	-
26Ek3208	0 - 100	32,500	0	-
	100 - 200	27,500	0	-
	200 - 300	5,000	0	-
	300 - 400	17,500	1	.57
26Ek3270	0 - 100	32,500	1	.31
	100 - 200	67,500	0	-
	200 - 300	82,500	6	.73
	300 - 400	77,500	23	2.97
	400 - 500	72,500	35	4.83
	500 - 600	72,500	23	3.17
	600 - 700	75,000	3	.40
	700 - 800	77,500	5	.65
	800 - 900	82,500	3	.36
	900 - 1000	82,500	5	.61
	1000 - 1100	67,500	14	2.07
	1100 - 1200	50,000	3	.60
26Ek3084	0 - 100	32,500	2	.61
	100 - 200	50,000	0	-
	200 - 300	60,000	0	-
	300 - 400	72,500	1	.14
	400 - 500	70,000	0	-
	500 - 600	80,000	4	.50
	600 - 700	87,500	2	.23
	700 - 800	75,000	4	.53
	800 - 900	32,500	0	-

As reflected in Table 228, distance-dependent densities in the Western Periphery are generally much lower than in the East, in part a function of the much larger areas contained within individual quarry zones. In large part, too, they are less meaningful in the aggregate since so many quarries lie outside the quarry zone to which they pertain, thereby lacking first, second, or, in one instance (26Ek3032/182), even third-order distance domains for comparison. (This is not strictly true; such domains of course occur around each quarry, but they lie beyond the boundary of the area for which we control data on the incidence of reduction stations).

To emphasize the variability of patterning in the West, Figure 280 compares reduction station densities by distance domains in the quarry zones only of 26Ek3084 and 26Ek3270, both of which lie within the subarea boundary (26Ek3208, the only other major quarry in the subarea, generates a quarry zone containing only one reduction station and is not plotted). Both patterns require comment, as neither appears to approximate the anticipations of the distance minimization model.

Both quarries lie on Red Hill and, as discussed above, give rise to quarry zones dominated by prohibitively steep slopes and in which the availability of even moderately level ground is severely limited. In the case of 26Ek3270, the nearest significant expanse of level ground occurs in distance domains 4 - 6 (i.e., 400 - 600 m from the quarry), precisely coincident with the peak of the distance/density profile in Table 230; most of these reduction stations, as well, fall within the residential zone of the Western Periphery. The quarry zone of 26Ek3084 is even more topographically constrained; level ground occurs only at a distance of 600 - 800 m from the quarry, again reflecting the distance/density profile. In this case, too, most reduction stations lie within the residential zone. These data suggest that the expectations of the model expressed in Chapter 4 and characterized in Figure 275 need to be qualified to accommodate the negative effect of pronounced slope on the location of reduction stations.

A second peak in the distance/density profile of 26Ek3270 (at a distance of 1000 - 1100 m from the quarry) is less easy to explain. All of these reduction stations are associated with six sites (26Ek3131, 26Ek3132, 26Ek3133, 26Ek3134, 26Ek3153, and 26Ek3154) lying, by project design, beyond the compass of both our testing and data recovery programs, and are known exclusively from initial survey data. 26Ek3154, however, containing nearly half this population, was found in survey to exhibit a few residential characteristics (Budy 1988:31), and it may be that a secondary residential zone lies about 1100 m from the quarry.

Comparison of the quarry zones around 26Ek3084 and 26Ek3270 exposes both liabilities and benefits of the analytic approach adopted here. In the first place, delineation of quarry zone boundaries does *not* mean that we assume all lithic material at reduction stations within the zone must have derived only from the central quarry, but rather that for all such places *that* was the quarry closest at hand and, other things being equal, probably the cheapest to exploit. Selection based on quality of material, however, as well as the depletion of exploited sources, topographically induced irregularities in travel patterns, and intervening opportunities and constraints all might result in the importation of toolstone from more distant sources. A case in point is found at residential site 26Ek3092 (in the quarry zone of 26Ek3270), where some highly distinctive debitage appears unquestionably to have derived from the red and purple jasper source at 26Ek3084 (in the adjacent quarry zone).

In the second place, the trends suggested by the approach generate expectations about the use of toolstone in a spatial context that could yield to explicit testing were it ever to become feasible to characterize toolstone by source unequivocally.

And in the third place, the approach in one instance yielded an unexpected, anecdotal corroboration. The largest quarry zone in either subarea encloses that portion of the Western Periphery closer to 26Ek3270 than to any other quarry. At the time of initial survey, the surface manifestation of 26Ek3270 had been compromised severely by recent mining activity (Budy 1988:26), and the site was included in neither testing nor data recovery programs. Its potential importance as a source became eclipsed in our concentration on the other exceptional

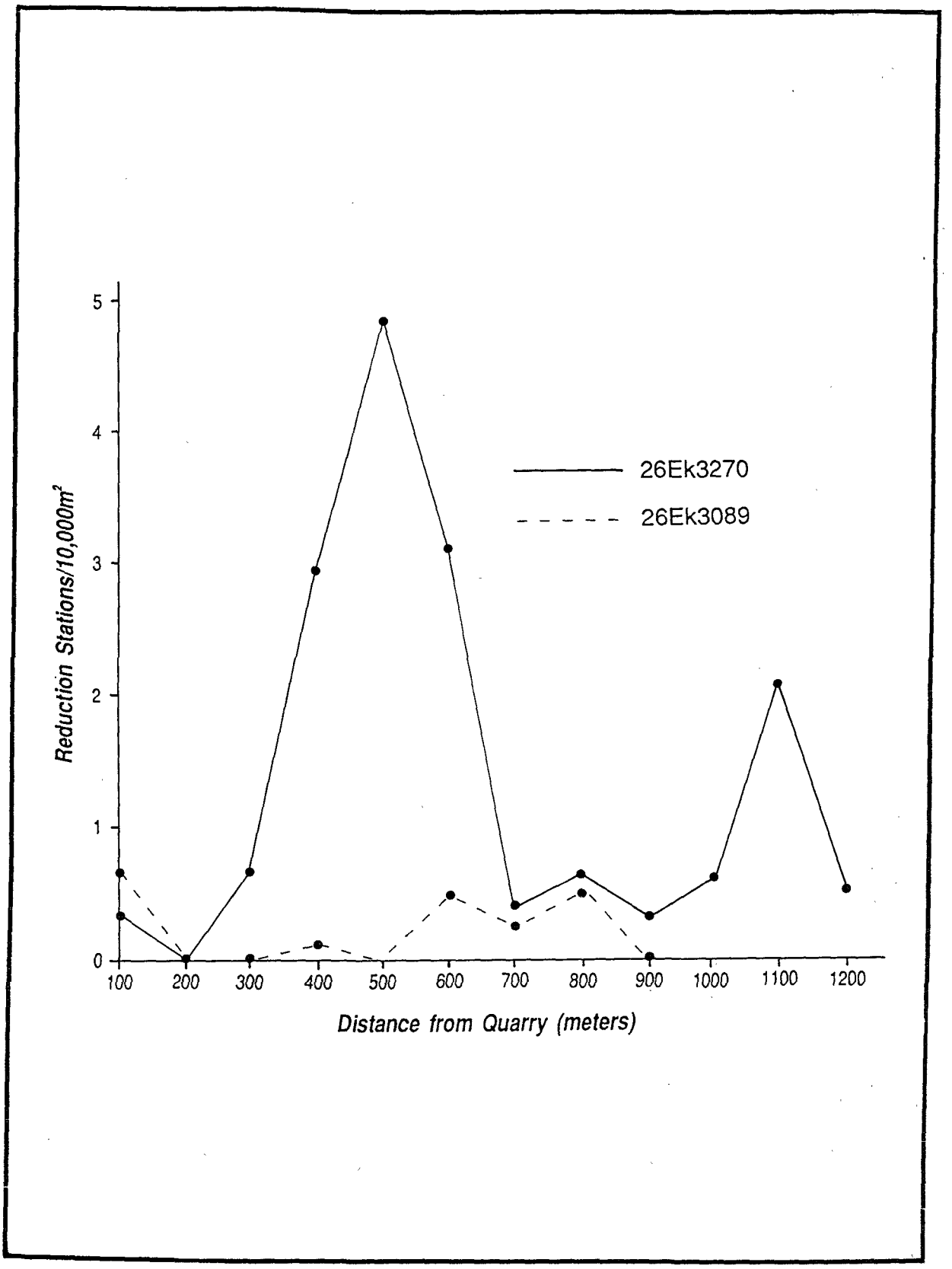


Figure 280. Areal frequency of Reduction Stations by distance from two nearest quarries, Western Periphery.

Red Hill quarries (26Ek3084 and 26Ek3208), and further consideration of it was dismissed. In spatial terms, however, it clearly is the most favorably located quarry in the entire subarea, and an astonishingly high number of reduction stations (121) are nearer it than any other source. Upon the dismantling of Red Hill in 1990, it was disclosed that the disturbed surface of 26Ek3270 in at least one area concealed quarry pit deposits containing an exceptional volume of high quality material, perhaps commensurate with the site's spatially inferred role as the preeminent toolstone source of the West.

To compare overall distance/density profiles in the Eastern and Western Peripheries, Table 231 ignores individual quarry zone boundaries but expresses areal frequencies of reduction stations exclusively as functions of distance domains. The resulting data, represented graphically in Figure 281, constitute the cumulative evaluation of how well the distribution of quarries actually predicts the location of reduction stations.

Table 231. Mean Areal Frequency of Reduction Stations by Distance from Nearest Quarry, Eastern and Western Peripheries.

Subarea	Radial Distance from Quarry (m)	Area (m^2)	Reduction Stations n	Reduction Stations/ 10,000 m^2
Eastern Periphery				
	0 - 100	100,625	43	4.27
	100 - 200	210,000	48	2.28
	200 - 300	201,875	42	2.08
	300 - 400	93,125	2	.21
	400 - 500	24,375	0	-
Western Periphery				
	0 - 100	100,000	3	.30
	100 - 200	237,500	10	.42
	200 - 300	260,000	13	.50
	300 - 400	282,500	37	1.31
	400 - 500	242,500	46	1.90
	500 - 600	242,500	38	1.57
	600 - 700	237,500	9	.38
	700 - 800	217,500	10	.46
	800 - 900	162,500	8	.49
	900 - 1000	117,500	6	.51
	1000 - 1100	92,500	14	1.51
	1100 - 1200	5,000	3	.54

Expressed as a pattern of overall areal frequencies, reduction stations in the Eastern Periphery accord very well with the expectations of the distance-dependent model; fall-off in density is rapid, articulated chiefly in the 200 - 300 m distance domain by the cluster of reduction stations at 26Ek3184. The Western Periphery, even with the uncorrected addition of attenuated quarry zones along its northern margin, exhibits a profile generally yielding to the dominance of the large population of reduction stations surrounding 26Ek3270; the topographic constraint of steep slopes in the lower distance domains (0 - 300 m from the quarry) is still evident, as are peaks at 400 - 600 m and 1000 - 1100 m representing clusters of reduction stations on flat ground and in the vicinity of residences.

Reduction Stations and Residences

To test the distance-dependency of reduction station locations relative to residences, the foregoing exercise was repeated with other variables; the residential zones of both subareas were

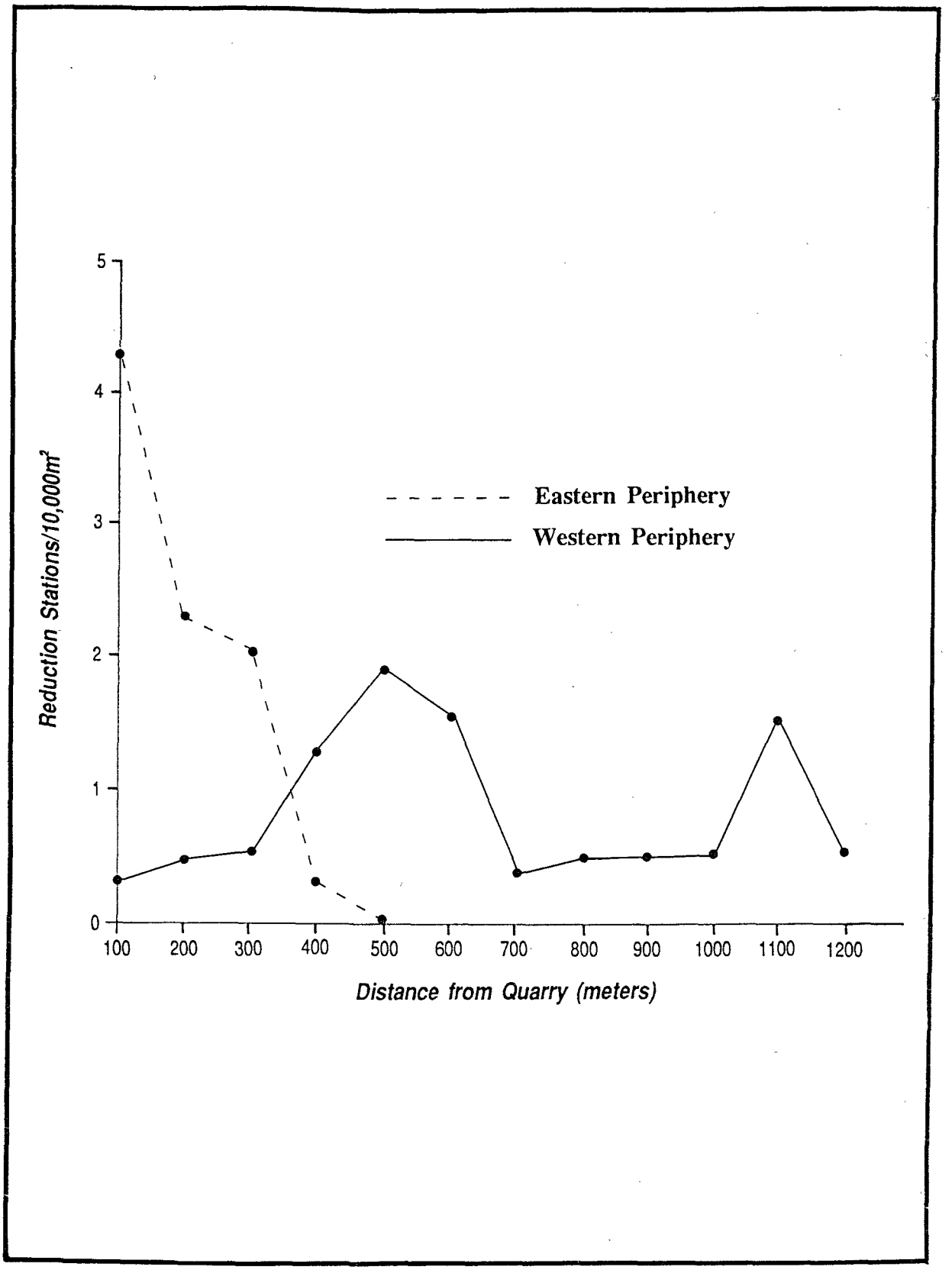


Figure 281. Mean areal frequency of Reduction Stations by distance from nearest quarry; Eastern and Western Peripheries compared.

delineated, and concentric margins representing 100 m increments of distance from them were mapped. Reduction stations were counted within each distance domain, and densities calculated by domain. The results of the exercise are presented in Table 232.

Table 232. Mean Areal Frequency of Reduction Stations by Distance from Residential Zone, Eastern and Western Peripheries.

Subarea	Distance from Residence (m)	Area (m^2)	Reduction Stations n	Reduction Stations/ 10,000 m
Eastern Periphery				
	Res. Zone	198,307	96	4.84
	0 - 100	147,020	18	1.22
	100 - 200	119,080	15	1.26
	200 - 300	111,588	4	.36
	300 - 400	52,825	2	.38
	400 - 500	1,180	0	--
Western Periphery				
	Res. Zone	314,036	81	2.58
	0 - 100	224,050	17	.76
	100 - 200	265,375	13	.49
	200 - 300	302,800	13	.43
	300 - 400	308,875	11	.36
	400 - 500	284,475	21	.74
	500 - 600	196,800	9	.46
	600 - 700	130,325	8	.61
	700 - 800	118,300	16	1.35
	800 - 900	53,650	5	.93
	900 - 100	36,600	3	.89
	1000 - 110	12,214	1	.82

The pattern expressed in Table 232 has some interesting characteristics that correspond well, but not perfectly, to the expectations of the model. As depicted in Figure 282, the residential zones of both subareas contain the highest densities of reduction stations, although that of the Eastern Periphery is packed almost twice as densely as the west. Too, the Eastern Periphery profile exhibits a fairly rapid, but slightly staggered, fall-off in frequency of reduction stations away from the residential zone (as expected).

The profile of the Western Periphery is more articulated; while fall-off occurs cleanly from the heart of the residential zone to some 400 m from its margin, a somewhat higher trend prevails beyond 500 m and peaks between 700 and 800 m from the zone. This deviation from expected patterns is difficult to explain in terms of variables observable within the immediate subarea precinct, and we suspect the influence of external factors. The various quarries lying in 26Ek3032 north of the subarea, for instance, induce the clustering of numerous reduction stations in their vicinity (500 - 1100 m from the residential zone), and the effect of undetected residences beyond surveyed boundaries should be similar. It may be, in fact, that the bimodal profile of the Western Periphery expresses the pattern depicted in Figure 275, in which high densities of late stage reduction stations are replaced, at increasing distance from residences and increasing proximity to quarries, by high densities of early stage reduction stations. The issue cannot be tested with data in hand, however, since no debitage patterns have been characterized in the northwestern half of the subarea (i.e., where most of the outlying reduction stations occur).

Additional to expectations regarding distance from residences and quarries, we advanced in Chapter 4 the proposition that, since toolstone comes *from* quarries and generally (we assume)

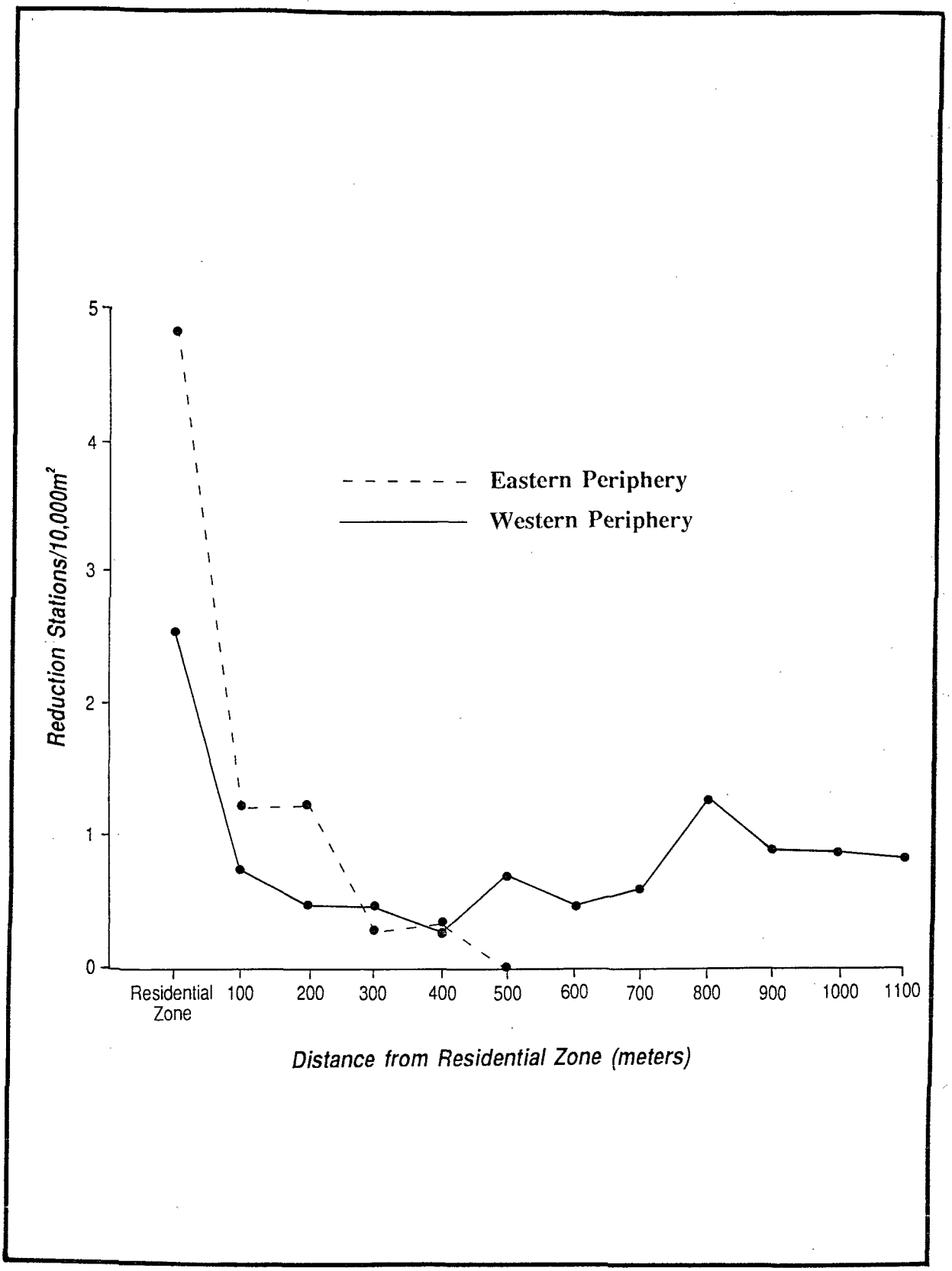


Figure 282. Mean areal frequency of Reduction Stations by distance from residential zone; Eastern and Western Peripheries compared.

is transported *to* residences, the location of reduction stations should exhibit directional preference for corridors between sources and destinations. To test this, we divided quarry zones into six sectors, centered on the subject quarry as in Figure 283; sectors were numbered, and oriented so that what we called Sector 1 always lay directly facing the nearest principal residence. Lacking areal data, we did not include the Northern Corridor in the examination. In the Eastern Periphery, sectors were oriented to the center of the Ramadan Ridge residential zone (especially 26Ek3170 and 26Ek3171), in the West, to the nexus of 26Ek3092 and 26Ek3095. We limited inquiry to quarries lying within the two subareas, eliminating that at 26Ek3171 because it falls within the principal residential zone of the East. We then counted reduction stations within each sector, ignoring those lying in quarry zones intervening between the subject quarry-residence pair, and calculated areal frequencies. Table 233 compares the cumulative Sector 1 densities with those of the remaining sectors in both subareas.

Table 233. Areal Frequency of Reduction Stations by Quarry Zone Sector.

	Sector	Reduction Stations n	Area (m^2)	Reduction Stations/ 10,000 m^2
Eastern Periphery (26Ek3195, 26Ek3197, 26Ek3200)				
	1	19	93,125	2.04
	2-4	40	265,000	1.51
Western Periphery (26Ek3084, 26Ek3270)				
	1	117	835,000	1.40
	2-4	17	425,000	.40
Eastern and Western Peripheries Combined				
	1	136	928,125	1.47
	2-4	57	690,000	.83

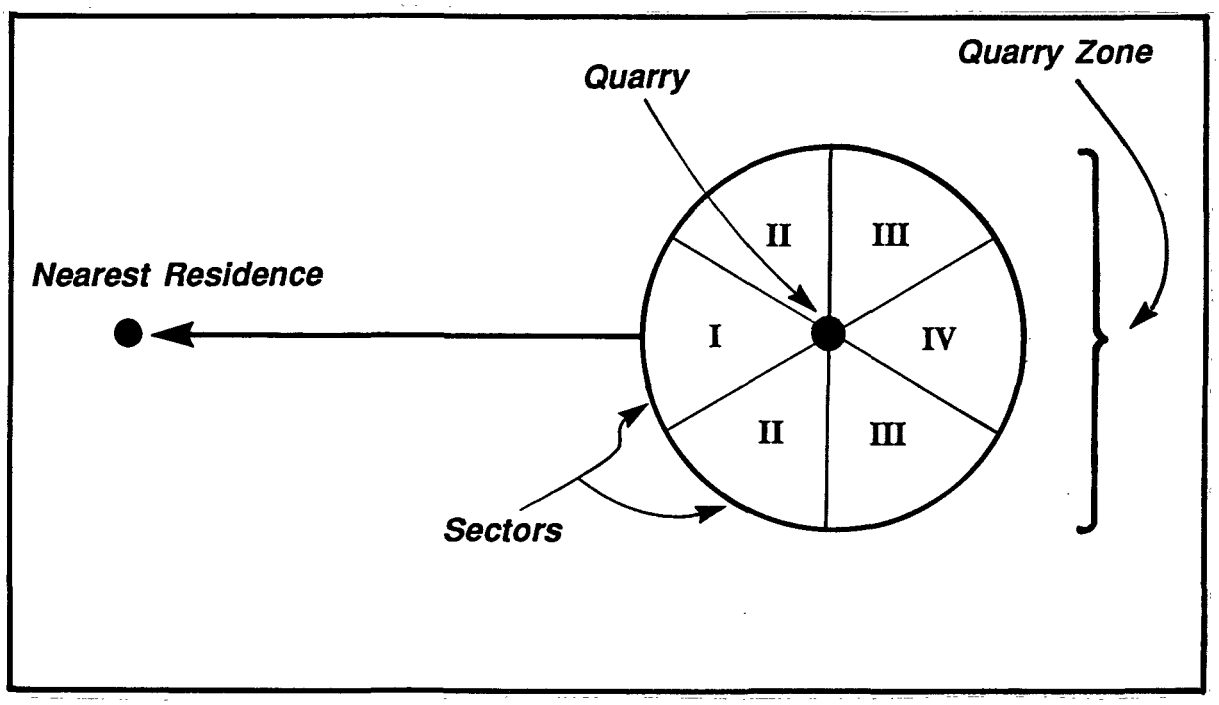


Figure 283. Quarry zone divided into sectors defined by direction of nearest residence.

Both subareas exhibit notable directional preference in favor of placing reduction stations toward residences, apparently imposing another level of order on the distance-dependency that organizes the location of reduction stations with respect to quarries. The pattern is somewhat less pronounced in the Eastern Periphery owing, probably, to the "noise" induced by the greater density of quarries in that subarea and the likely spill-over of related reduction stations into adjacent quarry zones. In both subareas, however, as in their combined figures, the areal frequency of reduction stations lying in the direction of residences is greater, and that of those lying away from residences lower, than would be expected were they located at random throughout the field (random expectation is 1.65/10,000 m^2 in the Eastern Periphery, 1.06 in the Western Periphery, and 1.19 in both subareas combined).

A final observation on the location of reduction stations is prompted not by expectations advanced in Chapter 4, but rather was inspired by carrying heavy excavation equipment (after a substantial breakfast of biscuits and gravy) up a steep slope to the canyon-rim rockshelter 26Ek3204. Throughout the Eastern and Western Peripheries, 77% of all reduction stations (61% in the East, 88% in the West) lie at elevations lower than the nearest quarry. This trend prevails despite that in both areas only slightly less than half the surface area lies higher than the major quarries. There is, of course, considerable opportunity for causes other than the obvious to have influenced this correlation; residences, for instance, which attract reduction stations, tend often to occupy lower settings where water gathers. Whatever the source of correlation, however, it meant that, more often than not, toolstone was carried *down*hill rather than up; we suspect that, even absent the attraction of residences, prudent quarriers would have seen the advantage in that.

Bifaces as Indices of the Geography of Production

It was observed in Chapter 23 that, on a macroscopic scale, the relative proportion of later stages of lithic reduction reflected in debitage tends to increase as a function of distance from toolstone sources. This accords well with expectations of the model depicted in Figure 275, and encouraged us to look at patterns smaller in scale to see whether we could determine within how narrow a compass distance minimization continued to influence where reduction was enacted and where its products were carried. We examined the distribution of bifaces in the Eastern and Western Peripheries, inquiring particularly how the frequency of occurrence of their stages relates to the location of quarries and residences.

In order to assemble populations of manipulatable size, we lumped the finer classificatory shadings by which bifaces are analyzed elsewhere in this report (Chapter 6) into a tripartite scheme recognizing only an early stage (equivalent to analytical Stage 1 through early Stage 3), a middle one (middle Stage 3), and a late (late Stage 3 through Stage 5). We ignored bifaces that, due to fragmentation, could not be assigned to stage. Too, we abandoned consideration of "site" associations, looking instead at the absolute distance each piece lies from the quarry or residence nearest it, on the assumption that each reflects a distinct and separable event of reduction or transport.

The 1780 classifiable specimens recovered from the Western Periphery lie on average 76 m from the nearest edge of the residential zone and 466 m from the nearest quarry; in the Eastern Periphery, the same distances of 1027 specimens average 81 m and 142 m, respectively. When average distances are calculated by subarea for each of the stages considered here, we can begin to test the efficacy of the model represented by Figure 275. As depicted in Figure 284, the pattern in the Western Periphery accords very well with the general expectations of the model; each successive stage of biface reduction lies progressively further from the nearest quarry than the immediately preceding stage, while each lies progressively closer the nearest residential zone. At this level of abstraction, however, neither

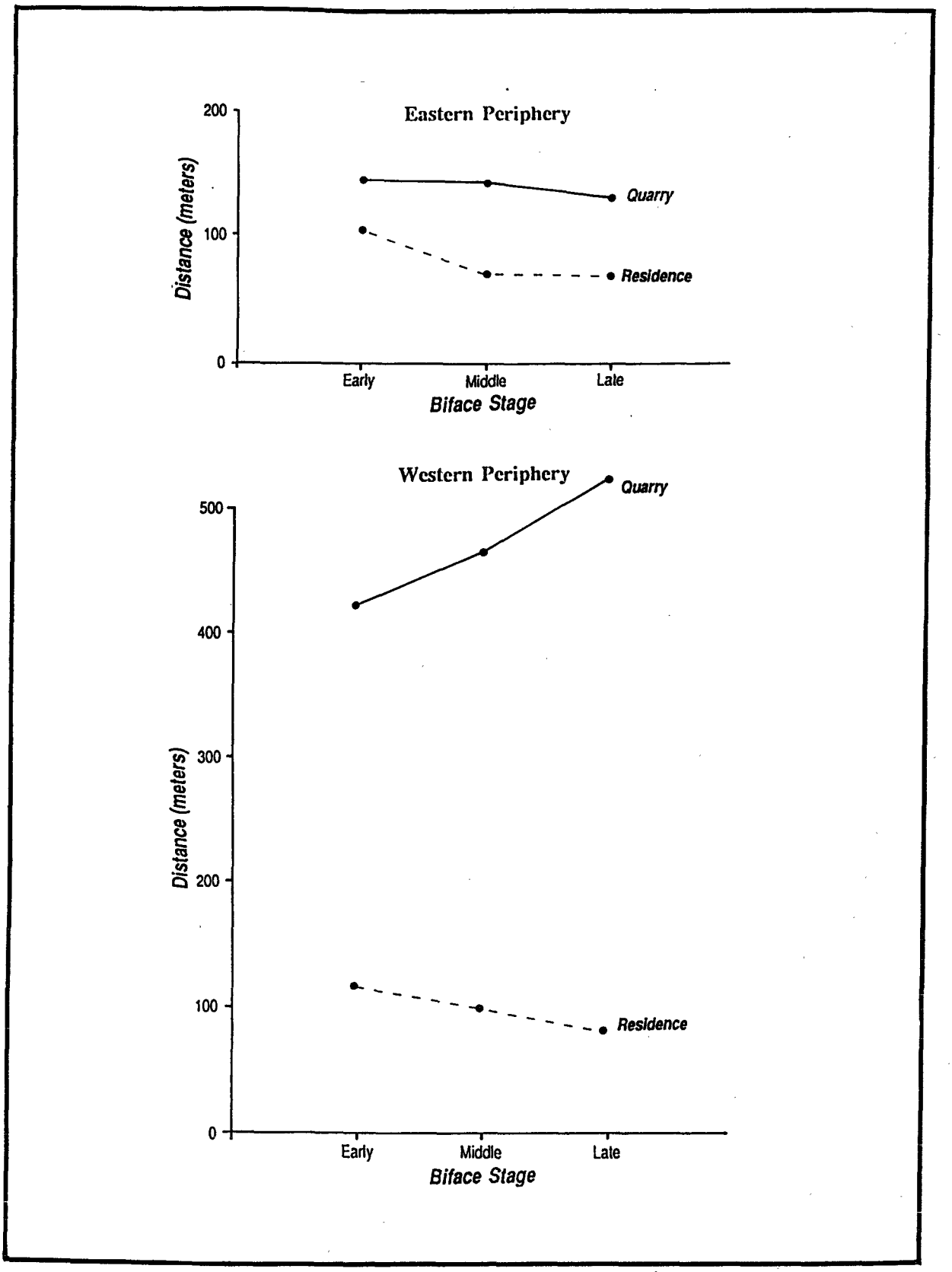


Figure 284. Average distances of bifaces by stage from nearest quarry and residence.

of the expected patterns is reflected in the Eastern Periphery, where later stages of biface appear on average to lie *closer* to quarries than earlier stages, and closer to residences than middle stage ones; two factors doubtless influenced this distribution.

In the first place, available distances between *all* classes of phenomenon simply are very much smaller in the East than in the West, with the result that opportunities for distance minimization to come into play necessarily were less frequent and less relevant to the efficiency of local spatial strategies. In the second place, the preponderance of quarries in the East occurs *within* the eastern residential zone, so that decisions regarding the appropriate relationship of transport to reduction stage cannot have been very important; as depicted in Figure 285, all stages of biface reduction occur most frequently within 100 m of the nearest quarry, but all, as well, occur within 100 m of the residential zone (cf. Figure 284). Thus there were fewer strategic motives to move unreduced, or preliminarily reduced, packages of toolstone around the local landscape of the Eastern Periphery, since origins and destinations there so frequently coincide.

Frequency distributions of all biface stages tend to peak in the Western Periphery at distances of about 400 m from the nearest quarry (Figure 286), a pattern reflecting, as discussed above, the distribution of relatively level ground in the subarea; at this average distance we find not only the nearest topographic opportunities to stage prolonged reduction episodes comfortably, but also the proximal edge of the residential zone. Beyond 400 m from quarries the relative frequency of early reduction stages declines in the relationships predicted by the model, while a second, slightly higher peak of late stage reduction (at about 600 m from quarries) clearly is induced by the location of far-lying residences at 26Ek3160 and, particularly, 26Ek3165.

While our data on the distribution of biface stages relative to distance from residences does not bear too much scrutiny (since in both subareas most of our work was conducted within or adjacent residential zones), the overall distributions of biface stages as a function of distance from nearest quarry exhibit strikingly different patterns in the Eastern and Western Peripheries. As can be seen in the area graph of Figure 287, the relative proportion of early stage bifaces declines with increasing distance from quarry in the West, that of middle stages increases modestly and irregularly, and that of late stages increases substantially. No such trend is evident in the East, where early stages dominate *furthest* from quarries, at a distance where no late stages are encountered whatsoever. We conclude, therefore, that it is only at distances greater than ca. 400 m, and in settings where major toolstone sources tend not to be coincident with residences, that principals of distance minimization visibly begin to affect the distribution of reduction activities in the immediate Tosawihi vicinity.

Clusters of Clusters

Archaeological places designated "sites" at Tosawihi consist of aggregations recognized at various scales, ranging from single clusters of artifacts widely separated from other, similar clusters in the same region to quite large complexes (clusters of clusters) unified topographically, functionally, or spatially. In many instances, discrimination of sites and delineation of their boundaries depended in the field on a kind of intuitive spatial analysis responding to perceptions of meaningful clustering, with the predictable result that various functional classes sometimes were grouped by proximity while more dispersed clusters sometimes were grouped by functional unity. While this is not intrinsically wrong, it means that sites do not constitute particularly useful units of comparison without fairly explicit qualification of what is being compared. Fortunately, most identifiable activity areas at Tosawihi have to do chiefly with toolstone extraction, lithic reduction, and residence, and most sites consist of various mixes of the features left by those activities.

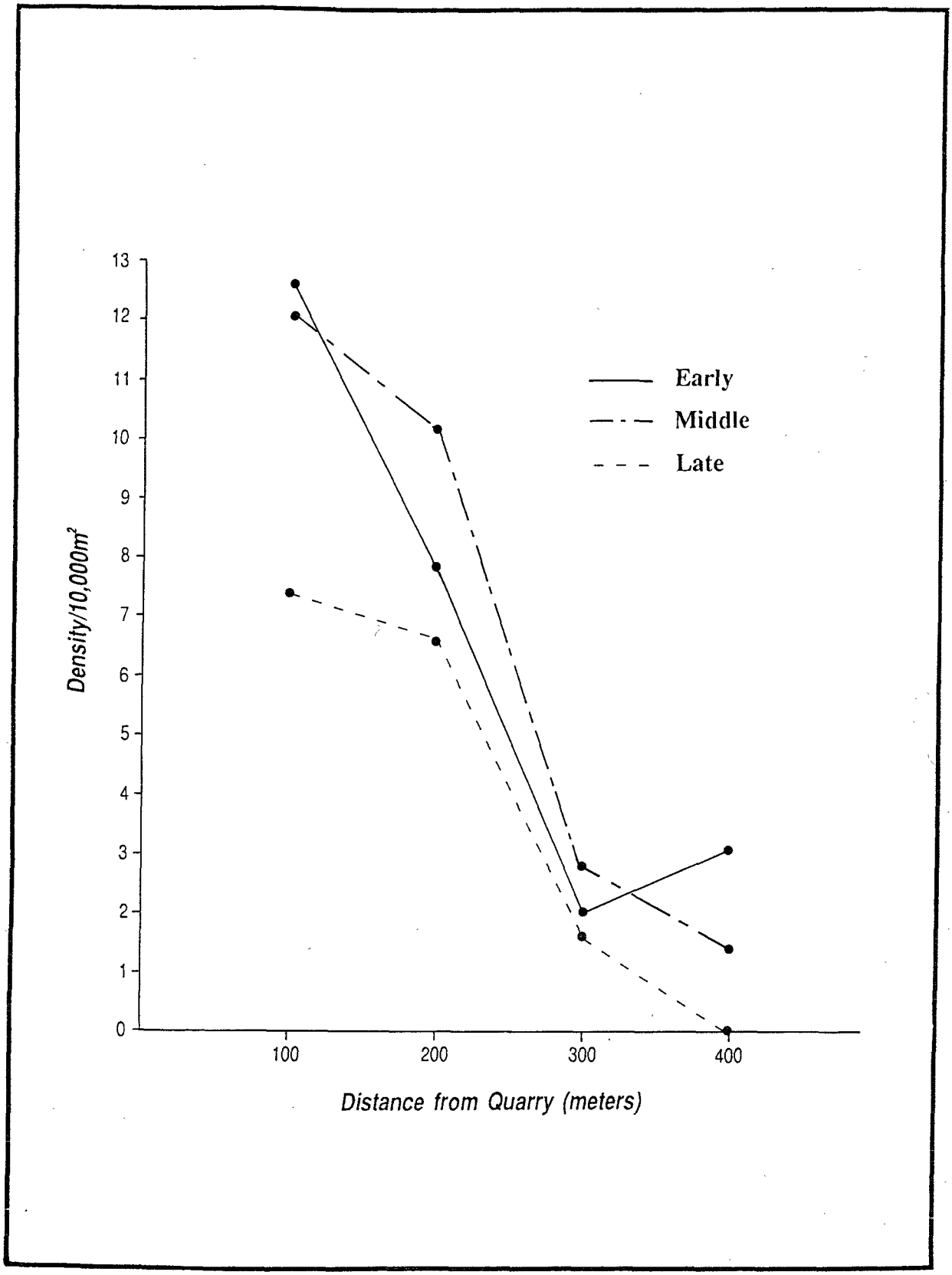


Figure 285. Areal frequency of biface stages by distance from nearest quarry, Eastern Periphery.

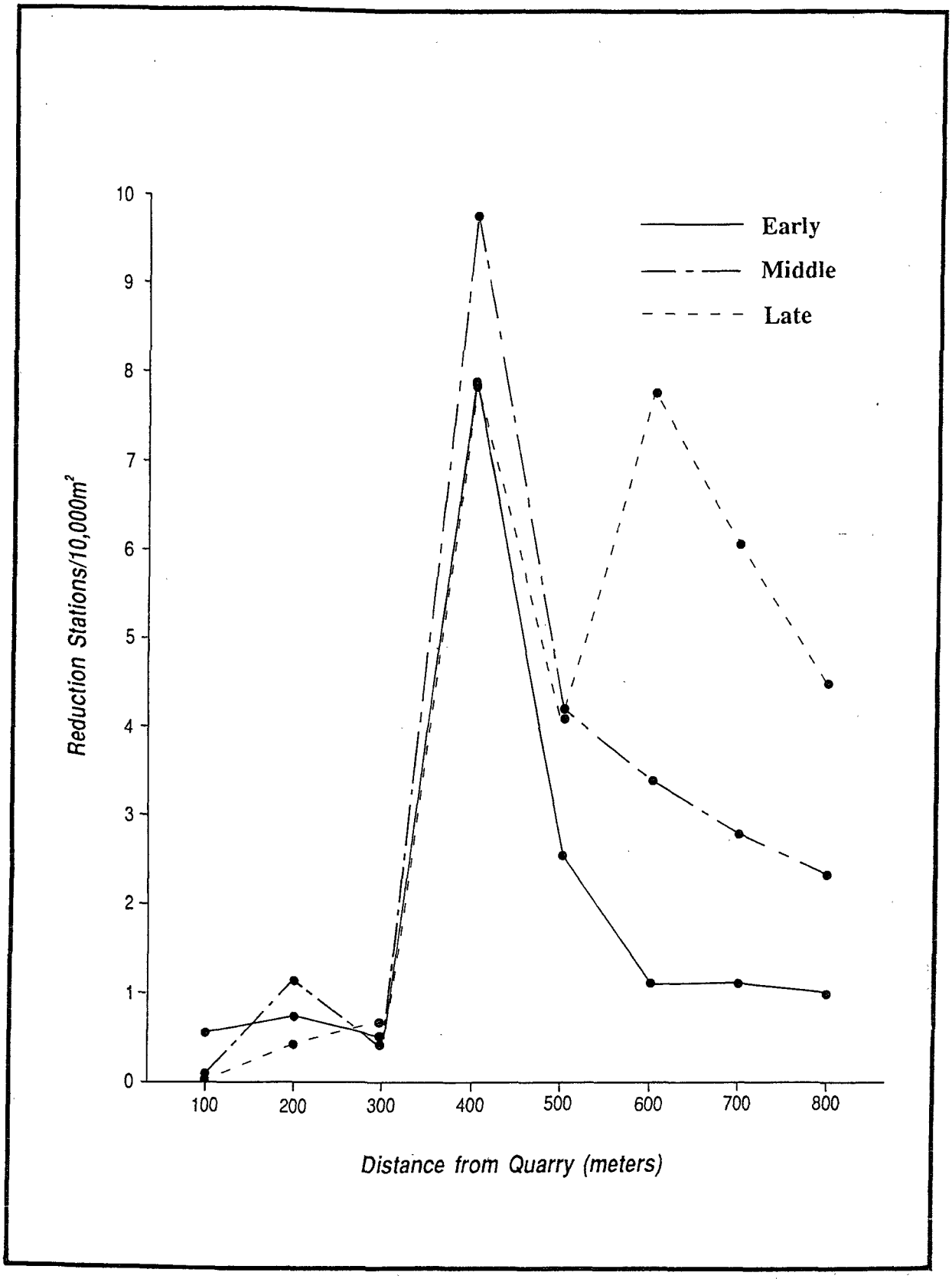


Figure 286. Areal frequency of biface stages by distance from nearest quarry, Western Periphery.

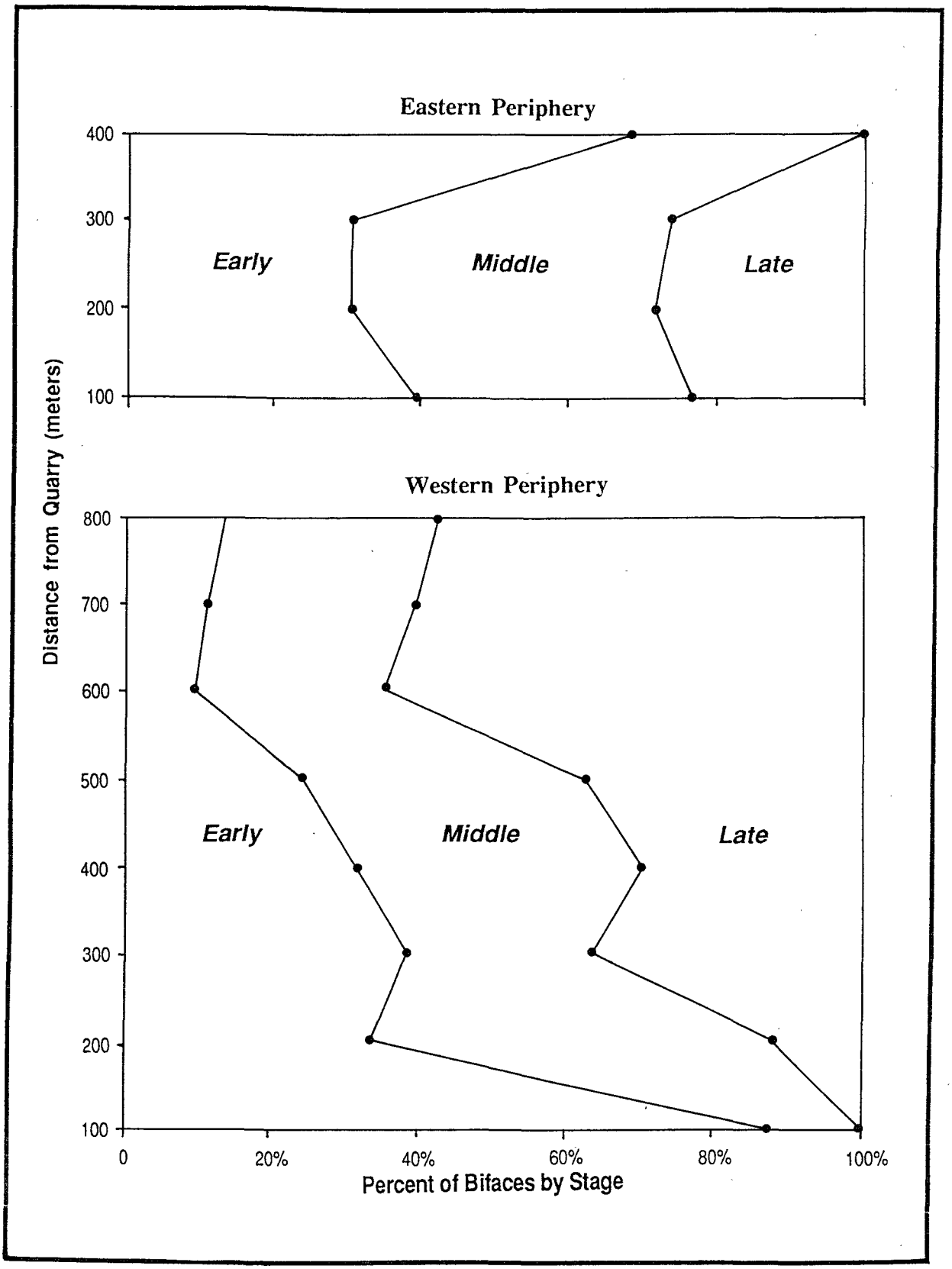


Figure 287. Percentage of bifaces by stage as a function of distance from nearest quarry.

Chapter 22 has dealt at length with the site formation processes and resulting spatial structures attending various strategies of toolstone extraction, and the units of that discussion (particularly quarries and quarry pits) will be employed here without further examination. We are more concerned at present with how quarries, reduction stations, and residential features form distinctive aggregates on the landscape. As in our discussions of location and distribution, reduction stations constitute our most populous and varied data class.

Reduction stations at Tosawihi occur in isolation or, more frequently, in aggregates composed of from two to as many as 25 members. Larger aggregates, particularly, may co-occur with quarry features and/or residential characteristics (cf. Chapters 23 and 24). Large aggregates of reduction features are self-evidently clustered with respect to surrounding patterns, and the site boundaries that now enclose them reflect a rapid fall-off in density at their perimeters. In order to inquire whether their spatial clustering is more likely the product of activity organization or simply the consequence of repeated use of the same spatial field, we looked at a sample of such aggregates from the perspective of the arrangement of reduction stations within them.

To ensure manipulability, we limited the sample to aggregates with populations having 20 or more reduction stations for which we control mapped locational data; these criteria selected three sites in the Western Periphery (26Ek3095, 26Ek3160, and 26Ek3271; cf. Chapter 16) and two in the east (26Ek3184 and 26Ek3198; cf. Chapter 17). To varying degrees, all exhibit residential attributes; two of them (26Ek3184 and 26Ek3198) contain very minor quarrying features as well.

We are less interested here in the density with which reduction stations are packed into these aggregates than we are in trends toward patterning in their arrangement. We assume, for instance, that multiple, concurrent episodes of work performed within a single spatial field are likely to be clustered, and that clustering is likely to intensify over longer periods of use as task-specific segmentation of site precincts emerges under the momentum of conventional usage. Absent locational constraints (e.g., microtopographic zonation) or the establishment of reusable facilities, however, we assume that aggregates resulting from repeated short-term visits are likely to be distributed largely at random.

Nearest neighbor analysis (Clark and Evans 1954; Boots and Getis 1988) measures trends toward clustering, randomness, and uniformity in the distribution of points in a field, and we applied the technique to our sample of reduction station aggregates. The results are summarized in Table 234.

Table 234. Summary Nearest Neighbor Statistics for Five Reduction Station Distributions.

Site	n	ρ	$\bar{r}_a$	$\bar{r}_e$	R	$\sigma\ \bar{r}_e$	C
26Ek3160	23	.0006889	11.96	19.05	.6278	2.076	–3.41
26Ek3184	25	.001242	12.92	14.19	.9105	1.483	–.86
26Ek3198	20	.0017974	14.25	11.79	1.2086	1.378	1.78
26Ek3271	22	.0009653	14.77	16.09	.918	1.7935	–.74
26Ek3095	25	.0017195	11.72	12.06	.9718	1.2606	–.27

n = number of cases (reduction stations)
ρ = density; n/area (m^2)
$\bar{r}_a$ = mean distance to nearest neighbor (m)
$\bar{r}_e$ = expected mean in random distribution of density ρ
R = nearest neighbor statistic, expressing deviation from random expectation
$\sigma\ \bar{r}_e$ = standard error in randomly distributed population of density ρ
C = standard variate of normal curve

The first issue of note is that nearest neighbor distances between reduction stations differs very little among the various sites (considerably less, for instance, than would be expected were all sites characterized by random distributions). Too, they appear relatively closely spaced; any reduction station from the population as a whole is likely on average to lie only 13.12 m from its nearest neighbor. More interesting is the nearest neighbor statistic (R), which characterizes the degree to which the individual populations deviate from randomness. In a random distribution, R will have a value of 1. R values less than one indicate trends toward clustering, to the point where, when R=0, all points occupy the same location. R values greater than one indicate trends toward uniformity, with the limit that when R=2.1491 the distribution is maximally dispersed and perfectly uniform (Clark and Evans 1954).

R values for the sample of reduction station aggregates reflect very slight degrees of clustering at 26Ek3184 and 26Ek3271, a very slight tendency toward uniformity at 26Ek3198, and an almost perfectly random distribution at 26Ek3095. C scores for these values, however, indicate that none of them differs significantly from randomness at the .05 level (C=1.96 at .05). This means, then, that we have no reason based on distribution to assume that the placement of reduction stations at these four sites responded to anything but a random process. Put another way, we cannot say that the use of space within their precincts was structured in any way reflected by the distribution of reduction stations. This may imply that the sites grew over a period of time, the consequence of several revisits during the cumulative course of which reduction stations were added to the population without being influenced by the locations of earlier episodes and without being added during any one visit in numbers sufficient to confer detectable patterning.

The case is different at 26Ek3160, where a low R value indicates a rather high degree of clustering and a high C score indicates a significant deviation from randomness (C=2.58 at the .01 level). This might imply that the site was formed during a single, highly structured occupation, but this is contradicted by the substantial depth of deposit and the wide diversity of projectile point types which it exhibits (cf. Chapters 8 and 16). Rather, it would appear that the site was reoccupied frequently, and that the use of space within it tended to follow generally reiterative patterns. The emergence of a dense background scatter of cultural materials and a deep deposit composed of blurred palimpsests of numerous activity episodes is characteristic of various other residential aggregations in the Eastern and Western Peripheries (most notably, 26Ek3170, 26Ek3171, and 26Ek3092), where intensive and frequent reuse of portions of the site has resulted in maximal clustering. At 26Ek3092, the most spatially constrained of these sites, the degree of overlap and blurring is so pronounced that discrete surface features are barely detectable, although excavation revealed a formidable concentration and "stacking" of features adjacent a large boulder constituting the site's principal activity focus. 26Ek3160 (as well as 26Ek3170 and 26Ek3171) occupies much broader, convex expanses (as opposed to the relatively small concavity occupied by 26Ek3092), and thus tolerated more diffuse patterning of activities. Within each, however, the attraction of a broad, relatively level zone (in each case toward the downridge margin of the site) resulted in the accumulation of a pattern so highly clustered that it has become extraordinarily difficult to discriminate its units.

The random distributions of reduction stations at 26Ek3184 and 26Ek3095 is particularly instructive, in that both sites occupy very similar spatial relationships to major residences (26Ek3170 and 26Ek3095, respectively). Both are proximal to sites in which activity areas have achieved the blurred degree of clustering described above, yet both are composed of a large number of discrete, relatively shallow reduction features the assemblages of which exhibit various residential attributes. It would appear that the broad, generally level expanses of both precincts may have served as occasional workshops satellite to the more intensely focused occupation of the neighboring residences, but that neither provided a degree of attraction resulting in highly structured use of their space.

Facilities in Clusters

Immovable, potentially reusable facilities can have particular spatial significance by attracting repetitions of the same activity to the same location (Binford 1983a:144-148; Wagner

1960). They are potent elements of place-making and, among mobile populations, may induce a spatial focus for certain classes of activity spanning numerous episodes of revisitation. In the Great Basin, for instance, house floors (O'Connell 1971; Zeier and Elston 1986), drive fences (Pendleton and Thomas 1983), and storage facilities (Ingbar 1985; Raven 1988) constitute diverse facilities likely to influence, over various scales of time, the activities performed in their vicinity. At Tosawihi, of course, the excavation of quarry pits constituted a quintessential act of place-making, since both the effort initially expended and the improved access to toolstone encouraged revisitation until the source was depleted. For this reason much of the present chapter has been concerned with how other aggregates of the archaeological record are related spatially to the location of quarries.

Other kinds of facility are likely to have exerted other kinds of influence, however, and we were at particular pains to look for residential structures, storage facilities, and hearths, suspecting that their patterns of co-occurrence with various classes of site and feature would help explain why activities were performed in certain locations. The hoped-for data, however, proved very slender. *No* residential facilities were detected, for instance, despite concerted efforts to discover them in what seem likely locations (i.e., major residential precincts in all three subareas), and we conclude that shelter at Tosawihi generally tended to be so ephemeral that it left little by way of detectable traces.

We were interested in hearths both as foci of small scale activity (warming hearths) and components of lithic reduction technology (heat-treatment facilities), and we expected to find them at residences as well as in occasional association with reduction stations away from residences. We found, however, only six indisputable hearths, all of them in residential or semi-residential contexts (two in the Western Periphery, at 26Ek3092 and 26Ek3160, one in the Eastern Periphery, at 26Ek3198, and three along the Northern Corridor, all at 26Ek3237). It was not possible to conclude from excavation of their contents whether the hearths at 26Ek3237 served primarily for cooking, personal warming, or the heat-treatment of toolstone, although the former two functions seem more likely (cf. Chapter 18). That they all occur within an 8 m radius suggests similar, reiterative use of the same location over time, but radiocarbon assay (spanning some 17 centuries) implies that the decision to build a fire in the vicinity probably was induced by factors other than the proximity of earlier fireplaces. Likewise, hearths at 26Ek3198 and 26Ek3160 proved not functionally diagnostic; although both occur within fairly complex reduction features, neither yielded subsistence residues or thermally altered opalite in quantities sufficient to clarify their use. Only the hearth at 26Ek3092 appears unequivocally to have functioned as a heat-treatment facility (cf. Chapter 16), although we were able to discern no evidence arguing convincingly that it had been used more than once.

The only functional equivalents of storage facilities we encountered consist of apparent caches of largely non-heat-treated bifaces (cf. Chapter 6). Four such features were found during testing and excavation, three in the Eastern Periphery (at 26Ek3170, 26Ek3192, and 26Ek3197) and one in the West (at 26Ek3095). All save that at 26Ek3197 (a quarry/reduction complex) occur in contexts exhibiting independent residential attributes, suggesting that the caching of bifaces tended to occur in places likely to be revisited for other reasons. Since storage of any resource implies at least the *contemplation* of a return to recover the cached goods, this accords well with the logic of distance minimization as a spatial strategy.

Conclusions

We have looked at several kinds of spatial relationship in Tosawihi archaeology, and tried to identify some of the regularities in how space was used prehistorically. We were interested particularly in how work was organized in space, and in how that organization was influenced by the geographies of resources and cultural places. The intent of our inquiry was

to learn whether spatial strategies are likely to have contributed importantly to improving the benefit/cost ratio of getting toolstone.

We have learned that principals of distance minimization seldom were violated at the quarries, especially where larger distances came into play, and that spatial decisions affecting the locations and distributions of various kinds of activity generally can be regarded as effective economizing measures. The spatial relationships of residences, quarries, and reduction stations all appear to have succeeded in reducing debts of travel and transport, so we conclude that prudent manipulation of the use of space was a beneficial, significantly rewarded strategy for diminishing the costs of extracting, reducing, and moving toolstone over the landscape.

Chapter 26

ECONOMICS AND STRATEGIES OF LITHIC PRODUCTION AT TOSAWIHI

Robert G. Elston

...it would be unprofitable to transport masses of material of which nine-tenths would finally have to be consigned to the refuse heap.
—William Henry Holmes 1897:26

Chapter 3 presented a cost-benefit model of hunter-gatherer lithic procurement and use in which components of lithic production strategies (mobility patterns, labor organization and technology) are varied to meet different contingencies that affect costs and risks of toolstone procurement. Basic cost reduction strategies and their archaeological consequences were discussed in Chapter 4. In both chapters, we assumed that prudent foragers seek to improve the benefit/cost ratio for lithic acquisition by minimizing procurement costs, thus freeing time and energy for other purposes, and also decreasing venture risk (the probability of investing more in toolstone procurement than is returned in tool utility). As discussed at length in previous chapters of this report, foragers may find the most latitude in cost reduction among *indirect costs* (lost opportunity, support, social overhead), through use of scheduling, labor organization and positioning.

Direct costs in lithic procurement (extraction and processing) are likely to offer less room for manipulation. It is true that foragers can adjust direct costs of procurement by choice among lithic sources, by choice of toolstone available at a specific source, and by choice of procurement technology. But such choices may be limited by access, scheduling conflicts, or time constraints. In any case, the decision to use a particular source and technology may narrow considerably the range of possible per-unit procurement costs.

Quarrying bedrock is the most costly means of directly acquiring lithic resources. A quarry such as Tosawihi thus strongly indicates that minimizing direct procurement cost was not the dominant consideration in lithic procurement. The advantages offered by bedrock quarrying all seem to involve production returns: yields are predictable under a range of conditions, quarries may withstand intensive production for long periods, and they may sustain high return rates. Indeed, the most compelling reason to quarry seems to be the need to maximize return (*profits*) that arises when the utility of a certain amount of toolstone is required in a given amount of time (e.g., when access to other sources is limited, subsistence tasks consume large amounts of toolstone over short intervals, or demand exceeds local needs).

The present study, focused on Tosawihi itself, sheds little light on *why* people quarried at Tosawihi; this is a question for future research on a regional scale. In this chapter we accept the fact that people *did* quarry at Tosawihi, and attempt to model some of economics of the process. First we outline costs and constraints of lithic procurement, then present experimental data regarding quarrying and processing returns. These data are employed to explore the marginal value of lithic processing, and to model tradeoffs between processing and transportation costs. Finally, we turn to an evaluation of archaeological evidence for use of various strategies of lithic procurement at Tosawihi in light of costs and benefits.

So far, our descriptions and analyses of Tosawihi sites and lithic artifacts confirm what has been suspected since Mary Rusco's pioneer work: the main business of quarrying at Tosawihi was biface production. While the production of flakes also occurred, this activity is not particularly visible in our analyses of the archaeological record. Indications from sites in the surrounding region suggest that flakes were produced at Tosawihi and transported *as flakes* prior to heat-treatment; how much of that went on we do not know, but we assume

that it was less important than biface production. Consequently, our actualistic experiments in quarrying and replication are focused on biface production, and the reader should be aware that unless some other technology is mentioned specifically, models and strategies of "lithic production" in the following discussions refer to only biface production.

Costs and Constraints of Lithic Procurement

The various costs of lithic procurement are outlined in Table 235. Direct costs are grouped under the rubrics of search and handling, while indirect costs include lost opportunities, subsistence activities that support the procurement foray, and social overhead. The former are amenable to estimation from ethnographic analogy and experimentation; the latter are much more difficult to quantify. In the following sections, each of these costs is discussed and data from our reduction and quarrying experiments are employed to estimate time and energy required for bedrock quarrying and processing, utility/waste ratios, extracted toolstone package size, point in reduction trajectory when bifaces should be transported, and risks of heat-treatment.

Table 235. Costs of Lithic Procurement.

DIRECT		INDIRECT
Search	**Handling**	**Opportunity**
Travel to Source	Extraction excavating wasterock quarrying bedrock	Non-Lithic Resources Unpursued
Prospecting inspection assaying excavating overburden	Processing blank production biface reduction heat-treatment	**Support**
		Social Overhead
	Transportation to Place of Use	Maintenance of Trade Partners
		Permission to Forage
		Permission to Quarry

Travel and Transportation

Time and energy expended in travel to source is a cost directly proportional to the distance traveled. Jones and Madsen (1989) estimate the cost of walking to be 100 calories per kilometer at 3 kilometers per hour, and the cost of load carrying to be 1.25 calories per kilogram per kilometer. For simplicity, this often is measured as straight line distance between source and point of departure. In actuality, long distance travel in a straight line often may be quite expensive in terms of opportunity costs, particularly if the route traverses passless mountains or waterless areas. Regional data from the Monitor Valley project (Thomas 1988:592-615) suggest that central Great Basin hunter-gatherers on long distance residential or logistic moves were more likely to travel over passes and along riparian routes offering natural shelter, where plants and game were more likely to be encountered and water more easily procured. In other words, the additional costs of taking a less direct route are likely to be more than balanced by the greater safety, comfort, and opportunities such a route can offer (Werner 1985:26-33). We assume that long distance moves to and from Tosawihi were made along major riparian routes.

Problems of supply should be less pressing for diurnal forays than for long distance travel. Nevertheless, travel time still is a crucial factor because with greater distance from camp, less time remains for work at the resource location. Therefore, as suggested in Chapter 4, the radius of diurnal travel should constrain procurement technique. With each increment of diurnal travel distance, the lithic forager must choose a less labor intensive extraction technique, defer processing, or both. This suggests a continuum for lithic resource procurement within a given daily foraging radius (Figure 288). At the maximum diurnal range, it would pay only to procure very high quality, pre-processed lithic material (for example, to retrieve cached flake blanks and bifaces). With shorter distances or travel times, a likely target might be previously quarried, but relatively unprocessed material available from the surface in cobble fields, in stream deposits, or on quarry pit berms and dumps. Closer still to the base camp, it might pay to grub through quarry pit berms in hopes of encountering chunks of high quality material that require minimal processing. Thus, bedrock quarrying, requiring a considerable investment of time and energy before any toolstone can be extracted (even from a known and productive quarry pit), is not expected beyond a relatively short distance from the base camp.

Work time (Tw) for lithic extraction and processing varies not only with travel time (Tt), but also with available daylight hours (Tl) and with the number of hours spent in activities other than travel or lithic work (Ta):

$$Tw = Tl - (Tt + Ta)$$

Belovsky (1987) suggests that time available to human foragers is constrained by their physiological ability to maintain thermal equilibrium (assisted, of course, by cultural adaptations such as clothing, fire, and shelter). In cold seasons, activities other than work and travel may include waiting for the air temperature to rise in the morning before venturing forth; in summer, folks may need to seek shade and rest during the hot part of the day.

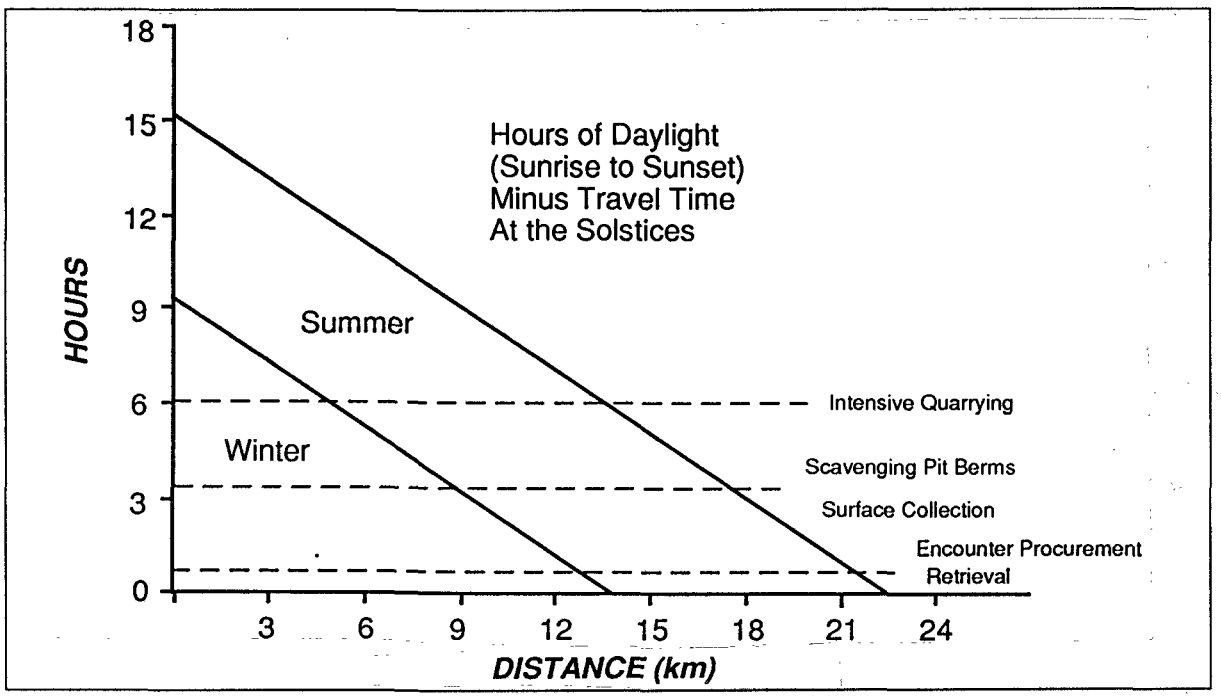


Figure 288. Diurnal work time.

As modeled in Figure 288, at the latitude of the Tosawihi Quarries (North 41° 7") there are 15 hours 13 minutes between sunrise and sunset at the summer solstice (June 21), but only 9 hours 15 minutes at the winter solstice (December 22). Assuming an average walking speed of 3 km per hour, the maximum one-way distance a forager can walk in the 15.13 hours of daylight at the summer solstice is 45.39 km. This translates to a maximum diurnal range of 22.7 km if the entire day is consumed in travel. In the high summer of north-central Nevada, a forager can make a 10 km round trip from base camp, consuming 6.7 hours, and still have 8.4 hours of work time at the procurement destination. Foragers making summertime lithic forays within something less than a 10 km range should have a surplus of time in which to pursue other activities, allowing greater flexibility in base camp location.

In contrast, foragers can walk only 27.75 km in the 9.25 hours of daylight at the winter solstice, yielding a maximum mid-winter diurnal range of 13.86 km. A forager making a 10 km diurnal foray to a lithic source in winter would consume 6.7 hours in travel and have only 2.5 hours of work time. Thus, available daylight appears to seriously constrain winter diurnal range and work time.

Prospecting

Prospecting involves the active search for toolstone. The prospector is looking not only for material that meets some standard of quality, but also is assessing other benefit/cost variables; attention is given the type of toolstone available, the structure of the deposit, the amount of overburden, the form in which the material occurs, the package size in which it can be extracted, and the difficulty of extracting it. Prospecting occurs at two scales. At one scale, people are involved in a search for toolstone sources; they watch for toolstone, and sample it when it is discovered (encounter prospecting), as they travel and forage through the annual range. We assume that shortly after the earliest people entered the north-central Great Basin, all the important sources of lithic material, including Tosawihi Quarries, were thus discovered and "mapped" into the culture as personal experience and myths passed on from generation to generation (cf. Gould and Saggers 1985; Jones and White 1988).

At the smaller scale of a known and previously exploited lithic source, such as the Tosawihi Quarries, the prospector's task is to find the most productive patch to exploit. Since the materials most easily collected and extracted probably were exhausted soon after initial discovery, this kind of prospecting requires experience, special knowledge, and focused attention; unlike encounter prospecting, it cannot be embedded as fully in other activities, if at all. Both direct and opportunity costs of focused prospecting are thus high, as they are with other search and extraction aspects of quarrying. The degree to which the establishment of a quarry results in reduced need for local prospecting, the lower the investment risked in the venture. As with any other kind of mining, the best prospect is a productive mine; this strategy explains efforts to expand or reexcavate existing quarry pits. Also a good bet is a place *near* a productive or formerly productive mine, which probably accounts for clusters of quarry features in the same locality. A third exploration strategy is to look for new places with geology, surface morphology, or other surface indications similar to those surrounding productive quarry pits.

Inspection and Assaying

Ethnographic accounts (Binford and O'Connell 1984:409-412; Jones and White 1988: 59-61) suggest that the first step in prospecting at a quarry is *inspection* of the surface to locate indications of buried toolstone. In the cited examples, such clues involved the presence of surface toolstone clasts (and possibly flakes), but we might imagine that the presence of toolstone in surface outcrops is the most reliable indicator. During inspection, likely pieces of toolstone are *assayed* to check quality by breaking or flake removal; the same process can be applied to outcrops.

Overburden Removal

When surface indications and assaying suggest the location of a likely spot, the next step is excavation of an exploratory pit, during which inspection and assay continues. An analogous process, but one with probably different time and energy requirements, is the removal of weathered and checked material from surface outcrops. Also included as "search time" is the removal of overburden when a productive pit is being expanded to expose additional toolstone deposits.

We have no ethnographic points of comparison for prospecting costs applicable to Tosawihi. The few ethnographic cases (Binford and O'Connell 1984; Jones and White 1988) for which prospecting is described involve extraction of cobble clasts from a sandy matrix, rather than from bedrock. People had not visited either ethnographic quarry for a long time prior to the recorded foray, and more prospecting probably was required than necessary had the quarry been recently active. O'Connell (personal communication) recalls that prospecting at the Alyawara quarry by three Aborigine men consumed about half an hour (1.5 person hours).

In a clast quarry, one need only remove soil matrix to isolate clasts which then can be assayed and processed if of adequate size and quality. Prospecting and extraction are the same when clasts are relatively small, as at Ngilpitji Quarry (Jones and White 1988); they are distinct only when clast size is sufficient to require a technique (fire setting, percussion reduction) for extraction different from that used for discovery (cf. Binford and O'Connell 1984). Compared to clast quarries, prospecting in bedrock offers quite different problems. For instance, experimental bedrock quarrying (Carambelas and Raven 1991) suggests that prehistoric prospectors at Tosawihi had to evaluate the type and amount of fracturing present to determine whether the bedrock allowed points of ingress through cracks or tuff beds. These factors influence difficulty of extraction (and even the *possibility* of extraction) and the size of extractable packages, which in turn affect net yield. Material easily extracted but available only in small packages may have less utility in terms of potential flexibility (number of different types of tools) than material more difficult to extract but available in larger packages. While the quality of raw material is lessened by many fractures, flaws, or high tuff/opalite ratio, massive, unfractured opalite is extremely difficult to quarry.

In the case of surface outcrops or ledges with substantial above surface exposure (Type 1 quarry; cf. Chapter 22), raw material quality can be judged in part from examination of the outcrop itself and the talus (if any) accumulated below it. At a previously unquarried outcrop, Carambelas and Raven (1991) removed nearly twenty kilos of weathered and fractured waste stone in several minutes, without exposing any toolstone they considered worth extracting and processing. Tuman ax makers spent up to one month removing poor quality stone from an outcrop before reaching toolstone quality material (Burton 1984).

Where beds of toolstone intersect the slope of the surface (Type 2 quarry; cf. Chapter 22), toolstone clasts on the slope below the outcrop will signal their presence even if buried by colluvium. Prospectors encountering toolstone clasts on colluvial slopes have merely to follow the material upslope to its source and excavate to expose it. Quarriers then face the same problems of evaluation outlined for the Type 1 quarry above, exacerbated, however, by the smaller window into the deposit that excavation provides. Getting a better look requires more work. The steeper the slope, the easier pit excavation may be, as gravity provides some help in moving waste material. The pit may not hit any good toolstone, however, in which case it must be expanded, another pit excavated, or the site abandoned.

Where a bed of toolstone parallels the surface (Type 3 quarry; cf. Chapter 22), soil processes may bring toolstone clasts to the surface, but where slope is gradual, the distribution of clasts is likely to provide fewer clues to the location and quality of subsurface deposits. The cost of exploration pits at Type 3 quarries should be somewhat higher than for Type 2 quarries, as lack of slope may make excavation and waste disposal more difficult.

Experimental Prospecting and Extraction

Five actualistic quarrying experiments were conducted at Tosawihi during the 1989 and 1990 field seasons (Carambelas and Raven 1991; Carambelas, personal communication). Three experiments involved removal of overburden. Experiment 1 was located north of Feature 7 (a Type 3 quarry) in site 26Ek3171. It entailed the excavation of a vertical pit through overburden and into tuff bedrock in an unsuccessful attempt to open a Type 3 quarry into an opalite bed thought to be parallel to the surface. Experiment 2 involved excavation from the margin of a cleaned quarry pit (26Ek3271, Feature 7), through a prehistoric berm, then against a vertical face of virgin soil to expose new toolstone; this was equivalent to moving into new ground from an existing pit. Experiment 3 entailed excavation through debris filling a prehistoric quarry pit (Feature 24 in Locality 36 of 36Ek3032) to bedrock, equivalent to cleaning out an old pit.

Overburden Excavation

Excavation rates (including time employed to resharpen digging sticks, clean out debris, and search the vicinity for hammerstones) for different types of soil and tuff bedrock are given in Table 236. The highest rates were achieved excavating loose, coarse material in the berm of an old quarry pit. This suggests that excavation rates also should be high in natural colluvium and talus-like debris piles found at the foot of outcrops in Type 1 quarries, or through coarse openwork layers in old pit fill. High excavation rates also were achieved in excavating loose surficial material typical of the upper 5 to 10 cm of soil profiles throughout the Tosawihi study area. Surprisingly high excavation rates were possible in moist clay containing large cobbles; the cobbles accounted for a large proportion of the volume and could be pried out with relative ease. Rates were low in clay with smaller or fewer clasts, and particularly so in clay lying directly on bedrock. Excavation of clay-rich fill in old quarry pits is similarly difficult. Moderate excavation rates were achieved in compact silts typical of undisturbed soil profiles in the area, as well as in silty fill of old quarry pits. The lowest rates are associated with excavation of tuff bedrock.

Table 236. Experimental Excavation Rates (liters per minute).

Deposit	Experiment 1	Experiment 2	Experiment 5
Loose Surficial	5.45	n/a	n/a
Compact Silt	2.26-3.34	n/a	n/a
Moist Clay w/ Large Cobbles	3.06-3.68	n/a	n/a
Moist Clay w/ Smaller Clasts	0.87-1.91	0.17-1.46	n/a
Moist Clay w/ Few Clasts	1.13-1.16	n/a	n/a
Moist Clay on Bedrock	0.40	0.91	n/a
Tuff Bedrock	0.25-0.27	n/a	n/a
Old Berm	n/a	8.58	n/a
Old Fill, silty	n/a	n/a	2.20
Old Fill, clayey	n/a	n/a	0.53-0.92
Mean	1.73	2.17	1.10
σ	1.47	2.57	0.78

Mean excavation rates illustrate the relative difficulty of the three goals represented by these experiments. Extending or moving a quarry pit (Experiment 2) entails cutting through the berm and excavating into a more or less vertical face. This offers several benefits compared to digging a vertical pit, as in Experiment 1: larger work space, greater mechanical advantage excavating against the vertical wall, better visibility, and easy waste disposal down hill into the older portion of the existing pit. It is interesting that the lowest mean excavation rate was returned by Experiment 5, entailing reexcavation of an old quarry pit. Reexcavation has all the disadvantages of a new vertical pit (small work space, poor visibility, awkward waste disposal) and, in this experimental case, the lower portion of the old pit also contained clay-rich fill that was particularly difficult to excavate.

Experiment 2 was terminated when tuff bedrock was encountered. Attempts to "penetrate" the tuff (hoping for a bed of opalite below) with hammerstone percussion failed; too little progress could be made for the effort expended, and the risk of continuing was too great. In retrospect, the attempt to batter through tuff was a losing exploration strategy.

In comparison, Jones and White (1988) observed the extraction of toolstone clasts at Ngilipitji Quarry from a sandy soil matrix, leaving a quarry pit measuring 1.20 x 1.00 x 0.55 m deep. One hour was spent excavating the pit. Assuming the pit to be roughly hemispherical, its volume would be about .070 m^3, or 35 liters, for an excavation rate of 0.58 liters per minute. This is at the low end of the range we observed in experimental overburden removal at Tosawihi.

Toolstone Extraction Returns

Extraction involves the removal of toolstone once it has been exposed, in packages (blanks) suitable for processing. Extraction includes the concurrent removal of poor quality toolstone and wasterock in order to isolate masses of better material. At Tosawihi, waste materials include tuff, opal, and vuggy, cracked, or otherwise badly flawed opalite, along with pieces of good quality opalite damaged by the quarrying process or too small for processing into bifaces. Prehistoric extraction techniques include hammerstone percussion, wedging with antler (and probably wood), and fire setting, all of which we employed in actualistic experiments.

Prehistoric quarriers took advantage of (and perhaps depended upon) natural features in the bedrock to improve return rates. At 26Ek3208 (cf. Chapter 16), quarriers created a Type 3 quarry by working into the face and along the foot of a bedrock outcrop, taking advantage of opportunities to isolate toolstone masses offered by alternating bands of tuff and toolstone, to detach these using large hammerstones and fire, and to use gravity to help dispose of waste down the slope. At 26Ek3200 (cf. Chapter 17), a Type 2 quarry, quarriers apparently started in weaker rock along a fissure, from which they worked back into the slope to form a face. In 26Ek3171 (cf. Chapter 17), Features 2 and 7 are Type 3 quarries excavated into beds of opalite more or less parallel to the surface. In the case of Feature 7, 20 cm of weathered tuff appears to have lain between solid overburden and opalite bedrock. We assume fissures or crack systems somehow provided ingress through the tuff into the bedrock; Experiment 2 suggests that, otherwise, vertical penetration of massive tuff is too expensive a strategy.

Toolstone Packages

Extracted toolstone packages include both blocks of toolstone and large flakes, some of which were struck from bedrock. Flakes account for most blanks from which cached bifaces were made (cf. Chapter 6), and we observed a few flake scars of the right size and shape for

biface blanks on bedrock quarry surfaces. In experimental extraction (conducted in Type 3 quarries), quarriers were never able to isolate bedrock masses large enough, and with surfaces meeting at the proper angles, to remove large flakes directly from the bedrock, nor were they able to detach large masses of toolstone. Although we have no return data for those strategies, we suspect they *can* produce the highest returns under the most favorable conditions (e.g., bedrock morphology of either Type 1 or Type 2, with sufficient crack systems and/or tuff stringers to permit ingress, etc.). In controlled experiments, quarriers removed only relatively small blocks ranging from 300 to 6250 grams.

Boulder Breakup Experiment

If extraction is defined as creation of toolstone packages suitable for processing into bifaces, then extraction (rather than processing) subsumes reduction of large, detached toolstone masses into smaller blocks and flake blanks. Many of our experimental flake blanks were produced from large blocks found in, or extracted from, historic mining features using steel tools; the blocks were not weighed, nor was flake blank production timed. A large opalite boulder was encountered during backhoe trenching in Locality 36 of 26Ek3032 (Leach and Botkin 1991). Although neither the boulder nor reduction waste was weighed in this experiment, the probable boulder weight exceeded 75 kg. It was reduced to blocks and flake blanks using stone hammers, the activity timed, and the products (blocks and flake blanks) weighed. Returns from the experiment are presented in Table 237.

These data inform regarding the relative efficiency of working on a large detached mass of toolstone. The greatest technical advantage lies in the ability to move the mass around to obtain the best striking angles as reduction proceeds, allowing the work to be accomplished in minimum time. In this experiment, series of block removals alternated with series of flake blank removals. Removal of groups of blocks helped set up platforms and surfaces for subsequent flake removal. Once this was done, several flake blanks could be removed in a matter of seconds, giving a high return rate for flake blanks. This rate is somewhat misleading, however, because it is difficult to sustain for more than a few flake blank removals.

Table 237. Returns for Timed Boulder Breakup.

	Blocks	Flake Blanks
Number	13*	11
Weight	48,650 gm mean 4,054.17 σ 3,742.11	8,400 gm mean 763.64 σ 386.06
Time	26.00 min	3.43 min
Minutes per Item	2.00	0.31
Return Rate	1,871.15 gpm	2,448.98 gpm
Total Time	29.43 min.	
Total Return	57,050 gm	
Overall Return Rate	1,938.50 grams per minute (gpm)	

* One item not weighed

Quarrying Experiment 4

Very different results were obtained in Experiment 4 (QE 4), the only timed experiment in which toolstone was extracted from bedrock and transformed into bifaces. The experiment was conducted in previously unquarried bedrock exposed in the bottom of a backhoe trench, adjacent a prehistoric quarry pit. The margin of the pit offered a short (10-15 cm) bedrock face from which to work, and the situation was more or less equivalent to extending an old pit into new territory, without, however, having to remove the 50 cm of overburden. The overburden consisted initially of 30 cm of silty colluvium over about 20 cm of red, pedogenic clay, which lay upon massive opalite. The opalite was not monolithic, but contained systems of cracks, especially at the upper surface. The backhoe operator tried to strip off the overburden with as little damage to the opalite as possible. Nevertheless, the bucket gouged the cracked surface in places and loosened some material which then could be picked up. We have noticed similar loose material on quarried opalite surfaces left exposed to winter weather, and have speculated that such weathering and frost action may have been sought deliberately as a low cost quarrying technique (Carambelas and Raven 1991).

In QE 4, quarrying was divided into timed work periods, or episodes, punctuated by note taking and rest, pit cleaning, and tool maintenance. The time devoted to these activities was included in an episode; time thus includes quarrying plus rest and maintenance. Time, returns, and other data describing the experiment are summarized by episode and presented in Table 238. QE 4 was conducted by a lone quarrier whose goal was to produce as many usable toolstone packages as possible, as fast as he could do so. Prior experience suggested that heavy hammerstone bashing of massive opalite yields little but dust and angular chunks covered with intersecting ring cracks. In this experiment, the quarrier attempted to finesse the stone, opening cracks by tapping it repeatedly with a small hammerstone, driving wedges, and enlarging the cracks with more tapping. He saved all extracted toolstone packages large enough, in his judgement, to process into bifaces. These later were culled by a knapper who, on the basis of size, shape, and toolstone quality (particularly the presence of cracks and vugs), discarded some without assay or further examination, and kept others for processing. The mean weight of the eighteen blocks rejected as too small was 577.78 ± 264.70 gm (already near the mean weight of Stage 3 bifaces), while that of the other fourteen other rejects was 1232.14 ± 526.46 gm. Of course, under aboriginal conditions, such culling probably was coincident with quarrying, "bad" pieces ending up in the pit berm or filling an adjacent pit. The knapper gauged the suitability of each piece at a glance; this process was not timed, but, if conducted during quarrying, is unlikely to have added significantly to extraction time.

In the following discussion, *Gross extraction return* (geR) is total mass (in grams) of material extracted, while *net extraction return* (neR) is geR minus culled material. The *net extraction return rate* (neRr) is neR divided by extraction time (Te):

$$neRr = neR / Te$$

In 820 minutes of work, the quarrier extracted 61 blocks of toolstone weighing 81,250 gm, for a gross extraction return rate (geRr) of 99.08 grams per minute (gpm). Of these, 31 blocks, weighing 27,650 gm (34.03%), later were rejected without assay by the knapper for a net extraction return (neR) of 53,600 gm and a net extraction return rate (neRr) of 65.37 gpm. In the first episode, the quarrier spent two minutes collecting loose material from the opalite surface exposed in the bottom of the backhoe trench, for a net return of 4825 gpm, twice that of the best rate (in creation of flake blanks) achieved in the Boulder Breakup experiment. We suspect that this reflects the rate possible for collecting material loosened from exposed quarry surfaces after a winter or two of frost action. The supply of loose material was limited, however, and extraction rates dropped sharply as soon as the quarrier began to attack the bedrock. Table 238 shows considerable variation in gross and net returns (geR and neR) per episode, as well as in return rates (geRr and neRr). There is virtually no correlation between the amount of time (Te) spent in an episode and either geR ($r = 0.183$) or neR ($r = 0.148$).

Table 238. Quarry Experiment 4 Extraction Returns and Return Rates.

Episode	Te	Blocks	geR (grams)	Mean geR	σ	gRr (geR/Te)	RejBlok	RejWt	% RejWt	neR (grams)	neRr (neR/Te)
1	2	7	10,800	1,542.86	1,320.17	5,400.00	2	800	7.40	10,000	4,825.00
2	11	6	5,450	908.33	494.39	495.46	5	3,850	70.60	1,600	145.46
3	13	3	3,400	1,133.33	689.81	261.54	1	350	89.70	3,050	234.62
4	29	8	13,300	1,662.50	2,055.61	458.62	4	2,900	21.80	10,400	358.62
5	35	8	7,050	881.25	302.30	201.43	6	4,950	70.21	2,100	60.00
6	49	3	6,250	2,083.33	1,172.96	127.55	0	0	0.00	6,250	127.55
8	4	4	4,200	1,050.00	529.15	4,200.00	4	4,200	100.00	0	0.00
19	44	1	1,350			30.68	0	0	0.00	1,350	30.68
20	12	1	900			75.00	0	0	0.00	900	75.00
24	37	1	650			17.57	1	650	100.00	0	0.00
25	1	1	1100			61.11	1	1,100	100.00	0	0.00
27	34	2	3150	1,575.00		92.65	1	1,250	39.70	1,900	55.88
31	36	1	800			22.22	0	0	0.00	800	22.22
37	97	2	1700	850.00		17.53	2	1,700	100.00	0	0.00
38	13	1	2500			192.31	0	0	0.00	2,500	192.31
39	34	2	2450	1,200.00		72.06	1	700	28.57	1,750	51.47
42	95	2	1900	950.00		20.00	1	450	23.70	1,450	15.26
43	7	1	6150			878.57	0	0	100.00	6,150	878.57
44	8	1	1400			175.00	1	1,400	100.00	0	0.00
49	146	2	1400	1,400.00		9.59	0	0	0	1,400	9.59
50	31	3	2850	950.00	100.00	91.94	1	850	29.82	2,000	64.52
52	65	1	2500			38.46	1	2,500	100.00	0	0.00
53	17	0	0			0.00	0	0	0.00	0	0.00
Totals	820	61	81,250			99.08	32	27,650	34.04	53,600	65.37

geR: Gross Extraction Return
geRr: Gross Extraction Return Rate (gm per min.)
neR: Net Extraction Return
neRr: Net Extraction Return Rate (gm per min.)
Te: Extraction Time
RejBlok: Rejected Block
RejWt: Rejected Weight

There is, however, a pattern to the work that *is* connected to toolstone yield. Figure 289 plots cumulative geR and cumulative neR against elapsed extraction time (Te). A curve is fitted to each distribution (weighted average LOWESS smoothing method; Cleveland 1979, 1981; Wilkinson 1989) that describes trends in the gross and net rates of extraction through the quarrying session. Gross rates are, of course, higher, but the curves are quite similar. Variability in neR per episode are plotted in Figure 290a, and elapsed time of each work episode against total elapsed time in Figure 290b. Although yields and work times are variable, the upward trend in extraction rate is relatively steep to episode 6 but then decreases. Through episode 6, geRr and neRr are, respectively, 332.7 gpm and 240.29 gpm, falling thereafter to 51.39 gpm and 29.66 gpm.

In spite of longer work sessions, the quarrier could gain no momentum after episode 6. A more experienced and prudent aboriginal quarrier might have recognized a losing proposition and abandoned the pit sooner, particularly if he or she had culled blocks during extraction for feedback on net extraction return, which, we see in Figure 289, describe a flatter curve after episode 6. Perhaps, too, a more experienced quarrier, particularly if assisted, could have changed techniques and continued to extract toolstone at a higher rate.

Compared to the Boulder Breakup, even neRr for episodes 1 through 6 may seem poor. But recall that the boulder was a gift of the backhoe. If quarriers had spent 139 minutes (the duration of episodes 1 through 6) detaching this mass of toolstone and breaking it up, their net extraction return rate would have been only 410.43 gpm; with 250 minutes of work, the net extraction return rate falls to 228.20 gpm, exactly that for episodes 1-6.

In fact, neither the Boulder Breakup nor QE 4 involved the removal of significant overburden. Excavating a pit with a two meter surface diameter at the location of Experiment 4 requires removing 86 liters of silty soil and 50 liters of clay. At the lowest experimental rates given in Table 236, removal of virgin overburden at this location would require 82 minutes. Added to the 139 minutes of episodes 1 through 6, this would decrease the net return rate to 143.89 gpm. Reexcavation of a filled pit would have required about 148 minutes at the highest rate for clay-rich fill, which would decrease the episode 1-6 net extraction rate to 110.87 gpm.

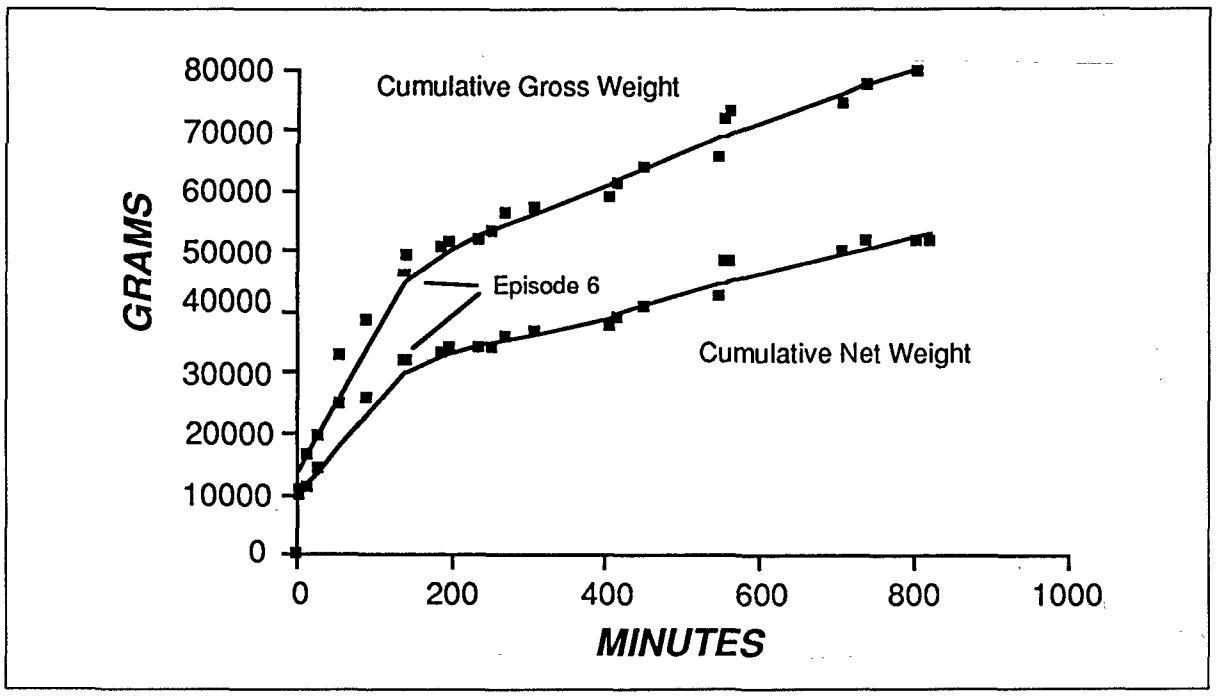


Figure 289. Quarry experiment 4: cumulative gross and net extraction returns.

Experimental Processing

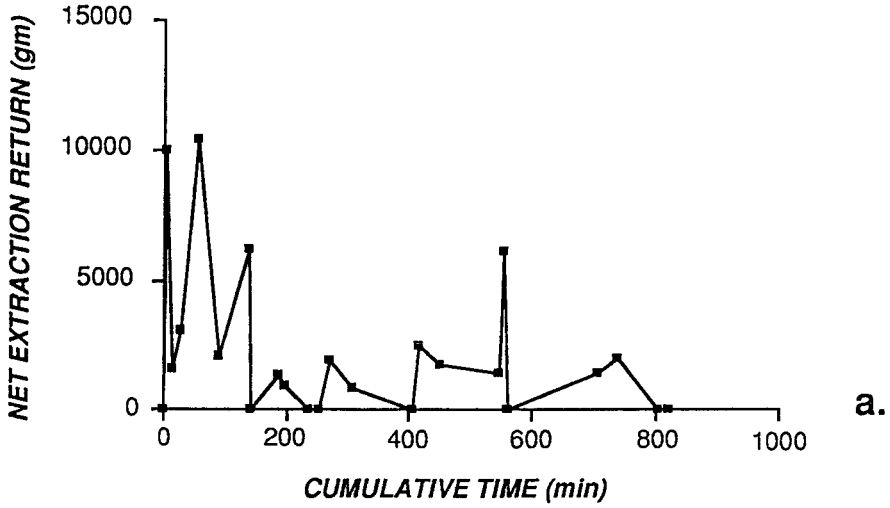
Processing involves rendering a package of extracted toolstone into usable form; at Tosawihi, this meant processing reduced toolstone blocks and large flakes into bifaces. Experimental bifaces were produced in a number of experiments performed by several knappers of both genders and various skill levels. The results of these replications are summarized in Table 239.

In the following discussion, the *processing return* (pR) is the mass of processed tools with fU of 1.0., and is a net return because processing failures are subtracted by definition. There is, however, a *gross processing return rate* (gpPr), which is pR divided by processing time (Tp). *Net processing return rate* (npRr) is pR divided by extraction time plus processing time:

$$npRr = pR/(Te + Tp)$$

Processing Returns

Of the twenty-nine blocks retained for processing in QE4, eighteen (weighing 34,150 grams) failed (half to breakage, half to flaws) during processing and were rejected. Fifteen bifaces were produced from the remaining eleven blocks. The discrepancy between numbers of blocks and bifaces is due to further reduction of fragments and spalls produced during processing some of the larger blocks; this also occurred in other processing experiments and accounts for deviations between numbers of blanks, failed bifaces, and completed bifaces. Altogether, processing the quarry blocks consumed 145 minutes; added to extraction time, search and processing time consumed 965 minutes, for a net processing return rate (nepRr) of 2.74 grams of biface per minute. Extraction and processing combined required an average 64 minutes



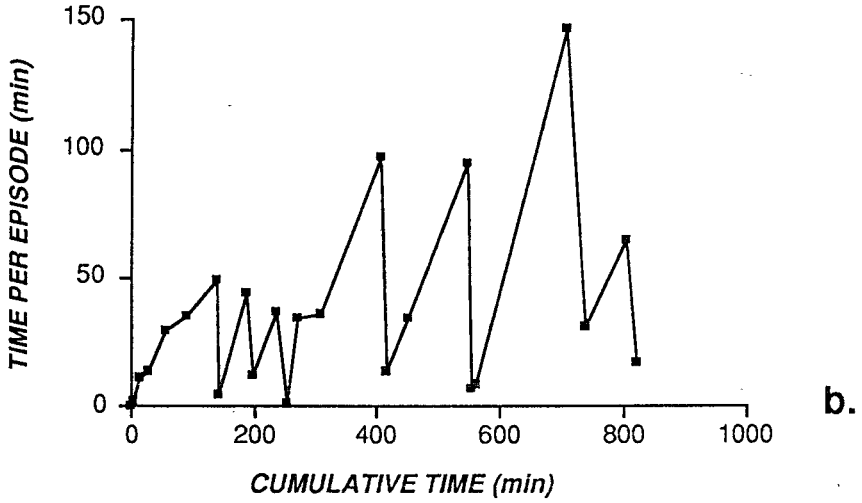


Figure 290. a. Net extraction return per episode; b. time per extraction episode.

per biface. Processed bifaces comprised 4.93 percent of the gross blank weight (Wbl) and 3.31 percent of all material extracted; over 95 percent of the processed material and over 98 percent of the extracted raw material was waste. While cost of this waste may be mitigated by retrieval of flakes from debitage for use as expedient tools and tool blanks, we ignore this for the time being.

Table 239. Experimental Processing Returns and Rates.

Experiment	Blank No. & Type*	Wbl	Nf	Np	pR	Tp	gpRr	npRr	nepRr	gbTbf	nTbf	gProbf	nProbf
QE4	29 BL	53600	18	15	2643	145	369.66	18.23	2.74	9.67	64.00	4.93	3.31
Boulder Breakup	13 BL	42550	2	20	18050	126	337.70	143.25	-	6.3	-	42.42	-
	11 FB	8400	0	11	3680	24	350.00	153.33	-	2.18	-	43.81	-
	1 RM	6100	-	1	6100	-	-	-	-	-	-	-	-
Moore Misc.	5 BL	5900	2	5	1640	83	71.08	19.76	-	16.60	-	27.80	-
	5 FB	3150	1	4	771	37	85.14	20.81	-	9.25	-	24.44	-
Bloomer/ Ataman	15 FB	15800	4	11	1983	577	27.38	3.44	-	52.46	-	12.55	-
Knap-In	40 FB	28406	8	32	4404	614	46.26	7.17	-	19.19	-	12.55	-
Totals	119	144456	35	99	39270	1606	89.95	125.45	-	16.22	-	27.18	-

*BL = Block; FB = Flake Blank; RM = Remnant bifacial core left at end of boulder reduction

Wbl: grams of blanks at beginning of processing.
Tp: Processing Time
Nf: Number of Failed Bifaces
gpRr: Gross Processing Return Rate - Wbl/Tp (gpm)
nepRr: Net Extraction & Processing Return Rate - pR / (Te + Tp)
npTbf: Net Processing Time per Biface - (Te + Tp) / Np
nProbf: Net Biface Proportion - pR / (gpR + Wbl)
pR: Processing Return (grams of processed bifaces)
Te: Extraction Time
Np: Number of Processed Bifaces
npRr: Net Processing Return Rate - pR/Tp (gpm)
gpTbf: Gross Processing Time per Biface - Tp/Np
gProbf: Gross Biface Proportion - pR/Wbl

Processing return data are compared in Table 239. Since extraction times and weights in the other experiments were not controlled, net statistics are calculated only for bifaces processed from blanks extracted in QE 4. Overall, the average time required to process a biface was 16.22 minutes, but Table 239 reveals considerable variation in processing rates and returns even for the same knapper. Notice that although Moore's gross processing return rate is similar for QE 4 and Miscellaneous (blocks collected by Elston and flake blanks produced by Moore), the net processing return rates (npRr) for the blanks he produced during the Boulder Breakup are nearly an order of magnitude greater, possibly due to the high quality of material and the opportunity to create blanks of optimum size and shape for application of his own technique. Moore also assayed the material as he struck off blocks and flakes, rejecting all but the best.

These data strongly indicate that one does not necessarily gain bifaces by investing more time in processing. In most of Moore's experiments (Boulder Breakup, Miscellaneous), less processing time per biface is associated with a much higher Gross Biface Proportion (proportion of raw material turned into bifaces). The exception was QE 4, where raw material quality was low. Here, each piece required assaying, accomplished in the initial flake removals of processing; over half the blanks failed, but most did so after only a few blows were struck. In this situation, it is doubtful that taking more time would have resulted in more successes, and Moore's high gross processing return rate (gpRr = 370 grams per minute) served to keep the average gross processing time per biface to a relatively low 9.67 minutes. Twenty to twenty-nine percent of blanks failed in those processing experiments where the gross processing return rate (gpRr) ranged between 27 and 85 grams per minute. The combined failure rate for blanks processed in QE 4 and Boulder Breakup experiments (where gpRr was over 337 grams per minute) was, at twenty-seven percent, in the same range. This suggests that, in the long run,

failure rates may remain about the same irrespective of processing speed; if substantiated by further experimentation, we may conclude that it always pays to process as fast as possible.

Experimental and Archaeological Bifaces

Experimental knappers sought to reproduce the range of size, morphology, and stage of Tosawihi bifaces as closely as possible. They did this not by calling on a base of quantitative data regarding these characteristics, but by examining examples in the Tosawihi collection and getting a feeling for what constitutes a "Tosawihi" biface. The knapper's ability or inability to approach some set of normative values is not in itself particularly interesting, but, as a reflection of the human ability to judge qualities and quantities subjectively in a consistent fashion, it has implications for the ability of people to perform in ways assumed by our model. It also speaks to the relevance of experimental statistics regarding processing returns and rates. Our confidence in these should be in direct proportion to the degree the experimental assemblage replicates the attributes of the archaeological assemblage.

One difference between the assemblages of experimental and archaeological bifaces is their distribution among reduction stages. While Tosawihi archaeological biface assemblages contain between 70 and 76 percent Stage 3 bifaces and one to eight percent Stage 4 bifaces, by design (we asked experimental knappers to stop reduction in stage 3), 86 percent of experimental bifaces are Stage 3 and over 10 percent Stage 4. We might expect, therefore, to find experimental bifaces smaller and lighter in weight than the archaeological specimens, but, as shown in Table 240, this is not the case. In fact, the mean weight for all experimental bifaces is nearly three times that of all intact Tosawihi bifaces, and over one and one-half times as great as bifaces from caches. Experimental bifaces produced from blocks are consistently heavier than the archaeological mean, but experimental bifaces made from flake blanks are lighter in all cases but one.

Table 240. Mean Weights (in grams) of Experimental and Archaeological Bifaces.

Experiment & Blank Type	**Mean**	**σ**
Quarry Experiment		
Blocks	285.96	128.95
Boulder Break up		
Blocks	902.50	948.93
Flake Blanks	334.55	86.53
All	790.30	1122.19
Moore Misc.		
Blocks	488.33	1465.00
Flake Blanks	192.62	121.88
Bloomer/Ataman		
Flake Blanks	165.25	160.87
Knap-In		
Flake Blanks	137.62	111.48
All Experimental Bifaces		
Various	419.13	791.56
Tosawihi Caches		
Various	275.30	130.21
All Intact Tosawihi Bifaces	202.50	148.88

The relatively small size of archaeological bifaces may owe to many causes; two seem obvious. First, nearly all the archaeological specimens are discards; the largest successful bifaces were transported. Second, the larger the piece, the easier it is to remove an isolated flaw, recover from a small failure, or redirect reduction after a massive failure, all of which make it less likely for large pieces to be discarded without further reduction in size and weight.

Bifaces recovered from caches are the most likely to reflect the prehistorically acceptable range of size and morphology. Processing opalite blocks extracted during Quarry Experiment 4 produced a set of bifaces with a mean weight (and morphology) nearly identical to that of bifaces from Tosawihi caches.

All in all, experimental and archaeological bifaces reflect a similar *range* of variability in size and form, and we are confident that experimental processing returns and rates are well within an order of magnitude of those achieved by prehistoric knappers.

Heat-Treatment

Heating microcrystalline minerals such as flint or opalite to a critical threshold called the eutectic temperature (which varies with the chemistry of the particular mineral) causes certain physical changes in the intercrystalline matrix surrounding the quartz microcrystals (Crabtree and Butler 1964; Purdy 1971, 1975). Compressive strength of the material is lowered, reducing the amount of force required to detach flakes. Most accumulated mechanical and thermal stresses are relieved and vitreousness is increased, making fracture more predictable and increasing the sharpness of resulting edges. These all serve to increase compliance during reduction, which in turn should allow a higher tool/waste ratio and increase ability to predict tool use life. These features must outweigh the attendant increase in brittleness and somewhat lower durability since among opalite artifacts in the Tosawihi collections, heat-treatment is found in most preforms and projectile points, in approximately half the bifaces, and in smaller proportions of other flaked stone tools.

Approximately 50 heat-treating experiments (the number is vague because some informal experiments were not recorded) were performed to address three methodological and analytical problems: recognition of heat-treated artifacts, effects of heat-treatment on durability and flaking quality of Tosawihi opalite, and time and effort involved in heat-treatment.

Actualistic experiments sought to replicate prehistoric techniques. In one set of experiments, 10 to 20 bifaces were placed in pits at a depth of 20 to 30 cm below the surface and covered with soil and then pine firewood. The pits were fired for up to eight hours and allowed to cool slowly. This procedure resulted in all bifaces in each trial reaching the eutectic point (not recorded owing to lack of pyrometer) with very little loss due to thermal stress.

Experiments using sagebrush as fuel were less successful. Sets of 10 to 20 bifaces were buried shallower (as little as 5 cm), but fires were maintained for up to 12 hours (one firing consumed two pickup truckloads of sagebrush). Burning sagebrush, however, created a great deal of fluffy, white ash which appeared to insulate the pit bottom, with the result that only bifaces at the top of the pit were well treated (again, temperature was not recorded due to lack of a pyrometer). Although not predicted by the concept of a finite eutectic "point," some pieces appeared to have been altered only slightly, improving their flaking qualities somewhat but not vitrifying them. This would account for artifacts of similar appearance noted in analysis as "possibly altered." We conclude that successfully firing quantities of bifaces with sagebrush fuel might be accomplished by placing bifaces in a special heat-treating earth oven lined with stones, perhaps with a preliminary firing to heat the pit. Only one possible heat-treating hearth (26Ek3092, Feature 9) was observed at Tosawihi, and such features have not been noted frequently anywhere in the world (Griffiths et. al 1987). In general, this series of experiments

suggests that in areas such as Tosawihi where sagebrush was the principal available fuel, it may have been necessary to fire only a few items at a time.

In the laboratory we had no trouble heat-treating experimentally produced artifacts to high degrees of vitreousness using a sand-filled electric deep fryer, thermometers, and a pyrometer. We tested the effect of heat-treatment on flakes versus bifaces and on different varieties of raw material from Tosawihi, with these findings:

The critical temperature for heat-treating Tosawihi opalite is relatively low: 450°F - 475° F (205°C - 230°C). Critical temperatures vary with source; finer materials require slightly lower temperatures to attain good results while jasper-like materials and local non-opalite cherts, as well as weathered pieces, need slightly higher temperatures. Once reached, the critical temperature need not be maintained; slow heating (at least two hours) and cooling (at least 12 hours), however, prevents thermal failure. A small amount (1-5%) of weight is lost in heat-treating.

Opalite does not change color significantly when heat-treated, although the exterior surfaces of light colored varieties sometimes become slightly stained with brown. Heat-treated opalite becomes more brittle, and when heat-treated well, extremely lustrous; it also may become slightly more opaque and quite glassy. Heat-treatment of opalite decreases the force needed to detach flakes, thereby resulting in easier pressure flaking and less attrition of soft hammer billets. When heat-treated opalite is flaked and then reheated, lustrous surfaces remain lustrous and the difference between original and post-heat-treatment flake scars remains visible.

Our experiments indicate that while Tosawihi opalite can be heat-treated successfully at relatively low temperatures, altering large quantities of bifaces in one firing with fuel available at the quarries could not be accomplished without special firing technology for which there is presently no evidence. We must conclude, therefore, that most heat-treatment occurred in ordinary campfire hearths, a few artifacts at a time. One of Steward's (1941) Reese River Shoshone informants recalled that flint was placed under the campfire for five days. We believe, however, that, under ideal conditions, in a campfire tended continuously, it is possible to heat-treat sets of up to six bifaces in a few hours (cooling is riskier), so that one person might be able to fire a dozen artifacts in one day. In less than ideal conditions, the number handled would be lower and the success rate probably would fall.

Prehistoric heat-treating probably worked sometimes and sometimes did not. A single biface might need to be cooked several times before heat-treatment "took." Heat-treatment certainly is risky, and can be very costly to support under some circumstances. On the other hand, it can be embedded easily in down time activities at camp if a few bifaces are slipped into the campfire each evening before sleep. Moreover, it can be accomplished anywhere: at any overnight stop, just throw another biface or two on the fire. This low volume strategy may account for both the increasing incidence of heat-treatment with distance from the quarries as well as the low proportion of heat-treated cached bifaces. Transporting as many heat-treated bifaces as possible and caching the unheat-treated remainder defers cost. Even though caching defers benefits, it does not extend venture risk beyond the procurement episode if sufficient bifaces also are transported. Moreover, future retrieval of unheat-treated caches incurs no extraction or processing costs, opportunity costs are minimized, and venture risk is reduced to that inherent in heat-treatment.

Modeling Lithic Procurement Decisions

So far, we have summarized ethnographic and experimental data regarding costs of prospecting for, extracting, and processing toolstone, as well as travelling to and from sources and transporting toolstone packages. We now employ these data in some simple models that allow us to

estimate cost in time and effort of lithic procurement at Tosawihi, and consider the basis of processing decisions that affected the structure of the archaeological record at Tosawihi Quarries.

Proportional Utility and Marginal Value

Lithic foragers are caught between the conflicting goals of minimizing the cost of both procuring and transporting toolstone. The more material removed during processing, the lower the transport cost, but the higher the processing cost. Metcalfe (1989; cf. Metcalfe and Barlow 1991) has developed a simple, deterministic model based on a model of central place foraging (Orians and Pearson 1979) in which the decision to transport a resource is partly a function of its *proportional utility*, or ratio of usable to non-usable material in a resource. Consider a nut that by weight is 70% edible meat with a utility of 1.0 and 30% non-edible shell with a utility of 0.0. Removing shells increases the utility of a load of nuts to 0.7; an unshelled load has a proportional utility of 1.0, and a partially shelled load a proportional utility of something in between. While it might be worthwhile to transport an unshelled load of nuts a short distance, at greater distances it would pay to first process the nuts, increasing the proportional utility of the load and decreasing the transport costs. Knowing the transport distance and the processing costs, the model predicts the amount of processing that *should* occur, given any transport distance.

Since reduction of lithic artifacts in manufacture constitutes processing during which unwanted material is removed and utility increased, Elston (1988c, 1990) and Metcalfe (1989) propose use of the proportional utility model to study variability in lithic debitage assemblages. Metcalfe and Barlow (1991) suggest that proportions of primary, secondary, and tertiary flakes should vary predictably in response to distance of the assemblage from known lithic sources and the relation of proportional utility to reduction stage. At Tosawihi, since most debitage was subjected to mass analysis, the data are not sufficiently fine grained to employ the Metcalfe and Barlow model. The Tosawihi biface sample, however, is large, and each artifact reflects reduction stage unambiguously. The following exploration illuminates both strengths and weaknesses of proportional utility in modeling lithic procurement.

In Chapter 3 we argued that although tools of different functional types differ in benefits of use, we can avoid having to consider this variability by assuming that the *functional utility* (fU) of any tool is 1.0 through its use life. This allows use life to be the measure of utility, with the further assumption that, for a given lithic material, mass is a proxy for *use life utility* (ulU) as long as objects under consideration have a similar range of function and morphology.

We assume that processing increases the functional utility (fU) of stone tools by removing lower quality and functionally superfluous material and by improving functional form. Since a biface is made by reducing a blank, the ratio of waste to usable material in a processed biface is a measure of cost that affects net returns, and monitors both functional and use life utility. As gross biface proportion (gProbf, Table 239), we used it to compare overall returns for processing different sizes and types of blanks in each reduction experiment. Here we use a variation of the measure to monitor the amount of material lost at different stages through reduction. Because experimental knappers employed blanks of different sizes and shapes, and found it difficult to halt a knapping episode at the threshold between analytically defined reduction stages (or even to stop episodes consistently at precisely the same stage), the number of episodes per reduction, as well as stage at end of episode, varies between experiments and among knappers. Nevertheless, reduction stage and biface weight were recorded at the end of each episode; they are used to calculate the proportion by weight remaining of the original blank (Probl). For instance, starting with a blank weighing 1000 gm and reducing it to a biface weighing 250 gm gives:

$$\text{Probl} = 250/1000 = .25$$

The following analysis employs only data from successfully processed experimental bifaces. Because several bifaces were reduced in two or three episodes, there are more data points than bifaces.

Figure 291 is a graph with two Y axes; that on the left is proportion of blank remaining (Probl), that on the right, time (Tp) per episode. Points on the graph are plots of stage versus Probl, showing a wide range of Probl in all stages of reduction, as we might expect from variability in toolstone quality and knapper skills. Probl tends to decrease as stage increases, although the spread of values keeps the linear correlation coefficient relatively low ($r = .517$; $P = 0.0$). That is, progressively less material is removed at each stage. At the same time, there is a general tendency for Tp to increase.

The slope of a line fit to the Probl data with the weighted average LOWESS smoothing method (not linear regression) trends downward, is steep to about middle Stage 3, and then flattens out. The slope of the line fit to the time data trends upward, is relatively shallow to middle Stage 3, then steepens. As in the similar analysis of gross and net extraction rates for QE 4, the changes in slope reflect a decrease in the rate at which material is removed, and an increase in the amount of time it takes. Together, these trends suggest that throughout reduction, it takes more and more time to remove less and less material; reduction after middle Stage 3 appears particularly costly. The rate changes at Middle Stage 3 signal the switch to soft hammer percussion (generally removing less mass), as well as patterned flake removal, and the greater difficulty of recovering from failures and mistakes; both necessitate more planning and platform preparation time.

Most Tosawihi bifaces are Stage 3. Most bifaces are heat-treated at Stage 3, and the spatial distribution by stage suggests that most are transported away from the quarries at Stage 3, as well. In this light, Figure 291 strongly suggests that Stage 3 is the point in lithic processing where functional utility (fU) approaches 1.0 and further reduction results in *loss* of use-life utility (ulU) without much change in the cost of transportation (Elston 1990); otherwise, most Tosawihi bifaces would reflect smaller, later stages.

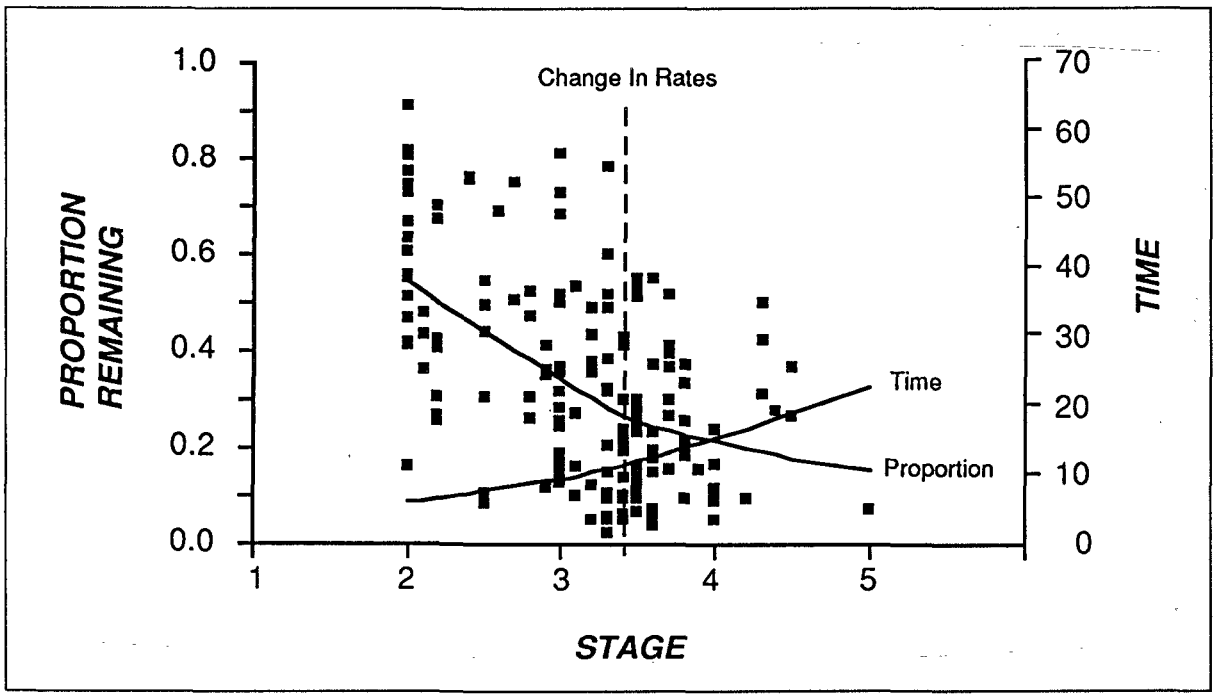


Figure 291. Proportion remaining of original blank and elapsed time per reduction episode by stage.

Because (as we have seen in other chapters) biface size tends to decrease with distance from source, and biface processing involves diminishing returns, the marginal value model can be used to explore relationships between lithic processing and transportation costs. For instance, proportion of original blank remaining (Probl) is scaled from 1.0 (no reduction; all of the original blank remains) to 0.0 (nothing of the original blank remains). Among experimental reductions plotted in Figure 291, Probl ranges from 0.91 to 0.02; the mean for middle Stage 3 is 0.253 ± 0.17.

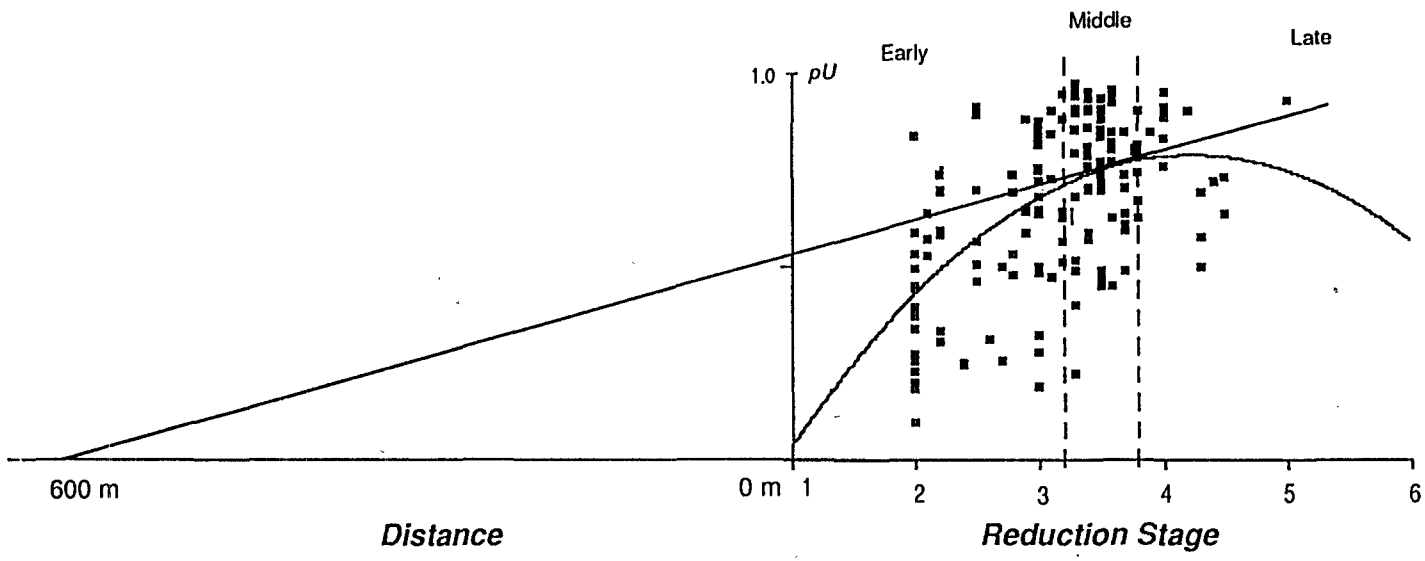
If proportional utility approaches 1.0 as unusable material is removed, then the lower the Probl value, the higher the utility. In fact, if we transform our Probl values by subtracting each from 1.0, and plot these against reduction stage, our data now form something that looks like a scale of proportional utility (pU) which we will call a *pseudo-utility scale* (*pU*) in order to denote our current inability to evaluate fully its validity (Figure 292). Out of several smoothing methods tried, a quadratic curve ($Y = a + bX + cX^2$) fitting these data approximates a marginal returns curve and reflects our general assumption regarding the waxing and waning of proportional utility through reduction. It does not exactly fit our model where pU is 1.0 at middle Stage 3 because of the large spread of *pU* values at every stage.

The reduction stage scale on the X axis is an approximation of processing cost. Extending the X axis of our graph to the left of the Y axis gives us a place to plot a cost factor such as transport time or distance. Metcalfe and Barlow (nd:9) explain:

> If the foragers maximize the utility of the load per unit time spent transporting, procuring and field processing, then they should decide whether to field process in a manner consistent with maximizing the value of the *y*-axis divided by the value of the *x*-axis. Graphically, the value to be maximized is the slope of the line originating from the required travel time and tangent to the utility function. Where the line touches, but does not intersect, the function indicates the appropriate decision.

The empirically derived distance-stage data presented by Raven in the previous chapter (Figure 287) suggest that, in the Western Periphery (where there is greatest separation between quarry and non-quarry sites), 66% of bifaces transported 200 meters have been reduced to middle Stage 3 or later, and by 600 meters, over 90% have been so reduced. I drew a tangent line from the middle Stage 3 point on the marginal value curve to a point on the cost axis I labeled "600 m" (Figure 292).

The swarm of points in the graph illustrates one reason why, while there is an inverse relationship between distance from source and biface stage (or weight), all biface stages occur at all distances from the quarries: there is considerable variation in biface *pU* at every stage, reflecting variation in material quality and knapper skills; we might add variation in production technology to this. All these factors influence the benefit derived from processing, and the larger the processing benefit, the shorter the transport time or distance at which processing pays off (Metcalfe and Barlow n.d.:15). For example, we expect rough block blanks, possessing little or no functional utility, to be processed at the spot they are extracted. In contrast, processing might be considerably deferred for large flake blanks having a certain amount of functional utility from the moment they are struck from a core. Another complication is that our analysis is based on bifaces, a mobile artifact class, rather than on relatively more static debitage. People may have cycled sets of bifaces through different stages as insurance for contingency risk, which certainly would obscure patterns of the kind we are looking for here. Our subsequent modeling exercise suggests a number of other reasons why processing might not occur at the source, or why it might occur in variable amounts. During any particular foray, any of these alternatives might or might not be employed, depending on the situation.



Other Possible Factors:

Material Quality
Value in Trade
Available Time

Figure 292. Marginal value model for biface reduction.

The Metcalfe and Barlow marginal value model calls for a unique solution to each processing cost-transportation cost decision. Our analysis suggests, however, that there are no unique solutions to the processing cost problem in our data, and this will be true of any archaeological data set. One might approach the problem by converting the deterministic model into a dynamic one that assigned a probability distribution to each alternative along with a range of possible outcomes (Stephens and Krebs 1986; Mangel and Clark 1988), taking care not to introduce so much complexity that the results could not be interpreted.

Processing and Transportation

Human load carrying capacity is the ultimate ceiling for the amount of toolstone that can be transported without vehicles or draft animals. Actual loads transported by hunters and gatherers seem to be much lower than the maximum; ethnographic ranges of between 5 and 30 kg are given by Metcalfe and Barlow (1991). Using the QE 4 extraction and processing data (Tables 238 and 239), we model the effects of varying procurement and transportation costs in the acquisition of 10 kg of toolstone (about the same weight as the biface cache from 26Ek3192). We also employ the transportation cost estimates of Jones and Madsen (1989), and estimates of caloric consumption for extraction and processing (Table 241) based on activities of roughly equivalent effort (ditch digging and gardening) given in Southmayed and Hoffman (1981:418-419). Our models do not include heat-treatment as a processing cost, which, aside from failures (the rate of which we cannot estimate at present) and the low volume mode described above, appears to amount to very little. Also, for simplicity, we assume the forager exploits a developed quarry pit and incurs no prospecting costs.

Table 241. Estimated Caloric Requirements for Various Activities.

Extraction	400 calories per hour
Processing	220 calories per hour
Walking	300 calories per hour (at 3 km per hour)
Carrying	1.25 calories per kg per km

Deferred Processing

First, we consider a lithic forager who makes a 50 km trip to Tosawihi and returns to home base on the Humboldt River (Table 242). Walking the 100 km will consume 10,000 calories, and carrying 10 kg of toolstone 50 km, 625 calories. Let us assume that the forager can extract toolstone at the 240 gpm average rate achieved in episodes 1 to 6 of QE 4; extracting 10 kg of toolstone consumes 41.67 minutes and 277.80 calories. At the gross processing rate of 369.66 gpm, processing requires 27.05 minutes and 99.28 calories. Let us assume, too, that, in light of these minimal costs, the forager decides to forgo processing until he returns home, dismissing the high failure rate intrinsic to Tosawihi opalite that results in a low net biface proportion (nProbf) of 3.31 percent. Reduction of the 10 kg of toolstone at the home camp yields only 331 grams of biface. The total cost of this foray (ignoring lost opportunity and a host of other costs that accrue in the real world) is 11,001.80 calories, so at home base the biface costs 33.24 calories per gram (cpg). It may be a nice biface, but 331 grams has a much lower use life utility than 10,000 grams. Would it pay not to process at the

source were the forager closer to home? Using the same returns, we see that the cost falls as transport distance decreases (Table 242), but at nProbf of 3.31, ulU cannot rise above 331 gm when 10 kg is the whole load; even at the highest possible nProbf, 10 kg of unprocessed toolstone will never yield 10 kg of tools. The steep slope of the line in Figure 293 describes the cost-distance relationship for deferred processing reflects the cost of transporting 9,669 gm of waste in order to procure 331 gm of bifaces.

Table 242. Effects of Distance on Caloric Costs of 10 kg Toolstone Procurement: Deferred Processing (neRr = 240 gpm; gpRr = 369.66 gpm).

	50 km	10 km	1 km	0 km
Travel (cal)	10,000	2,000	200	0.0
Transport (cal)	625	125.0	1.25	0.0
Extraction (cal)	277.8	277.8	277.8	277.8
Processing (cal)	99.0	99.0	99.0	99.3
Total (cal)	11,001.8	2,502.8	578.1	377.0
Net Return (gm)	331	331	331	331.0
Cost(cpg)	33.24	7.56	1.75	1.14
Benefit/Cost	0.03	0.13	0.56	0.88

Processing at the Source

Now the forager sees the light and vows never to move toolstone so much as an inch without processing it (Table 243), although remaining determined to carry a 10 kg load. With the high Tosawihi failure rate and net biface proportion of 3.31 percent, he must extract and process 302,114.8 grams of toolstone to obtain 10 kg of bifaces. Extraction of this much stone

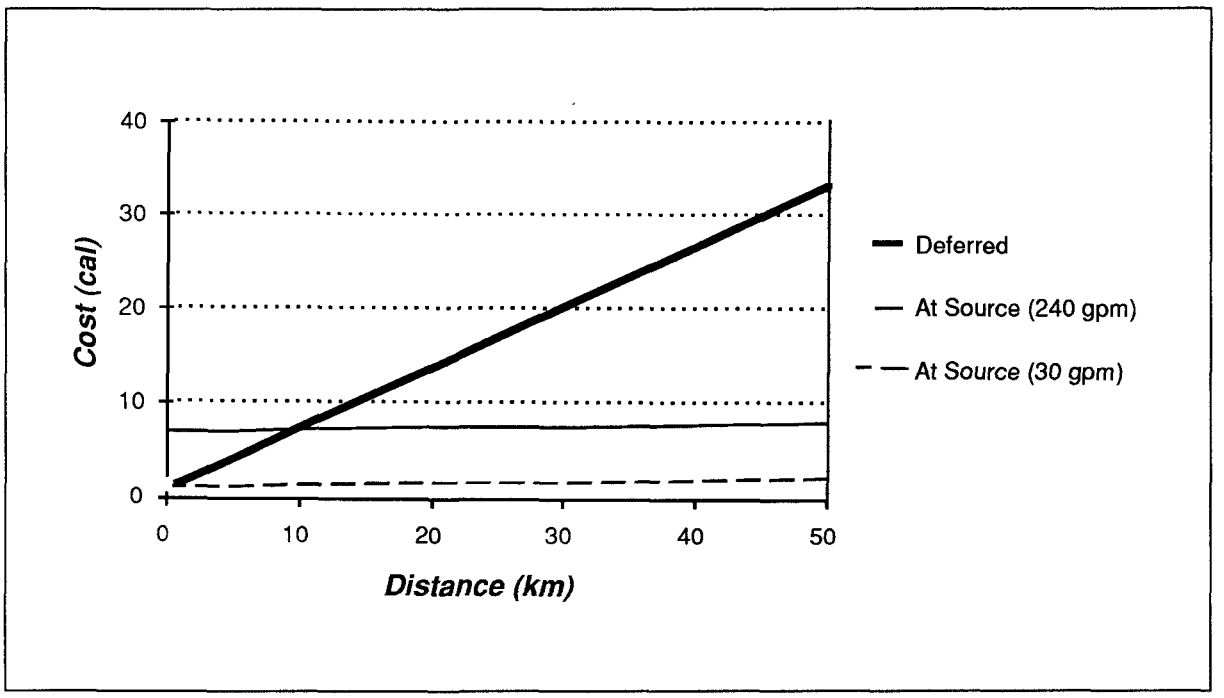


Figure 293. Biface cost per gram by transport distance with processing at source or deferred.

at 240 gpm takes about 21 person/hours, and processing it takes another 14 hours, consuming over 11,000 calories. With travel and transportation, the 50 km foray takes eight and half days and over 22,000 calories. Still, back at the base camp, the forager has 10,000 grams of bifaces and they cost only 2.20 calories per gram. This is a bargain compared to the returns of deferred processing; in fact, costs per gram for the 50 km foray with processing at the source are the same as costs for deferred processing and transport distance of about 1.3 km (Figure 293), and about 30 times as productive in terms of use life utility.

Table 243. Effects of Distance on Caloric Costs of 10 kg Toolstone Procurement: Processing at Source (neRr = 240 gpm; gpRr = 369.66 gpm).

	50 km	10 km	1 km	0 km
Travel (cal)	10,000	2,000	200	0
Transport (cal)	625	125.0	1.25	0
Extraction (cal)	8,392.8	8,392.8	8,392.8	8,392.8
Processing (cal)	2,999.7	2,999.7	2,999.7	2,999.7
Total (cal)	22,017.5	13,517.5	11,596.9	11,395.7
Net Return (gm)	10,000	10,000	10,000	10,000
Cost (cal/gm)	2.20	1.35	1.16	1.14
Benefit/Cost	0.45	0.64	0.86	0.88

On the next series of trips, the forager finds that the net extraction return rate of his favorite quarry pit has fallen to 29.66 gpm (the worst case in Quarry Experiment 4). This increases his costs, but he perseveres and procures his 10 kg load of bifaces. Now, however, he discovers that the cost per gram of biface for processing at the source is higher than experienced in deferred processing out to a transport distance of 8 or 9 kilometers (Table 244, Figure 293); beyond that, the cost per gram for bifaces processed at the source is lower than that for deferred processing. Moreover, at all distances, he has the use life utility of 10,000 grams of bifaces.

Table 244. Effects of Distance on Caloric Costs of 10 kg Toolstone Procurement: Processing at Source (neRr = 29.66 gpm; gpRr = 369.66 gpm).

	50 km	10 km	1 km	0 km
Travel (cal)	10,000	2,000	200	0
Transport (cal)	625	125.0	1.25	0
Extraction (cal)	67,136.6	67,136.6	67,136.6	67,136.6
Processing (cal)	2,999.7	2,999.7	2,999.7	2,999.7
Total (cal)	80,761.3	72,261.3	70,348.8	70,136.3
Net Return (gm)	10,000	10,000	10,000	10,000
Cost (cal/gm)	8.08	7.23	7.03	7.01
Benefit/Cost	0.12	0.14	0.14	0.14

Cost (calories per gram of biface) by distance for each of our three examples are plotted in Figure 293. This plot suggests that at the highest average experimental net return rate and biface failure rate, it will always pay to process at the source no matter what the transport distance. On the other hand, with the same biface failure rate and our lowest net return rate,

deferred processing is less expensive out to about 9 km; at longer transport distances, deferred processing is cheaper. Figure 294 is another way of looking at the data, where the benefit/cost ratio of biface procurement is plotted by distance for each of our three examples. Here we see that at less than 9 km, the benefit/cost ratio for deferred processing is much better than processing at the source when net return rate is low, but we also see a drastic change in the slope of the benefit/cost line for deferred processing between 5 and 10 km. This inflection suggests a logical decision point for prehistoric quarriers, from which we predict a change in assemblage composition: At distances less than about 10 km from the quarry source, we expect relatively high proportions of early stage bifaces and debitage, and the occasional occurrence of cores and/or unreduced blanks. At about 10 km from the quarry, we expect a sharp decrease in proportions of cores, blanks, early stage bifaces and debitage.

The venture risk model presented in Chapter 3 (Figure 11) assumes that the probability of costs exceeding benefits is highest between the times extraction begins and sufficient toolstone has been processed to amortise search and handling costs. In our modeling exercise above, deferred processing not only increased the caloric cost per gram of transported toolstone but also extended the duration of highest venture risk. A forager who transports loads of toolstone that deliver a low net biface proportion (nProbf) might get lucky and occasionally beat the odds, but in the long run will have less success in predicting returns. This increases the venture risk involved with each procurement foray, as well as the contingency risk of meeting situational demands adequately: perhaps there will be sufficient tool use life utility on hand to accomplish subsistence tasks, but perhaps not.

When Deferred Processing Pays Off

In light of the foregoing, we might predict that the higher the costs of travel, prospecting, and extraction, the more likely it is that processing will occur at the source. This may not always

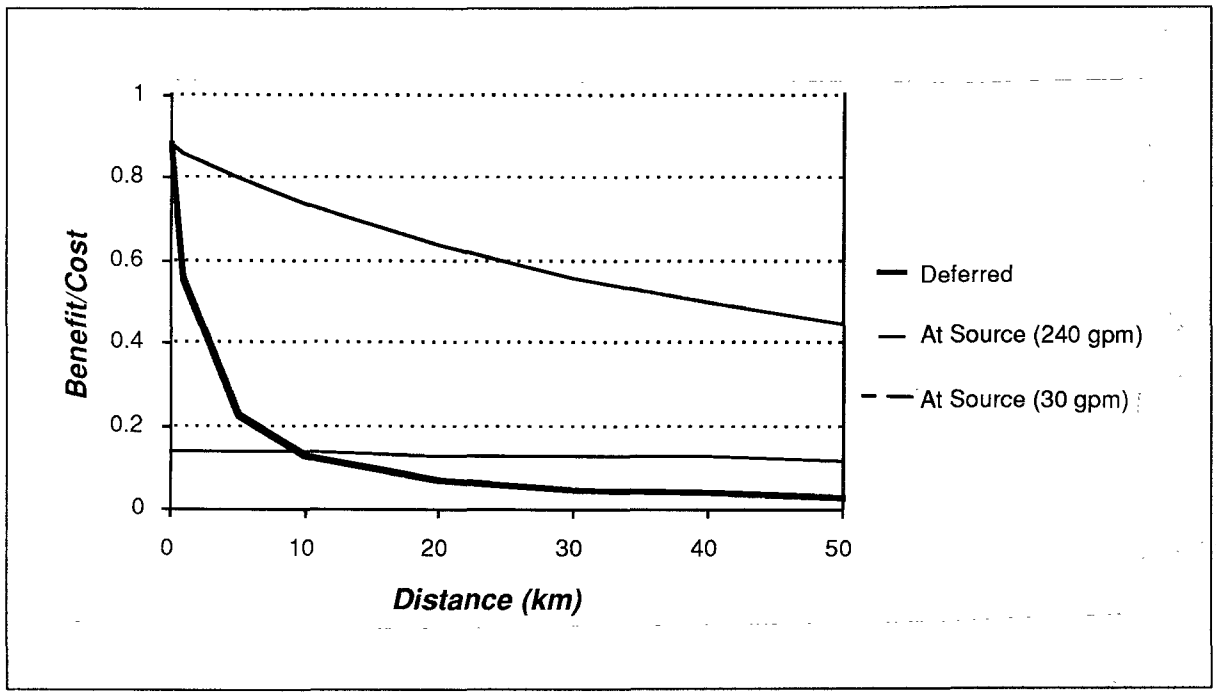


Figure 294. Benefit/cost ratio by transport distance with processing at source or deferred.

be the case, however. Studies in behavioral ecology (reviewed in Stephens 1990) suggest that animals may prefer certainty (low variation in amounts of food taken) when not stressed by hunger, and may prefer risk (wide variation in amounts of food taken) when they are hungry. Similarly, deferred processing seems an appropriate response to acute situational demands, particularly those that impose constraints on time at the quarry. When immediate contingencies must be met, one can gamble on toolstone quality, use life utility may be unimportant. If cache retrieval is not an option, most situational needs probably could be satisfied through surface collection or scavenging waste in quarry pit berms; processing could be deferred to point of use with little penalty in cost. Other situations limiting time at the source include inclement weather, lack of water, or presence of hostile people (particularly if poaching in another group's patch).

Since deferred processing has high costs and risks, anything that decreases venture risk makes deferred processing more viable. Consider a forager with access to a toolstone source of such high quality that nProbf is 50.0, that is, fifty percent of extracted mass can be processed into bifaces. After making the 50 km trip to and from the quarry, the forager arrives home with 10 kg of unprocessed raw material and manages to make 5000 grams of bifaces. Their cost is only 2.2 calories per gram, comparable to, or better than, the cost of poorer quality material processed at the source. Although the forager ends up with the use life utility provided by only 5000 grams of bifaces, the difference conceivably could be offset by avoided opportunity costs. Venture risk and cost also can be decreased by experience and skill of quarriers and knappers in finding high quality material to increase net extraction and processing rates. A forager who is able to judge toolstone quality more finely can estimate net biface proportion better, taking less chance on transporting unprocessed material.

The smaller the amount of toolstone procured, the less the cost, and at some point, cost becomes negligible. The cost of extracting 1000 grams of Tosawihi opalite is 27.8 calories and processing adds another 9.9 calories; carrying it 50 km costs 62.5 calories. At these levels, cost hardly can influence the decision of when and where to process. The combination of high quality and small package size converge with technology in the obsidian nodules that were transported over 100 km to Tosawihi without processing. These items apparently were intended to produce flake tools as well as blanks for projectile points and small bifaces, and served to decrease contingency risk. The proportion of waste in this core and flake technology probably was low; at less than 100 grams per item, carrying cost was next to nothing.

Deferred processing also might pay off in trade, where the producer and consumer are not the same. Time and effort involved in processing is small compared to that expended on bedrock extraction, so avoiding only processing cost is unlikely to balance the increased cost of transporting unprocessed material. In our experiments, the major cost of processing is reflected in processing failures and debitage. By trading unprocessed or minimally processed material (Jackson 1988), the producer can pass on to the consumer the costs of both processing and rejection, along with the associated venture risk. For deferred processing to be profitable to the producer in the long run, the return in trade (goods, foraging rights, access to mates, prestige, etc.) must be greater than the cost of extracting and transporting the unprocessed material.

Strategies of Lithic Procurement at the Tosawihi Quarries

This conclusion summarizes our view of lithic procurement strategies employed at Tosawihi in light of what we know about the economic costs of lithic procurement. In Chapter 3 we proposed that people can call on a variety of organizational and technological options for lithic procurement, depending on the nature and distribution of toolstone in the landscape, the location and distribution of food resources, seasonality, and other variables that affect costs and risks. But we see evidence for a limited number of possibilities at Tosawihi, suggesting that only a few procurement strategies were employed there; only one of those has much archaeological visibility.

Direct Winter Procurement from Humboldt Valley/Rock Creek Camps

Two days from the nearest recorded ethnographic winter camp on Rock Creek, winter lithic procurement would necessitate either winter residence at or near Tosawihi, a winter residential move there, or a logistical trip by a small, specialized task-group. Let us quickly dismiss the first two of these; Tosawihi is too cold, too dry, and too unproductive to support many people for any length of time even in the best season. Long-term residential occupation of the quarries, particularly over-wintering, by Tosawihi Shoshone (or earlier groups) is therefore unlikely. A residential move to the vicinity in winter would be even more costly and dangerous. It is possible, however, that intensive exploitation of the quarries was accomplished through logistically organized, direct toolstone procurement from winter residential base camps on the Humboldt River or lower Rock Creek.

In risking winter at Tosawihi, people would encounter conditions roughly equivalent to those at high altitude Great Basin sites such as Alta Toquima (Thomas 1981) and the White Mountains (Bettinger in press), and, reasonably, we might expect the presence of similar substantial residential structures and elaborate hearths, or the occupation of rockshelters. To date, however, there is *no* archaeological evidence for winter use of the Tosawihi Quarries.

In the event of toolstone shortage in the winter camp, it nearly always would pay to pursue alternatives such as scavenging, recycling, and use of lower quality local materials. If a visit *must* be made, the highest payoff would accrue from the shortest possible trip and retrieval of a cache; in fact, this might be the only payoff sufficient to justify a winter trip to the quarries. Cache retrieval, however, would create little or no archaeological signature.

Diurnal Lithic Procurement During Spring Foraging

Tosawihi lies near the center of the region exploited by the Shoshone in their spring and summer foraging mode. The perceived need for new supplies of toolstone probably was highest after winter in the base camp. Tosawihi is within the diurnal radius of foraging camps on Willow Creek, Rock Creek, Little Antelope Creek, Antelope Creek and Ivanhoe Creek; logistical procurement also is possible from camps outside that range.

In a residential-diurnal pattern, people collect toolstone at a source and return to camp the same day. However, the time available for toolstone procurement decreases with distance from the residential base, so lithic procurement is likely to be limited to encounter procurement, surface collection, or retrieval, none of which leaves a distinctive archaeological signature. Perhaps the most probable indicators of diurnal use are shallow pits excavated in quarry pit berms, apparently to glean previously quarried but discarded toolstone. Archaeological visibility of spring and summer logistical procurement also is low, but perhaps is signaled by the presence of domestic equipment at quarry localities (cf. Chapter 24). There remains, however, no sure way to distinguish very short term residential occupation from logistical use.

Intensive Spring Lithic Procurement

Our experimental quarrying and processing data indicate that, working 8 hours per day, it would take two people about 4 days to obtain 20 kg of Stage 3 bifaces. This leaves very little time (or energy) to obtain water, procure and prepare food, construct shelter (no matter how simple), and perform all the tasks of daily life. This suggests that quarriers were

either supported by other people or that quarrying required occupation of even longer duration. If full scale quarrying and processing required at least several days residence at the quarries by relatively large groups, we must imagine greater demands on local resources to support the foray. Local productivity is greatest in late spring and early summer, so we suspect strongly (although we have no *direct* evidence of seasonality) that Tosawihi quarrying was scheduled for that season. We have suggested further that the greater the demand on local resources, the more likely is occupation of places located not with perfect propinquity to toolstone sources, but with reference to water and food resources as well; the "sweet spots" in the Western Periphery are examples. Indeed, all such places are occupied by large sites with abundant and diverse assemblages, classified as domestic reduction sites. Are these sites in fact residential bases occupied during the spring and early summer by large groups on intensive quarrying forays? Perhaps, but they also exhibit the greatest time depth of all sites investigated, so their large and diverse assemblages might be solely the result of long term accumulation. On the other hand, assemblages of sites in this functional class are distinct; content differences are robust, even when domestic equipment is removed from consideration (Chapter 24). We suspect that domestic reduction sites are indeed the result of intensive procurement as modeled, expressed so vigorously in the archaeological record that everything else is nearly overshadowed. Confirmation of that hypothesis waits further study.

Conclusions

We provisionally conclude, therefore, that prehistoric foragers came to the quarries in the spring, mostly for the purpose of getting toolstone, when it was easiest and least costly to do so. This was expensive, requiring such a sustained effort one wonders whether people ever worked as hard to procure other kinds of resources. With this level of effort, we should not be surprised to find individual or family ownership of quarry pits (or perhaps entire localities), similar to pinenut groves and fish weirs (Steward 1938). The paucity of old tool discards indicates the move to the quarries was planned and deliberate—no need to pack all your old knives when you are going to the hardware store for a new set of cutlery. On the one hand, the lack of structures, constructed hearths, or intensely used ground stone suggests that few people tarried at Tosawihi longer than necessary. On the other, the occupation of sweet spots and the evidence for procurement of local resources in addition to toolstone suggest that intensive quarrying and processing forays may have involved residential moves by household groups. This makes sense if winter tool supplies had been consumed, and a spring foray to the quarries, located in the middle of the foraging range, would position people well for the rest of the foraging season.

The archaeological evidence suggests that opalite procurement was an important activity for prehistoric people and ethnographic Shoshone living along the Humboldt, imbued with ethnic and mythic significance. We do not want to leave the impression, however, that getting toolstone consumed these hunter-gatherers during every waking hour. Every once in while, people went to Tosawihi and worked hard for several days to accomplish a goal that helped them sustain life and make things easier. Then they went off and did a lot of other things.

EPILOGUE

Were this report the last word on the Tosawihi Quarries, the reader might expect a grand synthesis, a critique of methodology, and comprehensive recommendations for future research. As it happens, much more archaeological work remains to be reported and many new insights described. In the summer of 1990, data recovery was conducted at Locality 36 of 26Ek3032. The analysis and report currently in progress will provide a detailed look at a complex of more than fifty quarry pits with a history extending back to about 2000 B.C. In addition to examining such topics as technological change through time, quarry pit volumetrics, and relationships between toolstone occurrence, toolstone quality, and variability in extraction technique, the pending report will review and critique the methods of lithic data collection and analysis we have employed here. Too, the summer of 1991 saw field work completed on an intensive survey of over 400 acres adjacent the Eastern Periphery, and on a stratified random sample of a 44.5 square mile study area centered on the Tosawihi Quarries. These surveys will inform an understanding of the value of the Tosawihi uplands as a lithic terrane, as well as its environmental variability and productivity vis-à-vis other resources. Moreover, we expect to gain greater insight into the economic effects of distance on size and reduction stage of lithic artifacts than our present, areally restricted view allows.

In short, a synthesis is premature at present—it would have to be revised too soon to validate the cost of writing it or reading it—but later chapters of our undertaking will confront many of the questions that, only here, we have learned how to pose.

REFERENCES

Adams, J. L.
1989 Methods for Improving Ground Stone Artifacts Analysis: Experiments in Mano Wear Patterns. In *Experiments in Lithic Technology*, ed. Daniel S. Amick and Raymond P. Mauldin, pp. 259-276. BAR International Series 528. Oxford.

Ahler, S. A.
1971 *Projectile Point Form and Function at Rogers Shelter, Missouri.* Missouri Archaeological Society Research Series 8.

1986 *The Knife River Flint Quarries: Excavations at Site 32DU508.* State Historical Society of North Dakota. Bismark.

1989a Mass Analysis of Flaking Debris: Studying the Forest Rather than the Tree. In *Alternative Approaches to Lithic Analysis*, ed. Donald O. Henry and George H. Odell, pp. 85-118. Archaeological Papers of the American Anthropological Assocation No. 1. Washington, D.C.

1989b Experimental Knapping with KRF and Midcontinent Cherts: Overview and Applications. In *Experiments in Lithic Technology*, ed. Daniel Amick and Raymond Mauldin, pp. 67-88. BAR International Series, 528. Oxford

Ahler, S. A., and R. C. Christensen
1983 *A Pilot Study of Knife River Flint Procurement and Reduction at Site 32DU508, a Quarry and Workshop Location in Dunn County, North Dakota.* Department of Anthropology and Archeology, University of North Dakota. Submitted to the state Historical Society of North Dakota and to the Dickinson District Office of the Bureau of Land Management.

Aikens, C. M.
1970 *Hogup Cave.* University of Utah Anthropological Papers No. 93, Salt Lake City.

Akerman, K.
1979 Heat and Lithic Technology in the Kimberleys, W.A. *Archaeology and Physical Anthropology in Oceania* 14:144-151.

Ambro, R. D.
1970 A Basket Maker's Work Kit from Lovelock Cave, Nevada. In *Papers on Anthropology of the Great Basin.* Contributions of the University of California Archaeological Research Facility 7:73-79. Berkeley.

American Geological Institute
1976 *Dictionary of Geological Terms.* Anchor Press. Garden City, New Jersey.

Amick, D. S.
1985 Late Archaic Fort Payne Biface Manufacture at the Topsy Site (40WY204), Buffalo River Basin, Tennessee. *Southeastern Archaeology* 4(2):134-151.

Anderson-Gerfaud, P., and D. Helmer
1987 L'emmanchement au Moustérien. In *La Main et Outil: Manches et Emmanchements Préhistorique.* pp.37-54. Maison de l'Orient. Lyon. **No editor listed**

Andrews, P.
1990 *Owls, Caves, and Fossils.* University of Chicago Press. Chicago and London.

Antevs, E.
1948 Climatic Changes and Pre-white Man. In *The Great Basin, With Emphasis on Glacial and Postglacial Times*, pp. 168-191. Bulletin of the University of Utah, Vol. 38 No. 20. University of Utah, Salt Lake City.

Armentrout, L., and R. C. Hanes
1987 Archaeological Survey of the Susie Creek Area, Elko County, Nevada. *Nevada Archaeologist* 6(1):9-22.

Asch, M. I.
1981 Slavey. In *The Subarctic*, ed. J. Helm, pp.338-349. Handbook of North American Indians vol. 6. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Ataman, K. A.
1986 A Group of Projectile Points from Can Hasan III. IV. *Arastírma Sonuçlarí Toplantísí*, pp. 339-346. T.C. Kültür ve Turizm Bakanlígí, Eski Eserler ve Müzeler Genel Müdürlügü, Ankara.

1989 *The Chipped Stone Assemblage from Can Hasan III: A Study in Typology, Technology and Function.* Unpublished Ph.D. dissertation, Institute of Archaeology, University of London.

Ataman, K. A., and W. W. Bloomer
1990 Heat-Treatment and Tool Production at the Tosawihi Quarries. Paper presented at the Great Basin Archaeological Conference, Reno, Nevada.

Audoin, F., and Plisson, H.
1982 Les Ocres et Leurs Temoins au Paléolithique en France: Enquête et Expériences sur la Validité Archaéologique *Les Cahiers du Centre de Rechêrche Préhistorique de Paris* 1 (10).

Bailey, E. H., and D. A. Phoenix
1944 Quicksilver Deposits in Nevada. Nevada State Bureau of Mines and Mackay School of Mines, *Geology and Mining Series* No. 41. Reno.

Bamforth, D. B.
1986 Technological Efficiency and Tool Curation. *American Antiquity* 51(1):38-50.

Bard, J. C.
1980 *A Class III Cultural Resources Inventory of Sierra Pacific Power Company's North Valmy Power Plant Project: Valmy Unit #2 Well Field, Nevada.* Basin Research Associates, Oakland.

Bard, J. C., C. I. Busby, and L. S. Kobori
1979 *Ezra's Retreat: A Rockshelter/Cave in the North Central Great Basin.* Center for Archaeological Research at Davis. Publication No. 6. Davis, California.

Bartlett, M. W., M. S. Enders, and D. C. Hruska
1991 Geology of the Hollister Gold Deposit, Ivanhoe District, Elko County, Nevada. In *Geology and Ore Deposits of the Great Basin: Symposium Proceedings*, ed. G.L. Raines, R.E. Lisle, R.W. Schafer, and W.H. Wilkinson, pp. 957-978. Geological Society of Nevada, Reno.

Barton, R. N. E.
1981 Some Conjoined Artifacts from a New Mesolithic Site at Hengistbury Head, Dorset. *Proceedings of the Dorset Natural History and Archaeological Society.* 103:13-20.

Barton, R. N. E., and C. A. Bergman
1982 Hunters at Hengistbury: Some Evidence from Experimental Archaeology. *World Archaeology* 14(2):237-248.

Basgall, M. E.
1988 The Archaeology of CA-MNO-679: A Pre-Archaic Site in Long Valley Caldera, Mono County, California. In *Early Human Occupations in Far Western North America: The Clovis-Archaic Interface*, ed. Judith A Willig, C. Melvin Aikens, and John L. Fagan, pp.103-120. Nevada State Museum Anthropological Papers, No. 21. Carson City, Nevada.

Baumhoff, M. A., and J. S. Byrne
1959 Desert Side-Notched Points as a Time Marker in California. *University of California Archaeological Survey Reports* 48:32-65. Berkeley.

Beck, C.
1984 *Steen's Mountain Surface Archaeology: The Sites.* Unpublished Ph. D. Dissertation, Department of Anthropology, University of Washington, Seattle.

Bedwell, S. F.
1969 *Prehistory and Environment of the Pluvial Fort Rock Lake Area of Southeastern Oregon.* Unpublished Ph.D. dissertation, Department of Anthropology, University of Oregon, Eugene.

1973 *Fort Rock Basin: Prehistory and Environment.* University of Oregon Books, Eugene, Oregon.

Belovsky, G. E.
1987 Hunter-Gatherer Foraging: A Linear Programming Approach. *Journal of Anthropological Archaeology* 6:29-76.

Benson, W. T.
1956 *Investigation of Mercury Deposits in Nevada and in Malheur County, Oregon.* U.S. Department of Interior, Bureau of Mines Report of Investigations 5285.

Bergman, C. A., and M. H. Newcomer
1983 Flint Arrowhead Breakage: Examples from Ksar Akil, Lebanon. *Journal of Field Archaeology* 10:238-243.

Bettinger, R. L.
1975 *The Surface Archaeology of Owens Valley, Eastern California: Prehistoric Man-Land Relationships in the Great Basin.* Unpublished Ph.D. Dissertation, University of California, Riverside.

1989 *The Archaeology of Pinyon House, Two Eagles, and Crater Middens: Three Residential Sites in Owens Valley, Eastern California.* Anthropological Papers of the American Museum of Natural History 67. New York.

1991 Aboriginal Occupation at High Altitude: Alpine Villages in the White Mountains of Eastern California. *American Anthropologist*, vol. 93(3):656-679.

Bettinger, R. L., and M. A. Baumhoff
1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 47(3):485-503.

Beyries, S.
1983 Fonction et Mode d'utilisation d'une Serie de Lames Ocrées Capsiennes. In *Traces d'utilisation sur les Outils Néolithiques du Proche Orient*. Travaux de la Maison de l'Orient. No. 5:135-139. **No editor listed**

Beyries, S. (editor)
1988 *Industries Lithiques: Tracéologie and Technologié*, 1. Centre de Recherche Archaeologique du C.N.R.S.

Billings, W. D.
1951 Vegetational Zonation in the Great Basin of Western North America. *Union Internationale des Sciences Biologiques*, Series B (Colloques) 9:101-122.

Binford, L. R.
1977 Forty seven Trips: A Case Study in the Character of Archaeological Formation Processes. In *Stone Tools as Cultural Markers*, ed. R.V.S. Wright, pp. 24-36. Australian Institute of Aboriginal Studies, Canberra.

1978a Dimensional Analysis of Behavior and Site Structure: Learning from an Eskimo Hunting Stand. *American Antiquity* 43:330-361.

1978b *Nunamiut Ethnoarchaeology*. Academic Press, New York

1979 Organization and Formation Processes: Looking at Curated Technologies. *Journal of Anthropological Research* 35:255-273.

1980 Willow Smoke and Dogs' Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation. *American Antiquity* 45:4-20.

1981a *Bones: Ancient Men and Modern Myths*. Academic Press, New York.

1981b Behavioral Archaeology and the "Pompeii Premise". *Journal of Anthropological Research* 37(3):195-208.

1982 The Archaeology of Place. *Journal of Anthropological Archaeology* 1(1):5-31.

1983a *In Pursuit of the Past*. Thames and Hudson, New York.

1983b Long Term Land-Use Patterning: Some Implications for Archaeology. In *Working at Archaeology* by Lewis R. Binford, pp. 379-386. Academic Press, New York.

1986 An Alyawara Day: Making Men's Knives and Beyond. *American Antiquity* 51:547-562.

Binford, L. R., and J. F. O'Connell
1984 An Alyawara Day: The Stone Quarry. *Journal of Anthropological Research* 40:406-443.

Binford, L. R., and G. Quimby
1963 Indian Sites and Chipped Stone Materials in the Northern Lake Michigan Area. *Fieldiana-Anthropology* 36:277-307.

Binford, L. R., and N. M. Stone
1985 "Righteous Rocks" and Richard Gould: Some Observations on Misguided "Debate." *American Antiquity* 50(1):151-159.

Blalock, H. M.
1979 *Social Statistics*. McGraw-Hill Book Company, New York.

Bleed, P.
1986 The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51:737-747.

Bobrowsky, P. T., and B. F. Ball
1989 The Theory and Mechanics of Ecological Diversity in Archaeology. In *Quantifying Diversity in Archaeology*, ed. Robert D. Leonard and George T. Jones, pp. 4-12. Cambridge University Press, New York.

Boots, B. N., and A. Getis
1988 *Point Pattern Analysis*. Sage Scientific Geography Series, vol. 8. Sage Publications, Beverly Hills.

Botkin, S. G.
1989 Part V. USX-East Study Area. In *The Tosawihi Quarries: An Archaeological Testing Program*, ed. Robert G. Elston, pp. 251-398. Intermountain Reseach, Silver City, Nevada. Submitted to Galactic Services, Inc. and Ivanhoe Gold Company, Reno.

Botti, N.
1976 Cooperative Soil Survey for Southern Part Washoe County, Soil Survey Area #628 (CR3-79). Ms. on file, Carson City District Office, Bureau of Land Management, Nevada.

1985 *Archaeological Investigations of Rock Creek Dam and Reservoir, Lander County, Nevada*. Archaeological Research Services, Inc., Virginia City, Nevada.

Bradley, B.
1974 Comments on the Lithic Technology of the Casper Site Materials. In *The Casper Site: A Hell Gap Bison Kill on the High Plains*. Academic Press, New York.

Bradley, R. S.
1985 *Quaternary Paleoclimatology*. Allen and Unwin, Boston.

Bradley, R., and M. Edmonds
1988 Fieldwork at Great Langdale, Cumbria, 1985-1987: Preliminary Report. *The Antiquaries Journal*, vol. LXVIII, Part II.

Brauner, D.
1985 *Early Human Occupation in the Uplands of the Southern Plateau: Archaeological Investigations at the Pilcher Creek Site (35UN147), Union County, Oregon*. Department of Anthropology, Oregon State University, Corvallis. Submitted to the U.S. Soil Conservation Service, Portland, Oregon and the National Geographic Society.

Broadbent, N., and K. Knutsson
1975 An Experimental Analysis of Quartz Scrapers: Results and Applications. *Fornvännen* 70:113-128.

Brown, M.
1960 The Climate of Nevada. In *Climates of the States, vol. II, Western States*, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, pp. 779-793. Water Information Center, Port Washington, New York.

Budy, E. E.
1987 Incised Tablets and Polished Stone. In *Archaeological Investigations at Panaca Summit*, by R.G. Elston and K.E. Juell, pp. 79-104. Bureau of Land Management Cultural Resource Series No. 10. Reno.

1988 *An Archaeological Survey of the U.S. Steel Project Area*. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc., Reno, Nevada. Ms. on file, Bureau of Land Management, Elko.

1989 Part IV. USX-West Study Area. In *The Tosawihi Quarries: An Archaeological Testing Program*, ed. Robert G. Elston, pp. 149-250. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc. and Ivanhoe Gold Company, Reno.

Budy, E. E., and R. G. Elston
1986 Feature Descriptions. In *The Archaeology of the Vista Site 26WA3017*, by C.D. Zeier and R.G. Elston, pp. 53-82. Intermountain Research, Silver City, Nevada. Submitted to Cultural Resources Section, Environmental Services Division, Nevada Department of Transportation, Carson City.

Budy, E. E., R. G. Elston, and C. Raven
1989 Introduction. In *The Tosawihi Quarries: An Archaeological Testing Program*, ed. Robert G. Elston, pp. 1-12. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc. and Ivanhoe Gold Company, Reno.

Budy, E. E., and K. Katzer
1990 Chronology of Cultural Occupation. In *The Archaeology of James Creek Shelter*, ed. R.G. Elston and E.E. Budy, pp. 47-56. Anthropological Papers No. 115. University of Utah, Salt Lake City.

Buller, J.
1988 Handling, Hafting and Ochre Stains. In *Industries Lithiques: Tracélogie et Technologie*, ed. Sylvie Beyries. BAR International Series 411(i):5-32.

Burch, Jr., E. S.
1984 Kotzebue Sound Eskimo. In *The Artic*, ed. D. Damas, pp. 303-319. Handbook of North American Indians, vol. 5. William G. Sturtevant, general editor. Smithsonian Institution, Washington D.C.

Burton, J.
1984 Quarrying in a Tribal Society. *World Archaeology* 16:234-247.

Busby, C. I., and J. C. Bard
1979 *A Class III Cultural Resources Inventory of the Sierra Pacific Power Company's Transmission Line Corridor: Valmy to Mira Loma, Nevada*. Basin Research Associates, Oakland.

Butler, B. R.
1970 A Surface Collection from Coyote Flat, Southeastern Oregon. *Tebiwa* 13(1):34-57.

1979 The Native Pottery of the Upper Snake and Salmon River Country. *Idaho Archaeologist* 3(1):1-10.

Butler, B. M., and E. E. May (editors)
1984 *Prehistoric Chert Exploitation: Studies from the Midcontinent*. Center for Archaeological Investigations Occasional Paper No. 2. Southern Illinois University, Carbondale.

Callahan, E.
1979 The Basics of Biface Knapping in the Eastern Fluted Point Tradition: A Manual for Flint Knappers and Lithic Analysts. *Archaeology of Eastern North America* 9(1):1-180.

Callaway, D., J. Janetski, and O. C. Stewart
1986 Ute. In *Great Basin*, ed. W.L. D'Azevedo, pp. 336-367. Handbook of North American Indians, vol 11. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Calley, S., and R. Grace
1988 Technology and function of micro-borers from Kumartepe (Turkey). *Industries Lithiques: Tracéologie et technologie*, ed. Sylvie Beyries. BAR International Series 411(i):69-82.

Camilli, E. L.
1989 The Occupational History of Sites and the Interpretation of Prehistoric Technological Systems: An Example from Cedar Mesa, Utah. In *Time, Energy and Stone Tools*, ed. Robin Torrence, pp. 17-26. Cambridge University Press, Cambridge.

Campbell, E. W. C., and W. H. Campbell
1935 The Pinto Basin Site: An Ancient Aboriginal Camping Ground in the California Desert. *Southwest Museum Papers* No. 9. Los Angeles.

1940 A Folsom Complex in the Great Basin. *The Masterkey* 14(1):7-11.

Carambelas, K., and S. Raven
1991 Actualistic Quarrying Experiments at Tosawihi. Paper presented at the 56th meeting of the Society for American Archaeology, New Orleans.

Cauvin, M. C., G. Deraprahamian, et D. Helmer
1987 Grattoirs à Pans Coupées Convergents de Mureybet (Syrie) du 8e Millénaire: Définition, Essai de Fabrication et Emmanchement. In *La Main et Outil: Manches et Emmanchements Préhistorique*, pp.257-268. Maison de l'Orient. Lyon. **No editor listed**

Chadwick, O. A., and J. O. Davis
1990 Soil-Forming Intervals Caused by Eolian Sediment Pulses in the Lahonton Basin, Northwestern Nevada. *Geology* 18:243-246.

Charnov, E. L.
1976 Optimal Foraging: The Marginal Value Theorem. *Theoretical Population Biology* 9:129-136.

Christaller, W.
1933 *Die zentralen Orte in Suddeutchland*. Jena. [trans. by C.W. Baskin, 1966, as *Central Places in Southern Germany*, Prentice-Hall, Englewood Cliffs].

Clark, P. J., and F. C. Evans
1954 Distance to Nearest Neighbor as a Measure of Spatial Relationships in Populations. *Ecology* 35:445-453.

Clay, V. L., and M. L. Hemphill
1986 *An Evaluation of Five Sites in the Proposed Rock Creek Dam and Reservoir Project Area, Lander County, Nevada*. A.R.S., Virginia City. Submitted to SEA Engineers, Reno, and Lander County Board of Commissioners, Battle Mountain, Nevada.

Cleveland, W. S.
1979 Robust Locally Weighted Regression and Smoothing Scatterplots. *Journal of the American Statistical Association* 74:829-836.

1981 LOWESS: A Program for Smoothing Scatterplots by Robust Locally Weighted Regression. *The American Statistician* 38:261-269.

1985 *The Elements of Graphing Data.* Wiley-Interscience, New York.

Clewlow, C. W.
1967 Time and Space Relations of Some Great Basin Projectile Point Types. *University of California Archaeological Survey Reports* 70:141-150. Berkeley.

1968 Surface Archaeology of the Black Rock Desert, Nevada. *Reports of the University of California Archaeological Survey* 73:1-93. Berkeley.

Close, A. E.
1979 The Identification of Style in Lithic Artifacts. *World Archaeology* 10(2):223-236.

1989 Identifying Style in Lithic Artefacts: A Case Study from the Nile Valley. In *Alternative Approaches to Lithic Analysis*, ed. Donald O. Henry and George H. Odell, pp.3-26. Archaeological Papers of the American Anthropological Association No. 1. Washington, D.C.

Coats, R. R.
1987 *Geology of Elko County, Nevada.* Nevada Bureau of Mines and Geology Bulletin 101. University of Nevada, Reno.

Coffin, P. D.
1984 *Fishes of Nevada.* Nevada Department of Wildlife. Reno.

Cornucopia
1987 Unpublished Geologic Maps of the Ivanhoe Project Area, Elko County, Nevada. Produced by Touchstone Resources, Battle Mountain, Nevada.

Cotterell, B., and J. Kamminga
1979 The Mechanics of Flaking. In *Lithic Use-Wear Analysis*, ed. Brian Hayden, pp. 97-112. Academic Press, New York.

1987 The Formation of Flakes. *American Antiquity* 52(4):675-708.

Crabtree, D. E.
1966 A Stoneworker's Approach to Analyzing and Replicating the Lindenmeier Folsom. *Tebiwa* 9:3-39.

1972 An Introduction to Flintworking. *Occasional Papers of the Idaho State Museum* 28.

Crabtree, D. E., and B. R. Butler
1964 Notes on Experiments in Flintknapping: I. Heat Treatment of Silica Minerals. *Tebiwa* 7(1):1-6.

Crittenden, L., and R. G. Elston
1981 *A Class II Cultural Resource Reconnaissance of the Saval Ranch Research and Evaluation Area, Elko Coulty, Nevada.* Agricultural Experiment Station, Fleischmann College of Agriculture, University of Nevada, Reno.

Cronquist, A., A. H. Holmgren, N. H. Holmgren, J. L. Reveal, and P. K. Holmgren
1977 *Intermountain Flora: Vascular Plants of the Intermontane West, U.S.A., Vol. 6, The Monocotyledons*. Columbia University Press, New York.

Dalley, G. F.
1970 Worked Bone and Antler. In *Median Village and Fremont Culture Regional Variation*, by John P. Marwitt, pp. 96-127. University of Utah Anthropological Papers No. 95. Salt Lake City.

1976 *Swallow Shelter and Associated Sites*. University of Utah Anthropological Papers No. 96, Salt Lake City.

Daly, P.
1969 Approaches to Faunal Analysis in Archaeology. *American Antiquity* 34:146-153.

Dansie, A.
1982 Faunal Data. In *Archaeological Investigations at the Rossi Mine Sites, Elko County, Nevada*, by Mary K. Rusco, pp. 46-48. Nevada State Museum Archaeological Services Reports, Carson City.

1984 Human and Carnivore Modification of Small Mammals in the Great Basin. Paper presented at the First International Bone Modification Conference, Carson City.

Dansie, A., and T. Ringkob
1979 Faunal Analysis of the Glendale Site Assemblages. In *The Archaeology of the Glendale Site (26WA2065)*, by Margaret M. Miller and Robert G. Elston, pp. 184-220. Nevada Archaeological Survey, University of Nevada, Reno. Submitted to the Nevada Department of Transportation, Carson City.

Davis, D. D. (editor)
1978 *Lithics and Subsistence: The Analysis of Stone Tool Use in Prehistoric Economies*. Vanderbilt University Publication in Anthropology No. 20. Nashville, Tennessee.

Davis, E. L.
1964 An Archaeological Survey of Mono Lake Basin and Excavations of Two Rock Shelters, Mono County, California. *University of California Archaeological Survey Annual Report* 1963-64. Los Angeles.

Davis, E. L. (editor)
1978a *The Ancient Californians: Rancholabrean Hunters of the Mojave Lakes Country*. Natural History Museum of Los Angeles County Science Series 29. Los Angeles

1978b Associations of People and a Rancholabrean Fauna at China Lake in Early Man in America from a Circum-Pacific Perspective. *Occasional Papers* No. 1, Department of Anthropology, University of Alberta. Edmonton, Alberta, Canada: Archaeological Researches International.

Davis, E. L., and R. Shutler, Jr.
1969 Recent Discoveries of Fluted Points in California and Nevada. *Nevada State Museum Anthropological Papers* 14. Carson City.

Davis, J. O.
1978a *Quaternary Tephrochronology of the Lake Lahontan Area, Nevada and California*. Nevada Archeological Survey Research Paper No. 7. University of Nevada, Reno.

1978b Late Sehoo Discharge of the Humboldt River: Stratigraphic Archaeology at the North Valmy Power Plant, Humboldt County, Nevada (abstract). Geological Society of America, Abstracts with Programs 10(7):366.

1982 Bits and Pieces: The Last 35,000 Years in the Lahontan Area. In *Man and Environment in the Great Basin*, eds. D. B. Madsen and J.F. O'Connell, pp. 53-75. Society of American Archaeology Papers No. 2.

Davis, J. O., D. D. Fowler, and M. K. Rusco
1976 *Archaeological Investigations Near Treaty Hill, Humboldt County, Nevada.* Desert Research Institute, Social Science Center, Technical Report No. 2. Reno.

Dean, P. W.
1983 Black Rock Cave Ceramics. In *Black Rock Cave Revisited*, by David B. Madsen, pp. 60-66. Bureau of Land Management Cultural Resource Series No. 14, Salt Lake City, Utah.

Del Bene, T. A.
1979 Once upon a Striation: Current Models of Striation and Polish Formation. In *Lithic Use-Wear Analysis*, ed. B. Hayden. pp. 167-177. Academic Press, New York.

Deng, Q., and R. Gosse
1990 Unpublished geologic map prepared for Touchstone Resources Company, Battle Mountain, Nevada.

Dodson, P., and D. Wexlar
1979 Taphonomic Investigation of Owl Pellets. *Paleobiology* 5:275-284.

Downs, J. F.
1966 *The Two Worlds of the Washo.* Holt, Rinehart and Winston, New York.

Drews, M. P.
1986 Groundstone. In *The Archaeology of the Vista Site (26WA3017)*, ed. C.D. Zeier and R.G. Elston, pp. 253-274. Intermountain Research, Silver City, Nevada. Submitted to Environmental Services Division, Nevada Department of Transportation, Carson City.

1988 *An Intensive Archaeological Reconnaissance of the Proposed Ivanhoe/USX Access Road.* Report submitted to Galactic Services, Inc., Reno, Nevada. Intermountain Research, Silver City, Nevada. Ms. on file, Bureau of Land Management, Elko.

1990 Projectile Point Chronology. In *The Archaeology of James Creek Shelter*, ed. Robert G. Elston and Elizabeth E. Budy, pp. 77-86. University of Utah Anthropological Papers No. 115. Salt Lake City.

Drews, M. P., R. G. Elston, M. Leach, C. Raven, and D. N. Schmitt
1989 Summary and Conclusions. In *The Tosawihi Quarries: An Archaeological Testing Program*, ed. R.G. Elston, pp. 397-415. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services and Ivanhoe Gold Company, Reno.

Drews, M. P., and D. N. Schmitt
1986 Other Prehistoric Artifacts. In *The Archaeology of the Vista Site (26Wa3017)*, ed. C.D. Zeier and R.G. Elston, pp. 238-310. Intermountain Research, Silver City, Nevada. Submitted to Environmental Services Division, Nevada Department of Transportation, Carson City.

Duffé, L. D.
1976a "Tosawi Chert" Project Progress Report. Draft manuscript in author's possession.

1976b Tosawi Chert Project. Paper presented at the 15th Great Basin Anthropological Conference. Las Vegas.

Earle, T. K.
1980 A Model of Subsistence Change. In *Modeling Change in Prehistoric Subsistence Economies*, ed. Timothy K. Earle and Andrew L. Christensen, pp. 1-29. Academic Press, New York.

Eckert, R. E., Jr., F. Peterson, M. K. Wood, W. Blackburn, and J. L. Stephens
1989 *The Role of Soil-Surface Morphology in the Function of Semiarid Rangelands.* Nevada Agricultural Experiment Station Technical Bulletin 89(1). University of Nevada, Reno.

Ellis, C. J., and J. C. Lothrop (editors)
1989 *Eastern Paleoindian Lithic Resource Use.* Westview Press. Boulder, Colorado.

Elston, R. G.
1982 Good Times, Hard Times: Prehistoric Culture Change in the Western Great Basin. In *Man and Environment in the Great Basin*, ed. D.B. Madsen and J.F. O'Connell, pp. 186-206. Society for American Archaeology Papers No. 2. Washington, D.C.

1986a Prehistory of the Western Area. In *Great Basin*, ed. Warren L. d'Azevedo, pp. 135-148. Handbook of North American Indians, vol. 11. William G. Sturtevant, general editor. Smithsonian Institute, Washington, D.C.

1986b Flaked Stone Artifacts. In *The Archaeology of the Vista Site (26Wa3017)*, ed. C.D. Zeier and R.G. Elston, pp. 103-174. Intermountain Research, Silver City, Nevada. Submitted to Environmental Services Division, Nevada Department of Transportation, Carson City.

1986c *The Structural Analysis of Lithic Production Systems.* Unpublished Ph.D. dissertation, Washington State University.

1986d *A Class III Survey of the Proposed Crofoot Mine, Humboldt County, Nevada.* Intermountain Research, Silver City, Nevada. Submitted to Resource Concepts, Carson City, Nevada.

1988a *A Theoretical Approach to the Archaeology of Tosawihi Quarries.* Research design prepared for Galactic Services, Inc., Reno, Nevada. Ms. on file Elko District Office, Bureau of Land Management.

1988b Research Approach: Issues Relevant to the Ivanhoe Project Area. In *An Archaeological Data Recovery Plan for the Ivanhoe Project*, ed. Elizabeth E. Budy and Robert G. Elston, pp. 15-46. Submitted to Galactic Services, Inc., Reno, Nevada. Intermountain Research, Silver City, Nevada. Ms. on file Bureau of Land Management, Elko.

1988c Flaked Stone Tools. In *Preliminary Investigations in Stillwater Marsh: Human Prehistory and Geoarchaeology*, ed. Christopher Raven and Robert G. Elston, pp. 155-183. Cultural Resource Series No. 1. U.S. Fish and Wildlife Service, Region 1, Portland, Oregon.

1990 Costs and Benefits of Biface Manufacture at Tosawihi Quarries: Risk, Transport and Utility. Paper presented at the 1990 Great Basin Anthropological Conference, Reno, Nevada.

Elston, R. G. (editor)
1989 *The Tosawihi Quarries: An Archaeological Testing Program.* Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc. and Ivanhoe Gold Company, Reno, Nevada.

Elston, R. G., and E. E. Budy (editors)
1990 *The Archaeology of James Creek Shelter.* University of Utah Anthropological Papers No. 115. Salt Lake City.

Elston, R. G., J. O. Davis, S. Clerico, R. Clerico, and A. Becker
1981 *Archaeology of Section 20, North Valmy Power Plant, Humboldt County, Nevada.* University of Nevada, Desert Research Institute, Social Sciences Technical Report 19. Reno.

Elston, R. G., and K. Juell
1987 *Archaeological Investigations at Panaca Summit.* Cultural Resource Series No. 10. Bureau of Land Management, Reno, Nevada.

Elston, R. G., C. Raven, and E. E. Budy
1987 *An Intensive Reconnaissance of the Tosawihi Quarries Archaeological District (Site 26Ek3032).* Report prepared for Touchstone Resources Company, Battle Mountain, Nevada. Ms. on file at Elko District Office, Bureau of Land Management, Elko, Nevada.

Elston, R. G., and D. Turner
1968 *An Archaeological Reconnaissance of the Southern Truckee Meadows, Washoe County, Nevada.* Ms. on file, Archeological Survey, University of Nevada, Reno.

Elston, R. G., C. D. Zeier
1984 *The Sugarloaf Obsidian Quarry.* NWS Administrative Publication 313. Technical Information Department, Naval Weapons Center, China Lake, California.

Ericson, J. E.
1977 Egalitarian Exchange Systems in California: A Preliminary View. In *Exchange Systems in Prehistory* ed. Timothy K. Earl and Jonathon E. Ericson, pp. 109-126. Academic Press. New York.

1984 Toward the Analysis of Lithic Production Systems. In *Prehistoric Quarries and Lithic Production,* edited by Jonathon E. Ericson and Barbara A. Purdy, pp.1-9. Cambridge University Press. Cambridge.

Ericson, J. E., and T. K. Earle (editors)
1982 *Contexts for Prehistoric Exchange.* Academic Press, New York.

Ericson, J. E., and B. A. Purdy (editors)
1984 *Prehistoric Quarries and Lithic Production.* Cambridge University Press.

Everitt, B. S.
1977 *The Analysis of Contingency Tables.* John Wiley and Sons, New York.

Fagan, J. L.
1984 The Dietz Site: A Clovis Base Camp in South-Central Oregon. Paper presented at the 49th Annual Meeting of the Society of American Archaeology, Portland, Oregon.

Fedje, D.
1979 Scanning Electron Microscopy Analysis of Use-Striae. In *Lithic Use-Wear Analysis,* ed. B. Hayden, pp. 179-187. Academic Press, New York.

Fiero, B.
1986 *Geology of the Great Basin.* University of Nevada Press, Reno.

Findlow, F. J., and M. Bolognese
1984 Economic Aspects of Prehistoric Quarry Use: A Case Study in the American Southwest. In *Prehistoric Quarries and Lithic Production*, ed. Jonathan E. Ericson and Barbara A. Purdy, pp. 77-82. Cambridge University Press.

Fischer, A., P. E. Hansen, and P. Rasmussen
1984 Macro and Micro-wear Traces on Lithic Projectile Points: Experimental Results and Examples. *Journal of Danish Archaeology* 3:19-46.

Flenniken, J. J.
1978 Reevaluation of the Lindenmeier Folsom: A Replication Experiment in Lithic Technology. *American Antiquity* 43:473-480.

1981 Replicative Systems Analysis: A Model Applied to the Vein Quartz Artifacts from the Hoko River Site. *Reports of Investigations*, Laboratory of Anthropology, Washington State University, Number 59. Pullman.

1984 The Past, Present, and Future of Flintknapping: An Anthropological Perspective. *Annual Review of Anthropology* 13:187-203.

1985 Reduction Techniques as Cultural Markers. In *Stone Tool Analysis: Essays in Honor of Don Crabtree*, ed. M.G. Plew, J.C. Woods, and M.G. Pavesic, pp. 265-276. University of New Mexico Press, Albuquerque.

1987 *The Lithic Technology of the East Lake Site, Newberry Crater, Oregon*. Lithic Analysts Research Report, No. 1.

Flenniken, J. J., and J. C. Haggarty
1979 Trampling as an Agency in the Formation of Edge Damage: An Experiment in Lithic Technology. *Northwest Anthropological Research Notes* 13(2):208-214.

Flenniken, J. J., and T. L. Ozbun
1988 *Archaeological Investigations in Newberry Crater, Deschutes National Forest, Central Oregon*. Lithic Analysts Research Report, No. 4.

Flenniken, J. J., and A. W. Raymond
1986 Morphological Projectile Point Typology: Replication Experimentation and Technological Analysis. *American Antiquity* 51:603-614.

Flenniken, J. J., and P. J. Wilke
1989 Typology, Technology, and Chronology of Great Basin Dart Points. *American Anthropologist* 91(1):149-158.

Fowler, C. S.
1986 Subsistence. In *Great Basin*, ed. Warren L. d'Azevedo, pp. 64-97. Handbook of North American Indians, vol. 11. William G. Sturtevant, general editor. Smithsonian Institution, Washington.

Fowler, C. S., and S. Liljeblad
1986 Northern Paiute. In *Great Basin*, ed. W.L. d'Azevedo, pp. 435-465. Handbook of North American Indians, vol. 11. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Fowler, D. D.
1968 *Archaeological Survey in Eastern Nevada, 1966*. Desert Research Institute Publications in Social Sciences and Humanities No. 2. Reno.

Fowler, D. D., and C. S. Fowler
1971 *Anthropology of the Numa: John Wesley Powell's Manuscripts on the Numic Peoples of Western North America 1868-1880.* Smithsonian Contributions to Anthropology 14. Washington, D.C.

Fowler, D. D., D. B. Madsen, and E. M. Hattori
1973 *Prehistory of Southeastern Nevada.* Desert Research Institute Publications in the Social Sciences No. 6. Reno.

Frison, G. C.
1967 The Piney Creek Sites, Wyoming. *University of Wyoming Publications* 33(1):1-92.

1978 *Prehistoric Hunters of the High Plains.* Academic Press. New York, San Francisco, London.

1979 Observations on the Use of Stone Tools: Dulling of Working Edge of Some Chipped Stone Tools in Bison Butchering. In *Lithic Use-Wear Analysis*, ed. B. Hayden. pp. 259-268. Academic Press, New York.

Frison, G. C., and B. A. Bradley
1980 *Folsom Tools and Technology at the Hanson Site, Wyoming.* University of New Mexico Press, Albuquerque.

Frison, G. C., and D. J. Stanford (editors)
1982 The Agate Basin Site: A Record of Paleoindian Occupation of the Northwestern High Plains. Academic Press, New York.

Gallagher, J. P.
1977 Contemporary Stone Tools in Ethiopia: Implications for Archaeology. *Journal of Field Archaeology* 4:407-414.

Gibson, E. C.
1982 Upper Paleolithic Flintknapping Specialists? The Evidence from Corbiac, France. *Lithic Technology* 11(3):41-49.

Gifford, D. P.
1981 Taphonomy and Paleoecology: A Critical Review of Archaeology's Sister Disciplines. In *Advances in Archaeological Method and Theory*, Vol. 4, ed. Michael B. Schiffer, pp. 365-438. Academic Press, New York.

Gilbert, C. H., and B. W. Evermann
1985 A Report upon Investigations in the Columbia River Basin, with Description of Four New Species of Fish. *U.S. Fish Commission Bulletin* 14:169-202. Washington, D.C.

Goddard, P. E.
1903 Life and Culture of the Hepa. *University of California Publications in American Archaeology and Ethnography* 1(1):1-88.

Goodyear, A. C.
1979 *A Hypothesis for Use of Cryptocrystalline Raw Materials Among Paleo-Indian Groups of North America.* Research Manuscript Series 156. Institute of Archaeology and Anthropology, University of South Carolina, Columbia.

1985 Lithic Production for the Future: Quarry Behavior Among Early Hunter-Gatherers in South Carolina. Paper presented at the 50th Meeting of the Society for American Archaeology, Denver.

Gould, R. A.
1977 Ethno-archaeology; or Where Do Models Come From? In *Stone Tools as Cultural Markers, Change, Evolution and Complexity*, ed. R.V.S. Wright, pp. 162-168. Prehistory and Material Culture Series 12. Australian Institute of Aboriginal Studies.

1980 *Living Archaeology*. Cambridge University Press.

1985 The Empiricist Strikes Back: Reply to Binford. *American Antiquity* 50(3):638.

Gould, R. A., D. A. Koster, and A. H. L. Sontz
1971 The Lithic Assemblage of the Western Desert Aborigines of Australia. *American Antiquity* 26:149-169.

Gould, R. A., and S. Saggers
1985 Lithic Procurement in Central Australia: A Closer Look at Binford's Idea of Embeddedness in Archaeology. *American Antiquity* 50(1):117-136.

Grace, R., K. Ataman, R. Fabregas, and C. M. B. Haggren
1988 A Multivariate Approach to the Functional Analysis of Stone Tools. In *Industries Lithiques: Tracéologie et Technologie*, ed. S. Beyries. BAR International Series 411:217-230. Oxford.

Gramly, R. M.
1980 Raw Materials Source Areas and "Curated" Tool Assemblages. *American Antiquity* 45:823-833.

Grayson, D. K.
1977 On the Holocene History of Some Northern Great Basin Lagomorphs. *Journal of Mammalogy* 58(4):507-513.

1981 The Effects of Sample Size on Some Derived Measures in Vertebrate Faunal Analysis. *Journal of Archaeological Science* 8(1):77-88.

1982 Toward a History of Great Basin Mammals During the Past 15,000 Years. In *Man and Environment in the Great Basin*, ed. D.B. Madsen, and J.F. O'Connell, pp. 82-101. SAA Papers No. 2. Society for American Archaeology, Washington, D.C.

1983 The Paleontology of Gatecliff Shelter: Small Mammals. In *The Archaeology of Monitor Valley 2. Gatecliff Shelter*, by D.H. Thomas, pp. 99-126. Anthropological Papers of the American Museum of Natural History 59(1). New York.

1984 *Quantitative Zooarchaeology*. Academic Press, New York.

1985 The Paleontology of Hidden Cave: Birds and Mammals.In *The Archaeology of Hidden Cave, Nevada*, ed. D.H. Thomas, pp. 125-161. Anthropological Papers of the American Museum of Natural History 61(1). New York.

1988 *Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas*. Anthropological Papers of the American Museum of Natural History 66(1). New York.

1990 The James Creek Shelter Mammals. In *The Archaeology of James Creek Shelter*, ed. R.G. Elston and E.E. Budy, pp. 87-98. University of Utah Anthropological Papers No. 115. Salt Lake City.

Greiser, S. T.
1977 Micro-analysis of Wear Patterns on Projectile Points and Knives from the Jurgens Site, Kersey, Colorado. *Plains Anthropologist* 22:107-116.

Griffiths, D. R., C. A. Bergman, C. J. Clayton, K. Ohnuma, G. V. Robins, and N. J. Seeley
1987 Experimental Investigation of the Heat-Treatment of Flint. In *The Human Uses of Flint and Chert*, ed. G. de G. Sieveking, and M.H. Newcomer, pp. 43-52. Proceedings of the 4th International Flint Symposium, 10-15 April, 1983, Brighton Polytechnic, Cambridge. Cambridge University Press.

Griset, S.
1986 Notes on Ceramic Analysis. In *Pottery of the Great Basin and Adjacent Areas*, ed. S. Griset, pp. 119-124. University of Utah Anthropological Papers No. 111, Salt Lake City.

Grosscup, G. L.
1956 The Archaeology of the Carson Sink Area. *University of California Archaeological Survey Reports* No. 33. Berkeley.

Gruhn, R.
1961 *The Archaeology of Wilson Butte Cave, South Central Idaho.* Occasional Papers No. 6. Idaho State College Museum, Pocatello.

Hall, R. E.
1946 *Mammals of Nevada.* University of California Press, Berkeley.

1981 *The Mammals of North America*, 2nd edition. John Wiley and Sons, New York.

Harrington, M. R.
1933 *Gypsum Cave, Nevada.* Southwest Museum Papers No. 8. Los Angeles.

1951 A Colossal Quarry. *Masterkey* 25(1):14-18.

Harris, J. S.
1940 The White Knife Shoshoni of Nevada. In *Acculturation in Seven American Indian Tribes*, ed. Ralph Linton, pp. 39-116. Appleton-Century, New York.

Hattori, E. M.
1982 *The Archaeology of Falcon Hill, Winnemucca Lake, Washoe County, Nevada.* Nevada State Museum Anthropological Papers No. 18. Carson City.

Hayden, B.
1979a *Paleolithic Reflections: Lithic Technology and Ethnographic Excavations Among Australian Aborigines.* Humanities Press. Highlands, New Jersey.

1979b Snap, Shatter and Superfractures: Use-wear of Stone Skin Scrapers. In *Lithic Use-Wear Analysis*, ed. B. Hayden, pp. 207-229. Academic Press, New York.

Hayden, B., and W. K. Hutchings
1989 Whither the Billet Flake? In *Experiments in Lithic Technology*, ed. D.S. Amick and R.P. Mauldin, pp. 235-257. BAR International Series 528. Oxford.

Haynes, C. V., Jr.
1964 Flute and Projectile Points: Their Age and Dispersion. *Science* 145:1407-1413.

Heizer, R. F.
1974 Decorated Stone Discs from the Lower Humboldt Valley, Nevada. In *Four Papers on Great Basin Anthropology*. Contributions of the University of California Research Facility 21:65-70. Berkeley.

Heizer, R. F., and M. Baumhoff
1961 *The Archaeology of Two Sites at Eastgate, Churchill County, Nevada: Wagon Jack Shelter*. Anthropological Records 20(4):119-149. University of California, Berkeley.

Heizer, R. F., M. A. Baumhoff, and C. W. Clewlow, Jr.
1968 Archeology of South Fork Shelter (NV-EL-11), Elko County, Nevada. *University of California Archaeological Survey Reports* 71:1-58. Berkeley.

Heizer, R. F., and R. M. Berger
1970 Radiocarbon Age of the Gypsum Culture. *University of California Archaeological Survey Reports* 7:13-18. Berkeley.

Heizer, R. F., and C. W. Clewlow, Jr.
1968 Projectile Points from Site NV-Ch-15, Churchill County, Nevada. *University of California Archaeological Survey Reports* 71:59-88. Berkeley.

Heizer, R. F., and T. R. Hester
1973 *Review and Discussion of Great Basin Projectile Points: Forms and Chronology*. Contributions of the University of California Archaeological Research Facility. Berkeley.

1978 Great Basin. In *Chronologies in New World Archaeology*, ed. R.E. Taylor, and C.W. Meighan. Academic Press, New York.

Heizer, R. F., and A. D. Kreiger
1956 Humboldt Cave, Churchill County, Nevada. *University of California Publications in American Archaeology and Ethnology* 47(1). University of California Press, Berkeley.

Heizer, R. F., and L. K. Napton
1970 *Archaeology and the Prehistoric Great Basin Lacustrine Subsistence Regime as seen from Lovelock Cave, Nevada*. Contributions of the University of California Archaeological Research Facility No. 10. Berkeley.

Hester, T. R.
1974 Archaeological Materials from Site NV-WA-197, Western Nevada: Atlatl and Animal Skin Pouches. In *Four Papers on Great Basin Archaeology*. Contributions of the University of California Archaeological Research Facility 21:1-44.

Hester, T. R., and W. I. Follett
1976 Yukon Fish Knives: A Study of Wear Patterns and Adhering Salmon Scales. In *Experiment and Function: Four California Studies*. Contributions of the University of California Archaeological Research Facility 33:3-23.

Hester, T. R., L. Spencer, C. Busby, and J. Bard
1976 Butchering a Deer with Obsidian Tools. *Contributions of the University of California Archaeological Research Facility* 33:47-56.

Hicks, P. A.
1989 *A Class III Cultural Resources Inventory of 3698 Acres in Elko and Eureka Counties, Nevada, for Barrick Goldstrike Mines*, Inc. Desert Research Institute Report 8806. Bureau of Land Management Report 1-1244(p). Ms. on file, Bureau of Land Management, Elko.

Hockett, B. S.
1989 Burned Bones in Woodrat Nests from Northwestern Nevada. *Current Research in the Pleistocene* 6:41-42.

Hodder, I., and C. Orton
1976 *Spatial Analysis in Archaeology*. Cambridge University Press, Cambridge.

Hofman, J. L., L. C. Todd, and M. B. Collins
1991 Identification of Central Texas Edwards Chert at The Folsom and Lindenmeier Sites. *Plains Anthropologist* 36(137):297-308.

Hollister, V. F.
1986 *Report on the Ivanhoe District, Elko County, Nevada, on Behalf of Cornucopia Resources*. Nevada Bureau of Mines and Geology, File 62-Ivanhoe, Item 22. Reno.

Holmer, R. N.
1986 Common Projectile Points of the Intermountain West. In *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings*, ed. Carol J. Condie and Don D. Fowler, pp. 89-115. University of Utah Anthropological Papers 110. Salt Lake City.

Holmes, W. H.
1897 Stone Implements of the Potomac-Chesapeake Tidewater Province. Fifteenth Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution. Washington, D.C.

1919 Handbook of Aboriginal American Antiquities. Part I, Introductory: The Lithic Industries. *Smithsonian Institution, Bureau of American Ethnology Bulletin* 60. Reprinted as Burt Franklin: Research and Source Works Series American Classics in History and Social Science 256. Lenox Hill Publishing and Distribution Company. New York.

Honea, K.
1983 *Lithic Technology: An International Annotated Bibliography 1725-1980*, ed. Susanna R. Katz, and Paul R. Katz. Lithic Technology Special Publication No. 2. Center for Archaeological Research, University of Texas at San Antonio.

Houghton, J. G., C. M. Sakamoto, and R. O. Gifford
1975 *Nevada's Weather and Climate*. Nevada Bureau of Mines and Geology Special Publication 2. Reno.

Howes, D.
1980 Obsidian Butcher Knives: The Formation of Edge Damage on Unmodified Blades. *Northwest Anthropological Research Notes* 14:135-44.

Huckell, B.
1978 "Push" vs. "Pull" Flakery: A Reply to Patten. *Lithic Technology* 7(3):42-43.

Hughes, R. E.
1983 X-ray Fluorescence Characterization of Obsidian. In *The Archaeology of Monitor Valley 2. Gatecliff Shelter*, by David H. Thomas, pp. 401-408. Anthropological Papers of the American Museum of Natural History 59:Part 1. New York.

1990 Obsidian Sources at James Creek Shelter, and Trace Element Geochemistry of Some Northeastern Nevada Volcanic Glass. In *The Archaeology of James Creek Shelter*, ed. Robert G. Elston and Elizabeth E. Budy, Appendix C. University of Utah Anthropological Papers No. 115. Salt Lake City.

Hughes, R. E. (editor)
1984 Obsidian Studies in the Great Basin: Problems and Prospects. *Contributions of the University of California Archaeological Research Facility* 45. University of California, Berkeley.

Hughes, R. E., and J. A. Bennyhoff
1986 Early Trade. In *Great Basin*, ed. W.L. d'Azevedo, pp. 238-255. Handbook of North American Indians, vol. 11. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Hughes, R. E., and R. L. Bettinger
1984 Obsidian and Prehistoric Sociocultural Systems in California. In *Exploring The Limits: Frontiers and Boundaries in Prehistory*, ed. Suzanne P. De Atley and Frank J. Findlow. British Anthropological Reports International Series 223.

Hull, F. W., and N. M. White
1980 Spindle Whorls, Incised and Painted Stone, and Unfired Clay Objects. In *Cowboy Cave*, by Jesse D. Jennings, pp. 117-125. University of Utah Anthropological Papers No. 104. Salt Lake City.

Ingbar, E. E.
1985 Analysis of Hidden Cave Feature Morphology. In *The Archaeology of Hidden Cave, Nevada*, ed. D.H. Thomas, pp. 307-321. Anthropological Papers of the American Museum of Natural History, Vol. 1(1).

Ingbar, E. E., M. L. Larson, and B. A. Bradley
1989 A Nontypological Approach to Debitage Analysis. In *Experiments in Lithic Technology*, ed. Daniel Amick and Raymond Mauldin, pp. 117-136. British Anthropological Reports, International Series, 528.

Intermountain Research
1987 *A Draft Cultural Resources Management Plan for the Tosawihi Quarries Archaeological Site, Elko County, Nevada*. Intermountain Research, Silver City, Nevada.

1988a *An Archaeological Data Recovery Plan for the Ivanhoe Project, Volume 1: Introductory and Background Information*. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc., Reno, Nevada. Ms. on file, Bureau of Land Management, Elko.

1988b *An Archaeological Data Recovery Plan for the Ivanhoe Project, Volume 2: Data Recovery in the USX-West and USX-East Activity Areas*. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc., Reno, Nevada. Ms. on file, Bureau of Land Management, Elko.

1988c *An Archaeological Data Recovery Plan for the Ivanhoe Project, Volume 3: Data Recovery in the USX Access Road, Office Compound, and Causeway Activity Areas*. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc., Reno, Nevada. Ms. on file, Bureau of Land Management, Elko.

1988d *An Archaeological Data Recovery Plan for the Ivanhoe Project, Volume 4: Data Recovery in the USX-West and Main Access Road Activity Areas*. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc., Reno, Nevada. Ms. on file, Bureau of Land Management, Elko.

Irving, W.
1837 *The Adventures of Captain Bonneville, U.S.A., in the Rocky Mountains and the Far West*. Putnam, New York.

Isard, W.
1956 *Location and Space-Economy*. Technology Press, Massachusetts Institute of Technology. New York.

Jackson, T. L.
1988 Amending Models of Trans-Sierra Obsidian Tool Production and Exchange. *Journal of California and Great Basin Anthropology* 10(1):62-72.

James, S. R.
1986 What Mean these Sherds? A Functional Approach to Fremont Ceramics in the Western Periphery. In *Pottery in the Great Basin and Adjacent Areas*, ed. S. Griset, pp. 107-118. University of Utah Anthropological Papers No. 111, Salt Lake City.

James, S. R. (editor)
1981 Prehistory, Ethnohistory, and History of Eastern Nevada: A Cultural Resources Summary of the Elko and Ely Districts. *Bureau of Land Management, Nevada, Cultural Resources Series* No. 3.

Janetski, J. C.
1979 Implications of Snare Bundles in the Great Basin and Southwest. *Journal of California and Great Basin Anthropology*. 1:306-321.

Janetski, J. C., F. Nelson, and J. D. Wilde
1988 *The Loa Obsidian Cache*. Utah Archaeology 1(1):57-65.

Jennings, J. D.
1957 *Danger Cave*. University of Utah Anthropological Papers No. 27. Salt Lake City.

Jensen, J.
1988 Microdenticulates in the Danish Stone Age: A Functional Puzzle. In *Industries Lithiques: Tracélogie et Technologie*, ed. Sylvie Beyries. BAR International Series 411:231-253. Oxford.

Johnson, J. K.
1979 Archaic Biface Manufacture: Production Failures, A Chronicle of the Misbegotten. *Lithic Technology* VIII(2):25-35.

1981 *Lithic Procurement and Utilization Trajectories: Analysis, Yellow Creek Nuclear Power Plant Site, Tishomingo County, Mississippi*, Vol. II. Center for Anthropological Research, University of Mississippi, Archaeological Papers No. 1.

1989 The Utility of Production Trajectory Modeling as a Framework for Regional Analysis. In *Alternative Approaches to Lithic Analysis*, ed. D.O. Henry and G.H. Odell, pp. 119-138. Anthropological Papers of American Anthropological Association No. 1.

Johnson, J. K., and C. A. Morrow (editors)
1987 *The Organization of Core Technology*. Westview Press. Boulder, Colorado.

Jones, G. T., C. Beck, and D. K. Grayson
1989 Measures of Diversity and Expedient Lithic Technologies. In *Quantifying Diversity in Archaeology*, ed. R.D. Leonard and G.T. Jones, pp. 69-78. Cambridge University Press.

Jones, G. T., D. K. Grayson, and C. Beck
1983 Artifact Class Richness and Sample Size in Archaeological Surface Assemblages. In *Lulu Linear Punctated: Essays in Honor of George Irving Quimby*, ed. Robert C. Dunnell and Donald K. Grayson, pp. 55-73. Museum of Anthropology, University of Michigan Anthropological Papers, number 72.

Jones, K. T., and D. B. Madsen
1989 Calculating the Cost of Resource Transporation: A Great Basin Example. *Current Anthropology* 30(4):529-534.

Jones, P. R.
1981 Experimental Implement Manufacture and Use: A Case Study from Olduvai Gorge, Tanzania. *Philisophical Transactions of the Royal Society of London* 292:189-195.

Jones, R. and N. White
1988 Point Blank: Stone Tool Manufacture at the Ngilpitji Quarry, Arnhem Land, 1981. In *Archaeology with Ethnography: An Australian Perspective*, ed. Betty Meehan and Rhys Jones, pp. 51-87. Australian National University Press, Canberra.

Juell, K. E.
1987a Groundstone Artifacts. In *Archaeological Investigations at Panaca Summit*, by R.G. Elston and K.E. Juell, pp. 63-78. Bureau of Land Management Cultural Resources No. 10, Reno.

1987b Ceramic Artifacts. In *Archaeological Investigations at Panaca Summit*, by R.G. Elston and K.E. Juell, pp. 105-118. Bureau of Land Management Cultural Resources Series No. 10. Reno.

1990 Ground Stone Utilization. In *The Archaeology of James Creek Shelter*, ed. R.G. Elston and E.E. Budy, pp. 247-256. University of Utah Anthropological Papers No. 115. Salt Lake City.

Julien, M., P. Vaughan, and D. Lavallée
1987 Armes et Outils Emmanchés à Télemachay. In *Traces d'utilisation sur les Outils Néolithiques du Proche Orient*. Travaux de la Maison de l'Orient, No. 5:287-297. (No editor listed)

Kamp, K. A., and J. C. Whittaker
1986 Unproductive Lithic Resources at Lake Mead. *American Antiquity* 51(2):383-388.

Keeley, L. H.
1980 *Experimental Determination of Stone Tool Uses*. University of Chicago Press.

1982 Hafting and Retooling: Effects on the Archaeological Record. *American Antiquity* 47(4):798-809.

1983 Neolithic Novelties: The View from Ethnography and Microwear Analysis. In Traces d'utilisation sur les Outils Néolithiques du Proche Orient, pp.251-258. Travaux de la Maison de l'Orient. No. 5. Lyon.

Keene, A. S.
1981 *Prehistoric Foraging in a Temperate Forest*. Academic Press. New York.

Kelly, R. L.
1978 Paleo-Indian Settlement Patterns at Pleistocene Lake Tonapah, Nevada. Unpublished B.A. Honors Thesis in Anthropology, Cornell University, Ithaca, New York.

1983 Hunter-Gatherer Mobility Strategies. *Journal of Anthropological Research* 39:277-306.

1985 *Hunter-Gatherer Mobility and Sedentism: A Great Basin Study*. Unpublished Ph.D. dissertation, University of Michigan.

1988 The Three Sides of a Biface. *American Antiquity* 53:717-734.

1990 Hunter-Gatherers and Sedentism. Paper presented at the Sixth International Conference on Hunting and Gathering Societies, May 28-June 1, 1990. Fairbanks, Alaska.

Kelly, R. L., and L. C. Todd
1988 Coming Into the Country: Early Paleoindian Hunting and Mobility. *American Antiquity* 53:231-244.

Kent, S.
1984 *Analyzing Activity Areas: An Ethnoarchaeological Study of the Use of Space.* University of New Mexico Press, Albuquerque.

Kintigh, K. W.
1984 Measuring Archaeological Diversity by Comparison with Simulated Assemblages. *American Antiquity* 49(1):44-54.

1989 Sample Size, Significance, and Measures of Diversity. In *Quantifying Diversity in Archaeology*, ed. Robert D. Leonard and George T. Jones, pp. 25-36. Cambridge University Press, New York.

Knudson, R.
1979 Inference and Imposition in Lithic Analysis. In *Lithic Use-Wear Analysis*, ed. B. Hayden, pp.269-281. Academic Press, New York.

Kowta, M.
1969 The Sayles Complex: A Late Milling Stone Assemblage from Cajon Pass and the Ecological Implications of its Scraper Planes. University of California Publications in Anthropology 6. University of California Press, Berkeley.

Kramer, K., and D. H. Thomas
1983 Ground Stone. In *The Archaeology of Monitor Valley 2: Gatecliff Shelter*, by David H. Thomas, pp. 231-239. Anthropological Papers of the American Museum of Natural History 59(1). New York.

Kuffner, C. S.
1982 Ground and Pecked Stone Artifacts. In *Archaeological Investigations at the Rossi Mine Sites, Elko County, Nevada*, by Mary K. Rusco, pp. 40-45. Nevada State Museum Archaeological Services Reports, Carson City.

Lanning, E. P.
1963 *Archaeology of the Rose Spring Site Iny-372.* University of California Publications in American Archaeology and Ethnology 49(3):237-336.

LaRivers, I.
1962 Fishes and Fisheries of Nevada. *Nevada State Fish and Game Commission Publication 401.* Carson City.

Layton, T. N.
1979 Archaeology and Paleo-Ecology of Pluvial Lake Parman, Northwestern Great Basin. *Journal of New World Archaeology* 3(3):41-56. University of California, Los Angeles.

Leach, M., and S. G. Botkin
1991 *Sites 26Ek3032, Localities 26 and 27, and 26Ek3516: An Archaeological Testing Program.* Intermountain Research, Silver City, Nevada. Prepared for Bureau of Land Management, Elko Resource Area, on Behalf of Ivanhoe Gold Company, Winnemucca, Nevada. In preparation.

Lech, H., and J. Lech
1984 The Prehistoric Flint Mine at Wierzbica 'Zele': A Case Study from Poland. *World Archaeology* 16:186-203.

Lee, R. B., and I. DeVore (editors)
1968 *Man the Hunter*. Aldine-Atherton, Chicago.

Leonard, R. D. and G. T. Jones (editors)
1989 *Quantifying Diversity in Archaeology*. Cambridge University Press, New York.

Leroi-Gourhan, A., and M. Brézillon
1972 *Fouilles de Pincevent*. VIIe Supplément à Gallia Préhistoire. Paris.

Levi-Sala, I.
1984-86 Experimental Replication of Post-depositional Surface Modification on Flint. *Early Man News* 9/10/11(1):103-109.

1986 Use-wear and Post-depositional Surface Modification: A Word of Caution. *Journal of Archaeological Science* 13:229-244.

Lewenstein, S.
1987 Stone Tool Use at Cerros. University of Texas Press, Austin.

Linsdale, J. M.
1936 The Birds of Nevada. *Cooper Ornithological Club Pacific Coast Avifauna* 23.

Livingston, S. D., and C. Pierce
1988 *Prehistoric Archaeology of the West Sinter Quarry, Cortez Mountains, Nevada*. Desert Research Institute Technical Report No. 61. Reno, Nevada.

Losch, A.
1954 *The Economics of Location*. Translated by W. Stolper. Yale University Press, New Haven.

Lucius, W. A.
1980 Bone and Shell Material. In *Cowboy Cave*, by J.D. Jennings, pp. 97-107. Anthropological Papers No. 104. University of Utah, Salt Lake City.

Luedtke, B. E.
1978 Chert Sources and Trace Element Analysis. *American Antiquity* 43:413-423.

1984 Lithic Material Demand and Quarry Production. In *Prehistoric Quarries and Lithic Production*, ed. Jonathan E. Ericson and Barbara A. Purdy, pp. 65-76. Cambridge University Press.

Luedtke, B. E., and J. T. Meyers
1984 Trace Element Variation in Burlington Chert: A Case Study. In *Prehistoric Chert Exploitation Studies from the Midcontinent*, ed. Brian M. Butler and Ernest E. May, pp. 287-298. Center for Archaeological Investigations Occasional Paper No. 2. Southern Illinois University, Carbondale.

Lupo, K. D.
1990 Bone Assemblage Diversity and Taphonomic Traces: Some Considerations for Late Prehistoric Wetlands Subsistence. Paper presented at the 22nd Great Basin Anthropological Conference, Reno.

Lyman, R. L.
1982 Archaeofaunas and Subsistence Studies. In *Advances in Archaeological Method and Theory*, Vol. 5, ed. Michael B. Schiffer, pp. 357-403. Academic Press, New York.

1985 Bone Frequencies: Differential Transport, *In Situ* Destruction, and the MGUI. *Journal of Archaeological Science* 12:221-236.

1987 Archaeofaunas and Butchery Studies: A Taphonomic Perspective. In *Advances in Archaeological Method and Theory*, Vol. 10, ed. Michael B. Schiffer, pp. 249-337. Academic Press, New York.

1988 Was There a Last Supper at Last Supper Cave? In *Danger Cave, Last Supper Cave, and Hanging Rock Shelter: The Faunas*, by D. K. Grayson, pp. 81-104. Anthropological Papers of the American Museum of Natural History 66(1). New York.

Lyon, P. J.
1970 Differential Bone Destruction: An Ethnographic Example. *American Antiquity* 35:213-215.

MacCalman, H. R., and B. J. Grobbelaar
1965 Preliminary Report of Two Stone-working Ovatjimba Groups in the Northern Koakoveld of Southwest Africa. *Cimbebasia* 13:11-23.

Madsen, D. B.
1985 Two Holocene Pollen Records from the Central Great Basin. In *Late Quaternary Vegetation and Climates of the American Southwest, AASP Contribution Series* No. 16:113-126. American Association of Stratigraphic Palynologists Foundation.

1986 Prehistoric Ceramics. In *Great Basin*, ed. Warren L. d'Azevedo, pp. 206-214. Handbook of North American Indians, vol. 11. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

1990 Description of a Ceramic Sherd from James Creek Shelter. In *The Archaeology of James Creek Shelter*, ed. R.G. Elston and E.E. Budy, Appendix H. University of Utah Anthropological Papers No. 115. Salt Lake City.

Madsen, D. B., and K. T. Jones
1987 Contexts and Concepts: The Research Structure. Reports on the Silver Island Expedition II. Anthropological Papers, University of Utah, Salt Lake City. In preparation.

Madsen, R. E.
1977 *Prehistoric Ceramics of the Fremont*. Ceramic Series No. 6. Museum of Northern Arizona, Flagstaff.

Magee, M.
1964 A Flat-bottomed Earthenware Vessel from Central Nevada. *American Antiquity* 30:96-98.

Mangel, M., and C. W. Clark
1988 *Dynamic Modeling in Behavioral Ecology*. Princeton University Press. Princeton, New Jersey.

Marwitt, J. P.
1970 *Median Village and Fremont Culture Regional Variation*. University of Utah Anthropological Papers No. 95. Salt Lake City.

Maser, C., and R. M. Storm
1970 *A Key to Microtinae of the Pacific Northwest.* Oregon State University Bookstore, Corvallis.

Mauldin, R., and D. Amick
1989 Investigating Patterning in Debitage from Experimental Biface Core Reduction. In *Experiments in Lithic Technology*, ed. Daniel Amick and Raymond Mauldin, pp. 67-88. BAR International Series, 528. Oxford.

Mayhew, D. F.
1977 Avian Predators as Accumulators of Fossil Mammal Material. *Boreas* 6:25-31.

McBryde, I.
1978 Wil-im-ee Moor-ring: Or Where Do Axes Come From? *Mankind* 11:354-382.

1984 Kulin Greenstone Quarries: The Social Contexts of Production and Distribution for the Mt. William Site. *World Archaeology* 16:267-285.

McFadden, L. D., S. G. Wells, M. J. Jercinovich
1987 Influences of Eolian and Pedogenic Processes on the Origin and Evolution of Desert Pavements. *Geology* 15:504-508.

Mehringer, P. J., Jr.
1986 Prehistoric Environments. In *Great Basin*, ed. Warren L. d'Azevedo, pp. 31-50. Handbook of North American Indians, vol. 11. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

1988 Clovis Cache Found: Weapons of Ancient Americans. *National Geographic* 174:500-503.

Mehringer, P. J., Jr., and F. F. Foit, Jr.
1990 Volcanic Ash Dating of the Clovis Cache at East Wenatchee, Washington. *National Geographic Research* 6(4):495-503.

Meighan, C. W.
1955 Notes on the Archaeology of Mono County, California. *Reports of the University of California Archaeological Survey* No. 28. Berkeley, California.

Mercer, R. J.
1987 A Flint Quarry in the Hambledon Hill Neolithic Enclosure Complex. In *The Human Uses of Flint and Chert: Proceedings of the Fourth International Flint Symposium Held at Brighton Polytechnic 10-15 April 1983*, ed. G. de G. Sieveking and M.H. Newcomer, pp. 159-163. Cambridge University Press.

Merriam, C. H.
1889 Life Zones and Crop Zones of the United States. *Bulletin of the United States Biological Survey* 10. Washington, D.C.

Metcalfe, D.
1989 A General Cost/Benefit Model of the Tradeoff Between Transport and Field Processing. Paper presented at the 54th Annual Meeting of the Society for American Archaeology. Atlanta.

Metcalfe, D., and R. Barlow
1991 A Model for Exploring the Optimal Tradeoff Between Field Processing and Transport. *American Anthropologist.* In press.

Mifflin, M. D., and M. M. Wheat
1979 *Pluvial Lakes and Estimated Pluvial Climates of Nevada.* Nevada Bureau of Mines and Geology Bulletin 94. University of Nevada, Reno.

Miller, M. E., M. D. Stafford, and G. W. Brov
1991 The John Gale Site Biface Cache. *Plains Anthropologist* 36(133):43-56.

Miller, R.
1982 Pseudo-Tools Created by Livestock from Halwa, Syria. *Journal of Field Archaeology* 9:281-283.

1987 Sources and Specialists: Three Ancient Near Eastern Urban Flint Industries. In *The Human Uses of Flint and Chert*, ed. G. de G. Sieveking and M.H. Newcomer, pp. 205-211. Cambridge University Press, Cambridge.

Miller, T. O.
1979 Stonework of the Xêté Indians of Brazil. In *Lithic Use-Wear Analysis*, ed. B. Hayden, pp.401-407.

Miller, W. R.
1966 Anthropological Linquistics in the Great Basin. In *The Current Status of Anthropological Research in the Great Basin*, ed. W.L. d'Azevedo et al., pp. 75-112. Desert Research Institute Social Sciences and Humanities Publications, No. 1. Reno.

1986 Numic Languages. In *Great Basin*, ed. W.L. d'Azevedo, pp. 98-106. Handbook of North American Indians, vol. 11, W.C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Moore, M. W.
1990 A Summary of East-Central Indianian Prehistoric Knapping Techniques. In *Native American Cultures in Indiana*, ed. Ronald Hicks. Minnetrista Cultural Center and Ball State University, Muncie. In preparation.

Moss, E., and M. H. Newcomer
1982 Reconstructing Tool Use at Pincevent: Microwear and Experiments. *Studia Praestorica Belgica* 2:289-312.

Munz, P. A., and D. D. Keck
1973 *A California Flora.* University of California Press, Berkeley.

Muto, G. R.
1971a *A Technological Analysis of the Early Stages in the Manufacture of Lithic Artifacts.* Unpublished M.A. thesis, Department of Anthropology, Idaho State University, Pocatello.

1971b A Stage Analysis of the Manufacture of Stone Tools. In *Great Basin Anthropological Conference* 1970, ed. C.M. Aikens, pp. 109-118. University of Oregon Anthropological Papers 1.

Nance, J. D.
1971 Functional Interpretations from Microscopic Analysis. *American Antiquity* 36(3):361-366.

Newcomer, N. H.
1970 Some Quantitative Experiments in Handaxe Manufacture. *World Archaeology* 3:85-93.

Novick, A. L.
1987 *Traveling Light: Lithic Inference, Site Structure, and Hunter-Gatherer Mobility at Gatecliff Shelter, Nevada.* Unpublished Ph.D. dissertation. Washington State University, Pullman, Washington.

O'Connell, J. F.
1967 Elko Eared/Elko Corner-notched Projectile Points as Time Markers in the Great Basin. *University of California Archaeological Survey* 70:129-140.

1971 *The Archaeology and Cultural Ecology of Surprise Valley, Northeast California.* Ph.D. dissertation, Department of Anthropology, University of California, Berkeley.

1974 Spoons, Knives and Scrapers: The Function of Yilugwa in Central Australia. *Mankind* 9:189-194.

1975 *The Prehistory of Surprise Valley.* Ballena Press Anthropological Papers No. 4. Ramona, California.

1977 Aspects of Variation in Central Australian Lithic Assemblages. In *Stone Tools as Cultural Markers: Change, Evolution and Complexity*, ed. R. V. S. Wright, pp. 269-281. Prehistory and Material Culture Series 12. Australian Institute of Aboriginal Studies.

1987 Alyawara Site Structure and its Archaeological Implications. *American Antiquity* 52(1):74-108.

n.d. Unpublished Field Notes Regarding Alyawara Quarrying and Stone Tool Manufacturing. Ms. in possession of the author.

O'Connell, J. F., and K. Hawkes
1984 Food Choice and Foraging Sites among the Alyawara. *Journal of Anthropological Research* 40(4):504-535.

O'Connell, J. F., K. Hawkes, and N. B. Jones
1990 Reanalysis of Large Mammal Body Part Transport Among the Hadza. *Journal of Archaeological Science* 17:301-316.

1991 Distribution of Refuse Producing Activities at Hadza Residential Base Camps: Implications for Analyses of Archaeological Site Structure. In *The Interpretation of Archaeological Spatial Patterning*, ed. E.M. Kroll and T.D. Price, pp. 61-76. Plenum Press, New York.

O'Connell, J. F., K. T. Jones, and S. Simms
1982 Some Thoughts on Prehistoric Archaeology in the Great Basin. In *Man and Environment in the Great Basin*, edited by David B. Madsen and James F. O,Connell, pp. 227-242. SAA Papers No. 2. Washington, D.C.

Odell, G. H., and F. Cowan
1986 Experiments with Spears and Arrows on Animal Targets. *Journal of Field Archaeology* 13:195-212.

Ogden, P. S.
1910 The Peter Skene Ogden Journals: Snake Country Expedition, 1827-28 and 1928-29, ed. T.C. Elliott. *Oregon Historical Society Quarterly* 11:355-399.

Ohnuma, K., and C. Bergman
1982 Experimental Studies in the Determination of Flaking Mode. *Bulletin of the Institute of Archaeology* 19:161-170, University of London.

Orians, G. H., and N. E. Pearson
1979 On the Theory of Central Place Foraging. In *Analysis of Ecological Systems*, ed. D.J. Horn, R.D. Mitchell, and G.R. Stairs, pp. 154-177. Ohio State University Press, Columbus.

Orr, P. C.
1956 *Pleistocene Man in Fishbone Cave, Pershing County, Nevada.* Nevada State Museum Depart of Archaeology Bulletin 2. Carson City.

1974 Notes on the Archaeology of the Winnemucca Caves, 1952-1958. In *Collected Papers on Aboriginal Basketry*, ed. Donald. R. Tuohy and Dorris L. Rendall, pp. 47-59. Nevada State Museum Anthropological Papers 16(3). Carson City.

Parry, W. J., and R. L. Kelly
1987 Expedient Core Technology and Sedentism. In *The Organization of Core Technology*, ed. Jay K. Johnson and Carol A. Morrow, pp. 285-304. Westview Press, Boulder, Colorado.

Patten, B.
1980 Folsom Staging: A Speculative Approach. *Flintknapper's Exchange* 3(2):7-10.

Pavesic, M. G.
1985 Cache Blades and Turkey Tails: Piecing Together the Western Idaho Archaic Burial Complex. In *Stone Tool Analysis: Essays in Honor of Don E. Crabtree*, ed. M.G. Plew, J.C. Woods, and M.G. Pavesic, pp.55-89. University of New Mexico Press, Albuquerque.

Pedrick, K. E.
1985 *The Lake Range Quarry, Washoe County, Nevada.* Bureau of Land Management Technical Report No. 14. Reno, Nevada.

Peet, R. K.
1974 The Measurement of Species Diversity. *Annual Review of Ecology and Systematics* 5:285-307.

1975 Relative Diversity Indices. *Ecology* 56(2):496-498.

Pendleton, L. S.
1979 *Lithic Technology in Early Nevada Assemblages.* Un-published Master's thesis, California State University.

1985a Material Culture: Artifacts of Bone and Horn. In *The Archaeology of Hidden Cave, Nevada*, ed. D.H. Thomas, pp. 226-237. Anthropological Papers of the American Museum of Natural History 61(1). New York.

1985b Material Culture: Artifacts of Stone. In *The Archaeology of Hidden Cave, Nevada*, ed. D.H. Thomas. pp. 183-218. Anthropological Papers of the American Museum of Natural History 61(1). New York.

Pendleton, L. S. A., and D. H. Thomas
1983 *The Fort Sage Drift Fence, Washoe County, Nevada.* Anthropological Papers of the American Museum of Natural History 58(2). New York.

Pielou, E. C.
1975 *Ecological Diversity.* Wiley-Interscience, New York.

Pippin, L. C.
1980 *Prehistoric and Historic Patterns of Lower Pinyon-Juniper Woodland Ecotone Exploitation at Borealis, Mineral County, Nevada.* Technical Report No. 17, Social Sciences Center, Desert Research Institute, Reno.

Pippin, L. C., and E. M. Hattori
1980 *An Analysis of Prehistoric Artifacts from Lassen National Forest, California.* Desert Research Institute, Social Sciences Technical Report Series No. 15.

Plew, M. G., J. C. Woods, and M. G. Pavesic (editors)
1985 *Stone Tool Analysis: Essays in Honor of Don E. Crabtree.* University of New Mexico Press, Albuquerque.

Plisson, H.
1987 L'emmanchement dans l'habitation n° 1 de Pincevent. In *La Main et l'Outil: Manches et Emmanchements Préhistoriques*, pp. 75-88. Travaux de la Maison de l'Orient No. 15. Lyon.

Plisson, H., and M. Mauger
1988 Chemical and Mechanical Alteration of Microwear Polishes: An Experimental Approach. *Helinium* XXVIII(1):3-16.

Powell, J. W., and G. W. Ingalls
1874 *Report on the Condition of the Ute Indians of Utah; the Pi-Utes of Utah, Northern Arizona, Southern Nevada, and Southeastern California; the Go-Si Utes of Utah and Nevada; the Northwestern Shoshones of Idaho and Utah; and the Western Shoshones of Nevada.* Washington.

Powers, S.
1976 (1877) *Tribes of California.* University of Calififfornia Press.

Prinz, M., G. Harlow, and J. Peters (editors)
1977 *Guide to Rocks and Minerals.* Simon and Schuster, Inc., New York.

Purdy, B. A.
1971 *Investigations Concerning the Thermal Alteration of Silica Minerals: An Archaeological Approach.* Unpublished Ph.D. Dissertation. University of Florida, Gainsville.

1975 Fractures for the Archaeologist. In *Lithic Technology*, ed. Earl Swanson, pp 133-141. Mouton. The Hague.

1984 Quarry Studies: Technological and Chronological Significance. In *Prehistoric Quarries and Lithic Production*, ed. Jonathan E. Ericson and Barbara A. Purdy, pp. 107-118. Cambridge University Press.

Quaife, M. M. (editor)
1934 *Narrative of the Adventures of Zenas Leonard*, ed. M.M. Quaife. R.R. Donnelley, Chicago.

Rafferty, K., and L. Blair
1988 *A Cultural Resource Inventory of a 520 Acre Mining Exploration Area and an Access Road for Dee Gold Mining Company in the Tuscarora Mountains, Elko County, Nevada.* Division of Anthropological Studies Report 5-109-1. Bureau of Land Management Report 1-1203(p). Ms. on file, Bureau of Land Management, Elko.

Ragier, S., and J. Lancaster
1966 Analysis of a Surface Collection from High Rock Canyon, Nevada. *Reports of the University of California Archaeological Survey* No. 66:1-35. Berkeley.

Raven, C.
1985 *Landscape Evolution and Human Geography in Panamint Valley: Perspectives for Future Research*. Contributions of the Great Basin Foundation, No. 1. San Diego.

1988 *An Intensive Archaeological Survey of USX-East*. Intermountain Research, Silver City, Nevada. Report submitted to Galactic Services, Inc. Reno, Nevada. Ms. on file, Bureau of Land Management, Elko.

Raymond, A. W.
1984 *Prehistoric Reduction and Curation of Topaz Mountain, Utah, Obsidian: A Technological Analysis of Two Lithic Scatters*. Unpublished Master's thesis. Washington State University, Pullman.

Raytech Industries
1965 *The Story of Fluorescence*. Raytech Industries. Stafford Springs, Connecticut.

Renfrew, C.
1977 Alternative Models for Exchange and Spatial Distribution. In *Exchange Systems in Prehistory*, ed. Timothy K. Earle and Jonathon E. Ericson, pp. 71-90. Academic Press, New York.

Rhode, D.
1988 Measurement of Archaeological Diversity and the Sample-Size Effect. *American Antiquity* 54:708-716.

1990 On Transportation Costs of Great Basin Resources: An Assessment of the Jones-Madsen Model. *Current Anthropology* 31(4):413-419.

Riddell, F. A.
1960 The Archaeology of the Karlo Site (Las7), California. *University of California Archaeological Survey Reports* 53. Berkeley.

Riddell, H. S., Jr.
1951 The Archaeology of a Paiute Village Site in Owens Valley. *University of California Archaeological Survey Reports* 12(15):14-28. Berkeley.

Rondeau, M. F.
1981 An Additional Failture Type During Biface Manufacture. *Lithic Technology* 10(1):10-11.

Rosenfeld, A.
1971 The Examination of Use Marks on Some Magdalenian End-scrapers. *The British Museum Quarterly* 35:176-182.

Rudebeck, E.
1987 Flintmining in Sweden during the Neolithic Period: New Evidence from the Kvarnby-S. Sallerup Area. In *The Human Uses of Flint and Chert: Proceedings of the Fourth International Flint Symposium Held at Brighton Polytechnic 10-15 April 1983*, ed. G. de G. Sieveking and M.H. Newcomer, pp. 151-157. Cambridge University Press.

Rusco, M.
1976a Humboldt River Archaeological Project: Tosawi Chert Quarry. Draft manuscript in author's possession.

1976b Progress Report on Tosawi Opalite (Battle Mountain Chert) Quarry Project. Paper presented at the 15th Great Basin Anthropological Conference, Las Vegas.

1978 Distribution of Stone from the Tosawihi Quarries in Archaeological Sites along the AT&T Right-of-Way across Northern Nevada. Draft manuscript in author's possession.

1979 The Tosawihi or White Knife Quarries North of Battle Mountain, Nevada. Draft manuscript in author's possession.

1982 The Humboldt River Basin Study Units. In *An Archaeological Element for the Nevada Historic Preservation Plan*, edited by M. Lyneis. Nevada Division of Historic Preservation and Archaeology, Carson City.

1983 Tosawihi (White Knife) Quarry. Nomination to National Register of Historic Places.

Rusco, M. K., B. B. Brown, C. S. Kuffner, and A. J. Dansie
1982 Archaeological Investigations at the Rossi Mine Sites, Elko County, Nevada. Nevada State Museum. Carson City.

Rusco, M. K., and J. O. Davis
1979 *Archaeological Investigations Near Treaty Hill, Humboldt County, Nevada: Section 29*. Archaeological Services Report, Nevada State Museum. Submitted to Westinghouse Corporation, Environmental Services Division.

1987 *Studies in Archaeology, Geology and Paleontology at Rye Patch Reservoir, Pershing County, Nevada*. Anthropological Papers No. 20. Nevada State Museum, Carson City.

Rusco, M., J. O. Davis, and A. Jensen
1979 Archaeological Investigations Near Carlin, Elko County, Nevada. Ms. on file. Nevada State Museum.

Rusco, M., and E. Seelinger
1974 *Report of Archeological Reconnaissance Along Proposed 230 kv Transmission Line Right-of-Way of Sierra Pacific Power Company, Part II, Valmy to Jackpot, Nevada*. Nevada State Museum Project 18-9. Carson City.

Russell, K. W., A. M. Tratebas, and A. R. Schroedl
1986 *Cultural Resource Inventory and Testing in Little Boulder Basin, Eureka County, Nevada: Final Report*. Cultural Resources Report 416-27-8624. P-III Associates, Inc., Salt Lake City. Submitted to Bureau of Land Management, Elko.

Ryser, F. A., Jr.
1985 *The Birds of the Great Basin*. University of Nevada Press, Reno.

Sackett, J. R.
1982 Approaches to Style in Lithic Archaeology. *Journal of Anthropological Archaeology* 1(1):59-112.

Saggers, S.
1984 *Materialism and Archaeological Experimentation: Testing the Exotic Stone Hypothesis in the Central Desert of Australia*. Unpublished Ph. D. Dissertation, Boston University, Boston.

Salls, R. A.
1985 The Scraper Plane: A Functional Interpretation. *Journal of Field Archaeology* 12:99-106.

Sampson, C. G.
1985 *Nightfire Island: Later Holocene Lakemarsh Adaptation on the Western Edge of the Great Basin.* University of Oregon Anthropological Papers 33.

Sassaman, K. E.
1988 Scale of Biface Production in the Middle Savannah River Vally. Handout to accompany paper presented at the 53rd Annual Meeting of the Society for American Archaeology, Phoenix, Arizona.

Sassaman, K. E., G. T. Hanson, and T. Charles
1988 Raw Material Procurement and the Reduction of Hunter-Gatherer Range in the Savannah River Valley. *Southeastern Archaeology* 7(2):79-94.

Schiffer, M. B.
1975 Behavioral Chain Analysis: Activities, Organization, and the Use of Space. In *Chapters in the Prehistory of Eastern Arizona, IV.* Fieldiana: Anthropology 65:103-119.

1976 *Behavioral Archaeology.* Academic Press, New York.

1987 *Formation Processes of the Archaeological Record.* University of New Mexico Press. Albuquerque.

Schild, R.
1987 The Exploitation of Chocolate Flint in Central Poland. In *The Human Uses of Flint and Chert: Proceedings of the Fourth International Flint Symposium Held at Brighton Polytechnic 10-15 April 1983*, ed. G. de G. Sieveking and M.H. Newcomer, pp. 137-149. Cambridge University Press.

Schmitt, D. N.
1986 Faunal Analysis. In *The Archaeology of the Vista Site (26Wa3017)*, ed. C.D. Zeier and R.G. Elston, pp. 209- 239. Intermountain Research, Silver City, Nevada. Submitted to the Environmental Services Division, Nevada Department of Transportation, Carson City.

1988a Some Observations on Vertebrate Taphonomy and Site Formational Processes in Stillwater Marsh. In *Preliminary Investigations in Stillwater Marsh: Human Prehistory and Geoarchaeology*, ed. C. Raven and R.G. Elston, pp. 359-372. U.S. Fish and Wildlife Service Cultural Resource Series 1, Portland.

1988b Bone Artifacts. In *Preliminary Investigations in Stillwater Marsh: Human Prehistory and Geoarchaeology*, ed. C. Raven and R.G. Elston, pp. 228-239. U.S. Fish and Wildlife Service Cultural Resource Series 1, Portland.

1988c Site Description, 4-Alp-212. In *Changes in Washoe Land Use Patterns: A Study of Three Archaeological Sites in Diamond Valley, Alpine County, California*, ed. C.D. Zeier and R.G. Elston, pp. 33-48. Intermountain Research, Silver City, Nevada. Submitted to the South Tahoe Public Utility District, California.

1989a Ground, Battered, and Scratched Stone. In *The Tosawihi Quarries: An Archaeological Testing Program*, ed. R.G. Elston, pp. 95-116. Intermountain Research, Silver City, Nevada. Submitted to Galactic Services, Inc. and the Ivanhoe Gold Company, Reno.

1989b Part III. North Access Corridor Study Area. In *The Tosawihi Quarries: An Archaeological Testing Program*, ed. R.G. Elston, pp. 123-148. Intermountain Resarch, Silver City, Nevada. Submitted to Galactic Services, Inc. and the Ivanhoe Gold Company, Reno.

1990 Bone Artifacts and Human Remains. In *The Archaeology of James Creek Shelter*, ed. R.G. Elston and E.E. Budy, pp. 117-127. University of Utah Anthropological Papers No. 115. Salt Lake City.

Schmitt, D. N., and C. Carroll
1992 Hammerstones and Additional Artifacts. In *Archaeological Data Recovery at Localities 36 and 221, Tosawihi Quarries, Elko County, Nevada*, ed. R.G. Elston. Submitted to Ivanhoe Gold Company, Winnemucca, Nevada. Intermountain Research, Silver City, Nevada. In review.

Schmitt, D. N., and K. E. Juell
1989 On the Identification of Carnivore Scatological Faunal Accumulations in Archaeological Contexts. Paper presented at the 54th Annual Meeting of the Society for American Archaeology, Atlanta.

Schroedl, A. R.
1986 *Cultural Resource Inventory in Little Boulder Basin, Eureka County, Nevada.* Cultural Resources Report 416-24-8619. P-III Associates, Inc., Salt Lake City. Submitted to Bureau of Land Mangement, Elko.

Scott, S. A., C. M. Davis, and J. J. Flenniken
1986 The Pahoehoe Site: A Lanceolate Biface Cache in Central Oregon. *Journal of California and Great Basin Archaeology* 8:7-23.

Semenov, S.
1964 *Prehistoric Technology*. Translated by M.W. Thompson. Adams and Dart, Bath.

Shafer, H. J.
1985 A Technological Study of Two Maya Lithic Workshops at Colha, Belize. In *Stone Tool Analysis*, ed. Mark G. Plew, James C. Woods, and Max G. Pavesic, pp. 277-315. University of New Mexico Press, Albuquerque.

Shannon, C. E., and W. Weaver
1949 *The Mathematical Theory of Communication*. University of Illinois Press, Urbana.

Shepherd, R.
1980 *Prehistoric Mining and Allied Industries*. Academic Press, London.

Shipman, P., G. Foster, and M. Schoeninger
1984 Burnt Bones and Teeth: An Experimental Study of Color, Morphology, Crystal Structure, and Shrinkage. *Journal of Archaeological Science* 11:307-325.

Shott, M. J.
1989 Diversity, Organization, and Behavior in the Material Record: Ethnographic and Archaeological Examples. *Current Anthropology* 30(3):283-316.

Shutler, M. E., and R. Shutler, Jr.
1959 Clovis-like Points from Nevada. *The Masterkey* 33(1):30-32. Los Angeles.

Sigler, W. F., and J. W. Sigler
1987 *Fishes of the Great Basin: A Natural History*. University of Nevada Press, Reno.

Simms, S. R.
1983 The Effects of Grinding Stone Reuse on the Archaeological Record in the Eastern Great Basin. *Journal of California and Great Basin Anthropology* 5:98-102.

1985 Acquisition Cost and Nutritional Data on Great Basin Resources. *Journal of California and Great Basin Anthropology* 7:117-125.

1987 *Behavioral Ecology and Hunter-Gatherer Foraging, An Example from the Great Basin.* BAR International Series 381. Oxford.

1988 Conceptualizing the Paleo-Indian and Archaic in the Great Basin. In *Early Human Occupations in Far Western North America: The Clovis-Archaic Interface*, ed. Judith A Willig, C. Melvin Aikens, and John L. Fagan, pp.41-52. Nevada State Museum Anthropological Papers, No. 21. Carson City.

Singer, C. A., and J. E. Ericson
1977 Quarry Analysis at Bodie Hills, Mono County, California: A Case Study. In *Exchange Systems in Prehistory*, ed. Timothy K. Earle, and Jonathan E. Ericson. Academic Press, New York.

Smith, A.
1982 *A Mathematical Introduction to Economics.* Barnes and Noble. Totowa, New Jersey.

Smith, E. A.
1981 The Application of Optimal Foraging Theory to the Analysis of Hunter-Gatherer Group Size. In *Hunter-Gatherer Foraging Strategies,* ed. B. Winterhalder and E.A. Smith, pp. 36-65. University of Chicago Press.

1983 Anthropological Applications of Optimal Foraging Theory. *Current Anthropology* 24:625-651.

Smith, E. A., and B. Winterhalder
1981 New Perspectives on Hunter-Gatherer Socioecology. In *Hunter-Gatherer Foraging Strategies,* ed. B. Winterhalder and E.A. Smith, pp. 2-12. University of Chicago Press.

Smith, R. C., P. Jones, J. R. Roney and K. Pedrick
1983 Prehistory and History of the Winnemucca District. *Bureau of Land Management, Nevada, Cultural Resource Series* No. 6. Reno.

Smith, R.
1976 *Mineral Resources of Elko County, Nevada.* Nevada Bureau of Mines and Geology, Open File Report 1976-56.

Southmayed, W., and M. Hoffman
1981 *Sports Health.* Perigee Books. The Putnam Publishing Group, New York.

Spencer, L., R. Hanes, C. Fowler, and S. Jaynes
1987 *The South Fork Shelter Site Revisited: Excavation at Upper Shelter, Elko County, Nevada.* Bureau of Land Management Cultural Resource Series 11. Reno.

SPSS Institute
1986 SPSS-X Users Guide. SPSS Institute, Chicago.

Stahle, D. W. and J. E. Dunn
1982 An Analysis and Application of Size Distribution of Waste Flakes from the Manufacture of Bifacial Stone Tools. *World Archaeology* 14(1):84-97.

1984 *An Experimental Analysis of the Size Distribution of Waste Flakes from Biface Reduction.* Technical Paper Number 2, Arkansas Archaeological Survey, Fayetteville.

Stebbins, R. C.
1966 *A Field Guide to Western Reptiles and Amphibians.* National Audubon Society and National Wildlife Federation. Houghton-Mifflin Co., Boston.

Stephens, D. W.
1990 Risk and Incomplete Information in Behavioral Ecology. In *Risk and Uncertainty in Tribal and Peasant Economies*, ed. Elizabeth Cashden, pp. 19-46. Westview Press, Boulder.

Stephens, D. W., and J. R. Krebs
1986 *Foraging Theory*. Princeton University Press. Princeton, New Jersey.

Stephenson, R. L., and K. Wilkinson
1969 Archeological Reconnaissance of the Winnemucca-Battle Mountain Area of Nevada. *Nevada Archeological Survey Research Paper* No. 1, pp. 66. University of Nevada, Reno.

Steward, J. H.
1937 Linguistic Distributions and Political Groups of the Great Basin Shoshoneans. *American Anthropologist* 39(4):625-634.

1938 Basin-Plateau Aboriginal Sociopolitical Groups. *Bureau of American Ethnology Bulletin* 120. Washington.

1939 Some Observations on Shoshonean Distributions. *American Anthropologist* 41(2):261-265.

1941 *Culture Element Distributions: XIII, Nevada Shoshone*. Anthropological Records 4(2):209-359. University of California, Berkeley.

Stewart, J. H.
1980 *Geology of Nevada, a Discussion to Accompany the Geologic Map of Nevada*. Nevada Bureau of Mines and Geology Special Publication 4. Reno.

Stewart, O. C.
1939 The Northern Paiute Bands. *University of California Anthropological Records* 2(3):127-149. Berkeley.

1941 Culture Element Distribution: XIV, Northern Paiute. *University of California Anthropological Records* 4:361-446. Berkeley.

Stones, R. C., and C. L. Hayward
1968 The Natural History of the Desert Woodrat, *Neotoma lepida*. *The American Midland Naturalist* 80:458-476.

Sullivan, III, A. P., and K. C. Rozen
1985 Debitage Analysis and Archaeological Interpretation. *American Antiquity* 50:755-779.

Swanson, E. H., Jr.
1966 The Geographic Foundation of the Desert Culture. In *Current Status of Anthropological Research in the Great Basin: 1964*. Desert Research Institute Technical Report Series S-H:137-146.

Symens, N.
1986 A Functional Analysis of Selected Stone Artifacts from the Magdalenien Site at Verberie, France. *Journal of Field Archaeology* 3:213-222.

Tadlock, W. L.
1966 Certain Crescentic Stone Objects as a Time Marker in the Western United States. *American Antiquity* 31:662-675.

Taylor, P. J.
1977 *Quantitative Methods in Geography: An Introduction to Spatial Analysis.* Houghton-Miflin, Boston.

Taylor, W. W.
1964 Tethered Nomadism and Water Territoriality: An Hypothesis. In *Acts of the 35th International Congress of Americanists*, pp. 197-203. Mexico City.

Thomas, D. H.
1969 Great Basin Hunting Patterns: A Quantitative Method for Treating Faunal Remains. *American Antiquity* 34:392-401.

1971 *Prehistoric Subsistence and Settlement Patterns of the Reese River Valley, Central Nevada.* Ph.D. dissertation, University of California, Davis. University Microfilms, Ann Arbor, Michigan.

1976 *Figuring Anthropology*. Holt, Rinehart, and Winston. New York.

1978 Arrowheads and Atlatl Darts: How Stones Got the Shaft. *American Antiquity* 43:461-472.

1981 How to Classify the Projectile Points from Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3(1):7-43.

1982 An Overview of Central Great Basin Prehistory. In *Man and Environment in the Great Basin*, ed. D.B. Madsen and J.F. O,Connell, pp. 156-171. SAA Papers No. 2. Washington, D.C.

1983a *The Archaeology of Monitor Valley 1. Epistomology.* Anthropological Papers of the American Museum of Natural History 58:Part 1. New York.

1983b *The Archaeology of Monitor Valley 2. Gatecliff Shelter.* Anthropological Papers of the American Museum of Natural History 59:Part 2. New York.

1985 Integrative Synthesis: The Lacustrine Biome as Viewed from Hidden Cave. In *The Archaeology of Hidden Cave, Nevada*, ed. D.H. Thomas, pp. 374-391. Anthropological Papers of the American Museum of Natural History 61:Part 1.

1988 *The Archaeology of Monitor Valley 3: Survey and Additional Excavations.* Anthropological Papers of the American Museum of Natural History 66(2). New York.

Thomas, D. H., and R. L. Bettinger
1976 Prehistoric Piñon Ecotone Settlements of the Upper Reese River Valley, Central Nevada. Anthropological Papers of the American Museum of Natural History 53(3):263-366.

Thomas, D. H., and S. Bierwirth
1983 Material Culture and Gatecliff Shelter: Additional Stone Tools. In *The Archaeology of Monitor Valley 2. Gatecliff Shelter*, by David H. Thomas, pp. 212-231. Anthropological Papers of the American Museum of Natural History 59(1). New York.

Thomas, D. H., and C. S. Larsen
1988 Bradshaw Shelter (Es81). In *The Archaeology of Monitor Valley 3. Survey and Additional Excavations,* by David Hurst Thomas, pp. 305-315. Anthropological Papers of The American Museum of Natural History, Vol. 66: Part 2. New York.

Thomas, D. H., and D. Mayer
1983 Behavioral Faunal Analysis of Selected Horizons. In *The Archaeology of Monitor Valley 2. Gatecliff Shelter*, by D.H. Thomas, pp. 353-391. Anthropological Papers of the American Museum of Natural History 59(1). New York.

Thomas, D. H., L. S. A. Pendleton, and S. C. Cappannari
1986 Western Shoshone. In *Great Basin*, ed. Warren L. d'Azevedo, pp. 262-283. Handbook of North American Indians, vol. 11. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Thompson, R. S.
1984a Paleoenvironmental Studies in Pine Valley. In *The Analysis of Seven Sites in Pine Valley, Eureka County, Nevada*, ed. S.M. Sterns and P. Matranga. Nevada Department of Transportation, Carson City.

1984b *Late Pleistocene and Holocene Environments in the Great Basin*. Unpublished Ph.D. Dissertation, Department of Geoscience, University of Arizona.

Thompson, R. S., E. M. Hattori, and D. R. Tuohy
1987 Paleoenvironmental and Archaeological Implications of Early Holocene - Late Pleistocene Cave Deposits from Winnemucca Lake, Nevada. *Nevada Archaeologist* 6(1):34-38.

Tindale, N. B.
1965 Stone Implement Making Among the Nakako, Ngadadjara and Pitjandjara of the Great Western Desert. *Records of the South Australia Museum* 15(1):131-164.

Tipps, B. L.
1989 *Archaic and Numic Encampment in the Little Boulder Basin, Eureka County, Nevada*. Cultural Resources Report 424-1-8805. P-III Associates, Inc., Salt Lake City. Submitted to Bureau of Land Management, Elko.

Tite, M. S.
1972 *Methods of Physical Examination in Archaeology*. Seminar Press, New York.

Titmus, G. L.
1985 Some Aspects of Stone Tool Notching. In *Stone Tool Analysis: Essays in Honor of Don E. Crabtree*, ed. Mark G. Plew, James C. Woods, and Max G. Pavesic, pp. 243-264. University of New Mexico Press, Albuquerque.

Titmus, G. L., and J. C. Woods
1986 An Experimental Study of Projectile Point Fracture Patterns. *Journal of California and Great Basin Anthropology* 8:37-49.

Tohey, M. L.
1981 Carrier. In *The Subarctic*, ed. J. Helm, pp.413-432. Handbook of North American Indians, vol 6. William G. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Toney, J. T.
1972 *Aboriginal Quarrying Activity at Nine Sites in Pershing County, Nevada*. Unpublished Master's thesis, University of Nevada, Reno.

Torrence, R.
1983 Time Budgeting and Hunter-Gatherer Technology. In *Hunter-Gatherer Economy in Prehistory: A European Perspective*, ed. G. Bailey, pp. 11-22. Cambridge University Press. Cambridge.

1984 Monopoly or Direct Access? Industrial Organization at the Melos Obsidian Quarries. In *Prehistoric Quarries and Lithic Production*, ed. Jonathan E. Ericson and Barbara A. Purdy, pp. 49-64. Cambridge University Press.

1986 Production and Exchange of Stone Tools: Prehistoric Obsidian in the Aegean. Cambridge University Press, Cambridge.

Train, P., J. R. Henricks, and W. A. Archer
1957 *Contributions Toward A Flora of Nevada No. 45; Medicinal Uses of Plants by Indian Tribes of Nevada*. USDA Agricultural Research Service, Beltsville, Maryland.

Tremewan, S.
1964 Early Day Range, Livestock and Wildlife Observations as Recalled by Mr. Sid Tremewan, first Forest Supervisor of the Humboldt National Forest in an interview on March 31, 1964. On file, BLM, Elko, Nevada.

Tringham, R., G. Cooper, G. Odell, G. Voytek, and A. Whitman
1974 Experiments in the Formation of Edge Damage: A New Approach to Lithic Analysis. *Journal of Field Archaeology* 1:171-196.

Tunnell, C.
1977 Fluted Projectile Point Production as Revealed by Lithic Specimens from the Adair Steadman Site in Northwest Texas. In *Paleoindian Lifeways*, ed. E. Johnson, pp. 140-168. The Museum Journal 17.

Tuohy, D. R.
1968 Some Early Lithic Sites in Western Nevada. In *Early Man in Western North America*, ed. C. Irwin-Williams, pp. 27-38. Contributions in Anthropology Vol. 1(4). Portales, New Mexico.

1969 A Brief Note on Additional Fluted Points from Nevada, In *Miscellaneous Papers on Nevada Archaeology*, ed. D.L. Rendall and D.R. Tuohy, pp. 154-178. Nevada State Museum Anthropological Papers 14(7). Carson City.

1970a Notes on a Collection of California Shell Beads from the Humboldt Sink, Nevada. *Nevada Archaeological Survey Reporter* 4(1):4-9.

1970b The Coleman Locality: A Basalt Quarry and Workshop Near Falcon Hill, Nevada. *Nevada State Museum Anthropological Papers* No. 15, Carson City.

1974 A Comparative Study of Late Paleo-Indian Manifestations in the Western Great Basin. In *A Collection of Papers on Great Basin Archaeology*, ed. Robert G. Elston and Loretta Sabini, pp. 91-116. Nevada Archaeological Survey Research Paper No. 5, Reno.

1985 Notes on the Great Basin Distribution of Clovis Fluted and Folsom Projectile Points. *Nevada Archaeologist* 5(1):15-18.

1986a Portable Art Objects. In *Great Basin*, ed. Warren L. D'Azevedo, pp. 227-237. Handbook of North American Indians, vol. 11, William C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

1986b Ethnographic Specimens of Basin Brown Ware. In *Pottery of the Great Basin and Adjacent Areas*, ed. S. Griset, pp. 27-36. University of Utah Anthropological Papers No. 111, Salt Lake City.

Tuohy, D. R., and T. N. Layton
1977 Toward the Establishment of a New Series of Great Basin Projectile Points. *Nevada Archaeological Survey Reporter* 10(6):1-5. Reno.

Unger-Hamilton, R. Grace, R. Miller, and C. Bergman
1987 Drill Bits from Abu Salabikh. In *La Main et l'Outil: Manches et Emmanchements Préhistorique*, pp. 269-285. Travaux de la Maison de l'Orient No. 15. Lyon.

U.S. Fish and Wildlife Service
1978 *Stream Evaluation Map, State of Nevada*. U.S. Fish and Wildlife Service, Office of Biological Services, Denver.

Vehik, S. C. (editor)
1985 *Lithic Resource Procurement: Proceedings from the Second Conference on Prehistoric Chert Exploitation*. Center for Archaeological Investigations Occasional Paper No. 4. Southern Illinois University, Carbondale.

Velleman, P. F., and D. C. Hoaglin
1981 *Applications, Basics, and Computing of Exploratory Data Analysis*. Duxbury Press, Boston.

Wagner, G. E.
1982 Testing Flotation Recovery Rates. *American Antiquity* 47:127-132.

Wagner, P. L.
1960 *The Human Use of the Earth*. The Free Press, Glencoe.

Walker, P. L.
1978 Butchery and Stone Tool Function. *American Antiquity* 43(4):710-715.

Warren, C. N., and C. Phagan
1988 Fluted Points in the Mojave Desert: Their Technology and Cultural Context. In *Early Human Occupations in Far Western North America: The Clovis-Archaic Interface*, ed. Judith A Willig, C. Melvin Aikens, and John L. Fagan, pp. 121-130. Nevada State Museum Anthropological Papers, No. 21. Carson City, Nevada.

Wells, P. V.
1976 Macrofossil Analysis of Wood Rat (*Neotoma*) Middens as a Key to the Quaternary Vegetational History of Arid America. *Quaternary Research* 6:223-248.

1983 Paleobiogeography of Montane Islands in the Great Basin Since the Last Glaciopluvial. *Ecological Monographs* 54(4):341-382.

Wendorf, F.
1968 Site 117: A Nubian Final Paleolithic Graveyard Near Jebel Sahaba, Sudan. In *The Prehistory of Nubia*, Vol. 2, ed. F. Wendorf, pp. 954-995. Southern Methodist University Press, Dallas.

Werner, C.
1985 *Spatial Transportation Modeling*. Scientific Geography Series, vol. 5. Sage Publications, Newbury Park, California.

Wheat, J. B.
1979 The Jurgens Site. Memoir 15 *Plains Anthropologist* 84(2).

White, D. E., G. A. Thompson, and C. H. Sandberg
1964 *Rocks, Structure, and Geologic History of Steamboat Springs Thermal Area, Washoe County, Nevada.* Geological Survey Professional Paper 458-B. U.S. Government Printing Office, Washington, D.C.

White, J. P., and D. H. Thomas
1972 What Mean These Stones? Ethno-taxonomic Models and Archaeological Interpretations in the New Guinea Highlands. In *Models in Archaeology*, ed. D.L. Clark, pp. 275-308.

Whittaker, R. H.
1972 Evolution and Measurement of Species Diversity. *Taxon* 21(2/3):213-51.

Wiessner, P.
1977 *Hxaro: A Regional System of Reciprocity for Reducing Risk Among the !Kung San.* Unpubished Ph.D. dissertation. University of Michigan, Ann Arbor.

Wilke, P. J., and A. B. Schroth
1989 Lithic Raw Material Prospects in the Mojave Desert, California. *Journal of California and Great Basin Anthropology* 11(2):146-174.

Wilkinson, L.
1989 *SYGRAPH: The System for Graphics.* SYSTAT, Inc. Evanston, Illinois.

Willey, G. R., and P. Phillips
1958 *Method and Theory in American Archaeology.* University of Chicago Press.

Willig, J. A.
1988 Paleo-Archaic Adaptations and Lakeside Settlement Patterns in the Northern Alkali Basin, Oregon. In *Early Human Occupations in Far Western North America: The Clovis-Archaic Interface*, ed. J.A. Willig, C.M. Aikens, and J.L. Fagan, pp. 417-482. Nevada State Museum Anthropological Papers, No. 21. Carson City, Nevada.

Willig, J. A., and C. M. Aikens
1988 The Clovis-Archaic Interface in Far Western North America. In *Early Human Occupations in Far Western North America: The Clovis-Archaic Interface*, ed. J.A. Willig, C.M. Aikens, and J.L. Fagan, pp. 1-40. Nevada State Museum Anthropological Papers, No. 21. Carson City, Nevada.

Willig, J. A., C. M. Aikens, and J. L. Fagan (editors)
1988 *Early Human Occupations in Far Western North America: The Clovis-Archaic Interface.* Nevada State Museum Anthropological Papers, No. 21. Carson City, Nevada.

Wilmsen, E. N.
1973 Interaction, Spacing Behavior, and the Organization of Hunting Bands. *Journal of Anthropological Research* 29(1):1-30.

Winarska-Kabacinska, M.
1988 Examination of Hafting Traces on End-scrapers from the Site of Wojnowo "a", Concentration III/75. In *Tracéologie et Technologie*, ed. S. Beyries. BAR International Series 411(i):47-52.

Witthoft, J.
1952 *A Paleo-Indian Site in Eastern Pennsylvania: An Early Hunting Complex.* Proceedings of the American Philosophical Society 96:464-495.

Woods, J. C.
1986 *Manufacturing and Use Damage on Pressure-Flaked Stone Tools*. Unpublished Master's thesis, Idaho State University.

Work, J.
1913 Journal of John Work...Covering Snake Country Expedition of 1830-31, ed. T.C. Elliott. *Oregon Historical Quarterly* 14:280-314.Walker, P.L.

World Almanac
1991 *The World Almanac and Book of Facts, 1991*. World Almanac, New York.

Wright, R. V. S. (editor)
1977 Stone Tools as Cultural Markers. *Prehistory and Material Culture Series* No. 12. Australian Institute of Aboriginal Studies, Canberra.

Yellen, J. E.
1977a *Archaeological Approaches to the Present*. Academic Press, New York.

1977b Cultural Patterns in Faunal Remains: Evidence from the !Kung Bushman. In *Experimental Archaeology*, ed. D. Ingersoll, J. Yellen, and W. McDonald, pp. 271-331. Columbia University Press, New York.

Yerkes, R. W.
1987 *Prehistoric Life on the Mississippi Floodplain: Stone Tool Use, Settlement Organization, and Subsistence Practices at the Labras Lake Site, Illinois*. University of Chicago Press.

Young, A.
1972 *Slopes*. Oliver and Boyd. Edinburgh.

Young, D., and D. B. Bamforth
1990 On the Macroscopic Identification of Used Flakes. *American Antiquity* 55(2):403-409.

Young, D. E., and R. Bonnichsen
1984 *Understanding Stone Tools: A Cognitive Approach*. Peopling of the Americas Process Series, Vol. 1. Center for the Study of Early Man, University of Main at Orono.

Young, J. A., R. A. Evans, and P. T. Tueller
1976 Great Basin Plant Communities - Pristine and Grazed. In *Holocene Environmental Change in the Great Basin*, pp. 187-215. Nevada Archaeological Research Paper No. 6. Reno.

Zeier, C. D.
1987 *An Intensive Reconnaissance of Historic Resources in the Tosawihi Quarries Archaeological District, Elko County, Nevada*. Intermountain Research, Silver City, Nevada. Submitted to Touchstone Resources Company, Battle Mountain, Nevada.

Zeier, C. D., and R. G. Elston
1986 *The Archaeology of the Vista Site 26Wa3017*. Intermountain Research, Silver City, Nevada. Submitted to Cultural Resources Section, Environmental Services Division, Nevada Department of Transportation, Carson City, Contract No. P51-84-013.

Zeier, C. D., and D. Zeanah
1987 *A Class III Archaeological Survey and Site Locational Analysis in Thousand Springs Valley, Elko County, Nevada*. Intermountain Reserach, Silver City, Nevada. Submitted to Woodward-Clyde Consultants, Oakland, California.

Zeir, C. J.
1978 Functional Analysis of Projectile Points from Yellow Jacket, Colorado. *Plains Anthropologist* 23:31-45.

Zerga, D L., and R. G. Elston
1990 Flaked Stone Technology. In *The Archaeology of James Creek Shelter*, ed. R.G. Elston and E.E. Budy, pp. 191-226. University of Utah Anthropological Papers No. 115.

Zeveloff, S. I.
1988 *Mammals of the Intermountain West*. University of Utah Press, Salt Lake City.

APPENDIX A

Chert Chemistry Analyses

UNIVERSITY OF MISSOURI

Research Reactor Facility

Research Park
Columbia, Missouri 65211
Telephone (314) 882-4211

February 10, 1989

Robert G. Elston
Intermountain Research
Drawer A
Silver City, NV 89428

Dear Bob:

I have completed the NAA work on the samples of Tosawihi chert samples which you sent in November. By using a combination of three different irradiations with four measurements a total of 30 elements were measured in most samples. For your information, I will briefly describe the analytical procedures and measurements for you:

The samples were initially prepared by extracting interior fragments (chips) from each specimen. This was accomplished using a hand press to crush the large specimens. The specimens were placed inside plastic bags and cushioned with styrofoam to prevent contamination from the press. The resulting chips were of order 10-20 mg in mass. The chips from each of the crushed specimens were cleaned in alcohol and DI water and finally dried in an oven to remove any loose particles.

Three analytical samples were prepared from each specimen (a one gram sample for prompt gamma NAA, a 150 mg sample for short irradiation NAA and a one gram sample for long irradiation NAA). The PGNAA sample was irradiated for 1-2 hours per sample in the MURR PGNAA facility and the element B was measured. The short NAA sample was irradiated for 5 seconds and counted after a 25-minute decay with the elements Cl, Dy, K, Mn and Na being measured. The long NAA sample was irradiated for 72 hours and counted twice (after 10 days and then after 8 weeks) with the elements As, Ba, La, Lu, Nd, Sm, U, Yb, Ce, Co, Cr, Cs, Eu, Fe, Hf, Rb, Sb, Sc, Ta, Tb, Th, Zn, Zr and Hg being measured.

The data was then assembled into a spreadsheet using Lotus 2.01. An ASCII file was created and the data were then studied with the Brookhaven codes which I obtained from Ed Sayre. Note that due to the limited number of specimens many of the programs could not be used.

The first program I used was MADSTAT which can be used to output the univariate statistics for an input group of specimens. MADSTAT lists the input data and both the arithmetic and geometric means and standard deviations for the input group. A MADSTAT listing is enclosed. The second program was MADPLOT which outputs a bi-variate plot for a selected pair of elements. A MADPLOT output for several pairs of elements has been enclosed. From studying the MADSTAT and MADPLOT output results, I selected those elements which in my judgement were the most discriminating. In my opinion these elements were: Eu, Cs, Fe, Hf, Sb, Sc, Ta and Tb. These elements were then input to the program MCONDIST which calculated a distance matrix based on the Mean Euclidean Distance between specimens. The data were log normalized before calculating this distance matrix. The distance matrix calculated by MCONDIST was then input into the program MAGCLUS which outputs a dendrogram that illustrates the similarity between specimens. The resulting dendrogram is also enclosed.

In addition to the computer printouts mentioned above, I have enclosed an IBM diskette which contains the following:

1. A spreadsheet file named NEVADA.WK1 which is in LOTUS 2.01 format. The data are given in parts per million on this diskette.

2. An ASCII file named NEVADA.PRN which contains data from the above LOTUS spreadsheet also in parts per million. The data for each specimen is stored on three lines using 130 characters per line and the format of the data is as follows:
   On the first line there is a six-character id, three blank spaces, a single letter C indicating the sample type to be chert, twelve concentration in fields of 10 characters each; on the second line a repeat of the six-character id, followed by the three blank spaces, the letter C, and the next twelve concentrations; on the third line the six-character id is repeated, with three blank spaces, the letter C and finally the last six concentrations.

   If you are familiar with FORTRAN, the format could be written:
   (A6,3X,A1,12F10.3,/A6,3X,A1,12F10.3,/A6,3X,A1,6F10.3)
   The ordering of elements is:
   Line 1: As, Ba, La, Lu, Nd, Sm, U, Yb, Ce, Co, Cr, Cs,
   Line 2: Eu, Fe, Hf, Rb, Sb, Sc, Ta, Tb, Th, Zn, Zr, Hg,
   Line 3: Cl, Dy, K, Mn, Na, B
   All concentrations are given in parts per million.

A hard copy printout of the above listed ASCII file is also enclosed.

One of my students (Mike Elam) who is familiar with the use of the SAS procedures will be studying these data using SAS to see what he he may be able to learn.

Please look at these data for a couple of weeks and then call me. We can discuss what further treatment should be applied to these data. Also, we can discuss whether you are interested in addition analyses of specimens and the means of payment for these and future analyses. I would prefer one payment (by purchase order) which would be placed into a single grant account. However, we can discuss other options. If you decide that this will be your only request for specimen analyses, you will need to provide a P.O. for $2,100 according to our originally agreed charge of $100 per sample.

I look forward to hearing from you in a couple of weeks.

Sincerely,

Michael D. Glascock

Michael D. Glascock

Enclosures:

UNIVERSITY OF MISSOURI

Research Reactor Facility

Research Park
Columbia, Missouri 65211
Telephone (314) 882-4211

February 16, 1989

Dr. Robert G. Elston
Intermountain Research
Drawer A
Silver City, NV 89428

Dear Dr. Elston:

I have completed the statistical analysis of the Tosawihi Chert trace element data. This analysis was performed using the SAS procedures as Dr. Glascock informed you in his letter of February 10. These results are complimentary to the ones obtained using the Brookhaven codes.

The data were assembled into the SAS format via an ASCII file created from a Lotus 2.01 spreadsheet. As Dr. Glascock noted for the Brookhaven codes, the small sample size of the Tosawihi data set precluded use of some of the more rigorous statistical procedures available in SAS (any type of Factor Analysis for example) as well.

I first calculated the basic univariate statistics and a test for normality utilizing the UNIVARIATE procedure. The results of this procedure revealed the majority of elements to have a large amount of variance and several exhibited quite pronounced skew and kurtosis. However, most were found to be normally distributed by the Shapiro-Wilks Test for normality. Nonetheless, normality was improved by taking the base ten logarithms and all additional statistical tests were performed using the log-normalized variables. The bivariate plots obtained by Dr. Glascock via the MADPLOT program were then examined to determine the most discriminating elements. I came to the same conclusion as Dr. Glascock that the most discriminating elements were Eu, Cs, Fe, Hf, Sb, Sc, Ta, and Tb. These elements were then used to test the groupings of the samples.

Because the data obtained for the Tosawihi chert were rather rough, I felt that some improvement in the ability to group the data could be obtained by calculating Canonical Discriminant Functions and using these functions in the clustering procedure rather than the log-normalized scores. These were obtained with the ACECLUS procedure and I have included the results of this procedure. The initial estimate of the within-cluster covariance structure was obtained using the total-sample covariance. I felt this was necessary due to the degree of dispersion observed in the variables and looking at only sample variances or identities would result in a loss of discriminating power (as it turned out, no improvement was obtained through use of sample variances or an identity matrix). The ACECLUS procedure derived four (4) Canonical Discriminant Functions from the eight (8) log-

normalized variables. While the procedure will derive discriminant functions equal to the number of variables input, more than four Canonical Discriminant Functions caused the subsequent clustering algorithms to fail due to arithmetic errors such as attempts to divide by zero or to take square roots of negative numbers. The Canonical Discriminant Functions (defined as ELE1-4) were then plotted against each other. The samples are defined as letters such that sample numbers 1-3=A, 4-6=B, etc. As is apparent from the plots, the discriminant functions did not do very well in discriminating the samples into meaningful groups. The Canonical Discriminant Functions were then input into the procedure CLUSTER to see if they would be useful in grouping the samples by conventional cluster analysis. Three different clustering algorithms were used; average linkage, centroid (squared Euclidean Distance), and Ward's Minimum Variance. Unfortunately as can be seen from the tree diagrams, the Canonical Discriminant Functions did not do any better in discriminating the samples into meaningful groups through a clustering algorithm than they did by simply plotting one against the other. I concluded from this that discriminant functions would not be of much use in grouping the specimens into meaningful sets.

Because the discriminant functions failed, I then turned to using the log-normalized scores in the same clustering algorithms as mentioned above. SAS has a wider variety of algorithms than do the Brookhaven codes and I hoped that perhaps a better fit could be obtained using these algorithms. Average linkage is the most commonly used clustering algorithm. The Brookhaven codes use a variant of this algorithm and the results that Dr. Glascock sent you are via an average linkage analysis. Average linkage is usually defined as the average distance between pairs of observations, one in each cluster. The centroid method is similar, but the distance measure is defined as the squared Euclidean distance between the means of two clusters. It is more robust to outliers than most other clustering algorithms. Ward's minimum variance algorithm measures the distance between two clusters as the ANOVA sum of squares summed over all variables. It has the advantages of being biased toward producing clusters with roughly the same number of specimens (important in a data set such as the Tosawihi chert), but is very sensitive to outliers. The results of these analyses are presented in the

second enclosed printout. As can be seen by a perusal of the tree diagrams, the solutions obtained using the log-normalized scores and the average linkage and centroid algorithms are sensible. Samples 1-3, 10-12, 13-15, 16-18 and 19-21 are linked together as expected. The remaining samples did not link in the manner expected. This would tend to show the many of these samples are more similar than originally surmised. The solution obtained by the average linkage and centroid are slightly better than that obtained by the MCONDIST and MAGCLUS programs. The Ward's algorithm did not produce as good a solution as did the average linkage or centroid methods probably due to the methods susceptibility to influence by outlying observations.

These results are probably as good as are obtainable given the small size of the data set and the fact that there is a fair amount of heterogeneity in groups of samples that were considered to be homogenous. Also, since the Canonical Discriminant Functions did not work well as classification criteria, it is doubtful that other types of discriminant functions (i.e. quadratic) or dimension compression techniques (i.e. multidimensional scaling) would work well in this regard either.

I hope that these results are of some use to you in your research endeavors. If you have any questions, please do not hesitate to contact me. My phone number is (314) 882-5268. Thank you for your collaboration with both Dr. Glascock and myself. We enjoyed working with you on this project. If we can ever be of assistance in the future in other archaeometric investigations, please don't hesitate to contact us.

Sincerely,

Michael Elam, MA
Grad. Research Assistant

enclosures

APPENDIX B

Photographic Methods

Appendix B: Photographic Methods

To emphasize flaked surfaces on projectile points and most other tools, artifacts were treated with a smoked layer of ammonium carbonate. This opaque coating obliterates all but topical features, focusing on flaking patterns rather than on color, tone, or material type.

Artifacts were photographed with a *Pentax* 6 cm x 7 cm format camera and a *Macro-Takumar* 1:4/135 mm lens. Field photographs were made with a variety of 35 mm cameras and lenses.

Artifacts were photographed under artificial lighting. Smoked artifacts were arrayed on a light box designed to give even illumination, balanced for daylight (5000°K). One or two photoflood lamps supplied light. The main source was placed low, at the upper left or upper right corner. A white card occasionally was used to provide extra fill light from the shadow side. It was sometimes necessary to use a fill light at a 1:3 ratio with the main light. Untreated artifacts were staged on a plate of clear glass, suspended 12.5 cm from a background of milk-white plexiglass. The lighting ratio between the artifacts and the background varied from plate to plate, allowing grayness to vary as much as one-half zone on the gray scale.

A cm scale was included in each original negative, but was cropped from the print. Scales included in the reproductions were added subsequently.

Kodak Plus-X Professional 120 format film was used exclusively for the artifact plates. This film, normally rated at 125 ASA, was rated at 100 ASA for this project. It was developed normally in Ilford ID-11 developer without dilution. This combination allows very fine grain structure and full shadow detail. Field photographs were made using *Kodak Plus-X*, *Kodak Ektachrome*, and *Fujichrome*. Black and white internegatives were made from color slides for reproduction.

All images were printed on *Kodak Polyprint RC*, a resin-coated paper with a glossy surface. Artifact photographs were printed using a #2 *Ilford* multigrade filter; field photographs were made using a variety of contrast filters. These filters were interposed between the light source and the negative to achieve a sharper image and greater contrast.

All black and white films were processed to archival standards and stored in appropriate sleeves.

APPENDIX C

Summary Data for Bifaces

APPENDIX C

Table 1. Summary Data for Bifaces.

			REDUCTION STAGE							MATERIAL TYPE						
Site/Locus	Fea.	Total Bifaces	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
Subarea: **Quarry**																
3032	0	7	0	0	2	5	0	0	0	7	0	0	0	0	0	0
3032/L19																
	0	9	0	0	8	1	0	0	2	9	0	0	0	0	0	0
	1	45	0	6	35	1	0	3	2	45	0	0	0	0	0	0
Subtotal		54	0	6	43	2	0	3	4	54	0	0	0	0	0	0
3032/L20	0	4	0	0	3	1	0	0	0	4	0	0	0	0	0	0
	1	9	0	1	8	0	0	0	0	9	0	0	0	0	0	0
	2	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0
	3	3	0	1	2	0	0	0	0	3	0	0	0	0	0	0
Subtotal		17	0	3	13	1	0	0	0	17	0	0	0	0	0	0
3032/L21	0	4	0	1	3	0	0	0	0	4	0	0	0	0	0	0
	1	2	0	1	1	0	0	0	0	2	0	0	0	0	0	0
Subtotal		6	0	2	4	0	0	0	0	6	0	0	0	0	0	0
3032/L22	1	6	1	2	3	0	0	0	0	6	0	0	0	0	0	0
3032/L23	1	67	2	7	50	1	0	7	3	65	1	0	0	0	1	0
3032/L25	0	10	0	0	10	0	0	0	0	10	0	0	0	0	0	0
	1	5	0	1	3	1	0	0	0	5	0	0	0	0	0	0
	2	67	1	6	54	0	0	6	3	65	0	0	0	0	2	0
	4	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	5	8	0	2	5	0	0	1	0	8	0	0	0	0	0	0
Subtotal		91	1	9	73	1	0	7	4	89	0	0	0	0	2	0
3032/L27	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
3032/L98	1	7	0	0	6	0	0	1	1	7	0	0	0	0	0	0
Subarea: **East**																
0024	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
0118	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
0310	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0

Appendix C: Table 1, continued.

Site/Locus	Fea.	Total Bifaces	REDUCTION STAGE Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	MATERIAL TYPE Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
0311	0	3	0	0	1	1	0	1	1	3	0	0	0	0	0	0
0510	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
3170	0	124	0	4	99	12	0	9	40	114	3	0	0	4	3	0
	1	5	0	3	2	0	0	0	0	5	0	0	0	0	0	0
	2	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	3	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	5	6	0	0	5	1	0	0	3	6	0	0	0	0	0	0
	6	4	0	0	3	1	0	0	1	4	0	0	0	0	0	0
	7	9	0	2	6	0	0	1	2	9	0	0	0	0	0	0
	8	4	0	0	4	0	0	0	3	3	1	0	0	0	0	0
	9	2	0	1	1	0	0	0	0	2	0	0	0	0	0	0
	10	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	11	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	12	18	0	1	13	4	0	0	8	18	0	0	0	0	0	0
	13	7	0	0	5	1	0	1	4	7	0	0	0	0	0	0
	14	10	1	0	9	0	0	0	0	9	0	0	0	1	0	0
3170 A	8	7	0	0	5	1	0	1	6	7	0	0	0	0	0	0
3170 B	8	15	1	0	10	3	0	1	6	15	0	0	0	0	0	0
Subtotal		217	2	11	168	23	0	13	74	205	4	0	0	5	3	0
3171	0	50	0	3	33	10	0	4	10	46	0	0	2	0	2	0
	1	10	0	4	6	0	0	0	1	10	0	0	0	0	0	0
	2	9	0	2	7	0	0	0	0	9	0	0	0	0	0	0
	3	4	0	1	2	1	0	0	0	4	0	0	0	0	0	0
	4	4	0	0	4	0	0	0	0	4	0	0	0	0	0	0
	5	6	0	0	2	4	0	0	3	6	0	0	0	0	0	0
	6	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	7	6	0	0	6	0	0	0	0	6	0	0	0	0	0	0
	8	2	0	0	1	1	0	0	1	2	0	0	0	0	0	0
Subtotal		92	0	10	62	16	0	4	15	88	0	0	2	0	2	0
3172	0	5	0	0	5	0	0	0	0	5	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		6	0	0	6	0	0	0	0	6	0	0	0	0	0	0
3173	0	2	0	0	1	0	0	1	1	2	0	0	0	0	0	0
	1	6	0	0	5	1	0	0	0	6	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
Subtotal		9	0	0	7	1	0	1	2	9	0	0	0	0	0	0
3174	2	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0

Appendix C: Table 1, continued.

			REDUCTION STAGE							MATERIAL TYPE						
Site/Locus	Fea.	Total Bifaces	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
3175	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
3177	1	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
3178	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	1	13	0	0	9	1	0	3	3	13	0	0	0	0	0	0
Subtotal		14	0	0	10	1	0	3	4	14	0	0	0	0	0	0
3179	1	2	0	0	1	1	0	0	1	2	0	0	0	0	0	0
3180	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
3181	1	11	0	0	10	0	0	1	6	11	0	0	0	0	0	0
3183	1	4	0	0	2	1	0	1	0	4	0	0	0	0	0	0
3184	0	23	0	0	15	7	0	1	8	22	0	0	0	0	1	0
	1	16	0	0	13	3	0	0	6	15	1	0	0	0	0	0
	2	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	3	13	0	1	10	2	0	0	2	13	0	0	0	0	0	0
	5	5	0	0	5	0	0	0	1	5	0	0	0	0	0	0
	6	1	0	0	0	1	0	0	0	1	0	0	0	0	0	0
	8	101	0	2	85	11	0	3	46	101	0	0	0	0	0	0
	10	17	0	1	10	5	0	1	2	17	0	0	0	0	0	0
	11	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	12	23	2	0	18	2	0	1	6	23	0	0	0	0	0	0
	14	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	15	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	16	4	0	0	4	0	0	0	1	4	0	0	0	0	0	0
	18	3	0	0	3	0	0	0	1	3	0	0	0	0	0	0
	19	14	0	0	8	5	0	1	1	13	0	1	0	0	0	0
	20	3	0	2	1	0	0	0	0	3	0	0	0	0	0	0
	21	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
	22	6	0	0	3	3	0	0	5	6	0	0	0	0	0	0
	23	36	0	0	33	2	0	1	8	36	0	0	0	0	0	0
	24	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	26	5	0	0	2	3	0	0	0	5	0	0	0	0	0	0
Subtotal		277	2	6	216	45	0	8	89	274	1	1	0	0	1	0
3185	0	5	0	0	4	1	0	0	2	5	0	0	0	0	0	0
	1	8	0	0	7	1	0	0	2	8	0	0	0	0	0	0
	2	3	0	0	3	0	0	0	1	3	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0

Appendix C: Table 1, continued.

Site/Locus	Fea.	Total Bifaces	REDUCTION STAGE Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	MATERIAL TYPE Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
	5	4	0	0	4	0	0	0	0	4	0	0	0	0	0	0
	6	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		22	0	0	20	2	0	0	5	22	0	0	0	0	0	0
3186	2	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
3189	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
3190	0	12	0	0	12	0	0	0	1	12	0	0	0	0	0	0
	1	30	0	1	22	0	0	7	8	29	1	0	0	0	0	0
	2	13	0	0	9	0	0	4	2	12	1	0	0	0	0	0
	4	5	0	0	5	0	0	0	1	5	0	0	0	0	0	0
	5	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
	6	4	0	0	4	0	0	0	1	4	0	0	0	0	0	0
	7	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	11	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
Subtotal		69	0	1	57	0	0	11	15	67	2	0	0	0	0	0
3191	0	4	0	0	3	1	0	0	0	4	0	0	0	0	0	0
	1	3	0	0	3	0	0	0	0	0	3	0	0	0	0	0
Subtotal		7	0	0	6	1	0	0	0	4	3	0	0	0	0	0
3192	0	9	0	0	7	2	0	0	2	9	0	0	0	0	0	0
	1	141	1	4	108	12	1	15	23	141	0	0	0	0	0	0
	2	68	1	2	49	7	0	9	23	66	1	1	0	0	0	0
	3	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0
	4	4	0	0	3	1	0	0	1	4	0	0	0	0	0	0
	5	3	0	0	3	0	0	0	0	3	0	0	0	0	0	0
Subtotal		226	2	6	171	22	1	24	49	223	1	2	0	0	0	0
3193	0	7	0	0	5	2	0	0	1	7	0	0	0	0	0	0
	1	3	0	0	3	0	0	0	0	3	0	0	0	0	0	0
	2	4	0	0	4	0	0	0	1	4	0	0	0	0	0	0
	3	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	4	4	0	0	4	0	0	0	0	4	0	0	0	0	0	0
	5	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
Subtotal		22	0	0	20	2	0	0	3	22	0	0	0	0	0	0
3195	0	15	0	0	14	1	0	0	0	15	0	0	0	0	0	0
	1	2	0	0	1	0	0	1	0	2	0	0	0	0	0	0
	2	11	0	1	8	0	0	2	0	11	0	0	0	0	0	0

Appendix C: Table 1, continued.

			REDUCTION STAGE							MATERIAL TYPE						
Site/Locus	Fea.	Total Bifaces	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
	3	3	0	0	3	0	0	0	0	3	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	5	4	0	0	4	0	0	0	0	4	0	0	0	0	0	0
	6	3	0	0	3	0	0	0	0	3	0	0	0	0	0	0
	7	3	0	0	3	0	0	0	0	3	0	0	0	0	0	0
	8	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	700	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		45	0	1	40	1	0	3	0	45	0	0	0	0	0	0
3196	0	5	0	0	5	0	0	0	0	5	0	0	0	0	0	0
	1	6	0	1	5	0	0	0	0	6	0	0	0	0	0	0
	2	8	0	1	7	0	0	0	0	8	0	0	0	0	0	0
	3	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	4	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	6	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		23	0	2	21	0	0	0	0	23	0	0	0	0	0	0
3197	0	6	0	1	5	0	0	0	1	6	0	0	0	0	0	0
	1	4	0	0	4	0	0	0	0	4	0	0	0	0	0	0
	3	3	0	0	3	0	0	0	1	3	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	5	17	0	3	14	0	0	0	0	17	0	0	0	0	0	0
	7	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	8	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	9	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
Subtotal		35	0	4	31	0	0	0	2	35	0	0	0	0	0	0
3198	0	5	0	0	4	0	1	0	0	5	0	0	0	0	0	0
	1	11	0	1	3	6	0	1	3	11	0	0	0	0	0	0
	2	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	3	5	0	0	4	1	0	0	1	5	0	0	0	0	0	0
	4	2	0	0	0	2	0	0	1	2	0	0	0	0	0	0
	5	5	0	0	5	0	0	0	2	5	0	0	0	0	0	0
	6	5	0	0	3	2	0	0	0	5	0	0	0	0	0	0
	7	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	8	3	0	0	1	2	0	0	0	3	0	0	0	0	0	0
	9	2	0	0	1	1	0	0	1	2	0	0	0	0	0	0
	11	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	14	8	1	1	5	0	0	1	0	8	0	0	0	0	0	0
	15	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	16	7	0	0	6	1	0	0	1	7	0	0	0	0	0	0
	17	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	19	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0

Appendix C: Table 1, continued.

Site/Locus	Fea.	Total Bifaces	REDUCTION STAGE Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	MATERIAL TYPE Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
	21	5	0	0	4	1	0	0	2	5	0	0	0	0	0	0
	23	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
Subtotal		66	1	2	44	16	1	2	12	66	0	0	0	0	0	0
3200	1	12	0	1	10	1	0	0	1	12	0	0	0	0	0	0
3201	1	13	0	1	10	0	0	2	4	13	0	0	0	0	0	0
	2	21	0	2	19	0	0	0	9	21	0	0	0	0	0	0
	3	3	0	0	3	0	0	0	0	3	0	0	0	0	0	0
Subtotal		37	0	3	32	0	0	2	13	37	0	0	0	0	0	0
3202	1	2	0	1	0	1	0	0	1	2	0	0	0	0	0	0
3203	0	6	0	2	4	0	0	0	1	6	0	0	0	0	0	0
3204	0	43	0	4	34	2	0	3	5	43	0	0	0	0	0	0
	1	37	0	2	30	0	0	5	4	36	0	0	0	0	1	0
Subtotal		80	0	6	64	2	0	8	9	79	0	0	0	0	1	0
Subarea: **West**																
3084	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0
	2	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		2	0	0	2	0	0	0	0	1	0	0	0	1	0	0
3085	5	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
3086	0	4	0	2	2	0	0	0	0	4	0	0	0	0	0	0
3087	0	4	0	0	4	0	0	0	0	4	0	0	0	0	0	0
3088	0	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
3090	0	5	0	0	5	0	0	0	2	5	0	0	0	0	0	0
3091	0	6	0	0	5	1	0	0	1	6	0	0	0	0	0	0
3092	0	402	2	5	298	37	0	60	110	356	2	1	4	31	7	1
	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	2	3	0	0	3	0	0	0	3	3	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	5	2	0	0	2	0	0	0	2	2	0	0	0	0	0	0
	6	3	0	0	2	1	0	0	0	3	0	0	0	0	0	0

Appendix C: Table 1, continued.

Site/Locus	Fea.	Total Bifaces	REDUCTION STAGE Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	MATERIAL TYPE Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
	7	9	0	1	6	0	0	2	0	6	0	0	0	3	0	0
	9	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	12	38	1	0	32	4	0	1	6	33	0	0	0	5	0	0
	13	20	0	0	17	3	0	0	8	18	0	0	0	2	0	0
	14	10	0	0	7	1	0	2	3	9	0	0	0	1	0	0
	16	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	20	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	21	3	0	0	3	0	0	0	1	3	0	0	0	0	0	0
	23	4	0	0	2	0	0	2	0	3	1	0	0	0	0	0
Subtotal		499	3	6	377	46	0	67	135	441	3	1	4	42	7	1
3093	0	4	0	0	2	2	0	0	0	4	0	0	0	0	0	0
	1	3	0	0	2	1	0	0	1	3	0	0	0	0	0	0
	3	2	0	0	1	0	0	1	1	2	0	0	0	0	0	0
	4	21	0	2	8	5	0	6	4	21	0	0	0	0	0	0
	5	8	0	0	4	4	0	0	1	8	0	0	0	0	0	0
Subtotal		38	0	2	17	12	0	7	7	38	0	0	0	0	0	0
3095	0	72	0	3	44	18	0	7	34	71	1	0	0	0	0	0
	2	4	0	1	3	0	0	0	3	4	0	0	0	0	0	0
	3	6	0	0	4	2	0	0	3	6	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	5	10	0	0	7	3	0	0	7	10	0	0	0	0	0	0
	6	19	0	0	12	4	0	3	8	19	0	0	0	0	0	0
	7	6	0	0	4	2	0	0	1	6	0	0	0	0	0	0
	8	3	0	0	2	1	0	0	0	3	0	0	0	0	0	0
	9	5	0	0	5	0	0	0	2	5	0	0	0	0	0	0
	10	83	0	2	60	10	0	11	45	82	0	0	1	0	0	0
	11	6	0	0	5	1	0	0	3	6	0	0	0	0	0	0
	12	4	0	0	3	0	0	1	1	4	0	0	0	0	0	0
	13	10	0	0	9	1	0	0	1	10	0	0	0	0	0	0
	15	55	0	0	31	11	0	13	30	54	0	1	0	0	0	0
	16	3	0	0	3	0	0	0	1	3	0	0	0	0	0	0
	17	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	19	53	0	1	33	10	0	9	19	51	0	0	2	0	0	0
	20	7	0	2	4	1	0	0	3	7	0	0	0	0	0	0
	21	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	22	71	0	0	47	19	0	5	37	70	0	0	0	0	1	0
	23	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	24	45	0	1	26	11	0	7	2	43	0	0	0	2	0	0
	25	2	0	0	2	0	0	0	2	2	0	0	0	0	0	0
Subtotal		468	0	10	307	95	0	56	203	460	1	1	3	2	1	0

Appendix C: Table 1, continued.

			REDUCTION STAGE							MATERIAL TYPE						
Site/Locus	Fea.	Total Bifaces	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
3096	0	5	0	1	3	0	0	1	3	5	0	0	0	0	0	0
	1	4	0	0	4	0	0	0	4	4	0	0	0	0	0	0
	2	2	0	0	2	0	0	0	0	2	0	0	0	0	0	0
	3	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		13	0	1	11	0	0	1	8	13	0	0	0	0	0	0
3099	0	3	0	0	3	0	0	0	2	3	0	0	0	0	0	0
	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	3	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
	4	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
Subtotal		7	0	0	6	0	0	1	3	7	0	0	0	0	0	0
3101	0	16	0	0	13	1	1	1	12	14	0	1	0	0	0	1
3101 1	0	5	0	0	5	0	0	0	3	5	0	0	0	0	0	0
Subtotal		21	0	0	18	1	1	1	15	19	0	1	0	0	0	1
3102	0	8	0	1	6	0	0	1	4	8	0	0	0	0	0	0
	1	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
	2	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		11	0	1	9	0	0	1	5	11	0	0	0	0	0	0
3104	0	7	0	0	7	0	0	0	0	7	0	0	0	0	0	0
3106	0	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
	1	24	0	1	20	1	0	2	15	24	0	0	0	0	0	0
	2	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	4	21	0	0	18	2	0	1	9	20	0	0	0	0	1	0
	7	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
Subtotal		50	0	1	43	3	0	3	27	49	0	0	0	0	1	0
3107	0	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	3	2	0	1	0	1	0	0	1	2	0	0	0	0	0	0
Subtotal		4	0	1	2	1	0	0	1	4	0	0	0	0	0	0
3110	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0
3114	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	1	14	0	0	9	2	0	3	8	14	0	0	0	0	0	0
Subtotal		15	0	0	10	2	0	3	9	15	0	0	0	0	0	0
3115	1	8	0	2	3	2	0	1	5	8	0	0	0	0	0	0

Appendix C: Table 1, continued.

			REDUCTION STAGE							MATERIAL TYPE						
Site/Locus	Fea.	Total Bifaces	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
3116	0	5	0	0	5	0	0	0	0	5	0	0	0	0	0	0
	1	6	0	0	4	1	0	1	1	5	1	0	0	0	0	0
Subtotal		11	0	0	9	1	0	1	1	10	1	0	0	0	0	0
3149	0	8	0	0	6	2	0	0	4	8	0	0	0	0	0	0
	1	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	2	3	0	0	2	1	0	0	1	3	0	0	0	0	0	0
Subtotal		12	0	0	9	3	0	0	6	12	0	0	0	0	0	0
3160	0	444	1	11	308	111	0	13	306	435	1	0	4	1	3	0
3160 A	0	40	0	1	19	12	0	8	22	39	0	0	0	1	0	0
	17	15	0	1	9	4	0	1	6	15	0	0	0	0	0	0
	18	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	23	57	0	3	29	14	0	11	38	54	0	0	2	1	0	0
	24	7	0	2	4	1	0	0	3	7	0	0	0	0	0	0
3160 B	19	6	0	0	4	1	0	1	5	6	0	0	0	0	0	0
	20	8	1	0	6	0	0	1	5	8	0	0	0	0	0	0
	21	3	0	0	1	2	0	0	3	3	0	0	0	0	0	0
	22	4	0	0	4	0	0	0	1	4	0	0	0	0	0	0
3160 C	0	14	0	0	7	3	0	4	9	13	0	0	1	0	0	0
	1	82	0	1	48	20	1	12	52	81	0	0	1	0	0	0
	2	2	0	0	1	0	0	1	2	2	0	0	0	0	0	0
	3	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	4	6	0	1	0	4	0	1	5	6	0	0	0	0	0	0
	5	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
	6	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	7	4	0	0	3	1	0	0	3	4	0	0	0	0	0	0
	8	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	11	5	0	0	4	0	0	1	2	5	0	0	0	0	0	0
	12	24	0	3	13	5	0	3	20	24	0	0	0	0	0	0
	13	2	0	1	0	1	0	0	1	2	0	0	0	0	0	0
	14	10	0	0	7	3	0	0	4	10	0	0	0	0	0	0
	15	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	16	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	25	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		742	2	24	475	183	1	57	493	727	1	0	8	3	3	0
3165	0	14	0	1	9	2	2	0	6	14	0	0	0	0	0	0
	1	3	0	0	2	1	0	0	0	3	0	0	0	0	0	0
	2	36	0	6	28	1	0	1	8	36	0	0	0	0	0	0
3165 A	0	21	0	1	16	4	0	0	10	21	0	0	0	0	0	0
Subtotal		74	0	8	55	8	2	1	24	74	0	0	0	0	0	0

Appendix C: Table 1, continued.

Site/Locus	Fea.	Total Bifaces	REDUCTION STAGE Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	MATERIAL TYPE Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
3271	0	205	0	2	158	31	1	13	112	204	1	0	0	0	0	0
	15	2	0	0	1	0	0	1	0	2	0	0	0	0	0	0
	22	2	0	0	1	1	0	0	1	2	0	0	0	0	0	0
3271 A	0	9	0	0	7	0	0	2	7	9	0	0	0	0	0	0
	19	8	0	0	6	2	0	0	2	8	0	0	0	0	0	0
	20	7	0	0	6	1	0	0	3	7	0	0	0	0	0	0
	21	14	0	1	11	1	0	1	2	14	0	0	0	0	0	0
3271 B	12	67	0	4	44	13	0	6	32	67	0	0	0	0	0	0
	13	8	0	0	4	2	0	2	5	8	0	0	0	0	0	0
	14	15	0	1	9	4	0	1	3	15	0	0	0	0	0	0
	17	4	0	0	4	0	0	0	2	4	0	0	0	0	0	0
	18	7	0	1	1	1	0	4	2	7	0	0	0	0	0	0
3271 C	1	3	0	0	1	0	0	2	1	3	0	0	0	0	0	0
	2	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	5	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
	6	6	0	0	6	0	0	0	3	6	0	0	0	0	0	0
	8	3	0	2	0	0	0	1	1	3	0	0	0	0	0	0
	10	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0
	11	7	0	0	0	5	0	2	6	7	0	0	0	0	0	0
Subtotal		371	0	11	262	62	1	35	184	370	1	0	0	0	0	0
Subarea: **North**																
3228	0	4	0	0	3	1	0	0	2	4	0	0	0	0	0	0
	2	4	0	0	0	3	1	0	3	4	0	0	0	0	0	0
Subtotal		8	0	0	3	4	1	0	5	8	0	0	0	0	0	0
3231	0	1	0	0	1	0	0	0	1	1	0	0	0	0	0	0
	1	2	0	0	0	0	0	2	1	2	0	0	0	0	0	0
Subtotal		3	0	0	1	0	0	2	2	3	0	0	0	0	0	0
3232	0	2	0	0	2	0	0	0	2	2	0	0	0	0	0	0
	1	4	0	0	3	0	0	1	4	4	0	0	0	0	0	0
Subtotal		6	0	0	5	0	0	1	6	6	0	0	0	0	0	0
3234	0	2	0	0	2	0	0	0	2	1	1	0	0	0	0	0
3237	0	62	0	1	44	11	2	4	44	60	2	0	0	0	0	0
	1	3	0	0	3	0	0	0	1	3	0	0	0	0	0	0
3237 A	0	3	0	0	2	0	0	1	0	3	0	0	0	0	0	0
3237 C	0	125	0	1	75	26	0	23	49	114	0	5	2	0	4	0
3237 C	2	12	1	0	5	1	0	5	5	11	0	0	0	0	1	0
3237 C	3	2	0	0	2	0	0	0	1	2	0	0	0	0	0	0

Appendix C: Table 1, continued.

			REDUCTION STAGE							MATERIAL TYPE						
Site/Locus	Fea.	Total Bifaces	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Indet.	Heat-treated	Opalite	Obsidian	Basalt	Chalcedony	Jasper	Opal	Other
3237 C	4	1	0	0	1	0	0	0	0	1	0	0	0	0	0	0
Subtotal		208	1	2	132	38	2	33	100	194	2	5	2	0	5	0
3238	0	26	0	0	17	8	0	1	13	25	1	0	0	0	0	0
	1	8	0	1	5	1	0	1	3	8	0	0	0	0	0	0
Subtotal		34	0	1	22	9	0	2	16	33	1	0	0	0	0	0
3239	0	12	0	0	8	3	1	0	2	12	0	0	0	0	0	0
	1	19	0	0	7	6	0	6	14	18	1	0	0	0	0	0
Subtotal		31	0	0	15	9	1	6	16	30	1	0	0	0	0	0
3251	0	24	0	0	11	8	0	5	16	22	0	0	0	2	0	0
	1	82	0	2	33	12	0	35	73	82	0	0	0	0	0	0
	2	21	0	0	7	8	0	6	17	21	0	0	0	0	0	0
	4	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0
	5	1	0	0	0	1	0	0	1	1	0	0	0	0	0	0
	6	36	0	0	9	10	0	17	28	34	0	0	0	1	1	0
Subtotal		165	0	2	60	39	0	64	136	161	0	0	0	3	1	0
Total		4388	17	159	3091	666	12	443	1732	4248	24	11	19	56	28	2

APPENDIX C

Table 2. Summary Data for Cache Bifaces Analysis.

Specimen No.	Blank Type	Side-by-Side No. of Series	Skip-Patterned No. of Series	Flattening Scars	Margin Contouring Scars	Overstrikes	Thinning off Flat	Alternate Removals	Edge Run	Hard Hammer	Soft Hammer
Cache 26Ek3197											
2001-8	B	-	-	+	+	-	+	-	?	+	-
505-2	B?	-	-	-	+	-	-	-	-	+	-
2001-10	B	-	-	+	+	-	+	-	+	+	-
2001-1	F?	1	-	-	+	-	-	-	-	+	-
2001-2	B?	2*	-	+	+	-	+	-	-	+	-
505-3	B	-	-	+	+	-	+	-	+	+	-
2001-3	U	-	-	-	+	-	+	-	+	+	-
2001-7	B	1	-	+	+	-	+	-	+	+	-
2001-12	B	1	-	+	+	-	+	-	-	+	-
2001-5	F*	-	-	-	+	-	+	-	-	+	-
2001-4	F	-	-	-	+	-	-	-	-	?	-
505-1	U	-	-	+	+	-	+	-	-	+	-
2001-9	B	-	-	+	+	-	+	+	-	+	-
2001-11	B	-	-	-	+	-	-	-	-	+	-
2001-13	F?	1	-	+	+	+	+	-	+	+	-
505-4	F?	-	-	-	+	-	+*	-	+	+	-
2001-6	F?	-	-	+	+	+	-	-	-	+	-
	F = 6 (35%) B = 9 (53%) U = 2 (12%) Total = 16	6 (100%)	0	10 (59%)	17 (100%)	2 (12%)	12 (75%)	1 (6%)	7 (44%)	HH only = 17 (100%) SH only = 0 Both = 0	
Cache 26Ek3192											
2021-2	F	-	-	-	+	-	-	-	-	?	-
1010-8	B?	-	1?	+	+	-	+	+	-	+	-
2021-9	F?	1	-	?	+	+	-	-	-	+	-
2022-5	U	1	-	+	+	-	+	?	+	+	-
2021-10	B?	-	-	+	+	-	+	-	-	?	?
2022-10	U	-	-	+	+	-	+	-	-	+	-
2021-13	B?	1*	-	+	+	-	+	-	+*	+	?
1010-7	B	1	-	+	+	-	-	-	-	+	-
2021-5	B	-	-	-	+	-	-	+	-	+	-
2021-7	F?	-	-	+	+	+	-	?	-	+	?
2021-8	F	2	-	+	+	-	-	-	-	-	+
2022-2	U	?	-	+	+	-	-	-	-	-	+
2022-15	U	1	-	-	+	-	-	-	-	+	+
2021-6	B?	1	-	+	+	-	-	-	-	+	-
2022-14	F	1	-	-	+	-	-	-	-	?	?
2021-12	U	4	-	+	+	-	-	-	-	-	+
2021-11	B?	1	-	+	+	-	-	-	+	?	?
2022-22	U	1	-	+	+	-	+	-	-	?	+
1010-4	F	1	-	-	+	+	-	-	-	+	?
2022-8	F	-	-	-	+	-	+	-	?	?	?

APPENDIX C: Table 2, continued.

Specimen No.	Blank Type	Side-by-Side No. of Series	Skip-Patterned No. of Series	Flattening Scars	Margin Contouring Scars	Overstrikes	Thinning off Flat	Alternate Removals	Edge Run	Hard Hammer	Soft Hammer
Cache 26Ek3192, continued.											
2021-15	F?	-	-	-	+	-	-	-	-	+	-
1010-6	F	-	-	+	+	-	+	-	-	+	-
2021-1	U	2	-	+	+	-	-	-	-	+	?
2022-20	F	-	-	-	+	-	-	-	-	?	?
1012-2	F	-	-	?	+	-	-	-	-	+	-
2022-1	F	-	-	-	+	-	-	-	-	+	-
2022-9	B	-	-	+	+	-	+	-	+	+	-
2022-23	F?	1	-	-	+	-	-	-	-	+	?
1010-3	F	-	-	-	+	-	-	-	-	+	?
2022-13	B?	-	-	-	+	-	-	-	-	+	?
2022-18	F	-	-	+	+	-	+	-	-	?	+
1010-5	B?	1*	-	+	+	-	-	-	-	+	?
2022-21	B?	-	-	-	+	-	+	-	-	+	-
2022-19	B	1	-	+	+	-	+	-	+	+	?
2022-16	B	-	-	+	+	-	+	-	+	+	-
2021-14	B?	-	-	+	+	-	+	-	-	?	+
2021-3	F	1	-	+	+	-	+	-	-	+	-
2022-7	B?	-	1?	+	+	+	+	-	-	+	-
2021-4	F?	2	-	+	+	-	-	-	-	+	-
1010-9	F	-	-	-	+	-	-	-	-	?	?
2022-12	F	2	-	+	+	-	-	-	-	?	+
	F = 19 (46%) B = 15 (37%) U = 7 (17%) Total = 41	26 (93%)	2 (7%)	27 (66%)	41 (100%)	4 (10%)	16 (39%)	4 (10%)	7 (17%)	HH only = 18 (44%) SH only = 3 (7%) Both = 20 (49%)	
Cache 26Ek3032											
1	U	-	-	+	+	-	-	-	-	+	?
2	U	1	1	+	+	-	-	-	-	?	?
3	U	1	-	+	+	-	-	-	?	?	+
4	U	1	~2*	+	+	-	-	-	-	-	+
5	U	-	?	+	+	+	-	-	-	+	?
6	U	-	-	+	+	+	-	-	-	+	-
	U = 6 (100%)	3 (43%)	4 (57%)	6 (100%)	6 (100%)	2 (33%)	0	0	1 (17%)	HH only = 1 (17%) SH only = 1 (17%) Both = 4 (67%)	

APPENDIX C: Table 2, continued.

Specimen No.	Blank Type	Side-by-Side No. of Series	Skip-Patterned No. of Series	Flattening Scars	Margin Contouring Scars	Overstrikes	Thinning off Flat	Alternate Removals	Edge Run	Hard Hammer	Soft Hammer
Cache 26Ek3095											
1081-1	U	1	1	-	+	-	-	-	-	?	+
2082-3	U	1	-	+	+	-	-	-	-	+	?
2082-1	U	3	-	-	+	-	-	?	-	?	+
2081-1	B	-	-	-	+	-	-	?	-	+	?
2081-4	U	2	-	-	+	-	+	-	-	?	+
2081-3	F	-	1	-	+	-	-	-	-	-	+
2082-2	B?	-	-	+	+	-	-	-	-	+	?
	F = 1 (14%)	7 (78%)	2 (22%)	2 (29%)	7 (100%)	0	1 (14%)	2 (29%)	7 (44%)	HH only =	0 (0%)
	B = 2 (29%)									SH only =	1 (14%)
	U = 4 (57%)									Both =	6 (86%)
	Total = 7										
Cache 26Ek3170											
4501-3	U	1	-	+	+	1	-	-	-	-	+
4501-11	U	1	-	+	+	-	-	-	-	-	+
4501-10	B?	1	1?	-	+	-	-	-	?	-	+
4501-4	U	-	-	-	+	-	-	-	-	+?	?
4501-2	B?	-	1	+	+	1	-	-	+	-	+
4501-7	U	3	-	-	+	-	-	-	-	-	+
4501-5	F	2*	-	-	+	+	-	-	-	+	+
4501-8	B?	1	-	+	+	-	+	?	?	+	?
4501-1	U	?	-	+	+	-	+	-	-	+?	+
4501-6	F	-	-	-	+	-	-	-	-	+?	-
	F = 2 (20%)	9 (83%)	2 (17%)	5 (50%)	10 (100%)	3 (30%)	2 (20%)	1 (10%)	3 (30%)	HH only =	1 (10%)
	B = 3 (30%)									SH only =	5 (50%)
	U = 5 (50%)									Both =	4 (40%)
	Total = 10										

All are present/absent except Side-by-Side and Skip-Patterned which are tabulated as number of examples per biface.

F = Flake
B = Block
U = Unidentified

APPENDIX D

Summary Data for Flake Tools

Appendix D. Summary Data for Flake Tools.

Site/Loc.	Fea.	TYPE Sc	Pt	N/D	BF	MR	Md	Ds	Fr	F/B	Ot	MATERIAL Opalite	Obs	Bas	Jas	Chal	Opal	Other	Pressure Flaked	THERMAL ALTERATION Block	Flake	Red.	Ind.	Other	HT	MOTION OF USE Scrape	Cut.	Perf.	Drill.	Groove	Bore	Chop.	Multi-Use	Indet.	Unused	Not Exam.
Subarea: **Quarry**																																				
3032/L19	1	8	-	4	-	8	-	-	2	1	-	16	-	-	-	-	7	-	1	-	-	-	-	-	23	10	3	-	-	-	-	-	-	4	-	6
3032/L20	1	1	-	-	-	2	-	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-	-	-	3	1	1	-	-	-	-	-	-	1	-	-
	2	-	-	1	-	1	-	-	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	1	-	-	-	-	-	-	1	-	1
Total		1	-	1	-	3	-	-	1	-	-	6	-	-	-	-	-	-	1	-	-	-	-	-	6	1	2	-	-	-	-	-	-	2	-	1
3032/L21	1	-	1	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2	-	-
3032/L22	1	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
3032/L23	1	4	3	9	-	8	-	-	1	1	-	21	-	-	1	-	4	-	1	-	-	-	-	-	26	7	1	-	-	-	-	-	1	8	1	8
3032/L25	2	2	3	1	-	5	-	-	2	-	-	12	-	-	-	-	1	-	1	-	-	-	-	-	13	3	-	-	-	-	1	-	-	3	1	5
3032/L26	0	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
3032/L27	0	9	6	5	3	8	1	3	-	-	-	27	4	-	2	1	-	1	5	-	5	-	1	1	28	10	-	-	-	1	-	-	3	7	1	13
3032/L98	1	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Subarea: **East**																																				
230	0	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
123	0	1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-
311	0	-	2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-	-	1	-	-	-	1	-	-
3170	0	5	3	1	3	8	2	2	-	-	-	14	5	1	3	-	-	1	4	-	-	1	1	-	22	6	4	-	-	-	-	-	-	8	-	6
	4	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-
	7	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	8	5	-	3	-	4	3	-	-	-	-	10	-	-	1	4	-	-	-	1	-	-	1	-	13	3	-	-	-	-	-	-	1	6	-	5
	10	-	1	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	1	-	-
	13	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	14	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Total		12	5	6	3	13	5	2	-	-	-	29	6	1	4	5	-	1	4	1	-	1	2	1	41	12	4	-	-	-	-	-	1	18	-	11
3171	0	3	-	-	-	3	-	4	1	-	-	6	2	-	1	-	1	1	1	-	1	-	-	-	10	2	-	-	-	-	-	-	-	5	-	4
	2	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	3	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	4	-	1	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	2	-	-
	6	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
Total		4	2	-	-	4	-	4	2	-	-	11	2	-	1	-	1	1	3	-	1	-	-	1	14	3	-	-	-	-	-	-	-	8	-	5
3173	0	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	1	1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	-	-	-	1	-	-
	3	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-
Total		2	-	-	1	1	-	-	-	-	-	4	-	-	-	-	-	-	-	-	1	-	-	1	2	1	1	-	-	-	-	-	-	2	-	-
3179	1	2	-	-	-	-	-	-	1	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	1	-	1
3181	1	-	-	-	-	4	-	-	1	-	-	5	-	-	-	-	-	-	-	-	1	-	-	-	4	-	2	-	-	-	-	-	-	1	-	2
3184	0	3	1	-	-	3	-	-	3	-	-	7	1	-	1	1	-	-	2	-	-	-	-	-	10	1	1	-	-	-	-	-	2	3	-	3
	2	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	3	1	-	-	-	3	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-	-	-	1	-	2
	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	8	1	2	-	-	9	-	-	2	-	-	12	-	-	2	-	-	-	-	1	4	-	2	-	7	5	-	-	1	-	-	-	1	3	-	4
	10	1	2	-	-	2	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-	5	3	-	-	-	-	-	-	1	1	-	-
	12	2	-	3	-	4	-	-	1	1	-	11	-	-	-	-	-	-	-	1	-	-	-	1	9	-	-	-	-	-	-	-	-	4	1	6
	14	-	-	2	-	1	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	1	1	1

Appendix D, continued.

		TYPE										MATERIAL								THERMAL ALTERATION						MOTION OF USE										
Site/Loc.	Fea.	Sc	Pt	N/D	BF	MR	Md	Ds	Fr	F/B	Ot	Opalite	Obs	Bas	Jas	Chal	Opal	Other	Pressure Flaked	Block	Flake	Red.	Ind.	Other	HT	Scrape	Cut.	Perf.	Drill.	Groove	Bore	Chop.	Multi-Use	Indet.	Unused	Not Exam.
3184, cont.	18	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	19	3	1	-	-	5	-	-	1	-	-	10	-	-	-	-	-	-	-	4	-	-	1	-	5	2	1	-	-	-	-	-	-	3	-	4
	20	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	21	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	23	-	-	2	-	6	-	-	4	-	-	12	-	-	-	-	-	-	-	1	2	-	1	1	7	2	-	-	-	-	-	-	-	3	-	7
	26	1	-	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	2	1	1	-	-	-	-	-	-	-	-	-
Total		15	6	8	-	35	-	-	11	1	-	68	2	-	3	2	-	1	2	7	6	-	4	2	57	18	3	-	1	-	-	-	4	20	2	28
3185	0	-	-	1	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-	-	-	-	-	-	-	-	-
	1	6	-	-	-	3	-	-	-	-	-	9	-	-	-	-	-	-	2	-	1	-	1	-	7	5	-	-	-	-	-	-	-	2	-	2
	6	1	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	2	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
Total		7	-	1	2	3	-	-	-	-	-	12	-	-	-	-	-	1	2	-	3	-	1	-	9	6	3	-	-	-	-	-	-	2	-	2
3190	0	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-
	1	3	3	-	-	3	-	-	3	-	-	10	1	-	-	-	-	1	1	-	4	-	1	1	6	-	1	1	-	-	-	-	-	4	-	6
	2	-	1	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	2	-	-
	5	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	6	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-
Total		4	4	-	-	6	-	-	3	-	-	14	2	-	-	-	-	1	2	-	5	-	2	1	9	-	2	1	-	-	-	-	1	7	-	6
3191	1	1	-	-	-	5	-	-	-	-	-	2	3	-	-	-	-	-	-	-	-	-	-	-	5	2	1	-	-	-	-	-	-	1	-	1
3192	0	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	1	19	4	1	-	21	-	-	5	-	1	48	1	-	-	-	-	2	4	1	6	-	1	4	37	15	7	1	-	-	-	-	3	15	1	9
	2	5	-	-	1	10	-	-	-	1	-	15	1	-	1	-	-	-	1	1	2	-	-	-	14	5	1	-	-	-	-	-	1	5	-	5
Total		25	4	1	1	31	-	-	5	1	1	64	2	-	1	-	-	2	5	2	8	-	1	4	52	21	8	1	-	-	-	-	4	20	1	14
3193	4	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
3195	0	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	2	1	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	1
Total		3	-	-	-	-	-	1	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	4	2	-	-	-	-	-	-	-	1	-	1
3196	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Total		1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	3	2	-	-	-	-	-	-	-	-	-	1
3197	5	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
3198	1	2	1	-	1	5	-	-	1	-	-	10	2	-	-	-	-	-	1	1	1	-	1	-	9	1	4	-	-	-	-	-	2	3	-	2
	2	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Total		2	1	-	1	5	-	-	2	-	-	11	2	-	-	-	-	-	1	1	1	-	1	-	10	1	4	-	-	-	-	-	2	3	-	3
3200	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
3201	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-
3204	0	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	-	-	-	2	1	-	-	-	-	-	-	1	-	-	-
	1	2	4	3	-	9	-	-	1	-	-	18	1	-	-	-	-	-	1	2	2	-	1	1	13	3	3	-	1	-	-	-	-	5	1	6
Total		3	5	3	-	9	-	-	1	-	-	19	1	-	-	-	-	1	2	2	2	-	1	1	15	4	3	-	1	-	-	-	1	5	1	6
Subarea: **West**																																				
3084	1	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	2	1	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	1	-	-
Total		1	-	-	-	2	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	1	-	2	-	-
3086	0	1	-	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-
3088	0	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3090	0	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-

Appendix D, continued.

		TYPE										MATERIAL							Pressure	THERMAL ALTERATION					MOTION OF USE										
Site/Loc.	Fea.	Sc	Pt	N/D	BF	MR	Md	Ds	Fr	F/B	Ot	Opalite	Obs	Bas	Jas	Chal	Opal	Other	Flaked	Block	Flake	Red.	Ind.	Other	HT	Scrape	Cut.	Perf.	Drill.	Groove	Bore	Chop.	Multi-Use	Indet.	Unused	Not Exam.
3092	0	21	13	5	4	58	2	-	20	3	2	100	1	2	21	3	1	-	10	12	15	2	2	2	95	23	12	3	-	1	-	-	6	30	1	52
	2	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2
	6	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	7	-	-	-	-	2	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	1
	12	1	-	1	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	2	-	-
	13	1	-	-	-	1	-	1	-	-	-	1	-	-	1	-	-	1	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	2	-	1
	14	1	-	-	-	6	-	-	1	-	-	6	-	-	2	-	-	-	-	-	-	-	1	-	7	2	-	-	-	-	-	-	1	3	-	2
	23	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1
Total		24	13	6	4	71	2	1	21	3	2	111	1	2	27	3	2	1	10	12	15	2	3	2	113	25	12	3	-	1	-	-	7	39	2	59
3093	4	-	1	-	-	2	-	-	-	-	-	3	1	-	-	-	-	-	1	-	-	-	-	3	-	-	1	1	-	-	-	-	-	1	-	-
3095	0	1	1	-	1	1	-	-	-	-	-	3	1	-	-	-	-	-	1	-	1	-	-	1	2	-	2	-	-	-	-	-	-	1	1	-
	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	5	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
	6	1	-	-	-	2	-	-	-	-	-	3	-	-	-	-	-	-	-	-	2	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1
	9	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	10	1	3	1	-	4	-	-	5	-	-	12	2	-	-	-	-	-	2	-	4	-	1	-	9	2	-	1	-	-	-	-	-	4	1	6
	11	2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	1	-	-	-	1	2	-	-	-	-	-	-	-	-	-	-
	15	-	-	-	-	4	-	-	1	-	-	4	-	-	-	1	-	-	-	1	1	-	-	-	3	1	-	-	-	-	-	-	-	1	-	3
	16	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	19	3	1	1	-	4	-	-	-	-	-	9	-	-	-	-	-	-	1	-	1	-	-	1	7	2	3	-	-	-	-	-	-	2	-	2
	20	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-
	22	-	2	-	-	1	-	-	-	-	-	1	-	-	2	-	-	-	-	-	-	-	-	-	3	-	-	-	1	-	-	-	-	-	-	2
	24	-	-	2	-	6	2	-	3	-	-	10	1	-	1	1	-	-	-	-	1	-	-	-	12	4	-	-	-	-	-	-	1	3	-	5
	25	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
Total		9	8	4	1	25	2	-	10	-	-	49	4	-	4	2	-	-	6	1	13	-	1	2	42	12	6	1	1	-	-	-	1	12	4	22
3101	0	-	2	-	-	1	-	-	-	-	-	3	-	-	-	-	-	-	-	1	1	-	-	-	1	1	-	-	-	-	-	-	-	2	-	-
3102	0	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
3106	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
	4	2	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	-	-	-	1	-	-	-
Total		3	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	2	-	-	-	-	1	1	-	-	-	-	-	-	2	-	-	-
3114	1	1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	1	-	-
3115	1	1	1	-	-	2	-	-	-	-	-	4	-	-	-	-	-	-	1	-	1	-	1	-	2	2	1	-	-	-	-	-	-	1	-	-
3116	1	3	2	-	-	2	-	-	1	-	-	8	-	-	-	-	-	-	1	-	-	-	-	-	8	4	-	2	-	-	-	-	-	-	-	2
3149	0	-	-	1	-	1	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	1	1	-	-
	2	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	1	-	-	-	1
Total		-	-	1	-	3	-	-	-	-	-	3	-	-	-	1	-	-	-	-	1	-	-	-	3	-	-	-	-	-	-	1	1	1	-	1
3160	0	6	6	1	-	14	-	-	9	-	-	30	-	-	1	3	-	2	7	1	10	-	1	5	19	4	2	1	-	-	1	-	1	12	-	15
	1	2	1	2	1	4	-	-	2	-	1	11	2	-	-	-	-	-	4	2	-	1	-	1	9	3	1	-	-	-	-	-	-	5	-	4
	4	-	1	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	2	-	-
	12	-	1	-	-	1	1	-	1	-	1	5	-	-	-	-	-	-	1	1	-	-	-	-	4	1	-	-	-	1	-	-	-	-	-	3
	17	-	1	-	1	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	-	-	1	-	1	-	1	-	-	-	-	-	-	1	-	-
	19	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	22	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	23	2	4	1	-	6	-	-	6	-	-	17	-	-	1	1	-	-	6	2	5	-	-	1	11	2	-	-	1	-	1	-	1	3	-	11
	24	1	-	-	-	1	-	-	-	2	-	4	-	-	-	-	-	-	-	-	-	-	-	-	4	1	1	-	-	-	-	-	-	-	-	2
Total		12	15	5	2	26	1	-	18	2	2	72	2	-	2	4	-	3	19	6	15	1	2	8	51	12	5	1	1	1	2	-	2	24	-	35
3165	0	-	-	-	-	4	-	-	1	-	-	4	1	-	-	-	-	-	-	-	-	-	-	-	5	-	1	-	-	-	-	-	-	3	-	1
	1	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	2	-	1	-	-	2	1	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1	3	-	2	-	-	-	-	-	-	2	-	-
Total		-	2	-	-	6	1	-	1	-	-	9	1	-	-	-	-	-	-	-	-	-	-	1	9	1	3	-	-	-	-	-	-	5	-	1

Appendix D, continued.

		TYPE										MATERIAL							Pressure	THERMAL ALTERATION					MOTION OF USE										
Site/Loc.	Fea.	Sc	Pt	N/D	BF	MR	Md	Ds	Fr	F/B	Ot	Opalite	Obs	Bas	Jas	Chal	Opal	Other	Flaked	Block	Flake	Red.	Ind.	Other	HT	Scrape	Cut.	Perf.	Drill.	Groove	Bore	Chop.	Multi-Use	Indet.	Unused	Not Exam.
3208	0	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Total		2	-	-	-	-	-	-	1	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	1	-	1
3271	0	2	8	-	-	1	-	-	-	1	-	9	-	1	-	1	1	-	6	3	4	-	-	-	5	1	2	3	1	-	-	-	-	3	-	2
	1	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	3	-	1	-	1	2	-	-	-	-	-	3	-	1	-	-	-	-	-	1	1	-	-	-	2	1	2	1	-	-	-	-	-	-	-	-
	4	-	-	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
	8	-	-	-	-	1	-	-	1	-	-	2	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2
	12	4	-	3	-	8	-	1	1	-	-	15	-	-	-	1	1	-	-	-	1	-	-	1	15	4	-	-	-	-	-	-	-	4	1	8
	14	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
	18	-	-	-	-	1	-	-	1	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2
	19	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
	21	1	-	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	-	-	-	1	-	-
Total		7	10	5	2	14	-	1	4	1	-	37	-	2	1	2	2	-	6	4	9	-	1	1	29	9	5	4	1	-	-	-	-	9	1	15
Subarea: **North**																																			
3237	0	6	5	2	2	6	-	5	-	-	-	23	2	-	-	-	-	1	4	-	6	1	-	-	19	2	3	-	-	-	-	-	2	12	-	7
	2	-	1	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	2
Total		6	6	2	2	7	-	5	-	-	-	25	2	-	-	-	-	1	4	-	6	1	-	-	21	2	3	-	-	-	-	-	2	12	-	9
3238	0	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
3239	0	-	1	-	-	-	1	-	-	-	-	2	-	-	-	-	-	-	2	1	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	1
	1	1	1	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-
Total		1	2	-	-	-	1	-	-	-	-	4	-	-	-	-	-	-	3	1	1	-	-	1	1	-	-	-	-	-	-	-	-	3	-	1
3251	0	1	3	-	-	1	-	-	-	-	-	4	-	-	-	1	-	-	2	1	3	-	-	-	1	1	1	2	-	-	-	-	-	1	-	-
	1	2	2	-	-	7	-	-	11	-	-	22	-	-	-	-	-	-	2	2	9	-	2	-	9	-	1	1	-	-	-	-	-	3	-	17
	3	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
	6	-	4	1	-	-	-	-	5	-	-	8	1	1	-	-	-	-	2	1	3	-	-	-	6	-	1	2	-	-	-	-	-	3	-	4
Total		4	9	1	-	8	-	-	16	-	-	35	1	1	-	1	-	-	6	4	15	-	2	-	17	2	3	5	-	-	-	-	-	7	-	21

Key:

TYPE
- Sc = Scrapers
- Pt = Pointed tools
- N/D = Notches & Denticulars
- BF = Bifacial Flake tools
- MR = Misc. Retouched tools
- Md = Microdenticulars
- Ds = Discoids
- Fr = Fragmentary tools
- F/B = Flaked/Battered tools
- Ot = Other

MATERIAL
- Obs = Obsidian
- Bas = Basalt
- Jas = Jasper
- Chal = Chalcedony

THERMAL ALTERATION
- Block = Tool made on flake from heat treated block
- Flake = Tool made on heat treated flake
- Red. = Tool heat treated during reduction
- Ind. = Heat treatment stage indeterminate
- Other = Possibly heat treated or burned
- HT = Not heat treated

MOTION OF USE
- Scrape = Scraping
- Cut. = Cutting
- Perf. = Perforating
- Drill. = Drilling
- Groove = Grooving
- Bore = Boring
- Chop. = Chopping
- Multi-Use = Multiple Use
- Indet. = Indeterminate
- Not Exam. = Not Examined

APPENDIX E

Attributes of Projectile Points

Appendix E. Attributes of Projectile Points.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/ Lt	Lt/ Wm	Wb/ Wm	Lm/ Lt
3237	000	6740	901	CLO	OPL	1	101.6	0.0	0.0	65.4	0.0	0.0	12.8	108.7	0.0	0	0	0	0.00	0.00	0.00	0.00
0214	000	2672	001	CT	OBS	1	25.1	25.1	4.1	12.8	12.4	0.0	2.9	0.6	0.8	0	0	0	1.00	1.96	0.96	0.16
3092	000	6066	001	CT	OPL	1	26.5	24.7	0.0	13.4	13.4	0.0	2.0	0.3	0.6	0	0	0	0.90	1.98	1.00	0.00
3092	000	6104	001	CT	OPL	2	25.4	25.4	7.8	10.9	3.4	0.0	3.2	0.8	0.8	0	0	0	1.00	2.33	0.31	0.31
3092	000	6221	047	CT	OBS	1	23.1	23.1	15.7	10.6	7.5	9.2	2.3	0.4	0.7	0	0	0	1.00	1.47	0.71	0.68
3092	000	6304	004	CT	OPL	1	24.3	22.9	0.0	11.5	11.5	0.0	1.9	0.3	0.6	0	0	0	0.90	2.11	1.00	0.00
3092	000	6822	005	CT	OPL	2	20.6	20.6	0.0	14.7	14.7	0.0	2.5	0.7	0.7	0	0	0	1.00	1.40	1.00	0.00
3092	000	8263	001	CT	OPL	1	26.1	25.1	0.0	11.9	11.9	0.0	2.2	0.5	0.8	0	0	0	1.00	2.19	1.00	0.00
3095	000	0509	005	CT	OBS	2	23.0	23.0	8.5	15.5	15.1	0.0	3.4	1.5	1.5	0	0	0	1.00	1.48	0.97	0.35
3095	000	0514	001	CT	OPL	2	17.7	14.9	2.5	9.5	9.5	0.0	2.4	0.3	0.4	0	0	0	0.80	1.86	1.00	0.17
3095	000	6001	001	CT	OBS	2	22.3	22.3	10.5	8.7	3.9	0.0	3.7	0.7	0.7	0	0	0	1.00	2.56	0.45	0.47
3095	000	6041	001	CT	OBS	2	21.8	21.8	11.2	9.0	1.9	0.0	3.4	0.6	0.6	0	0	0	1.00	2.42	0.21	0.51
3095	000	6801	003	CT	OPL	1	29.8	28.9	0.0	13.5	13.5	0.0	2.8	0.6	1.0	0	0	0	1.00	2.20	1.00	0.00
3106	000	2001	004	CT	OPL	2	16.8	15.2	0.0	11.8	11.8	0.0	3.0	0.5	0.5	0	0	0	0.90	1.42	1.00	0.00
3160	000	0500	326	CT	OBS	1	24.9	24.9	0.0	17.8	17.8	0.0	4.0	1.0	1.2	0	0	0	1.00	1.39	1.00	0.00
3160	000	1003	009	CT	OPL	2	29.8	29.0	7.9	14.8	13.6	0.0	2.5	1.1	1.1	0	0	0	1.00	2.01	0.91	0.26
3160	000	6081	003	CT	OPL	2	26.4	26.4	2.5	13.6	13.6	0.0	2.7	0.9	0.9	0	0	0	1.00	1.95	1.00	0.09
3160	000	6081	004	CT	OBS	1	26.6	26.6	0.0	11.0	11.0	0.0	2.9	0.6	0.7	0	0	0	1.00	2.42	1.00	0.00
3160	000	6082	002	CT	BAS	1	28.0	28.0	7.2	13.6	13.6	0.0	2.0	0.4	1.0	0	0	0	1.00	2.06	1.00	0.26
3160	000	6541	005	CT	OPL	2	26.9	25.7	3.4	12.5	12.5	0.0	3.0	0.7	0.8	0	0	0	1.00	2.15	1.00	0.13
3160	000	8542	007	CT	OPL	1	26.9	25.9	5.0	12.1	12.1	0.0	2.8	0.6	0.8	0	0	0	1.00	2.22	1.00	0.19
3160	000	8542	010	CT	BAS	1	28.5	27.5	0.0	12.8	12.6	0.0	2.9	1.0	1.2	0	0	0	1.00	2.23	0.98	0.00
3170	000	2002	001	CT	OBS	2	21.2	20.1	0.0	16.3	16.3	0.0	2.7	0.8	0.8	0	0	0	0.90	1.30	1.00	0.00
3184	000	0503	028	CT	OPL	1	29.7	29.7	3.7	15.7	15.7	0.0	3.1	1.2	1.3	0	0	0	1.00	1.89	1.00	0.12
3185	000	0016	002	CT	OBS	1	29.7	28.7	12.6	16.6	16.6	0.0	2.9	0.3	0.6	0	0	0	1.00	1.79	1.00	0.42
3185	000	1003	002	CT	OPL	1	29.0	29.0	7.6	15.9	15.9	0.0	2.3	1.4	1.4	0	0	0	1.00	1.82	1.00	0.26
3192	000	2067	001	CT	OPL	1	28.4	27.7	8.3	17.1	15.8	0.0	2.5	1.2	1.8	0	0	0	1.00	1.66	0.92	0.29
3198	000	1017	001	CT	OPL	2	24.5	23.6	4.6	14.2	14.2	0.0	2.4	0.7	0.7	0	0	0	1.00	1.73	1.00	0.19
3198	000	1018	004	CT	OPL	1	30.0	29.3	0.0	16.0	16.0	0.0	2.3	0.7	1.2	0	0	0	1.00	1.88	1.00	0.00
3198	000	1018	901	CT	OBS	2	26.0	25.5	0.0	14.7	14.7	0.0	2.8	0.7	0.7	0	0	0	1.00	1.77	1.00	0.00
3198	000	1025	901	CT	OBS	2	23.7	26.0	11.0	13.5	12.8	0.0	3.1	0.9	0.9	0	0	0	1.00	1.97	0.94	0.44
3237	000	6820	001	CT	OPL	1	16.1	15.4	0.0	10.8	10.8	0.0	1.9	0.4	0.4	0	0	0	1.00	1.49	1.00	0.00
3251	000	1003	001	CT	OPL	1	26.5	26.5	3.5	18.3	18.3	0.0	3.2	1.1	1.3	0	0	0	1.00	1.45	1.00	0.13
3032	004	0069	012	DSN	OBS	2	27.1	26.4	10.2	15.3	13.7	9.0	4.3	1.5	1.5	187	146	41	0.90	1.77	0.90	0.38
3092	000	0001	001	DSN	OPL	2	28.9	28.1	5.4	10.4	9.1	5.6	3.0	0.7	0.7	191	170	21	1.00	2.78	0.88	0.19
3092	000	0500	002	DSN	OBS	1	32.0	29.7	3.7	14.9	14.9	7.4	3.4	1.0	1.4	180	180	0	0.90	2.14	1.00	0.12
3092	000	2024	002	DSN	OPL	2	23.5	21.1	0.0	13.8	13.8	7.2	2.8	0.7	0.8	204	186	18	0.90	1.70	1.00	0.00
3092	000	2042	014	DSN	OPL	1	25.1	19.7	0.0	12.3	12.3	5.9	2.0	0.2	0.9	179	74	5	0.80	2.04	1.00	0.00
3092	000	6285	004	DSN	OBS	1	8.8	18.3	0.0	9.0	9.0	5.1	1.9	0.1	0.5	0	157	0	1.00	2.10	1.00	0.00
3092	000	6362	001	DSN	OBS	2	14.1	14.1	5.2	9.2	7.0	4.6	2.6	0.3	0.3	190	150	40	1.00	1.53	0.76	0.37
3092	000	6362	002	DSN	OPL	1	21.7	20.4	0.0	12.4	12.4	4.3	2.4	0.4	0.4	198	160	38	0.90	1.75	1.00	0.00
3092	000	6786	001	DSN	OPL	1	26.6	23.6	7.3	13.2	12.0	5.2	3.1	0.6	1.1	179	161	18	0.90	2.02	0.91	0.27
3095	000	0510	038	DSN	OPL	2	23.4	20.5	0.0	11.7	11.7	6.2	2.6	0.5	0.5	182	168	14	0.90	2.00	1.00	0.00
3095	000	2023	001	DSN	BAS	1	31.2	27.6	0.0	12.4	12.3	6.9	2.4	0.7	0.9	185	182	3	0.90	2.53	1.00	0.00
3095	000	6480	002	DSN	OBS	1	13.5	0.0	0.0	8.3	0.0	6.2	2.3	0.2	0.5	201	0	0	0.00	0.00	0.00	0.00
3095	000	7240	001	DSN	OPL	1	20.6	17.9	0.0	13.5	13.5	8.7	2.0	0.5	0.5	200	163	37	0.90	1.53	1.00	0.00
3114	000	1010	001	DSN	OPL	2	18.8	17.3	0.0	12.8	12.8	9.5	2.3	0.5	0.6	255	144	81	0.90	1.46	1.00	0.00
3116	000	1002	001	DSN	OBS	1	24.3	21.8	0.0	14.7	14.7	9.5	3.0	0.4	1.0	202	159	43	0.90	1.65	1.00	0.00
3116	000	1007	001	DSN	OPL	2	21.3	19.1	0.0	12.7	12.7	7.5	2.5	0.5	0.8	191	179	12	0.90	1.67	1.00	0.00
3160	000	1002	003	DSN	OPL	2	21.5	18.7	0.0	13.4	13.4	9.5	2.5	0.4	0.5	206	163	43	0.90	1.60	1.00	0.00
3160	000	1003	004	DSN	OBS	1	21.6	19.6	0.0	10.8	10.8	7.8	2.3	0.2	0.6	201	171	30	0.90	2.00	1.00	0.00
3160	000	1005	007	DSN	OPL	1	23.4	19.4	0.0	13.6	13.6	9.3	2.0	0.2	0.5	191	135	56	0.80	1.72	1.00	0.00
3160	000	4049	001	DSN	OPL	1	23.3	23.3	2.1	9.1	9.1	6.5	2.6	0.4	0.5	161	148	13	1.00	2.56	1.00	0.09
3160	000	6541	006	DSN	OPL	1	18.9	17.2	0.0	13.0	13.0	6.1	1.8	0.3	0.5	200	177	23	0.90	1.46	1.00	0.00
3160	000	6541	007	DSN	OPL	1	25.8	23.9	0.0	11.9	11.9	7.3	3.0	0.6	0.8	190	181	9	0.90	2.17	1.00	0.00

Appendix E, continued.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/ Lt	Lt/ Wm	Wb/ Wm	Lm/ Lt
3160	000	8522	008	DSN	OPL	1	17.1	17.1	0.0	10.5	10.5	5.1	2.2	0.4	0.5	174	141	33	1.00	1.63	1.00	0.00
3170	000	2001	001	DSN	OPL	1	28.3	25.6	0.0	15.9	15.9	10.0	2.6	1.2	1.3	169	166	3	0.90	1.78	1.00	0.00
3170	000	2001	006	DSN	OPL	1	30.8	28.1	15.4	13.2	12.4	8.7	2.5	0.6	1.2	163	155	8	0.90	2.33	0.93	0.50
3170	000	5078	001	DSN	OBS	2	19.0	17.6	1.0	11.3	11.3	8.0	3.0	0.6	0.6	206	146	60	0.90	1.68	1.00	0.05
3171	000	0505	002	DSN	BAS	1	31.2	26.9	0.0	15.0	15.0	5.6	3.1	0.8	1.0	204	175	29	0.90	2.08	1.00	0.00
3178	000	0501	007	DSN	OPL	1	30.0	26.1	0.0	16.4	16.4	7.4	2.8	0.9	1.2	178	178	0	0.90	1.83	1.00	0.00
3178	000	0502	001	DSN	OBS	1	15.4	13.7	0.0	10.6	10.6	6.1	2.9	0.4	0.4	214	168	46	0.90	1.45	1.00	0.00
3184	000	4156	001	DSN	OPL	2	25.2	22.8	3.4	12.6	11.1	9.4	3.2	1.0	1.0	214	150	64	0.90	2.00	0.88	0.13
3185	000	0016	001	DSN	OBS	1	30.1	26.9	0.0	15.6	15.6	6.4	2.9	0.7	1.0	191	171	20	0.90	1.92	1.00	0.00
3185	000	1004	002	DSN	OPL	1	32.9	28.6	0.0	16.8	16.8	7.2	3.3	1.2	1.3	207	169	38	0.90	1.96	1.00	0.00
3185	000	1015	001	DSN	OPL	1	27.8	24.6	0.0	13.4	13.4	6.7	2.8	0.6	1.0	182	164	17	0.90	2.10	1.00	0.00
3190	000	0508	002	DSN	OPL	1	27.8	24.8	0.0	11.8	11.8	6.4	2.4	0.5	0.8	191	183	8	0.90	2.34	1.00	0.00
3190	000	1003	001	DSN	OPL	1	25.9	22.8	0.0	14.2	14.2	5.3	3.2	0.5	1.0	0	150	0	0.90	1.82	1.00	0.00
3192	000	0502	008	DSN	OBS	1	22.9	18.8	0.0	13.7	13.7	7.8	3.8	0.6	1.1	0	163	0	0.80	1.67	1.00	0.00
3192	000	1054	001	DSN	OPL	1	26.0	24.8	3.4	12.4	0.0	8.3	2.7	0.6	0.8	194	160	34	1.00	2.10	0.00	0.13
3192	000	2061	006	DSN	OBS	1	19.1	17.8	0.0	13.8	13.8	9.2	3.1	0.7	0.8	254	153	101	0.90	1.38	1.00	0.00
3192	000	6522	008	DSN	OPL	1	22.1	19.5	0.0	13.0	13.0	6.1	2.6	0.2	0.6	2	151	49	0.90	1.70	1.00	0.00
3198	000	0503	007	DSN	OPL	2	28.3	24.9	0.0	12.6	12.6	7.0	3.0	0.9	0.9	178	163	15	0.90	2.25	1.00	0.00
3198	000	0508	001	DSN	OBS	1	32.0	29.6	0.0	11.8	11.8	6.0	2.4	0.5	0.7	186	181	5	0.90	2.71	1.00	0.00
3198	000	1016	001	DSN	OBS	2	21.4	17.4	0.0	14.2	14.2	8.5	2.9	0.7	0.7	210	181	29	0.80	1.51	1.00	0.00
3198	000	6101	003	DSN	OPL	2	24.3	24.3	0.0	14.0	14.0	10.3	2.2	0.7	0.7	191	163	28	1.00	1.74	1.00	0.00
3237	000	6701	001	DSN	OPL	1	17.1	15.1	0.0	11.5	11.5	8.6	1.8	0.3	0.4	192	150	42	0.90	1.49	1.00	0.00
3237	000	6721	001	DSN	OPL	1	16.7	15.8	0.0	9.1	9.1	6.8	1.9	0.2	0.3	190	166	24	1.00	1.84	1.00	0.00
3237	000	6722	001	DSN	OPL	1	19.8	17.9	0.0	11.1	11.1	7.5	2.0	0.3	0.4	163	158	5	0.90	1.78	1.00	0.00
3237	000	6741	003	DSN	OPL	2	15.5	13.8	0.0	11.9	11.9	9.0	2.2	0.3	0.3	209	158	51	0.90	1.30	1.00	0.00
3237	000	6742	001	DSN	BAS	2	11.6	9.6	0.0	10.3	10.3	7.8	1.7	0.2	0.2	205	154	51	0.80	1.13	1.00	0.00
3237	000	6761	001	DSN	OPL	2	10.4	8.6	0.0	9.8	9.8	8.2	1.9	0.2	0.2	195	152	43	0.80	1.06	1.00	0.00
3237	000	6801	004	DSN	OPL	1	21.3	17.6	9.2	11.1	10.7	8.6	1.7	0.2	0.4	208	166	42	0.80	1.92	0.96	0.43
3251	000	0500	027	DSN	OPL	1	24.8	21.5	0.0	12.4	12.4	5.5	2.1	0.4	0.6	188	171	17	0.90	2.00	1.00	0.00
3251	000	3006	005	DSN	OPL	1	27.2	27.2	2.0	12.9	12.3	5.9	3.5	0.6	1.2	148	138	10	1.00	2.11	0.95	0.07
3271	000	0500	087	DSN	OPL	2	25.2	22.2	0.0	12.0	12.0	7.2	2.8	0.7	0.7	182	178	4	1.10	2.10	1.00	0.00
3271	000	0522	001	DSN	OBS	1	16.5	13.6	0.0	13.3	13.3	7.0	2.5	0.3	0.7	241	165	77	0.80	1.24	1.00	0.00
3032	138	0053	01A	ELK	CHA	1	41.0	38.1	11.5	19.0	14.0	12.5	6.0	2.5	5.0	215	113	102	0.90	2.16	0.74	0.28
3032	107	0L1A	001	ELK	OPL	1	38.6	38.6	9.5	20.1	16.4	11.4	4.2	2.4	2.9	164	138	26	1.00	1.92	0.82	0.25
3032	020	4002	009	ELK	OPL	1	37.3	34.2	12.4	15.9	14.0	10.8	5.7	3.4	3.6	224	124	100	0.90	2.35	0.88	0.33
3095	000	0510	019	ELK	OPL	1	55.9	53.9	6.9	35.3	17.4	15.7	4.3	5.5	6.0	151	115	36	1.00	1.58	0.49	0.12
3095	000	3007	001	ELK	OPL	1	31.2	31.2	6.9	22.9	15.8	12.0	6.1	3.1	3.5	165	122	43	1.00	1.36	0.69	0.22
3123	000	0078	001	ELK	OPL	1	40.6	40.6	5.8	22.1	12.3	10.9	4.9	2.2	3.0	151	118	33	1.00	1.84	0.56	0.14
3160	000	0001	190	ELK	OPL	1	54.5	53.0	7.7	24.0	15.3	11.9	5.8	3.8	6.0	157	118	39	1.00	2.27	0.64	0.14
3160	000	0001	221	ELK	OBS	1	32.2	30.0	9.7	21.9	15.5	10.2	4.9	1.7	2.1	155	134	21	0.90	1.47	0.71	0.30
3160	000	0001	300	ELK	OPL	1	36.8	36.8	6.4	21.9	13.5	11.1	4.5	2.8	3.1	150	110	40	1.00	1.68	0.62	0.17
3160	000	0500	026	ELK	OPL	1	57.8	57.8	7.4	22.5	16.3	11.7	5.1	4.3	5.0	150	135	15	1.00	2.56	0.72	0.13
3160	000	0500	063	ELK	OPL	1	53.6	53.6	7.0	17.7	13.7	10.7	5.5	4.2	5.0	167	110	57	1.00	3.02	0.77	0.13
3160	000	0500	078	ELK	OPL	1	32.5	27.2	6.0	28.0	18.8	14.3	4.3	3.0	3.5	127	126	1	0.80	1.16	0.67	0.19
3160	000	0500	131	ELK	OPL	1	47.5	43.5	5.9	29.2	19.3	15.6	4.9	4.1	4.5	125	111	14	0.90	1.62	0.66	0.12
3160	000	0500	260	ELK	OPL	1	42.8	42.8	4.6	21.6	12.0	9.6	3.9	2.8	3.0	139	110	29	1.00	2.42	0.55	0.11
3160	000	4053	001	ELK	OPL	1	43.3	38.3	0.4	23.1	18.7	12.2	6.5	3.1	5.0	174	136	38	0.90	1.87	0.81	0.01
3160	000	6083	001	ELK	OBS	1	59.8	59.8	8.2	31.6	19.7	14.0	4.3	2.5	5.5	157	131	26	1.00	1.89	0.62	0.14
3160	000	6641	001	ELK	OBS	1	37.8	37.8	3.3	28.8	15.3	13.0	4.2	2.4	3.2	134	115	19	1.00	1.31	0.53	0.09
3184	000	0015	001	ELK	OPL	2	43.8	41.1	9.4	28.2	16.4	13.4	6.1	5.8	5.8	159	107	52	0.90	1.55	0.58	0.22
3184	000	5055	002	ELK	OPL	2	37.3	34.7	10.9	21.3	12.0	9.1	4.7	2.9	3.0	168	120	48	0.90	1.75	0.56	0.29
3237	000	0001	022	ELK	OPL	1	39.2	34.4	8.2	17.4	16.5	12.6	4.6	2.5	2.6	193	120	73	0.90	2.25	0.95	0.21
3237	000	0001	029	ELK	BAS	1	43.1	43.1	6.6	24.8	14.8	12.7	6.9	4.4	5.0	145	111	34	1.00	1.74	0.60	0.15
3237	000	4029	001	ELK	OPL	1	48.5	48.5	8.9	20.3	14.1	10.1	4.6	2.3	5.0	188	122	66	1.00	2.39	0.70	0.18
3237	000	6084	001	ELK	OBS	1	54.6.0	52.7	9.9	18.4	17.5	9.2	5.9	4.0	6.0	165	134	39	1.00	2.97	0.95	0.18

Appendix E, continued.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/ Lt	Lt/ Wm	Wb/ Wm	Lm/ Lt
3237	000	6322	001	ELK	OPL	1	39.3	35.6	8.1	23.5	18.4	13.3	4.7	1.9	3.5	133	123	10	0.90	1.67	0.78	0.21
3237	000	6744	001	ELK	OBS	1	45.1	45.1	5.7	23.0	10.9	9.0	5.1	2.7	3.2	165	118	47	1.00	1.96	0.47	0.13
3237	000	6762	001	ELK	OPL	1	45.2	44.9	6.7	22.5	15.3	12.7	4.6	3.0	5.0	189	19	70	1.00	2.00	0.68	0.15
3237	000	9084	001	ELK	OPL	1	62.8	62.8	7.7	27.2	16.0	11.9	5.1	4.1	8.2	136	120	16	1.00	2.30	0.59	0.13
3239	000	0500	005	ELK	OBS	1	34.8	33.8	3.1	18.0	10.6	9.3	4.5	1.9	2.3	146	120	26	1.00	1.93	0.58	0.09
3271	000	0500	159	ELK	OPL	1	33.2	30.6	4.3	21.4	12.6	0.0	4.2	1.7	2.1	160	136	30	0.90	1.54	0.59	0.13
3516	000	0001	009	ELK	OPL	1	36.8	34.6	3.5	21.2	14.5	8.4	3.7	1.4	2.2	140	129	11	0.90	1.73	0.68	0.10
3516	000	0001	901	ELK	OBS	1	43.1	43.1	6.6	20.6	11.7	8.8	5.6	3.5	3.8	145	101	44	1.00	2.09	0.57	0.15
3032	027	0001	130	FRG	OBS	1	23.3	0.0	0.0	19.5	0.0	0.0	3.9	2.0	0.0	193	0	0	0.00	0.00	0.00	0.00
3032	072	0066	009	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3032	023	3001	052	FRG	OBS	1	18.8	0.0	0.0	12.4	0.0	0.0	2.9	0.6	0.0	201	0	0	0.00	0.00	0.00	0.00
3032	023	4003	009	FRG	OPL	1	9.2	0.0	0.0	20.5	0.0	0.0	3.9	0.7	0.0	201	0	0	0.00	0.00	0.00	0.00
3032	027	6001	017	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3032	027	6122	001	FRG	OPL	1	33.1	0.0	0.0	22.9	0.0	0.0	3.5	2.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	0500	012	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	2002	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	2024	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	2042	013	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6062	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6166	004	FRG	OPL	1	10.9	0.0	0.0	8.6	0.0	0.0	2.4	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6202	012	FRG	BAS	1	7.5	0.0	0.0	8.4	0.0	0.0	2.0	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6301	002	FRG	OPL	1	18.7	0.0	0.0	11.7	0.0	0.0	3.5	0.6	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6382	001	FRG	OPL	1	14.4	0.0	0.0	7.0	0.0	0.0	1.2	0.1	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6543	002	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6623	001	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6702	009	FRG	BAS	1	10.5	0.0	0.0	9.4	0.0	0.0	1.8	0.2	0.0	181	0	0	0.00	0.00	0.00	0.00
3092	000	6722	002	FRG	OPL	1	27.8	0.0	0.0	15.9	0.0	0.0	3.4	1.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6782	003	FRG	OBS	1	20.1	0.0	0.0	10.9	0.0	0.0	3.0	0.7	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	0500	089	FRG	OPL	0	28.5	0.0	0.0	11.6	0.0	0.0	2.5	0.7	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	0516	004	FRG	OPL	0	20.4	0.0	0.0	15.5	0.0	0.0	2.6	0.8	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	2001	006	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	3010	002	FRG	OPL	1	23.1	0.0	0.0	17.9	0.0	0.0	3.9	1.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	6021	002	FRG	OPL	1	19.9	0.0	0.0	15.9	0.0	0.0	3.7	1.1	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	6501	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	6502	001	FRG	OPL	1	22.4	0.0	0.0	15.4	0.0	0.0	3.4	0.8	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	7180	001	FRG	OPL	1	20.8	0.0	0.0	12.2	0.0	0.0	3.9	0.9	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	7181	002	FRG	OPL	1	25.8	0.0	0.0	18.9	0.0	0.0	4.6	2.3	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	7201	003	FRG	OPL	1	16.4	0.0	0.0	13.3	0.0	0.0	2.0	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	7281	004	FRG	OBS	1	23.1	0.0	0.0	13.0	0.0	0.0	2.5	0.7	0.0	195	0	0	0.00	0.00	0.00	0.00
3095	000	9480	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3095	000	9481	001	FRG	OPL	0	4.2	0.0	0.0	5.8	0.0	0.0	1.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3099	000	0500	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3116	000	1006	001	FRG	OPL	0	9.5	0.0	0.0	8.0	0.0	0.0	2.1	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3116	000	1010	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3116	000	1011	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3125	000	0080	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3144	000	0099	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3149	000	0500	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3149	000	1002	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3149	000	1004	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	0001	017	FRG	OBS	1	25.6	0.0	0.0	17.6	0.0	0.0	2.5	0.7	0.0	156	0	0	0.00	0.00	0.00	0.00
3160	000	0500	097	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	0500	194	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	0500	242	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	0512	009	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00

Appendix E, continued.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/ Lt	Lt/ Wm	Wb/ Wm	Lm/ Lt
3160	000	1062	001	FRG	BAS	1	31.8	30.5	9.1	14.7	14.7	0.0	4.2	2.0	2.3	0	0	0	1.00	2.16	1.00	0.29
3160	000	1103	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	2104	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	4049	007	FRG	OPL	1	9.3	0.0	0.0	7.8	0.0	0.0	2.2	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	4052	005	FRG	OPL	1	26.0	0.0	0.0	17.2	0.0	0.0	3.7	1.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	4053	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	4056	002	FRG	BAS	1	12.1	0.0	0.0	9.1	0.0	0.0	3.2	0.3	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	4062	007	FRG	OPL	1	10.9	0.0	0.0	3.6	0.0	0.0	3.0	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	6362	003	FRG	OPL	1	10.4	0.0	0.0	16.9	0.0	8.7	4.0	0.9	0.0	160	0	0	0.00	0.00	0.00	0.00
3160	000	6521	004	FRG	OPL	1	13.8	0.0	0.0	10.2	0.0	0.0	2.9	0.3	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	6641	002	FRG	OPL	1	17.8	0.0	0.0	10.3	0.0	0.0	2.2	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	6723	002	FRG	OPL	1	16.5	0.0	0.0	7.6	0.0	0.0	4.5	0.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	8522	002	FRG	BAS	1	23.4	0.0	0.0	13.1	0.0	0.0	2.6	0.7	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	8542	008	FRG	OPL	1	14.9	0.0	0.0	7.5	0.0	0.0	1.9	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3162	000	0117	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3165	000	0500	015	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3165	000	1025	001	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3165	000	4048	001	FRG	OBS	1	19.0	0.0	0.0	19.5	0.0	0.0	2.3	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3170	000	4061	001	FRG	OPL	1	14.6	0.0	0.0	14.8	0.0	0.0	2.2	0.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3170	000	6822	002	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3173	000	1010	001	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3173	000	1011	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3178	000	0501	006	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3184	000	0503	014	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3185	000	1003	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3185	000	1011	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3190	000	0510	001	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3190	000	1001	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3190	000	1002	005	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3190	000	1002	006	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3190	000	1007	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3190	000	1019	005	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3191	000	1004	001	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	0502	011	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	1055	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	2061	007	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	2061	026	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	2061	027	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	2121	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	6121	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	6201	009	FRG	OBS	1	16.0	0.0	0.0	12.7	0.0	0.0	2.4	0.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3192	000	6581	004	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	0503	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1001	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1014	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1014	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1015	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1017	003	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1017	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1017	010	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1017	011	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1018	003	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1019	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1019	003	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	1025	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00

Appendix E, continued.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/ Lt	Lt/ Wm	Wb/ Wm	Lm/ Lt
3198	000	2001	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	2001	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3198	000	2001	005	FRG	OBS	0	3.5	0.0	0.0	5.2	0.0	0.0	1.3	0.1	0.0	0	0	0	0.00	0.00	0.00	0.00
3204	000	2003	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3204	000	2005	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3204	000	6007	001	FRG	OPL	1	11.0	0.0	0.0	9.5	0.0	0.0	2.3	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	0001	023	FRG	OPL	1	22.9	0.0	0.0	22.2	0.0	0.0	4.6	2.6	0.0	123	0	0	0.00	0.00	0.00	0.00
3237	000	0001	064	FRG	OPL	0	20.8	0.0	0.0	14.8	0.0	0.0	4.1	0.9	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	0001	065	FRG	OPL	1	17.1	0.0	0.0	10.3	0.0	0.0	2.6	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	0500	008	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	0500	036	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	2081	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	4030	001	FRG	OPL	1	21.3	0.0	0.0	19.3	0.0	0.0	4.2	1.8	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	6744	002	FRG	OPL	1	18.8	0.0	0.0	12.0	0.0	0.0	3.6	0.6	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	6745	001	FRG	OPL	1	28.1	0.0	0.0	13.6	0.0	0.0	3.9	1.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	6763	006	FRG	OPL	1	16.8	0.0	0.0	13.1	0.0	0.0	3.7	0.7	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	6865	001	FRG	OPL	1	10.9	0.0	0.0	10.7	0.0	0.0	2.5	0.3	0.0	0	0	0	0.00	0.00	0.00	0.00
3238	000	0500	014	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	0001	006	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	0500	013	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	0501	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1004	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1004	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1010	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1021	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1022	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1027	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1030	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	1030	003	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	2003	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	2061	004	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	3003	001	FRG	OPL	1	25.4	0.0	0.0	11.8	0.0	0.0	2.0	0.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	4015	003	FRG	OPL	1	17.4	0.0	0.0	12.6	0.0	0.0	2.3	0.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	4020	001	FRG	OPL	1	21.1	0.0	0.0	11.0	0.0	0.0	2.7	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	4021	007	FRG	OPL	1	9.2	0.0	0.0	8.9	0.0	0.0	3.9	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6001	002	FRG	OPL	1	15.7	0.0	0.0	9.2	0.0	0.0	3.9	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6022	001	FRG	OPL	1	12.3	0.0	0.0	6.2	0.0	0.0	1.7	0.1	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6040	007	FRG	OPL	1	17.2	0.0	0.0	13.3	0.0	0.0	4.2	0.6	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6081	001	FRG	OPL	1	15.3	0.0	0.0	8.3	0.0	0.0	1.9	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6120	002	FRG	OBS	1	7.3	0.0	0.0	15.5	0.0	0.0	3.5	0.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6121	008	FRG	OPL	1	17.8	0.0	0.0	9.2	0.0	0.0	0.2	0.3	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6121	013	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6141	004	FRG	OPL	1	13.0	0.0	0.0	11.4	0.0	0.0	3.0	0.5	0.0	225	155	70	0.00	0.00	0.00	0.00
3251	000	6421	008	FRG	OPL	1	17.4	0.0	0.0	13.1	0.0	0.0	2.0	0.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6501	002	FRG	OPL	1	25.5	0.0	0.0	15.6	0.0	0.0	2.9	0.9	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6561	001	FRG	OPL	1	15.2	0.0	0.0	8.4	0.0	0.0	2.2	0.3	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	6561	002	FRG	OPL	1	15.2	0.0	0.0	18.3	0.0	0.0	2.8	0.9	0.0	0	0	0	0.00	0.00	0.00	0.00
3251	000	9042	001	FRG	OPL	1	15.5	0.0	0.0	9.5	0.0	0.0	1.9	0.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	0045	001	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	0500	110	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	0500	130	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	0500	134	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	0500	203	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	0500	309	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	0511	001	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00

Appendix E, continued.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/Lt	Lt/Wm	Wb/Wm	Lm/Lt
3271	000	1045	002	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	2021	008	FRG	OBS	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3271	000	2021	014	FRG	OPL	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3032	028	0081	01A	GAT	OPL	1	54.2	51.7	10.7	31.1	14.4	15.3	5.8	3.6	7.5	145	94	59	1.00	1.74	0.45	0.20
3032	027	6062	002	GAT	OPL	2	34.2	30.0	8.5	26.3	11.6	12.3	3.5	2.7	2.7	150	94	56	0.90	1.30	0.44	0.25
3092	000	2009	002	GAT	OBS	1	43.4	42.0	6.8	21.7	10.7	11.2	4.7	3.0	4.0	190	95	95	1.00	2.00	0.50	0.16
3092	000	6041	014	GAT	OPL	1	40.1	36.9	9.7	25.5	10.6	9.8	4.5	2.1	4.2	166	96	70	0.90	1.57	0.42	0.24
3092	000	6482	003	GAT	OPL	1	45.4	43.5	3.9	28.3	12.9	12.1	5.0	4.0	5.1	134	96	38	1.00	1.60	0.46	0.09
3095	000	0001	004	GAT	OPL	2	42.8	39.7	5.6	17.1	9.1	8.8	4.8	3.5	3.5	168	81	87	0.90	2.50	0.53	0.13
3095	000	0500	008	GAT	OPL	1	65.1	59.6	9.5	20.0	11.4	11.3	4.9	4.5	5.0	198	95	74	0.90	3.25	0.56	0.15
3095	000	0516	010	GAT	OPL	1	51.3	49.5	12.4	21.8	11.5	11.5	4.7	3.2	4.0	179	93	86	1.00	2.35	1.00	0.24
3095	000	6941	001	GAT	OPL	1	32.1	32.1	9.1	22.3	12.2	12.4	4.4	2.4	2.6	211	84	127	1.00	1.44	0.55	0.28
3142	000	0097	001	GAT	OPL	1	53.4	51.0	9.1	24.0	13.9	12.8	5.3	5.1	5.6	131	96	35	1.00	2.23	0.58	0.17
3160	000	0001	103	GAT	OPL	1	42.5	40.3	9.5	22.0	10.9	12.6	5.7	3.6	3.7	169	80	89	1.00	1.93	0.50	0.22
3160	000	0500	308	GAT	OPL	1	55.4	52.4	7.2	24.2	17.5	15.2	4.5	3.4	7.0	169	96	73	0.90	2.28	0.72	0.13
3170	000	0001	044	GAT	OBS	1	33.5	33.5	8.0	26.0	12.4	13.7	5.2	3.3	3.5	199	86	113	1.00	1.29	0.48	0.24
3198	000	0500	004	GAT	OPL	1	57.0	50.3	8.5	24.3	11.4	10.4	5.9	4.5	5.1	155	98	57	0.90	2.25	0.20	0.16
3237	000	0500	074	GAT	OPL	1	53.7	49.7	10.1	23.7	11.0	13.2	5.8	6.0	6.2	184	97	87	0.90	2.26	0.46	0.19
3237	000	6064	001	GAT	OBS	1	37.5	34.6	5.3	21.6	11.7	10.2	4.1	2.3	2.4	157	95	62	0.90	1.74	0.54	0.14
3237	000	6401	001	GAT	OPL	1	79.5	76.2	12.0	33.9	17.9	17.5	5.3	8.1	15.8	159	97	62	1.00	2.35	0.53	0.15
3237	000	6704	002	GAT	OPL	2	41.3	39.6	8.8	24.8	16.4	14.7	4.8	4.6	4.6	140	95	45	1.00	1.67	0.66	0.21
3238	000	0500	001	GAT	OPL	1	52.7	49.6	12.9	25.5	11.8	0.0	6.1	6.7	0.0	195	94	101	0.90	2.06	0.46	0.25
3251	000	8001	901	GAT	OPL	1	51.1	47.3	8.7	24.2	11.8	10.2	5.0	3.0	3.0	6	168	98	0.90	2.11	0.49	0.17
3092	000	6606	002	HUM	OPL	2	34.0	32.5	16.8	15.2	9.4	0.0	3.8	2.0	2.0	0	0	0	1.00	2.24	0.69	0.49
3092	000	6728	001	HUM	OPL	1	37.1	35.8	18.0	12.6	10.3	0.0	4.2	1.3	2.4	0	0	0	1.00	2.94	0.82	0.48
3116	000	2500	001	HUM	OBS	1	42.4	38.1	10.4	17.9	15.7	0.0	5.3	3.7	3.9	0	0	0	0.90	2.36	0.87	0.25
3160	000	0500	267	HUM	OPL	1	49.6	47.6	20.9	18.8	15.9	0.0	5.2	3.4	4.8	0	0	0	1.00	2.63	0.84	0.42
3192	000	2203	002	HUM	OPL	2	27.3	26.7	17.9	18.4	13.6	0.0	5.3	2.8	4.0	0	0	0	1.00	1.48	0.73	0.65
3198	000	1007	902	HUM	OPL	2	35.2	33.0	0.0	14.7	14.2	0.0	2.0	1.4	1.4	0	0	0	0.90	2.39	0.97	0.00
3198	000	1012	004	HUM	OPL	1	51.6	49.4	18.8	23.3	20.3	0.0	3.2	1.3	4.5	0	0	0	1.00	2.21	0.87	0.36
3237	000	0001	048	HUM	OPL	1	49.6	47.9	14.8	17.8	16.9	0.0	6.1	3.6	5.0	0	0	0	1.00	2.79	0.95	0.30
3237	000	6142	001	HUM	BAS	1	44.5	43.1	23.4	18.4	10.9	0.0	4.7	2.1	4.2	0	0	0	1.00	2.42	0.59	0.53
3237	000	6881	901	HUM	OPL	2	94.9	93.8	34.1	21.1	11.2	0.0	5.9	11.7	11.7	0	0	0	1.00	4.50	0.53	0.36
3251	000	0001	004	HUM	OPL	1	21.6	19.4	8.5	13.2	10.1	0.0	3.7	1.0	1.2	0	0	0	0.90	1.64	0.77	0.39
3251	000	0505	001	HUM	OPL	1	68.2	67.4	17.5	23.4	17.0	0.0	7.1	6.3	11.0	0	0	0	1.00	2.91	0.72	0.26
3271	000	1032	005	HUM	OPL	1	42.5	40.8	12.7	16.9	14.7	0.0	3.0	1.7	2.5	0	0	0	1.00	2.52	0.87	0.30
3093	000	0505	004	LSN	OPL	2	41.6	38.3	0.0	15.5	15.5	6.6	3.1	5.5	5.5	177	172	5	0.90	2.67	1.00	0.00
3160	000	0115	001	LSN	OBS	1	38.2	36.2	0.0	17.1	17.1	7.0	3.8	1.7	2.0	182	178	4	0.90	2.23	1.00	0.00
3184	000	0524	002	LSN	OPL	1	49.3	46.6	0.0	24.9	24.9	11.8	3.7	3.5	5.0	202	182	20	0.90	1.97	1.00	0.00
3204	000	6004	001	LSN	OBS	1	39.4	33.5	0.0	23.2	23.2	6.1	3.0	0.5	2.3	0	181	0	0.90	1.70	1.00	0.00
3237	000	0500	043	LSN	OPL	1	31.4	31.0	0.0	17.0	17.0	7.9	4.2	1.3	1.5	189	184	5	1.00	1.84	1.00	0.00
3237	000	4014	004	LSN	OBS	1	37.2	37.2	0.0	16.1	16.1	8.4	3.6	1.5	1.8	186	150	36	1.00	2.31	1.00	0.00
3237	000	6902	001	LSN	OBS	2	32.6	26.6	0.0	21.3	21.3	6.7	3.8	1.6	1.6	199	182	17	0.80	1.53	1.00	0.00
3238	000	0500	037	LSN	OPL	1	43.6	41.6	0.0	16.7	16.7	9.2	4.3	2.5	3.0	180	152	28	1.00	2.61	1.00	0.00
3271	000	0500	270	LSN	OPL	2	34.7	31.2	0.0	19.3	17.6	10.1	4.4	3.2	3.2	165	165	0	0.90	1.80	0.91	0.00
3032	158	0035	004	OOK	OBS	1	20.4	19.8	5.9	10.9	7.7	5.2	2.2	0.4	0.5	191	144	47	1.00	1.87	0.71	0.29
3032	040	0056	003	OOK	OBS	1	26.9	26.9	7.0	17.7	5.0	6.8	3.6	1.2	1.3	161	62	99	1.00	1.52	0.28	0.26
3032	023	4002	021	OOK	OBS	1	44.5	44.5	0.0	22.7	22.7	0.0	3.9	3.3	3.5	0	0	0	1.00	1.96	1.00	0.00
3032	027	6521	001	OOK	OBS	2	18.5	18.5	6.7	9.5	7.4	6.8	0.2	0.4	0.4	151	101	50	1.00	1.95	0.78	0.36
3092	000	2500	001	OOK	OBS	1	24.2	23.2	0.0	10.0	9.8	7.0	3.0	0.6	0.7	225	111	114	1.00	2.44	0.98	0.00
3093	000	0505	011	OOK	OPL	1	38.0	37.2	0.0	17.1	17.1	0.0	2.8	1.5	1.5	0	0	0	1.00	2.22	1.00	0.00
3095	000	0510	044	OOK	OPL	1	34.5	32.8	0.0	14.3	14.3	0.0	2.3	0.8	1.2	0	0	0	1.00	2.41	1.00	0.00
3095	000	0510	046	OOK	OBS	1	18.8	18.8	0.0	9.5	9.5	6.8	3.8	0.6	0.8	183	116	67	1.00	0.37	1.00	0.00
3095	000	0510	049	OOK	OPL	1	37.7	36.8	8.4	20.0	17.3	13.1	5.4	4.3	4.4	195	128	67	1.00	1.88	0.88	0.22
3095	000	0519	012	OOK	OBS	1	22.6	20.9	4.6	12.5	9.2	7.4	3.0	0.6	0.7	190	117	73	0.90	1.80	0.73	0.20

Appendix E, continued.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/ Lt	Lt/ Wm	Wb/ Wm	Lm/ Lt
3095	000	3011	001	OOK	OBS	1	20.0	17.6	1.8	8.1	8.1	4.2	2.7	0.3	0.3	230	120	110	0.90	2.47	1.00	0.09
3106	000	2002	001	OOK	BAS	2	16.3	14.2	1.4	9.4	9.4	6.8	3.0	0.4	0.4	252	120	132	0.90	1.73	1.00	0.09
3148	000	0103	001	OOK	OBS	1	48.6	44.0	0.0	16.1	16.1	0.0	4.6	2.2	4.0	0	0	0	0.90	3.00	1.00	0.00
3154	000	0109	001	OOK	OBS	2	30.3	29.3	9.8	18.6	11.0	11.3	4.5	2.2	2.2	243	97	146	1.00	1.63	0.59	0.32
3160	000	0500	002	OOK	OPL	1	46.9	41.9	14.6	20.2	20.2	0.0	4.3	3.0	3.2	0	0	0	0.90	2.32	1.00	0.31
3160	000	0520	002	OOK	OPL	1	27.6	25.0	0.0	17.7	17.7	0.0	4.0	2.2	2.3	0	0	0	0.90	1.55	1.00	0.00
3170	000	4060	002	OOK	OPL	2	14.5	13.1	0.0	10.5	10.5	7.5	2.4	0.3	0.3	256	136	120	0.90	1.38	1.00	0.00
3171	000	0504	007	OOK	OBS	1	35.0	33.5	4.4	12.1	11.8	0.0	2.8	1.1	1.4	0	0	0	1.00	1.04	0.97	0.12
3177	000	2001	001	OOK	OPL	2	43.5	41.8	1.4	18.0	17.6	15.7	4.4	3.0	3.0	242	140	102	1.00	2.46	0.97	0.03
3177	000	2001	010	OOK	OPL	2	16.1	16.1	0.0	10.2	5.9	7.0	3.5	0.1	0.1	228	75	53	1.00	1.58	0.58	0.00
3184	000	4156	002	OOK	OBS	1	41.2	40.9	11.8	21.7	18.9	0.0	5.5	2.4	5.0	0	0	0	1.00	1.90	0.87	0.29
3185	000	0016	003	OOK	OPL	1	53.1	53.1	15.1	22.1	18.5	0.0	3.6	2.2	5.0	0	0	0	1.00	2.40	0.84	0.28
3190	000	1004	005	OOK	OPL	1	34.3	31.8	0.0	17.9	17.9	0.0	2.9	1.2	2.0	0	0	0	0.90	1.91	1.00	0.00
3237	000	0001	127	OOK	OPL	1	39.7	37.8	12.7	20.9	14.9	12.1	4.9	2.1	4.2	198	109	89	1.00	1.90	0.71	0.32
3237	000	0500	017	OOK	OPL	1	49.2	49.2	12.4	20.4	12.5	9.6	4.8	2.6	3.0	188	106	82	1.00	2.41	0.61	0.25
3251	000	0001	001	OOK	OPL	1	50.1	47.4	20.0	17.8	13.5	12.3	7.6	5.7	6.2	260	104	156	1.00	2.81	0.76	0.40
3251	000	3006	004	OOK	OBS	1	24.4	21.9	8.7	11.6	8.4	5.6	2.6	0.4	0.6	202	116	86	0.90	2.10	0.72	0.36
3251	000	6541	001	OOK	OPL	2	17.0	17.0	6.4	9.0	5.0	5.4	2.3	0.3	0.3	205	71	134	1.00	1.89	0.56	0.38
3075	000	0028	001	RSG	OPL	1	28.4	28.4	4.4	20.1	7.5	6.2	3.6	1.0	2.0	127	101	26	1.00	1.41	0.37	0.16
3092	000	8266	002	RSG	OPL	1	37.0	36.3	3.4	18.5	8.8	7.0	2.8	1.5	3.0	140	112	28	1.00	2.00	0.48	0.09
3092	000	8302	001	RSG	OPL	1	33.6	32.4	4.6	14.5	9.8	6.8	4.0	1.3	1.5	151	110	41	1.00	2.31	0.68	0.14
3095	000	0001	002	RSG	OPL	1	35.8	35.8	4.5	18.8	8.1	5.6	4.0	1.3	2.5	125	108	17	1.00	1.90	0.43	0.13
3095	000	0500	045	RSG	OPL	1	26.6	26.6	2.9	17.0	7.5	5.6	2.8	0.7	1.3	129	124	5	1.00	1.56	0.44	0.11
3095	000	6082	001	RSG	OPL	1	25.9	25.9	4.1	16.3	7.8	6.7	3.5	0.8	1.6	146	117	29	1.00	1.59	0.48	0.16
3102	000	0500	010	RSG	OPL	2	25.3	25.3	5.1	11.8	6.5	5.7	3.4	0.9	1.0	146	98	48	1.00	2.14	0.55	0.20
3160	000	0500	103	RSG	OPL	1	37.4	37.4	4.1	14.5	6.4	4.2	3.7	1.2	1.5	139	118	21	1.00	2.57	0.44	0.11
3160	000	0500	259	RSG	OPL	1	41.3	41.3	1.7	12.6	6.4	4.7	3.2	1.4	1.7	120	104	16	1.00	3.27	0.50	0.04
3160	000	0500	310	RSG	OPL	1	38.6	38.6	2.0	15.0	7.0	6.5	3.4	1.6	7.0	137	110	27	1.00	2.57	0.46	0.05
3160	000	0517	001	RSG	OPL	2	26.8	26.8	1.3	15.5	5.3	4.7	3.2	1.3	1.3	126	105	21	1.00	1.72	0.34	0.05
3160	000	1009	002	RSG	OPL	2	20.8	20.8	2.6	11.1	6.8	3.9	2.3	0.4	0.4	130	115	15	1.00	1.87	0.61	0.13
3160	000	4032	001	RSG	OPL	1	33.8	33.8	3.7	17.7	8.7	8.5	3.9	1.6	1.8	169	99	70	1.00	1.91	0.49	0.11
3204	000	2002	001	RSG	OPL	1	35.7	35.7	2.6	14.7	6.4	5.0	3.1	1.3	1.4	140	112	28	1.00	2.43	0.44	0.07
3204	000	6002	005	RSG	OPL	1	27.8	27.8	4.5	18.4	7.6	7.6	2.9	0.4	1.0	128	114	14	1.00	1.51	0.41	0.16
3231	000	0500	001	RSG	OPL	1	29.5	29.5	3.9	19.0	7.9	7.6	3.7	1.3	1.6	133	104	29	1.00	1.55	0.41	0.13
3237	000	0001	107	RSG	OPL	1	25.9	24.6	2.6	18.8	7.3	5.2	3.5	0.6	1.2	131	111	20	1.00	1.38	0.39	0.10
3237	000	0500	056	RSG	OPL	1	35.3	35.3	2.9	21.5	8.7	7.4	2.9	1.1	1.5	123	109	14	1.00	1.64	0.40	0.08
3237	000	1544	001	RSG	OPL	1	31.5	31.5	4.7	14.3	7.9	6.9	3.3	1.2	1.5	159	98	61	1.00	2.20	0.55	0.15
3239	000	0500	001	RSG	OBS	1	26.3	26.1	4.0	11.5	5.8	5.5	2.8	0.7	0.9	174	109	65	1.00	2.28	0.50	0.15
3251	000	0001	008	RSG	OPL	1	19.1	19.1	3.6	12.4	6.7	4.7	2.9	0.6	0.7	129	108	21	1.00	1.54	0.54	0.19
3251	000	0001	010	RSG	OBS	1	21.9	21.9	2.2	14.6	7.0	4.8	2.1	0.5	0.7	133	105	28	1.00	1.50	0.48	0.10
3251	000	1022	003	RSG	OPL	1	29.5	29.5	7.7	13.3	8.2	0.5	2.4	0.7	1.3	158	115	43	1.00	2.21	0.61	0.26
3251	000	4015	002	RSG	OPL	1	23.2	23.2	7.7	12.7	8.2	6.1	2.3	0.5	0.5	199	110	89	1.00	1.83	0.64	0.33
3251	000	4017	001	RSG	OBS	1	15.9	15.9	2.6	11.4	5.4	3.7	2.4	0.3	0.3	135	104	31	1.00	1.40	0.47	0.16
3251	000	4018	001	RSG	OPL	1	25.4	25.4	2.1	16.9	6.1	4.9	2.4	0.4	0.8	135	102	33	1.00	1.50	0.36	0.08
3271	000	0500	138	RSG	OPL	1	28.9	28.9	2.8	19.8	8.8	6.4	3.7	1.3	1.7	135	118	17	1.00	1.46	0.44	0.10
3271	000	0500	146	RSG	OPL	2	20.9	20.9	4.6	10.0	8.0	6.7	3.0	0.5	0.5	151	125	26	1.00	2.09	0.80	0.22
3271	000	0500	191	RSG	OBS	1	35.0	35.0	5.5	21.4	8.7	10.5	4.0	1.7	1.8	158	110	48	1.00	1.64	0.41	0.16
3271	000	0500	293	RSG	OPL	1	32.7	32.7	5.1	12.9	10.0	7.9	3.7	1.1	1.3	152	112	40	1.00	2.53	0.78	0.16
3271	000	0500	301	RSG	OPL	1	29.2	29.2	3.6	16.5	7.7	5.8	3.3	1.0	1.2	123	118	5	1.00	1.77	0.47	0.12
3271	000	0513	004	RSG	BAS	1	34.1	34.1	3.2	19.5	7.3	5.6	3.4	1.3	1.6	130	105	25	1.00	1.75	0.37	0.09
3271	000	1046	005	RSG	OBS	1	28.5	28.5	2.3	14.6	9.8	8.2	2.6	0.7	1.2	123	111	12	1.00	1.95	0.67	0.08
3271	000	1050	001	RSG	OPL	1	34.0	34.0	0.0	20.3	6.7	6.5	2.8	1.4	1.5	123	96	27	1.00	1.67	3.02	0.00
3032	000	0001	001	STM	OPL	1	65.1	0.0	0.0	31.3	11.0	21.8	7.9	16.2	0.0	239	85	154	0.00	0.00	0.00	0.00
3032	023	0001	501	STM	OPL	1	45.9	0.0	0.0	32.2	0.0	0.0	9.5	15.8	0.0	0	0	0	0.00	0.00	0.00	0.00
3032	023	0001	502	STM	OBS	1	24.5	0.0	0.0	20.0	0.0	0.0	4.7	2.9	0.0	0	0	0	0.00	0.00	0.00	0.00

Appendix E, continued.

Site	Locality	Reference	Specimen	Type	Material	Con-dition	Lt	La	Lm	Wm	Wb	Nw	Th	Wt	Est Wt	DSA	PSA	NOI	La/Lt	Lt/Wm	Wb/Wm	Lm/Lt
3032	027	0001	045	STM	OPL	1	41.2	0.0	0.0	17.7	0.0	0.0	5.1	3.9	0.0	0	0	0	0.00	0.00	0.00	0.00
3032	138	0053	01B	STM	OBS	1	36.8	0.0	0.0	25.7	0.0	0.0	7.6	7.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3032	152	3000	001	STM	CHA	1	38.1	0.0	0.0	0.0	37.3	0.0	9.1	20.2	0.0	0	0	0	0.00	0.00	0.00	0.00
3032	023	3001	035	STM	OBS	1	21.1	0.0	0.0	22.3	0.0	0.0	9.1	5.8	0.0	0	0	0	0.00	0.00	0.00	0.00
3092	000	6421	004	STM	OPL	1	35.9	0.0	0.0	22.6	20.7	0.0	4.7	10.0	0.0	254	0	0	0.00	0.00	0.00	0.00
3101	000	0500	007	STM	OPL	1	42.1	0.0	0.0	33.5	0.0	0.0	10.9	17.5	0.0	0	0	0	0.00	0.00	0.00	0.00
3107	000	0500	002	STM	CHA	1	52.3	0.0	0.0	18.8	0.0	0.0	7.4	0.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3160	000	0001	153	STM	OPL	1	32.4	0.0	0.0	23.7	0.0	0.0	6.0	5.8	0.0	249	90	150	0.00	0.00	0.00	0.00
3170	000	0500	031	STM	OBS	1	25.3	0.0	0.0	21.5	0.0	0.0	8.0	4.1	0.0	0	0	0	0.00	0.00	0.00	0.00
3170	000	0500	067	STM	OBS	1	25.4	0.0	0.0	23.1	0.0	0.0	7.1	3.9	0.0	0	0	0	0.00	0.00	0.00	0.00
3170	000	4072	001	STM	OBS	2	32.1	16.0	18.4	15.9	6.6	11.6	4.2	2.0	2.0	230	76	154	0.50	2.02	0.42	0.57
3192	000	0502	020	STM	CHA	1	28.2	0.0	0.0	25.1	0.0	0.0	6.6	6.1	0.0	0	0	0	0.00	0.00	0.00	0.00
3208	000	0505	001	STM	CHA	1	50.0	0.0	0.0	30.3	0.0	0.0	6.5	14.9	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	0500	021	STM	OBS	1	20.2	0.0	0.0	17.3	0.0	0.0	8.5	3.4	0.0	0	0	0	0.00	0.00	0.00	0.00
3237	000	6761	002	STM	BAS	2	47.4	47.4	16.4	17.2	8.8	13.2	5.7	5.0	5.0	219	75	44	1.00	2.76	0.51	0.35
3238	000	0500	023	STM	OBS	1	25.3	0.0	0.0	19.3	0.0	0.0	7.9	4.0	0.0	0	0	0	0.00	0.00	0.00	0.00
3238	000	0500	025	STM	OBS	1	22.5	0.0	0.0	21.3	0.0	0.0	7.8	4.3	0.0	0	0	0	0.00	0.00	0.00	0.00

KEY:

TYPE
- CLO = Clovis
- CT = Cottonwood
- DSN = Desert Side-notched
- ELK = Elko
- FRG = Fragment
- GAT = Gatecliff
- HUM = Humboldt
- LSN = Large Side-notched
- RSG = Rosegate
- STM = Stemmed
- OOK = Out of Key

MATERIAL
- OPL = Opalite
- OBS = Obsidian
- BAS = Basalt
- CHA = Chalcedony

CONDITION
- 1 = Complete
- 2 = Incomplete

MEASUREMENT
- Lt = Total Length
- La = Length of Longitudinal Axis
- Lm = Length from Proximal End to Maximum Width
- Wm = Maximum Width
- Wb = Basal Width
- Nw = Neck Width
- Th = Thickness
- Wt = Weight in grams
- Est Wt = Estimated Weight
- DSA = Distal Shoulder Angle, between 90°-270°
- PSA = Proximal Shoulder Angle, between 0°-270°y
- NOI = Notch Opening Index

APPENDIX F

Summary Data for Preforms

Appendix F. Summary Data for Preforms.

Subarea	Site/Loc.	Fea.	Total	MATERIAL Opalite	Obs	Bas	Chal	Jas	Opal	STAGE 2	3	4	5	Ind.	THERMAL ALTERATION HT Block	HT Blank	HT Red.	HT Stage Indet.	Other	Not HT	BLANK TYPE Biface Thin.	Other	Ind.	TIP ORIENTATION Prox.	Dist.	Trans.	Ind.
Quarry	3032/L23	1	1	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	-	-	-	1
	3032/L27	0	6	5	1	-	-	-	-	3	1	2	-	-	-	1	-	1	1	3	1	1	4	-	1	2	3
East	2140	0	2	1	1	-	-	-	-	-	-	2	-	-	1	-	-	-	-	1	-	-	2	-	-	-	2
	3170	0	4	2	1	-	1	-	-	1	2	1	-	-	-	2	-	-	-	2	-	1	3	-	3	1	-
		8	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	1
	Total		5																								
	3171	0	4	2	2	-	-	-	-	3	-	1	-	-	-	-	-	-	1	3	-	-	4	2	-	1	1
	3184	0	2	1	1	-	-	-	-	-	1	1	-	-	-	1	-	-	-	1	-	-	2	-	-	1	1
		3	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1
		8	3	2	1	-	-	-	-	-	1	2	-	-	-	-	-	-	-	3	-	2	1	1	1	-	1
	Total		6																								
	3185	1	3	3	-	-	-	-	-	-	2	1	-	-	-	-	1	1	1	-	2	-	1	-	1	-	2
		6	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1
	Total		4																								
	3189	0	1	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1
	3190	1	1	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	1	-	-	1	-	-	-	1
		7	1	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1
	Total		2																								
	3192	1	3	3	-	-	-	-	-	1	-	1	1	-	1	1	-	-	-	1	-	-	3	-	2	-	1
		2	1	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1
	Total		4																								
	3198	1	15	10	4	-	1	-	-	3	3	7	1	1	-	2	-	2	2	9	1	2	12	4	5	-	6
	3204	0	1	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	1	-	1	-	-
		1	4	4	-	-	-	-	-	2	-	2	-	-	1	2	-	-	-	1	1	-	3	1	1	-	2
	Total		5																								
West	3092	0	28	25	1	-	-	2	-	7	7	9	-	5	2	4	-	7	6	9	2	3	23	2	2	2	22
		13	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1
	Total		29																								
	3093	3	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	1	-	-
		4	4	3	-	1	-	-	-	2	1	1	-	-	-	-	-	2	1	1	-	-	4	2	1	-	1
		5	1	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	1
	Total		6																								
	3095	0	3	3	-	-	-	-	-	-	3	-	-	-	-	3	-	-	-	-	-	-	3	1	-	-	2
		10	8	6	1	-	1	-	-	2	4	2	-	-	-	3	-	1	2	2	1	-	7	1	3	1	3
		11	1	1	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	1	-	-	-
		15	1	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	1
		16	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-
		19	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	-	1	-	-	-
		24	2	2	-	-	-	-	-	1	-	1	-	-	-	1	-	1	-	-	-	-	2	-	-	-	2
	Total		17																								

Appendix F, continued.

Subarea	Site/Loc.	Fea.	Total	MATERIAL Opalite	Obs	Bas	Chal	Jas	Opal	STAGE 2	3	4	5	Ind.	THERMAL ALTERATION HT Block	HT Blank	HT Red.	HT Stage Indet.	Other	Not HT	BLANK TYPE Biface Thin.	Other	Ind.	TIP ORIENTATION Prox.	Dist.	Trans.	Ind.
	3116	1	3	3	-	-	-	-	-	-	-	3	-	-	-	-	-	2	-	1	-	-	3	-	-	-	3
	3155	0	1	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1
	3160	0	17	15	-	-	-	1	1	2	7	6	1	1	-	6	-	3	2	6	-	2	15	2	3	1	11
		1	4	3	-	-	1	-	-	1	-	3	-	-	-	-	-	-	1	3	-	-	4	1	-	-	3
		2	1	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	1	1	-	-	-
		6	1	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	1	1	-	-	-
		11	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1
		12	3	1	1	-	1	-	-	1	1	1	-	-	1	1	-	-	-	1	-	1	2	1	-	-	2
		13	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1
		14	1	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1
		17	1	1	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	1
		20	2	1	1	-	-	-	-	-	-	2	-	-	-	-	-	-	-	2	-	-	2	1	-	1	-
		23	17	12	-	-	4	1	-	6	8	2	1	-	2	9	-	3	2	1	1	4	12	2	3	4	8
		24	2	2	-	-	-	-	-	1	1	-	-	-	-	2	-	-	-	-	-	1	1	-	-	-	2
	Total		51																								
	3165	0	2	1	1	-	-	-	-	-	1	1	-	-	-	-	-	-	-	2	-	-	2	1	-	-	1
		2	1	1	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	1	-	-	-	1
	Total		3																								
	3271	0	3	3	-	-	-	-	-	-	1	2	-	-	-	1	-	1	-	1	-	-	3	-	-	-	3
		3	2	2	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	1	1	1	-	1	-	-	1
		11	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1
		12	2	2	-	-	-	-	-	1	1	-	-	-	-	1	-	-	-	1	2	-	-	1	1	-	-
		14	2	2	-	-	-	-	-	-	-	2	-	-	-	-	-	2	-	-	-	-	2	-	-	-	2
	Total		10																								
North	3231	1	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	1	-
	3237	0	16	14	1	-	-	-	1	3	2	8	1	2	2	3	-	7	1	3	1	2	13	1	-	-	15
		2	1	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-	1
	Total		17																								
	3239	1	3	3	-	-	-	-	-	1	2	-	-	-	2	1	-	-	-	-	1	1	1	2	-	-	1
	3251	0	8	8	-	-	-	-	-	2	1	4	-	1	-	2	-	5	1	-	1	-	7	-	1	-	7
		1	31	29	2	-	-	-	-	10	5	13	-	3	2	13	1	8	3	4	2	3	26	4	2	1	24
		2	4	3	-	-	1	-	-	1	1	2	-	-	1	-	-	2	-	1	-	-	4	2	-	-	2
		3	1	1	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	1
		6	19	17	-	-	1	1	-	7	6	6	-	-	-	8	1	6	2	2	2	4	13	2	2	2	13
	Total		63																								
	3262	0	1	1	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	1	-	-	1	-

APPENDIX G

Summary Data for Cores

Appendix G. Summary Data for Cores.

				ATTRIBUTES														
				MATERIAL					BLANK TYPE				CORE TYPE					
Subarea	Site	Fea.	Total Cores	Opalite	Obsidian	Basalt	Jasper	Other	Flake	Cobble	Indet.	Assay Pc.	Block	Sphere	Split Nodule	Frag	Other	Poss. Core
Quarry	Loc. 19	0	1	1	-	-	-	-	1	-	-	-	-	-	-	-	1	-
		1	4	4	-	-	-	-	1	-	3	-	1	-	-	1	1	1
	Total		5															
	Loc. 20	2	3	3	-	-	-	-	-	2	1	-	-	-	2	1	-	-
		3	1	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-
	Total		4															
	Loc. 21	1	8	8	-	-	-	-	1	1	6	-	4	4	-	-	-	-
	Loc. 22	0	1	1	-	-	-	-	-	-	1	-	1	-	-	-	-	-
		1	2	2	-	-	-	-	-	1	1	1	1	-	-	-	-	-
	Total		3															
	Loc. 23	1	10	10	-	-	-	-	3	1	6	-	1	2	-	4	3	-
	Loc. 24	0	1	-	1	-	-	-	-	1	-	-	1	-	-	-	-	-
	Loc 25	2	5	5	-	-	-	-	3	1	1	-	-	1	-	1	3	-
		5	1	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-
	Total		6															
	Loc. 26	0	5	5	-	-	-	-	3	-	2	-	4	1	-	-	-	-
	Loc. 27	0	14	13	1	-	-	-	8	2	4	-	5	3	1	1	3	1
East	3170	0	3	2	1	-	-	-	-	1	2	1	-	1	-	-	1	-
	3171	0	4	3	1	-	-	-	1	2	1	-	-	-	1	-	1	2
		1	2	2	-	-	-	-	-	2	-	-	-	-	-	1	1	-
		2	1	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-
		7	1	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-
	Total		8															
	3173	1	1	1	-	-	-	-	-	1	-	1	-	-	-	-	-	-

				ATTRIBUTES														
				MATERIAL					BLANK TYPE				CORE TYPE					
Subarea	Site	Fea.	Total Cores	Opalite	Obsidian	Basalt	Jasper	Other	Flake	Cobble	Indet.	Assay Pc.	Block	Sphere	Split Nodule	Frag	Other	Poss. Core
	3184	0	1	-	1	-	-	-	-	-	1	-	1	-	-	-	-	-
		8	2	2	-	-	-	-	1	-	1	-	1	-	-	1	-	-
		19	1	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-
		20	3	3	-	-	-	-	1	-	2	-	1	-	1	-	1	-
		23	2	2	-	-	-	-	1	-	1	-	1	1	-	-	-	-
	Total		9															
	3191	0	1	1	-	-	-	-	-	-	1	-	-	-	-	-	1	-
	3192	1	1	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-
		2	3	2	1	-	-	-	-	1	2	-	1	1	-	-	1	-
	Total		4															
	3198	1	7	7	-	-	-	-	7	-	-	6	-	-	-	-	-	1
	3204	0	1	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-
		1	1	1	-	-	-	-	1	-	-	-	1	-	-	-	-	-
	Total		2															
West	3091	0	1	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-
	3092	0	11	5	1	2	2	1	4	4	3	-	6	1	-	3	1	-
		6	1	1	-	-	-	-	1	-	-	-	-	1	-	-	-	-
		12	1	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-
	Total		13															
	3093	5	2	-	-	2	-	-	-	2	-	-	2	-	-	-	-	-
	3095	0	1	1	-	-	-	-	1	-	-	-	-	-	-	1	-	-
		15	2	2	-	-	-	-	-	2	-	-	1	-	-	-	1	-
		19	3	2	-	1	-	-	1	1	1	-	2	-	-	-	1	-
		24	1	1	-	-	-	-	-	1	-		-	-	-	1	-	-
	Total		7															
	3099	1	1	1	-	-	-	-	1	-	-	-	-	-	-	-	1	-
	3104	0	4	4	-	-	-	-	-	3	1	1	1	-	-	-	2	-
	3106	4	2	2	-	-	-	-	1	-	1	-	1	-	-	-	-	1

				ATTRIBUTES														
				MATERIAL					BLANK TYPE				CORE TYPE					
Subarea	Site	Fea.	Total Cores	Opalite	Obsidian	Basalt	Jasper	Other	Flake	Cobble	Indet.	Assay Pc.	Block	Sphere	Split Nodule	Frag	Other	Poss. Core
	3160	0	1	1	-	-	-	-	-	-	1	-	1	-	-	-	-	-
		17	1	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
	Total		2															
	3271	0	3	2	1	-	-	-	-	2	1	1	-	1	-	1	-	-
		12	3	1	-	2	-	-	1	2	-	-	1	-	-	1	1	-
	Total		6															
North	3232	0	1	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-
	3237	0	4	-	1	1	2	-	1	2	1	-	1	-	-	1	2	-
	3238	0	1	-	-	-	-	1	-	1	-	-	1	-	-	-	-	-

APPENDIX H

Summary Data for Modified Chunks

Appendix H. Summary Data for Modified Chunks.

Subarea	Site	Feature No.	Total Mod. Chunks	MATERIAL Opalite	Jasper	Other	CORTEX Present	Absent
Quarry	Loc. 21	0	1	1	-	-	-	1
		1	3	3	-	-	2	1
	Total		4					
	Loc. 23	1	3	3	-	-	-	3
	Loc. 25	2	2	2	-	-	-	2
East	3170	0	1	-	-	1	-	1
		1	1	1	-	-	-	1
		7	1	1	-	-	-	1
	Total		3					
	3171	0	2	2	-	-	-	2
		1	2	2	-	-	2	-
		2	1	1	-	-	1	-
		4	1	1	-	-	1	-
	Total		6					
	3178	1	1	1	-	-	-	1
	3184	8	3	3	-	-	-	3
		12	1	1	-	-	-	1
		23	1	1	-	-	-	1
	Total		5					
	3192	1	2	2	-	-	1	1
		2	2	2	-	-	-	2
	Total		4					
	3196	1	4	4	-	-	-	4
	3203	0	2	2	-	-	1	1
	3204	0	4	4	-	-	1	3
		1	2	2	-	-	-	2
	Total		6					
West	3092	0	6	6	-	-	1	5
		1	1	1	-	-	-	1
	Total		7					
	3095	0	1	1	-	-	-	1
		6	1	-	1	-	-	1
		14	1	1	-	-	-	1
		24	1	1	-	-	1	-
	Total		4					
	3096	2	1	1	-	-	-	1
	3100	1	1	1	-	-	-	1
	3101	0	1	1	-	-	1	-
	3102	1	1	1	-	-	-	1
	3104	0	1	1	-	-	1	-

Appendix H, continued.

Subarea	Site	Feature No.	Total Mod. Chunks	MATERIAL Opalite	Jasper	Other	CORTEX Present	Absent
	3106	1	1	1	-	-	-	1
	3160	0	1	1	-	-	-	1
		1	1	1	-	-	-	1
		11	1	1	-	-	-	1
		21	1	1	-	-	-	1
	Total		4					
	3165	0	1	1	-	-	1	-
	3271	0	1	1	-	-	-	1
		18	1	1	-	-	-	1
	Total		2					
North	3237	0	3	3	-	-	1	2

APPENDIX I

Summary Statistics and Results for Debitage Mass Analysis

Appendix I.

Table 1. Mass Analysis Debitage Assemblage Characterizations of Composite Site Samples.

Site (26Ek)	Material	Characterization	Total Number	Total Weight
**** Northern Corridor**				
3228	Opalite	Mixed Bif	495	356.3
3231	Opalite	Mixed Bif	254	176.6
3232	Opalite	ESB	77	179.7
3232	Jasper	N<51	1	0.7
3234	Opalite	N<51	10	3.4
3234	Jasper	N<51	1	0.2
3237	Opalite	ESB	11329	13118.8
3237	Jasper	ESB	140	213.9
3237	Basalt	N<51	12	39.2
3237	Other	NoG3	3	9.1
3238	Opalite	Mixed Bif	3229	2501.5
3238	Jasper	N<51	30	37.3
3238	Basalt	N<51	3	4.7
3238	Other	N<51	2	0.3
3239	Opalite	Mixed Bif	1519	1473.4
3239	Jasper	N<51	6	2.7
3251	Opalite	Mixed Bif	19803	10239.4
3251	Jasper	Mixed Bif	65	53.1
3251	Basalt	N<51	3	0.4
3251	Other	Mixed Bif	59	51.5
**** Eastern Periphery**				
3170	Opalite	ESB	31038	62392.4
3170	Jasper	Core Red	465	440.0
3170	Basalt	N<51	26	91.7
3170	Other	N<51	36	162.1
3171	Opalite	Core Red	19180	180734.1
3171	Jasper	ESB	57	117.7
3171	Basalt	N<51	6	9.5
3171	Other	N<51	26	485.3
3172	Opalite	ESB	1250	1967.2
3172	Jasper	N<51	7	2.2
3172	Other	N<51	1	0.5
3173	Opalite	ESB	3452	8671.9
3173	Jasper	N<51	3	1.1
3177	Opalite	ESB	370	570.6
3178	Opalite	ESB	3736	6443.4
3178	Jasper	NoG3	1	20.3
3179	Opalite	Mixed Bif	1218	1420.9
3179	Jasper	N<51	1	0.6
3181	Opalite	ESB	3030	6248.7
3181	Jasper	N<51	24	16.6
3183	Opalite	Mixed Bif	2169	2453.2
3183	Jasper	N<51	2	0.3
3184	Opalite	ESB	53428	155807.4
3184	Jasper	Core Red	95	382.8
3184	Basalt	N<51	4	1.2
3184	Other	N<51	2	21.2
3185	Opalite	ESB	1959	3183.0
3185	Jasper	NoG3	1	8.4
3185	Other	N<51	2	0.9
3190	Opalite	ESB	8051	11098.7
3190	Jasper	N<51	13	14.9
3190	Basalt	N<51	1	0.1

Table 1 (continued)

Site (26Ek)	Material	Characterization	Total Number	Total Weight
3191	Opalite	N<51	21	71.5
3191	Other	NoG3	1	7.0
3192	Opalite	ESB	35724	67903.0
3192	Jasper	Core Red	236	1063.1
3192	Basalt	N<51	18	60.5
3192	Other	N<51	5	40.4
3193	Opalite	Core Red	3296	12204.2
3195	Opalite	Core Red	623	3983.7
3196	Opalite	Core Red	4480	21035.6
3196	Other	N<51	6	341.1
3197	Opalite	Core Red	1171	6738.0
3198	Opalite	Core Red	7129	26186.6
3198	Other	N<51	1	0.3
3200	Opalite	Core Red	240	1012.1
3201	Opalite	ESB	4061	6076.4
3202	Opalite	ESB	1060	2013.5
3203	Opalite	Core Red	388	1745.5
3204	Opalite	ESB	39171	69305.6
3204	Jasper	N<51	37	28.2
3204	Basalt	N<51	2	0.7
3204	Other	N<51	6	28.2
**** Western Periphery**				
3082	Opalite	N<51	4	17.9
3084	Opalite	Core Red	55	279.7
3084	Jasper	Core Red	244	2425.6
3090	Opalite	Core Red	95	612.4
3090	Jasper	N<51	2	2.8
3092	Opalite	ESB	98189	159677.8
3092	Jasper	ESB	6455	13464.1
3092	Basalt	Core Red	371	2585.4
3092	Other	ESB	59	88.3
3093	Opalite	ESB	2532	2911.3
3093	Jasper	N<51	1	1.8
3095	Opalite	ESB	65286	74928.0
3095	Jasper	Mixed Bif	254	172.4
3095	Basalt	N<51	35	113.3
3095	Other	N<51	2	3.8
3096	Opalite	ESB	790	996.9
3100	Opalite	Core Red	845	2883.3
3101	Opalite	ESB	925	1709.8
3101	Jasper	N<51	27	34.5
3102	Opalite	Core Red	1364	6669.8
3102	Jasper	N<51	5	7.2
3104	Opalite	Core Red	541	3807.4
3106	Opalite	ESB	10940	26236.1
3106	Jasper	N<51	15	12.7
3106	Basalt	N<51	12	28.9
3106	Other	NoG3	2	43.3
3107	Opalite	ESB	1446	4683.4
3107	Jasper	ESB	58	133.0
3114	Opalite	ESB	3772	5024.9
3115	Opalite	Mixed Bif	1785	1886.8
3115	Basalt	N<51	1	0.8
3116	Opalite	ESB	2377	3495.1
3116	Basalt	N<51	1	0.4
3116	Other	N<51	4	1.4

Table 1 (continued)

Site (26Ek)	Material	Characterization	Total Number	Total Weight
3149	Opalite	ESB	360	530.2
3149	Jasper	N<51	32	26.5
3160	Opalite	ESB	45742	61506.7
3160	Jasper	Mixed Bif	330	321.3
3160	Basalt	Core Red	57	586.1
3160	Other	N<51	9	21.2
3165	Opalite	ESB	12426	16218.2
3165	Jasper	Mixed Bif	64	81.6
3165	Basalt	N<51	9	20.2
3207	Opalite	NoG3	7	184.5
3271	Opalite	ESB	47073	63579.3
3271	Jasper	Mixed Bif	55	63.1
3271	Basalt	Core Red	238	3302.0
3271	Other	N<51	6	12.1
**** 26EK3032 Localities**				
Loc.19	Opalite	Core Red	14665	73009.6
Loc.19	Jasper	N<51	7	7.5
Loc.19	Other	N<51	1	0.7
Loc.20	Opalite	Core Red	8633	32594.7
Loc.20	Jasper	N<51	2	9.5
Loc.20	Other	ESB	168	286.6
Loc.21	Opalite	Core Red	1793	39885.1
Loc.21	Other	NoG3	1	11.4
Loc.22	Opalite	Core Red	2066	13681.1
Loc.22	Jasper	N<51	1	0.5
Loc.23	Opalite	Core Red	12828	75726.8
Loc.25	Opalite	Core Red	23315	80951.0
Loc.25	Basalt	N<51	9	63.1
Loc.25	Other	N<51	11	33.2
Loc.98	Opalite	Core Red	1286	12250.6
Loc.98	Other	NoG3	15	2.7

Characterizations:
Mixed Bif = Mixed biface
Core Red = Core reduction
ESB = Early biface, Stage 1 to Stage 3.5
LSB = Late biface, Stage 3.5+
NoG3 = Not classified, no G3 size grade items
N<51 = not classified, n<51.

Table 2. Mass Analysis Characterizations of Composite Feature Samples.

Site (26Ek)	Locus	Fea. No.	Type	Material	Character-ization	Total sample wt.	Total sample n	% Fea. Sample	Est. Total Weight	Stage 3
**** Northern Corridor**										
3228	0	1	Red. locus	Opalite	LSB	48.3	135	66.67	72.4	0
3228	0	2	Red. locus	Opalite	Mixed Bif	308.0	360	100.00	308.0	0
3231	0	1	Red. locus	Opalite	Mixed Bif	176.6	254	66.67	264.9	0
3232	0	1	Red. locus	Opalite	ESB	179.7	77	80.00	224.6	0
3232	0	1	Unknown	Jasper	N<51	0.7	1	80.00	0.9	0
3234	0		Nonfeat.	Opalite	N<51	3.4	10	0.05	6800.0	5
3234	0		Nonfeat.	Jasper	N<51	0.2	1	0.05	400.0	0
3237	A		Nonfeat.	Opalite	ESB	10967.3	9553	0.00	10967.3	8
3237	C		Nonfeat.	Jasper	ESB	206.1	133	0.00	206.1	0
3237	C		Nonfeat.	Obsid.	N<51	19.0	28	0.00	19.0	0
3237	C		Nonfeat.	Basalt	N<51	38.3	8	0.00	38.3	0
3237	C		Nonfeat.	Other	NoG3	9.1	3	0.00	9.1	0
3237	C	2	Other	Opalite	ESB	2144.9	1769	69.70	3077.3	2
3237	C	2	Unknown	Jasper	N<51	7.8	7	69.70	11.2	0
3237	C	2	Unknown	Obsid.	N<51	0.2	2	69.70	0.3	0
3237	C	2	Unknown	Basalt	N<51	0.9	4	69.70	1.3	0
3237	C	3	Other	Opalite	N<51	2.3	6	0.00	2.3	0
3237	C	5	Unknown	Opalite	NoG3	4.3	1	0.00	4.3	0
3238	A		Nonfeat.	Opalite	Mixed Bif	298.9	397	0.00	298.9	0
3238	A		Nonfeat.	Jasper	N<51	10.8	13	0.00	10.8	
3238	0		Nonfeat.	Obsid.	N<51	0.4	3	0.00	0.4	0
3238	A		Nonfeat.	Other	N<51	0.3	2	0.00	0.3	0
3238	0	1	Red. locus	Opalite	Mixed Bif	2202.6	2832	57.14	3854.7	3
3238	0	1	Unknown	Jasper	N<51	26.5	17	57.14	46.4	0
3238	0	1	Unknown	Obsid.	N<51	0.4	3	57.14	0.7	0
3238	0	1	Unknown	Basalt	N<51	4.7	3	57.14	8.2	0
3239	0	1	Red. locus	Opalite	Mixed Bif	1473.4	1519	10.53	13992.4	11
3239	0	1	Unknown	Jasper	N<51	2.7	6	10.53	25.6	0
3239	0	1	Unknown	Obsid.	N<51	0.3	1	10.53	2.8	0
3251	0		Nonfeat.	Opalite	Mixed Bif	244.9	308	0.00	244.9	0
3251	0		Nonfeat.	Obsid.	N<51	1.2	3	0.00	1.2	0
3251	0	1	Other	Opalite	Mixed Bif	3986.8	8097	33.33	11961.6	9
3251	0	1	Unknown	Jasper	N<51	8.0	10	33.33	24.0	0
3251	0	1	Unknown	Obsid.	N<51	7.0	12	33.33	21.0	0
3251	0	1	Unknown	Basalt	N<51	0.4	3	33.33	1.2	0
3251	0	1	Unknown	Other	N<51	7.9	5	33.33	23.7	0
3251	0	2	Other	Opalite	Mixed Bif	3901.9	8024	16.67	23406.7	18
3251	0	6	Other		Mixed Bif	84.4	117	0.00	84.4	0
3251	0	6	Unknown	Opalite	Mixed Bif	2105.8	3374	0.00	2105.8	2
3251	0	6	Unknown	Jasper	Mixed Bif	45.1	55	0.00	45.1	0
3251	0	6	Unknown	Obsid.	N<51	14.5	41	0.00	14.5	0
3251	0	6	Unknown	Other	Mixed Bif	43.6	54	0.00	43.6	0
**** Eastern Periphery**										
3170	0		Nonfeat.	Opalite	ESB	20435.3	9919	0.00	20435.3	15
3170	0		Nonfeat.	Jasper	Core Red	374.9	453	0.00	374.9	0
3170	0		Nonfeat.	Obsid.	N<51	3.2	5	0.00	3.2	0
3170	0		Nonfeat.	Basalt	N<51	91.7	26	0.00	91.7	0
3170	0		Nonfeat.	Other	N<51	135.3	22	0.00	135.3	0
3170	0	1	Quarry fea	Opalite	Core Red	4155.0	886	0.52	799038.5	601
3170	0	1	Unknown	Jasper	N<51	60.2	9	0.52	11576.9	9

Table 2, continued.

Site (26Ek)	Locus	Fea. No.	Type	Material	Character-ization	Total sample wt.	n	% Fea. Sample	Est. Total Weight	Stage 3
3170	A	8	Unknown	Opalite	ESB	31840.8	17458	40.51	78599.9	59
3170	A	8	Red. locus	Obsid.	N<51	4.0	4	40.51	9.9	0
3170	A	8	Unknown	Other	N<51	26.8	14	40.51	66.2	0
3170	0	9	Unknown	Opalite	ESB	5779.1	2659	100.00	5779.1	4
3170	0	9	Red. locus	Jasper	N<51	4.9	3	100.00	4.9	0
3170	0	9	Unknown	Obsid.	N<51	0.6	2	100.00	0.6	0
3170	0	14	Other	Opalite	ESB	182.2	116	100.00	182.2	0
3171	0		Nonfeat.	Opalite	ESB	24285.2	6705	0.00	24285.2	18
3171	0		Nonfeat.	Jasper	ESB	114.7	56	0.00	114.7	0
3171	0		Nonfeat.	Obsid.	N<51	0.7	1	0.00	0.7	0
3171	0		Nonfeat.	Basalt	N<51	9.5	6	0.00	9.5	0
3171	0		Nonfeat.	Other	N<51	4.5	1	0.00	4.5	0
3171	0	1	Red. locus	Opalite	Core Red	23661.8	1694	100.00	23661.8	18
3171	0	1	Unknown	Jasper	NoG3	3.0	1	100.00	3.0	0
3171	0	1	Unknown	Obsid.	N<51	0.1	1	100.00	0.1	0
3171	0	1	Unknown	Other	N<51	73.3	8	100.00	73.3	0
3171	0	2	Unknown	Opalite	Core Red	123799.3	8848	1.03	12019350.0	9037
3171	0	2	Quarry fea	Other	N<51	407.5	17	1.03	39563.1	30
3171	0	3	Red. locus	Opalite	Core Red	8987.8	1933	0.00	8987.8	7
3172	0	1	Red. locus	Opalite	ESB	1967.2	1250	100.00	1967.2	1
3172	0	1	Unknown	Jasper	N<51	2.2	7	100.00	2.2	0
3172	0	1	Unknown	Other	N<51	0.5	1	100.00	0.5	0
3173	0	1	Red. locus	Opalite	ESB	8671.9	3452	100.00	8671.9	7
3173	0	1	Unknown	Jasper	N<51	1.1	3	100.00	1.1	0
3173	0	1	Unknown	Obsid.	N<51	1.2	1	100.00	1.2	0
3177	0	1	Red. locus	Opalite	ESB	570.6	370	0.70	81514.3	61
3178	0	1	Red. locus	Opalite	ESB	6443.4	3736	11.36	56720.1	43
3178	0	1	Unknown	Jasper	NoG3	20.3	1	11.36	178.7	0
3179	0	1	Red. locus	Opalite	Mixed Bif	1420.9	1218	100.00	1420.9	1
3179	0	1	Unknown	Jasper	N<51	0.6	1	100.00	0.6	0
3181	0	1	Unknown	Opalite	ESB	6248.7	3030	100.00	6248.7	5
3181	0	1	Red. locus	Jasper	N<51	16.6	24	100.00	16.6	0
3181	0	1	Unknown	Obsid.	N<51	0.2	2	100.00	0.2	0
3183	0	1	Red. locus	Opalite	Mixed Bif	2453.2	2169	100.00	2453.2	2
3183	0	1	Unknown	Jasper	N<51	0.3	2	100.00	0.3	0
3183	0	1	Unknown	Obsid.	N<51	0.5	4	100.00	0.5	0
3184	0		Nonfeat.	Opalite	ESB	7258.3	3084	0.00	7258.3	5
3184	0		Nonfeat.	Jasper	N<51	16.9	17	0.00	16.9	0
3184	0		Nonfeat.	Obsid.	N<51	5.1	2	0.00	5.1	0
3184	0	1	Unknown	Opalite	N<51	16.9	9	100.00	16.9	0
3184	0	1	Other	Obsid.	N<51	15.1	2	100.00	15.1	0
3184	0	2	Red. locus	Opalite	Core Red	8797.3	1988	100.00	8797.3	7
3184	0	2	Unknown	Obsid.	N<51	0.1	1	100.00	0.1	0
3184	0	3	Red. locus	Opalite	ESB	2102.8	1096	1.39	151280.6	114
3184	0	3	Unknown	Jasper	N<51	0.5	2	1.39	36.0	0
3184	0	3	Unknown	Obsid.	N<51	6.7	3	1.39	482.0	0
3184	0	8	Red. locus	Opalite	ESB	26250.3	12617	65.63	39997.4	30
3184	0	8	Unknown	Jasper	Core Red	343.2	59	65.63	522.9	0
3184	0	8	Unknown	Obsid.	N<51	34.1	20	65.63	52.0	0
3184	0	8	Unknown	Other	NoG3	20.8	1	65.63	31.7	0
3184	0	12	Unknown	Opalite	Core Red	26325.0	6353	81.82	32174.3	24
3184	0	12	Unknown	Jasper	N<51	0.2	1	81.82	0.2	0
3184	0	12	Red. locus	Obsid.	N<51	3.8	6	81.82	4.6	0
3184	0	14	Red. locus	Opalite	ESB	3332.4	2015	100.00	3332.4	3

Table 2, continued.

Site (26Ek)	Locus	Fea. No.	Type	Material	Character-ization	Total sample wt.	n	% Fea. Sample	Est. Total Weight	Stage 3
3184	0	14	Unknown	Jasper	N<51	0.3	1	100.00	0.3	0
3184	0	19	Unknown	Opalite	ESB	18016.6	9021	100.00	18016.6	14
3184	0	19	Red. locus	Jasper	N<51	9.5	13	100.00	9.5	0
3184	0	19	Unknown	Obsid.	Mixed Bif	61.6	67	100.00	61.6	0
3184	0	19	Unknown	Basalt	N<51	1.2	4	100.00	1.2	0
3184	0	19	Unknown	Other	N<51	0.4	1	100.00	0.4	0
3184	0	20	Red. locus	Opalite	Core Red	43587.9	5378	0.00	43587.9	33
3184	0	20	Unknown	Jasper	NoG3	12.2	2	0.00	12.2	0
3184	0	23	Red. locus	Opalite	ESB	20119.9	11867	39.68	50705.4	38
3184	0	23	Unknown	Obsid.	N<51	0.1	1	39.68	0.3	0
3185	0	1	Red. locus	Opalite	ESB	3183.0	1959	100.00	3183.0	2
3185	0	1	Unknown	Jasper	NoG3	8.4	1	100.00	8.4	0
3185	0	1	Unknown	Obsid.	N<51	0.2	1	100.00	0.2	0
3185	0	1	Unknown	Other	N<51	0.9	2	100.00	0.9	0
3190	0	1	Unknown	Opalite	ESB	6644.4	5054	90.32	7356.5	6
3190	0	1	Unknown	Jasper	N<51	4.3	11	90.32	4.8	0
3190	0	1	Red. locus	Obsid.	N<51	54.6	41	90.32	60.5	0
3190	0	1	Unknown	Basalt	N<51	0.1	1	90.32	0.1	0
3190	0	2	Red. locus	Opalite	ESB	4454.3	2997	100.00	4454.3	3
3190	0	2	Unknown	Jasper	NoG3	10.6	2	100.00	10.6	0
3190	0	2	Unknown	Obsid.	NoG3	2.1	3	100.00	2.1	0
3191	0	1	Red. locus	Opalite	N<51	71.5	21	25.00	286.0	0
3191	0	1	Unknown	Obsid.	N<51	0.8	1	25.00	3.2	0
3191	0	1	Unknown	Other	NoG3	7.0	1	25.00	28.0	0
3192	0	1	Unknown	Opalite	ESB	43778.7	20823	100.00	43778.7	33
3192	0	1	Unknown	Jasper	Core Red	988.1	209	100.00	988.1	1
3192	0	1	Other	Obsid.	N<51	6.3	12	100.00	6.3	0
3192	0	1	Unknown	Basalt	N<51	54.3	10	100.00	54.3	0
3192	0	1	Unknown	Other	N<51	0.5	2	100.00	0.5	0
3192	0	2	Unknown	Opalite	ESB	24124.3	14901	1.39	1735561.2	1305
3192	0	2	Unknown	Jasper	N<51	75.0	27	1.39	5395.7	4
3192	0	2	Other	Obsid.	N<51	20.2	28	1.39	1453.2	1
3192	0	2	Unknown	Basalt	N<51	6.2	8	1.39	446.0	0
3192	0	2	Unknown	Other	N<51	39.9	3	1.39	2870.5	2
3193	0	1	Quarry fea	Opalite	Core Red	1615.3	290	0.44	367113.6	276
3193	0	4	Red. locus	Opalite	ESB	10588.9	3006	66.67	15882.6	12
3195	0	1	Quarry fea	Opalite	Core Red	1011.6	171	0.13	778153.8	585
3195	0	2	Quarry fea	Opalite	Core Red	2972.1	452	0.57	521421.1	392
3196	0	1	Other	Opalite	Core Red	11564.1	3035	0.39	2965153.8	2229
3196	0	1	Unknown	Other	N<51	341.1	6	0.39	87461.5	66
3196	0	2	Quarry fea	Opalite	Core Red	9471.5	1445	0.12	7892916.7	5935
3197	0		Nonfeat.	Opalite	Core Red	1282.4	267	0.00	1282.4	1
3197	0	1	Quarry fea	Opalite	Core Red	3029.4	499	1.76	172125.0	129
3197	0	5	Other	Opalite	Core Red	1694.4	144	0.00	1694.4	1
3197	0	10	Red. locus	Opalite	Core Red	731.8	261	0.00	731.8	1
3198	0	1	Unknown	Opalite	Core Red	17859.6	5717	100.00	17859.6	13
3198	0	1	Red. locus	Obsid.	N<51	38.8	39	100.00	38.8	0
3198	0	1	Unknown	Other	N<51	0.3	1	100.00	0.3	0
3198	0	2	Red. locus	Opalite	Core Red	1939.1	598	100.00	1939.1	1
3198	0	9	Red. locus	Opalite	ESB	247.2	107	0.84	29428.6	22
3198	0	14	Quarry fea	Opalite	Core Red	6140.7	707	1.82	337401.1	254
3200	0	1	Quarry fea	Opalite	Core Red	1012.1	240	0.31	326483.9	245
3201	0	1	Red. locus	Opalite	Mixed Bif	1517.2	1257	1.96	77408.2	58
3201	0	1	Unknown	Obsid.	N<51	12.2	23	1.96	622.4	0

Table 2, continued.

Site (26Ek)	Locus	Fea. No.	Type	Material	Character-ization	Total sample wt.	n	% Fea. Sample	Est. Total Weight	Stage 3
3201	0	2	Red. locus	Opalite	Mixed Bif	2760.0	2616	4.64	59482.8	45
3201	0	3	Red. locus	Opalite	N<51	43.3	24	0.00	43.3	0
3201	0	4	Quarry fea	Opalite	Core Red	1755.9	164	0.22	798136.4	600
3202	0	1	Red. locus	Opalite	ESB	2013.5	1060	6.25	32216.0	24
3203	0		Nonfeat.	Opalite	Core Red	1745.5	388	0.05	3491000.0	2625
3204	0	1	Unknown	Opalite	ESB	69305.6	39171	6.25	1108889.6	834
3204	0	1	Red. locus	Jasper	N<51	28.2	37	6.25	451.2	0
3204	0	1	Unknown	Obsid.	N<51	1.2	7	6.25	19.2	0
3204	0	1	Unknown	Basalt	N<51	0.7	2	6.25	11.2	0
3204	0	1	Unknown	Other	N<51	28.2	6	6.25	451.2	0
**** Western Periphery**										
3082	0	2	Red. locus	Opalite	N<51	17.9	4	3.75	477.3	0
3084	0	1	Quarry fea	Opalite	N<51	34.2	32	0.68	5029.4	4
3084	0	1	Unknown	Jasper	Core Red	758.3	120	0.68	111514.7	84
3084	0	2	Unknown	Opalite	N<51	245.5	23	2.08	11802.9	9
3084	0	2	Unknown	Jasper	Core Red	1667.3	124	2.08	80158.7	60
3090	0		Nonfeat.	Opalite	Core Red	612.4	95	0.00	612.4	0
3090	0		Nonfeat.	Jasper	N<51	2.8	2	0.00	2.8	0
3092	0		Nonfeat.	Opalite	ESB	142812.1	92356	0.00	142812.1	107
3092	0		Nonfeat.	Jasper	ESB	11657.3	5922	0.00	11657.3	9
3092	0		Nonfeat.	Obsid.	Mixed Bif	61.0	69	0.00	61.0	0
3092	0		Nonfeat.	Basalt	Core Red	2153.8	346	0.00	2153.8	2
3092	0		Nonfeat.	Other	Mixed Bif	62.2	58	0.00	62.2	0
3092	0	6	Quarry fea	Opalite	ESB	749.5	202	0.00	749.5	1
3092	0	6	Unknown	Jasper	N<51	21.5	10	0.00	21.5	0
3092	0	7	Unknown	Opalite	Core Red	4019.1	880	0.00	4019.1	3
3092	0	7	Unknown	Jasper	N<51	188.3	42	0.00	188.3	0
3092	0	7	Red. locus	Basalt	N<51	288.9	4	0.00	288.9	0
3092	0	9	Other	Opalite	ESB	107.7	65	0.00	107.7	0
3092	0	9	Unknown	Jasper	N<51	0.7	2	0.00	0.7	0
3092	0	9	Unknown	Basalt	N<51	1.8	1	0.00	1.8	0
3092	0	12	Other	Opalite	ESB	2136.0	56	0.00	2136.0	2
3092	0	12	Unknown	Jasper	NoG3	428.4	8	0.00	428.4	0
3092	0	12	Unknown	Basalt	NoG3	65.2	1	0.00	65.2	0
3092	0	13	Red. locus	Opalite	Mixed Bif	2398.5	61	0.00	2398.5	2
3092	0	13	Unknown	Jasper	N<51	446.9	19	0.00	446.9	0
3092	0	13	Unknown	Basalt	NoG3	42.1	1	0.00	42.1	0
3092	0	13	Unknown	Other	NoG3	26.1	1	0.00	26.1	0
3092	0	14	Red. locus	Opalite	ESB	3001.9	2067	0.00	3001.9	2
3092	0	14	Unknown	Jasper	ESB	366.1	238	0.00	366.1	0
3092	0	14	Unknown	Basalt	N<51	1.3	5	0.00	1.3	0
3092	0	15	Red. locus	Opalite	ESB	124.5	84	0.00	124.5	0
3092	0	15	Unknown	Jasper	N<51	127.2	50	0.00	127.2	0
3092	0	16	Unknown	Opalite	Mixed Bif	96.9	102	0.00	96.9	0
3092	0	16	Unknown	Jasper	N<51	0.6	2	0.00	0.6	0
3092	0	17	Unknown	Opalite	N<51	22.3	31	0.00	22.3	0
3092	0	17	Unknown	Jasper	N<51	2.1	2	0.00	2.1	0
3092	0	18	Unknown	Opalite	N<51	197.4	35	0.00	197.4	0
3092	0	18	Unknown	Jasper	N<51	0.6	1	0.00	0.6	0
3092	0	20	Unknown	Opalite	ESB	194.7	105	0.00	194.7	0
3092	0	20	Other	Jasper	N<51	5.2	6	0.00	5.2	0
3092	0	21	Red. locus	Opalite	ESB	1203.8	802	0.00	1203.8	1
3092	0	21	Unknown	Jasper	N<51	58.8	41	0.00	58.8	0
3092	0	21	Unknown	Basalt	NoG3	9.6	1	0.00	9.6	0
3092	0	23	Red. locus	Opalite	ESB	2410.9	1249	0.00	2410.9	2

Table 2, continued.

Site (26Ek)	Locus	Fea. No.	Type	Material	Character-ization	Total sample wt.	n	% Fea. Sample	Est. Total Weight	Stage 3
3092	0	23	Unknown	Jasper	ESB	160.1	110	0.00	160.1	0
3092	0	23	Unknown	Obsid.	N<51	0.7	2	0.00	0.7	0
3092	0	23	Unknown	Basalt	N<51	22.3	10	0.00	22.3	0
3092	0	24	Quarry fea	Opalite	ESB	202.5	94	0.00	202.5	0
3092	0	24	Unknown	Jasper	N<51	0.3	2	0.00	0.3	0
3092	0	24	Unknown	Basalt	N<51	0.4	2	0.00	0.4	0
3093	0	4	Unknown	Opalite	ESB	2911.3	2532	100.00	2911.3	2
3093	0	4	Unknown	Jasper	N<51	1.8	1	100.00	1.8	0
3093	0	4	Unknown	Obsid.	N<51	9.1	18	100.00	9.1	0
3095	0	6	Red. locus	Opalite	ESB	4533.8	3977	0.00	4533.8	3
3095	0	6	Unknown	Obsid.	N<51	0.8	2	0.00	0.8	0
3095	0	10	Unknown	Opalite	ESB	8717.6	5231	0.38	2294105.3	1725
3095	0	10	Unknown	Jasper	N<51	0.3	1	0.38	78.9	0
3095	0	10	Unknown	Obsid.	N<51	8.5	7	0.38	2236.8	2
3095	0	10	Unknown	Other	NoG3	3.6	1	0.38	947.4	1
3095	0	15	Unknown		N<51	5.5	6	25.00	22.0	0
3095	0	15	Unknown	Opalite	Mixed Bif	7673.1	7119	25.00	30692.4	23
3095	0	15	Unknown	Obsid.	N<51	9.1	14	25.00	36.4	0
3095	0	15	Unknown	Basalt	NoG3	0.0	0	25.00	0.0	0
3095	0	15	Unknown	Other	N<51	0.2	1	25.00	0.8	0
3095	0	19	Unknown	Opalite	ESB	18218.8	15057	8.75	208214.9	157
3095	0	19	Unknown	Jasper	N<51	21.3	17	8.75	243.4	0
3095	0	19	Unknown	Obsid.	N<51	17.9	18	8.75	204.6	0
3095	0	19	Unknown	Basalt	N<51	112.9	34	8.75	1290.3	1
3095	0	22	Unknown	Opalite	Mixed Bif	17364.3	15716	40.00	43410.8	33
3095	0	22	Unknown	Jasper	N<51	36.6	38	40.00	91.5	0
3095	0	22	Unknown	Obsid.	Mixed Bif	41.9	64	40.00	104.8	0
3095	0	22	Unknown	Basalt	N<51	0.4	1	40.00	1.0	0
3095	0	24	Other	Opalite	Mixed Bif	18420.4	18186	33.33	55266.7	42
3095	0	24	Unknown	Jasper	Mixed Bif	114.2	198	33.33	342.6	0
3095	0	24	Unknown	Obsid.	N<51	14.9	33	33.33	44.7	0
3096	0	1	Red. locus	Opalite	ESB	996.9	790	100.00	996.9	1
3100	0	1	Red. locus	Opalite	Core Red	2883.3	845	100.00	2883.3	2
3101	0		Nonfeat.	Opalite	ESB	1709.8	925	0.03	5699333.3	4285
3101	1		Nonfeat.	Jasper	N<51	34.5	27	0.03	115000.0	86
3101	1		Nonfeat.	Obsid.	NoG3	0.0	0	0.03	0.0	0
3102	0	1	Unknown	Opalite	Core Red	6669.8	1364	100.00	6669.8	5
3102	0	1	Red. locus	Jasper	N<51	7.2	5	100.00	7.2	0
3104	0		Nonfeat.	Opalite	Core Red	3807.4	541	0.00	3807.4	3
3106	0	1	Red. locus	Opalite	ESB	14139.3	4430	37.50	37704.8	28
3106	0	1	Unknown	Basalt	NoG3	1.6	1	37.50	4.3	0
3106	0	4	Unknown	Opalite	ESB	11206.8	6269	100.00	11206.8	8
3106	0	4	Other	Jasper	N<51	11.3	13	100.00	11.3	0
3106	0	4	Unknown	Obsid.	N<51	6.7	7	100.00	6.7	0
3106	0	4	Unknown	Basalt	N<51	26.2	10	100.00	26.2	0
3106	0	4	Unknown	Other	NoG3	43.3	2	100.00	43.3	0
3106	0	700	Unknown	Opalite	ESB	890.0	241	999.99	890.0	1
3106	0	700	Unknown	Jasper	N<51	1.4	2	999.99	1.4	0
3106	0	700	Unknown	Basalt	NoG3	1.1	1	999.99	1.1	0
3107	0		Nonfeat.	Opalite	ESB	100.5	53	0.00	100.5	0
3107	0		Nonfeat.	Jasper	ESB	131.9	54	0.00	131.9	0
3107	0	1	Red. locus	Opalite	Core Red	4582.9	1393	100.00	4582.9	3
3107	0	1	Unknown	Jasper	N<51	1.1	4	100.00	1.1	0

Table 2, continued.

Site (26Ek)	Locus	Fea. No.	Type	Material	Character-ization	Total sample wt.	n	% Fea. Sample	Est. Total Weight	Stage 3
3114	0	1	Red. locus	Opalite	ESB	5024.9	3772	90.91	5527.3	4
3115	0	1	Red. locus	Opalite	Mixed Bif	1886.8	1785	62.50	3018.9	2
3115	0	1	Unknown	Obsid.	N<51	0.1	1	62.50	0.2	0
3115	0	1	Unknown	Basalt	N<51	0.8	1	62.50	1.3	0
3116	0	1	Red. locus	Opalite	ESB	3495.1	2377	100.00	3495.1	3
3116	0	1	Unknown	Basalt	N<51	0.4	1	100.00	0.4	0
3116	0	1	Unknown	Other	N<51	1.4	4	100.00	1.4	0
3149	0		Nonfeat.	Opalite	ESB	286.1	86	0.00	286.1	0
3149	0		Nonfeat.	Jasper	N<51	25.9	31	0.00	25.9	0
3149	0	2	Other	Opalite	Mixed Bif	244.1	274	100.00	244.1	0
3149	0	2	Unknown	Jasper	N<51	0.6	1	100.00	0.6	0
3149	0	2	Unknown	Obsid.	N<51	0.7	1	100.00	0.7	0
3160	A		Nonfeat.	Opalite E	B	9524.5	7715	0.00	9524.5	7
3160	A		Nonfeat.	Jasper	Mixed Bif	157.3	145	0.00	157.3	0
3160	A		Nonfeat.	Obsid.	N<51	1.1	4	0.00	1.1	0
3160	C		Nonfeat.	Basalt	N<51	15.0	17	0.00	15.0	0
3160	C	1	Unknown	Opalite	ESB	27048.7	19384	43.00	62904.0	47
3160	C	1	Unknown	Jasper	N<51	16.8	46	43.00	39.1	0
3160	C	1	Unknown	Obsid.	ESB	72.1	55	43.00	167.7	0
3160	C	1	Unknown	Basalt	N<51	551.6	32	43.00	1282.8	1
3160	C	1	Unknown	Other	N<51	10.3	6	43.00	24.0	0
3160	C	2	Red. locus	Opalite	Mixed Bif	843.1	1150	85.11	990.6	1
3160	C	3	Red. locus	Opalite	ESB	4621.1	2247	100.00	4621.1	3
3160	C	3	Unknown	Jasper	N<51	1.5	3	100.00	1.5	0
3160	C	11	Red. locus	Opalite	Core Red	3869.4	1238	0.00	3869.4	3
3160	C	11	Unknown	Jasper	NoG3	6.6	2	0.00	6.6	0
3160	C	11	Unknown	Basalt	N<51	14.6	4	0.00	14.6	0
3160	C	11	Unknown	Other	N<51	10.9	3	0.00	10.9	0
3160	C	12	Red. locus	Opalite	ESB	4177.9	3340	12.86	32487.6	24
3160	C	12	Unknown	Jasper	N<51	67.7	46	12.86	526.4	0
3160	C	12	Unknown	Obsid.	N<51	0.3	2	12.86	2.3	0
3160	C	12	Unknown	Basalt	N<51	4.4	2	12.86	34.2	0
3160	C	14	Red. locus	Opalite	Mixed Bif	2271.4	2841	6.30	36054.0	27
3160	C	14	Unknown	Jasper	N<51	2.0	7	6.30	31.7	0
3160	C	14	Unknown	Obsid.	N<51	4.6	16	6.30	73.0	0
3160	A	17	Red. locus	Opalite	Mixed Bif	1816.5	2411	2.72	66783.1	50
3160	A	17	Unknown	Jasper	N<51	2.6	27	2.72	95.6	0
3160	B	20	Unknown	Opalite	Mixed Bif	1055.1	886	2.70	39077.8	29
3160	B	20	Unknown	Jasper	N<51	7.8	7	2.70	288.9	0
3160	A	23	Unknown	Opalite	ESB	4540.1	3945	100.00	4540.1	3
3160	A	23	Unknown	Jasper	N<51	47.2	38	100.00	47.2	0
3160	A	23	Unknown	Basalt	N<51	0.5	2	100.00	0.5	0
3160	A	24	Other	Opalite	ESB	1131.9	475	0.00	1131.9	1
3160	A	24	Unknown	Jasper	N<51	11.8	9	0.00	11.8	0
3160	C	25	Other	Opalite	Core Red	607.0	110	0.00	607.0	0
3165	0		Nonfeat.	Opalite	ESB	4892.8	3745	0.00	4892.8	4
3165	A		Nonfeat.	Jasper	N<51	56.9	50	0.00	56.9	0
3165	A		Nonfeat.	Obsid.	N<51	3.5	11	0.00	3.5	0
3165	A		Nonfeat.	Basalt	N<51	20.0	8	0.00	20.0	0
3165	0	1	Other	Opalite	Mixed Bif	1561.7	1710	80.00	1952.1	1
3165	0	2	Unknown	Opalite	ESB	9763.7	6971	100.00	9763.7	7
3165	0	2	Other	Jasper	N<51	24.7	14	100.00	24.7	0
3165	0	2	Unknown	Basalt	N<51	0.2	1	100.00	0.2	0
3207	0		Nonfeat.	Opalite	NoG3	184.5	7	0.05	369000.0	277
3271	A		Nonfeat.	Opalite	ESB	2566.0	1626	0.00	2566.0	2
3271	A		Nonfeat.	Jasper	N<51	40.8	39	0.00	40.8	0
3271	A		Nonfeat.	Obsid.	N<51	5.5	8	0.00	5.5	0

Table 2, continued.

Site (26Ek)	Locus	Fea. No.	Type	Material	Character-ization	Total sample wt.	n	% Fea. Sample	Est. Total Weight	Stage 3
3271	A		Nonfeat.	Basalt	N<51	20.6	8	0.00	20.6	0
3271	C	2	Unknown	Opalite	ESB	1542.2	1214	100.00	1542.2	1
3271	C	2	Red. locus	Obsid.	N<51	2.4	4	100.00	2.4	0
3271	B	12	Unknown	Opalite	ESB	50019.3	36214	100.00	50019.3	38
3271	B	12	Unknown	Jasper	NoG3	6.9	2	100.00	6.9	0
3271	B	12	Unknown	Obsid.	N<51	23.3	32	100.00	23.3	0
3271	B	12	Unknown	Basalt	Core Red	3267.5	214	100.00	3267.5	2
3271	B	12	Unknown	Other	N<51	3.4	2	100.00	3.4	0
3271	B	18	Other	Opalite	Mixed Bif	2153.8	2874	40.00	5384.5	4
3271	B	18	Unknown	Jasper	N<51	12.5	9	40.00	31.3	0
3271	B	18	Unknown	Obsid.	NoG3	2.1	1	40.00	5.3	0
3271	A	19	Unknown	Opalite	ESB	856.8	582	0.00	856.8	1
3271	A	19	Unknown	Jasper	N<51	2.7	4	0.00	2.7	0
3271	A	19	Unknown	Obsid.	NoG3	0.0	0	0.00	0.0	0
3271	A	19	Red. locus	Basalt	N<51	9.0	10	0.00	9.0	0
3271	A	21	Unknown	Opalite	ESB	6441.2	4563	83.33	7729.7	6
3271	A	21	Unknown	Jasper	N<51	0.2	1	83.33	0.2	0
3271	A	21	Red. locus	Obsid.	N<51	2.5	4	83.33	3.0	0
3271	A	21	Unknown	Basalt	N<51	4.9	6	83.33	5.9	0
3271	A	21	Unknown	Other	N<51	8.7	4	83.33	10.4	0
**** 26EK3032 Localities**										
Loc.19	0	1	Quarry fea	Opalite	Core Red	73009.6	14665	3.14	2325146.5	1748
Loc.19	0	1	Unknown	Jasper	N<51	7.5	7	3.14	238.9	0
Loc.19	0	1	Unknown	Other	N<51	0.7	1	3.14	22.3	0
Loc.20	0	1	Red. locus	Opalite	ESB	21172.6	5752	57.14	37053.9	28
Loc.20	0	1	Unknown	Jasper	N<51	1.4	1	57.14	2.5	0
Loc.20	0	1	Unknown	Other	ESB	286.6	168	57.14	501.6	0
Loc.20	0	2	Red. locus	Opalite	Core Red	4306.7	1023	40.00	10766.8	8
Loc.20	0	3	Red. locus	Opalite	Core Red	7115.4	1858	7.69	92528.0	70
Loc.20	0	3	Unknown	Jasper	NoG3	8.1	1	7.69	105.3	0
Loc.21	0	1	Red. locus	Opalite	Core Red	39885.1	1793	100.00	39885.1	30
Loc.21	0	1	Unknown	Other	NoG3	11.4	1	100.00	11.4	0
Loc.22	0	1	Red. locus	Opalite	Core Red	13681.1	2066	66.67	20520.6	15
Loc.22	0	1	Unknown	Jasper	N<51	0.5	1	66.67	0.7	0
Loc.23	0	1	Unknown	Opalite	Core Red	75726.8	12828	10.00	757268.0	569
Loc.23	0	1	Red. locus	Obsid.	N<51	8.8	5	10.00	88.0	0
Loc.25	0	2	Red. locus	Opalite	ESB	57984.3	20678	100.00	57984.3	44
Loc.25	0	2	Unknown	Basalt	N<51	63.1	9	100.00	63.1	0
Loc.25	0	2	Unknown	Other	N<51	20.3	8	100.00	20.3	0
Loc.25	0	5	Red. locus	Opalite	Core Red	22966.7	2637	17.39	132068.4	99
Loc.25	0	5	Unknown	Other	N<51	12.9	3	17.39	74.2	0
Loc.98	0	1	Quarry fea	Opalite	Core Red	12250.6	1286	1.11	1103657.7	830
Loc.98	0	1	Unknown	Other	NoG3	52.7	1	1.11	4747.7	4

Feature Type:
- Red. locus = reduction locus/lithic scatter
- Quarry fea = quarry pit, bedrock outcrop quarry, cobble quarry
- Unknown = various, not recorded in field data
- Other = hearth, living surface, presumed non-reduction features
- Nonfeat. = non-feature context (general site or locality area)

Characterizations:
- Core Red = Core reduction
- ESB = Early biface, Stage 1 to Stage 3.5
- LSB = Late biface, Stage 3.5+
- EdgeMain = Edge maintenance and resharpening
- NoG3 = not classified, no G3 size grade items
- Mixed Bif = Mixed biface, Stage 1 to Stage 4+
- N<51 = not classified, n<51

Table 3. Mass Analysis Debitage Sample Characterizations of Feature Strata.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
Site 26Ek3032, Locality 23								
1	1	1	2599	74	Opalite	Core Red	595	1243.4
1	1	1	2599	080	Opalite	Core Red	1063	1379.4
1	1	1	2599	086	Opalite	Core Red	954	1724.7
1	1	8	2599	073	Opalite	ESB	888	848.0
1	1	1	2599	078	Opalite	ESB	1684	1876.4
1	1	1	2599	102	Opalite	Core Red	646	2077.4
1	1	1	2599	103	Opalite	Core Red	727	751.1
1	1	2	2599	085	Opalite	Core Red	1679	1115.0
1	1	2	2599	083	Opalite	Core Red	357	609.3
1	1	2	2599	101	Opalite	ESB	645	851.2
1	1	2	2599	082	Opalite	Core Red	253	2333.0
1	1	3	2599	079	Opalite	ESB	1049	508.1
1	1	3	2599	092	Opalite	Core Red	1494	1632.2
1	1	3	2599	087	Opalite	Core Red	276	1399.1
1	1	3	2599	094	Opalite	Core Red	1317	1705.6
1	1	3	2599	088	Opalite	Core Red	910	1043.1
1	1	3	2599	095	Opalite	Core Red	785	2890.3
1	1	4	2599	090	Opalite	ESB	2215	2822.3
1	1	4	2599	089	Opalite	Core Red	3710	2083.1
1	1	1	2599	102	Other	NoG3	2	0.5
1	1	1	2599	103	Other	NoG3	2	0.1
1	1	2	2599	085	Other	NoG3	5	5.5
1	1	2	2599	083	Other	NoG3	1	0.0
1	1	3	2599	087	Other	NoG3	1	0.0
** 26Ek3084								
1	2	1	2599	910	Opalite	NoG3	1	665.1
1	2	1	2599	920	Opalite	NoG3	5	8.6
1	2	6	2599	917	Jasper	Core Red	91	3356.6
1	2	1	2599	915	Jasper	Core Red	137	1032.1
1	2	1	2599	905	Jasper	Core Red	325	1573.7
1	2	1	2599	920	Jasper	Core Red	1264	3457.5
1	2	1	2599	914	Jasper	Core Red	785	1035.8
1	2	2	2599	904	Jasper	Core Red	921	3598.6
1	2	2	2599	903	Jasper	Core Red	1964	2261.1
1	2	3	2599	900	Jasper	NoG3	2068	799.8
1	2	3	2599	921	Jasper	Core Red	610	3414.1
1	2	3	2599	922	Jasper	NoG3	1	82.7
1	2	6	2599	916	Basalt	NoG3	1	1595.3
1	2	3	2599	921	Basalt	NoG3	4	65.1
** 26Ek3170								
1	1	1	2599	100	Opalite	Core Red	761	1347.1
1	1	2	2599	098	Opalite	Core Red	1193	1953.5
1	1	2	2599	107	Opalite	Mixed Bif	424	109.9
1	1	2	2599	108	Opalite	Core Red	880	2007.0
1	1	2	2599	110	Opalite	Core Red	1289	3611.5
1	1	3	2599	099	Opalite	Core Red	644	1796.3
1	1	3	2599	109	Opalite	Core Red	354	2613.6
1	1	3	2599	112	Opalite	Core Red	950	1327.0
1	1	7	2599	111	Opalite	Core Red	79	335.0
1	1	1	2599	100	Jasper	N<51	7	4.9

Table 3, continued.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
1	1	2	2599	110	Jasper	NoG3	2	0.3
1	1	3	2599	099	Jasper	NoG3	15	1.1
1	1	1	2599	100	Basalt	NoG3	2	0.1
1	1	2	2599	110	Basalt	NoG3	1	0.1
**** 26Ek3171**								
2	1	2	2599	113	Opalite	Core Red	253	2907.4
2	1	2	2599	115	Opalite	Core Red	671	2250.2
2	1	2	2599	117	Opalite	Core Red	107	114.0
2	1	2	2599	118	Opalite	ESB	548	363.7
2	1	2	2599	121	Opalite	Core Red	290	639.8
2	1	3	2599	114	Opalite	N<51	20	2.1
2	1	5	2599	125	Opalite	ESB	173	96.5
2	1	7	2599	119	Opalite	Core Red	244	1742.2
2	1	8	2599	116	Opalite	Core Red	381	1236.0
2	1	9	2599	126	Opalite	ESB	259	115.3
2	1	1	2599	124	Opalite	Core Red	51	24.8
2	1	1	2599	122	Opalite	Core Red	2249	953.7
2	1	1	2599	123	Opalite	Core Red	146	195.6
2	1	1	2599	120	Opalite	ESB	143	175.7
2	1	2	2599	113	Obsidian	NoG3	1	0.1
2	1	1	2599	123	Other	NoG3	1	11.6
**** 26Ek3195**								
2	1	1	2599	505	Opalite	N<51	28	5.6
2	1	2	2599	506	Opalite	ESB	632	300.3
2	1	3	2599	507	Opalite	Core Red	291	632.6
2	1	4	2599	508	Opalite	ESB	346	181.5
2	1	6	2599	509	Opalite	Mixed Bif	1019	300.9
2	1	7	2599	510	Opalite	Core Red	354	558.2
2	1	8	2599	511	Opalite	Core Red	1329	1191.8
2	1	9	2599	512	Opalite	ESB	1543	441.1
2	1	1	2599	513	Opalite	ESB	3938	832.6
2	1	1	2599	514	Opalite	Core Red	817	2861.9
2	1	1	2599	515	Opalite	Core Red	1506	1431.7
2	1	1	2599	516	Opalite	ESB	1142	593.9
2	1	1	2599	518	Opalite	ESB	3215	1029.9
2	1	1	2599	517	Opalite	ESB	5170	2021.0
2	2	1	2599	521	Opalite	ESB	2256	1307.1
2	1	2	2599	519	Opalite	Mixed Bif	946	185.9
2	2	2	2599	520	Opalite	Core Red	1661	2491.5
2	2	2	2599	525	Opalite	ESB	1422	391.0
2	2	2	2599	526	Opalite	Core Red	3152	1365.7
2	2	2	2599	522	Opalite	Core Red	459	2090.5
2	2	3	2599	527	Opalite	Core Red	1373	3490.9
2	2	3	2599	524	Opalite	Core Red	1770	2725.9
2	2	3	2599	523	Opalite	ESB	843	637.4
2	2	3	2599	533	Opalite	Core Red	852	1539.5
2	2	3	2599	532	Opalite	Mixed Bif	1706	439.8
2	2	4	2599	531	Opalite	Core Red	410	1951.5
2	2	4	2599	530	Opalite	ESB	442	256.2
2	2	4	2599	528	Opalite	ESB	1828	2027.6
2	2	4	2599	529	Opalite	Core Red	1067	1017.4
2	2	4	2599	534	Opalite	ESB	755	931.5
2	1	2	2599	506	Other	NoG3	1	8.0
2	1	1	2599	513	Other	ESB	232	55.3

Table 3, continued.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
2	1	1	2599	515	Other	N<51	1	0.5
2	1	1	2599	518	Other	NoG3	7	3.2
2	1	1	2599	517	Other	NoG3	11	2.1
2	2	1	2599	521	Other	N<51	24	4.5
2	2	2	2599	520	Other	N<51	4	1.3
2	2	2	2599	525	Other	N<51	4	1.5
2	2	2	2599	526	Other	EdgeMain	90	12.0
2	2	3	2599	524	Other	N<51	1	0.4
2	2	3	2599	533	Other	NoG3	1	74.8
2	2	4	2599	528	Other	N<51	6	32.9
2	2	4	2599	529	Other	N<51	4	1.6
4	1	1	2599	504	Opalite	Core Red	357	1706.7
4	1	2	2599	502	Opalite	ESB	337	224.7
4	1	3	2599	503	Opalite	Core Red	248	664.3
4	1	4	2599	501	Opalite	Core Red	335	319.6
4	1	5	2599	500	Opalite	ESB	294	238.5
**** 26Ek3208**								
3	1	u	2599	157	Opalite	Core Red	2581	2597.4
3	1	u	2599	158	Opalite	Core Red	1001	3303.3
3	1	u	2599	173	Opalite	Core Red	3798	5958.5
3	2	1	2599	039	Opalite	ESB	1619	1738.9
3	2	2	2599	040	Opalite	Core Red	852	2178.9
3	2	3	2599	056	Opalite	ESB	1045	1321.2
3	1	3	2599	199	Opalite	Core Red	2915	1712.1
3	3	3	2599	204	Opalite	Core Red	999	2078.8
3	2	4	2599	057	Opalite	ESB	2967	1982.8
3	2	4	2599	149	Opalite	Core Red	1549	3530.4
3	1	4	2599	192	Opalite	Core Red	1759	3382.2
3	1	4	2599	200	Opalite	Core Red	2114	2023.6
3	3	4	2599	233	Opalite	Core Red	648	3103.7
3	2	5	2599	058	Opalite	Core Red	995	2241.7
3	3	5	2599	203	Opalite	Core Red	1568	1322.0
3	2	6	2599	041	Opalite	Core Red	2261	2056.0
3	3	6	2599	202	Opalite	Core Red	815	1690.0
3	2	7	2599	042	Opalite	Core Red	1868	1593.1
3	3	7	2599	201	Opalite	NoG3	8	65.1
3	2	8	2599	043	Opalite	Core Red	3508	2152.6
3	3	9	2599	230	Opalite	Core Red	599	2267.3
3	2	1	2599	045	Opalite	Core Red	844	3515.9
3	2	1	2599	046	Opalite	Core Red	1238	2852.0
3	3	1	2599	228	Opalite	Core Red	837	1980.4
3	2	1	2599	059	Opalite	Core Red	2155	2201.6
3	1	1	2599	188	Opalite	Core Red	2507	3067.3
3	3	1	2599	227	Opalite	Core Red	2486	1943.9
3	2	1	2599	060	Opalite	Core Red	1140	1950.5
3	3	1	2599	226	Opalite	Core Red	785	1924.1
3	2	1	2599	061	Opalite	ESB	2323	1411.5
3	3	1	2599	210	Opalite	Core Red	2117	2382.9
3	3	1	2599	215	Opalite	Core Red	905	2234.9
3	3	1	2599	225	Opalite	Core Red	2093	2941.3
3	2	1	2599	044	Opalite	Core Red	1531	2339.8
3	3	1	2599	224	Opalite	ESB	3737	1567.7
3	3	1	2599	223	Opalite	Core Red	592	468.7
3	2	1	2599	047	Opalite	Core Red	519	2884.1
3	3	1	2599	205	Opalite	Core Red	2692	1270.8

Table 3, continued.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
3	2	1	2599	048	Opalite	ESB	2372	917.1
3	1	1	2599	216	Opalite	Core Red	2732	4907.1
3	3	1	2599	221	Opalite	Core Red	985	2401.7
3	2	1	2599	050	Opalite	Core Red	3031	2096.6
3	2	2	2599	049	Opalite	Core Red	2932	2203.3
3	2	2	2599	051	Opalite	Core Red	228	1413.4
3	1	2	2599	174	Opalite	Core Red	1007	2966.2
3	1	2	2599	175	Opalite	Core Red	1015	3395.2
3	1	2	2599	156	Opalite	Core Red	604	1756.8
3	2	2	2599	064	Opalite	Core Red	1623	3704.9
3	1	2	2599	155	Opalite	Core Red	251	1160.0
3	1	2	2599	163	Opalite	Core Red	1774	1631.9
3	1	2	2599	165	Opalite	Core Red	1585	4455.6
3	2	2	2599	063	Opalite	Core Red	1410	2583.4
3	2	2	2599	062	Opalite	Core Red	1126	1006.6
3	1	2	2599	164	Opalite	Core Red	2075	3615.0
3	1	2	2599	171	Opalite	Core Red	769	2262.5
3	1	2	2599	168	Opalite	Core Red	2809	2975.9
3	1	2	2599	167	Opalite	Core Red	2739	2789.1
3	1	2	2599	189	Opalite	Core Red	1055	2326.3
3	2	3	2599	053	Opalite	Core Red	1493	1528.5
3	1	3	2599	166	Opalite	Core Red	2587	2542.5
3	2	3	2599	055	Opalite	Core Red	3805	3173.8
3	1	3	2599	169	Opalite	Core Red	1413	5438.3
3	1	3	2599	191	Opalite	Core Red	959	963.6
3	1	3	2599	190	Opalite	Core Red	1562	1570.3
3	2	3	2599	052	Opalite	Core Red	4321	1729.5
3	1	3	2599	170	Opalite	Core Red	961	1631.1
3	2	3	2599	054	Opalite	Core Red	1227	1140.4
3	2	3	2599	142	Opalite	Core Red	650	828.6
3	1	3	2599	159	Opalite	Core Red	2555	2503.6
3	3	3	2599	212	Opalite	Core Red	1684	3087.5
3	1	3	2599	162	Opalite	Core Red	2520	2759.4
3	3	3	2599	211	Opalite	Core Red	1317	3334.8
3	3	3	2599	214	Opalite	Core Red	537	3488.2
3	1	3	2599	161	Opalite	Core Red	1655	2262.2
3	3	3	2599	213	Opalite	Core Red	1368	2036.0
3	2	3	2599	148	Opalite	Core Red	2568	1910.2
3	1	3	2599	160	Opalite	Core Red	916	1784.1
3	3	3	2599	209	Opalite	Core Red	1294	1804.5
3	2	3	2599	068	Opalite	Core Red	1114	2091.7
3	1	3	2599	172	Opalite	Core Red	571	1317.0
3	3	3	2599	207	Opalite	Core Red	658	1626.1
3	2	4	2599	147	Opalite	Core Red	502	2625.9
3	1	4	2599	176	Opalite	Core Red	1685	3112.3
3	2	4	2599	150	Opalite	Core Red	806	1573.3
3	1	4	2599	193	Opalite	Core Red	334	2473.1
3	3	4	2599	206	Opalite	ESB	1624	939.4
3	2	4	2599	067	Opalite	Core Red	968	1427.7
3	2	4	2599	146	Opalite	Core Red	1734	1607.0
3	1	4	2599	194	Opalite	Core Red	1531	2286.4
3	3	4	2599	263	Opalite	Core Red	1441	1709.9
3	2	4	2599	145	Opalite	Core Red	1249	2065.6
3	1	4	2599	198	Opalite	Core Red	344	705.7
3	3	4	2599	260	Opalite	Core Red	422	2556.3
3	3	4	2599	261	Opalite	Core Red	1388	1926.5
3	2	4	2599	144	Opalite	Core Red	740	2092.8
3	1	4	2599	186	Opalite	Core Red	1511	1657.9

Table 3, continued.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
3	2	4	2599	066	Opalite	Core Red	1139	1420.4
3	2	4	2599	143	Opalite	Core Red	2076	2875.6
3	1	4	2599	185	Opalite	Mixed Bif	495	129.8
3	2	4	2599	065	Opalite	Core Red	727	514.6
3	1	4	2599	178	Opalite	Core Red	1138	1772.8
3	1	4	2599	184	Opalite	Core Red	1361	1251.2
3	1	4	2599	187	Opalite	ESB	4411	1830.4
3	1	5	2599	177	Opalite	Core Red	1485	2135.7
3	1	5	2599	183	Opalite	ESB	2945	1834.6
3	1	5	2599	182	Opalite	Core Red	1222	1268.6
3	1	5	2599	181	Opalite	Core Red	1763	2173.9
3	1	5	2599	180	Opalite	ESB	366	224.8
3	1	5	2599	179	Opalite	Core Red	524	418.0
3	1	5	2599	152	Opalite	Core Red	1117	1777.0
3	1	5	2599	154	Opalite	Core Red	705	740.1
3	1	5	2599	151	Opalite	Core Red	1042	1799.8
3	1	5	2599	153	Opalite	Core Red	772	2451.1
3	2	3	2599	056	Jasper	NoG3	1	0.1
3	1	3	2599	199	Jasper	NoG3	3	0.1
3	2	4	2599	057	Jasper	NoG3	1	0.2
3	2	5	2599	058	Jasper	NoG3	3	0.6
3	3	1	2599	224	Jasper	NoG3	3	0.6
3	2	2	2599	064	Jasper	NoG3	1	0.1
3	3	3	2599	213	Jasper	NoG3	1	0.1
3	2	3	2599	148	Jasper	NoG3	2	0.2
3	2	4	2599	147	Jasper	NoG3	1	0.1
3	2	4	2599	067	Jasper	NoG3	1	0.1
3	2	4	2599	066	Jasper	NoG3	2	1.4
3	2	4	2599	143	Jasper	NoG3	1	0.1
3	1	u	2599	157	Basalt	NoG3	6	33.5
3	2	2	2599	040	Basalt	NoG3	4	5.3
3	2	3	2599	056	Basalt	NoG3	15	26.0
3	1	3	2599	199	Basalt	NoG3	19	11.8
3	3	3	2599	204	Basalt	NoG3	4	6.9
3	2	4	2599	057	Basalt	NoG3	21	2.2
3	2	4	2599	149	Basalt	NoG3	15	50.9
3	3	4	2599	233	Basalt	NoG3	1	0.2
3	2	5	2599	058	Basalt	NoG3	5	2.3
3	3	5	2599	203	Basalt	NoG3	14	1.9
3	2	6	2599	041	Basalt	NoG3	16	74.1
3	3	6	2599	202	Basalt	NoG3	4	0.7
3	2	7	2599	042	Basalt	NoG3	16	4.5
3	2	8	2599	043	Basalt	NoG3	38	43.4
3	3	9	2599	230	Basalt	NoG3	4	0.5
3	2	1	2599	046	Basalt	NoG3	5	0.7
3	3	1	2599	228	Basalt	NoG3	1	0.4
3	2	1	2599	059	Basalt	NoG3	7	34.3
3	1	1	2599	188	Basalt	NoG3	9	2.5
3	3	1	2599	227	Basalt	NoG3	15	3.2
3	2	1	2599	061	Basalt	NoG3	19	1.8
3	3	1	2599	210	Basalt	NoG3	19	40.0
3	3	1	2599	215	Basalt	NoG3	10	2.9
3	3	1	2599	225	Basalt	NoG3	21	2.9
3	2	1	2599	044	Basalt	NoG3	10	4.5
3	3	1	2599	224	Basalt	NoG3	15	2.1
3	3	1	2599	223	Basalt	NoG3	5	2.7
3	2	1	2599	047	Basalt	NoG3	2	0.3
3	3	1	2599	205	Basalt	NoG3	8	0.9

Table 3, continued.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
3	3	1	2599	221	Basalt	NoG3	4	2.0
3	2	1	2599	050	Basalt	NoG3	19	9.9
3	2	2	2599	049	Basalt	NoG3	31	15.8
3	2	2	2599	051	Basalt	NoG3	15	7.7
3	1	2	2599	174	Basalt	NoG3	7	10.8
3	1	2	2599	175	Basalt	NoG3	6	383.8
3	1	2	2599	155	Basalt	NoG3	1	3.7
3	1	2	2599	163	Basalt	NoG3	14	34.1
3	1	2	2599	165	Basalt	NoG3	11	1.2
3	2	2	2599	063	Basalt	NoG3	29	12.2
3	2	2	2599	062	Basalt	NoG3	17	8.1
3	1	2	2599	164	Basalt	NoG3	11	5.9
3	1	2	2599	171	Basalt	NoG3	1	1.9
3	1	2	2599	168	Basalt	NoG3	16	12.6
3	1	2	2599	167	Basalt	NoG3	27	27.0
3	1	2	2599	189	Basalt	NoG3	4	19.8
3	2	3	2599	053	Basalt	NoG3	4	148.9
3	1	3	2599	166	Basalt	NoG3	25	18.2
3	2	3	2599	055	Basalt	NoG3	8	1.3
3	1	3	2599	190	Basalt	NoG3	6	56.0
3	2	3	2599	052	Basalt	NoG3	1	17.8
3	1	3	2599	170	Basalt	NoG3	5	1.7
3	2	3	2599	054	Basalt	NoG3	7	21.6
3	2	3	2599	142	Basalt	NoG3	4	0.6
3	1	3	2599	159	Basalt	NoG3	34	7.5
3	3	3	2599	212	Basalt	NoG3	13	3.0
3	1	3	2599	162	Basalt	NoG3	21	24.4
3	3	3	2599	211	Basalt	NoG3	13	27.6
3	3	3	2599	214	Basalt	NoG3	3	0.2
3	1	3	2599	161	Basalt	NoG3	10	11.7
3	3	3	2599	213	Basalt	NoG3	13	6.6
3	2	3	2599	148	Basalt	NoG3	37	9.5
3	1	3	2599	160	Basalt	NoG3	4	1.2
3	3	3	2599	209	Basalt	NoG3	16	1.2
3	2	3	2599	068	Basalt	NoG3	16	4.8
3	1	3	2599	172	Basalt	NoG3	2	3.8
3	2	4	2599	147	Basalt	NoG3	3	1.6
3	1	4	2599	176	Basalt	NoG3	9	2.9
3	2	4	2599	150	Basalt	NoG3	6	0.8
3	1	4	2599	193	Basalt	NoG3	1	5.3
3	3	4	2599	206	Basalt	NoG3	44	27.4
3	2	4	2599	146	Basalt	NoG3	22	109.5
3	1	4	2599	194	Basalt	NoG3	8	35.1
3	3	4	2599	263	Basalt	NoG3	5	1.3
3	2	4	2599	145	Basalt	NoG3	26	3.7
3	3	4	2599	260	Basalt	NoG3	2	3.5
3	3	4	2599	261	Basalt	NoG3	3	15.9
3	2	4	2599	144	Basalt	NoG3	6	0.6
3	2	4	2599	066	Basalt	NoG3	10	5.6
3	2	4	2599	143	Basalt	NoG3	15	6.0
3	1	4	2599	184	Basalt	NoG3	12	1.5
3	1	4	2599	187	Basalt	NoG3	15	3.2
3	1	5	2599	177	Basalt	NoG3	1	224.7
3	1	5	2599	183	Basalt	NoG3	10	2.9
3	1	5	2599	182	Basalt	NoG3	12	13.3
3	1	5	2599	181	Basalt	NoG3	5	4.9
3	1	5	2599	180	Basalt	NoG3	2	8.6
3	1	5	2599	154	Basalt	NoG3	2	292.3

Table 3, continued.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
3	1	5	2599	153	Basalt	NoG3	8	68.1
3	1	unk	2599	157	Other	NoG3	23	15.5
3	1	unk	2599	158	Other	NoG3	5	25.7
3	1	unk	2599	173	Other	NoG3	56	125.1
3	2	3	2599	056	Other	NoG3	6	14.4
3	1	3	2599	199	Other	NoG3	29	28.3
3	3	3	2599	204	Other	NoG3	3	0.5
3	2	4	2599	057	Other	NoG3	7	22.6
3	2	4	2599	149	Other	NoG3	7	4.3
3	3	4	2599	233	Other	NoG3	1	0.5
3	2	5	2599	058	Other	NoG3	3	0.5
3	3	5	2599	203	Other	NoG3	7	11.7
3	2	8	2599	043	Other	NoG3	11	6.7
3	3	9	2599	230	Other	NoG3	1	0.1
3	2	1	2599	046	Other	NoG3	5	6.8
3	3	1	2599	228	Other	NoG3	10	45.1
3	2	1	2599	059	Other	NoG3	7	1.3
3	1	1	2599	188	Other	NoG3	32	4.3
3	3	1	2599	227	Other	NoG3	19	56.8
3	3	1	2599	226	Other	NoG3	3	9.2
3	2	1	2599	061	Other	NoG3	15	10.1
3	3	1	2599	215	Other	NoG3	9	31.5
3	3	1	2599	225	Other	NoG3	19	4.0
3	2	1	2599	044	Other	NoG3	20	84.9
3	3	1	2599	224	Other	NoG3	25	7.8
3	3	1	2599	223	Other	NoG3	5	1.2
3	2	1	2599	047	Other	NoG3	1	17.1
3	3	1	2599	205	Other	NoG3	3	0.3
3	2	1	2599	048	Other	NoG3	21	3.4
3	3	1	2599	221	Other	NoG3	25	6.4
3	2	2	2599	049	Other	NoG3	15	8.9
3	2	2	2599	051	Other	NoG3	8	9.1
3	1	2	2599	174	Other	NoG3	13	3.2
3	1	2	2599	175	Other	NoG3	12	52.4
3	1	2	2599	156	Other	NoG3	9	38.4
3	2	2	2599	064	Other	NoG3	14	152.9
3	1	2	2599	155	Other	NoG3	1	1.3
3	1	2	2599	165	Other	NoG3	2	32.6
3	2	2	2599	063	Other	NoG3	19	5.2
3	2	2	2599	062	Other	NoG3	7	11.9
3	1	2	2599	164	Other	NoG3	1	265.4
3	1	2	2599	168	Other	NoG3	51	21.0
3	1	2	2599	167	Other	NoG3	15	126.4
3	1	2	2599	189	Other	NoG3	18	4.9
3	2	3	2599	053	Other	NoG3	15	59.4
3	1	3	2599	166	Other	NoG3	8	3.1
3	2	3	2599	055	Other	NoG3	32	8.7
3	1	3	2599	191	Other	NoG3	7	39.5
3	1	3	2599	190	Other	NoG3	8	16.2
3	2	3	2599	052	Other	NoG3	25	8.8
3	1	3	2599	170	Other	NoG3	16	104.7
3	2	3	2599	054	Other	NoG3	9	20.0
3	2	3	2599	142	Other	NoG3	5	0.8
3	1	3	2599	159	Other	NoG3	24	28.7
3	3	3	2599	212	Other	NoG3	3	28.9
3	1	3	2599	162	Other	NoG3	11	4.4
3	3	3	2599	211	Other	NoG3	10	2.7
3	3	3	2599	214	Other	NoG3	4	2.6

Table 3, continued.

Feature Number	Trench Number	Stratum Number	Reference Number	Specimen Number	Material	Character-ization	Total No.	Weight
3	1	3	2599	161	Other	NoG3	11	7.5
3	3	3	2599	213	Other	NoG3	2	0.2
3	2	3	2599	148	Other	NoG3	20	2.9
3	1	3	2599	160	Other	NoG3	5	1.9
3	3	3	2599	209	Other	NoG3	2	0.2
3	2	3	2599	068	Other	NoG3	4	0.3
3	1	3	2599	172	Other	NoG3	7	8.2
3	2	4	2599	147	Other	NoG3	8	2.5
3	1	4	2599	176	Other	NoG3	3	23.2
3	3	4	2599	206	Other	NoG3	1	29.7
3	2	4	2599	067	Other	NoG3	5	1.2
3	2	4	2599	146	Other	NoG3	5	2.7
3	1	4	2599	194	Other	NoG3	9	22.3
3	2	4	2599	145	Other	NoG3	7	6.6
3	2	4	2599	144	Other	NoG3	5	1.3
3	1	4	2599	186	Other	N<51	11	5.9
3	2	4	2599	066	Other	NoG3	1	33.3
3	2	4	2599	143	Other	NoG3	35	2.6
3	1	4	2599	185	Other	N<51	4	3.7
3	2	4	2599	065	Other	NoG3	3	2.7
3	1	4	2599	184	Other	NoG3	7	1.6
3	1	5	2599	183	Other	NoG3	12	8.3
3	1	5	2599	182	Other	NoG3	5	3.7
3	1	5	2599	181	Other	NoG3	12	16.0
3	1	5	2599	180	Other	NoG3	3	34.0
3	1	5	2599	152	Other	NoG3	3	27.0
3	1	5	2599	154	Other	NoG3	1	0.4

Characterizations:
Core Red = Core reduction
ESB = Early biface, Stage 1 to Stage 3.5
LSB = Late biface, Stage 3.5+
Mixed Bif = Mixed biface, Stage 1 to Stage 4+
EdgeMain = Edge maintenance and resharpening
NoG3 = not classified, no G3 size grade items
N<51 = not classified, n<51

APPENDIX J

Attributes of Hammerstones and Cobble Tools

APPENDIX J

Attributes of Hammerstones and Cobble Tools.
(ALL MEASUREMENTS IN CENTIMETERS)

Site No. (26Ek)	Specimen No.	Fea.	Material	Length	Width	Thick-ness	Weight (gms)	Type	Shaped	Complete
3032, Loc. 19	01-6	-	QZ	13.3	9.8	6.2	1142.6	HM	-	+
	01-11	-	QZ	12.4	11.6	4.2	835.1	HM	+	+
3032, Loc. 23	3001-23	1	QZ	8.5	5.3	4.6	251.0	HM	-	+
	3001-25	1	JA	10.0	6.8	4.6	407.0	HM	-	+
3032, Loc. 25	01-5	-	QZ	6.0	5.4	4.3	186.7	HM	-	+
	01-11	-	QZ	6.2	5.5	4.5	203.8	HM	-	+
	01-12	-	QZ	6.7	8.5	3.6	289.3	HM	+	-
	4003-1	5	OP	8.7	6.6	4.1	299.1	HM	-	+
	4009-21	2	OP	8.4	8.3	3.8	347.8	CH	+	?
3032, Loc. 98	3001-2	1	QZ	6.8	7.8	3.2	259.7	HM	-	-
3084	502-1	2	MB	12.3	11.5	6.8	1253.2	HM	-	-
	502-2	2	RH	13.2	6.6	6.9	756.2	HM	?	-
	502-3	2	MB	10.2	3.4	3.8	163.2	HM	+	-
	502-4	2	MB	13.1	11.6	6.0	1032.9	HM	?	+
	1021-1	2	OP	16.0	10.5	4.8	813.1	SV	+	+
3085	508-1	8	MB	8.1	6.4	5.5	427.3	HM	-	+
	508-2	8	TB	13.9	9.6	4.0	452.9	CH	+	-
3092	2041-1	-	OP	6.4	5.4	3.5	159.5	HM	+	+
	6062-11	-	TB	6.7	8.4	3.3	253.9	HM	-	-
	6063-6	-	QZ	7.3	6.3	5.4	335.8	HM	-	+
	6083-2	-	QZ	11.0	5.7	4.8	478.4	HM	-	+
	6122-6	-	TB	11.2	8.2	4.2	349.0	CH	?	-
	6161-1	-	QZ	5.8	9.7	4.0	28.2	HM	-	-
	6242-1	-	OQ	7.0	5.7	4.2	245.1	HM	-	+
	6525-2	-	MB	10.4	8.7	5.5	538.5	HM	-	+
	6562-5	-	MB	15.8	11.3	3.6	911.8	CH	+	+
	6562-6	-	MB	6.6	6.6	5.8	416.1	HM	-	-
	6642-2	-	MB	10.3	12.5	4.2	755.6	CH	+	+
	8283-2	7	MB	10.0	6.9	3.0	296.7	HM	-	+
	8290-2	24	MB	7.1	5.9	5.3	312.6	HM	-	+
	8302-4	7	MB	9.7	7.4	7.0	602.2	HM	-	-
	8364-1	13	TB	10.9	13.7	2.8	653.1	CH	?	?
	8382-5	13	MB	5.9	5.3	5.2	220.8	HM	-	+
	8403-3	13	RH	6.0	6.0	1.8	60.5	HM	-	-
	8403-4	13	QZ	9.9	7.6	3.8	357.2	HM	-	+
	8482-1	13	MB	6.4	5.7	4.2	201.4	HM	-	-
	8522-6	13	MB	11.1	8.3	4.8	511.6	HM	-	-
	8644-1	9	TB	13.7	9.7	4.0	918.1	CH	?	-
	9263-1	14	RH	4.8	4.5	3.7	106.7	HM	-	+
3093	505-9	5	QZ	11.8	7.8	3.6	401.2	CH	+	+
3095	500-21	-	OP	10.8	7.2	6.8	523.3	CH	+	+
	500-49	-	QZ	10.4	9.7	7.3	925.1	HM	-	+
	500-57	-	RH	10.0	7.9	2.6	252.0	SS	-	-
	505-5	5	OP	8.6	6.6	4.7	348.8	HM	?	+
	511-3	11	MB	17.5	13.3	6.4	3000.0	HM	-	-
	513-1	13	QZ	8.3	6.2	5.9	433.5	HM	-	+
	514-3	14	MB	8.6	7.3	4.8	283.9	HM	+	-
	514-4	14	MB	7.5	2.8	3.2	80.7	HM	+	-

Appendix J, continued.

Site No. (26Ek)	Specimen No.	Fea.	Material	Length	Width	Thick-ness	Weight (gms)	Type	Shaped	Complete
	1004-3	19	MB	10.3	8.1	5.1	484.6	HM	-	+
	1006-1	19	MB	8.7	8.6	4.7	589.6	HM	-	-
	3015-4	15	MB	7.0	5.6	5.2	247.6	HM	-	+
	3019-8	19	MB	10.9	5.8	5.2	572.9	HM	-	+
	6660-1	10	TB	11.0	9.3	3.2	629.3	CH	?	+
3096	500-3	-	QZ	8.4	6.6	2.6	190.8	HM	-	+
	502-3	2	MB	10.4	7.8	5.5	568.0	CH	+	+
	504-1	4	MB	6.7	5.2	3.8	221.0	HM	-	+
3099	501-1	1	OP	9.2	8.0	3.6	28.0	HM	+	+
	502-1	2	OP	8.0	8.0	3.1	161.9	CH	+	+
3101	500-2	-	OP	10.2	6.0	2.9	211.5	CH	+	+
3104	500-5	-	MB	11.2	10.5	8.0	2000.0	CH	+	+
	500-10	-	QZ	10.8	8.9	8.2	889.2	HM	-	+
3106	1050-1	4	TB	12.1	7.1	3.5	280.8	SS	-	-
	2021-4	5	MB	12.0	9.7	6.1	751.0	HM	+	+
3107	1002-1	1	TF	13.6	10.4	4.7	663.0	CH	+	+
3114	1007-5	1	TB	10.9	10.0	3.2	447.8	SS	?	+
3149	500-11	-	OP	9.7	7.0	3.7	269.4	CH	+	+
3160	01-9	-	MB	9.3	5.9	3.2	250.2	HM	+	-
	500-67	-	RH	7.6	6.9	3.3	227.6	CH	+	+
	500-118	-	MB	14.6	8.7	6.1	778.5	PL	+	+
	501-1	1	TB	30.5	25.6	2.6	2600.0	SV	+	-
	501-15	1	MB	11.4	8.5	4.4	441.9	PL	+	+
	507-4	7	RH	6.7	6.0	5.5	280.2	HM	-	+
	1001-1	1	MB	14.4	8.8	5.7	752.5	PL	+	+
	1005-4	1	TB	11.4	9.7	1.9	430.3	HM	?	-
	1007-4	1	TB	8.0	4.3	2.4	115.7	SS	-	?
	2001-1	1	MB	9.4	6.6	2.6	162.0	HM	-	-
	6341-2	-	QZ	6.9	5.6	2.9	156.6	HM	-	+
	6862-3	-	OP	10.2	9.5	6.2	691.0	HM	?	+
3170	01-25	-	RH	10.7	10.3	6.2	1046.3	PL	+	+
	500-11	-	QZ	6.3	2.7	2.6	51.7	HM	?	-
	500-50	-	MB	8.6	6.5	5.9	326.1	HM	-	-
	500-52	-	OP	7.9	6.3	4.9	244.1	CH	+	-
3171	500-4	-	TF	11.6	12.9	3.0	447.6	SS	?	+
	6365-1	-	QZ	9.5	9.0	4.8	553.2	HM	-	+
	6907-7	2	QZ	12.8	5.2	5.2	635.7	HM	-	?
3177	501-1	1	RH	13.2	8.3	5.6	746.9	HM	-	+
3184	503-3	3	OP	10.8	8.9	5.2	382.7	CH	+	?
	2021-13	13	QZ	6.8	5.7	4.4	207.0	HM	-	+
	4125-2	8	OP	8.6	7.6	6.2	415.5	HM	+	+
	6001-4	12	JA	9.2	5.4	3.5	219.8	HM	-	+
3185	504-1	4	QZ	9.5	4.3	5.8	349.9	HM	-	+
	1010-1	1	TF	14.0	12.4	3.9	731.8	SS	+	+
	1012-1	1	QZ	9.2	9.1	8.0	832.2	HM	-	+

Appendix J, continued.

Site No. (26Ek)	Specimen No.	Fea.	Material	Length	Width	Thick-ness	Weight (gms)	Type	Shaped	Complete
3192	2062-1	2	TF	11.4	9.6	4.6	615.6	HM	-	+
	2064-1	2	QZ	10.9	9.8	5.6	639.7	HM	-	+
	2122-1	1	QZ	8.0	7.4	6.5	390.5	HM	-	+
	6063-1	1	QZ	11.6	8.0	5.9	563.4	HM	-	-
	6322-1	2	HE	17.9	9.3	8.1	847.7	SS	-	+
	6602-3	1	TF	2.7	1.7	0.8	4.2	SS	-	-
3193	506-1	6	TF	4.3	3.2	0.9	14.6	SS	-	+
3195	502-1	2	RH	25.0	14.0	6.8	3600.0	HM	-	+
	502-2	2	RH	25.0	14.5	9.3	2440.0	HM	-	-
	503-1	3	QZ	6.1	4.8	1.9	73.4	HM	-	-
	507-1	7	QZ	5.7	5.8	3.6	155.4	HM	-	+
	507-2	7	QZ	10.6	7.1	6.0	627.5	HM	-	+
	507-6	7	MB	8.1	7.5	6.4	469.7	HM	-	+
3196	501-2	1	QZ	9.2	6.8	3.4	196.8	HM	-	-
	502-1	2	QZ	9.2	7.7	2.6	126.6	HM	-	-
	502-8	2	QZ	10.7	10.0	6.7	755.1	HM	-	+
	502-0	2	QZ	18.5	13.0	5.8	1497.1	HM	-	+
	1007-1	1	QZ	8.6	7.5	5.2	391.4	HM	-	+
	1033-1	2	QZ	9.5	9.3	4.3	354.3	HM	-	-
	2002-1	1	OP	12.2	8.9	7.1	816.7	HM	-	+
	2002-3	1	QZ	8.8	7.3	3.6	338.1	HM	-	-
3197	504-2	4	QZ	9.4	6.9	5.7	320.1	HM	?	-
	504-4	4	QZ	8.0	5.5	1.7	53.9	HM	-	-
	506-1	6	MB	6.8	6.6	3.9	191.4	HM	?	-
	506-2	6	OQ	7.6	6.0	3.4	158.4	HM	-	-
	507-2	7	QZ	11.9	6.8	4.4	361.0	HM	-	-
	509-5	9	QZ	9.0	8.4	3.8	263.1	HM	-	+
3198	514-5	14	QZ	6.7	5.1	3.1	104.3	HM	-	-
	514-6	14	QZ	4.7	5.1	1.2	38.5	HM	-	-
3200	501-2	1	QZ	16.8	14.4	3.0	1328.8	SV	+	-
	2500-1	-	QZ	9.1	8.8	5.1	500.4	HM	-	+
3201	500-1	-	QZ	11.4	7.0	6.9	827.4	HM	-	+
	502-14	2	QZ	8.1	8.2	4.3	382.7	HM	?	+
	503-4	3	QZ	13.8	9.7	5.0	928.5	HM	-	-
	504-1	4	MB	5.9	4.6	4.9	139.3	HM	-	-
	1002-1	1	TF	13.0	10.9	3.5	387.8	SS	?	-
3204	500-22	-	QZ	13.0	9.9	2.5	501.4	HM	-	-
	500-23	-	RH	10.1	8.1	2.6	326.7	SS	-	-
	500-26	-	QZ	10.9	10.4	4.9	529.0	HM	-	+
	500-32	-	QZ	7.8	6.4	4.0	208.2	HM	-	+
	500-33	-	QZ	12.1	8.8	5.0	708.6	HM	-	+
	2005-12	-	OP	5.9	3.6	3.2	51.4	HM	-	-
	2500-7	-	MB	9.8	8.2	5.2	495.2	HM	-	+
	2599-1	1	MB	4.3	4.2	3.5	88.4	HM	+	+
	9001-1	1	RH	7.7	5.9	5.1	268.7	HM	-	+
3208	501-1	1	MB	13.9	11.4	5.0	818.4	HC	+	-
	501-2	1	MB	18.6	12.3	11.0	2500.0	HM	-	+
	508-1	8	QZ	15.5	8.5	6.7	1259.0	HM	-	-
	2500-3	-	MB	8.3	6.8	5.9	413.3	HM	+	+
	2599-17	3	TF	10.1	7.4	3.7	194.9	SS	-	+
	2599-244	3	QZ	15.3	13.2	5.5	1600.0	HM	?	+

Appendix J, continued.

Site No. (26Ek)	Specimen No.	Fea.	Material	Length	Width	Thick-ness	Weight (gms)	Type	Shaped	Complete
3237	01-6	-	QZ	6.7	5.7	4.4	234.7	HM	-	+
	01-28	-	JA	12.4	9.5	5.2	756.8	CH	+	?
	500-6	-	OP	9.4	6.7	4.9	361.9	HM	-	+
	2599-3	-	OP	11.2	7.4	4.1	341.0	CH	+	+
	6702-1	2	RN	11.0	8.7	2.8	445.7	CH	+	?
	6723-6	2	OP	7.7	5.5	5.0	268.7	HM	?	+
	6881-2	-	OT	7.9	5.5	4.5	234.3	HM	-	+
3238	500-33	-	QZ	18.1	12.7	4.2	1282.4	CH	+	-
3239	500-22	-	TB	11.2	7.1	5.8	576.1	CH	+	+
	500-23	-	QZ	16.0	8.5	7.7	1109.7	HM	-	+
	500-24	-	MB	5.3	5.7	5.1	227.4	HM	-	+
	500-27	-	OQ	5.9	4.8	3.4	77.1	CH	+	+
	500-29	-	OP	10.4	10.2	3.6	412.9	CH	+	+
3251	500-20	-	QZ	9.9	6.9	3.5	293.5	CH	+	+
	1009-1	1	TB	12.4	7.7	3.3	449.0	CH	+	+
	6063-2	6	QZ	6.4	5.8	3.1	179.0	HM	-	-
3271	500-4	-	TB	13.5	8.5	3.4	601.9	CH	+	+
	500-18	-	QZ	7.8	5.4	3.2	188.2	HM	-	+
	500-21	-	MB	13.8	9.5	2.8	494.8	CH	+	?
	500-62	-	TF	7.7	7.2	3.4	137.8	SS	+	+
	500-82	-	RH	7.5	5.9	3.6	184.0	HM	-	+
	500-163	-	OQ	6.1	4.5	2.1	58.5	CH	+	-
	500-261	-	MB	10.7	9.2	4.2	560.1	HM	-	+
	500-311	-	QZ	7.7	9.0	4.8	467.4	HM	-	-
	505-2	5	OP	8.2	6.0	3.6	201.0	CH	+	+
	506-5	6	QZ	7.6	5.9	2.6	172.6	HM	-	-
	516-1	16	MB	20.0	17.0	11.9	4000.0	HM	-	+
	516-2	16	OP	7.1	6.8	3.4	148.6	CH	+	-
	519-3	19	MB	11.3	8.7	6.2	745.4	CH	+	+
	1022-3	12	OP	11.1	7.5	4.7	344.9	CH	+	+
	1023-2	12	OP	11.9	8.0	4.9	525.2	CH	+	+
	1026-1	12	OQ	7.5	6.0	5.0	379.4	HM	?	+
	1038-1	12	MB	8.3	5.2	3.1	155.0	CH	+	?
	1047-2	12	TB	12.6	7.0	2.7	410.5	SS	-	-

Key:

Material
MB = Mass Basalt
TB = Tabular Basalt
QZ = Quartzite
OP = Opalite
OQ = Opalite w/Quartzite
JA = Jasper
RH = Rhyolite
TF = Tuff
HE = Hematite
OT = Other

Type
HM = Hammerstones
CH = Chopper
PL = Scraper Plane
SS = Scratched Stone
HC = Hammer/Chopper
SV = Shovel

APPENDIX K

Attributes of Ground Stone Artifacts

(Attributes of stone beads and ornaments are presented in Chapter 11)

APPENDIX K

Attributes of Groundstone Artifacts.
(ALL MEASUREMENTS IN CENTIMETERS)

Site No. (26Ek)	Specimen No.	Fea.	No. Frags.	Material	% Complete-ness	Plan Outline	Shaped	Facial Use	Use Surface Profile	Use Wear	Type	Length	Width	Thick-ness	Weight (gms)	Fire Affected
3032, Loc. 19	01-9	-	1	TB	50	SR	-	U	PL	M	ME	16.5	11.9	3.5	1,122.3	-
3032, Loc. 93	01-1	-	1	RH	75	SR	-	U	CN	L	ME	40.2	15.8	7.3	>400.0	-
3092	01-2	-	1	TB	?	SR	-	B	PL	M	ME	10.4	7.4	3.1	542.9	-
	500-3	-	1	TF	100	SR	+	M	PL	H	AB	4.5	1.4	1.4	8.4	-
	2599-12	-	1	TB	90	SR	+	U	PL	H	AB	4.5	1.4	1.4	8.4	-
	6165-2	-	1	MB	100	IR	-	U	CN	L	MR	24.5	18.4	22.4	13,600.0	-
	6170-1	-	2	TB	60	OV	-	U	PL	L	ME	(22.2)	(19.4)	4.6	3,000.0	-
	6222-4	-	1	MB	75	SR	+	U	CN	L	ME	16.4	15.0	4.6	2,200.0	-
	6462-1	-	1	TB	75	IR	-	U	PL	M	ME	20.3	10.7	4.7	1,800.0	-
	6545-1	-	1	TB	90	SR	-	U	PL	M	ME	20.3	15.0	2.2	1,275.3	-
	8402-7	12	1	TB	20	IN	?	U	PL	L	ME	13.5	7.7	3.2	411.0	+
3095	01-3	-	1	TB	20	IN	-	U	CN	M	ME	20.8	7.2	10.0	3,000.0	-
	500-22	-	1	RH	50	SR	+	U	CV	L	PE	9.9	6.8	4.7	470.5	-
	500-31	-	1	TB	?	IN	-	U	CN	L	ME	7.9	5.9	1.6	101.6	-
	500-26	-	1	TB	50	IR	-	U	CN	L	ME	9.0	15.8	2.8	998.1	-
	510-10	10	1	RH	50	OV	+	U	CV	L	MO	6.0	9.1	4.2	232.5	-
	515-9	15	1	MB	25	IN	-	U	PL	M	ME	8.0	15.0	12.2	4,200.0	-
	519-20	19	1	SS	20	OV	+	B	CV	H	ME	19.0	12.5	1.2	535.1	-
	525-3	24/25	2	TB	25	SR	-	U	PL	M	ME	(19.0)	(10.2)	2.7	879.7	+
	1002-2	15/19	14	IG	?	OV	+	B	PL	M	ME	?	?	3.1	1,810.3	?
	1002-7	19	1	SS	25	SR	+	U	GV	H	SA	3.2	4.1	1.9	27.6	-
	1023-1	15	36	TF	95	OV	+	B	ML	L/H	ME	(40.5)	(20.2)	1.8	2,242.7	-
	1025-1	15	1	SS	75	OV	+	U	GV	H	SA	11.7	6.6	2.0	203.1	-
	1029-1	15	4	TB	60	IN	-	B	PL	L	ME	(34.0)	(30.0)	2.9	3,458.4	-
	1032-5	15	1	TB	?	SR	-	U	PL	M	ME	15.4	10.0	3.0	955.7	-
	1044-1	22	6	TB	60	IN	-	U	PL	M	ME	(33.35)	(20.5)	5.9	4,930.4	+
	6381-4	19	1	TF	50	SR	+	M	M	M	AB	3.7	3.6	1.9	28.2	-
3096	1002-2	1	1	MB	100	OV	-	U	CV	L	MO	13.2	8.4	5.5	782.1	-
3106	1037-1	4	1	TB	?	IN	?	U	PL	L	ME	6.6	5.1	3.6	227.6	-
3149	500-6	-	1	MB	95	OV	?	U	PL	M	ME	30.0	24.5	14.0	9,500.0	-
	500-7	-	1	RH	40	OV	?	B	CV	L	MO	5.9	8.7	4.3	220.2	-

Appendix K, continued.

Site No. (26Ek)	Specimen No.	Fea.	No. Frags.	Material	% Completeness	Plan Outline	Shaped	Facial Use	Use Surface Profile	Use Wear	Type	Length	Width	Thickness	Weight (gms)	Fire Affected
3160	01-30	-	1	MB	75	OV	-	U	CN	L	MR	19.7	17.6	9.7	5,000.0	-
	01-33	-	1	MB	100	SR	-	U	PL	L	ME	29.6	20.8	18.0	14,600.0	-
	01-63	-	1	MB	75	IR	-	U	PL	M	ME	27.9	25.4	9.4	8,600.0	-
	01-115	-	1	TB	100	SR	-	U	CN	L	MR	31.8	22.0	16.6	15,000.0	-
	01-119	-	1	TB	100	SR	-	U	CV	M	ME	25.0	22.6	4.2	4,800.0	-
	01-208	-	1	TB	100	OV	+	M	M	M	PE	18.0	6.0	5.6	992.3	-
	01-210	-	1	MB	100	OV	-	U	CN	L	ME	31.5	21.7	17.5	16,400.0	-
	01-219	-	1	TB	25	IN	-	U	CV	M	ME	14.7	14.2	5.4	1,552.8	-
	500-53	-	2	TB	100	SR	+	M	ML	M	PE	(19.5)	(6.8)	6.7	1,431.2	-
	500-74	-	1	SS	10	OV	+	B	PL	L	ME	7.0	5.0	2.5	75.9	-
	500-110	-	1	TB	?	IR	-	U	PL	L	ME	21.2	12.0	2.0	682.1	-
	501-2	1	1	RH	100	SR	+	B	CV	L	MO	13.1	8.8	4.9	747.5	-
	515-1	15	1	TF	50	OV	+	U	GV	H	SA	4.6	2.8	2.2	17.6	-
	520-7	20	1	TB	50	IR	-	U	CN	M	ME	28.1	19.0	3.0	2,140.1	-
	519-8	19	1	TB	100	SR	-	U	PL	L	MR	28.5	15.0	9.5	6,400.0	-
	523-14	23	1	TB	50	OV	-	U	CN	L	MR	20.5	12.3	9.9	3,600.0	-
	1005-2	1	1	RH	40	SR	+	U	CV	M	MO	6.8	8.0	4.7	358.4	-
	2041-1	-	1	RH	75	OV	+	U	CV	M	MO	13.1	7.4	4.6	612.4	-
	4019-1	1	1	MB	90	IR	-	U	ML	L	ME	43.5	23.5	16.0	19,800.0	-
3165	01-4	-	1	TB	100	IR	-	U	PL	L	ME	47.5	30.0	3.0	6,800.0	-
	501-1	1	1	TB	100	IR	+	U	CN	L	ME	41.4	26.9	2.5	4,000.0	-
	502-1	2	1	TB	?	IR	-	U	CN	M	ME	24.7	20.0	3.4	3,900.0	-
	6181-2	-	1	TB	25	IR	-	U	PL	L	ME	16.4	11.5	2.0	675.1	-
3170	500-5	-	1	QZ	50	OV	+	U	CV	L	MO	10.4	8.3	3.8	402.0	-
	2023-1	-	1	TB	25	IN	?	B	PL	M	ME	18.9	13.0	2.7	975.8	-
3171	2022-1	-	1	RH	75	SR	?	B	CV	L	MO	15.2	9.1	4.3	628.7	-
3181	1015-1	1	1	RH	100	OV	?	B	CV	L	MO	18.2	11.0	7.4	1,627.0	+
3184	503-27	3	1	SS	100	OV	+	U	CV	H	SA	9.9	5.0	4.0	177.0	-
	3010-3	10	1	TF	75	OV	+	B	ML	L	MO	11.7	7.5	4.5	406.5	-
3185	1010-2	1	1	RH	50	OV	+	U	CV	L	MO	12.5	8.9	4.8	500.9	-
3190	505-4	5	3	TF	25	IN	+	U	PL	L	ME	(14.3)	(8.9)	6.7	835.6	-
	1006-3	1	1	TF	100	IR	-	M	ML	M	AB	4.2	2.6	1.9	19.2	-

Appendix K, continued.

Site No. (26Ek)	Specimen No.	Fea.	No. Frags.	Material	% Complete-ness	Plan Outline	Shaped	Facial Use	Use Surface Profile	Use Wear	Type	Length	Width	Thick-ness	Weight (gms)	Fire Affected
3192	01-1	-	1	TF	100	OV	+	U	PL	M	MO	16.4	9.5	3.5	752.3	-
	1015-3	1	1	TB	?	IN	?	U	PL	L	ME	8.4	4.3	1.5	73.3	-
	2061-1	2	1	QZ	100	OV	+	B	ML	L	MO	6.3	9.9	3.4	327.9	-
	2599-2	1	1	TF	50	IN	-	U	PL	L	ME	17.5	14.5	2.6	849.3	-
	6141-3	1	1	TF	40	SR	+	U	PL	L	ME	14.6	14.2	2.3	753.2	-
	6121-5	-	1	RH	20	IN	?	U	PL	L	ME	14.1	10.8	5.2	1,239.9	-
	6581-1	1	1	MB	10	IN	?	U	PL	M	ME	8.9	5.2	2.3	129.8	-
3196	502-5	2	1	TF	100	SR	-	U	PL	L	ME	7.0	4.1	3.6	60.7	-
3198	1003-1	1	1	SS	100	SR	+	M	GV	H	SA	5.5	2.6	1.7	33.9	-
3201	502-15	2	1	RH	100	OV	?	U	CV	L	MO	13.2	9.0	5.8	956.6	-
	503-5	3	17	RH	50	IN	+	U	PL	L	ME	(36.0)	(22.5)	5.3	4,077.4	+
3204	2500-8	-	1	QZ	50	OV	?	U	CV	L	MO	7.6	7.4	2.9	238.0	+
3228	1001-1	1	2	TB	95	IR	-	U	PL	L	ME	(22.7)	(19.6)	4.9	2,1911.3	-
3237	01-3	-	1	RH	25	IR	-	U	CV	L	ME	22.3	9.9	12.7	3,300.0	-
	01-4	-	1	MB	25	?	?	U	PL	M	ME	17.4	12.5	5.8	1,295.1	-
	01-27	-	2	TF	20	OV	+	B	PL	L	ME	(11.0)	(8.4)	2.3	320.7	-
	01-123	-	1	RH	100	IR	-	U	PL	L	ME	28.0	23.5	5.4	5,000.0	-
	500-81	-	1	RH	10	IN	?	U	CN	L	ME	9.0	5.4	4.3	232.8	-
	6200-1	-	1	TF	5	OV	+	B	PL	L	ME	7.7	6.7	2.3	142.7	-
	6401-2	-	1	TF	?	?	?	U	PL	M	ME	7.2	5.7	3.2	176.1	+
	6700-2	-	1	RH	?	IR	-	U	PL	L	ME	10.4	8.3	4.1	443.3	-
3238	500-16	-	1	RH	?	SR	+	U	CN	L	ME	9.1	8.2	4.6	541.7	-
3251	01-16	-	1	RH	10	IN	?	U	PL	M	ME	6.5	5.7	5.4	278.1	-
	500-4	-	1	RH	25	OV	+	U	CN	M	ME	19.0	19.0	5.2	2,108.9	-
	500-6	-	1	QZ	20	IN	?	U	CN	M	ME	10.8	9.3	5.9	558.4	-
	500-8	-	1	TF	?	IN	?	U	PL	L	ME	8.6	7.9	5.1	365.0	-
	500-11	-	1	TF	?	IN	?	U	PL	L	ME	4.8	5.3	2.1	62.1	-
	500-14	-	1	RH	20	SR	+	U	CN	L	ME	11.6	9.6	2.6	480.2	-
	500-15	-	1	TF	100	OV	+	U	CV	L	MO	14.4	8.4	6.7	1,146.0	-
	501-1	1	1	RH	25	OV	+	U	CN	M	ME	15.0	17.0	3.3	1,006.4	-
	501-4	1	1	RH	40	OV	-	U	CV	L	MO	9.8	6.5	4.4	384.7	+

Appendix K, continued.

Site No. (26Ek)	Specimen No.	Fea.	No. Frags.	Material	% Complete-ness	Plan Outline	Shaped	Facial Use	Use Surface Profile	Use Wear	Type	Length	Width	Thick-ness	Weight (gms)	Fire Affected
3251, continued	506-1	6	1	TF	?	IN	?	B	PL	L	ME	13.6	7.6	3.3	402.5	-
	506-5	6	1	RH	?	IN	?	U	PL	L	ME	12.2	5.8	2.6	211.0	-
	1006-5	1	1	TF	5	OV	+	B	PL	L	ME	5.8	4.6	3.7	123.8	+
	3006-2	6	1	RH	50	OV	-	U	CV	M	AB	8.5	8.6	3.3	386.8	-
	3006-6	6	1	QZ	10	?	-	U	PL	M	ME	6.6	6.2	2.3	74.2	-
	3006-9	6	1	TF	20	SR	+	B	ML	M	MO	5.2	5.2	2.6	90.8	-
	6462-1	1	1	QZ	50	IR	-	U	PL	L	MO	9.2	7.4	4.5	401.3	+
	6501-1	1	1	TF	60	SR	+	U	CV	L	MO	9.9	6.4	3.5	326.0	-
	6502-1	1	1	TF	20	SR	+	U	PL	M	MO	3.7	4.9	4.3	80.8	+
3271	500-73	-	1	RH	75	SR	+	M	CV	L	MO	12.0	6.2	3.8	532.0	+
	500-133	-	1	TB	?	IN	?	U	PL	M	ME	11.0	10.3	2.9	481.0	+
	500-150	-	1	RH	40	SR	+	M	ML	L	PE	7.1	7.4	5.6	501.1	-
	500-273	-	2	TB	?	SR	?	U	PL	L	ME	(17.0)	(10.8)	2.8	882.8	-
	1008-1	2	1	RH	25	OV	?	U	CV	L	MO	7.4	5.1	2.4	108.3	-
	1101-2	18	1	MB	100	OV	-	U	PL	M	MR	22.0	18.5	11.0	2,600.0	-

Key:

Material
IG = Ignimbrite
MB = Mass Basalt
TB = Tabular Basalt
QZ = Quartzite
RH = Rhyolite
SS = Sandstone
TF = Tuff

Plan Outline
SR = Sub-rectangular
OV = Ovoid
IR = Irregular
IN = Indeterminant

Parentheses denote measurement of two or more refitted pieces.

Facial Use
U = Unifacial
B = Bifacial
M = Multiple

Use Surface Profile
CN = Concave
CV = Convex
PL = Planar
ML = Multiple

Use Wear
L = Light use; polished facets only on elevated areas of surface; retains characteristics of original surface.

M = Moderate use; thin layer of original surface of stone is removed by grinding; polished facets cover ca. 50% of surface area.

H = Heavy use; perceptible trough developed below original surface; ground facets over entire surface; often resharpened by pecking.

Type
MO = Mano
ME = Metate
PE = Pestle
MR = Mortar
AB = Abrader
SA = Shaft Abrader/ Smoother

APPENDIX L

Radiocarbon Analysis Results

Beta Analytic, Inc.

BETA ANALYTIC INC.

MURRY A. TAMERS, PH. D.
JERRY J. STIPP, PH. D.
CO-DIRECTORS

4985 S.W. 74 COURT
MIAMI, FLORIDA
33155 U.S.A.

May 5, 1990

Mr. Steven G. Botkin
Intermountain Research
Drawer A
Silver City, Nevada 89428

Dear Mr. Botkin:

Please find enclosed the results on your nineteen charcoal samples recently submitted for radiocarbon dating analyses. We trust these dates will be interesting for your work.

As before, the charcoals were pretreated by first examining for rootlets. They were then given our acid, alkali, acid series of soakings to remove carbonates and humic acids. The following benzene syntheses and counting went normally. The pouch B portion was used only in the case of Beta-36984.

Two of the samples were small, as indicated on the date report sheet. They were given extended counting time (four times the normal amount) to reduce the statistical errors as much as practical.

We are enclosing our invoice. As always, if there are any questions or if you would like to discuss the dates, call us at any time.

Sincerely yours,

Murry Tamers

Murry Tamers, Ph.D.
Co-director

TELEPHONE: 305-667-5167 / FAX: 305-663-0964 / BITNET: XNRBET22@SERVAX

BETA ANALYTIC INC.
(305) 667-5167
UNIVERSITY BRANCH
P.O. BOX 248113
CORAL GABLES, FLA. 33124

REPORT OF RADIOCARBON DATING ANALYSES

FOR: Steven G. Botkin
Intermountain Research

DATE RECEIVED: April 12, 1990
DATE REPORTED: May 5, 1990
SUBMITTER'S PURCHASE ORDER #

OUR LAB NUMBER	YOUR SAMPLE NUMBER	C-14 AGE YEARS B.P. ±1σ	
Beta-36976	3092-8584-5 (Sample #21)	750 +/- 70 BP	(charcoal)
Beta-36977	3092-8645-1 (Sample #36)	650 +/- 50 BP	(charcoal)
Beta-36978	3171-2599-5	410 +/- 70 BP	(charcoal)
Beta-36979	3195-2599-129	320 +/- 50 BP	(charcoal)
Beta-36980	3195-2599-130	500 +/- 80 BP	(charcoal)
Beta-36981	3195-2599-131	360 +/- 60 BP	(charcoal)
Beta-36982	3198-8462-6 (Sample #10)	300 +/- 60 BP	(charcoal)
Beta-36983	3208-2599-15	900 +/- 80 BP	(charcoal)
Beta-36984	3208-2599-21 (0.43 gram carbon)	870 +/- 80 BP	(charcoal)
Beta-36985	3208-2599-22	650 +/- 100 BP	(charcoal)
Beta-36986	3208-2599-23	570 +/- 80 BP	(charcoal)
Beta-36987	3208-2599-24	480 +/- 60 BP	(charcoal)
Beta-36988	3208-2599-25 (0.69 gram carbon)	840 +/- 60 BP	(charcoal)
Beta-36989	3208-2599-28	560 +/- 70 BP	(charcoal)

These dates are reported as RCYBP (radiocarbon years before 1950 A.D.). By international convention, the half-life of radiocarbon is taken as 5568 years and 95% of the activity of the National Bureau of Standards Oxalic Acid (original batch) used as the modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation statistics (68% probability), based on the random nature of the radioactive disintegration process. Also by international convention, no corrections are made for DeVries effect, reservoir effect, or isotope fractionation in nature, unless specifically noted above. Stable carbon ratios are measured on request and are calculated relative to the PDB-1 international standard; the adjusted ages are normalized to -25 per mil carbon 13.

BETA ANALYTIC INC.
(305) 667-5167
UNIVERSITY BRANCH
P.O. BOX 248113
CORAL GABLES, FLA. 33124

REPORT OF RADIOCARBON DATING ANALYSES

FOR: _____

DATE RECEIVED: _____

DATE REPORTED: _____

SUBMITTER'S PURCHASE ORDER # _____

OUR LAB NUMBER	YOUR SAMPLE NUMBER	C-14 AGE YEARS B.P. ±1σ	
Beta-36990	3208-2599-31	770 +/- 80 BP	(charcoal)
Beta-36991	3208-2599-33	740 +/- 80 BP	(charcoal)
Beta-36992	3208-2599-36	590 +/- 80 BP	(charcoal)
Beta-36993	3237-8802-4 (Sample #3)	970 +/- 60 BP	(charcoal)
Beta-36994	3237-8845-1 (Sample #9)	1860 +/- 70 BP	(charcoal)

Note: the small samples Beta-36984 and 36988 were given extended counting time

These dates are reported as RCYBP (radiocarbon years before 1950 A.D.). By international convention, the half-life of radiocarbon is taken as 5568 years and 95% of the activity of the National Bureau of Standards Oxalic Acid (original batch) used as the modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation statistics (68% probability), based on the random nature of the radioactive disintegration process. Also by international convention, no corrections are made for DeVries effect, reservoir effect, or isotope fractionation in nature, unless specifically noted above. Stable carbon ratios are measured on request and are calculated relative to the PDB-1 international standard; the adjusted ages are normalized to -25 per mil carbon 13.

BETA ANALYTIC INC.

RADIOCARBON DATING, STABLE ISOTOPE RATIOS
P.O. BOX 248113 CORAL GABLES, FLORIDA 33124 - (305) 667-5167
BITNET XNRBET22@SERVAX

August 10, 1988

Dr. Robert G. Elston
Intermountain Research
Drawer A
Silver City, Nevada 89428

Dear Dr. Elston:

Please find enclosed the results on the two charcoal samples recently submitted for radiocarbon dating analyses. We hope these dates will be useful in your research.

Your charcoals were pretreated by first examining for rootlets. The samples were then given a hot acid wash to eliminate carbonates. They were repeatedly rinsed to neutrality and subsequently given a hot alkali soaking to take out humic acids. After rinsing to neutrality, another acid wash followed and another rinsing to neutrality. The following benzene syntheses and counting proceeded normally.

A sample date (Beta-26828) came out to be very young. However, as stated on the date report sheet, this has not been adjusted using the dendrochronology (tree ring calibration) tables. There are ambiguities in the curves for very young samples due to both heliomagnetic and fossil fuel burning effects. In your case the age could be between cal 272 BP (cal AD 1678) and 0 BP on the two sigma basis.

We are enclosing our invoice. If there are any questions or if you would like to confer on the dates, my direct telephone number is listed above. Please don't hesitate to call us if we can be of help.

Sincerely yours,

Murry Tamers

Murry Tamers, Ph.D.
Co-director

BETA ANALYTIC INC.
(305) 667-5167
UNIVERSITY BRANCH
P.O. BOX 248113
CORAL GABLES, FLA. 33124

REPORT OF RADIOCARBON DATING ANALYSES

FOR: Robert G. Elston
Intermountain Research

DATE RECEIVED: July 21, 1988
DATE REPORTED: August 10, 1988
SUBMITTER'S PURCHASE ORDER #

OUR LAB NUMBER	YOUR SAMPLE NUMBER	C-14 AGE YEARS B.P. ±1σ
Beta-26827	26Ek3106-2021-1	300 +/- 70 BP
Beta-26828	26Ek3204-2003-13	40 +/- 50 BP

These dates are reported as RCYBP (radiocarbon years before 1950 A.D.). By international convention, the half-life of radiocarbon is taken as 5568 years and 95% of the activity of the National Bureau of Standards Oxalic Acid (original batch) used as the modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation statistics (68% probability), based on the random nature of the radioactive disintegration process. Also by international convention, no corrections are made for DeVries effect, reservoir effect, or isotope fractionation in nature, unless specifically noted above. Stable carbon ratios are measured on request and are calculated relative to the PDB-1 international standard; the adjusted ages are normalized to -25 per mil carbon 13.

BETA ANALYTIC INC.

RADIOCARBON DATING, STABLE ISOTOPE RATIOS
P.O. BOX 248113 CORAL GABLES, FLORIDA 33124 - (305) 667-5167
BITNET XNRBET22@SERVAX

July 30, 1988

Dr. Robert G. Elston
Intermountain Research
Drawer A
Silver City, Nevada 89428

Dear Dr. Elston:

Please find enclosed the results on the two charcoal samples recently submitted for radiocarbon dating analyses. We hope these dates will be useful in your studies.

Your charcoals were pretreated the same as the other materials of this sort submitted previously. They were first examined for rootlets. The samples were then given our acid, alkali, acid soakings to get out carbonates and humic acids. The following benzene syntheses and counting proceeded normally.

The Beta-26754 sample was small, as shown on the date report sheet. It was given extended counting time (four times the normal amount) to reduce the statistical error as much as practical.

We are enclosing our invoice. Would you forward this to the appropriate office for payment. If there are any questions or if you would like to confer on the dates, please call us.

Sincerely yours,

Murry Tamers

Murry Tamers, Ph.D.
Co-director

BETA ANALYTIC INC.
(305) 667-5167
UNIVERSITY BRANCH
P.O. BOX 248113
CORAL GABLES, FLA. 33124

REPORT OF RADIOCARBON DATING ANALYSES

FOR: Robert G. Elston
Intermountain Research

DATE RECEIVED: July 15, 1988
DATE REPORTED: July 30, 1988
SUBMITTER'S PURCHASE ORDER #

OUR LAB NUMBER	YOUR SAMPLE NUMBER	C-14 AGE YEARS B.P. ± 1σ	
Beta-26754	26Ek3208 2500-2/Sample #4 (sorted fraction)	800 +/- 60 BP	(0.7 gram carbon)
Beta-26755	26Ek3208 2500-4/Sample #5 (sorted and unsorted fractions)	650 +/- 60 BP	

Note: the small sample Beta-26754 was given extended counting time.

These dates are reported as RCYBP (radiocarbon years before 1950 A.D.). By international convention, the half-life of radiocarbon is taken as 5568 years and 95% of the activity of the National Bureau of Standards Oxalic Acid (original batch) used as the modern standard. The quoted errors are from the counting of the modern standard, background, and sample being analyzed. They represent one standard deviation statistics (68% probability), based on the random nature of the radioactive disintegration process. Also by international convention, no corrections are made for DeVries effect, reservoir effect, or isotope fractionation in nature, unless specifically noted above. Stable carbon ratios are measured on request and are calculated relative to the PDB-1 international standard; the adjusted ages are normalized to -25 per mil carbon 13.

APPENDIX M

Obsidian Hydration Analysis

Thomas M. Origer

SONOMA STATE UNIVERSITY
ACADEMIC FOUNDATION, INC.

ANTHROPOLOGICAL STUDIES CENTER
CULTURAL RESOURCES FACILITY
707 664-2381

Steve Botkin
Intermountain Research
Drawer A
Silver City, NV 89428

January 9, 1991

Dear Steve:

This letter reports hydration band measurements obtained from specimens from Tosawihi Quarry and vicinity, northcentral Nevada. This work was completed per your letter dated November 29, 1990. The specimens were returned to you in December 1990.

The analysis was completed at the Sonoma State University Obsidian Hydration Laboratory, an adjunct of the Anthropological Studies Center, Department of Anthropology. Procedures used by our hydration lab for thin section preparation and hydration band measurement are described below.

Each specimen was examined in order to find two or more surfaces that would yield edges which would be perpendicular to the microslide when preparation of the thin section was completed. Two small parallel cuts were made at an appropriate location along the edge of each specimen with a 4 inch diameter circular saw blade mounted on a lapidary trimsaw. The cuts resulted in the isolation of a small sample with a thicknesses of approximately one millimeter. Each sample was removed from its specimen and mounted with Lakeside Cement onto permanently etched petrographic microslide.

The thickness of the samples was reduced by manual grinding with a slurry of #500 silicon carbide abrasive on a glass plate. The grinding was completed in two steps. The first grinding was terminated when the sample's thickness was reduced by approximate 1/2, thus eliminating any micro-chips created by the saw blade during the cutting process. The slides were then reheated, which liquified the Lakeside Cement, and the samples inverted. The newly exposed surfaces were then ground until the proper thickness was attained.

The correct thin section thickness was determined by the "touch" technique. A finger was rubbed across the slide, onto the sample, and the difference (sample thickness) was "felt." The second technique employed for arriving at proper thin section thickness is termed the "transparency" test. The microslide was held up to a strong source of light and the translucency of the thin section observed. The sample was sufficiently reduced in thickness when the thin section readily allowed the passage of light.

A protective coverslip was affixed over the thin sections when all grinding was completed. The completed microslides are curated at our hydration lab under File No. 90-H979.

1801 East Cotati Avenue

Rohnert Park, California 9492

The hydration bands were measured with a strainfree 40 power objective and a Bausch and Lomb 12.5 power filar micrometer eyepiece on a Nikon petrographic microscope. Six measurements were taken at several locations along the edge of the thin section. The mean of the measurements was calculated and listed on the enclosed table with other information. These hydration measurements have a range of +/- 0.2 due to normal limitations of the equipment.

The abbreviation "NVB" under the "Mean" column on the enclosed tables marks specimens which had no visible hydration band. Under the same column, "DH" indicates specimens with diffuse hydration, which was not measureable. The abbreviations used under the "Remarks" column include "w," and "Band 1" and "Band 2." The "w" indicates the specimen had surfaces which were weathered, and "Band 1" means that this is the smaller hydration band measurement of a specimen with multiple bands. "Band 2" marks the larger band measurement from a particular specimen.

If you have questions or comments about this hydration work, please don't hesitate to contact us.

Cordially,

Thomas M. Origer, Director
Obsidian Hydration Laboratory

Lab#	Catalog#	Description	Provenience	Remarks	Readings	Mean	Source
01	4067-1	Preform (3170)	67/surface(0-2)	none	1.0 1.1 1.1 1.1 1.2 1.2	1.1	
02	5077-1	Preform (3170)	77/surface	none	1.3 1.3 1.3 1.3 1.4 1.4	1.3	
03	500-11	Preform (3171)	IA/surface	none	1.1 1.2 1.2 1.3 1.3 1.3	1.2	
04	1-9	Preform (3171)	IA/surface	none	1.7 1.7 1.7 1.8 1.8 1.9	1.8	
05	1-2	Preform (3184)	IA/surface	none	1.3 1.4 1.4 1.4 1.6 1.6	1.5	
06	508-5	Preform (3184)	IA/surface	none	1.2 1.3 1.3 1.3 1.3 1.3	1.3	
07	500-1	Preform (3189)	IA/surface	none		NVB	
08	507-1	Preform (3190)	IA/surface	none	3.1 3.1 3.2 3.2 3.2 3.2	3.2	
09	1004-1	Point (3191)	4/surface(0-2)	none	1.3 1.4 1.4 1.4 1.4 1.4	1.4	
10	1003-2	Preform (3198)	3/surface	none	1.7 1.7 1.7 1.7 1.7 1.8	1.7	
11	1007-1	Preform (3198)	7/surface	none	1.6 1.7 1.7 1.8 1.8 1.8	1.7	
12	1017-2	Preform (3198)	17/surface	none	1.6 1.6 1.6 1.6 1.7 1.7	1.6	
13	1018-2	Preform (3198)	18/surface	none	1.9 2.0 2.1 2.1 2.3 2.3	2.1	
14	500-74	Preform (3204)	IA/surface	none	1.4 1.6 1.6 1.6 1.6 1.6	1.6	
15	510-3	Preform (3095)	IA/surface	none	1.4 1.4 1.6 1.6 1.6 1.7	1.6	
16	501-1	Preform (3116)	SF/IF/surface	none	3.8 3.8 3.8 3.9 4.1 4.1	3.9	
17	500-1	Preform (3165)	IA/surface	none	4.1 4.2 4.2 4.2 4.3 4.4	4.2	
18	512-13	Preform (3160)	IF/surface	none	4.9 4.9 5.0 5.0 5.1 5.3	5.0	
19	1084-1	Preform (3160)	4/surface	none		DH	
20	1001-1	Preform (3231)	1/surface	none	2.3 2.3 2.3 2.4 2.4 2.4	2.4	
21	6422-5	Preform (3251)	13/10-20	none		NVB	
22	6543-1	Preform (3251)	18/20-30	Band 1	1.2 1.2 1.3 1.3 1.4 1.4	1.3	
22	6543-1	Preform (3251)	18/20-30	Band 2	4.7 4.7 4.8 4.8 4.8 4.9	4.8	
23	2141-1	Preform (3237)	5/0-10	none	4.1 4.1 4.2 4.2 4.3 4.3	4.2	
24	6903-3	Preform (3237)	66/20-30	none	3.0 3.1 3.1 3.2 3.2 3.2	3.1	
25	501-1	Preform (3239)	IF/surface	Band 1	1.4 1.6 1.6 1.7 1.7 1.8	1.6	
25	501-1	Preform (3239)	IF/surface	Band 2	4.1 4.1 4.1 4.1 4.2 4.4	4.2	
26	500-30	Core (3170)	ISO/surface	none		NVB	
27	500-3	Core (3184)	IA/surface	none	1.3 1.4 1.4 1.6 1.6 1.6	1.5	
28	2065-7	Core (3192)	4/40-50	none	4.2 4.2 4.3 4.4 4.4 4.5	4.3	
29	6222-1	Core (3092)	15/10-20	none	1.2 1.3 1.3 1.3 1.3 1.4	1.3	
30	1045-1	Core (3095)	5/surface	none	1.2 1.2 1.2 1.2 1.3 1.3	1.2	
31	2021-1	Core (3271)	2/0-10	none	2.1 2.1 2.3 2.3 2.3 2.4	2.3	
32	1-26	Core (3237)	IA/surface	none	1.7 1.7 1.7 1.7 1.7 1.8	1.7	
33	1-1	Core (3032)	Locus 24/surface	none	5.8 5.8 6.0 6.1 6.1 6.1	6.0	
34	500-44	Biface (3170)	ISO/surface	none		NVB	
35	500-43	Biface (3170)	IA/surface	none	2.9 2.9 3.0 3.0 3.0 3.0	3.0	
36	500-59	Biface (3170)	IA/surface	none	1.6 1.6 1.6 1.7 1.7 1.7	1.7	
37	508-3	Biface (3170)	IF/surface	Band 1	2.7 2.7 2.9 2.9 3.0 3.0	2.9	
37	508-3	Biface (3170)	IF/surface	Band 2	8.4 8.4 8.5 8.6 8.6 8.7	8.5	
38	1001-9	Biface (3184)	SFC/surface	none	1.4 1.4 1.4 1.6 1.6 1.7	1.5	
39	1019-1	Biface (3190)	SFC/surface	none	7.8 7.9 8.0 8.0 8.0 8.1	8.0	
40	1045-1	Biface (3190)	5/surface 0-2	none	3.1 3.3 3.3 3.3 3.3 3.3	3.3	
41	501-14	Biface (3191)	IFSA/surface	none	3.8 3.8 3.9 4.1 4.1 4.1	4.0	
42	501-12	Biface (3191)	IFSA/surface	none	3.0 3.1 3.1 3.1 3.2 3.3	3.1	
43	501-13	Biface (3191)	IFSA/surface	none	3.2 3.2 3.3 3.5 3.5 3.5	3.4	
44	6205-1	Biface (3092)	14/40-50	none		DH	
45	2599-13	Biface (3092)	--/surface	none	3.9 3.9 4.1 4.1 4.2 4.3	4.1	
46	500-107	Biface (3160)	IA/surface	none	7.3 7.3 7.3 7.4 7.4 7.5	7.4	
47	500-27	Biface (3271)	IA/---	none	7.3 7.3 7.4 7.5 7.5 7.6	7.4	
48	500-3	Biface (3234)	IA SC/surface	none	11.7 11.7 11.9 11.9 11.9 11.9	11.8	
49	500-22	Biface Cut 1 (3237)	IA SC/surface	none	6.1 6.1 6.1 6.1 6.2 6.2	6.1	
50	500-22	Biface Cut 2 (3237)	IA SC/surface	none	6.2 6.3 6.4 6.4 6.6 6.6	6.4	
51	500-22	Biface Cut 3 (3237)	IA SC/surface	none	3.3 3.5 3.6 3.6 3.6 3.7	3.6	
52	500-33	Biface (3237)	IA/surface	none	5.6 5.6 5.6 5.7 5.7 5.7	5.7	
53	500-24	Biface (3238)	IA/surface	none	4.5 4.7 4.7 4.9 5.0 5.0	4.8	
54	3001-8	Biface (3032)	IF/surface	none		NVB	
55	500-7	Debitage (3172)	IA/surface	none	1.3 1.3 1.4 1.6 1.6 1.6	1.5	
56	500-6	Debitage (3172)	IA/surface	w	1.7 1.8 1.8 1.8 1.8 1.8	1.5	
57	501-25	Debitage (3191)	IFSA/surface	none	3.0 3.1 3.1 3.2 3.3 3.3	3.2	
58	501-23	Debitage (3191)	IFSA/surface	none	3.0 3.0 3.0 3.1 3.3 3.3	3.1	
59	501-24	Debitage (3191)	IFSA/surface	none		NVB	
60	6264-3	Debitage (3192)	29/30-40	none	6.1 6.2 6.2 6.3 6.4 6.4	6.3	

Lab Accession No.: 90-H979 Technician: Thomas M. Origer

Lab#	Catalog#	Description	Provenience	Remarks	Readings	Mean	Source
61	500-264	Debitage (3160)	IA/surface	none	5.0 5.0 5.0 5.0 5.1 5.3	5.1	
62	6744-7	Debitage (3237)	58/30-40	none	3.6 3.6 3.6 3.6 3.6 3.6	3.6	
63	6065-1	Debitage (3251)	28/40-50	none	5.7 5.7 5.7 5.8 6.0 6.0	5.8	
64	2001-2	Debitage (3238)	1/0-10	none	6.0 6.0 6.0 6.0 6.1 6.1	6.0	
65	1001-5	Debitage (3239)	1/surface	none	5.7 5.8 6.0 6.0 6.1 6.2	6.0	
66	6063-1	Debitage (3237)	34/20-30	none	3.1 3.1 3.0 3.2 3.3 3.5	3.2	
67	6185-2	Debitage (3251)	34/40-50	none	7.2 7.2 7.3 7.4 7.4 7.5	7.3	
68	6183-3	Debitage (3251)	3/20-30	none	6.3 6.3 6.4 6.4 6.6 6.6	6.4	
69	6481-2	Debitage (3251)	21/2-10	none	4.2 4.2 4.2 4.2 4.3 4.3	4.2	
70	3001-55	Debitage (3032)	IF Locus 23/surface	none	1.6 1.6 1.7 1.7 1.7 1.8	1.7	
71	509-5	Point (3095)	IF Locus 23/surface	none	1.6 1.6 1.7 1.7 1.7 1.8	1.7	
72	6001-1	Point (3095)	5/2-10	none	1.7 1.8 1.8 1.8 1.8 1.8	1.8	
73	6041-1	Point (3095)	7/2-10	Band 1	2.3 2.4 2.4 2.5 2.5 2.5	2.4	
73	6041-1	Point (3095)	7/2-10	Band 2	5.0 5.0 5.1 5.3 5.3 5.4	5.2	
74	2672-1	Point (DSC)	1/surface	none		NVB	
75	500-326	Point (3160)	IA/surface	none	3.5 3.5 3.5 3.5 3.6 3.7	3.6	
76	6081-4	Point (3160)	52/2-10	none	1.2 1.2 1.2 1.2 1.2 1.2	1.2	
77	2002-1	Point (3170)	1/10-20	none	1.1 1.2 1.2 1.3 1.4 1.4	1.3	
78	1025-1	Point (3198)	25/surface 0-2	none	2.1 2.3 2.4 2.4 2.4 2.5	2.4	
79	1018-1	Point (3198)	18/surface 0-2	none	2.5 2.6 2.6 2.6 2.7 2.7	2.6	
80	16-2	Point (3185)	--/surface 0-2	none	2.5 2.5 2.6 2.6 2.6 2.6	2.6	
81	500-2	Point (3092)	150/surface 0-2	none		NVB	
82	6285-4	Point (3092)	18/20 cm	none	1.2 1.2 1.2 1.2 1.2 1.3	1.2	
83	6362-1	Point (3092)	22/10-20	none	1.6 1.6 1.7 1.7 1.8 1.8	1.7	
84	6480-2	Point (3095)	29/0-2	none	1.7 1.7 1.7 1.8 1.8 1.8	1.8	
85	1002-1	Point (3116)	2/0-2	none	1.2 1.2 1.2 1.2 1.3 1.3	1.2	
86	1003-4	Point (3160)	3/0-2	none	1.2 1.2 1.2 1.3 1.3 1.3	1.3	
87	5078-1	Point (3170)	78/0-2	none	1.0 1.0 1.0 1.0 1.0 1.0	1.0	
88	502-1	Point (3178)	IFSA/surface	none	1.2 1.2 1.2 1.2 1.3 1.3	1.2	
89	502-8	Point (3192)	IFSA/surface	none	1.0 1.1 1.1 1.2 1.2 1.2	1.1	
90	2061-6	Point (3192)	4/0-10	none	1.3 1.3 1.3 1.3 1.3 1.3	1.3	
91	508-1	Point (3198)	IFSA/surface	none	1.7 1.7 1.8 1.8 1.8 1.8	1.8	
92	1016-1	Point (3198)	18/0-2	none	1.7 1.8 1.8 1.8 1.8 1.9	1.8	
93	522-1	Point (3271)	IF/0	none	1.7 1.7 1.8 1.8 1.9 1.9	1.8	
94	16-1	Point (3185)	--/surface	none	2.1 2.3 2.4 2.4 2.4 2.4	2.3	
95	500-1	Point (3239)	IASC/surface	none	2.4 2.4 2.5 2.5 2.5 2.5	2.5	
96	01-10	Point (3251)	IA/surface	none	3.3 3.5 3.5 3.6 3.6 3.7	3.5	
97	4017-1	Point (3251)	17/0-2	none	2.1 2.1 2.3 2.3 2.4 2.4	2.3	
98	500-191	Point (3271)	IA/0-2	none	4.8 4.8 4.9 4.9 4.9 5.1	4.9	
99	1046-5	Point (3271)	26/0-2	none		NVB	
100	01-221	Point (3160)	IA/5	none	3.3 3.3 3.5 3.6 3.6 3.7	3.5	
101	6083-1	Point (3160)	52/20-30	none	3.3 3.5 3.5 3.6 3.6 3.6	3.5	
102	6641-1	Point (3160)	86/2-10	none	3.8 3.9 3.9 3.9 4.1 4.1	4.0	
103	6084-1	Point (3237)	35/30-40	none	3.9 4.1 4.2 4.2 4.3 4.3	4.2	
104	6744-1	Point (3237)	5/30-40	none	3.2 3.2 3.2 3.2 3.3 3.5	3.3	
105	2009-2	Point (3092)	1/80-90	none	4.5 4.5 4.7 4.7 4.7 4.8	4.7	
106	1-44	Point (3170)	IA/surface	none	4.5 4.7 4.7 4.8 4.8 4.9	4.7	
107	6064-1	Point (3237)	34/30-40	none	2.7 2.7 2.7 2.9 3.0 3.0	2.8	
108	2500-1	Point (3116)	--/surface	none	6.7 6.7 6.7 6.8 6.9 6.9	6.8	
109	115-1	Point (3160)	--/surface	none	6.2 6.2 6.2 6.3 6.4 6.4	6.3	
110	6004-1	Point (3204)	3/30-40	none	1.2 1.2 1.2 1.2 1.3 1.3	1.2	
111	4014-4	Point (3237)	14/surface	none	3.9 3.9 3.9 3.9 4.1 4.2	4.0	
112	6902-1	Point (3237)	66/10-20	none		DH	
113	01-502	Point (3032)	--/surface	none	5.4 5.4 5.4 5.5 5.6 5.6	5.5	
114	500-31	Point (3170)	--/surface	none	4.1 4.2 4.2 4.2 4.3 4.3	4.2	
115	500-67	Point (3170)	--/surface	none		NVB	
116	4072-1	Point (3170)	U72/surface	none	7.4 7.4 7.4 7.5 7.6 7.6	7.5	
117	500-21	Point (3237)	--/surface	none		NVB	
118	500-23	Point (3238)	--/surface	none		NVB	
119	500-25	Point (3238)	--/surface	none		NVB	
120	1019-5	Point (3190)	U19/surface	none	3.3 3.3 3.3 3.3 3.5 3.5	3.4	
121	4002-21	Point (3032)	U2/	none	1.3 1.3 1.4 1.4 1.4 1.4	1.4	
122	2500-1	Point (3092)	-----	none	1.0 1.0 1.0 1.1 1.1 1.2	1.1	

Lab Accession No.: 90-H979 Technician: Thomas M. Origer

NV-Misc. **Steve Botkin - Intermountain Research** **December 1990**

Lab#	Catalog#	Description	Provenience	Remarks	Readings	Mean	Source
123	510-46	Point (3095)	surface	none	1.3 1.3 1.4 1.4 1.6 1.6	1.4	
124	3011-1	Point (3095)	surface	none	1.3 1.4 1.4 1.6 1.6 1.6	1.5	
125	504-7	Point (3171)	surface	none	1.6 1.6 1.6 1.7 1.7 1.8	1.7	
126	4156-2	Point (3184)	U156/surface	none	1.2 1.2 1.2 1.2 1.3 1.4	1.3	
127	519-12	Point (3095)	surface	none	1.7 1.7 1.7 1.8 1.8 1.9	1.8	
128	103-1	Point (3148)	surface	none	1.7 1.7 1.8 1.8 1.9 1.9	1.8	
129	3006-4	Point (3251)	surface	none	2.4 2.4 2.5 2.5 2.5 2.5	2.5	
130	1018-3	Point (3198)	U18/surface	none	1.8 1.8 1.9 1.9 1.9 1.9	1.9	
131	500-8	Point (3237)	surface	none	4.8 4.9 4.9 5.0 5.0 5.0	4.9	
132	109-1	Point (3154)	surface	none	5.0 5.0 5.1 5.1 5.1 5.3	5.1	
133	500-5	Point (3239)	surface	none	5.3 5.3 5.3 5.3 5.4 5.4	5.3	
134	510-6	Flake Tool (3170)	surface	none	2.4 2.5 2.6 2.6 2.6 2.7	2.6	
135	500-33	Flake Tool (3170)	surface	none		NVB	
136	5069-1	Flake Tool (3184)	U69/surface	none	1.3 1.4 1.4 1.4 1.6 1.6	1.5	
137	3026-1	Flake Tool (3184)	surface	none	3.9 3.9 4.1 4.1 4.2 4.2	4.1	
138	506-2	Flake Tool (3190)	surface	none	7.4 7.4 7.4 7.5 7.6 7.8	7.5	
139	501-17	Flake Tool (3191)	surface	none		NVB	
140	501-7	Flake Tool (3191)	surface	none		NVB	
141	1021-1	Flake Tool (3192)	U21/surface	none	1.0 1.0 1.0 1.0 1.1 1.1	1.0	
142	1001-1	Flake Tool (3201)	U1/surface	none		NVB	
143	510-2	Flake Tool (3095)	surface	none	3.0 3.1 3.2 3.3 3.3 3.3	3.2	
144	6581-3	Flake Tool (3165)	U38/2-10	none	1.2 1.3 1.3 1.3 1.3 1.4	1.3	
145	500-32	Flake Tool (3237)	surface	none	6.4 6.6 6.6 6.6 6.7 6.7	6.6	

Lab Accession No.: 90-H979 Technician: Thomas M. Origer

APPENDIX N

Obsidian Source Characterizations

Richard E. Hughes

February 14, 1991

Dr. Robert G. Elston
Intermountain Research
Drawer 'A'
Silver City, NV 89428

Dear Bob:

Enclosed with this letter you will find copies of ten tables presenting x-ray fluorescence data generated from the analysis of 148 artifacts from the Tosawihi quarries and other sites in the immediate vicinity, Elko County, Nevada. The analyses were conducted pursuant to letter requests from Steve Botkin for IMR project 638-46.

Laboratory investigations were performed on a Spectrace™ 5000 (Tracor X-ray) energy dispersive x-ray fluorescence spectrometer equipped with a Rh x-ray tube, a 50 kV x-ray generator, 1251 pulse processor (amplifier), 1236 bias/protection module, a 100 mHz analog to digital converter (ADC) with automated energy calibration, and a Si(Li) solid state detector with 150 eV resolution (FWHM) at 5.9 keV in a 30 mm^2 area. The x-ray tube was operated at 35.0 kV, .30 mA, using a .127 mm rhodium (Rh) primary beam filter in an air path at 200 seconds livetime to generate x-ray intensity data for the trace elements zinc (Zn Kα), gallium (Ga Kα), rubidium (Rb Kα), strontium (Sr Kα), yttrium (Y Kα), zirconium (Zr Kα) and niobium (Nb Kα). Titanium (Ti Kα), manganese (Mn Kα), and total iron ($Fe_2O_3^T$) intensities were generated by operating the x-ray tube at 15.0 kV, .32 mA, with a .127 mm aluminum (Al) filter in an air path at 300 seconds livetime. Iron vs. manganese (Fe Kα/Mn Kα) ratios were computed from data generated by operating the x-ray tube at 12.0 kV, .30 mA, with a .127 mm Al filter in an air path at 300 seconds livetime. Data processing is executed by a Hewlett Packard Vectra™ microcomputer with operating software and analytical results stored on a Hewlett Packard 20 megabyte fixed disk. Trace element intensities were converted to concentration estimates by employing a least-squares calibration line established for each element from analysis of up to 26 international rock standards certified by the U.S. Geological Survey, the U.S. National Institute of Standards and Technology (formerly National Bureau of Standards), the Geological Survey of Japan, and the Centre de Recherches Petrographiques et Geochimiques (France). Further details pertaining to x-ray tube operating conditions and calibration appear in Hughes (1988).

Trace element values on the enclosed tables are expressed in quantitative units (i.e. parts per million [ppm] by weight), and these were compared directly to values for known obsidian sources that appear in Hughes (1985, 1986, 1990), Jack and Carmichael (1969), Nelson (1984) and Skinner (1983, 1986), and unpublished data in my possession on certain other Nevada obsidians. Artifacts were matched to the profiles of known chemical types of obsidian on the basis of correspondences (at the 2-sigma level) in diagnostic trace element concentration values (i.e., ppm values for Rb, Sr, Y, Zr and, when necessary, Ba, Ti, Mn and $Fe_2O_3^T$ compositions) and/or Fe Kα/Mn Kα ratios. Artifact-to-source (geochemical type) correspondences were considered reliable if diagnostic mean measurements for artifacts fell within 2 standard deviations of mean values for source standards. The term "diagnostic" is used to specify those trace elements that are well-measured by x-ray fluorescence, and whose concentrations show low intra-source variability

and marked variability across sources. Diagnostic elements, then, are those whose concentration values allow one to draw the clearest geochemical distinctions between sources (Hughes 1990). Although Ga and Nb ppm concentrations also were measured and reported for each specimen, they are not considered "diagnostic" because they don't usually vary significantly across obsidian sources (see Hughes 1982, 1984). This is particularly true of Ga, which occurs in concentrations between 10-30 ppm in nearly all sources in the study area. Zn ppm values are infrequently diagnostic; they are always high in Zr-rich, Sr-poor peralkaline volcanic glasses, but otherwise they do not usually vary significantly between non-peralkaline sources.

The trace elemental composition measurements presented in the enclosed tables are reported to the nearest ppm to relect the resolution capabilities of non-destructive energy dispersive x-ray fluorescence spectrometry. The resolution limits of the present x-ray fluorescence instrument for measurement of all elements appears in Hughes (1988) and Hughes and Lees (1991). When counting and fitting error uncertainty estimates (the "±" value in the tables) for a sample are greater than calibration-imposed limits of resolution, the larger number is preferred as a more conservative, robust reflection of elemental composition and measurement error due to variations in sample size, surface and x-ray reflection geometry (see Hughes 1988).

The enclosed data tables present the source attribution for each specimen, so I will not repeat individual artifact-to-source assignments. The majority of samples (71 of 146 [two samples were not obsidian]) match the trace element signature of parent obsidians of the Paradise Valley geochemical type, while 37 samples correspond with the trace element profiles of Browns Bench volcanic glass. As I discussed with you over the telephone, the Browns Bench obsidian is somewhat variable in trace element composition due to the fact that it was formed in a large ash-flow tuff sheet. Such sheets can produce artifact-quality glasses that vary in geochemical composition both horizontally and vertically. I am currently writing a paper with Bob Smith (due to be published later this year in the GSA Special Papers series) which deals with ash-flow tuff glasses (Browns Bench in paricular) from the standpoint of geochemistry and sourcing studies. Other glass types also are represented in the collection, albeit in smaller numbers. Pinto Peak, Bordwell Spring, Fox Mountain and Double H Mountains obsidians occur to the west of Tosawihi while Majuba Mountain and Malad are located, respectively, to the southwest and northeast of the Tosawihi sites. Several "Unknown" chemical types were identified employing supplementary xrf analyses but despite the geochemical coherence of the groupings, I know of no parent source locations for any of them.

Supplementary xrf analyses were conducted on 49 samples to generate barium (Ba), Fe/Mn ratios and Ti, Mn and $Fe_2O_3^T$ data. Ba ppm values appear on the data tables and the other measurements, by sample, follow. 3032.1.502, Fe/Mn =74; 3092.6205.1, Fe/Mn = 66; 3160.1084.1, Fe/Mn = 35; 3170.500.31, Fe/Mn = 60; 3170.510.6, Fe/Mn = 50; 3171.504.7, Fe/Mn = 67; 3198.508.1, Fe/Mn = 71 and 3251.1.10, Fe/Mn = 72. Sample 3092.6285.4: Ti = 467 ± 28 ppm, Mn = 206 ± 24 ppm, $Fe_2O_3^T$ = 1.03 ± .09 %; 3095.6041.1: Ti = 364 ± 24 ppm, Mn = 209 ± 23 ppm, $Fe_2O_3^T$ = 1.07 ± .09 %; 3170.508.3: Ti = 601 ± 23 ppm, Mn = 211 ± 23 ppm, $Fe_2O_3^T$ = 1.25 ± .09 %; 3172.500.7: Ti = 407 ± 23 ppm, Mn = 208 ± 23 ppm, $Fe_2O_3^T$ = 1.18 ± .09 %; 3237.6063.1: Ti = 405 ± 24 ppm, Mn = 198 ± 23 ppm, $Fe_2O_3^T$ = 1.02 ± .09%; 3238.2001.2: Ti = 395 ± 24 ppm, Mn = 193 ± 23 ppm; $Fe_2O_3^T$ = 1.05 ± .09%; 3251.4017.1: Ti = 559 ± 24 ppm, Mn = 197 ± 23 ppm, $Fe_2O_3^T$ = 1.02 ± .09 %; 3251.6183.3: Ti = 405 ± 25 ppm, Mn = 183 ± 23 ppm, $Fe_2O_3^T$ = 1.10 ± .09%; 3251.6422.5: Ti = 697 ± 26 ppm, Mn = 216 ± 23 ppm, $Fe_2O_3^T$ = 1.26 ± .09 %; and 3251.6481.2: Ti = 496 ± 26 ppm, Mn = 219 ± 23 ppm, $Fe_2O_3^T$ = 1.30 ± .09 %.

Overall I am struck by the large number of geochemically distinct obsidians represented in the Tosawihi project-- particularly when compared with the much more limited number represented at James Creek Shelter, a mere 50 km to the southeast. Some (much?) of this might be attributable to differences in sample sizes, site function, and/or time but the differences are noteworthy. Once these Tosawihi data are ordered by artifact class and time period some very interesting patterns may emerge.

Let me know if I can provide further assistance. I will return the samples to you under separate cover.

Sincerely,

Richard

Richard E. Hughes, Ph.D.

encl.

References

Hughes, Richard E.

1982 Age and Exploitation of Obsidian from the Medicine Lake Highland, California. **Journal of Archaeological Science**, Vol. 9 (2): 173-185.

1983 X-ray Fluorescence Characterization of Obsidian. *In* David Hurst Thomas, The Archaeology of Monitor Valley 2. Gatecliff Shelter. **Anthropological Papers of the American Museum of Natural History**, Vol. 59, Part 1, pp. 401-408.

1984 Obsidian Sourcing Studies in the Great Basin: Problems and Prospects. **In** Richard E. Hughes (ed.) Obsidian Studies in the Great Basin. **Contributions of the University of California Archaeological Research Facility**, No. 45, pp. 1-19.

1985 Obsidian Source Use at Hidden Cave. *In* David Hurst Thomas, The Archaeology of Hidden Cave, Nevada. **Anthropological Papers of the American Museum of Natural History**, Vol. 61, Part 1, pp. 332-353.

1986 Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon. **University of California Publications in Anthropology**, Vol. 17.

1988 The Coso Volcanic Field Reexamined: Implications for Obsidian Sourcing and Hydration Dating Research. **Geoarchaeology: An International Journal** 3: 253-265.

References (continued)

Hughes, Richard E. (continued)
1990 Obsidian Sources at James Creek Shelter, and Trace Element Geochemistry of Some Northeastern Nevada Volcanic Glasses. *In* Robert G. Elston and Elizabeth Budy (eds.), The Archaeology of James Creek Shelter, Nevada. **University of Utah Anthropological Papers**, No. 115. In press.

Hughes, Richard E., and William B. Lees
1991 Provenance Analysis of Obsidian from Two Late Prehistoric Archaeological Sites in Kansas. **Transactions of the Kansas Academy of Science**, Vol. 94, Nos. 1-2. In press.

Hughes, Richard E., and Pat Mikkelsen
1986 Trace Element Geochemistry of Obsidian Along the Sycan and Sprague Rivers, Winema National Forest, Oregon. Report on File at the Winema National Forest, Klamath Falls, Oregon.

Jack, R. N., and I.S.E. Carmichael
1969 The Chemical 'Fingerprinting' of Acid Volcanic Rocks. **California Division of Mines and Geology, Special Report** 100: 17-32. San Francisco.

Skinner, Craig
1983 Obsidian Studies in Oregon: An Introduction to Obsidian and an Investigation of Selected Methods of Obsidian Characterization Utilizing Obsidian Collected at Prehistoric Quarry Sites in Oregon. M.A. Thesis in Interdisciplinary Studies, University of Oregon, Eugene.

1986 The Occurrence, Characterization, and Prehistoric Utilization of Geologic Sources of Obsidian in Central Western Oregon: Preliminary Research Results. Manuscript in possession of the author.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
2672.1	72 ±6	21 ±3	225 ±5	46 ±3	64 ±2	443 ±5	46 ±4	---	Browns Bench
3032.23.1.502	200 ±6	25 ±3	208 ±5	0 ±3	96 ±2	532 ±5	32 ±3	---	Pinto Peak or Double H Mtns.
3032.24.01.1	66 ±5	20 ±3	344 ±5	0 ±3	74 ±2	72 ±4	15 ±3	---	Paradise Valley
3032.23.3001.8	46 ±5	19 ±3	252 ±5	21 ±3	67 ±2	365 ±5	46 ±3	---	Browns Bench
3032.23.3001.55	35 ±6	17 ±3	118 ±5	63 ±3	34 ±2	85 ±4	16 ±3	1457 ±15	Unknown A
3032.23.4002.21	68 ±5	21 ±3	362 ±6	1 ±3	83 ±2	71 ±4	14 ±3	---	Paradise Valley
3092.500.2	106 ±6	20 ±3	225 ±5	29 ±3	87 ±2	396 ±5	51 ±4	782 ±13	Browns Bench
3092.2009.2	68 ±5	23 ±3	367 ±5	1 ±3	80 ±2	76 ±4	19 ±3	---	Paradise Valley
3092.2500.1	70 ±6	26 ±3	373 ±6	0 ±3	84 ±2	75 ±4	17 ±4	---	Paradise Valley
3092.2599.13	67 ±5	20 ±3	360 ±6	0 ±3	81 ±2	72 ±4	19 ±3	---	Paradise Valley
3092.6205.1	191 ±6	23 ±6	198 ±5	0 ±3	96 ±2	486 ±5	26 ±3	---	Pinto Peak or Double H Mtns.
3092.6222.1	31 ±5	15 ±3	113 ±5	63 ±3	30 ±2	78 ±4	14 ±3	1225 ±12	Unknown A
3092.6285.4	93 ±8	25 ±4	399 ±7	1 ±3	84 ±3	77 ±4	18 ±4	---	Paradise Valley
3092.6362.1	85 ±7	23 ±4	384 ±6	2 ±3	86 ±3	73 ±4	20 ±4	---	Paradise Valley
3095.500.72	52 ±5	16 ±3	207 ±5	47 ±3	64 ±2	413 ±5	45 ±3	---	Browns Bench
3095.509.5	69 ±5	19 ±3	205 ±5	38 ±3	73 ±2	408 ±5	53 ±4	---	Browns Bench

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3095.510.2	74 ±5	17 ±3	214 ±5	32 ±3	84 ±2	400 ±5	50 ±3	---	Browns Bench
3095.510.3	42 ±5	15 ±3	123 ±5	68 ±3	34 ±2	88 ±4	14 ±3	1411 ±14	Malad, Idaho
3095.510.46	85 ±6	26 ±3	363 ±6	0 ±3	81 ±2	72 ±4	16 ±4	---	Paradise Valley
3095.519.12	43 ±5	15 ±3	127 ±5	70 ±3	35 ±2	87 ±4	15 ±3	1467 ±15	Malad, Idaho
3095.1045.1	58 ±5	22 ±3	356 ±5	0 ±3	79 ±2	73 ±4	17 ±3	---	Paradise Valley
3095.3011.1	81 ±6	22 ±3	347 ±6	0 ±3	81 ±2	71 ±4	16 ±4	---	Paradise Valley
3095.6001.1	71 ±6	23 ±3	348 ±6	0 ±3	77 ±2	74 ±4	16 ±4	---	Paradise Valley
3095.6041.1	81 ±6	30 ±3	401 ±6	1 ±3	87 ±2	79 ±4	18 ±4	---	Paradise Valley
3095.6480.2	52 ±6	20 ±3	160 ±5	22 ±3	18 ±2	79 ±4	21 ±4	28 ±12	Unknown
3116.501.1	60 ±5	21 ±3	339 ±5	0 ±3	75 ±2	69 ±4	15 ±3	---	Paradise Valley
3116.1002.1	72 ±6	23 ±3	379 ±6	0 ±3	79 ±2	76 ±4	16 ±4	---	Paradise Valley
3116.2500.1	66 ±5	23 ±3	347 ±6	0 ±3	75 ±2	69 ±4	14 ±3	---	Paradise Valley
3148.103.1	69 ±5	17 ±3	358 ±6	0 ±3	75 ±2	73 ±4	15 ±3	---	Paradise Valley
3154.109.1	66 ±5	21 ±3	365 ±6	0 ±3	81 ±2	72 ±4	17 ±3	---	Paradise Valley
3160.1.221	71 ±5	19 ±3	363 ±6	0 ±3	83 ±2	78 ±4	20 ±3	---	Paradise Valley
3160.115.1	79 ±5	21 ±3	382 ±6	2 ±3	80 ±2	75 ±4	16 ±3	---	Paradise Valley

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3160.500.107	66 ±5	21 ±3	356 ±6	0 ±3	80 ±2	70 ±4	17 ±3	---	Paradise Valley
3160.500.264	61 ±5	20 ±3	341 ±5	0 ±3	75 ±2	71 ±4	19 ±3	---	Paradise Valley
3160.500.326	64 ±5	19 ±3	334 ±6	0 ±3	81 ±2	69 ±4	16 ±3	---	Paradise Valley
3160.512.13	80 ±6	23 ±3	392 ±6	0 ±3	89 ±2	79 ±4	18 ±4	---	Paradise Valley
3160.1003.4	88 ±6	26 ±3	378 ±6	0 ±3	89 ±2	75 ±4	15 ±4	---	Paradise Valley
3160.1084.1	50 ±6	16 ±3	168 ±5	127 ±3	24 ±2	176 ±4	12 ±3	---	Majuba Mtn.
3160.6081.4	69 ±6	16 ±3	373 ±6	2 ±3	81 ±2	72 ±4	20 ±4	---	Paradise Valley
3160.6083.1	65 ±5	17 ±3	348 ±6	0 ±3	78 ±2	71 ±4	15 ±3	---	Paradise Valley
3160.6641.1	71 ±5	23 ±3	355 ±5	0 ±3	80 ±2	70 ±4	18 ±3	---	Paradise Valley
3165.500.1	63 ±5	21 ±3	338 ±5	0 ±3	80 ±2	70 ±4	15 ±3	---	Paradise Valley
3165.6581.3	67 ±5	19 ±3	363 ±6	0 ±3	80 ±2	74 ±4	16 ±3	---	Paradise Valley
3170.1.44	62 ±5	19 ±3	354 ±5	0 ±3	80 ±2	72 ±4	17 ±3	---	Paradise Valley
3170.500.30	62 ±5	17 ±3	210 ±5	43 ±3	64 ±2	424 ±5	43 ±3	---	Browns Bench
3170.500.31	148 ±6	25 ±3	172 ±5	1 ±3	77 ±2	406 ±5	23 ±3	---	Bordwell Spring
3170.500.33	14 ±11	4 ±4	0 ±3	29 ±3	3 ±2	10 ±4	2 ±4	---	Not obsidian
3170.500.43	89 ±5	19 ±3	227 ±5	32 ±3	86 ±2	417 ±5	54 ±3	---	Browns Bench

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3170.500.44	52 ±5	14 ±3	200 ±5	42 ±3	63 ±2	423 ±5	43 ±3	---	Browns Bench
3170.500.59	70 ±5	23 ±3	353 ±6	0 ±3	78 ±2	71 ±4	14 ±3	---	Paradise Valley
3170.500.67	55 ±5	20 ±3	213 ±5	41 ±3	63 ±2	409 ±5	44 ±3	---	Browns Bench
3170.508.3	65 ±5	13 ±3	276 ±5	0 ±3	73 ±2	74 ±4	15 ±3	---	Paradise Valley
3170.510.6	121 ±5	15 ±3	120 ±5	0 ±3	59 ±2	340 ±4	20 ±3	---	Fox Mtn.?
3170.2002.1	90 ±6	17 ±3	111 ±5	19 ±3	62 ±2	425 ±5	32 ±3	---	Browns Bench
3170.2599.900	43 ±6	20 ±3	211 ±5	25 ±3	29 ±2	96 ±4	13 ±3	134 ±13	Unknown D
3170.4067.1	63 ±5	21 ±3	345 ±5	0 ±3	80 ±2	70 ±4	15 ±3	---	Paradise Valley
3170.4072.1	51 ±5	19 ±3	328 ±6	2 ±3	50 ±2	106 ±4	38 ±3	0 ±10	Unknown E
3170.5077.1	41 ±5	14 ±3	118 ±5	66 ±3	32 ±2	83 ±4	15 ±3	1479 ±14	Unknown A
3170.5078.1	35 ±7	14 ±4	101 ±5	68 ±3	27 ±2	105 ±4	11 ±4	1339 ±15	Unknown A
3171.1.9	38 ±5	15 ±3	187 ±5	36 ±3	26 ±2	103 ±4	25 ±3	147 ±12	Unknown D
3171.500.11	62 ±5	16 ±3	362 ±6	1 ±3	80 ±2	76 ±4	19 ±3	---	Paradise Valley
3171.504.7	190 ±7	23 ±3	183 ±5	0 ±3	97 ±2	491 ±5	28 ±3	---	Pinto Peak or Double H Mtns.
3172.500.6	66 ±5	21 ±3	357 ±6	0 ±3	75 ±2	69 ±4	16 ±3	---	Paradise Valley
3172.500.7	69 ±5	18 ±3	319 ±6	0 ±3	79 ±2	68 ±4	19 ±3	---	Paradise Valley

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3178.502.1	74 ±7	13 ±4	214 ±6	50 ±3	71 ±2	429 ±6	49 ±4	---	Browns Bench
3184.1.2	70 ±5	21 ±3	354 ±5	0 ±3	75 ±2	73 ±4	15 ±3	---	Paradise Valley
3184.500.3	41 ±5	16 ±3	201 ±5	21 ±3	32 ±2	91 ±4	12 ±3	156 ±11	Unknown D
3184.508.5	73 ±5	23 ±3	352 ±5	0 ±3	75 ±2	74 ±4	18 ±3	---	Paradise Valley
3184.1001.9	58 ±5	20 ±3	172 ±5	13 ±3	45 ±2	54 ±4	32 ±3	29 ±11	Timber Butte, Idaho
3184.3026.1	42 ±5	16 ±3	205 ±5	23 ±3	32 ±2	93 ±4	11 ±3	133 ±11	Unknown D
3184.4156.2	45 ±5	17 ±3	206 ±5	30 ±3	30 ±2	114 ±4	14 ±3	358 ±12	Unknown
3184.5069.1	41 ±6	18 ±3	132 ±5	27 ±3	37 ±2	195 ±4	20 ±3	510 ±13	Unknown
3185.16.1	76 ±6	16 ±3	225 ±5	50 ±3	68 ±2	449 ±5	43 ±4	---	Browns Bench
3185.16.2	66 ±5	16 ±3	211 ±5	48 ±3	65 ±2	465 ±5	52 ±3	---	Browns Bench
3189.500.1	60 ±5	17 ±3	194 ±5	39 ±3	73 ±2	401 ±5	52 ±3	---	Browns Bench
3190.506.2	51 ±5	19 ±3	181 ±5	42 ±3	68 ±2	400 ±5	42 ±3	---	Browns Bench
3190.507.1	52 ±5	22 ±3	209 ±5	42 ±3	67 ±2	405 ±5	46 ±3	---	Browns Bench
3190.1019.1	58 ±5	16 ±3	216 ±5	46 ±3	69 ±2	438 ±5	43 ±3	---	Browns Bench
3190.1019.5	66 ±5	17 ±3	241 ±5	20 ±3	71 ±2	358 ±5	46 ±3	---	Browns Bench
3190.1045.1	65 ±6	19 ±3	231 ±5	21 ±3	70 ±2	354 ±5	43 ±3	---	Browns Bench

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3191.501.7	58 ±5	22 ±3	224 ±5	20 ±3	68 ±2	333 ±4	44 ±3	---	Browns Bench
3191.501.12	62 ±5	16 ±3	197 ±5	40 ±3	61 ±2	398 ±5	41 ±3	---	Browns Bench
3191.501.13	64 ±5	16 ±3	225 ±5	18 ±3	65 ±2	338 ±4	44 ±3	---	Browns Bench
3191.501.14	78 ±5	24 ±3	235 ±5	19 ±3	74 ±2	366 ±5	47 ±3	---	Browns Bench
3191.501.17	50 ±5	17 ±3	224 ±5	23 ±3	63 ±2	340 ±5	43 ±3	---	Browns Bench
3191.501.23	50 ±6	14 ±3	195 ±5	39 ±3	64 ±2	389 ±5	44 ±3	---	Browns Bench
3191.501.24	45 ±5	15 ±3	232 ±5	19 ±3	65 ±2	324 ±5	44 ±3	---	Browns Bench
3191.501.25	59 ±5	16 ±3	211 ±5	18 ±3	69 ±2	351 ±5	45 ±3	---	Browns Bench
3191.1004.1	73 ±6	25 ±3	374 ±6	0 ±3	81 ±2	73 ±4	19 ±4	---	Paradise Valley
3192.502.8	61 ±5	14 ±3	100 ±5	149 ±3	26 ±2	92 ±4	8 ±4	1019 ±14	Unknown C
3192.1021.1	57 ±5	22 ±3	103 ±5	134 ±3	28 ±2	85 ±4	13 ±3	887 ±14	Unknown
3192.2061.4	36 ±5	15 ±3	195 ±5	21 ±3	31 ±2	94 ±4	13 ±3	146 ±11	Unknown D
3192.2061.6	47 ±6	24 ±3	214 ±5	24 ±3	34 ±2	105 ±4	10 ±4	182 ±12	Unknown D
3192.2065.7	72 ±5	21 ±3	195 ±5	122 ±3	34 ±2	154 ±4	30 ±3	559 ±11	Unknown
3192.6264.3	37 ±7	10 ±4	132 ±5	178 ±4	15 ±2	159 ±5	10 ±4	893 ±19	Unknown
3198.508.1	220 ±7	23 ±3	210 ±5	0 ±3	97 ±2	509 ±6	30 ±4	---	Pinto Peak or Double H Mtns.

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3198.1003.2	40 ±5	18 ±3	211 ±5	26 ±3	30 ±2	107 ±4	11 ±3	239 ±11	Unknown F
3198.1007.1	36 ±5	14 ±3	199 ±5	26 ±3	27 ±2	105 ±4	12 ±3	221 ±12	Unknown F
3198.1016.1	44 ±5	17 ±3	120 ±5	69 ±3	37 ±2	87 ±4	15 ±3	1548 ±15	Malad, Idaho
3198.1017.2	15 ±34	14 ±6	115 ±6	71 ±4	17 ±3	151 ±5	15 ±4	1060 ±12	Unknown
3198.1018.1	76 ±6	20 ±3	207 ±5	49 ±3	68 ±2	449 ±5	48 ±4	---	Browns Bench
3198.1018.2	63 ±5	16 ±3	207 ±5	45 ±3	66 ±2	449 ±5	43 ±3	---	Browns Bench
3198.1018.3	66 ±5	21 ±3	198 ±5	45 ±3	63 ±2	445 ±5	43 ±3	---	Browns Bench
3198.1025.901	72 ±6	21 ±3	216 ±5	45 ±3	72 ±2	416 ±5	43 ±4	---	Browns Bench
3201.1001.1	50 ±6	19 ±3	205 ±5	44 ±3	64 ±2	443 ±5	42 ±4	---	Browns Bench
3204.500.74	73 ±5	22 ±3	367 ±6	0 ±3	83 ±2	75 ±4	17 ±3	---	Paradise Valley
3204.6004.1	70 ±6	17 ±3	363 ±6	1 ±3	86 ±2	77 ±4	19 ±4	---	Paradise Valley
3231.1001.1	56 ±5	16 ±3	193 ±5	42 ±3	61 ±2	459 ±5	40 ±3	---	Browns Bench
3234.500.3	54 ±5	16 ±3	194 ±5	48 ±3	64 ±2	444 ±5	41 ±3	---	Browns Bench
3237.1.17	66 ±5	22 ±3	328 ±6	0 ±3	76 ±2	68 ±4	15 ±3	---	Paradise Valley
3237.1.18	57 ±5	20 ±3	346 ±6	0 ±3	75 ±2	69 ±4	18 ±3	---	Paradise Valley
3237.1.26	72 ±5	21 ±3	365 ±6	0 ±3	83 ±2	75 ±4	15 ±3	---	Paradise Valley

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3237.500.8	68 ±6	24 ±3	355 ±6	0 ±3	81 ±2	71 ±4	19 ±3	---	Paradise Valley
3237.500.21	60 ±6	20 ±3	211 ±5	40 ±3	67 ±2	407 ±5	44 ±3	---	Browns Bench
3237.500.22	52 ±5	16 ±3	169 ±5	16 ±3	24 ±2	123 ±4	34 ±3	38 ±11	Unknown
3237.500.32	58 ±5	23 ±3	336 ±6	0 ±3	74 ±2	69 ±4	16 ±3	---	Paradise Valley
3237.500.33	78 ±5	22 ±3	361 ±6	0 ±3	80 ±2	70 ±4	18 ±3	---	Paradise Valley
13237.2141.1	89 ±8	23 ±4	359 ±7	0 ±3	77 ±3	74 ±4	16 ±4	---	Paradise Valley
3237.4014.4	69 ±5	20 ±3	342 ±6	1 ±3	77 ±2	72 ±4	17 ±3	---	Paradise Valley
3237.6063.1	82 ±7	31 ±4	393 ±7	0 ±3	82 ±3	77 ±4	18 ±4	---	Paradise Valley
3237.6064.1	73 ±5	21 ±3	358 ±6	1 ±3	81 ±2	71 ±4	18 ±3	---	Paradise Valley
3237.6084.1	67 ±5	17 ±3	353 ±6	1 ±3	79 ±2	69 ±4	18 ±3	---	Paradise Valley
3237.6744.1	66 ±5	22 ±3	341 ±5	0 ±3	76 ±2	69 ±4	15 ±3	---	Paradise Valley
3237.6744.7	68 ±5	22 ±3	339 ±5	0 ±3	76 ±2	69 ±4	18 ±3	---	Paradise Valley
3237.6902.1	73 ±5	22 ±3	360 ±6	1 ±3	78 ±2	74 ±4	18 ±3	---	Paradise Valley
3237.6903.3	77 ±7	24 ±3	367 ±6	2 ±3	80 ±3	77 ±4	16 ±4	---	Paradise Valley
3238.500.23	31 ±5	12 ±3	125 ±5	149 ±3	15 ±2	150 ±4	10 ±3	926 ±12	Unknown B
3238.500.24	49 ±5	14 ±3	151 ±5	109 ±3	23 ±2	156 ±4	13 ±3	911 ±12	Unknown B

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3238.500.25	41 ±8	0 ±4	16 ±5	82 ±3	32 ±2	13 ±5	4 ±4	---	Not obsidian
3238.2001.2	90 ±6	21 ±3	401 ±6	0 ±3	84 ±2	71 ±4	19 ±4	---	Paradise Valley
3239.500.1	77 ±6	16 ±3	364 ±6	0 ±3	80 ±2	71 ±4	16 ±3	---	Paradise Valley
3239.500.5	67 ±5	24 ±3	365 ±6	0 ±3	79 ±2	72 ±4	19 ±3	---	Paradise Valley
3239.501.1	69 ±5	23 ±3	356 ±5	0 ±3	76 ±2	71 ±4	15 ±3	---	Paradise Valley
3239.1001.5	68 ±6	18 ±3	366 ±6	0 ±3	80 ±2	71 ±4	18 ±4	---	Paradise Valley
3251.1.10	211 ±7	25 ±4	216 ±5	3 ±3	104 ±2	538 ±6	29 ±4	---	Double H Mtns.
3251.3006.4	79 ±6	21 ±3	376 ±6	1 ±3	87 ±2	76 ±4	17 ±4	---	Paradise Valley
3251.4017.1	94 ±7	23 ±4	395 ±6	1 ±3	91 ±3	80 ±4	22 ±4	---	Paradise Valley
3251.6065.1	80 ±6	19 ±3	356 ±6	1 ±3	81 ±2	74 ±4	15 ±3	---	Paradise Valley
3251.6183.3	96 ±8	33 ±4	422 ±7	0 ±3	86 ±3	76 ±4	16 ±4	---	Paradise Valley
3251.6185.2	76 ±6	27 ±3	373 ±6	1 ±3	87 ±2	77 ±4	18 ±4	---	Paradise Valley
3251.6442.5	99 ±6	28 ±4	392 ±6	1 ±3	82 ±2	75 ±4	16 ±4	---	Paradise Valley
3251.6481.2	112 ±8	35 ±4	459 ±8	1 ±3	93 ±3	82 ±4	17 ±4	---	Paradise Valley?
3251.6543.1	70 ±5	23 ±3	214 ±5	44 ±3	66 ±2	417 ±5	46 ±3	---	Browns Bench
3271.500.27	74 ±5	20 ±3	353 ±5	0 ±3	84 ±2	75 ±4	15 ±3	---	Paradise Valley

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

Trace Element Concentrations

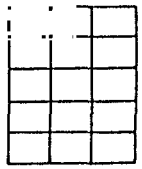
Specimen Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba*	Obsidian Source (Geochemical Type)
3271.500.191	68 ±5	21 ±3	335 ±5	0 ±3	75 ±2	70 ±4	17 ±3	---	Paradise Valley
3271.522.1	81 ±6	20 ±3	253 ±6	5 ±3	72 ±2	101 ±4	44 ±4	8 ±11	Unknown
3271.1046.5	57 ±5	12 ±3	104 ±5	161 ±3	29 ±2	98 ±4	13 ±3	1034 ±14	Unknown C
3271.2021.1	79 ±5	21 ±3	340 ±5	1 ±3	76 ±2	71 ±4	16 ±3	---	Paradise Valley

Trace element values in parts per million (ppm,±=pooled estimate (in ppm) of x-ray counting uncertainty and linear regression fitting error at 200 and 300 (*) seconds livetime.---=not measured.

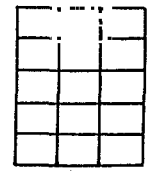
APPENDIX O

Tool Assemblages, by Site and Locus

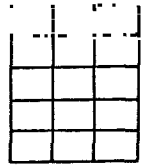
Appendix O. Tool assemblages, by site and locus



			TOOL TYPES												FLAKE TOOLS									
			PROJECTILE POINTS																					
Site	Locality	Locus	Cottonwood	Desert S.N.	Rosegate	Elko	Gatecliff	Humboldt	Large S.N.	Stemmed	Clovis	Out of key	Fragmentary	Cores	Preforms	Scrapers	Pointed tools	Bifacial tools	Retouched flakes	Tool fragments	Notch/denticulate	Crude ret'd. flakes	Microdenticulate	Discoidal tools
3032	4		-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	19		-	-	-	-	-	-	-	-	-	-	-	5	-	8	-	-	5	2	4	3	-	-
3032	20		-	-	-	1	-	-	-	-	-	-	-	4	-	1	-	-	3	1	1	-	-	-
3032	21		-	-	-	-	-	-	-	-	-	-	-	8	-	-	1	-	1	-	-	-	-	-
3032	22		-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-
3032	23		-	-	-	-	-	-	-	3	-	1	2	10	1	4	3	-	6	1	9	2	-	-
3032	24		-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
3032	25		-	-	-	-	-	-	-	-	-	-	-	6	-	2	3	-	5	2	1	-	-	-
3032	26		-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-
3032	28		-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	40		-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
3032	72		-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
3032	93		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	98		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3032	107		-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	138		-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	152		-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	158		-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
3075			-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3082			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3084			-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2	-	-	-	-	-
3085			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3086			-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-



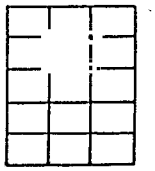
					GROUNDSTONE						CERAMIC WARES			BONE ARTIFACTS						HAMMERSTONES/HEAVY TOOLS				
Site	Locality	Locus	Chopper-hammers	Misc. flake tools	Manos	Metates	Mortars	Pestles	Abraders	Exotics	Brown	Gray	Indet.	Awls	Beads	Misc. tools	Flakers	Scoops	Wedges	Med.& small hammers	Choppers	Scratched stones	Shovels	Large hammers
3032	4		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	19		1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
3032	20		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	21		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	22		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	23		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	-
3032	24		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	25		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-
3032	26		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	28		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	40		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	72		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	93		-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	98		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
3032	107		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	138		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	152		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3032	158		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3075			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3082			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3084			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	1	1
3085			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
3086			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



				BIFACES		TOOL CLASSES						SUMMARY DATA			RESOURCE DISTANCES	
Site	Local-ity	Lo-cus	Mod-ified chunks	Stages 1-3.5	Stages 3.5-5	Quar-ry tools	Weap-ons	Fabricating/ Processing byproducts	tools	General utility tools	Domes-tic equipt.	Type Rich-ness	Class Rich-ness	Assem-blage size	to water (m)	to tool-stone(m)
3032	4		-	-	-	-	1	-	-	-	-	1	1	1	<250	<250
3032	19		-	28	26	-	-	33	12	39	1	11	4	85	<500	<250
3032	20		-	8	11	-	1	12	2	15	-	8	4	30	<500	<250
3032	21		4	4	1	-	-	16	1	2	-	6	3	19	<500	<250
3032	22		-	5	-	-	-	8	-	1	-	3	2	9	<500	<250
3032	23		3	43	14	1	6	57	16	26	-	17	5	106	<500	<250
3032	24		-	-	-	-	-	1	-	-	-	1	1	1		
3032	25		2	67	12	-	-	75	6	24	-	11	3	105	<500	<250
3032	26		-	-	-	-	-	5	-	1	-	2	2	6	<250	<250
3032	28		-	-	-	-	1	-	-	-	-	1	1	1	<250	<250
3032	40		-	-	-	-	1	-	-	-	-	1	1	1	500+	<250
3032	72		-	-	-	-	1	-	-	-	-	1	1	1	<250	<250
3032	93		-	-	-	-	-	-	-	-	1	1	1	1		
3032	98		-	6	2	-	-	6	1	3	-	4	3	10	<500	<250
3032	107		-	-	-	-	1	-	-	-	-	1	1	1	<500	<250
3032	138		-	-	-	-	2	-	-	-	-	2	1	2	<250	<250
3032	152		-	-	-	-	1	-	-	-	-	1	1	1		
3032	158		-	-	-	-	1	-	-	-	-	1	1	1	500+	<250
3075			-	-	-	-	1	-	-	-	-	1	1	1		
3082			-	-	-	-	-	-	-	-	-	-	-	-		
3084			-	2	-	1	-	2	1	6	-	6	4	10	<250	<250
3085			-	-	-	-	-	-	-	2	-	2	1	2	<250	<250
3086			-	4	-	-	-	4	2	-	-	3	2	6	<250	<500

Appendix O. Tool assemblages, by site and locus

			TOOL TYPES												FLAKE TOOLS									
			PROJECTILE POINTS																					
Site	Locality	Locus	Cottonwood	Desert S.N.	Rosegate	Elko	Gatecliff	Humboldt	Large S.N.	Stemmed	Clovis	Out of key	Fragmentary	Cores	Preforms	Scrapers	Pointed tools	Bifacial tools	Retouched flakes	Tool fragments	Notch/ denticulate	Crude ret'd. flakes	Microdenticulate	Discoidal tools
3087			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3088			-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
3090			-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
3091			-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
3092			6	8	2	-	3	2	-	1	-	1	14	13	29	24	13	4	67	21	6	4	2	1
3093			-	-	-	-	-	-	1	-	-	1	-	2	6	-	1	-	2	-	-	-	-	-
3095			5	4	3	2	4	-	-	-	-	5	13	7	17	9	8	2	23	10	3	2	2	-
3096			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3099			-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-
3100			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3101			-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-
3101		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-
3102			-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
3104			-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-
3106			1	-	-	-	-	-	-	-	-	1	-	2	-	3	-	-	-	-	-	-	-	-
3107			-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3110			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3114			-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-
3115			-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	2	-	-	-	-	-
3116			-	2	-	-	-	1	-	-	-	-	3	-	3	3	2	-	2	1	-	-	-	-
3123			-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3125			-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
3142			-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

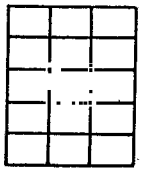


					GROUNDSTONE						CERAMIC WARES			BONE ARTIFACTS						HAMMERSTONES/HEAVY TOOLS				
Site	Local-ity	Lo-cus	Chopper-hammers	Misc. flake tools	Manos	Meta-tes	Mor-tars	Pes-tles	Abra-ders	Exo-tics	Brown	Gray	Indet.	Awls	Beads	Misc. tools	Fla-kers	Scoops	Wedges	Med.& small hammers	Chop-pers	Scrat-ched stones	Sho-vels	Large ham-mers
3087			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3088			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3090			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3091			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3092			3	2	-	7	1	-	1	-	3	2	-	1	1	1	1	-	-	18	4	-	-	-
3093			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3095			-	-	1	11	-	1	3	14	-	-	-	-	-	-	-	-	-	9	2	1	-	1
3096			-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-
3099			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
3100			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3101			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3101		1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3102			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3104			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
3106			-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-
3107			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3110			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3114			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
3115			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3116			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3123			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3125			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3142			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site	Locality	Locus	Modified chunks	BIFACES Stages 1-3.5	BIFACES Stages 3.5-5	TOOL CLASSES Quarry tools	Weapons	Fabricating/ Processing byproducts	tools	General utility tools	Domestic equipt.	SUMMARY DATA Type Richness	Class Richness	Assemblage size	RESOURCE DISTANCES to water (m)	to toolstone(m)
3087			-	4	-	-	-	4	-	-	-	1	1	4	<250	<250
3088			-	2	-	-	-	2	1	-	-	2	2	3	<250	<250
3090			-	2	2	-	-	2	1	2	-	3	3	5	<250	<250
3091			-	2	1	-	-	3	-	1	-	3	2	4	<250	<250
3092			7	196	161	-	37	245	48	286	14	35	5	630	<250	<250
3093			-	7	22	-	2	15	1	25	-	9	4	43	<250	<500
3095			4	162	212	1	36	190	26	260	27	29	6	540	<250	<500
3096			1	10	1	-	-	11	-	4	1	6	3	16	<250	<500
3099			-	1	5	-	1	2	-	7	-	6	3	10	<250	<250
3100			1	-	-	-	-	1	-	-	-	1	1	1	500+	<250
3101			-	3	11	-	1	3	1	12	-	5	4	17	<500	<250
3101		1	1	2	2	-	-	3	1	3	-	5	3	7	<500	<250
3102			1	6	5	-	1	7	-	6	-	5	3	14	<500	<250
3104			1	-	5	-	-	5	-	7	-	5	2	12	500+	<250
3106			1	28	16	-	2	31	4	17	1	10	5	55	500+	<250
3107			-	3	1	-	1	3	-	2	-	4	3	6	<500	<250
3110			-	-	1	-	-	-	-	1	-	1	1	1	<500	<500
3114			-	4	2	-	1	4	2	3	-	6	4	10	<500	500+
3115			-	3	3	-	-	3	2	5	-	5	3	10	<500	<500
3116			-	1	5	-	6	4	5	8	-	10	4	23	<500	<500
3123			-	-	-	-	1	-	-	-	-	1	1	1		
3125			-	-	-	-	1	-	-	-	-	1	1	1		
3142			-	-	-	-	1	-	-	-	-	1	1	1		

Appendix O. Tool assemblages, by site and locus

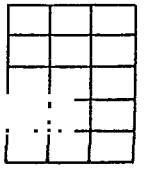
			TOOL TYPES																					
			PROJECTILE POINTS												FLAKE TOOLS									
Site	Locality	Locus	Cottonwood	Desert S.N.	Rosegate	Elko	Gatecliff	Humboldt	Large S.N.	Stemmed	Clovis	Out of key	Fragmentary	Cores	Preforms	Scrapers	Pointed tools	Bifacial tools	Retouched flakes	Tool fragments	Notch/denticulate	Crude ret'd. flakes	Microdenticulate	Discoidal tools
3144			-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
3148			-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
3149			-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	3	-	1	-	-	-
3154			-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-
3155			-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
3160			1	-	3	8	2	1	1	1	-	1	4	1	10	6	4	-	10	6	1	-	-	-
3160		A	6	4	1	3	-	-	-	-	-	-	12	1	27	3	6	1	9	8	1	-	-	-
3160		B	-	-	-	-	-	-	-	-	-	1	-	-	2	1	1	-	-	-	-	-	-	-
3160		C	1	3	2	-	-	-	-	-	-	-	3	-	12	2	4	1	7	4	3	-	1	-
3162			-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
3165			-	-	-	-	-	-	-	-	-	-	3	-	2	-	-	-	2	-	2	-	1	-
3165		A	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4	1	-	-	-	-
3171			-	1	-	-	-	-	-	-	-	1	-	8	4	4	2	-	4	2	-	-	-	4
3172			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3173			-	-	-	-	-	-	-	-	-	-	2	1	-	2	-	1	1	-	-	-	-	-
3174			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3175			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3177			-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
3178			-	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
3179			-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	1	-	-	-	-
3180			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3181			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	-
3183			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



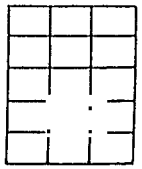
				GROUNDSTONE							CERAMIC WARES			BONE ARTIFACTS						HAMMERSTONES/HEAVY TOOLS				
Site	Locality	Locus	Chopper-hammers	Misc. flake tools	Manos	Metates	Mortars	Pestles	Abraders	Exotics	Brown	Gray	Indet.	Awls	Beads	Misc. tools	Flakers	Scoops	Wedges	Med.& small hammers	Choppers	Scratched stones	Shovels	Large hammers
3144			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3148			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3149			-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3154			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3155			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3160			-	-	-	7	2	2	-	1	-	-	-	-	-	-	-	-	-	1	2	-	-	-
3160		A	2	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
3160		B	-	-	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3160		C	-	2	2	1	-	-	1	-	-	-	-	-	-	-	-	-	-	4	2	1	1	-
3162			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3165			-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3165		A	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3171			-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	1	-	-
3172			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3173			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3174			-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3175			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3177			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
3178			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3179			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3180			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3181			-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
3183			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site	Locality	Locus	Modified chunks	BIFACES Stages 1-3.5	BIFACES Stages 3.5-5	TOOL CLASSES Quarry tools	Weapons	Fabricating/ Processing byproducts	tools	General utility tools	Domestic equipt.	SUMMARY DATA Type Richness	Class Richness	Assemblage size	RESOURCE DISTANCES to water (m)	to toolstone(m)
3144			-	-	-	-	1	-	-	-	-	1	1	1		
3148			-	-	-	-	1	-	-	-	-	1	1	1		
3149			-	5	3	-	3	5	1	7	2	8	5	18	<250	<500
3154			-	-	-	-	1	-	-	-	-	1	1	1		
3155			-	-	-	-	-	1	-	-	-	1	1	1		
3160			1	59	345	-	22	71	11	364	12	25	5	480	<500	<500
3160		A	-	24	66	-	26	52	10	87	2	19	5	177	<500	<500
3160		B	1	4	11	-	1	7	2	11	3	10	5	24	<500	500+
3160		C	2	31	95	-	9	45	12	116	3	23	5	185	<500	<500
3162			-	-	-	-	1	-	-	-	-	1	1	1		
3165			1	14	35	-	3	17	3	37	3	9	5	63	500+	500+
3165		A	-	7	12	-	-	8	-	17	1	6	3	26	500+	500+
3171			6	34	52	-	2	52	7	64	2	16	5	127	<250	<250
3172			-	1	5	-	-	1	-	5	-	2	2	6	<250	<250
3173			-	3	5	-	2	4	2	7	-	7	4	15	<250	<500
3174			-	-	1	-	-	-	-	1	1	2	2	2	<500	<500
3175			-	-	-	-	-	-	-	-	-	-	-	-		
3177			-	2	1	-	2	2	-	2	-	4	3	6	<250	<250
3178			1	6	4	-	3	7	-	4	-	5	3	14	<250	<250
3179			-	-	2	-	-	-	2	3	-	3	2	5	<250	<250
3180			-	-	-	-	-	-	-	-	-	-	-	-		
3181			-	1	4	-	-	1	-	9	2	6	3	12	<500	<250
3183			-	-	3	-	-	-	-	3	-	1	1	3	<500	<250

Appendix O. Tool assemblages, by site and locus



			TOOL TYPES																					
			PROJECTILE POINTS												FLAKE TOOLS									
Site	Locality	Locus	Cottonwood	Desert S.N.	Rosegate	Elko	Gatecliff	Humboldt	Large S.N.	Stemmed	Clovis	Out of key	Fragmentary	Cores	Preforms	Scrapers	Pointed tools	Bifacial tools	Retouched flakes	Tool fragments	Notch/denticulate	Crude ret'd. flakes	Microdenticulate	Discoidal tools
3184			1	1	-	2	-	-	1	-	-	1	1	9	6	16	5	-	34	11	8	1	-	-
3185			2	3	-	-	-	-	-	-	-	1	2	-	4	7	-	2	3	-	1	-	-	-
3186			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3189			-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
3190			-	2	-	-	-	-	-	-	-	1	6	2	2	4	4	-	6	3	-	-	-	-
3191			-	-	-	-	-	-	-	-	-	-	1	1	-	1	-	-	4	-	-	-	-	-
3192			1	4	-	-	-	1	-	1	-	-	9	4	4	25	4	1	31	5	1	-	-	-
3193			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
3195			-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	1
3196			-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-
3197			-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
3198			4	4	-	-	1	2	-	-	-	-	16	7	15	2	1	1	5	4	-	-	-	-
3200			-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
3201			-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
3202			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3203			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3204			-	-	2	-	-	-	1	-	-	-	3	2	5	3	5	-	9	1	3	-	-	-
3207			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3208			-	-	-	-	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-
3228			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3231			-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
3232			-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
3234			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

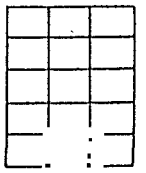


				GROUNDSTONE							CERAMIC WARES			BONE ARTIFACTS						HAMMERSTONES/HEAVY TOOLS				
Site	Locality	Locus	Chopper-hammers	Misc. flake tools	Manos	Metates	Mortars	Pestles	Abraders	Exotics	Brown	Gray	Indet.	Awls	Beads	Misc. tools	Flakers	Scoops	Wedges	Med.& small hammers	Choppers	Scratched stones	Shovels	Large hammers
3184			1	-	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	3	1	-	-	-
3185			-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-
3186			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3189			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3190			-	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3191			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3192			1	1	2	5	-	-	-	1	1	-	-	-	-	-	-	-	-	4	-	2	-	-
3193			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
3195			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	2
3196			-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	-
3197			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-
3198			-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	2	-	-	-	-
3200			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-
3201			-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	1	-	-
3202			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3203			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3204			-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	1	-	-
3207			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3208			1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	4	1	1	-	-
3228			-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3231			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3232			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3234			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Site	Locality	Locus	Modified chunks	BIFACES Stages 1-3.5	Stages 3.5-5	TOOL CLASSES Quarry tools	Weapons	Fabricating/ Processing byproducts	tools	General utility tools	Domestic equipt.	SUMMARY DATA Type Richness	Class Richness	Assemblage size	RESOURCE DISTANCES to water (m)	to toolstone(m)
3184			5	74	165	-	7	94	30	216	2	23	5	349	<500	<250
3185			-	15	4	-	8	19	9	11	1	14	5	48	<250	<250
3186			-	-	1	-	-	-	-	1	-	1	1	1	<250	<250
3189			-	1	-	-	-	2	-	-	-	2	1	2	<250	<250
3190			-	29	15	-	9	33	9	24	1	13	5	76	<250	<250
3191			-	2	1	-	1	3	1	5	-	6	4	10	<250	<250
3192			4	86	89	-	16	98	32	132	9	24	5	287	<250	<250
3193			-	10	10	-	-	10	1	11	-	4	3	22	<250	<250
3195			-	23	12	2	-	23	3	17	-	6	4	45	<250	<250
3196			4	17	2	-	-	21	2	11	1	7	4	35	<250	<250
3197			-	26	2	-	-	26	1	8	-	4	3	35	<250	<250
3198			-	20	41	-	27	42	4	53	1	17	5	127	<250	<250
3200			-	7	2	1	-	7	1	4	-	6	4	13	<500	<250
3201			-	19	8	-	-	19	2	12	2	7	4	35	<250	<250
3202			-	2	1	-	-	2	-	1	-	2	2	3	<500	<250
3203			2	5	-	-	-	7	-	-	-	2	1	7	<500	<250
3204			6	55	18	-	6	68	12	36	1	16	5	123	<500	<250
3207			-	-	-	-	-	-	-	-	-	-	-	-		
3208			-	-	-	-	1	-	3	6	1	7	4	11	<250	<250
3228			-	2	5	-	-	2	-	5	1	3	3	8	<250	<250
3231			-	-	1	-	1	1	-	1	-	3	3	3	<250	<250
3232			-	5	-	-	-	6	-	-	-	2	1	6	<250	<250
3234			-	2	-	-	-	2	-	-	-	1	1	2	<250	<250

Appendix O. Tool assemblages, by site and locus

			TOOL TYPES																					
			PROJECTILE POINTS												FLAKE TOOLS									
Site	Locality	Locus	Cottonwood	Desert S.N.	Rosegate	Elko	Gatecliff	Humboldt	Large S.N.	Stemmed	Clovis	Out of key	Fragmentary	Cores	Preforms	Scrapers	Pointed tools	Bifacial tools	Retouched flakes	Tool fragments	Notch/denticulate	Crude ret'd. flakes	Microdenticulate	Discoidal tools
3237			-	-	1	-	1	-	1	1	-	1	2	2	2	2	-	-	1	1	-	-	-	-
3237		A	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
3237		B	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3237		C	1	7	1	7	2	3	2	1	1	1	9	2	15	4	5	2	6	4	2	-	-	-
3238			-	-	-	-	1	-	1	2	-	-	1	1	-	1	-	-	-	-	-	-	-	-
3238		A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3239			-	-	1	1	-	-	-	-	-	-	-	-	3	1	2	-	-	-	-	-	-	1
3251			1	2	6	-	1	2	-	-	-	3	30	-	63	4	9	-	8	16	1	-	-	-
3262			-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
3271			-	2	5	1	-	-	1	-	-	-	6	2	3	1	8	-	1	-	-	-	-	-
3271		A	-	-	-	-	-	-	-	-	-	-	2	1	-	2	-	-	1	-	1	-	-	-
3271		B	-	-	3	-	-	1	-	-	-	-	1	3	4	4	-	1	9	2	3	-	-	1
3271		C	-	-	-	-	-	-	-	-	-	-	1	-	3	-	2	1	3	2	1	-	-	-
3170			1	3	-	-	1	-	-	2	-	-	1	3	4	8	5	3	9	2	3	1	-	2
3170		A	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	1	2	-	-	-	-
3170		B	-	-	-	-	-	-	-	1	-	-	1	-	1	3	-	-	2	1	3	-	-	-



					GROUNDSTONE						CERAMIC WARES			BONE ARTIFACTS						HAMMERSTONES/HEAVY TOOLS				
Site	Locality	Locus	Chopper-hammers	Misc. flake tools	Manos	Metates	Mortars	Pestles	Abraders	Exotics	Brown	Gray	Indet.	Awls	Beads	Misc. tools	Flakers	Scoops	Wedges	Med.& small hammers	Choppers	Scratched stones	Shovels	Large hammers
3237			-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-
3237		A	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3237		B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3237		C	-	-	-	6	-	-	-	1	-	-	-	-	-	-	-	-	-	3	2	-	-	-
3238			-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3238		A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3239			-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	3	-	-	-
3251			-	-	6	11	-	-	1	-	1	-	-	1	-	-	-	-	-	1	1	-	-	-
3262			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3271			1	-	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	5	4	1	-	-
3271		A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
3271		B	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	3	1	-	-
3271		C	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-
3170			-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	-	-	-
3170		A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3170		B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

				BIFACES		TOOL CLASSES						SUMMARY DATA			RESOURCE DISTANCES	
Site	Locality	Locus	Modified chunks	Stages 1-3.5	Stages 3.5-5	Quarry tools	Weapons	Fabricating/ Processing byproducts	tools	General utility tools	Domestic equipt.	Type Richness	Class Richness	Assemblage size	to water (m)	to toolstone(m)
3237			1	19	32	-	7	24	2	37	1	17	5	71	<250	<250
3237		A	-	1	2	-	2	1	1	2	1	6	5	7	<250	<250
3237		B	1	-	-	-	1	1	-	-	-	2	2	2	<250	<250
3237		C	1	44	62	-	35	62	11	79	7	26	5	194	<250	<250
3238			-	13	16	-	5	14	1	17	1	10	5	38	<250	<250
3238		A	-	-	-	-	-	-	-	-	-	-	-	-		
3239			-	7	17	-	2	10	3	23	1	11	5	39	<250	<250
3251			-	39	51	-	45	102	16	77	18	22	5	258	<250	<250
3262			-	-	-	-	-	1	-	-	-	1	1	1		
3271			1	76	94	-	15	82	10	105	4	20	5	216	<250	<500
3271		A	-	15	12	-	2	16	3	14	-	8	4	35	<250	<500
3271		B	1	42	43	-	5	50	8	60	1	18	5	124	<250	<500
3271		C	-	9	6	-	1	12	3	14	1	12	5	31	<250	<500
3170			3	99	58	-	8	109	16	79	2	22	5	214	<500	<250
3170		A	-	2	3	-	1	2	1	6	-	6	4	10	<500	<250
3170		B	-	7	8	-	2	8	6	11	-	9	4	27	<500	<250

APPENDIX P

Provenience of Illustrated Artifacts

Appendix P. Provenience of Illustrated Artifacts

	Figure No.		Site/Locality	Reference Number	Specimen Number
Chapter 6. Bifaces					
	6.2	a.	26Ek3192	1010	009
		b.	26Ek3192	2022	012
		c.	26Ek3092	8265	007 refit w/8424-001
	6.3	a.	number unavailable		
		b.	number unavailable		
		c.	number unavailable		
	6.4	a.	26Ek3160	6280	001
		b.	26Ek3106	1052	001
		c.	number unavailable		
	6.5	a.	26Ek3115	1001	005 refit w/501-001
		b.	26Ek3160	501	017 refit w/2001-003
	6.6	a.	26Ek3160	01	083
		b.	26Ek3093	1029	001
		c.	26Ek3101	500	016
		d.	26Ek3271	1022	009
		e.	26Ek3160	523	001
		f.	26Ek3237	8802	002
		g.	26Ek3160	500	226
		h.	26Ek3271	1044	006
		i.	26Ek3271	500	132
		j.	26Ek3160	500	018
		k.	26Ek3160	500	169
		l.	number unavailable		
	6.7	a.	26Ek3197	505	003
		b.	26Ek3192	1010	003
		c.	26Ek3192	2022	014
	6.10	a.	26Ek3237	500	022
		b.	26Ek3160	500	107
		c.	26Ek3092	6205	001
		d.	26Ek3170	508	003
		e.	26Ek3238	500	024
		f.	26Ek3170	500	044
		g.	26Ek3170	500	043
		h.	26Ek3192	501	014
		i.	26Ek3192	2061	004
		j.	26Ek3184	1001	009
	6.11.		26Ek3237	500	022
	6.12	a.	26Ek3095	1081	001
		b.	26Ek3095	2082	003
		c.	26Ek3095	2082	001
		d.	26Ek3095	2081	001

Appendix P, continued.

Figure No.		Site/Locality	Reference Number	Specimen Number
6.13	a.	26Ek3170	4501	005
	b.	26Ek3170	4501	001
	c.	26Ek3170	4501	007
	d.	26Ek3170	4501	008
6.15	a.	26Ek3192	2022	014
	b.	26Ek3192	1010	003
	c.	26Ek3197	505	003
6.16	a.	26Ek3192	2022	009
	b.	26Ek3197	2001	002
	c.	26Ek3192	1010	006
	d.	26Ek3197	2001	010
Chapter 7. Flake Tools				
7.1	a.	26Ek3184	4137	001
	b.	26Ek3092	2041	004
	c.	26Ek3197	2001	014
7.2	a.	26Ek3095	511	010
	b.	26Ek3184	1067	001
	c.	26Ek3192	6101	001
	d.	26Ek3195	1005	001
	e.	26Ek3192	6541	001
	f.	26Ek3086	500	001
	g.	26Ek3185	1013	002
7.3	a.	26Ek3095	2022	011
	b.	26Ek3192	6600	002
	c.	26Ek3032/27	6002	004
	d.	26Ek3192	502	035
7.4	a.	26Ek3204	9006	001
	b.	26Ek3184	6062	001
	c.	26Ek3092	6265	005
	d.	26Ek3160	6521	002
	e.	26Ek3271	500	306
	f.	26Ek3192	1022	003
	g.	26Ek3271	500	095
	h.	26Ek3170	500	020
	i.	26Ek3160	500	128
	j.	26Ek3160	512	012
	k.	26Ek3092	2006	003
	l.	26Ek3095	519	001
7.5	a.	26Ek3271	503	001
	b.	26Ek3237	6842	001
	c.	26Ek3237	6322	002
	d.	26Ek3271	500	263
	e.	26Ek3237	4011	001
	f.	26Ek3032/27	01	119

Appendix P, continued.

Figure No.		Site/Locality	Reference Number	Specimen Number
7.6	a.	26Ek3032/98	4004	001
	b.	26Ek3271	1042	003
	c.	26Ek3160	504	002
	d.	26Ek3086	500	006
	e.	26Ek3095	1081	002
7.7	a.	26Ek3032/27	01	030
	b.	26Ek3185	506	004
	c.	26Ek3170	01	028
	d.	26Ek3160	1007	006
	e.	26Ek3160	517	006
	f.	26Ek3102	500	003
7.8	a.	26Ek3092	6683	009
	b.	26Ek3160	01	195
	c.	26Ek3092	6262	006
	d.	26Ek3095	1029	007
	e.	26Ek3271	503	003
	f.	26Ek3181	1010	002
	g.	26Ek3192	1055	007
	h.	26Ek3092	6082	009
	i.	26Ek3192	2121	009
	j.	26Ek3184	4109	008
	k.	26Ek3160	9020	010
	l.	26Ek3170	4062	004
	m.	26Ek3184	4141	003
	n.	26Ek3092	6163	007
	o.	26Ek3184	3010	009
	p.	26Ek3160	6061	010
7.9	a.	26Ek3239	500	101
	b.	26Ek3092	8382	006
	c.	26Ek3195	2599	084
7.10	a.	26Ek3092	6186	004
	b.	26Ek3160	4072	006
	c.	26Ek3165	4069	003
	d.	26Ek3095	7181	005
	e.	26Ek3095	7200	003
7.11	a.	26Ek3208	2599	013
	b.	26Ek3032/19	4001	016
7.12	a.	26Ek3192	2121	012
	b.	26Ek3160	6521	002
	c.	26Ek3192	6521	009
	d.	26Ek3190	1050	002
	e.	26Ek3192	2101	009
	f.	26Ek3192	6522	003
	g.	26Ek3092	6081	004

Appendix P, continued.

Figure No.		Site/Locality	Reference Number	Specimen Number
Chapter 8. Projectile Points and Preforms				
8.1	a.	26Ek3271	500	270
	b.	26Ek3184	524	002
	c.	26Ek3184	103	001
	d.	26Ek3107	500	002
	e.	26Ek3032/72	66	009
8.3	a.	26Ek3107	500	002
	b.	26Ek3237	6761	002
	c.	26Ek3032/27	01	045
	d.	26Ek3192	502	020
	e.	26Ek3032	01	001
	f.	26Ek3032/138	53	018
	g.	26Ek3032/152	3000	001
	h.	26Ek3092	6421	004
	i.	26Ek3032/23	01	501
8.4	a.	26Ek3238	500	037
	b.	26Ek3184	524	002
	c.	26Ek3271	500	027
	d.	26Ek3092	6606	002
	e.	26Ek3198	1007	902
	f.	26Ek3237	6881	901
	g.	26Ek3192	2203	002
	h.	26Ek3251	505	001
8.5	a.	26Ek3095	6941	001
	b.	26Ek3095	01	004
	c.	26Ek3198	500	004
	d.	26Ek3095	500	008
	e.	26Ek3160	01	103
	f.	26Ek3142	97	001
	g.	26Ek3237	6401	001
	h.	26Ek3032/27	6062	002
	i.	26Ek3238	500	001
	j.	26Ek3237	01	022
	k.	26Ek3160	500	131
	l.	26Ek3184	45	001
	m.	26Ek3237	6322	001
	n.	26Ek3231	4629	001
	o.	26Ek3160	500	266
	p.	26Ek3095	510	019
	q.	26Ek3237	9084	001
	r.	26Ek3237	01	029
8.6	a.	26Ek3271	500	146
	b.	26Ek3251	1022	003
	c.	26Ek3204	2002	001
	d.	26Ek3160	500	103
	e.	26Ek3092	8266	002
	f.	26Ek3251	4015	002
	g.	26Ek3251	4018	001
	h.	26Ek3271	500	301

Appendix P, continued.

Figure No.		Site/Locality	Reference Number	Specimen Number
8.6, cont.	i.	26Ek3160	517	001
	j.	26Ek3237	01	002
	k.	26Ek3160	1009	002
	l.	26Ek3095	01	002
	m.	26Ek3271	1050	001
	n.	26Ek3237	500	056
	o.	26Ek3160	500	310
	p.	26Ek3237	1544	001
8.7	a.	26Ek3092	01	001
	b.	26Ek3198	6101	003
	c.	26Ek3271	500	089
	d.	26Ek3092	6786	001
	e.	26Ek3095	7240	001
	f.	26Ek3092	6362	002
	g.	26Ek3095	510	038
	h.	26Ek3198	503	002
	i.	26Ek3170	2001	001
	j.	26Ek3092	2024	002
	k.	26Ek3095	2023	001
	l.	26Ek3185	1004	002
	m.	26Ek3171	505	002
	n.	26Ek3237	6742	001
	o.	26Ek3237	6701	001
	p.	26Ek3237	6721	001
	q.	26Ek3237	6741	003
	r.	26Ek3237	6722	001
	s.	26Ek3092	6104	001
	t.	26Ek3237	6820	001
	u.	26Ek3092	6822	005
	v.	26Ek3090	8263	001
	w.	26Ek3160	8542	007
	x.	26Ek3061	6541	005
	y.	26Ek3160	6081	008
	z.	26Ek3198	1017	001
	aa.	26Ek3184	503	028
	bb.	26Ek3160	1003	004
	cc.	26Ek3185	1003	002
8.10	a.	26Ek3192	9021	002
	b.	26Ek3095	7121	003
	c.	26Ek3160	4069	002
	d.	26Ek3160	4045	005
	e.	26Ek3095	3010	001
	f.	26Ek3184	4132	001
	g.	26Ek3271	1028	003
	h.	26Ek3093	1011	002
	i.	26Ek3093	505	011
	j.	26Ek3251	6121	007
	k.	26Ek3170	500	061
	l.	26Ek3192	1009	004
	m.	26Ek3185	1009	001
	n.	N14	2674	001

Appendix P, continued.

Figure No.		Site/Locality	Reference Number	Specimen Number
8.10, cont.	o.	26Ek3185	1010	010
	p.	26Ek3160	520	001
	q.	26Ek3093	503	003
Chapter 9. Cores and Modified Chunks				
9.1	a.	26Ek3160	517	016
	b.	26Ek3095	1025	002
	c.	26Ek3190	500	016
	d.	number unavailable		
9.2	a.	26Ek3093	505	007
	b.	26Ek3095	519	021
	c.	26Ek3093	505	013
9.3	a.	26Ek3184	500	003
	b.	26Ek3237	01	026
	c.	26Ek3170	500	030
	d.	26Ek3032/27	01	183
	e.	26Ek3095	1045	001
	f.	26Ek3092	6222	001
	g.	26Ek3192	2065	007
	h.	26Ek3032/24	-	001
	i.	26Ek3271	2021	001
9.4	a.	26Ek3170	2599	900
	b.	26Ek3032/24	-	001
Chapter 11. Hammerstones and Additional Cobble Tools				
11.1.	a.	26Ek3208	2500	003
	b.	26Ek3032/25	01	005
	c.	26Ek3095	3019	008
	d.	26Ek3095	514	003
11.2.		26Ek3204	2599	001
11.4.		26Ek3237	01	006
11.5.	a.	26Ek3237	6702	001
	b.	26Ek3251	500	200
	c.	26Ek3092	8364	001
	d.	26Ek3251	1009	001
11.6		26Ek3160	1001	001
12.1	a.	26Ek3251	501	004
	b.	26Ek3160	1005	002
	c.	26Ek3160	501	002
	d.	26Ek3170	500	005
12.2.		26Ek3095	1023	001
12.4	a.	26Ek3160	500	053
	b.	26Ek3160	01	208

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Figure No.		Site/Locality	Reference Number	Specimen Number
12.5	a.	26Ek3095	1025	001
	b.	26Ek3198	1003	001
	c.	26Ek3160	515	001
12.8	a.	26Ek3160	500	031
	b.	26Ek3237	2142	001
	c.	26Ek3095	1001	003
	d.	26Ek3192	502	010
	e.	26Ek3184	2021	020
13.1	a.	26Ek3192	6521	002
	b.	26Ek3092	6663	002
	c.	26Ek3160	4027	001
	d.	26Ek3192	6541	005
13.2	a.	26Ek3192	6141	002
	b.	26Ek3160	4042	002
	c.	26Ek3092	6662	006
14.2	a.	26Ek3092	9085	005
	b.	26Ek3092	8382	001
	c.	26Ek3092	6403	006
	d.	26Ek3208	2599	019
Chapter 21. Reduction Trajectories				
21.10		26Ek3184	6001	002
21.11		26Ek3184	4094	001
21.12		26Ek3160	501	017 refit w/2001-003