DOLORES ARCHAEOLOGICAL PROGRAM TECHNICAL REPORTS

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Additive Technologies Group Midlevel Research Design

by

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ABSTRACT

The Additive Technologies Group of the Dolores Archaeological Program is responsible for analyses of ceramic and worked vegetal artifacts. Preliminary analyses are carried out on items of each material class to provide descriptive data for field reports and for inventory control. Ceramic data include temper classification and technological attributes as well as typological affiliation and vessel form. Descriptions of worked vegetal artifacts include both material identifications and technological attributes. Ceramic data are maintained in a computer file, but vegetal descriptions are kept as paper records. Intensive analyses are also carried out on subsets of these material classes to provide data for specific research problems.

Both the preliminary and intensive analyses are designed to satisfy the data needs of the program research design. Economy and adaptation are evaluated in terms of patterns of resource use as contrasted with resource availability, ceramic and basketry manufacturing technology, the use of ceramic vessels, and evidence of the organizational aspects of ceramic production. Ceramic data are being investigated as proxy measures of human population and site occupation duration, and they provide evidence for instances of immigration into the project area. Studies of social organization include interaction measures based on local exchange of ceramics and on the evaluation of the distribution patterns of "higher cost" ceramics between sites and households. Foreign interactions are studied through ceramic exchange patterns both within and without the Mesa Verde region, and ceramic dating using typology, regression, and seriation provides the temporal control for studies of culture process.

INTRODUCTION

Whether explicitly or implicitly, all archaeological investigations are conducted within the framework of research designs. These designs consist of problem statements, theoretical orientations, methods of data collection and manipulation, and logical structures of inference which relate data back to the original problems. Explicit presentations of research designs allow independent assessment of the strength and appropriateness of archaeological inferences and conclusions. Also, explicit research designs are invaluable planning tools, providing step-by-step frameworks for data selection, collection, and manipulation. This is especially true in mitigation archaeology where sampling decisions, both in regard to field collection and laboratory analysis, become more critical in the face of the imminent destruction of archaeological resources.

The guiding framework of DAP (Dolores Archaeological Program) research is provided by the general research design (Kane et al. 1981). This document establishes a broad series of research goals and a generalized research structure for the program as a whole. Specific portions of the general research design are currently being elaborated as part of a coordinated modeling effort (Lipe 1981, 1982) which is more detailed in terms of both problem definition and proposed methods of investigation. Both the general research design and the modeling effort are synthetic in approach, integrating diverse categories of archaeological data in specific studies. Data generation, however, is partitive in that analyses of various archaeological materials are the responsibilities of administratively separate analysis groups (Additive Technologies Group, Reductive Technologies Group, and Environmental Archaeology Group).

Administrative responsibility for ceramic materials and for worked vegetal artifacts (primarily basketry) lies with the ATG (Additive Technologies Group). The ATG carries out analyses in support of descriptive reporting, as well as in support of a subset of the problems stated in the program research design and of those devolving from the modeling effort. These analyses are described in the following analysis group research design which outlines specific problems chosen for study, the theoretical biases adopted, and the methods used to gather appropriate data. Although this document has been produced at the approximate midpoint of the analysis program, aspects of its content have undergone minimal change since the design of the original analysis system (Lucius 1978). Other aspects of this design reflect current research developments within the DAP as a whole, and although this research design is intended to be as comprehensive as possible, future changes in program goals may make portions either inadequate or inapplicable.

The ATG research design begins with a discussion of the categories of materials to which it applies. This section also contains a review of the preliminary analysis systems which define, record, and manage basic descriptive data on the various material classes. The body of the design is a combined response to both the problems defined in the general research design and those specific problems identified to date by the modeling effort. Since the modeling effort is flexible and is in essence a fine-tuning of the overall research design, the discussion of modeling studies is integrated into that of the general research design. The final section of this document is a brief summary and a statement of anticipated contributions of the ATG to the program and to the archaeological discipline as a whole.

ANALYSIS RESPONSIBILITIES

The broad definition of ATG analysis responsibility is those categories of material culture that result from technological combinations of a variety of raw materials. Ceramic materials fall within this definition and are the primary focus of ATG activities. Ceramics include fired pottery (whether potsherds or whole items), unfired clay from archaeological contexts, and ceramic raw materials (clay, temper, and pigment) in their natural or resource contexts. Ceramics are abundant in most project area sites that date after A.D. 600, and ceramics form the largest single class of artifacts recovered by the DAP.

Basketry and textiles along with other worked vegetal artifacts are the second focus of ATG analyses. These items are constructed of perishable vegetal or occasionally animal materials, and their preservation in project area archaeological contexts is rare. Although not restricted in time of occurrence as ceramics are, discoveries of preserved vegetal artifacts have so far been limited to sites of the post-A.D. 600 time period. Miscellaneous worked vegetal artifacts (e.g., carved wood) are very rare, and although not strictly qualifying as the products of "additive" technologies, they are analyzed by the ATG as a matter of administrative convenience.

All data from ATG analyses are maintained as paper records. Where numbers of records are large and where information can be summarized in a format that is suitable for computer storage and manipulation, computerized data files have been created. Both existing data sets and planned data sets are listed in table 1 and are described in later portions of the research design.

Table 1. Additive Technologies Group data files

File name*	Status	Description
CERAM10	C	Descriptive and inventory data on all ceramics recovered by DAP excavations and surveys (preliminary analysis file).
Vessel analysis	CP	Morphological and functional descriptive data on DAP reconstructable ceramics.
Neckband dating	CP	Provenience information and neckband measurements for the calculation of neckband style dates from Moccasin Gray and Mancos Gray sherds.
Stylistic analysis	CP	Stylistic element descriptions and resource data for samples of decorated red and white ware sherds.
Energy/input	P	Measures of technological input for ceramic items as approximations of an energy based social value measure.
Resource survey	P	Location inventory of potential ceramic resources and laboratory evaluations of resource attributes.
Refiring analysis	P	Results of refiring experiments on clay resources and sherds.
MACRO10	C	Vegetal artifact inventory information only.
Worked vegetal	P	Technological descriptions of worked vegetal artifacts.

* Names in capital letters are official computer file designations.

NOTE: C - Computerized data file.
CP - Paper file that is scheduled for computerization.
P - Paper file that is not scheduled for computerization.

Preliminary Analysis

Preliminary analysis is the recording of basic descriptive data on all material recovered by DAP field operations. These analyses serve to satisfy the minimal contractual responsibility of the DAP (Contract No. 8-07-40-S0562), to support the archaeological inferences that are part of the descriptive reporting of fieldwork, and to provide inventories of materials for collections management. Preliminary analysis of ceramics and basketry accounts for the majority of ATG analysis time.

Ceramic Materials

Minimal descriptive data for ceramic materials are defined as those data categories that are traditionally considered in Southwestern archaeological research (i.e., type affiliation, vessel form, modifications subsequent to firing, and the identification of reconstructable vessels). These data are recorded for ceramic materials from each collected provenience as set forth in the Ceramics Coding Manual (Fay and Lucius 1980), and the data are maintained as a computerized file. Quantification consists of recording both counts and weights for each unique attribute string from each field provenience. The coding manual and variable value definitions are subject to continual revision as circumstances warrant, and changes in variable value definitions are documented in yearly administrative reports.

Typological affiliation. Artifact typologies are designed for specific analytical purposes (Hill and Evans 1972), and ceramic typologies in the Southwest (and those used by the ATG) have been traditionally designed to represent broad spatial and temporal origins (Colton 1953:55). Published type descriptions (e.g., Breternitz et al. 1974; Colton 1952, 1955, 1956; Abel 1955; Windes 1977) are the basis for type definition, and

assignment of sherds to types is based on comparison with these descriptions and on comparison with available type specimens. The ATG uses the concept of "culture category" to designate large geographic regions that are associated with the provenance of specific types, and the concept of "tract" is used to designate smaller manufacturing areas within culture categories (Lucius 1981). Groups have also been defined by the ATG to accommodate sherds that lack attributes necessary for assignment to established types (e.g., gray ware body sherds that could have originated from Chapin Gray, Moccasin Gray, or Mancos Gray vessels are classified as Early Pueblo Gray). In addition to typological assignment, seven technological attributes are recorded: firing atmosphere, temper, surface manipulation, surface compaction, surface cover, paint type, and paint color. These data provide an internal error check for typological assignment as well as increasing the utility of the data file for research purposes.

Vessel form. Vessel form data can be important for descriptive reporting and are recorded during preliminary analysis. Since vessel form assignments must be made on the basis of sherd attributes, definitions of vessel form are based on expected correlations between vessel shape and the surface treatment or rim form of sherds. For example, jar sherds are defined by apparent axial symmetry and by either no surface manipulation or manipulation (painting, polishing, banding or corrugation) only of the exterior surface of the sherd. Assignments to specially defined forms (e.g., Kiva Jars, Kidder 1962:202) are made when the analyst can confidently infer the original form of the vessel. Some vessels can be broken into sherds that are misclassified by this system (e.g., some sherds from a bowl dipper may be classified as a bowl due to the lack of evidence

of a handle), and this bias is acknowledged as systematic and unavoidable.

Modifications. Postfiring modifications are traces of abrasion or chipping on sherds or vessels and are not uncommon in Southwestern archaeological sites (Cattanach 1980:231-237; Di Peso et al. 1974:330-381; Haury 1976:251-252; Swannack 1969:99-104). Modifications reflect either wear associated with the original intended function of an item, repair of an item, or reshaping of an item or fragment for a different purpose. Sherds with modification are identified during preliminary analysis and are placed into descriptive categories (Waterworth 1982). These categories are defined by morphological attributes or clusters of attributes which are correlated with inferred patterns of abrasion or chipping. These patterns are then interpreted as representing specific activities or categories of activities, and in some instances, specific functional labels are applied (e.g., ceramic scraper, dipper wear, repair hole). Where functional labels are not warranted, categories are simply descriptive of a specific morphology.

Reconstructable vessels. Excavations often yield RCs (reconstructable ceramics) and they provide data for functional inferences in descriptive reporting and for stratigraphic correlation within some sites (Bradley and Lucius 1982). The definition of what constitutes an RC is flexible, incorporating any ceramic item that can provide useful information when viewed as an item rather than just as a cluster of sherd attributes. Whole or partial vessels comprise the bulk of the RCs, but small fragments of vessels may be designated as RCs if enough of each item is present for vessel size or shape measurements (Blinman 1982a). Small fragments of vessels may also be designated as RCs if documentation of the association of their sherds is important to stratigraphic interpretation.

Descriptions of sherds that comprise RCs follow the same format as all other sherds, but an identifying vessel number is appended to each data line. Actual reconstructions of vessels are carried out when appropriate and when analysis schedules permit such time expenditures. Detailed descriptions of RCs are not part of preliminary analysis, but are carried out as part of intensive analyses.

Worked Vegetal Materials

Worked vegetal material is the subset of recovered vegetal material that has been visibly modified by human action. This category of artifacts is further broadened to include some composite or nonvegetal materials that are most appropriately analyzed by the same techniques (e.g., rabbit fur blankets). Minimal descriptive data for these items are highly variable due to the great diversity of form, but they usually include material identification (provided by the Environmental Archaeology Group), form, technological attributes, and postmanufacture modification. Studies of basketry technology have yielded spatial and temporal data similar to, but of less resolution than that provided by Southwestern pottery types (Morris and Burgh 1941; Adovasio 1970); detailed technological descriptions of DAP specimens are made roughly following the system presented by Adovasio (1977). Descriptions of other types of vegetal artifacts focus on morphology and, where appropriate, inferences of function. All descriptive data are recorded in written form, and because of the heterogeneity of this artifact category only inventory-level information is computerized.

ARTICULATION WITH THE PROGRAM RESEARCH DESIGN

Descriptive reporting and collections management needs are satisfied by preliminary analysis, but a greater DAP responsibility is to contribute to broader synthetic questions about the prehistory of the Dolores Project area. These questions are expressed in the five major problem domains of the general research design (Kane et al. 1981), are integrated by the modeling effort (Lipe 1981, 1982), and provide a structure of inquiry to be addressed by the DAP as a whole. Ceramic or worked vegetal data are directly applicable to a subset of these questions, and that subset is summarized below.

Problem Domain 1: Economy and Adaptations

This problem domain is concerned with resource availability and resource use through time within the Dolores Project area. It includes definition of potential resources, their spatial distribution, inferred prehistoric exploitation patterns, prehistoric technologies, and organizational strategies of resource exploitation. Although this domain is focused primarily on subsistence resources, raw materials and technologies for ceramic and worked vegetal production are included.

Ceramic Resources

Ceramic raw materials consist of clays, tempers, and pigments. Clays are a group of fine-grained minerals that become plastic when combined with water and become irreversibly hard when subjected to extreme heat. Temper refers to inorganic or organic materials that are added to clay to lessen shrinkage during drying and to facilitate water vapor loss during firing. Pigments are inorganic or organic substances which are used to decorate the

surfaces of ceramic forms. These definitions encompass a very large universe of potential resources, but the characteristics and suitability of any potential clay, temper, or pigment can be highly variable. Although often faced with an abundance of potential resources, traditional potters tend to rely on only a small subset of what is available (e.g., Arnold 1971); the potential resources that remain are judged as either functionally less desirable, stylistically inappropriate, or they simply cannot be exploited by the traditional technology. Thus, the selectivity of potters makes the study of resource use a manageable endeavor.

An important part of ceramic resource evaluation is the definition of local vs. nonlocal. Exchange of ceramics on both the intraregional and interregional level is common in the Southwest (e.g., Shepard 1965; Travis 1981) and must be considered when attempting to define local resource use. Unfired tempered clay from archaeological sites is assumed to represent locally used resources, and it is likely that such clay and temper is also locally obtained. The same assumption cannot be made for individual fired ceramics, but local resource use inferences can be made from populations of fired ceramics. Fired ceramic items will tend to be more abundant at the point of manufacture than elsewhere (Renfrew 1977:72), and resources represented by a majority or plurality of sherds are most likely to be local. Correspondence between the unfired clay, the resources represented in the plurality of sherds, and the locally available clays and tempers is the strongest argument for local resource identification.

Clay resources. Evaluation by the ATG of prehistoric ceramic resource use varies with the type of resource. Sources of pottery clay are usually discrete geological deposits and their evaluation consists of locating such deposits within the project area, describing the characteristics of the

clay in terms of modern ceramic technology, describing the clay composition, and contrasting the characteristics of these located clay deposits with those of clays that have been recovered from archaeological sites. Clay sources are common in the project area, with deposits identified in all but one of the local geological formations (Shawe et al. 1968). In addition to these geological occurrences, a limited number of clays have been noticed in some restricted soil horizons and in alluvial deposits of the Dolores River. One survey has been carried out to locate and sample potential clay resources in portions of the project area (Travis 1981), focusing on documenting the range of variability of clays associated with specific geological formations. This survey will be augmented by several catchment-oriented surveys around a sample of Anasazi sites.

Chemical characterization and identification of clay resources can be accomplished by a variety of techniques (Shepard 1956:viii-x). Of these techniques, clay minerals can be identified by X-ray diffraction, and elemental composition can be determined by neutron activation analysis (e.g., Deutchman 1980; Plog 1980). Both techniques can help correlate archaeological clay with natural sources, depending in part on the relative magnitudes of within- and between-source variability. Elemental study is most appropriate for untempered clay, because bulk techniques like neutron activation analysis cannot differentiate the elemental composition of clay from that of the included temper in fired sherds. Variability of some project area clay sources is currently being studied with neutron activation analysis, and the results will determine whether or not more such studies are warranted.

A more practical, although less precise, method of characterizing clay is by firing samples at a controlled temperature (950° C) in an oxidizing

atmosphere (Shepard 1939:250; Wilson 1980). This procedure removes included carbonaceous matter and standardizes the oxidation states of iron impurities, making possible the comparison of samples on the basis of color. This technique is relatively simple, can be applied to sherds as well as to clay samples, and can be carried out on a much larger number of samples than is feasible with other techniques. Preliminary results of these analyses suggest that unfired clay from DAP archaeological sites could have been obtained from local sources, and that there are only limited local sources for extremely red firing clays. Red firing clays are necessary for the production of red ware vessels, and their limited occurrence in the project area suggests that red ware ceramics may be items of exchange rather than local productions (Lucius and Breternitz 1981).

Studies of clay composition and attempts to identify clay sources make the assumption that prehistoric potters were not combining clays from two or more different sources. Depending upon the original working characteristics of the clays, such combinations could produce superior pottery clay than any of the contributing source clays, and such combinations would wreak havoc on compositional and source studies. Prehistoric blending of clay in the project area is possible, but given the abundance of clays that are suitable for ceramic manufacture without blending, instances of combination are unlikely. Circumstantial arguments in support of this assumption include compositional similarity between archaeological clays and the local resources, low variability in the composition of clay samples from prehistoric sites or households, and the lack of examples of markedly different untempered clays from prehistoric sites or households.

Temper and pigment resources. Potential temper and pigment resources are ubiquitous given the range of materials known to have been used by prehistoric and historic potters (Shepard 1956:26, 31-48). This abundance precludes surveying for all potential sources in the project area. Instead, ATG efforts are focused on defining those materials that were used prehistorically, and ATG survey efforts have been designed to look for those specific materials.

Temper categories have been established for preliminary analysis, and sherds are placed into these categories on the basis of examination using a binocular microscope (20-50 power magnification). Temper form and composition are used to infer the probable source material or materials for each category, and samples of sherds from temper categories have been submitted for petrographic analysis. This analysis is designed to evaluate both the source material inferences and the accuracy of the binocular microscope classifications. Archaeological caches of potential temper have also been recovered from project area sites, and these finds have helped focus survey efforts. ATG surveys for temper sources in selected geological formations were carried out in conjunction with the survey for clay sources (Travis 1981), and catchment-oriented surveys are planned.

Pigments are far more difficult to evaluate due to their alteration during the preparation and firing processes and due to the ease with which the small quantities that are needed can be exchanged or transported over large distances. Organic pigment sources cannot be investigated because there is no significant difference in visual effect to distinguish one charred plant extract from another (Shepard 1956:33-34). Mineral pigments can be characterized by a variety of chemical tests (Shepard 1956:171-172; Littmann 1975; Nelson 1975), but sourcing usually is not practical or

possible. However, a variety of unprocessed/unfired potential pigment materials have been found in DAP archaeological contexts, and samples of these materials can be evaluated for suitability as ceramic pigments. This entails powdering samples of the materials, applying the powders to clay tablets, and firing samples in both oxidizing and reducing atmospheres. Those materials which prove to be suitable candidates for ceramic pigments can then be sought in the ATG catchment surveys.

Vegetal Resources

Worked vegetal materials encompass a wide variety of forms (basketry, juniper berry beads, carved sticks, the hewn ends of construction timbers, etc.). The universe of potential resources is as diverse as the artifact category, and the biotic diversity of the project area provides sources for all items that have been analyzed through 1981. Basketry is the most abundant category, and there appears to be a clear preference for two taxa as construction material: *Yucca* and *Rhus aromatica* ssp. *trilobata* (squaw-bush). Both of these taxa are common today in association with pinyon and juniper, and there is no reason to believe that their distribution was significantly different during Anasazi occupation of the Dolores River valley. Preservation of worked vegetal material is usually fortuitous (dry deposits or carbonization), and the data set is a small and not necessarily representative sample of material culture. For this reason, quantitative studies of resource use or of changing resource use through time will not be attempted.

Ceramic Technology

Aspects of ceramic manufacturing technology have been used to support inferences of status differentiation, cultural-ecological relationships, economic specialization, and long-distance migration in prehistoric

societies (Upham et al. 1981; Arnold 1975; Rice 1981; Wilson 1981). Broad stages of technology include resource procurement, resource preparation, vessel construction, and firing. Of these stages, vessel construction techniques and sequences can be inferred directly from sherd collections. Firing atmosphere can also be inferred, but the specifics of firing technique, resource procurement, and resource preparation must be based on inferences from archaeological feature and artifact patterning and from analogies with the techniques of ethnographic potters (e.g., Guthe 1925).

Reconstructions of resource procurement are dependent in part on our ability to associate archaeological clays with particular sources. In an ethnographic context, where suitable clay is both local and abundant (Longacre 1981), household potters gather their own clay when they need it and in quantities appropriate to their immediate needs. In situations where clay sources are removed, potters may enlist the aid of others in collecting and transporting clay (Bunzel 1972:6; Stanislawski 1979:592), and tend to collect more than they anticipate needing for the immediate future. When access to clay is seasonally restricted (as in frozen clay beds in winter), greater than usual quantities are collected in anticipation of the restricted access (Guthe 1925:20). Household production entails procurement of smaller quantities at any one time than characterizes specialist production for markets or exchange (contrast Arnold 1971 with Longacre 1981). Procurement of excess clay will result in storage of the unused portion (usually in an unprocessed state; see below), and such a pattern may be detectable in the archaeological record.

Preparation of clay usually consists of cleaning in either the dry or wet state, and depending upon the raw material, it may also require pounding, grinding, or soaking (Shepard 1956:51; Guthe 1925:19-21).

Although a few ethnographic potters age clay to improve its plasticity (Rogers 1936:8), in most North American cases it is either unnecessary or the technique is unknown (Shepard 1956:52). Instead, clay tends to be prepared for use as it is needed, being ground, tempered (if necessary), and kneaded in one processing sequence (Guthe 1925:19-23; Rogers 1936:5-8). Archaeological traces of preparation may be found as residues on grinding or pounding implements, or as residues in vessels used for soaking. Although traces of preparation activities may be preserved on enclosed surfaces, if preparation took place in open air contexts the probability of recovering archaeological evidence would be very low.

The most easily reconstructed part of ceramic technology is the vessel construction process. Three major vessel construction patterns (wares; Colton 1953:51) exist within the context of the Anasazi archaeology of the Dolores River valley. Gray wares are constructed by coiling, scraping at least one surface of the vessel, and then firing in a neutral or slightly reducing atmosphere. Impressions on the base sherds of some vessels reflect at least the occasional use of a rigid or basketry base to support the vessel in initial stages of forming. White wares are constructed by coiling, scraping, painting with a mineral or organic pigment, and firing in a neutral or slightly reducing atmosphere; occasionally smoothing, polishing, or slipping may occur prior to painting. Red wares are manufactured in the same manner as the white wares, but they are painted with inorganic pigment and are fired in an oxidizing atmosphere. Choice of raw material is coordinated with technology; whereas most clays are suitable for gray ware manufacture, red-firing (high iron content) clays are necessary for red ware manufacture. Deviations from these patterns can be

detected easily, and provide data for inferences of exchange or migration (Wilson 1981; Waterworth 1981).

Given the basic construction techniques outlined above, selected ethnographic data can be used to model tools and associations of tools which are part of the manufacturing process. Pounding or grinding implements used in clay preparation tend not be be specialized for clay, and it is likely that metates and manos would have served this purpose if needed. Kneading clay, both to incorporate temper and to thoroughly wet the mass, is facilitated by a work surface, whether it is a metate, slab, hide, or a clean patch of hard ground. Recycled basketry or ceramic forms (pukis) are often used to support and shape the base of a vessel during the initial forming process. Small scrapers made of pottery or gourd rind with convex edges are used to obliterate coil junctures and to shape vessel walls (Guthe 1925:27; see Morris 1939:167-168 for a description of archaeological ceramic scrapers, including one with adhering clay). Slips are clays that are mixed with an excess of water to produce a fluid mass which is usually daubed onto the surface of the vessel with a soft or absorbent pad. Decorative surfaces of white and red ware vessels are often polished by rubbing with a smooth, hard stone, and paints are applied with brushes of vegetal or animal fiber. Of these potential tools the basketry supports, gourd rind scrapers, slip applicators, and brushes are not likely to be preserved in project area sites except in rare dry contexts or in catastrophically burned structures.

Inferences of the existence of or location of ceramic manufacturing activities depend upon the recovery of and spatial correlation of raw materials and a subset of the above-mentioned tools. Such inferences must first assume the contemporaneity of the items and how their provenience

reflects their systemic context (Schiffer 1972:157). Due to the functional ambiguity of some of the associated tools, raw material (unfired tempered clay) and ceramic scrapers are prerequisites for such inferences. In most sites the occurrence of raw material and tools in midden or fill proveniences is adequate to infer the existence of ceramic manufacture at the site. Spatial proximity of tools and raw material on floor or occupation surfaces may be used for activity area definition, but proximity may be accounted for by storage as well as use. Not all potential tools need to be proximate, due to their use at different points in the manufacturing sequence and to the lack of a need to carry out the sequence in a single delimited area.

Firing is the final stage of pottery manufacture. Physical characteristics of sherds will reflect the final atmosphere and the relative temperature of their firing. An abundance of oxygen at a high temperature results in the oxidation of carbonaceous material (if present) in the clay followed by oxidation of any iron compounds. Partial oxidation will result in a white, gray, or red surface, and a dark core; whereas complete oxidation will remove carbon from the core and result in the formation of red ferric oxide when iron compounds are present. Lack of oxygen will not affect carbonaceous content but may reduce previously oxidized iron compounds to ferrous oxide. Under conditions of only partial oxidation or a lack of oxygen, the sherds will be gray or black in color (Shepard 1956: 219-221). If smudging occurs in the last stages of firing, the surface of the pottery becomes covered with black carbon which can only be removed by refiring in an oxidizing atmosphere (Shepard 1956:88). Firing temperature necessary to produce a strong vessel varies with the clay being used. For this reason, only a relative firing temperature can be inferred by

examining the sherds alone. Soft and extremely porous sherds represent inadequate firing temperatures, and vitrification of sherds usually reflects overfiring (Shepard 1956:222). Experimental firing of local clays indicates that temperatures in excess of 800° C are necessary to produce durable wares.

Although atmosphere and temperature can be inferred from sherds, techniques of firing must be reconstructed from other evidence. Some features that may represent kilns have been found within the Anasazi region (Morris 1939:111-112; Helm 1973), but most evidence (or lack thereof) suggests that firing was done in the open or in shallow pits. Expected characteristics of firing features include concentrations of ash and charcoal, bloated and vitrified sherds, and heat-affected earth or rock. Heat effects are oxidation (reddening of soil and rock) at the periphery of the firing area with probable evidence of reduction at the center. Such effects need not be extreme due to the insulating qualities of rapidly accumulating ash. Due to the danger of fire the location of firing features is likely to be removed from habitations, and in the absence of surface indications, discovery by archaeologists will probably be fortuitous or as a result of stripping large areas around sites. An extremely wide range of fuels is used by ethnographic potters (grass, wood, brush, dung, etc.), but there is as yet no evidence of what types of fuels were used prehistorically in the project area. Identification of charcoal in suspected firing features will help evaluate types of firing fuel and whether pottery firing could have been a factor in local fuel resource depletion.

Basketry and Woodworking Technologies

Manufacturing technologies are as diverse as the categories of worked

vegetal material. Aspects of basketry technology have been studied in detail and have been used to characterize broad temporal and spatial units in North American prehistory (Adovasio 1970). In addition, details of technology have been used to quantify style and to identify the work of individual weavers in the archaeological record (Adovasio and Gunn 1977). Woodworking technology has been studied on a descriptive level, focusing primarily on inferences of artifact function and on inferences of shaping processes (Osborne 1980; Rohn 1971).

Nearly all DAP basketry items are charred and have been recovered from a few catastrophically burned structures. They form a small and highly clustered sample which is less suited to studies of technological change through time than to studies of household tool kit composition or to tests of the influence of individual style on technology (the latter topics are elaborated in the discussion of "Problem Domain 3: Social Organization"). ATG studies of basketry technology as such will be limited to description and to evaluation of activity area inferences. No studies of woodworking technology other than description are planned.

Use of Ceramic Forms

Vessels (jars and bowls) are the overwhelming majority of DAP ceramics and presumably filled a variety of functions within prehistoric households. Functional classifications of "culinary" and "serving" are loosely associated with the definitions of wares, but more specific functional classes such as cooking, liquid storage, or solid storage would be more useful for archaeological interpretation. These classes of function are the subject of a vessel form study to be implemented by the ATG (Blinman 1982a).

This study assumes that probable function will be reflected in attributes of shape and attributes of wear of vessels. Shape includes variables of size, rim diameter, minimum orifice diameter, base conformation, and the presence or absence of handles and spouts. Wear includes abrasion of interior, exterior, or rim surfaces; chipping of the rim; and heat effects such as sooting. Attribute values are expected to correlate with function as follows:

1. Cooking vessels will have relatively large rim and orifice diameters to facilitate access, and the vessels can be of variable size; wear may be evident as abrasion of base or interior, chipping of the rim, and sooting is expected in all cases.
2. Liquid storage (and transport) will be facilitated by restricted orifice and rim diameters, presence of spouts and handles, and relatively large size; wear is likely to be restricted to abrasion of the base, chipping of the rim if the orifice is large enough to admit a dipper, and heat effects will be absent.
3. Solid storage entails larger orifice and rim diameters than those associated with liquid storage, lower weight will reduce the frequency of handles, and the need for security (especially for long-term storage) will be reflected in the occasional presence of attachments or holes to facilitate closure; abrasive wear will be confined to the base exterior, rims may be slightly abraded or chipped, and heat effects should be absent.
4. Serving containers will have large rim and orifice diameters to facilitate access, need not have handles, and will not have closure attachments; wear may include light abrasion on the interior of the vessel or on the exterior base and will not include heat effects.

Although these models assume that actual use of a particular vessel was restricted to one of the functional classes listed above, it is likely that some (and perhaps many) vessels could be put to a variety of uses on an occasional basis. Such overlap between classes is expected to occur most frequently between the cooking and solid storage functions due to the similarity of access requirements. Adequacy of these models will be evaluated by comparison of expected with observed attribute clusters and by correlation of form with contents in the few instances where contents can be identified.

Organizational Aspects of Ceramic Production

Syntheses of social evolution have often correlated the appearance of craft specialization with increasing social complexity, and specialization of ceramic manufacture has been investigated from this point of view. Rice (1981) describes an archaeological situation in which she has typological ceramic data and a generalized reconstruction of social complexity, but no data on ceramic manufacture. Working from the premise that specialized manufacture will result in decreased variability within wares (in both technological and stylistic attributes), she calculates indices of variability and infers various levels of specialization for the archaeological cultures she is studying. These levels of specialization correspond satisfactorily with what is known about changes in social complexity, but reviewers criticize the general applicability of her initial premise (for the clearest statement, see Hodder 1981a:231).

An alternative perspective on ceramic specialization is presented by Arnold (1975). Present day potters in part of the Ayacucho Basin, Peru, are part-time specialists who devote the remainder of their time to agriculture. Arnold interprets this mixed strategy as an adaptation to population pressure which forced some agriculturalists to exploit land that is

marginally suited to agriculture. This land receives rainfall sufficient for a single crop each year, in contrast with better land upslope that can support two crops. Farmers on the poorer land are thus idled for half the year and need to supplement their income. Ceramic raw materials are abundant, and the climate during the nonagricultural season is conducive to ceramic manufacture. Farmers on the better lands produce two crops and thus have much less time for ceramic manufacture. Also, the wetter climate in the upslope regions limits the period during the year that pottery manufacture could be carried out if a farmer were so inclined. Ceramic specialization is thus more a result of the interplay of ecology and economy than a correlate of local social complexity.

Ceramic specialization in the Dolores area is a possibility, with potential correlates in social, ecological, or other variables. Between about A.D. 600 and 950, the settlement pattern changes from individual dispersed households to aggregations of from 8 to greater than 20 households. In addition, pitstructure architecture changes, encompassing the transition from pithouse to kiva (Kane 1981). Both of these changes imply increasing levels of social interaction and may entail changes in the organizational aspects of economic activities, including ceramic manufacture.

Ecological factors may also be involved as the population in the project area increases and as less desirable agricultural lands are used. Intensity of use would emphasize the variable nature of arable land in the local environment, especially in those areas that could be subject to damage from cold air drainage. Households exploiting marginal agricultural land would need to diversify their economic base in anticipation of having to exchange goods (possibly ceramics) or services for staples in bad years. Although purely hypothetical, this scenario would parallel the situation described by Arnold (1975) and would be a plausible explanation

if differential evidence of specialization were found between upland and valley sites.

Myriad other factors may affect or facilitate specialization, and specialization may occur at levels of institutionalization far above or below those implied by the previous discussions. Preliminary indications are that the Dolores River valley Anasazi as a whole participated in an exchange network that involved areal specialization in the production of specific wares. Because local sources of red firing clays are rare, red clays had to be imported or finished vessels had to be acquired through exchange. The latter seems to have occurred with fairly high frequency, but the local contributions (pottery or other goods) to the exchange network have not yet been determined. Also, individual ability or preference may have resulted in small scale cooperative divisions of labor between households, with one individual specializing in ceramic manufacture and satisfying the pottery needs of several families.

Changes through time in the relative degree of ceramic specialization in the Dolores River valley can be directly inferred from DAP excavation data. The existence of ceramic manufacture at the site or household level can be inferred from the presence of unfired clay and manufacturing tools. Relative intensity of ceramic manufacture can also be estimated for some prehistoric households by the ratio of discarded ceramic scrapers to other household refuse. Changes in the proportion of pottery-making households through time or dramatic changes in the intensity of ceramic manufacture can then be used to infer the presence or degree of ceramic specialization. If specialized production can be demonstrated, ceramic data can then be used to test Rice's (1981) premise that specialization decreases technological and stylistic variability within wares, but we do not feel that

Rice's measures can be used to infer the existence of specialization in the Dolores area without considerable supporting evidence.

Problem Domain 2: Paleodemography

Number, structure, and distribution of human populations are the focus of this problem domain. This includes population size estimates for each time period and for the spatial units of households, interhousehold groups, and communities. Inferences of the age and gender structure of each of these populations are goals, as are assessments of health, fertility, and mortality. Finally, population distribution across the project area will be assessed as part of settlement pattern reconstructions. Studies of ceramic materials can contribute to the solution of these problems, including evaluation of household size, estimation of duration of occupation for sites and structures, and identification of instances of immigration into the project area.

Household Size

Habitation area is considered to be a reasonable correlate of population size for archaeological studies of prehistoric demography (Hassan 1981:72-77), and pitstructure floor area varies significantly through time in the project area (Hewitt et al. 1981). However, coincident with pitstructure floor area variations are variations in surface structure area and probable changes in social organization which make demographic interpretation from pitstructure data problematic. Surface structure area estimates which could conceivably be combined with the pitstructure data are neither reliable nor abundant due to the extreme disturbance that characterizes most shallow archaeological proveniences. Thus, independent lines of evidence for household size are desirable.

As part of a study of prehistoric demography in the Kayenta region, Turner and Lofgren (1966) proposed a measure of household size based on the relative capacities of cooking jars, serving bowls, and ladles. Their premise was that the size of cooking jars will reflect the number of people that are regularly being fed from a single cooking hearth. Thus, if household size changes, cooking jar size should also change. Data from vessels were gathered from six time periods from A.D. 600 to 1900, and variation in serving bowl and ladle sizes were used to measure variation in portion size. Their conclusion was that household size increased slowly from Basketmaker III through Pueblo I, stabilized at about five persons per household, and then increased sharply to about seven persons per household during the historic period. There is no independent test of their conclusions apart from estimates of historic Pueblo household size that range from about five to over seven persons.

The assumptions of Turner and Lofgren's study have been criticized as oversimplifications of a more complex problem. Nelson (1981) carried out an ethnographic study of the relationship between household size and vessel size. He also examined other variables that may affect the relationship, and he found that a variety of factors (including status and age grade composition of households) interacted significantly with vessel size in his sample. Also, some measures of vessel capacity (e.g., summed capacity over a class of vessels within the household) were more highly correlated with household size than were mean capacities. These findings restrict the use of Turner and Lofgren's approach, but Nelson concludes that attempts to implement the measure in archaeological contexts are still warranted (1981:127).

DAP ceramic data will be used to evaluate household size variation using the Turner and Lofgren premise. Data on vessel capacity and function will be collected as part of the vessel use study, and changing capacities through time within functional classes can be compared with changes in other measures of household size. Excavation and other artifact data can be used to control for possible status differences, and age grade effects can be investigated by working with whole site data (including household refuse) as well as reconstructable vessels from surfaces (Nelson 1981:127).

Population Estimation and Occupation Duration (Excavated Collections)

Another use of artifact data has been to estimate human population size from quantities of specific artifact types (Cook 1972; Kohler 1978). Estimations have focused on total site populations (Cook) and on simulation of possible rates and patterns of population growth and decline (Kohler). Such approaches typically estimate numbers of person-years at habitation sites, where person-years incorporate the concepts of average momentary population and duration of occupation.

Estimates of occupation duration can be made from the accumulated refuse (including ceramics) associated with archaeological sites. Assumptions and data necessary for ceramic-based duration estimates are derived from ethnographic records, contents of prehistoric pitstructures, preliminary analysis data, and data from probability samples of excavated sites. Numbers of vessels in use by a household are recorded in various ethnographies (Foster 1960; DeBoer and Lathrap 1979) and can be assessed in the few structures excavated by the DAP that were destroyed by fire while in use. Rates of pottery breakage can only be assessed from ethnographic accounts (Foster 1960; DeBoer and Lathrap 1979; Longacre 1981). Average vessel weight can be determined by examining reconstructable vessels, and

total sherd weight per site can be calculated from the contents of probability samples. Manipulation of these assumptions and data will result in a person-year estimate for the site.

A preliminary assessment of population size estimators for DAP sites (Kohler and Gross 1981:178-180) contrasts artifact population estimates with the subjective judgments by excavators of site population (expressed in person-years). Artifact population estimates for ceramics and flaked lithic debitage correlated extraordinarily highly with the excavators' judgments of person-years ($r = 0.96$ and $r = 0.98$, respectively), and by this measure, artifact population estimates would seem to be an appropriate yardstick for human population estimates. However, artifact population point estimates (based on probability samples) have error terms (95 percent confidence intervals) that range from 47 to 225 percent of the estimated value (Kohler and Gross 1981:tables 8 and 9). These wide confidence intervals may require the use of less precise expressions of population and time (i.e., households rather than persons, generations rather than years).

Population Estimation and Occupation Duration (Surface Collections)

A minority of project area sites are scheduled for excavation, and the remainder can only be characterized by survey observations and surface collections. Population size and occupation duration estimates for these unexcavated sites are necessary for settlement pattern studies, and several attempts at estimation have been made (Kohler and Schlanger 1980; Schlanger and Kohler 1981). These efforts have looked at the relationships between quantities of surface collection materials and estimates of site size and site occupation duration based on excavation data. Numbers of bowl sherds are better estimators of pithouse and surface structure habitation areas than are other artifact classes, and total numbers of ceramics are strong

(although not the best) correlates of person-years of occupation as estimated from excavation data (Schlanger and Kohler 1981:tables 14, 15 and 18). Further efforts to refine predictions from surface artifacts (including ceramics) are continuing, but they are being conducted outside of the jurisdiction of the ATG.

Instances of Immigration

Anasazi occupation of the project area began about A.D. 600 with a few scattered households. The few sites of this early time period contrast with the abundant sites dating to the time period about 250 years later (A.D. 850), which reflect considerable increase in population. This increase could be a product of natural population growth, or it could be augmented by immigration from outside areas. The general impression of researchers in the area is that immigration is likely as part of a regional pattern of population movement (Breternitz 1981). Estimates of the occurrence and relative contribution of immigration can be made by modeling rates of natural population growth from an initial colonizing population through the period of Anasazi occupation of the project area. Predicted populations can then be compared with population estimates based on archaeological data. Discrepancies can be accounted for by either immigration, emigration, or by rejecting the initial assumptions used in the modeling of population growth.

Ceramic data can be used to identify possible instances of immigration (Waterworth 1981; Wilson 1981) and can lend support to the immigration inferences based on demographic models. The ceramic-based model of immigration depends upon a contrast between local and nonlocal ceramic resources and local and nonlocal ceramic technologies. Sherds and vessels that exhibit nonlocal resources and technologies are usually interpreted as

reaching their archaeological context after being part of prehistoric exchange systems. Movement of ceramics as part of household equipment during migration is an alternative explanation, but usually cannot be argued without considerable supporting evidence from other data sets. If, however, migrating groups included potters, it is likely that nonlocal technologies (e.g., smudging or glazing) would have been applied to local materials, at least during the first generation of residence. Thus, association of nonlocal ceramics and nonlocal technologies expressed in local resources within a restricted temporal and spatial context can be interpreted as an instance of immigration of a potter from outside the local area.

The primary limitation of this approach is that of recognizing technological contrasts. Ceramic technology within the Mesa Verde region is sufficiently uniform that resource use is the only consistently applicable local/nonlocal determiner. Thus, potters from a quite large area could blend into the local population on the basis of ceramic products alone (an exception to this is the use of glaze paint in the Durango/La Plata area, Waterworth 1981). Extraregional potters do use identifiably different technologies, and at least one probable instance of immigration from the Mogollon area has been identified within the project area (Wilson 1981). This approach to identifying immigration still requires supporting evidence from other artifactual and architectural data sets, but provides a strong argument in and of itself.

Problem Domain 3: Social Organization

Social organization is a broad topic encompassing individual and group interaction on social, economic, political, and ceremonial levels.

Specific topics of inquiry include definition of social groups, status differentiation, social control of behavior, mechanisms for group integration, division of labor, differential patterns of consumption, and participation in ceremonial activities. Ceramic and worked vegetal data can contribute to some of these studies, although in most cases they will only be part of a larger research effort.

Identification of Individuals

Ceramic and basketry data have been applied to a variety of archaeological problems of group definition; the most basic of which has been the identification of products of individual craftsmen (Hill 1977; Huse 1976; Adovasio and Gunn 1977; Croes and Davis 1977). These studies make use of variation in motor patterns of individuals, variations in stylistic expression, and idiosyncracies of technology to distinguish products of various artisans. The most convincing archaeological case for the identification of individuals is provided by Huse, who was able to group vessels based on stylistic attributes and to test her groupings by comparison with grave lot proveniences. However, all of the above studies suffer from an inability to demonstrate conclusively that one individual was responsible for a given set of attribute values (Redman 1977:42). Instead, they provide arguments for the identification of what Redman calls an "analytical individual" (1977:44), which may be either a person or a number of people who share aspects of technology and style to the point of being indistinguishable by the type of archaeological analysis being performed.

Analytical individuals may be discernable in DAP archaeological materials, but only in limited contexts. Most such studies focus on decorated pottery, but most (and perhaps all) decorated red wares occur in

the project area as exchange items. Decorated white wares may have been locally produced during the early occupation of the project area, but by A.D. 850 at least 20 percent are demonstrably nonlocal on the basis of temper alone (the proportion is expected to be much higher after evaluation of clay resources is completed). Also, frequencies of decorated white wares are low, accounting for approximately 10 percent of all ceramics by weight. Due to these constraints, the ATG plans to search for analytical individuals among the ceramic materials only after clays have been evaluated for nonlocal origin and only in contexts of adequate sample size. Temporal and spatial discreteness of proveniences will also be a prerequisite of any such study.

Basketry remains from sites in the project area are not common but are suitable for studies of analytical individuals. Excavations prior to the 1982 field season have recovered four carbonized basketry assemblages from catastrophically burned pithouses. These assemblages represent baskets that are both temporally and spatially associated with a single household. They may or may not be products of single weavers, and analyses of their technological variability can be compared with studies in which the presence of products of individual weavers has been argued from archaeological contexts (Adovasio and Gunn 1977; Croes and Davis 1977). Descriptive data necessary for these analyses are collected as part of preliminary analysis of worked vegetal materials.

Social Group Definition

Ceramic data have been used in a variety of studies to define social groups above the level of the individual. Longacre (1964) interpreted clusters of ceramic design elements at the Carter Ranch Site as representing localized matrilineages. Hill (1966) carried out a similar

study in which nonrandom distributions of design elements (along with other patterns of artifact data) at Broken K Pueblo were interpreted as representing the presence of two uxorilocal residence groups. Both studies have been criticized (Plog 1978) on methodological grounds and for not giving adequate consideration to alternative explanations (e.g., temporal differences and exchange patterns). There are also ethnographic data which question the validity of the mother-daughter learning pattern assumption on which both of these studies are based (Stanislawski 1969:30-31; Hodder 1981b:93-95).

Preliminary studies of DAP ceramic data suggest that attempts at social group definition through design element studies would not be fruitful. Comparisons of DAP resource data with excavated sherd assemblages have resulted in the belief that most, if not all, decorated red ware in the project area are exchange items originating from areas to the west (Lucius and Wilson 1980). Also, there is reason to believe that a large proportion of decorated white wares are extralocal in origin, and if the frequency of intraregional exchange seen in gray wares (Travis 1981) is similar for white wares, it would be improper to assume that provenience and provenance were equivalent for any assemblage of stylistic elements. Thus, stylistic analysis of design elements could explain little about local group definition or composition.

Group Interaction

Although residence groups cannot be studied through stylistic analysis of DAP ceramics, other ceramic data can be used to infer the directions and the relative strengths of group interaction on both an intraregional and interregional level (interregional interaction will be considered in greater detail in the discussion of Problem Domain 4). Group interaction

is a broad concept encompassing both social and economic elements (e.g., marriage patterns, ritual obligations, political alliances, and provisioning). Ethnographic studies of interaction in stateless societies have led to the view that social and economic elements are essentially a single system of interaction, with material goods moving as part of the same network as social relations (Rappaport 1968; Dalton 1981). This interpretation allows inferences of social interactions to be drawn from the patterning of material goods in the archaeological record.

Studies of ceramic patterning by the ATG consist primarily of establishing contrasts between provenance and provenience. Compositional observations (controlled oxidation) of unfired pottery clays from sites and households indicate that some resources are clearly associated with particular geographic areas (procurement-production zones [Travis 1981] or communities of potters [Arnold 1971]). However, compositional variability in sherds from these sites and households is relatively greater, implying an active system of local exchange (i.e., interaction). Although controlled oxidation lacks resolution, a pilot study (Travis 1981) using paste compositional data and temper frequencies has identified distribution patterns that may be interpreted as defining interaction spheres. More compositional data are being gathered (possibly augmented by the results of neutron activation analysis), and the pilot study will be expanded to verify its finding and to define changing patterns of interaction through time.

Social Differentiation

Recently, ceramic data have been used to support inferences of social differentiation in the prehistoric Southwest (Upham et al. 1981). These inferences are based on the assumption that "value" ascribed to a ceramic

item by prehistoric Puebloans is positively correlated with the energy or effort expended in its production (Feinman et al. 1981). Thus, a slipped, polished, and painted bowl is of intrinsically more value than a corrugated jar, and a corrugated jar is of more value than a plain gray jar. When the distribution of various value classes of ceramics from the Pinedale and Chavez Pass areas of Arizona were compared with site characteristics, Upham et al. (1981) found that high value ceramics were disproportionately concentrated in central places (associated with large amounts of storage space and with nonresidential structures). They argue that this pattern fits a model of social differentiation with a central community serving as the ritual and administrative focus for surrounding communities.

Given the apparent settlement pattern changes in the Dolores River valley between A.D. 600 and 950 (Kane 1981), changes in the relative social status of local communities are likely. As in Arizona, ceramic items may reflect these changes in status, and a measure similar to that described above can be implemented for DAP collections (Wilson 1982). Although this measure can be calculated for any project area provenience using data recorded in the preliminary analysis file (Blinman and Wilson 1982), proveniences must be carefully evaluated for comparability. Any production-step measure will increase through time when applied to sites in the project area due to temporal changes in prevailing ceramic technology. Chapin Black-on-white is painted but is usually not polished; Piedra Black-on-white is painted and polished, and in later occurrences it may be slipped; Cortez Black-on-white is painted, polished and usually slipped. Thus, if two noncontemporaneous proveniences are compared, the later provenience is likely to contain "higher value" wares without necessarily implying a different relative status. Sample size will also affect the

interpretation of value measures because the higher value items are also rarer. Provenience samples will have to be evaluated so that absences of high value items can confidently be attributed to status differences and not to sampling error. Finally, functional differences between proveniences will have to be considered, so that storage-related ceramics at one site are not being compared unconsciously with serving-related ceramics at another. (Note that this caveat does not imply that only functionally equivalent proveniences should be compared; central places of differing status are likely to be functionally differentiated from other settlements by definition.)

Problem Domain 4: Foreign Interactions

Interactions between project area populations and prehistoric groups outside of the project area are the focus of this problem domain. In part, these interactions will be simple extensions of the interactions explored in Problem Domain 3, but they also include the possibiliy of long-distance trade and long-distance political and religious influence. Activities of the ATG that can contribute significantly to the study of this problem domain are primarily studies of the extent, intensity, and to some degree the content of the prehistoric exchange network (in so far as it included ceramics as items or vehicles of exchange). This study of exchange will include the development of a priori models of exchange from archaeological and anthropological literature, development of descriptive models, and evaluation of the contrasts between the two. In addition, identification of instances of migration into the project area may aid the study of foreign interactions.

A Priori Models

Renfrew (1975:41-51) has detailed a set of exchange system models that are derived from ethnographic studies and economic anthropology. These models span the range of exchange complexity from simple reciprocal exchange to ports of trade. Not all of these models can be successfully translated into unique sets of archaeological expectations (Renfrew 1977:88), but several may be applicable in the context of Southwestern archaeology. Two of primary interest are variants of the reciprocity systems and central place redistribution. A preliminary consideration of exchange models has been carried out by the ATG (Travis 1981), and more detailed development of a priori models of reciprocity and redistribution is planned.

Descriptive Models

Expected ceramic distributions based on the a priori models of reciprocity and redistribution will be contrasted with descriptive models developed directly from DAP data. These descriptive models will attempt to address the characteristics of exchange networks presented by Plog (1977: 129): content, magnitude, diversity, extent, directionality, symmetry, centralization, and complexity. Not all of these characteristics can be inferred due to the limitation of ATG activities to analysis of collections from within the confines of the project area. However, the few comparable studies of Mesa Verde region ceramics (Lucius 1980, 1982) will be used to broaden the geographic perspective where possible. Preliminary review of ATG data suggests that separate descriptive models should be constructed for each ware. This is due to the potential existence of a variety of exchange systems arising as correlates of ware function. Red wares may have become the objects of redistributive networks during the later

occupation of the project area, whereas gray ware vessels may have remained associated with reciprocity systems throughout the occupation.

Migration

In addition to interaction through exchange systems, migration of people into the project area from elsewhere may have affected local cultural development. Difficulties involved in the inference of intra-regional migration have been discussed previously under Problem Domain 2. However, some instances of extraregional migration may be detectable and will contribute to the study of foreign interacton.

Problem Domain 5: Cultural Process

The objectives of the previous problem domains are to generate sets of synchronic inferences about cultural systems in the Dolores River valley. Problem Domain 5 introduces the diachronic element, intending to describe and offer explanations for temporal changes in the cultural systems. The modeling effort (Lipe 1981, 1982) is the main vehicle for exploring this problem domain, and diachronic syntheses of the previously discussed ATG studies will contribute significantly to model development. In addition, a primary contribution of the ATG to this effort is the provision of dating inferences for ceramic-bearing archaeological proveniences. For most DAP archaeological contexts, these inferences will be the only available chronological control.

Typological Dating

Ceramic types are temporally sensitive by definition. They are defined as clusters of technological and stylistic attributes that have limited time spans of manufacture or popularity. In most cases, these types are assigned date ranges based on associations with tree-ring dated

sites or structures. Once the date range of a given type is established for a region, the occurrence of the type in an undated site can be used to infer the age of the site. Pottery types in the Mesa Verde region and their date ranges are summarized in Breternitz et al. (1974). Slight modifications in this calibration have been made by the ATG based on dated structures and associated ceramics within the project area (Blinman 1981a). In addition to the typological dating, sherds that cannot be classified to type are placed into groups that are characterized by time-sensitive technological attributes. These groups have also been calibrated and are used in addition to the types to infer the ages of otherwise undated proveniences. Within the context of ATG application, typological dating is a form of occurrence dating and is used to set conservative estimates of the occupation range of a site (i.e., the true date of the site occupation will fall within the stated range with a high degree of confidence). These range estimates are often too great to be useful in studies of cultural process, and less conservative dating techniques are necessary.

Dating Using Regression Techniques

The recovery of ceramics from well-dated proveniences in the project area allows the use of regression techniques to characterize change in ceramic assemblages and to estimate the age of otherwise poorly dated proveniences. Regression techniques take advantage of frequency changes that describe the waxing and waning of a particular type's abundance, and they can be used to date ceramic assemblages with much greater resolution than is possible with an occurrence approach to typological dating. In addition, these techniques offer the potential to provide error term estimations and thus provide explicit evaluations of the confidence which

can be placed in any individual dating inference. Although these concepts have been subjectively applied to the dating of site survey collections (Blinman 1982b), no regression-based dating using pottery type frequencies has yet been attempted for project area proveniences. The initiation of such a study is planned following the reporting of the 1981 field season tree-ring dates.

Ceramic attribute frequency or value changes within a type or related types are other possible data sources for regression-based dating techniques. Plog and Hantman (n.d.) have used multiple regression analysis of white ware decorative element frequencies to revise dating assignments for Black Mesa ceramic collections. Unfortunately, low frequencies of demonstrably locally produced white wares precludes such an approach on DAP sites. However, a single regression analysis of neckband height variation (Moccasin Gray and Mancos Gray ceramic types) was carried out for DAP proveniences (Blinman 1981b) and is continuing to be refined by the ATG.

Seriation Dating

Seriation has a considerable history and literature in archaeology, and Marquardt (1978) has recently summarized both its theory and application. Seriation dating is the ordering of archaeological proveniences in an effort to approximate their actual temporal sequence. It assumes the existence of temporally related frequency or attribute value changes, and it is usually applied in situations where calibration is not possible. Given the number of tree-ring dated ceramic assemblages recovered by the DAP, calibration and regression dating are more appropriate, and no seriation studies are planned.

CONCLUSION

Expected contributions of the ATG to the goals of the program research design and to the modeling effort are many and varied. This analysis group research design outlines the major studies that are planned and provides various levels of background information. Detailed research designs will be created for each individual study (as in the modeling study designs) and will be incorporated into the substantive reporting of results. Anticipated written outlets for ATG studies include descriptive site reports, phase reports, substantive reports of ATG activities, modeling reports, and reports for professional distribution (table 2). The annual ATG substantive report series will include the comprehensive presentation of all studies other than preliminary analyses, and modeling reports and professional reports will be abstracted and synthesized from these.

Table 2. Analyses and reporting

Analysis	Descriptive site reports	Phase reports	Task group substantive reports	Modeling reports	Professional distribution*
Ceramic preliminary analysis	X	X	X	X	
Worked vegetal preliminary analysis	X			X	
Ceramic resource study		X	X	X	X
Ceramic technology	X		X	X	X
Basketry technology	X		X		
Vessel form/use	X	X	X	X	X
Ceramic craft specialization			X	X	X
Household size study			X	X	X
Population and duration estimation			X	X	X
Immigration			X	X	X
Group definition			X	X	X
Social differentiation			X	X	X
Exchange			X	X	X
Ceramic dating	X	X	X	X	X

* Professional distribution implies presentation as a paper at a professional meeting or publication through a juried journal or volume.

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