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The Dolores Archaeological Program Magnetic Reconnaissance Survey Program: Field Operations

by

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

A magnetic reconnaissance survey was implemented in the initial year of the Dolores Archaeological Program to determine if this method would be useful in revealing subsurface archaeological features and in delineating the boundaries of the archaeological sites. The following report is a description of the field activities for the 1978 field season. The magnetic survey was useful in locating two pitstructures at Site 5MT2193 (excavated during the 1978 and 1979 field seasons by Dolores Archaeological Program field crews), and subsequent investigations of magnetically surveyed sites are expected to yield similar results.

INTRODUCTION

A magnetic reconnaissance survey was initiated 28 August 1978 for the first year of field operations of the Dolores Archaeological Program. Magnetic survey is a relatively new research method which records variations in the earth's magnetic field enabling detection and definition of subsurface archaeological features prior to excavation. The survey is instrumental in determination of perimeters, grid placement, and general delineation of features present on the sites.

Because this is among the first magnetic surveys attempted in the southwestern region of Colorado, the results of the survey need to be tested archaeologically to verify analysis of the anomalies. Essentially this need only be done until a correlation can be established between the characteristics of magnetic anomalies and archaeological features.

During the 1978 field season, two prehistoric sites (Site 5MT2193, Dos Casas Hamlet, and Site 5MT2198, Sagehill Hamlet) were magnetically surveyed and consequently tested by excavation. For both sites, hand-drawn magnetic contour maps were drawn in the field. One site, 5MT2193, revealed two high anomalies which were then excavated and determined to represent two pithouse structures (Emerson, et al. [1]). The other site, Site 5MT2198, produced an anomaly which was thought to be of archaeological origin; however, test excavations proved to be sterile (Hewitt [2]). It was later concluded that the anomaly was due to a fragment of metal (a spike or tire rim, etc.), but nothing was conclusively proven. With ongoing magnetic analysis and research, nonarchaeological and archaeological features will be distinguishable by the type of

anomaly produced. See Huggins and Weymouth [3] for a discussion of the criteria on which these distinctions can be based.

Different types of maps and an explanatory narrative for each site are being produced by the Nebraska Center for Archaeophysical Research (NEBCAR) to aid in the analysis of the data (Huggins and Weymouth [3]). Future research will focus on the description of magnetically subtle features as well as the more obvious ones. It is also possible to filter out such obtrusive anomalies as produced from ferrous objects which are of no consequence in determination of prehistoric archeaological features. Dr. John Weymouth of the Department of Physics and Astronomy at the University of Nebraska is conducting the computer programming and analysis with the assistance of Rob Huggins, a graduate student at that institution.

METHODOLOGY

The magnetic field of the earth varies throughout the world according to latitude and to more local phenomena. This field of intensity is not temporally constant, but fluctuates diurnally and seasonally, and also exhibits longer-term variability as well. Within the main field, local magnetic fluctuations are apparently due to varying topographic, geologic, and vegetal factors as well as the to more subtle factors produced from cultural features. It is these subtle deviations from the magnetic field which are of more interest to the archaeological discipline.

Magnetic surveying consists of measuring, mapping, and interpreting the magnetic intensities within specific areas of interest. These local variances from the magnetic field are referred to as anomalies and indicate fluctuations in the magnetic field which might be caused by a variety of factors. It is the interpretation of these anomalies which enable the analyst to infer the presence of subsurface archaeological features.

The shape and type of anomaly produced from the data can be interpreted in terms of underlying causes, and it is possible to estimate the type of feature creating the anomaly. The size and amplitude of the anomaly are dependent on the vertical and horizontal distance from the instrument sensor, the amount of object magnetism, and the size of the magnetized object. Ferrous objects occasionally produce erratic results and obscure nearby archaeological features. Geological influences can also obscure the more subtle features. All of these factors are pertinent in the final analysis and success of magnetic surveying.

The reliability of the data is dependent upon numerous factors; this is why magnetic surveying must be treated with professionalism by the entire field crew. It is essential that the "sensor holder" (that is, the person responsible for moving the remote sensor over the area being surveyed) be magnetically clean, as any metal objects close to the instrument will cause fluctuations and inaccurate information. The sensors must be very still during the readings or this can also obscure the data. When surveying, objects such as electrical wires, fences, and automobiles should be avoided. The presence of any of these types of materials will produce inaccurate data and therefore affect the analysis.

In extracting data from an area, several methods are possible, but the one found most effective for the Dolores Archaeological Program Survey is the differential method. This method entails the use of two magnetometers, one to record the apparent spatial fluctuations in the area surveyed, and the other to record the diurnal fluctuations in the magnetic field. Variations in the readings of the two instruments are then calibrated to determine the true local subsurface readings, and these readings are interpreted to identify anomalies.

Most magnetometers used for geological purposes are sensitive to one gamma ($1 \times 10_{-5}$ Gauss, the measurement used for indicating the intensity of the magnetic field), as this is all that is necessary to detect features of geological origin. However, in detecting features of archaeological interest, a much more sensitive instrument is necessary due to the subtle nature of the features under study. Therefore, the magnetometers used for archaeological study are equipped with

one-fourth gamma features, which enable them to be four times more sensitive. The use of this instrument in magnetic surveying enables a more accurate analysis of the possible features in the area.

PRELIMINARY PROCEDURES

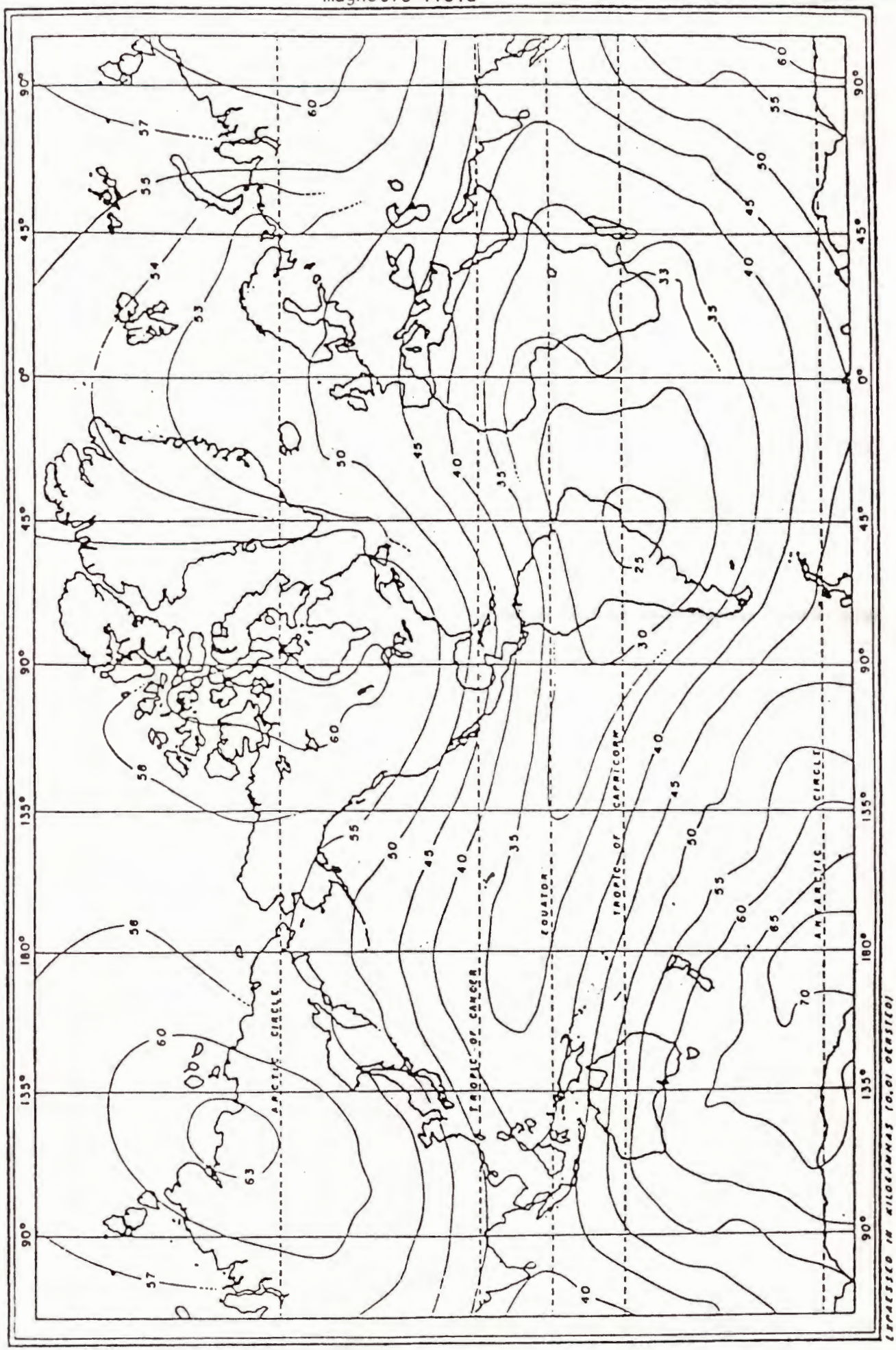
The sites to be magnetically surveyed were selected from areas which will be affected in the near future by land-modifying activities of the Dolores Project. All sites selected, with the exception of 5MT0023 (Grass Mesa Village), are located in Borrow Area A, a location where material will be removed for dam construction (Figures 13.1 and 13.2). The process of selection consisted of reviewing the site survey reports for the priority area and noting those sites that possess suitable physical characteristics for magnetic survey (suitable soils, topography, etc.). Site types, temporal assignments, and excavation priorities are then considered in selecting the sample. Most sites magnetically surveyed in the 1978 field season are scheduled for excavation in the 1979 field season; however, four additional sites (Site 5MT4652, Site 5MT4657, Site 5MT4659, and Site 5MT2672), were selected because immediate input for evaluation was critical (the sites would be impacted by a proposed project haul road).

Al Kane, Co-Principal Investigator for the Dolores Archaeological Program, and Robert Huggins of NEBCAR, made the decisions as to which sites and what areas of the sites were to be magnetically surveyed. Subsequent to the actual survey procedure, the desired area for each site must be located and physically delimited. To accomplish this a transit is set up on one of the established perimeter corners of the study area. From here the desired number of survey blocks are defined and staked; the grid blocks are oriented according to magnetic north. In general, blocks measure 20 by 20 m, but it is occasionally necessary to use 20 by 10 m

Figure 13.1: Location of sites subject to magnetic survey during 1978 (with the exception of 5MT0023, Grass Mesa Village).

Figure 1: Intensity distribution of the earth's magnetic field

Not Fig 1



The Total Intensity of the Earth's Magnetic Field

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Figure 13.2: Location of Site 5MT0023, Grass Mesa Village.

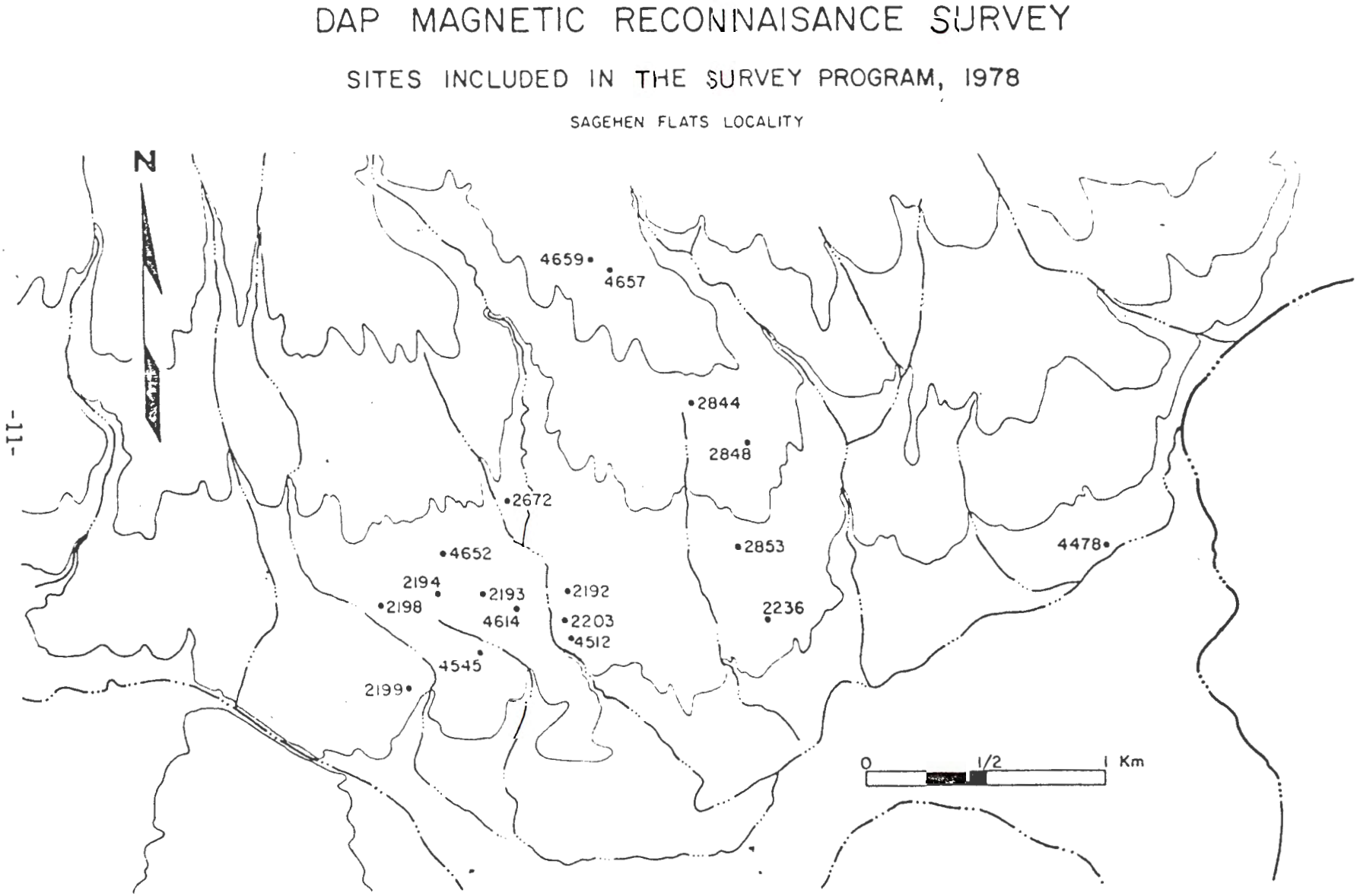

Figure 2: Location of sites subject to magnetic survey during 1978

blocks because of unsuitable topography or limits of areas of interest. Once the perimeters of the blocks are staked, each corner is marked according to location,with " 1,1" indicating the southwest corner. In these designations, the first coordinate relates to the south-north location and the second coordinate relates to the west-east location, as shown in Figure 13.3. This method facilitates interpretation of the computer maps (SYMAPS) and relates easily to the actual layout of the grid in the field. One or more blocks with shared boundaries constitute a grid (Figure 13.3). There may be one or more grids per site, depending on the site size and/or the areas to be investigated.

In order to conduct magnetic reconnaissance survey, a minimum of three technicians is required: one person to operate the stationary magnetometer and record data, another to operate the moving sensor, and a third to operate the moving magnetometer. It is necessary that the crew be magnetically clean so as not to affect the data; fluctuations of more than 4 quarter gammas from a position an arm's length from the sensor risk contamination.

Following the establishment of the grids, the instruments should be positioned with the stationary sensor sufficiently far from the study blocks so as not to cause interference. Once the stationary sensor is installed in an area of low magnetic variance, it should not be bumped or moved until completion of the survey.

In order to keep the stations consistent within the block, ropes are utilized which are marked in one m intervals, and four guidelines are employed to mark the south-north and west-east lines which the moving magnetometer crew follow. Surveying begins in the southwest corner of the grid and/or block and the crew moves north and east. The stations

Figure 13.3: Schematic of magnetic survey provenience system.

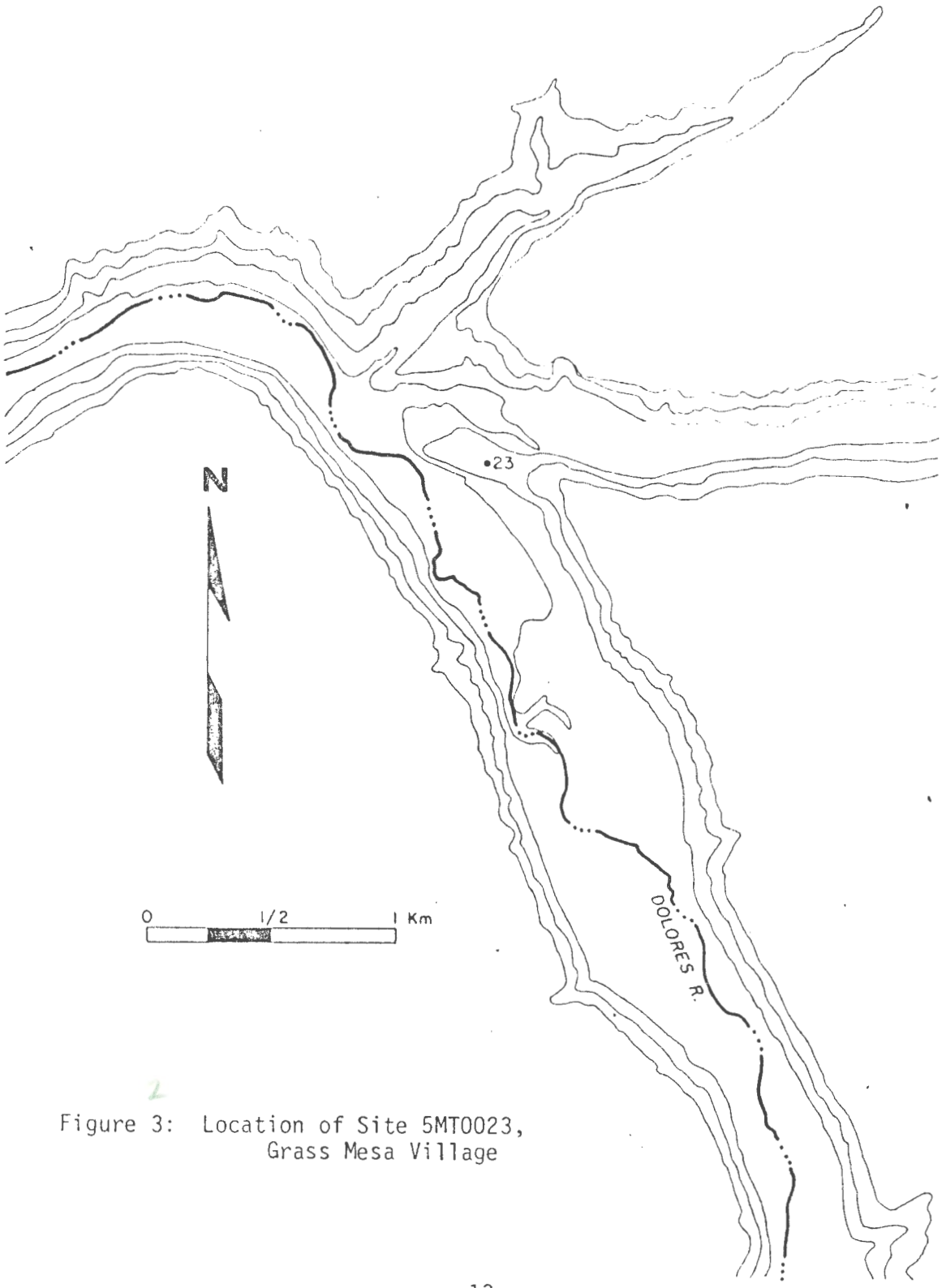

Figure 3: Location of Site 5MT0023, Grass Mesa Village

normally progress to the north, along the guideline until the end of the line is reached. The crew then moves east one line and repeats the procedure. Both magnetometers are activated simultaneously at the call of the moving magnetometer operator and information is recorded by the stationary magnetometer operator. When all grids from a site have been surveyed, this information is sent to NEBCAR for computer processing, print out (SYMAPS), and subsequent interpretation. It is also possible to draw hand-contoured maps, although these are less accurate and more limited than the SYMAPS.

SUMMARY OF 1978 OPERATIONS

On 28 August 1978 Robert Huggins of NEBCAR arrived to begin field operations in conjunction with Dolores Archaeological Program personnel at several of the high priority sites in the dam project area.

From 28 August through 5 September Huggins, with the assistance of Laura Maness (a University of Colorado field crew member), surveyed the study sites with a transit to delineate the boundaries of the magnetic survey test squares. At this time a total of forty-seven 20 by 20 m and two 20 by 10 m blocks were established at 15 prehistoric sites.

On 11 September 1978 Huggins conducted a field training session to teach techniques necessary to accomplish a magnetic reconnaissance survey. This session consisted of procedural enactment, participatory discussions on the mechanics involved in magnetic surveying, general description of computer data print out and subsequent analysis, and procedure for hand-contouring magnetic maps. Those attending the session were Kyle Bauman, Laura Maness, and Holly Hathaway (author). Gary Brown, Ray Harriman, and Jacqueline Litvak (University of Colorado crew members) were later trained by Hathaway and used to augment the Magnetic Reconnaisance Survey Crew.

The Special Studies Crew was organized on 25 September 1978 with implementation of the Magnetic Reconnaissance Survey as one of the major tasks. During the 1978 field season Holly Hathaway, served as crew leader with Kyle Bauman, Gary Brown, Ray Harriman, Jacqueline Litvak, and Laura Maness as Magnetic Reconnaissance Survey Crew members.

The Magnetic Reconnaissance Survey field season began on 11 September and ended 6 November (because of inclement weather and poor road conditions). A total of 39 working days, or 840 man-hours, were expended in laying out the blocks and collecting data on the sites, with crew sizes varying from two to three technicians.

Fifty-two 20 by 20 m blocks, four 20 by 10 m blocks, and one 20 by 5 m block were established at 19 prehistoric sites (Table 13.1). Seven of the 20 by 20 m blocks were not magnetically surveyed by the end of the 1978 field season due to inclement weather. Five of the 20 by 20 m blocks were hand-mapped at the project and were not sent to NEBCAR for computer analysis and interpretation. Those sites surveyed were a subset of those eligible for excavation during the 1979 and 1980 field seasons.

Efficiency for the 1978 field season was somewhat hampered by the inexperience of the crew and maintenance problems with the sensitive instruments; however, a minimum of two blocks were surveyed per working day. Table 13.1 lists all the sites, the number of blocks per site, and the date(s) surveyed.

The two magnetometers used on the Dolores Archaeological Program were of the portable proton magnetometer type, Model Number G-826, and were purchased from geoMetrics of Sunnyvale, California on 11 September 1978.

Table 13.1. Inventory of Work Completed, Dolores Archaeological Program Magnetic Reconnaissance Survey, 1978 Field Season.

SITE #	# of 20x20 m Blocks	# of 20x10 m Blocks	DATE SURVEYED
5MT0023	2 (Grid 1)		3 October
		2 (Grid 2)	4 October
	5 (Grid 2)		**
5MT2192	4		22 & 25 September
		2	11 November
5MT2193	1		12 September
5MT2194	2		13 & 14 September
5MT2198	1		13 September
5MT2199	2		1 November
5MT2203	2		6 October
5MT2236	6		10 & 11 October 2 November
5MT2672*	1		4 November
5MT2844	4		20 & 23 October
5MT2848	4		19 & 20 October
5MT2853	2		12 October
5MT4478	2		22 & 25 October
5MT4512	2		6 October
5MT4545	4		19-21 September
5MT4614	4		12, 15 & 19 September
5MT4652*	2		3 November
5MT4657*	1		5 November
5MT4659*	1		5 November

* Hand-contoured maps only; no SYMAPS available.
**Blocks not magnetically surveyed in 1978 field season.

RESULTS

Computer SYMAPS, line contour maps and interpretive narratives for sites surveyed in 1978 appear in NEBCAR report (Hugggins and Weymouth [3]).

The four sites which will be discussed in the preliminary report are as follows: Site 5MT4652, Site 5MT4657, Site 5MT4659, and Site 5MT2672. These sites were not programmed into the NEBCAR computer but were hand-contoured for result expedience; the sites would be impacted by a proposed Bureau of Reclamation access road, and a quick evaluation of the cultural resources present along the proposed access route was needed. As previously mentioned, the hand-contoured maps are less accurate than computer SYMAP print outs and the interpretive discussions take into account these limitations.

Site 5MT4652

Two grids, with one 20 by 20 m block in each, were established and surveyed at Site 5MT4652. The site is located on a south sloping ridge of a plowed field in the Sagehen Flats area north of Road X (Figure 13.1). Grid 2 is located approximately 10 m north and west of Grid 1. Grid 1 is offset to the east of the ridgetop and appeared to be a good location for a structure. Block A, Grid 1, is fairly quiet magnetically (Figure 13.4); however, two anomalies are present. One large anomaly located at (E13,N12) is a dipolar phenomenon which is probably due to a metal object in the vicinity; it is oriented in WSW-ENE position rather than than in standard north-south orientation resulting from fire-hardened archaeological features or other features containing in situ burnings.

Figure 13.4: Site 5MT4652, Block A, Grid 1, magnetic contour map.

DAP MAGNETIC RECONNAISANCE SURVEY

PROVENIENCE SYSTEM SCHEMATIC

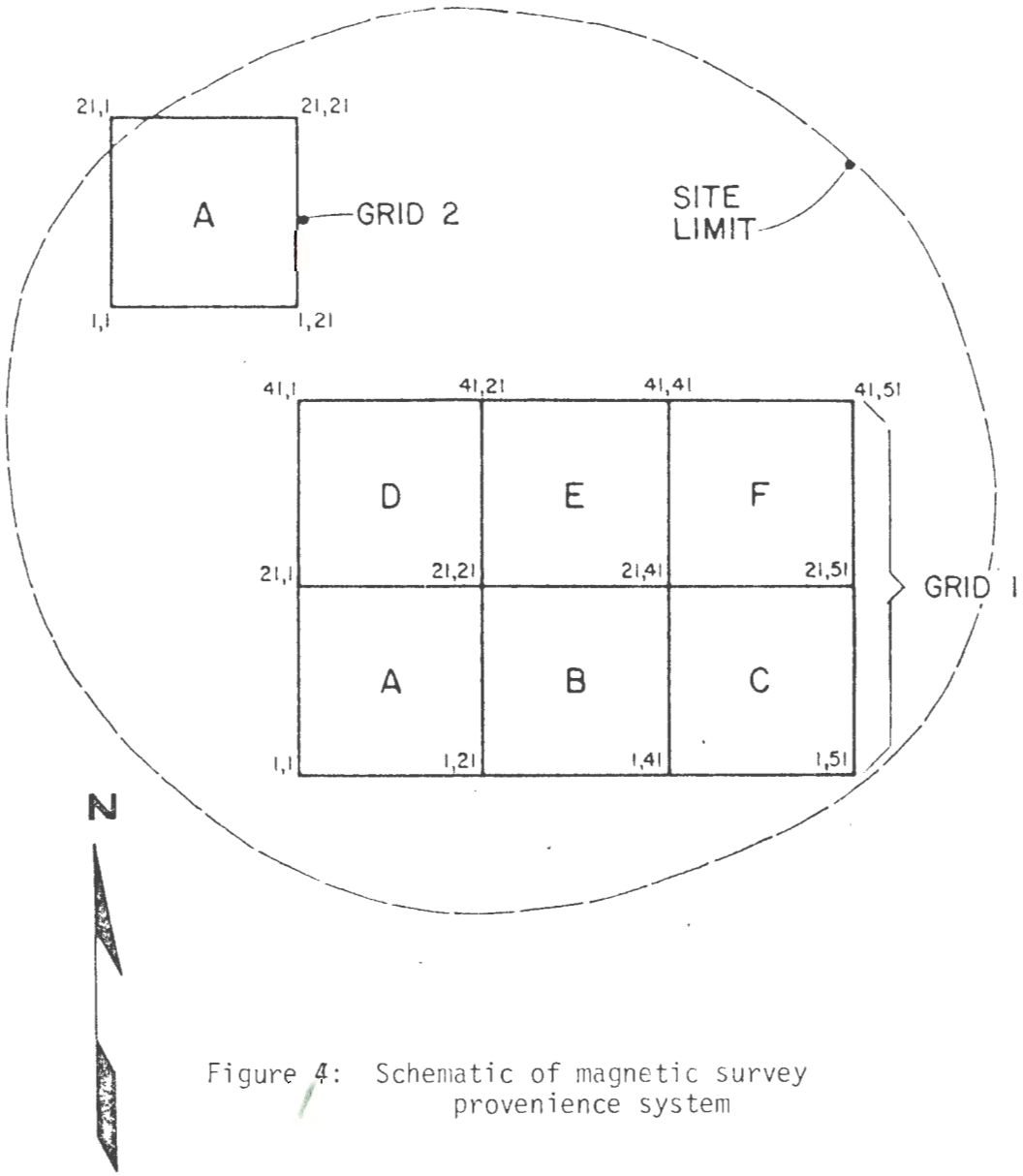

Figure 4: Schematic of magnetic survey provenience system

The anomaly located at (E4,N14) is a dipolar phenomenon, oriented north-south, which probably indicates an archaeological feature. The anomaly is relatively small, possibly resulting from a fire hearth or other such small feature.

Grid 2, Block A, is located on top of the ridge and is centered on one of the Bureau of Reclamation's road survey stakes. A metal rebar (road stake) situated at (E7,N10) (Figure 13.5) produced a large anomaly which does not appear to be dipolar, probably due to the vertical position of the rebar in the ground. A dipolar anomaly located at (E15, N14), oriented WNW-ESE, is again probably due to a metal object which was not observed in the survey. Two separate anomalies located at (E13.5,N5) exhibit high magnetic areas with no associated negative pole (that is, a monopole), these may be of archaeological origin.

There is one other area which is apparently producing a dipolar effect, but the majority of the anomaly is located east of the survey perimeters and proper assessment is not possible without complete information.

Site 5MT4657

This site is located in a plowed field of rolling hills and ridges at the bottom of a slightly depressed area (Figure 13.1). The site consists of a scant sherd and lithic scatter, with a rubble pile to the south. One grid, with a 20 by 20 m block, is located north of the rubble pile and centered over the sherd and lithic scatter. No anomalies are apparent in the hand-contoured maps; the field appears magnetically flat (Figure 13.6).

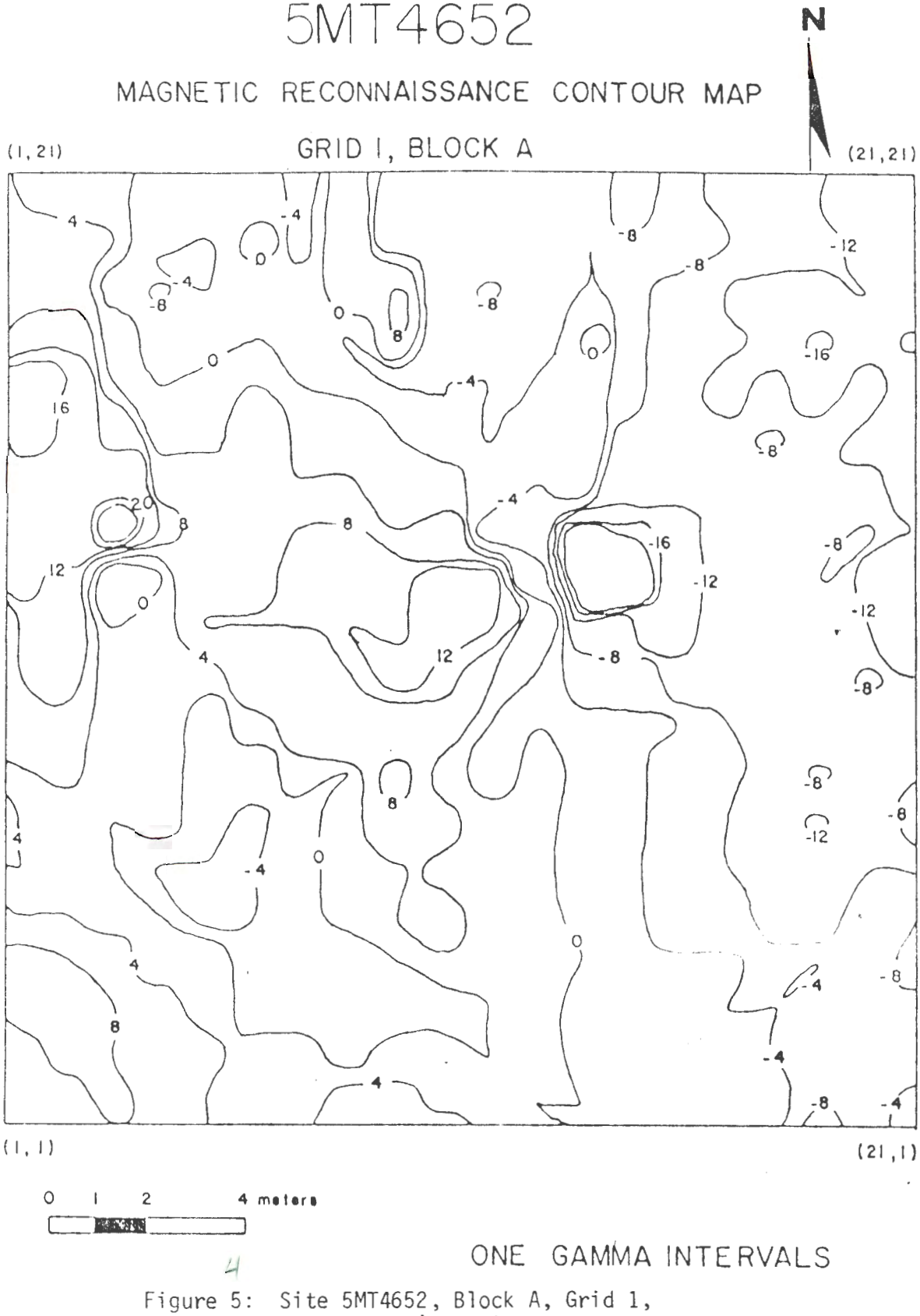

Figure 5: Site 5MT4652, Block A, Grid 1, magnetic contour map

Figure 13.5: Site 5MT4652, Block A, Grid 2, magnetic contour map.

Figure 13.6: Site 5MT4657, Block A, Grid 1, magnetic contour map.

5MT4652

MAGNETIC RECONNAISSANCE CONTOUR MAP

GRID 2, BLOCK A

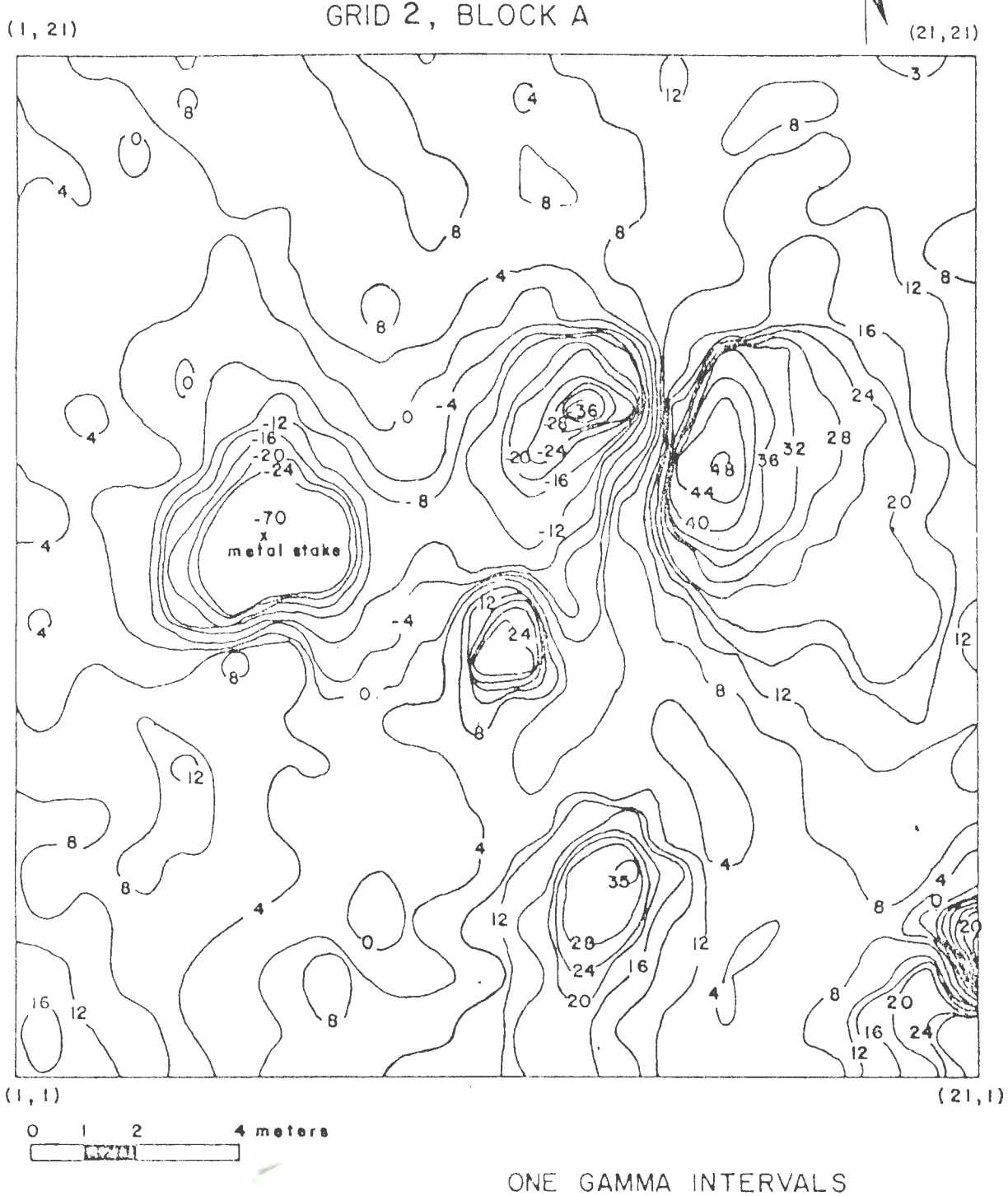

Figure 6: Site 5MT4652, Block A, Grid 2, magnetic contour map

Site 5MT4659

This site is located approximately 50 m west of 5MT4652 on a ridge top in a plowed field (Figure 13.1). One grid with a 20 by 20 m block was surveyed centering on a small rubble mound with surrounding scattered sherds and lithics.

A very strong dipolar anomaly is located (E6,N18) (Figure 13.7) with a NW-SE orientation; it is very prominent and probably not due to archaeological origins. The anomaly might be due to a rather large metal object located below the surface and situated in a NW-SE position.

Another anomaly, located slightly south of the rubble mound at (E11,N9) a high monopolar phenomenon which is probably due to the proximity of sandstone rubble. Distinguishing features (walls, etc.) are not discernible on the hand-contoured map.

A very high anomaly is located at (E20,N2) and influences a large area; it is very possibly due to an archaeological feature, probably a prehistoric pithouse. This anomaly extends outside the east and south perimeters of the surveyed area, so a complete description is not possible.

There is an odd triad of anomalies located in the northeast corner of the block. This consists of a high area at (E19,N18) with an associated low area at (E16,N17) to the west-southwest. Another low area at (E16,N14) exists due south of the first low area but is wider and more shallow and probably not related in origin. These anomalies are likely not due to archaeological factors.

Site 5MT2672

Site 5MT2672 lies on a small ridge in a plowed field (Figure 13.1)

Figure 13.7: Site 5MT4659, Block B, Grid 1, magnetic contour map.

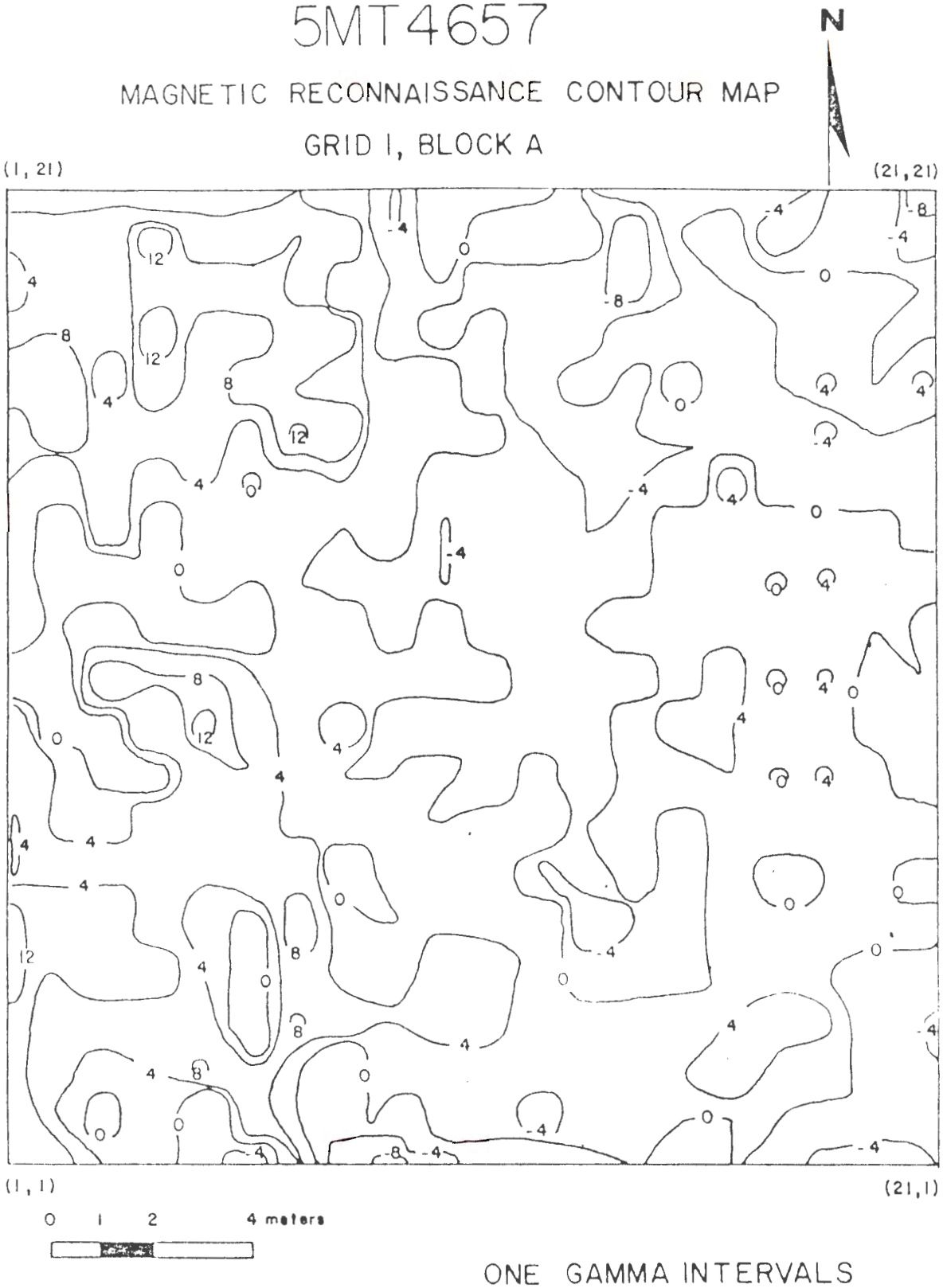

Figure 7: Site 5MT4657, Block A, Grid 1, magnetic contour map

and consists of a fairly small but scattered area of sherds and lithics. One 20 by 20 block was plotted on top of the ridge and covered the majority of artifactual debris. A fairly wide linear feature is apparent on this map, running north-south in the center of the block (Figure 13.8); it is perhaps due to the ridgetop or other topographic features. Just to the east of this feature at (E14,N12), a small anomaly with a high magnetic field is apparent with an associated slight negative anomaly to the south-southwest, this possibly indicates a fire hearth or other such archaeological feature.

Figure 13.8: Site 5MT2672, Block A, Grid 1, magnetic contour map.

5MT4659

MAGNETIC RECONNAISSANCE CONTOUR MAP

GRID I, BLOCK B

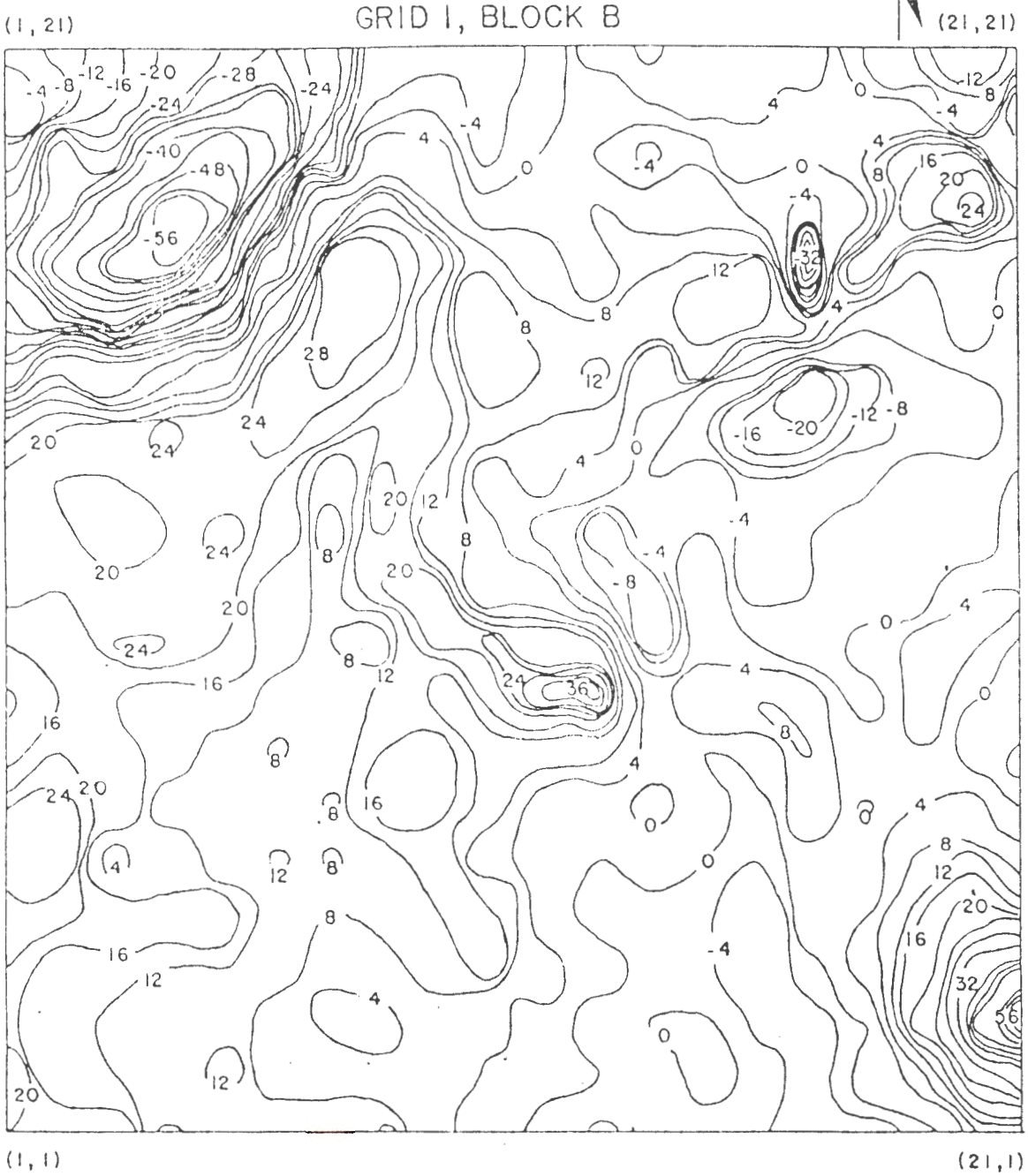

Figure 8: Site 5MT4659, Block B, Grid 1, magnetic contour map

CONCLUSIONS

The 1978 field season of the Magnetic Reconnaissance Survey program was successful in locating two verified pithouses on a site excavated in the 1978 field season (Site 5MT2193). During the 1979 field season, most of the remainder of the sites magnetically surveyed in 1978 will be tested. Analysis and interpretation resulting from the magnetic survey will assist in formulating excavation strategy for these sites. With continuing analysis of anomalies produced and actual archaeological features discovered, better and more detailed interpretation will be possible. It is anticipated that Dolores Archaeological Program magnetic survey operations will be expanded in future years as the technique undergoes further refinement. In addition to providing input for conceiving excavation strategies and schedules at sites to be intensively investigated, other possible applications are in mapping of large prehistoric sites and regional sampling procedures.

Interpretation of the magnetometer survey of the four sites present in the proposed right-of-way for the project haul road suggested that significant subsurface archaeological structures or features were probably present at Site 5MT4652 and Site 5MT4659. It was therefore recommended to the Bureau of Reclamation that the road be rerouted to avoid these sites; the Bureau of Reclamation later changed the location of the road in lieu of the potentially damaging alignment.

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