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A MAGNETOMETER SURVEY OF THE KNIFE RIVER INDIAN VILLAGES

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ABSTRACT

There are several Indian village sites at the confluence of the Knife and Missouri rivers near the town of Stanton, North Dakota. Two of them were examined or tested by D. J. Lehmer in 1965. Four of the sites are now being incorporated into the Knife River Indian Villages National Historic Site. As part of the development of this Historic Site a proton magnetometer survey was carried out in 1976 on parts of Sakakawea Village and the Buchfink Site. In addition, a survey was conducted on part of the Amahami Village in Stanton. This article discusses the theory of magnetic surveying, the varying nature of the regions surveyed, and the extensive results obtained. These results include the identification of at least 12 earth lodge sites with associated features, the correlation of some features in the magnetic data with soil probe information, and a number of suggestive but unidentifed features on which the magnetic measurements focus.

INTRODUCTION

In 1965 Donald J. Lehmer conducted a study of a group of Mandan and Hidatsa villages near the confluence of the Knife and Missouri rivers, north of Stanton, North Dakota (Lehmer 1965). Although the sites had been recognized, mapped and occasionally tested archaeologically since early in this century, relatively little was known about them except from ethnographic sources (e.g., Bowers 1965; Wilson 1917, 1924, 1934) prior to Lehmer's study. Subsequently, an act of Congress in 1974 authorized the approximately 1200-acre Knife River Indian Villages National Historic Site which will encompass these sites for preservation and interpretation.

The National Historic Site will include four Indian villages. The Big Hidatsa Village (32ME12) is the largest of these. At the time of Lehmer's study it had over 80 house depressions and traces of a fortification ditch, or perhaps two, around the village. Lehmer did not excavate, but examined pottery from the site in the State Historical Society of North Dakota collections. He concluded that it was occupied not only during the last or Knife River Phase (A.D. 1780-1845) but also during the Heart River Phase (about A.D. 1675 to 1780).

Sakakawea Village (32ME11) lies about 1.7 miles (2.7 km) south of Big Hidatsa Village. A small portion of the southern part of the site has been disturbed by cultivation. This is the village from which, it is believed, Toussiant Charboneau and his Shoshone wife Sakakawea joined the Lewis and Clark expedition in the winter of 1804-05. Lehmer reported over 30 house depressions and traces of a fortification ditch on two sides. The site at that time, and even more so now, is being eroded by the Knife River. Lehmer dug a 5 ft. x 10 ft. (1.5 m x 3.1 m) pit in an inter-house area. The refuse was 4.3 ft. (1.3 m) deep at this point but he reported that all of the pottery belonged to the Knife River Phase.

Lower Hidatsa Village (32ME10), some 0.6 km south of Sakakawea, has also been partially cultivated. Lehmer in 1965 noted over 40 large circular house depressions. He excavated a5 ft. x 10 ft. (1.5mx3.1 m) pit down through 6 ft. (1.8 m) of refuse. In this case the pottery content indicated both Knife River and the earlier Heart River phases. Here as at Sakakawea the thick middens are complex and overlay evidence of earlier structures. Thus the presence of superimposed lodges can be expected to occur frequently.

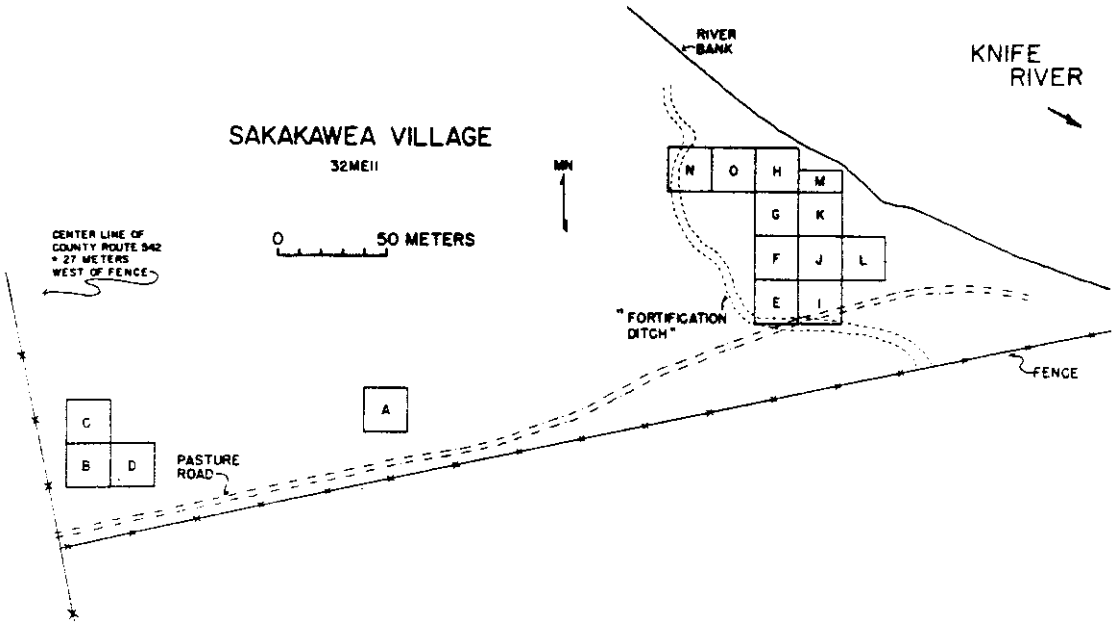

Figure 1. Layout of magnetic survey blocks at Sakakawea Village.

Finally, the Buchfink Site (32ME9) is south of the above sites and just north of the town of Stanton in a cultivated field. There are no surface indications but, on the basis of the pottery at the State Historical Society of North Dakota, Lehmer felt that there were indications of the still earlier Fort Yates Phase of Mandan-Hidatsa culture (roughly A.D. 1100-15001.

The Amahami Site (32ME8), south of Buchfink and in the town of Stanton, is not in the Historic Site but is intimately related to the other villages. Unfortunately it has been almost completely destroyed. One house depression has been preserved in the courthouse *yard.* The village was occupied by the Amahami branch of the Hidatsa when Lewis and Clark wintered nearby in 1804-05 (Dill 19771.

As part of a program of development of the National Historic Site and in anticipation of a National Park Service construction project to stabilize the bank of the Knife River at Sakakawea, preliminary archaeological investigations were initiated in the summer of 1976 by the Midwest Archeological Center. These activities included bank salvage and profiling, aerial photo-mapping and magnetic surveying.. This article will deal with the magnetic survey carried out on these villages for the National Park Service.

PRINCIPLES OF MAGNETIC SURVEYING

The magnetic field of the earth naar the earth's surface will be influenced by subsurface features having a different magnetization than that of the surrounding soil. If such a feature is localized it will produce an anomaly in the magnetic field which decreases in strength as the inverse cube of the distance between the feature and the point of measurement. Because of this rapid drop-off in strength, measurements within a meter of the surface will respond to features within 1 or 2 m below the surface, while deeper geological structures will produce broader and perhaps weaker changes in the magnetic field. Thus archaeological features have the potential of being detected in the pattern of magnetic anomalies as revealed by measuring the magnetic field over the area of interest.

The most widely used instrument for measuring magnetic fields on archaeological

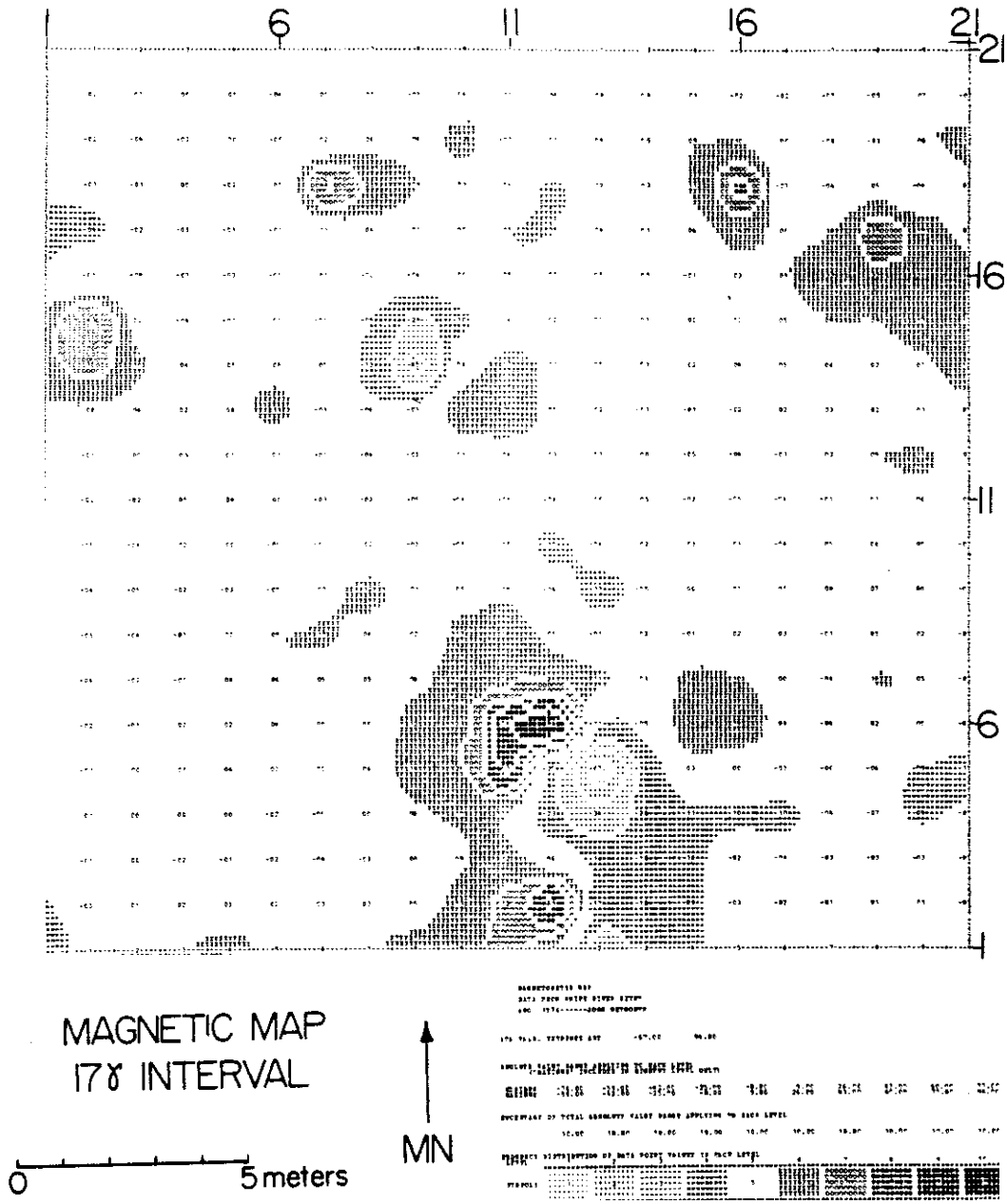

Figure 2. Magnetic contour map of Block A, Sakakawea Village. Contour interval is 17 gamma with the symbols for the central interval blank.

sites is the proton magnetometer, which has a typical sensitivity of one gamma. In these units the earth's total field in the central plains states varies from 55000 to 60000 gamma,, while anomalies of archaeological interest vary from several hundred gamma down to the limit of sensitivity.

The strength of an anomaly produced by a sub-surface feature depends on the size of the feature and its magnetic susceptibility, that is,

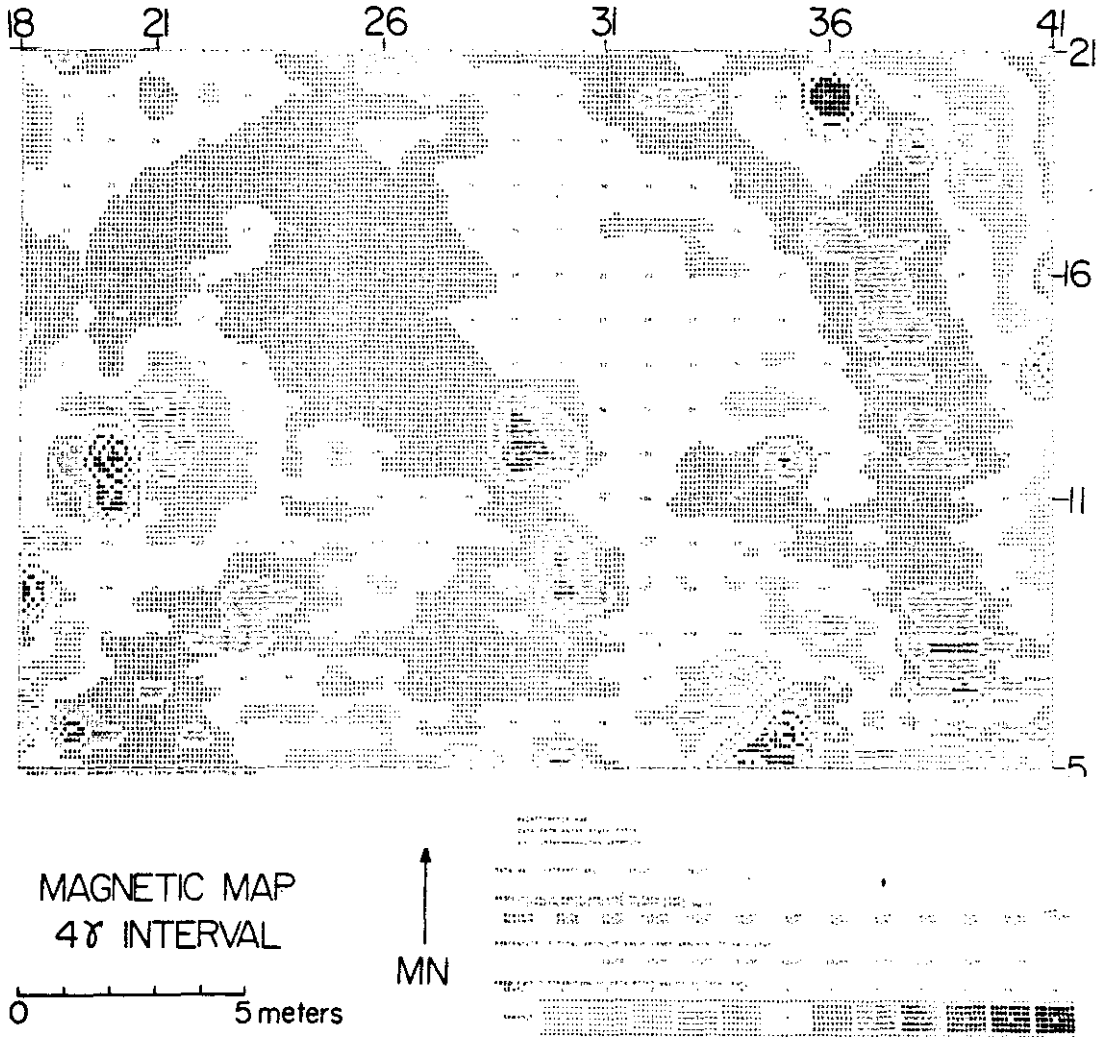

Figure 3. Magnetic contour map of the Amahami Site. The contour interval is 4 gamma and shows the residuals or differences between the raw data and a sixth order polynonial trend surface. Symbols for the central interval are blank.

the degree of its magnetization as caused by the earth's field. The shape of the anomaly is determined by the size and depth of the source. For a feature that is not large compared to its depth, the south-north profile of the associated anomaly will have a width at half-maximum value about equal to the depth of the source below the magnetometer sensor. There will be a small negative anomaly north of the positive anomaly. In general, a magnetized object will produce a positive-negative anomaly pair with this pair oriented along the axis of magnetization and with the negative anomaly nearest the north pole of the magnetized object.

An obvious example of an anomaly would be that due to a concentration of iron. For instance, one kilogram of iron could produce an anomaly of about 50 gamma at 1 m and about 7 gamma at 2 m. The widths of these anomalies would be 1 m in the first case and 2 m in the second case. Fired earth or bricks will also have good susceptibility contrast with respect to the surrounding soil. For instance,

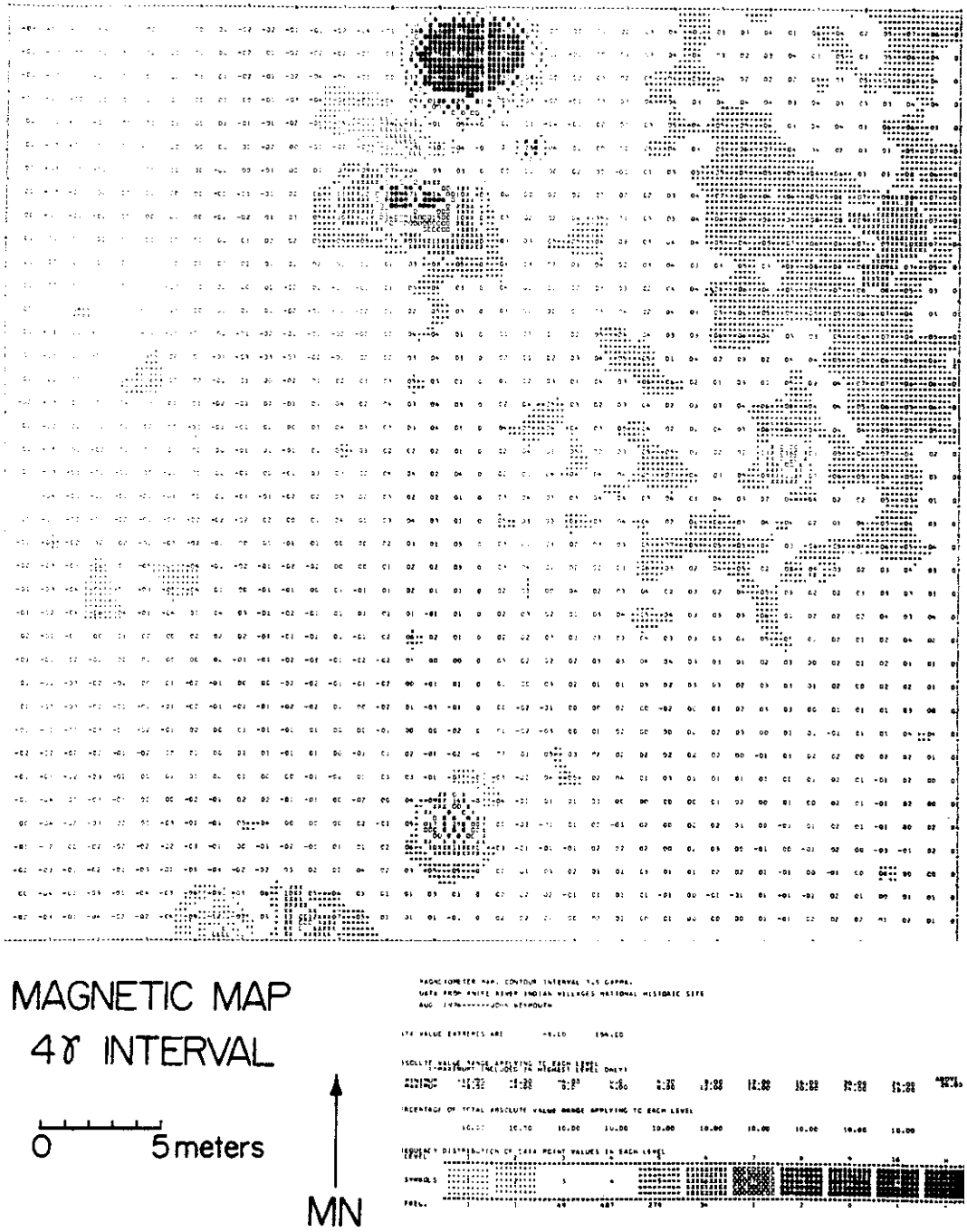

Figure 4. Magnetic contour map for the Buchfink Site. Contour interval is 4 gamma with the symbols for the two central intervals blank.

a fire pit 120 cm deep in a house at might produce anomalies Sakakawea Village caused an anomaly of 30 gamma — a typical result. Other features that are foundations, cache pits, or even soil differences at house edges.

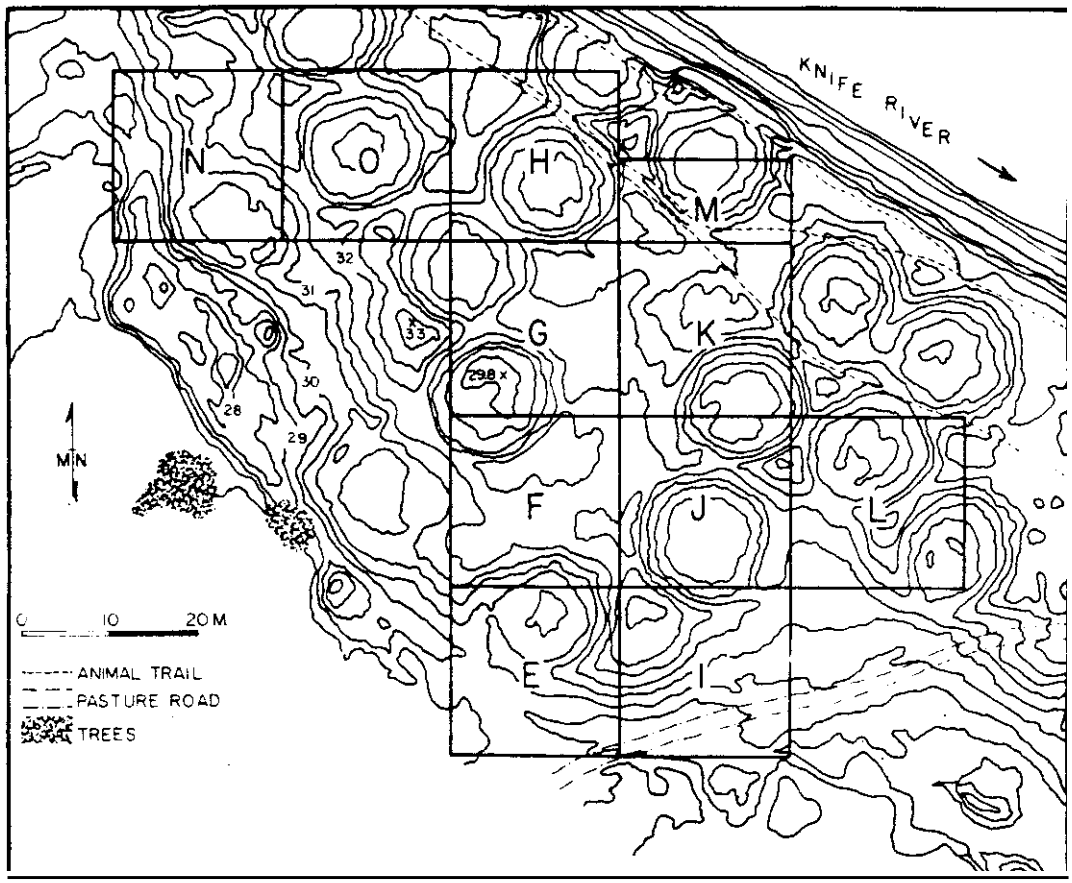

Figure 5. Topographic map of Sakakawea Village obtained from aerial photographs. Contour interval is 6 inches (Lyons 1976).

In doing careful surveying it is not sufficient to use one magnetometer because the total magnetic field at any one point can vary by some tens of gamma throughout the day — the so-called "diurnal variation." Even shorter term fluctuations can be superimposed on this variation. To cancel such changes a second, reference, magnetometer must be operated simultaneously with the moving, or grid, magnetometer. The difference between the pair of readings at each point is used for analysis. For further discussions of the theory see Tite (1972) or Aitken (1974). For the method and applications to a Central Plains site see Weymouth (1974).

In order to get sufficient data to produce meaningful anomaly patterns, it is necessary to measure the magnetic field on a grid of points over the area being studied. Typical grid intervals are 2 feet 1 meter or even 4 feet. One meter is a good compromise between detail sought and time expended.

Because of the large amount of data that can be collected on a sizeable site, it is desirable to process the data by means of computer programs. We have developed a package of programs that can produce a variety of level maps, profiles, and three-dimensional views, and that can also prepare the data for manipulation by the program SYMAP (1976). This latter program can print a variety of contour, trend surface and residual maps on the line-printer. The magnetic contour maps are printed with symbols of different degrees of darkness to indicate the different contour levels.

All the data collected at the Knife River

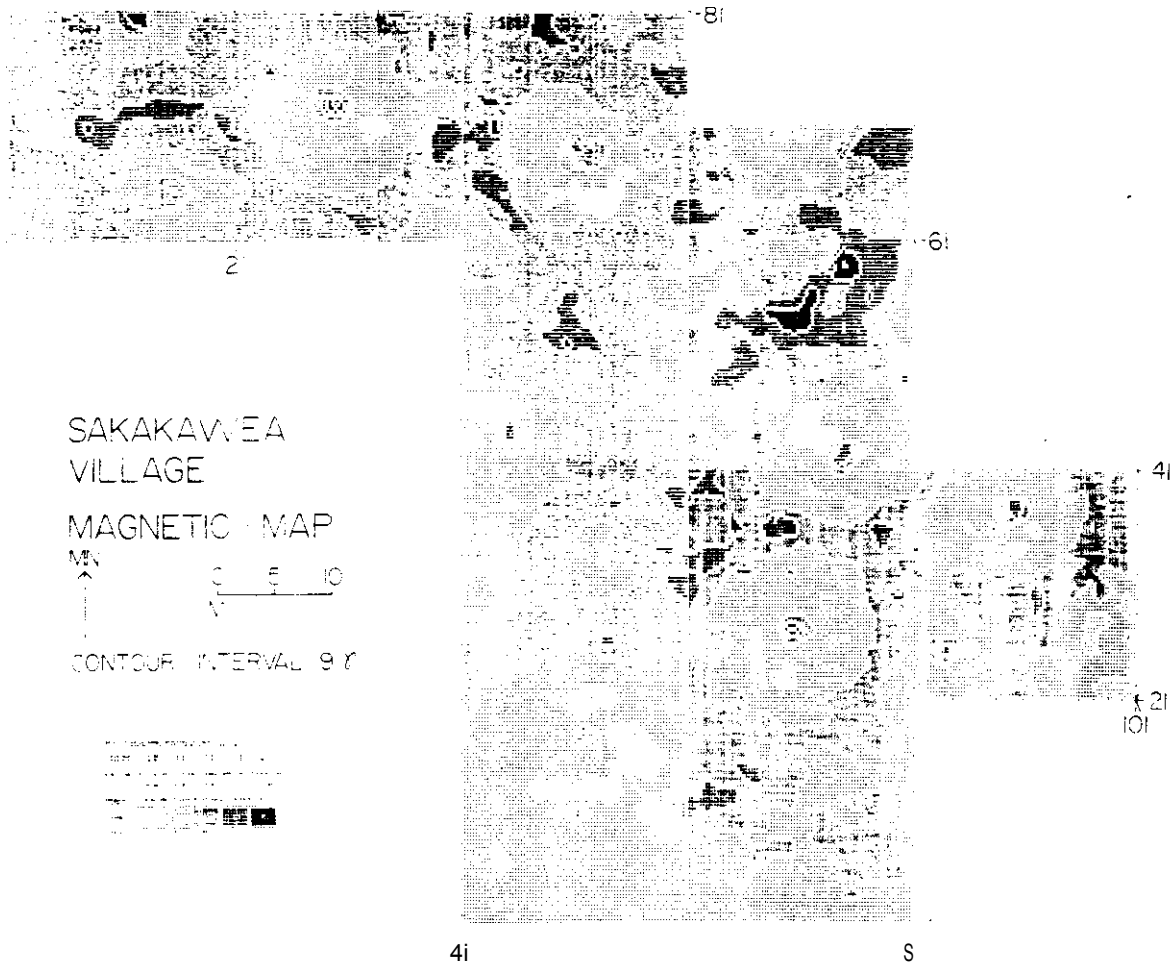

Figure 6. Magnetic contour map of Sakakawea Village. Contour interval is 9 gamma.

Indian Villages were obtained with two proton magnetometers over a period of eight days. In that time about 9000 pairs of data values were measured at one meter grid intervals over a total area of about 0.76 hectares. A sizeable fraction of the data were computer processed while at the site by means of a telephone-linked remote terminal.

AREAS COVERED BY THE SURVEY

Five separate areas in and adjacent to the Knife River Historic Site were covered in the survey of 1976. In terms of 20 m x 20 m blocks they were as follows: ten and a half blocks in the main area of Sakakawea Village (Blocks E through 01, a single block on an intermediate terrace above the village (Block A), three blocks on a terrace above block A (Blocks B, C, and D), four contiguous blocks at the Buchfink Site, and one block at the Amahami Site. The position of the blocks in the vicinity of Sakakawea Village are shown in Figure 1. Since the main Sakakawea Village survey produced the most information of archaeological interest we shall discuss that survey after dealing with the other areas.

Sakakawea Site Vicinity
Block A

This area is on an intermediate terrace half way between the village and the present

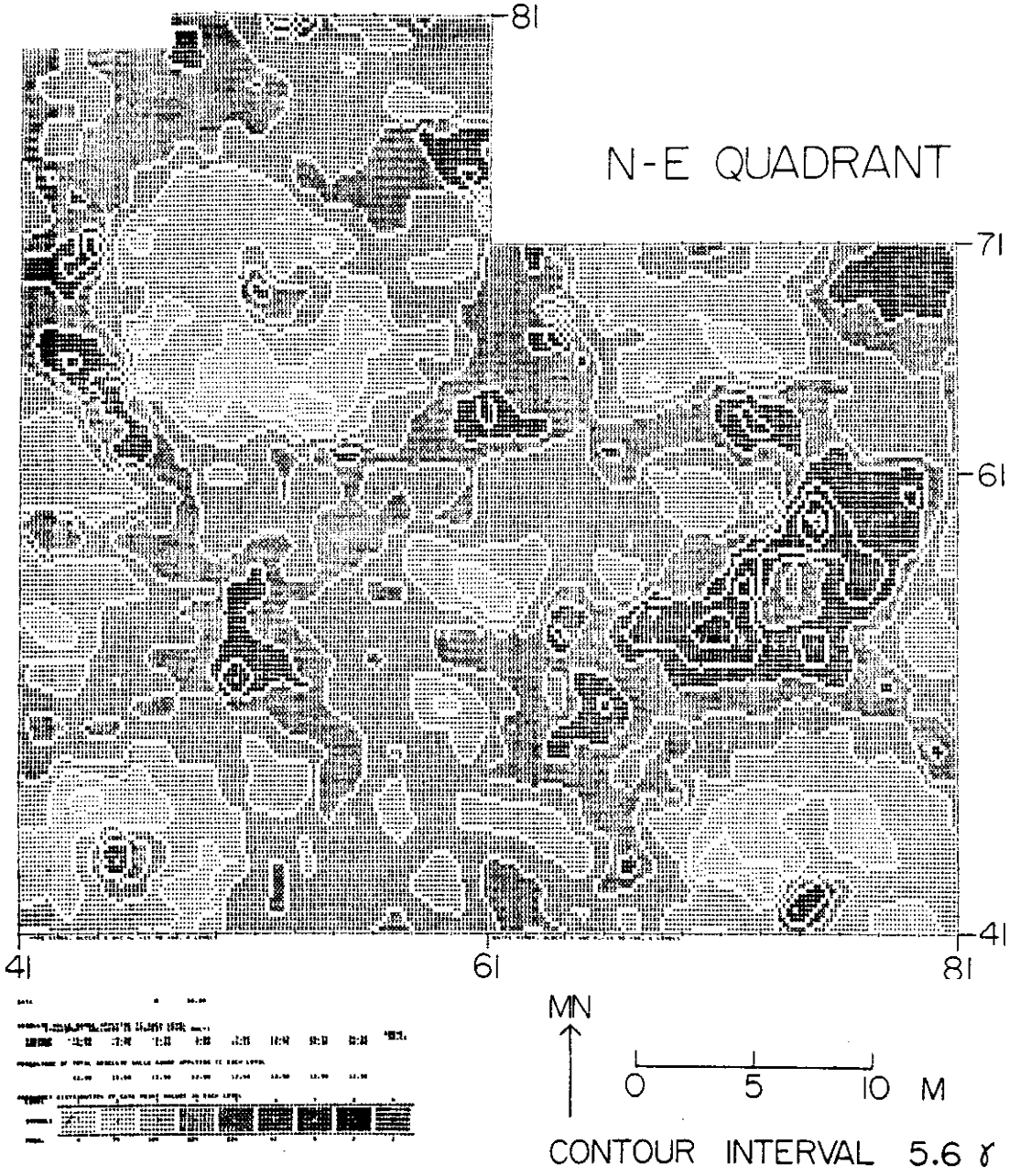

Figure 7. Magnetic contour map of the north-east quadrant of Sakakawea Village. Contour interval is 5.6 gamma.

county road (Fig. 1). It aroused interest because of some barely visible surface irregularities in the form of two depressions about 4 to 6 meters in diameter and a faint ridge running east-west. A survey was conducted on one 20 m block. The results are shown in Figure 2, which is a magnetic contour map in which the contour interval is 17 gamma and the symbol for the intermediate or "normal" value has been removed to reduce confusion. The most striking feature is a 94 gamma anomaly near grid point (6N,

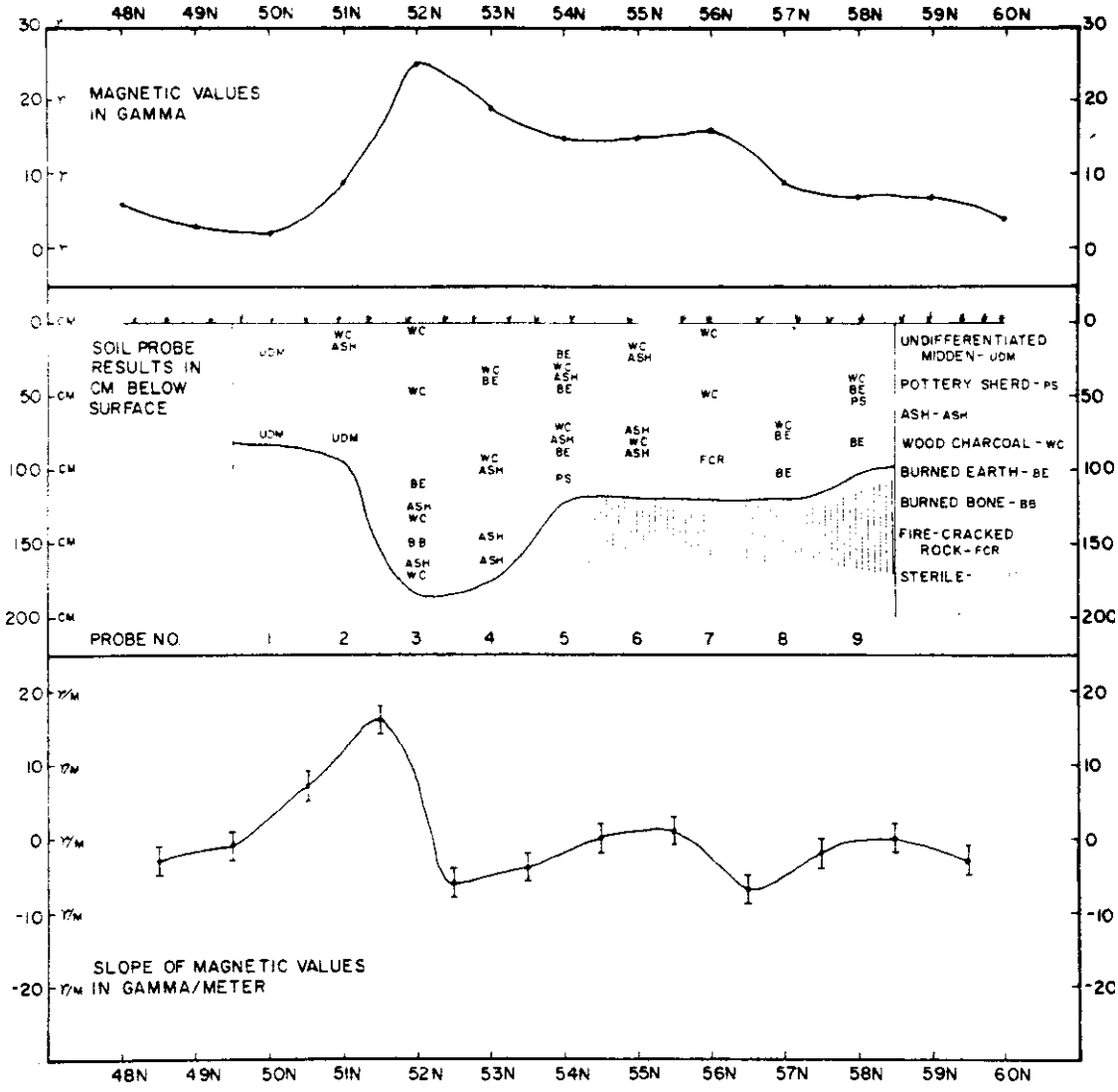

Figure 8. Magnetic profile soil probe profile and horizontal derivative of magnetic field along column E50, Sakakawea Village.

12E). This is associated with a low value of -68 gamma at (5N, 13E1. Such a pair of anomalies could be due to a single magnetic "dipole" oriented 45° S of E and at a dip angle considerably less than that of the earth's field. In other words, this is probably due to a piece of iron in a position different from that in which it was originally magnetized. In a separate measurement involving a series of magnetic readings at various heights above the surface it was estimated that this anomaly could be due to about 7 to 10 kg (15 to 20 lbs.) of iron at a depth of 60 to 70 cm. Other fairly strong anomalies at (2N, 12E), (13N, 11E), (15N, 2E), (18N, 7E), (18N, 16E), and (17N, 19E) are very likely due to iron. None of the other areas surveyed exhibit such a number of strong anomalies typical of iron in such a concentrated region. This suggests either a special use area involving iron artifacts used

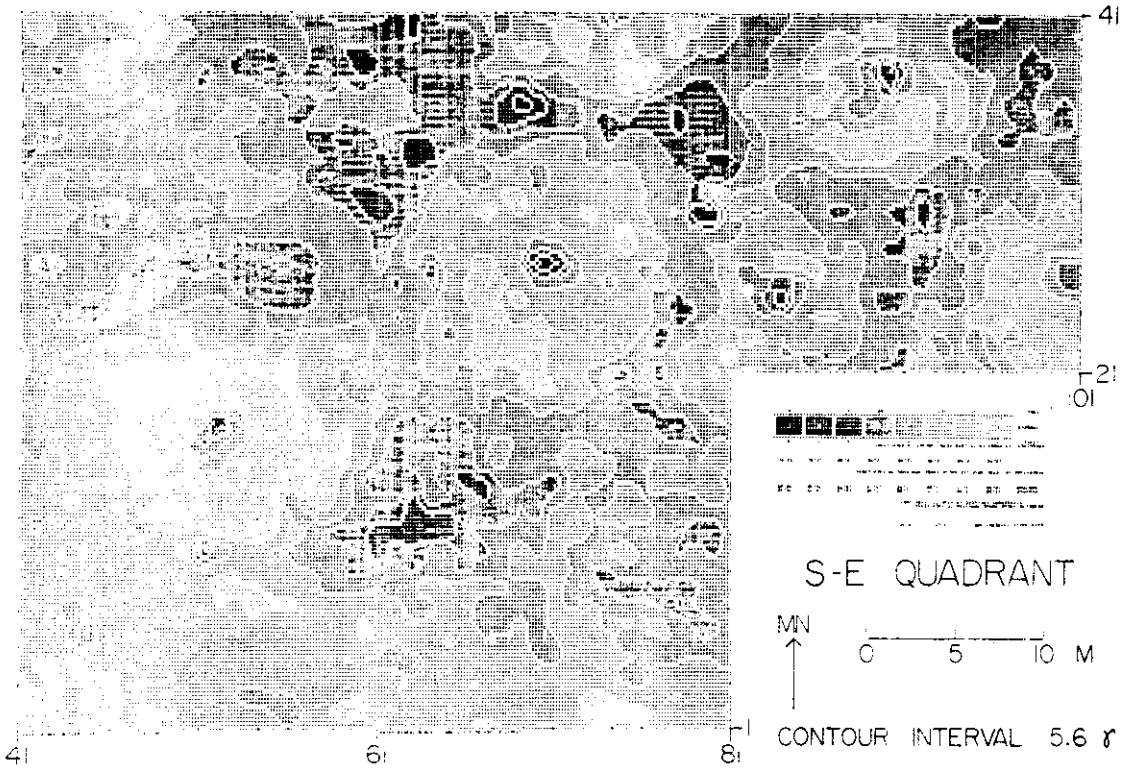

Figure 10. Magnetic contour map of the south-east quadrant of Sakakawea Village. Contour interval is 5.6 gamma.

tracted from the original data, leaving the significant residuals. These results are shown in Figure 3, which is a magnetic contour map of the residuals using a 3.4 gamma contour interval and with the central interval blank.

Part of the edge of the house depression can be seen as an arc sweeping around the east and north sides of the block. This is a typical result arising both from the topographic effect of a slight change in elevation with a possible contribution due to a soil difference. Such house edges are clearly visible in the Sakakawea Village survey. The prominent anomaly in the center at (12N, 29E), which is some 12 gamma above the surroundings is probably due to a fire pit, while the anomaly 3 m to the south of this indicates either a cache pit or another fire pit. The sharp anomalies at (12N, 20E1 and (6N, 35E) are probably due to iron. The anomalies at (12N, 35E), (19N, 38E), and (9N, 23E) are suggestive of cache pits. The anomaly at (20N , 36E) is quite sizeable, about 30 gamma, but occurs only on one grid point so is possibly due to iron near the surface.

Buchfink Site

The site lies in a flat, cultivated field. Because of this cultivation, and also because of the presumed age of the site, it can be anticipated that archaeological features might produce less distinct anomalies. In addition, pieces of iron near the surface often occur because of the agricultural activity. Four contiguous 20 m blocks were surveyed. The results can be seen in Figure 4. This is a 4 gamma interval contour map, but the printing symbols for the two contour levels representing the average of normal magnetic field have been suppressed. There is a strong anomaly (150 gamma) near the north border. Because of the width of the anomaly and the position of a negative anomaly to the southwest of it, a possible interpretation is that it is due to a concentration of several

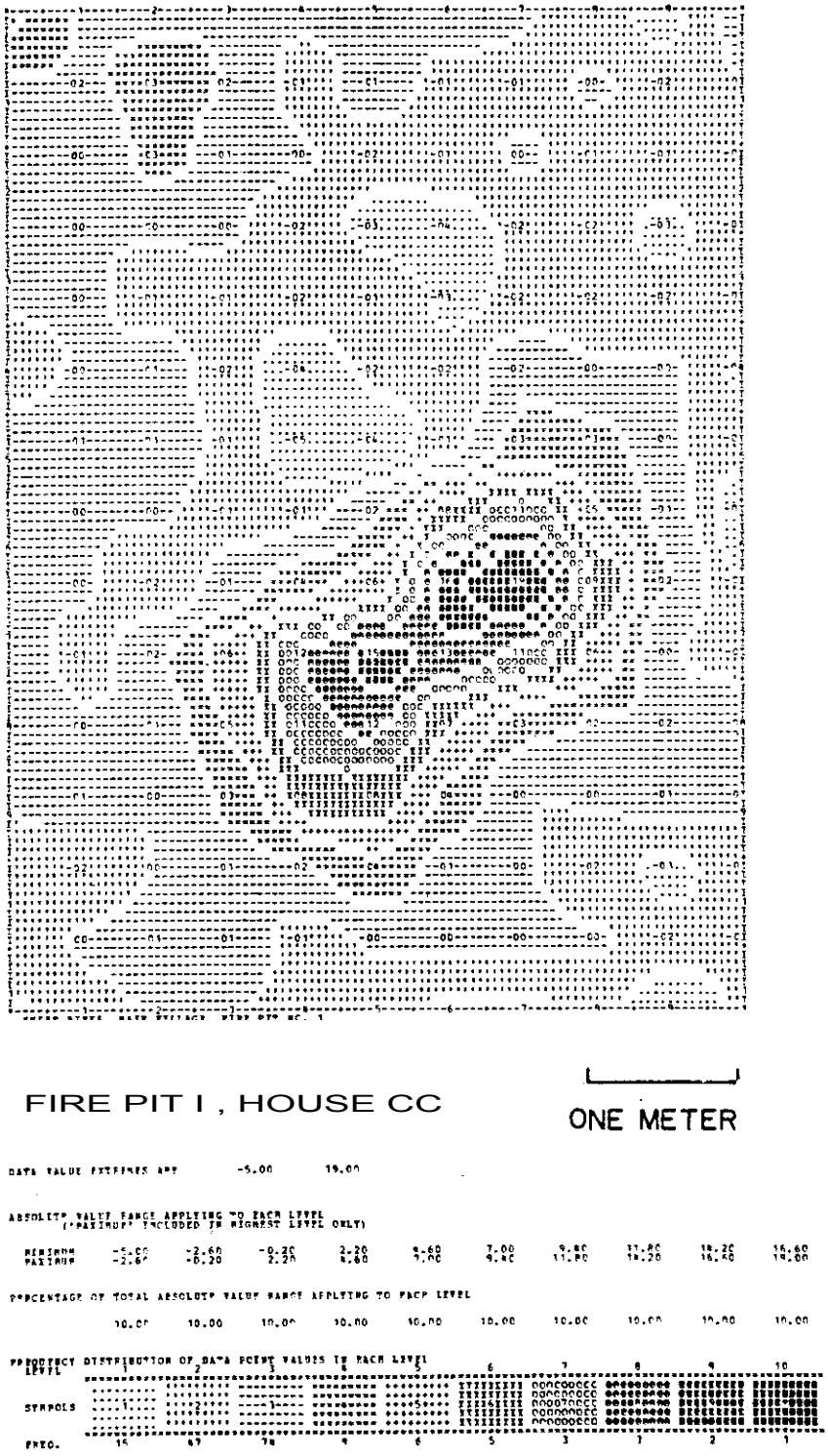

Figure 11. Magnetic contour map of fire pit 4, House X, Sakakawea Village. Contour interval is 3.1 gamma and the grid interval is 50 cm.

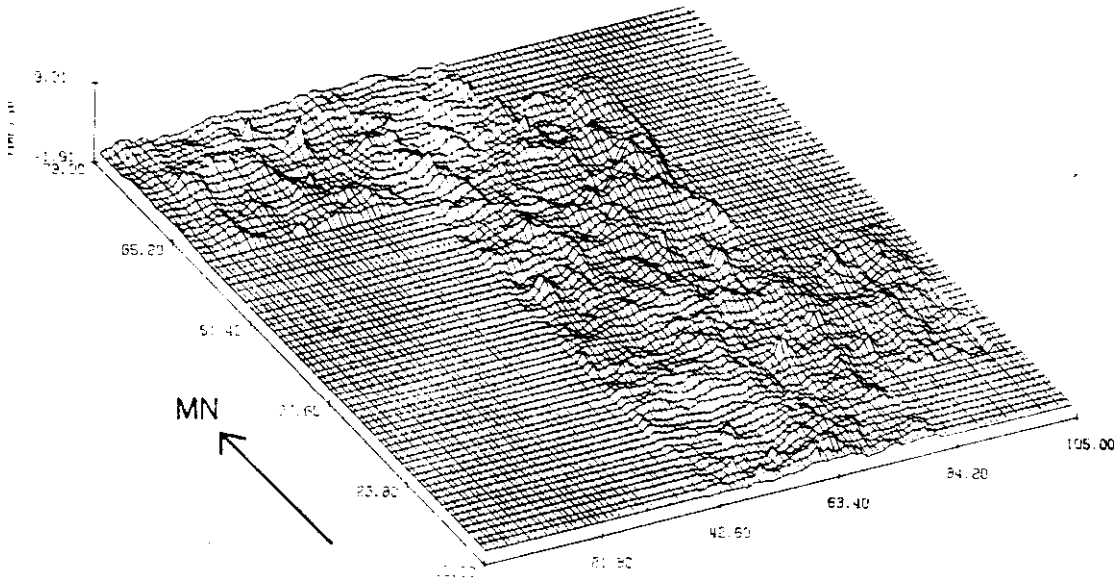

Figure 12. Three-deminsional view of magnetic map, Sakakawea Village. Range of vertical scale is -19 to +9C gamma.

kilograms of iron about a meter deep, but this explanation does not seem plausible. A deposit of iron this deep would not result from normal cultivation, and such a concentration of iron does not agree with the belief that this site is prehistoric. There is a group of weaker anomalies in the eastern half which is very suggestive of an occupation area with associated pits. No probing was conducted on this site.

Sakakawea Village
Blocks E Through 0

The main village area is marked by a number of visible house depressions. This is shown in Figure 5, which is a topographic map with 6 inch elevation contours obtained by means of aerial photographs (Lyons 1976). Preliminary excavation was conducted on this site by Lehmer (1965).

The magnetic survey conducted on this area took four days and covered ten and a half 20 m blocks. Figure 5 shows the position and designation of the blocks. An overall view of the results is shown in Figure 6, which is a magnetic contour map using a large interval of 9 gamma to simplify the map.

It is immediately obvious that the visible house depressions are reflected in the magnetic values. In fact, all of the house depression in the aerial map or visible by observers on the ground show up on the magnetic map. This is the combined topographic-soil effect discussed in connection with the Amahami Site. There s the additional possibility that some or all of the houses were burned down. The resulting layer of burned earth terminating at the house edge would enhance the magnetic anomalities at the edge of the occupied area. That there is a soil difference contribution can be seen from the fact that at least two houses barely visible on the ground (or not visible at all) can be seen in the magnetic map. These are in the south-west corner of Block L and at the north edge of Block N. Also obvious on the magnetic map are the fire pits. Anomalies due to these can be seen in the center of all of the houses. In order to examine these and other features in more detail we shall break this map up into quadrants, only three of which contain information.

NORTHEAST QUADRANT

This quadrant is shown in Figure 7 with a 5.6 gamma contour interval. The fire pits are even more clearly seen on this map. The entrance to the house in Block H, which was not visible from the air or on the ground, can be seen on the east side of the house. Several anomalies internal to the houses become noticeable in this contour map. These are very likely due to cache pits. The central region is marked by a number of strong anomalies. Several soil probes at meter intervals in the general vicinity of grid point 51N, 51E revealed layers of charcoal flecked earth, burned earth and burned branches, probably from a burned and collapsed house roof.

A series of nine soil probes were made and carefully recorded along a south-north line running from 50N to 58N along 50E. The probe results, along with the magnetic values, are shown in Figure 8. This figure also has a plot of the horizontal derivative or slope of the magnetic values obtained from the difference of adjacent pairs. Such a plot shows more clearly the changes in the magnetic field produced by differences in the soil. In this case an abrupt change in the field occurs at the position of a major feature apparently lying below the collapsed house roof. This is not a topographic effect since the surface is flat in this region. Thus we have evidence that this flat region covers a previous structure and debris which postdates its occupation. The region of strong anomalies around 53N, 73E has not yet been probed. We suspect that the magnetic pattern in this region is due, as in the previous case, to a deeply buried house.

NORTHWEST QUADRANT

This quadrant is shown in Figure 9, again with a 5.6 gamma interval. The house in Block 0 is very well outlined. The entrance to the east was not visible on the ground, unless one knew where to look, and is barely suggested in the aerial map, but it is clear on the magnetic map. The fire pit is obvious as well as several other anomalies that are probably cache pits. The strong anomaly on the northwest edge of the house is actually inside the house and is probably due to iron. Two more houses in Block N can be seen. These are at most only suggested by surface observation.

SOUTHEAST QUADRANT

As before, this quadrant is displayed with a 5.6 gamma interval (Fig. 10). The house in the vicinity of 25N, 83E, which was not visible at all on the surface, becomes quite clear. The distorted shape on the west side of this house suggests that the house to the west of it was built at a later time. The full outline of the house in Block E becomes obvious. The general lack of contours in the southwest region of this quadrant is due to the compacting effect of a recent road. Again, as in the other maps, there are anomalies outside of the houses that are suggestive but have not been tested as yet. The anomaly in the vicinity of 12N, 63E is possibly due to an earlier house.

In order to study some fire pits in more detail, restricted grid blocks on a 1/2 m grid unit were set up over four fire pits. Figure 11 is a magnetic contour map of such a survey over the fire pit of the house in Block E. In this case the shape of the anomaly indicates a compound fire pit. By plotting south-north profiles through the two maxima of this anomaly one can conclude that there are two fire pits, that the one to the south-west is perhaps 100 cm deep, and the other one is about 50 cm deep. A similar survey and analysis of another, single fire pit predicted the depth to be 70 to 90 cm. Soil probes located the burned earth at a depth of 60 to 70 cm.

SUMMARY OF SAKAKAWEA VILLAGE

An overall view of the magnetic map may be seen in Figure 12, which is a three-dimensional representation. Most of the houses with their firepits can be seen in this view. The obvious results of the survey of the village can be summarized as follows: The survey located 11 houses that were visible on the surface, 2 to 4 more houses not visible, 13 fire pits, at least 2 house entrances, 9 or 10 regions of

major anomalies between houses, and a large number of anomalies within the houses.

SUMMARY AND CONCLUSION

A proton magnetometer survey was conducted on several sites in and adjacent to the Knife River Indian Villages National Historic Site. In eight days the equivalent of 20 squares 20 m on a side were covered on a one meter grid. A wealth of information was obtained in the form of magnetic anomalies indicating subsurface features. These included the verification of houses visible on the surface, the location of houses not visible, and the indication of house features such as fire pits, entrances and cache pits. In addition, a number of anomalies were observed, the sources of which were not obvious but which undoubtedly involved deeper-lying archaeological features.

The survey of the Buchfink Site demonstrated the value of identifying areas of interest as well as areas that most likely do not contain significant features. The Amahami survey demonstrated the possibility of extracting useful information from a site close to modern structures.

It should be emphasized that this survey obtained considerable information with no alteration of the sites. In continuing the archaeological work initiated by Lehmer in 1965, tests can now be guided by the results of this and subsequent magnetic surveys.

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