GEOPHYSICAL INVESTIGATIONS AT THE SAND CREEK MASSACRE SITE, COLORADO

by

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INTRODUCTION

From May 18 to May 26, the National Park Service conducted an archeological investigation of Sand Creek Massacre site in Kiowa County, Colorado (Figure 1). In addition to the metal detector reconnaissance survey of the project area, geophysical investigations were conducted on a portion of the probable Cheyenne village location in order to provide an assessment of these applications to future archeological investigations of the site (Research Design to Locate the Site of the Sand Creek Massacre, Kiowa County, Colorado, dated April 30, 1999). Four twenty by twenty meter (20 x 20 m) grids were established on a portion of the William Dawson property along the western boundary of the village location (Scott 1999). Approximately ten artifacts were identified and collected during the metal detector sweep of the area. Three types of geophysical surveys were conducted over this area. They included a magnetic gradient survey with a Geoscan Research FM36 fluxgate gradiometer, a soil conductivity survey with a Geonics EM38 ground conductivity meter, and a high sensitivity metal detection survey with a time-phase Geonics EM61 high sensitivity metal detector.

ENVIRONMENTAL SETTING

The artifact concentration associated with the Sand Creek Massacre Site village location is situated on a terrace above the left bank of the Big Sandy Creek in Section 24, Township 17 South, Range 46 West, in Kiowa County, Colorado (Figure 2). It lies at and elevation of approximately 3980 feet above mean sea level. The project location is within the Colorado Piedmont of the Great Plains Province (Fenneman 1931:30-37). The region surrounding the project area is nearly level to gently sloping uplands where the dominant slope is less than three percent. The Big Sandy Creek valley is surrounded by rolling uplands with slopes greater than three percent. The valley floor is nearly level, rolling, or shaped like sand dunes. Sand hills border the Big Sandy Creek in several locations near the present project location.

The soils within the Big Sandy Creek valley belong to the Bankard-Fluvaquents soil association (Anderson et al. 1981:8). The soils within this association are "nearly level, somewhat excessive drained to poorly drained, deep soils, on terraces and flood plains" (Anderson et al. 1981:8). Anderson et al. (1981:17-18, 58, Sheet No. 7) identifies the soil mapping unit as nearly level fluvaquents (soil mapping unit 12). These soils are somewhat poorly drained to poorly drained. These soils formed in mixed alluvium. A more detailed analysis of the geomorphology is presently being conducted by LaRamie Soils Service, Laramie, Wyoming (Holmes and McFaul 1999). The initial analysis of a portion of the Dawson property by Homes and McFaul (1999) would apparently place the village site on the T1 terrace.

The project location also lies within the Kansan biotic province of North America (Dice 1943:26-27). This area is part of the shortgrass prairie region of the semiarid Great Plains (Brown 1985:54-63; Shelford 1963:344-347). Climax vegetation is identified as a mixture of short grasses and grasses of mid-height (Clements and Shelford 1939:260-264). Overgrazing has resulted in the removal of the midgrasses. Important short grasses include blue grama and buffalo grass. Midgrasses include needle-and-thread grass and bluestem. Many grasses have adapted a bunch habit in the more arid portions of the province. Numerous flowering annual and perennials are also found throughout the Kansan biotic province. Trees are rare but do occur along major rivers and smaller streams where a viable source of water is present. Groves of cottonwoods and other deciduous trees are present in these locations.

Bison was the dominate animal until the late nineteenth century when they were decimated and cattle were introduced (Shelford 1963:344-347). The pronghorn antelope remains one of the dominant wild animal species. Lesser influents include black-tailed jack rabbits, badgers, coyotes, and prairie dogs (Brown 1985:62-63). Numerous rodents are also present. Larks, sparrows, owls, and hawks are present. Plains garter snake and the western rattlesnake, and bullsnake represent the major reptiles present in the province. While grasshoppers are one of the more abundant groups of insects, numerous species are present throughout the region.

The region is subject to rather cold winters and fairly hot summers (Anderson et al. 1981:1-2). The average winter temperature is 32° F with an average daily minimum temperature of 17° F (Anderson et al. 1981:82). During the summer, the average monthly temperature is 74° F with an average daily maximum temperature of 90° F. Record temperatures have ranged from -25° F in the winter of 1963 to 110° F in the summer of 1963 (recorded at Eads, Colorado). The annual precipitation averages 14 inches (Anderson et al. 1981:82). The majority of the precipitation falls as rain during the warm months of April through September. Thunderstorms are common with occasional hailstorms. Snowstorms occur every winter with an average seasonal snowfall of 27 inches. During the course of the present investigations, the region had received substantial amounts of rainfall prior to the investigations that caused the Big Sandy to flood.

GEOPHYSICAL TECHNIQUES

Three separate geophysical investigations were conducted across the geophysical grid. These included a magnetic survey with a Geoscan Research FM36 fluxgate gradiometer, a Geonics EM 38 ground conductivity meter, and a Geonics EM61 high sensitivity metal detector. Of the three methods used at the village site, the magnetic gradient investigation represented a passive geophysical technique (Heimmer and De Vore 1995:7). The conductivity and the high sensitivity metal detection investigations were active geophysical techniques (Heimmer and De Vore 1995:9).

Passive techniques measure the physical property of naturally occurring local or planetary fields created by earth related processes under study. The primary method used in archeology is magnetic surveying. Active techniques transmit an electrical, electromagnetic, or acoustic signal into the ground. The interaction of these signals and buried materials produces an altered return signal that is measures by the appropriate geophysical instrument. The ground conductivity meter and the high sensitivity metal detector utilize electromagnetic signals.

Authors, Anthony Clark (1996), and Don H. Heimmer and Steven L. De Vore (1995), discuss the basic concepts of electromagnetic conductivity (conductivity) and magnetic (magnetometry) surveys. Melissa Connor and Douglas D. Scott (1998) provide and introduction to the use of metal detectors in archeological investigations. Field methodology is discussed in Geoscan Research's instruction manuals for the RM15 resistance meter (Geoscan Research 1993) and the FM36 fluxgate gradiometer (Geoscan Research 1987), and in the Geonics Limited instruction manuals for the EM38 ground conductivity meter (Geonics Limited 1992a), the EM61 high sensitivity metal detector (Geonics Limited 1998b), and the DL720 polycorder (Geonics Limited 1998a).

GEOPHYSICAL SURVEY METHODOLOGY

Initially, a metal detector sweep was made across the area. Based on the number of artifacts (approximately ten artifacts) recovered after the metal detector sweep of the western edge of the T1 terrace located at the western edge of the Sand Creek village site, a geophysical grid was established over this area. The cluster of artifacts suggested the potential for cultural features within the artifact concentration on the William Dawson property and on the adjacent August Kern property. The grid consisted of four 20 x 20 meter grids with overall dimensions of 40 meters by 40 meters. The grid was oriented to magnetic north (Figure 3). Wooden two-inch hubs were used as corner stakes for each 20 x 20 meter grid unit. Base lines of 20-meter long ropes were laid between the wooden hubs in an east-west orientation. The ropes were divided into 0.5 meter sections by alternating colored tape. This allowed the investigator to maintain the correct spacing for the acquisition of the data. In the north-south direction, the ropes were placed at meter intervals across each 20 x 20 meter grid unit. Geophysical data were collected along the north-south oriented grid ropes at 8 samples per meter for the magnetic survey, 2 samples per meter for the conductivity survey and 4 samples per meter for the metal detection survey. Data were also collected along each meter interval across the individual grid units.

The ground was covered in a sequence of one-meter traverses adjacent to one another (Geoscan Research 1987:43-48, 1993:5/1-5/7). The survey was conducted in a zig-zag fashion beginning at the southwest corner of each grid unit. The zig-zag method reduces the time required to conduct a survey by eliminating the return walk back to the southern starting point of the next transverse.

Upon completion of the area survey, the individual grid unit data files were downloaded into a laptop computer and processed. The data from each grid unit was stored in separate grid data files. The grid data files were combined into a composite data file for further processing and display. Shade, dot density, image, and trace line plots were generated in the evenings as the field work progressed. The data transfer for the magnetic data from the gradiometer to the laptop computer occurred in the field. Data from the conductivity and metal detection survey or at the office during the day or at the motel in the evening. Data analysis and interpretation can occur at any time once the data from the instruments have been transferred to a computer.

Magnetic Gradient Survey

A magnetic survey is a passive geophysical techniques used to measure the earth's total magnetic field at a point location. Its application to archeology results from the effects of magnetic materials on the earth's magnetic field. These anomalous conditions result from magnetic materials and minerals buried in the soil. Iron artifacts have a very strong effect on the local earth's magnetic field. Other cultural features which affect the local earth's magnetic field include fire hearths, soil disturbances (e.g., pits, mounds, wells, pithouses, dugouts, etc.), and geological strata (Clark 1996; Heimmer and De Vore 1995). Two types of magnetic surveys exist. One type is the total field survey while the other is the gradient survey. The total field survey uses a single magnetic sensor. The instrument is designed to measure the absolute total intensity of the total magnetic field. The type used in this survey is the magnetic gradient survey. The magnetometer has two magnetic sensors mounted in the vertical mode. This helps minimize the strong gradient influences and solar or diurnal effect on the survey data. It also provides for greater feature resolution and potentially provided for better classification of the magnetic anomalies. The sensor separation in the FM36 fluxgate gradiometer is approximately 0.5 meters. Due to the distance dependence of the sensors to the anomaly, the gradient or difference of the measurements between the two sensors helps define the buried material or object with increased resolution (Heimmer and De Vore 1995:11-20).

The magnetic gradient survey (Figure 4) was conducted with a Geoscan Research FM36 fluxgate gradiometer (Geoscan Research 1987). The gradiometer consists of a control unit that contains the electronics and memory. A handle connects the control unit to the vertical sensor tube that contains the two fluxgate magnetometer sensors. With a built-in data logger, the gradiometer provides fast and efficient survey data acquisition. Two readings are taken at each point along the survey traverse, one at the upper sensor and one at the lower sensor. The difference of gradient between the two is calculated and recorded in the instrument's memory.

A sample trigger (ST1) was connected to the front of the control unit of the fluxgate (Geoscan Research 1987:110-116). This trigger enables the gradiometer to collect and record data measurements at 1 m, 0.5 m, 0.25 m, and 0.125 m intervals. The gradiometer was configured to record data at a sampling interval of 0.125 meters or 8 samples per meter. The magnetic gradient data were recorded in nanotesla (nT) which is a unit of magnetic flux density (Sheriff 1973:148). A total of 3,200 data values were recorded per each 20 m x 20 m grid unit. A total of 12,800 data values were collected during the survey. The mean for the magnetic gradient data was -0.00555 nT with a standard deviation of 1.13076 nT. The minimum value was -15.43789 nT and the maximum value was 10.46154 nT.

The data were downloaded to a laptop computer and processed using the Geoscan Research GEOPLOT ver. 2.02 software (Walker and Somers 1995). Data from each individual grid unit were placed in its own grid data file. The grid data files were combined to form a composite file of all the data collected during the magnetic survey.

The creation of the composite file allowed for further processing of the magnetic gradient data. A zero mean of each transverse processed on the data set. This function sets the background mean of each traverse within the grid to zero. It is useful in removing the striping effects on the data in the traverse direction of a zig-zag fluxgate gradiometer survey. The function operates over the entire data set. Shade, dot density, and trace line plots were generated upon completion of the magnetic survey. The data were transferred in a XYZ data file for further processing and display in Golden Software's SURFER FOR WINDOWS program (Keckler 1997). In SURFER, the data were presented in a gray scale image plot (Figure 5) and a color image plot (Figure 6).

Electromagnetic Conductivity Survey

An electromagnetic conductivity (commonly referred to as a conductivity survey) was also conducted at the village site (Figure 7). The conductivity survey was conducted with a Geonics EM38 ground conductivity meter (Geonics Limited 1992). The instrument is light weight and approximately one meter in length. The transmitting and receiving coils are located at opposite ends of the meter. An electromagnetic field in induced into the ground through the transmitting coil. The receiving coil detects the response alteration (secondary electromagnetic field) in the primary electromagnetic field resulting from changes in the materials buried in the soil or soil disturbances from natural or cultural modifications to the soil. Thus the instrument has the ability to detect lateral changes on a rapid data acquisition, high resolution basis. In archeology, the instrument has been used to identify areas of compaction and excavation as well as buried metallic objects. It has the potential to identify cultural features that affect the water saturation in the soil (Clark 1996; Heimmer and De Vore 1995:35-41).

Digital meters are located on the top and side of the EM38 for the vertical and horizontal dipole measurements. The controls are located beside the vertical digital meter on top of the instrument. The controls include the range switch, the mode switch for setting the quadrature (Q/P) or conductivity, the in-phase (I/P) or magnetic susceptibility, and the battery check. Other switches include the Q/P zero control, the I/P coarse zero control, and the I/P fine zero control.

The meter was connected to the DL720 Polycorder for digital data acquisition (Geonics Limited 1998a). Data were collected manually with the push of the button located on the EM38 handle. The data stored in the polycorder were downloaded into the laptop computer at the end of the day. The apparent Conductivity data were recorded in units of millisiemens per meter (mS/m). The siemens is a unit of electrical conductivity that is the reciprocal of an ohm (Sheriff 1973197). Conductivity is the reciprocal of soil resistivity.

Data were collected at 0.5 meter intervals along 1 meter traverses. The survey was conducted in a zig-zag fashion beginning at the southwest corner of each 20 x 20 meter grid unit. The Em38 was used in the quadrature or conductivity phase. It provided an exploration depth of approximately 1.5 meters with its effective depth around 0.6 meters in the vertical dipole mode. A total of 800 data values were recorded per each 20 m x 20 m grid unit. A total of 3,200 data values were collected during the survey. The mean for the conductivity data was 33.96272 mS/m with a standard deviation of 6.50743 mS/m. The minimum value was 13.91600 mS/m and the maximum value was 61.79497 mS/m.

The data were downloaded to a laptop computer in the motel room following the day's field acquisition and processed using the DAT38 version 3.40 software (Geonics Limited 1997a). Data from each individual grid unit was placed in separate grid data file. The files were then converted from the DL polycorder files to the DAT38 file format. The individual EM38 grid data files were converted to SURFER data files for further processing in SURFER FOR WINDOWS (Keckler 1997). In SURFER, the data were presented in contour, surface, shade, and image plots. The SURFER data files were also formatted for input into the Geoscan Research software GEOPLOT (Walker and Somers 1995). The data files were stripped of the locational data columns leaving only the conductivity data values. The file was checked for the correct number of data values. In this case, with data collection every 0.5 meters at 1 meter intervals, there is a total of 800 data values per grid file. The data was imported into GEOPLOT where the grid files were combined to form a composite file. The creation of the composite file allowed for the further processing of the conductivity survey data. A bias, or numeric correction, was established for the data files that provided the same background level across the entire survey area. The composite was then further processed with the Edge Match function. This function is used to remove grid edge discontinuities. These discontinuities resulted from differences in the nulling and zero balancing operations before data collection and for instrument drift during data collection. Shade, dot density, and trace line plots were generated. The data was transferred in a XYZ data file for further processing and display in Golden Software's SURFER FOR WINDOWS program (Keckler 1997). In SURFER, the data were presented in a gray scale image plot (Figure 8) and a color image plot (Figure 9).

High Sensitivity Metal Detection Survey

In addition to the metal detector survey using commercially available metal detectors (Connor and Scott 1998), the present geophysical investigations of the Sand Creek village location utilized a Geonics EM61 high sensitivity metal detector (Figure 10). The instrument is a "High sensitivity high resolution time-domain metal detector which is used to detect both ferrous and non-ferrous metallic objects" (Geonics Limited 1998b:1). The instrument consists of a transmitter and two receiver coils. The transmitter generates a pulsed primary magnetic field that induces eddy currents in near surface or surface metallic objects. The decay of these eddy currents are measured by the two receiver coils and recorded and displayed by an integrated data logger as two channel information. The unit consists of a backpack with battery and processing electronics, the coil assembly, and digital data recorder (DL720 Polycorder). The present survey used the hand held unit (EM61-HH) with the wheel option for the sensor assembly (Geonics Limited 1998b:7-11). The coil assembly consists of a small set of coils attached to a wand that can be attached to a set of wheel are carried in the hands. More inline control is present when the wand with the sensors is set into the wheel assembly. Data acquisition is initiated by the odometer mounted inside the wheel assembly in the wheel operation mode. The odometer is designed to trigger the recordation of the receiver coil data approximately every 0.2 meters. The two receiving sensors are identified as the top coil (T) and the bottom coil (B).

The meter was connected to the DL720 Polycorder for digital data acquisition (Geonics Limited 1998b). Data were collected automatically as the odometer on the wheel assembly triggered the polycorder at 0.196 m intervals (Geonics Limited 1998b:26). The data stored in the polycorder were downloaded into the laptop computer at the end of the day. The high sensitivity metal detection data were recorded in units of millivolts (mV).

Data acquisition was attempted at 0.25 meter intervals along 1 meter traverses. The survey was conducted in a zig-zag fashion beginning at the southwest corner of each 20 x 20 meter grid unit. A total of 1,600 data values were recorded per sensor for each 20 m x 20 m grid unit. A total of 6,400 data values were collected during the survey for each sensor. The mean for the top sensor data was 39.87806 mV with a standard deviation of 1.93394 mV. The minimum value was -27.02668 mV and the maximum value was 50.27815 mV. The mean for the bottom sensor data was 19.98458 mV with a standard deviation of 1.05560 mV. The minimum value was 3.79044 mV and the maximum value was 32.03297 mV.

The data were downloaded to a laptop computer in the motel room following the day's field acquisition and processed using the DAT61 version 1.70 software (Geonics Limited 1997b). Data from each individual grid unit was placed in separate grid data file. The files were then converted from the DL polycorder files to the DAT61 file format. The individual EM61 grid data files were converted to SURFER data files for further processing in SURFER FOR WINDOWS (Keckler 1997). In SURFER, the data were presented in contour, surface, shade, and image plots. The SURFER data files were also formatted for input into the Geoscan Research software GEOPLOT (Walker and Somers 1995). The data files were stripped of the locational data columns leaving only the metal detection data values. Two files were created one for the top sensor data and one for the bottom sensor data. These files were checked for the correct number of data values. In this case, with data collection every 0.25 meters at 1 meter intervals, there is a total of 1,600 data values per grid file. The data was imported into GEOPLOT where the grid files were combined to form a composite file. The creation of the composite file allowed for the further processing of the conductivity survey data. A bias, or numeric correction, was established for the data files that provided the same background level across the entire survey area. The composite was then further processed with the Edge Match function. This function is used to remove grid edge discontinuities. These discontinuities resulted from differences in the nulling and zero balancing operations before data collection and for instrument drift during data collection. Shade, dot density, and trace line plots were generated. The data was transferred in a XYZ data file for further processing and display in Golden Software's SURFER FOR WINDOWS program (Keckler 1997). In SURFER, the data were presented in top and bottom gray scale image plots (Figure 11 and 12) and top and bottom color image plots (Figure 13 and 14).

INTERPRETATIONS AND CONCLUSIONS

The magnetic gradient data from the 40 meter square geophysical grid contained few magnetic anomalies (Figure 15). Three major anomalous areas are located at N7/E14, N10/E26, and N29/E24. Three smaller magnetic anomalies are located at N40/E17, N40/E18, and N35/E20. Two areas along the N200 line in the vicinity of E15 and E18 reflect some edge matching problems with the northwest and southwest quadrants of the geophysical grid. Given the recovery of iron artifacts from the site during the metal detector investigations, it is probably safe to say that the six anomalies probably represent iron artifacts dating to the 1864 massacre.

The conductivity data appear to represent natural changes in the terrace. Areas of high conductivity appear at the north central portion of the area, as well as along much of the southern edge. A third area of high conductivity is found near the middle portion of the west edge of the project area. Two areas within the grid appear to be associated with the magnetic gradient anomalies. These are located at N7/E14 and N29/E24. These two low conductivity anomalies are probably the same two magnetic anomalies in the gradient data set.

The high sensitivity metal detection data provide indications that there are several metallic objects within the geophysical grid. The top coil data indicate a number of targets throughout the grid; however, those along the N20 line appear to represent an edge matching problem that resulted during the data acquisition phase. Two of the three large magnetic anomalies are present in the top coil data of the EM61; however, they are not the same two present in the EM38 conductivity data. These are located at N7/E14 and N10/E26. The bottom coil data suggests that there are four to five times as many anomalous objects or targets. Again, the edge matching problem along N20 is visible. The two coil system is very useful in recognition of shallow objects from deeper ones. The amplitude of response is highly dependent upon the distance between the coil assembly and target object. Often smaller near surface objects will produce a response orders of magnitude higher than larger objects buried at greater depths (Geonics Limited 1998b:44,46). This masking effect can be reduced by using the data from the two coils and process them in a differential mode. "...output from channel B(2) subtracted from channel T(1). Channel T(1) represents data from the top receiver coil, whereas channel B(2) is data from the coil closer to the ground. The calculation is automatically preformed by EM61 DAT61 computer program" (Geonics Limited 1998b:44,46). This is the most common way to interpret the EM61 is to use the channel B92) data and the differential channel data:

> The differential channel is calculated by the program in the following way:
>
> **D = k * CHT(1) - CHB(2)**
>
> where: D is differential output in mV
> CHT(1) is output from top coil in mV
> CHB(2) is output from bottom coil in mV
> K is depth coefficient normally set to 1

> It is possible to vary **k**, and adjust the depth at which the response will be suppressed the most. If **k** is selected to be 1, the response from targets right below the surface will be reduced the most. If the coefficient **k** is made smaller than 1, the deeper target will be suppressed more than the shallow targets. In this case surface anomalies will have negative response in the differential channel.
>
> It should be noted that the degree of cancellation will be effected by size, shape and depth of targets. The response from the targets with small dimensions shaped like balls, shales or small plate-like targets parallel with the ground, is possible to reduce much more than response from larger 3 dimensional targets (Geonics Limited 1998b:46).

Figure 16 represents the anomalous areas after the receiver data from the top and bottom coils have been differentially corrected with a **k** value of 1.

Although it would archeological excavation to identify the nature of the geophysical anomalies identified in the magnetic gradient, conductivity, and high sensitivity metal detection data sets; it is apparent that the methods are appropriate for the area of the village location. The small area extent of the geophysical investigations have provided positive data concerning the presence of buried archeological material, which some objects have already been identified and collected during the metal detector survey of the Sand Creek Massacre Site. Should the site be placed under governmental or tribal control, it is recommend that geophysical investigations be considered as an appropriate means of evaluating the site extent and integrity.

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FIGURES

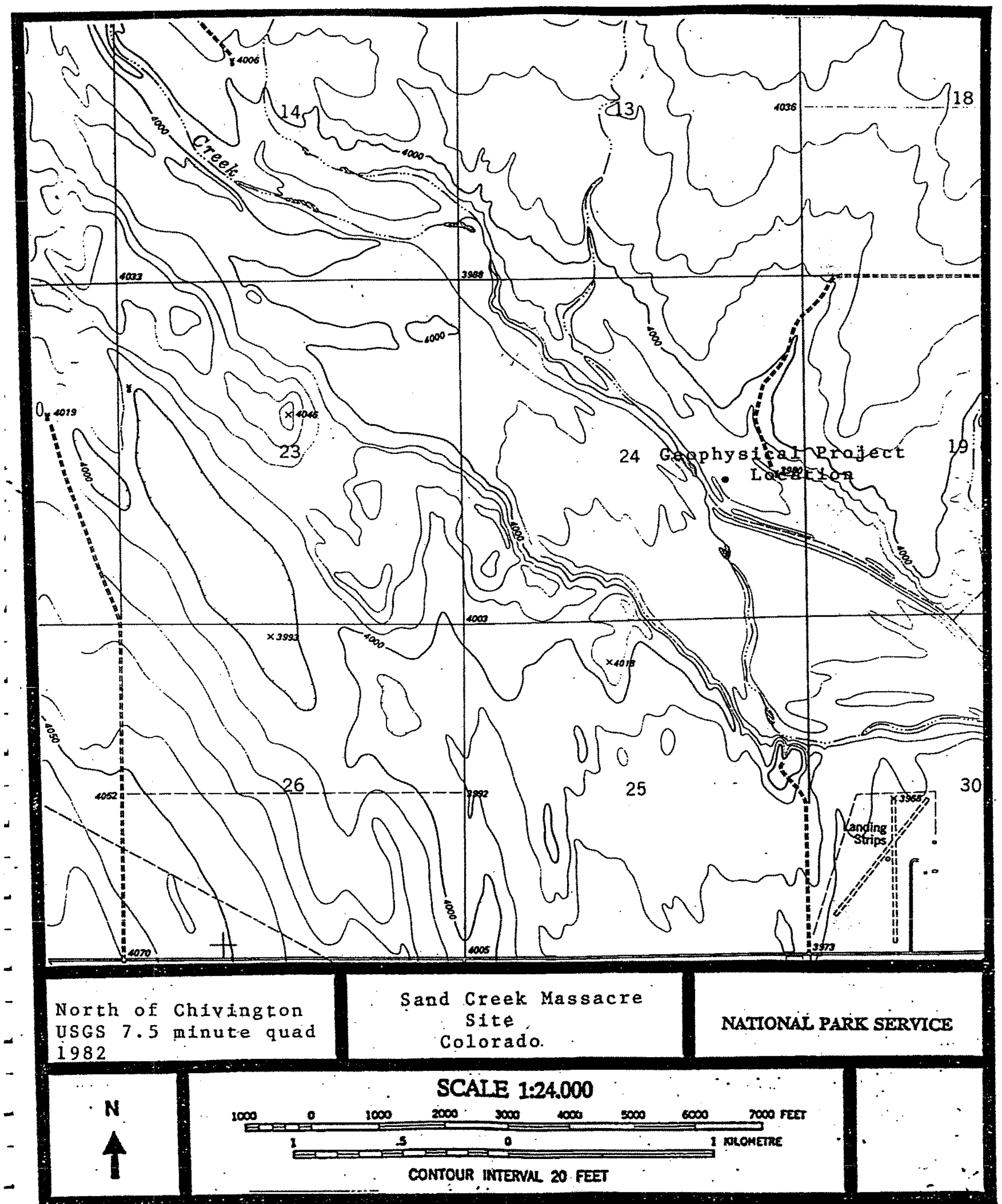

Figure 1. Sand Creek Massacre Site Project Area.

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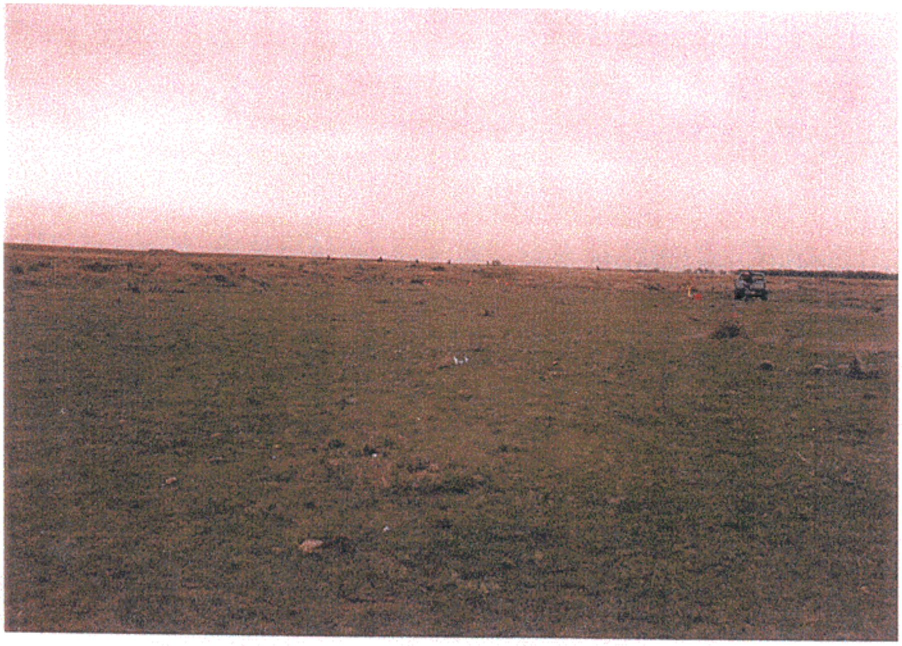

Figure 2. Sand Creek Village Location (view to the east).

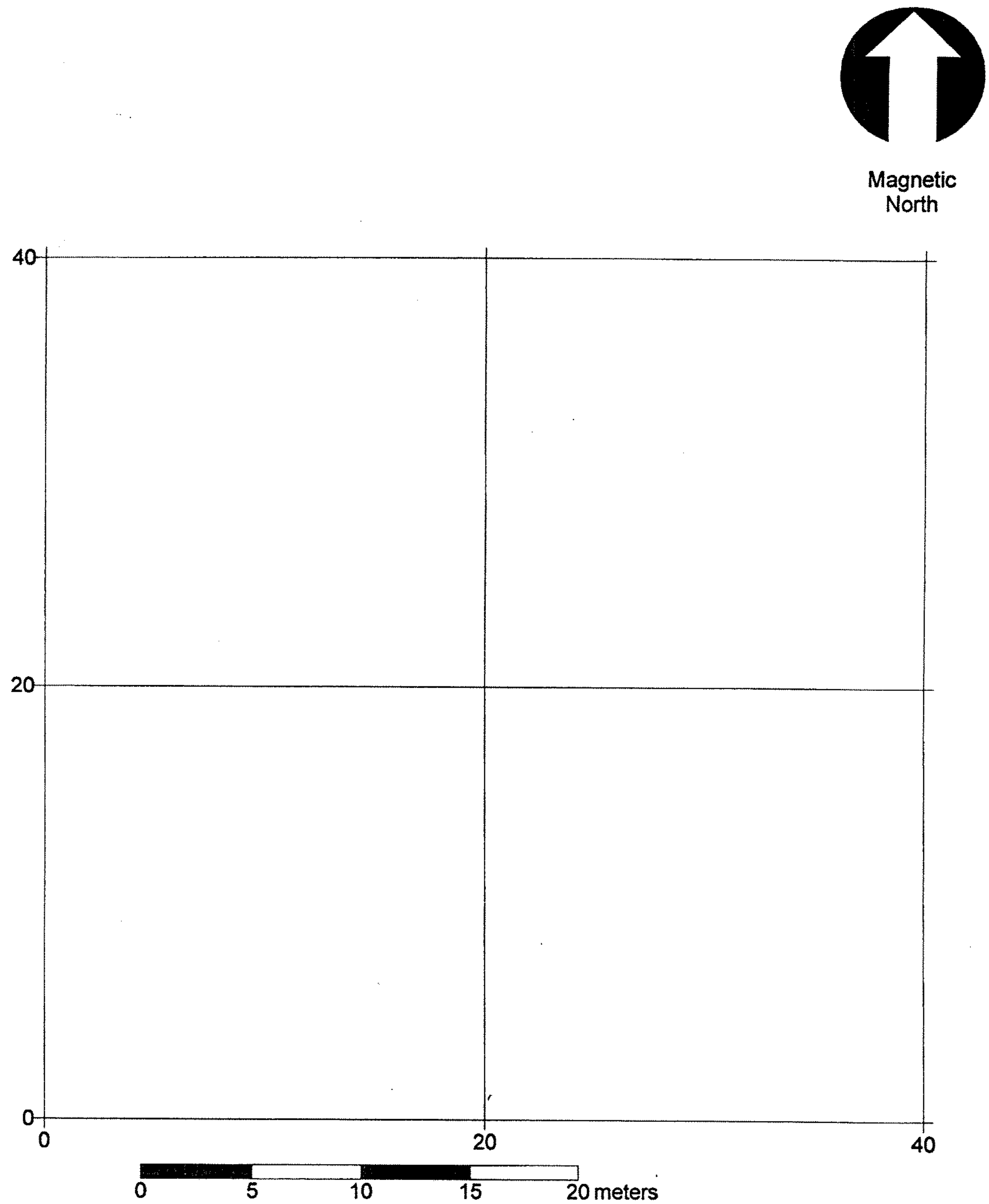

Figure 3. Geophysical Grid at the Sand Creek Village Location.

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Figure 4. Magnetic Gradient Survey with Geoscan Research FM36 Fluxgate Gradiometer (view to the northeast).

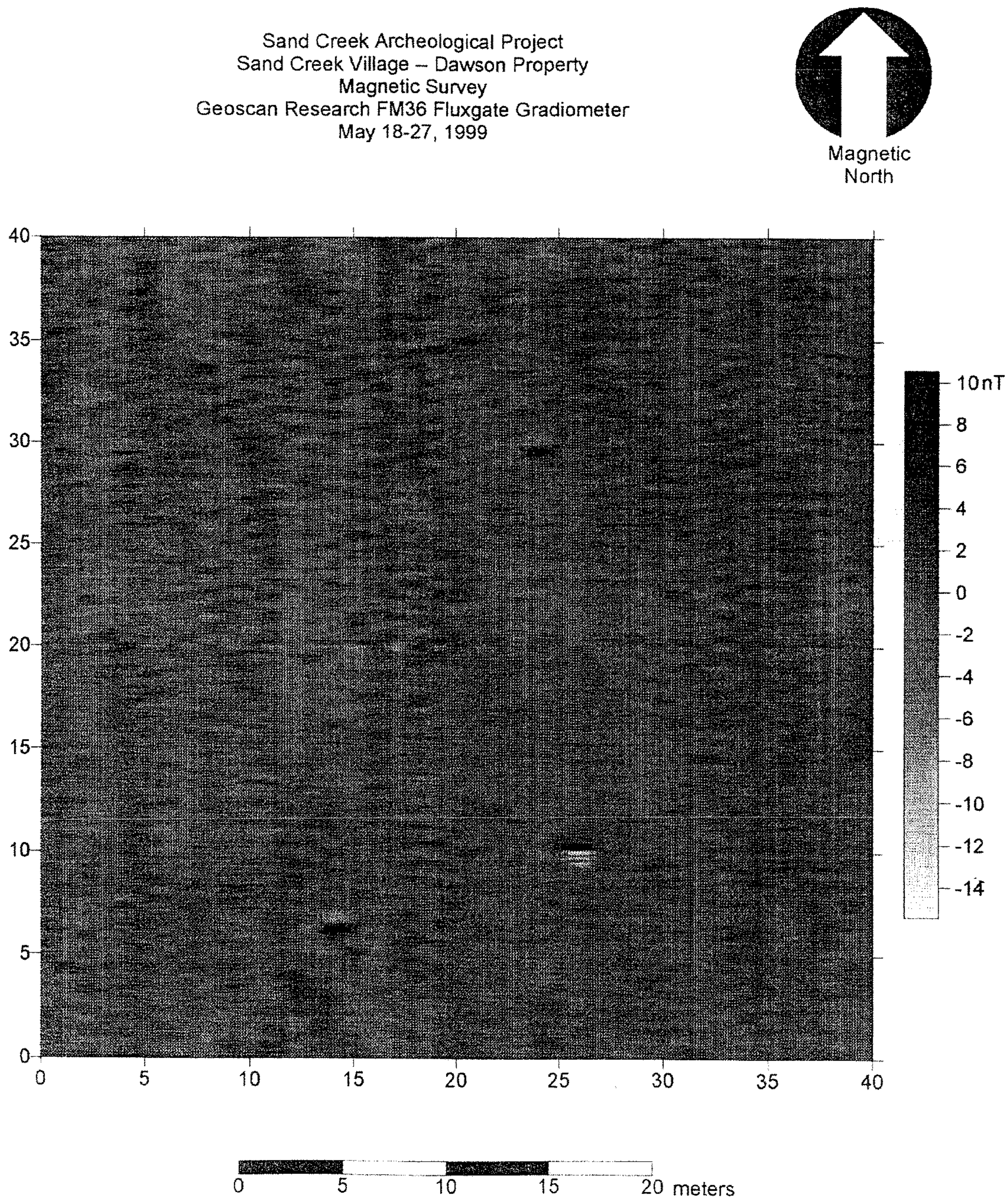

Figure 5. Gray Scale Image Plot of Magnetic Gradient Data.

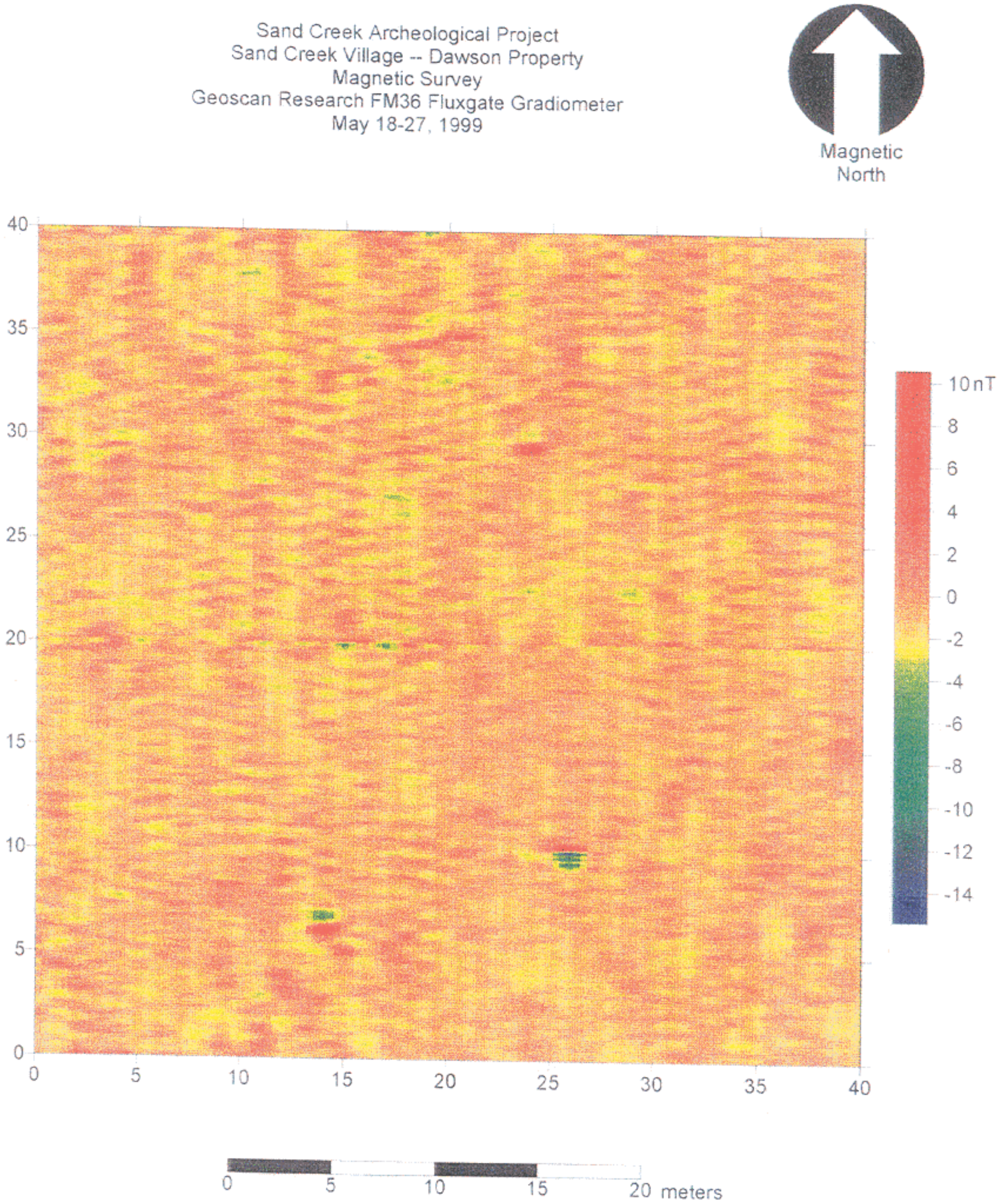

Figure 6. Color Scale Image Plot of Magnetic Gradient Data.

Figure 7. Geonics EM38 Ground Conductivity Meter (view to the northeast).

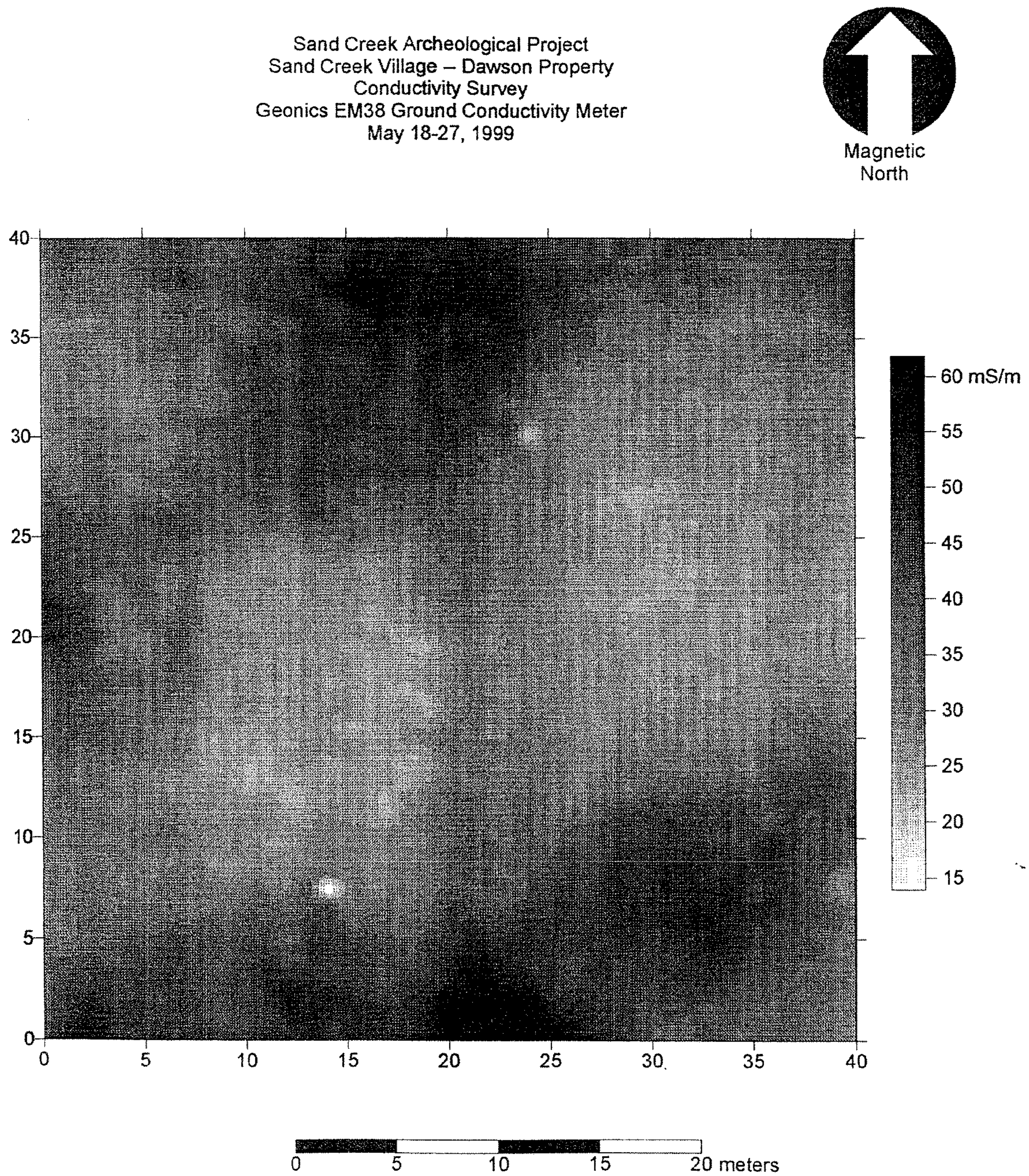

Figure 8. Gray Scale Image Plot of Conductivity Data.

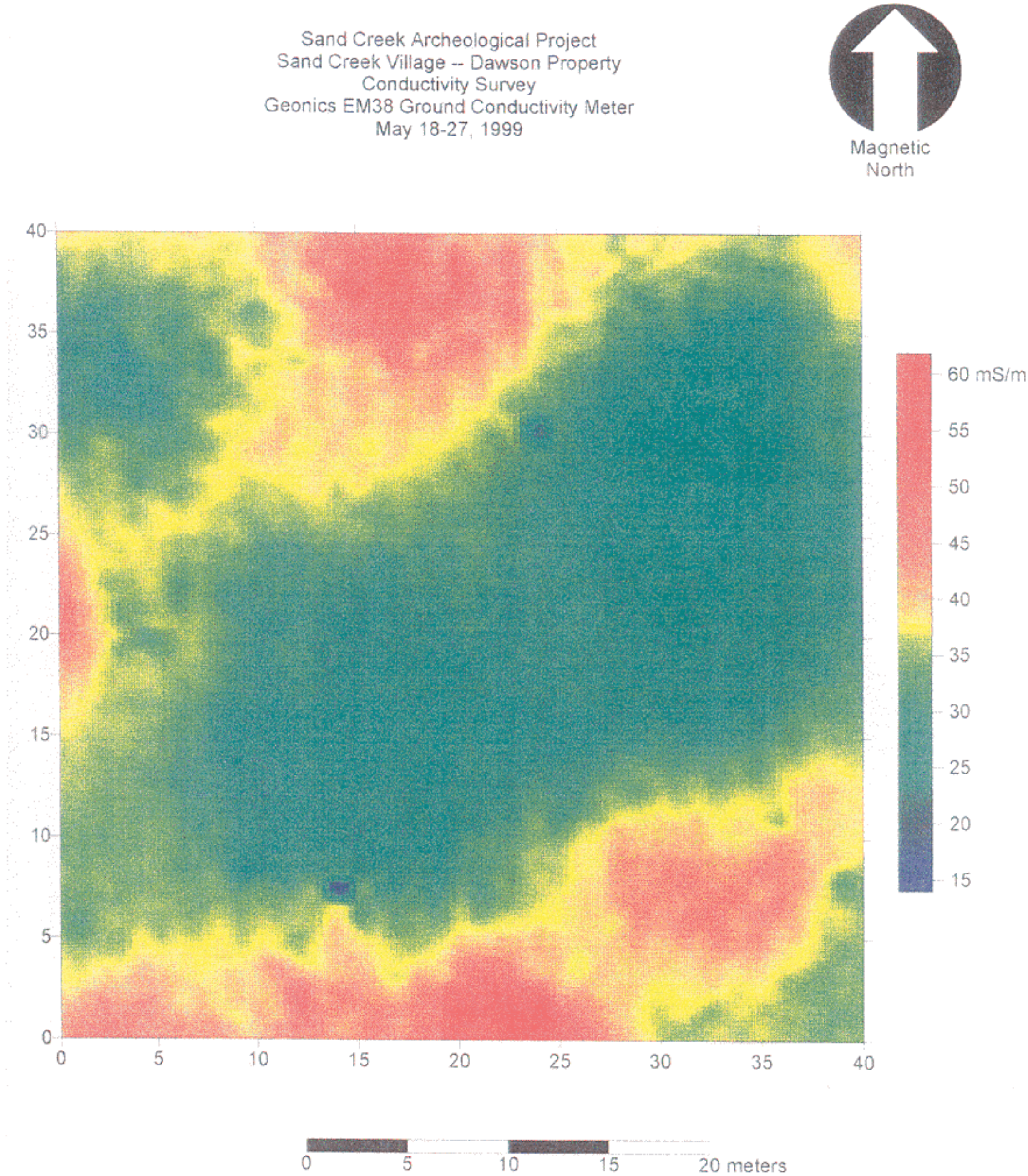

Figure 9. Color Scale Image Plot of Conductivity Data.

Figure 10. Geonics EM61 High Sensitivity Metal Detector (view to the southwest).

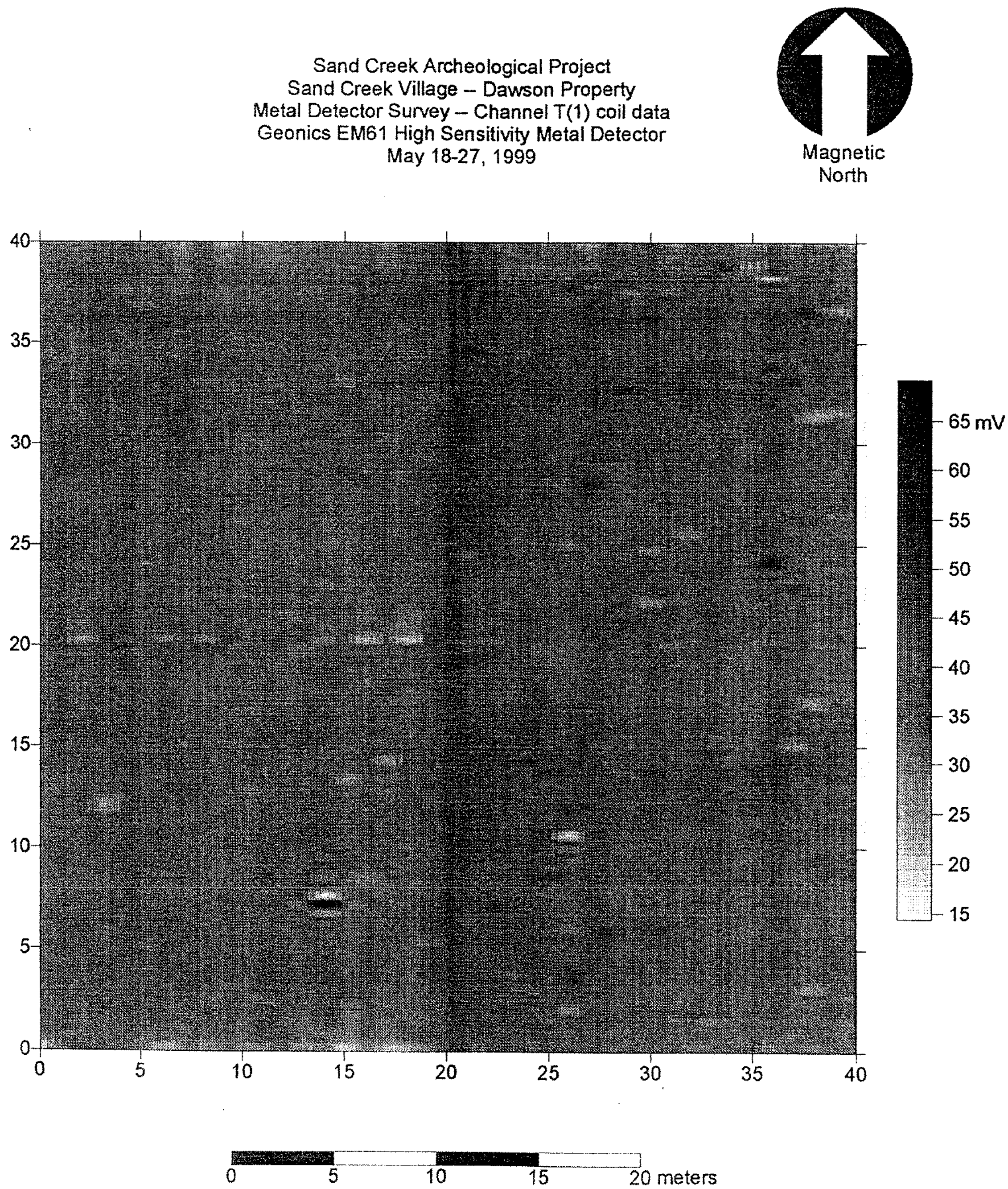

Figure 11. Gray Scale Image Plot of the Channel T(1)/Top Sensor Data.

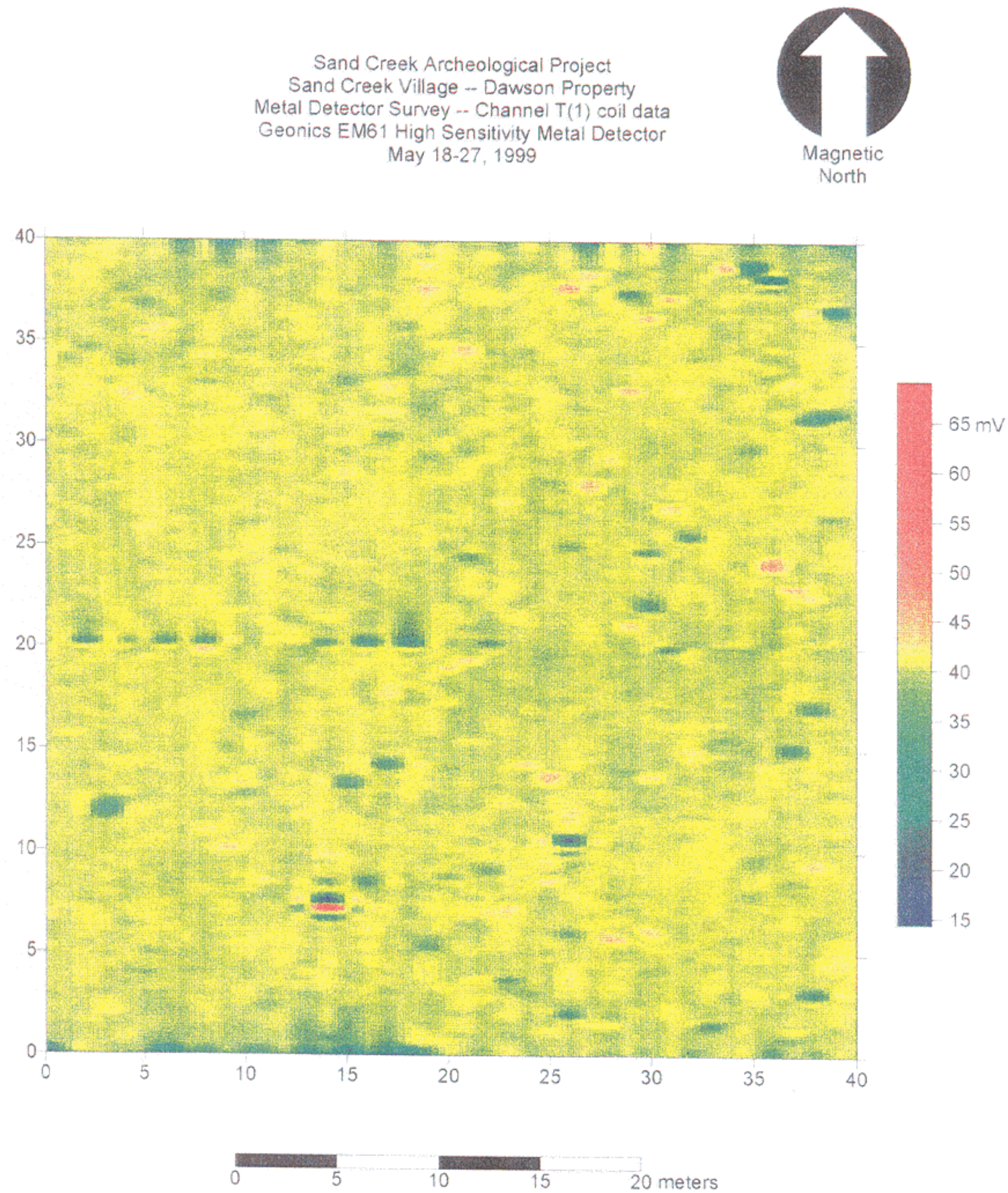

Figure 12. Color Scale Image Plot of the Channel T(1)/Top Sensor Data.

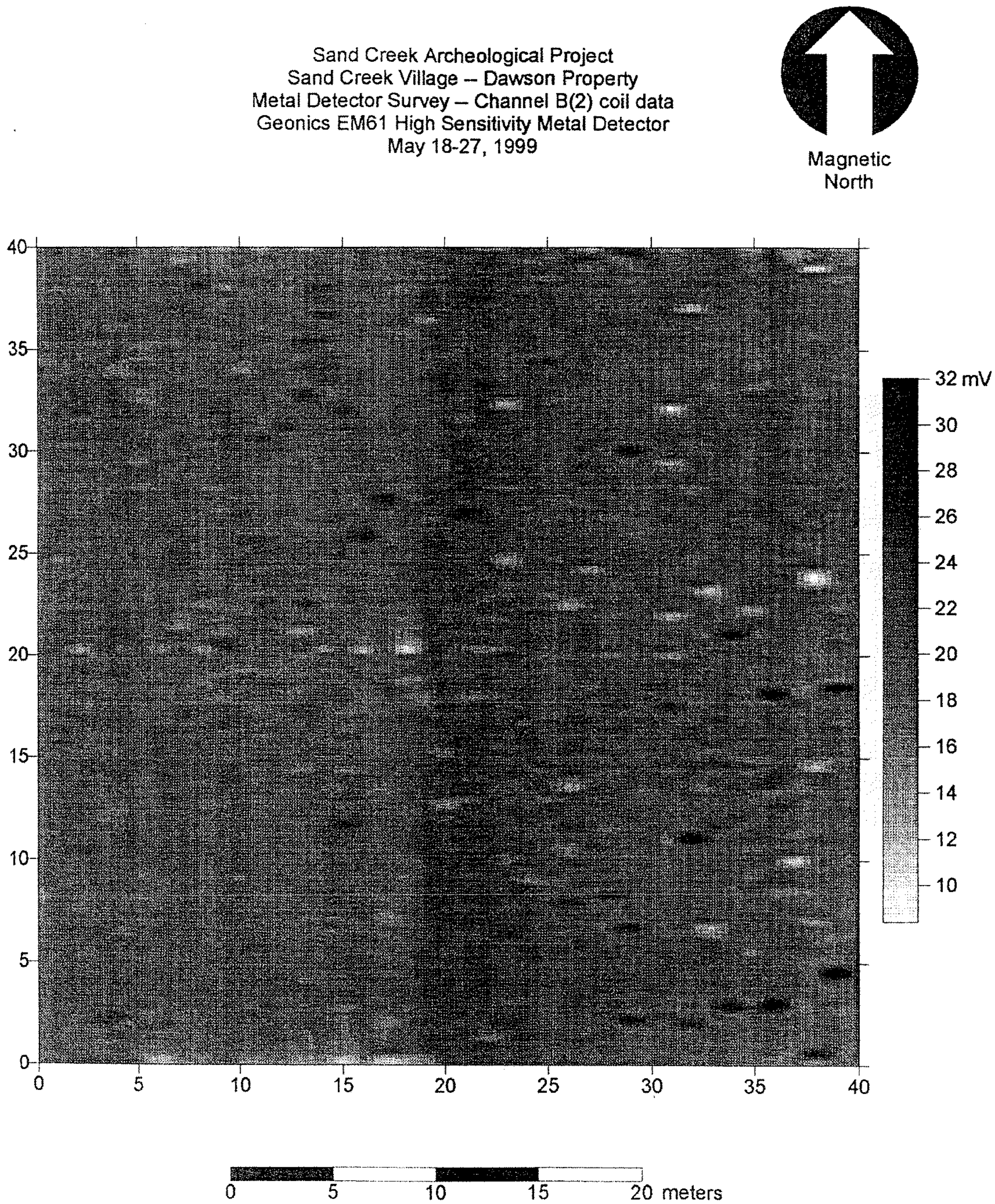

Figure 13. Gray Scale Image Plot of the Channel B(2)/Bottom Sensor Data.

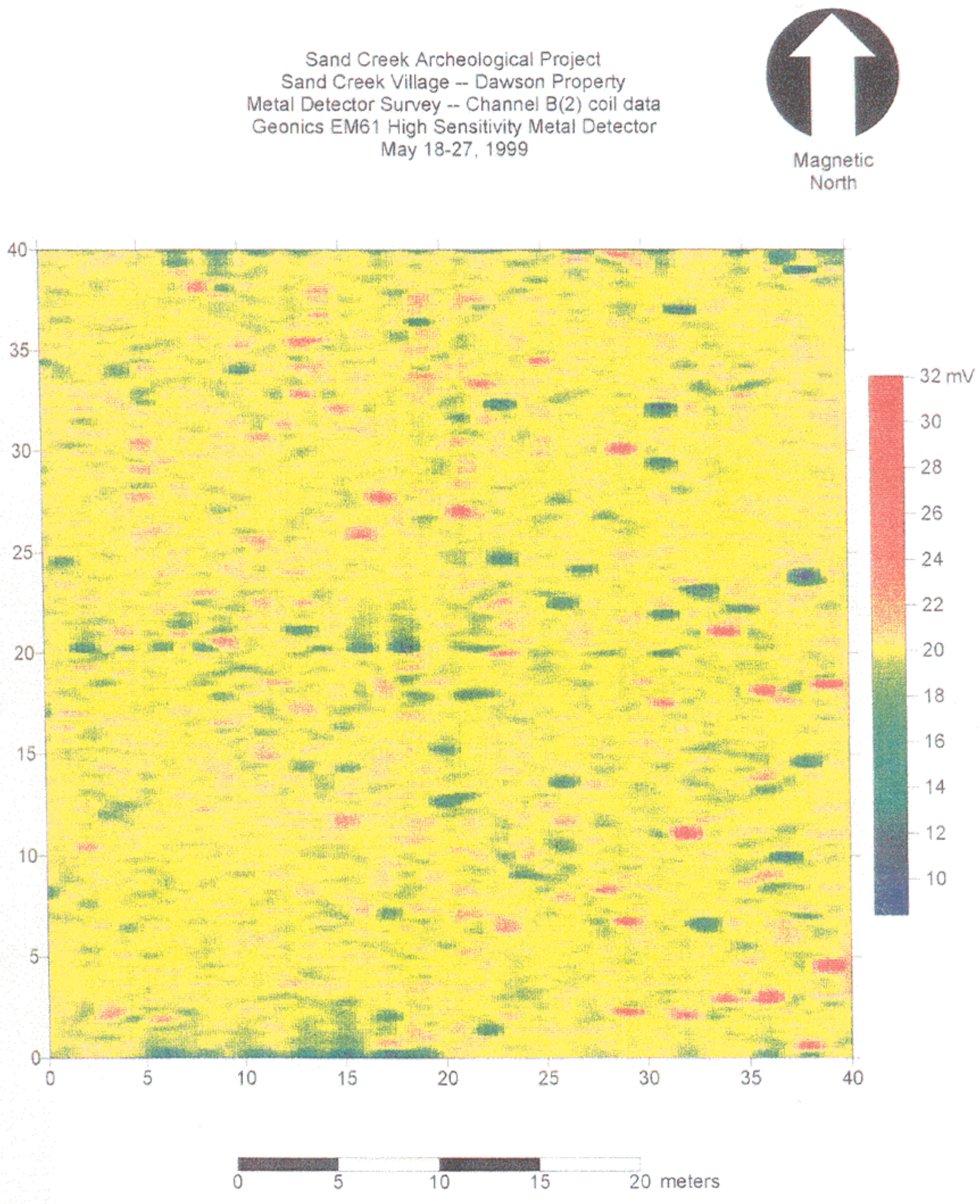

Figure 14. Color Scale Image Plot of the Channel B(2)/Bottom Sensor Data.

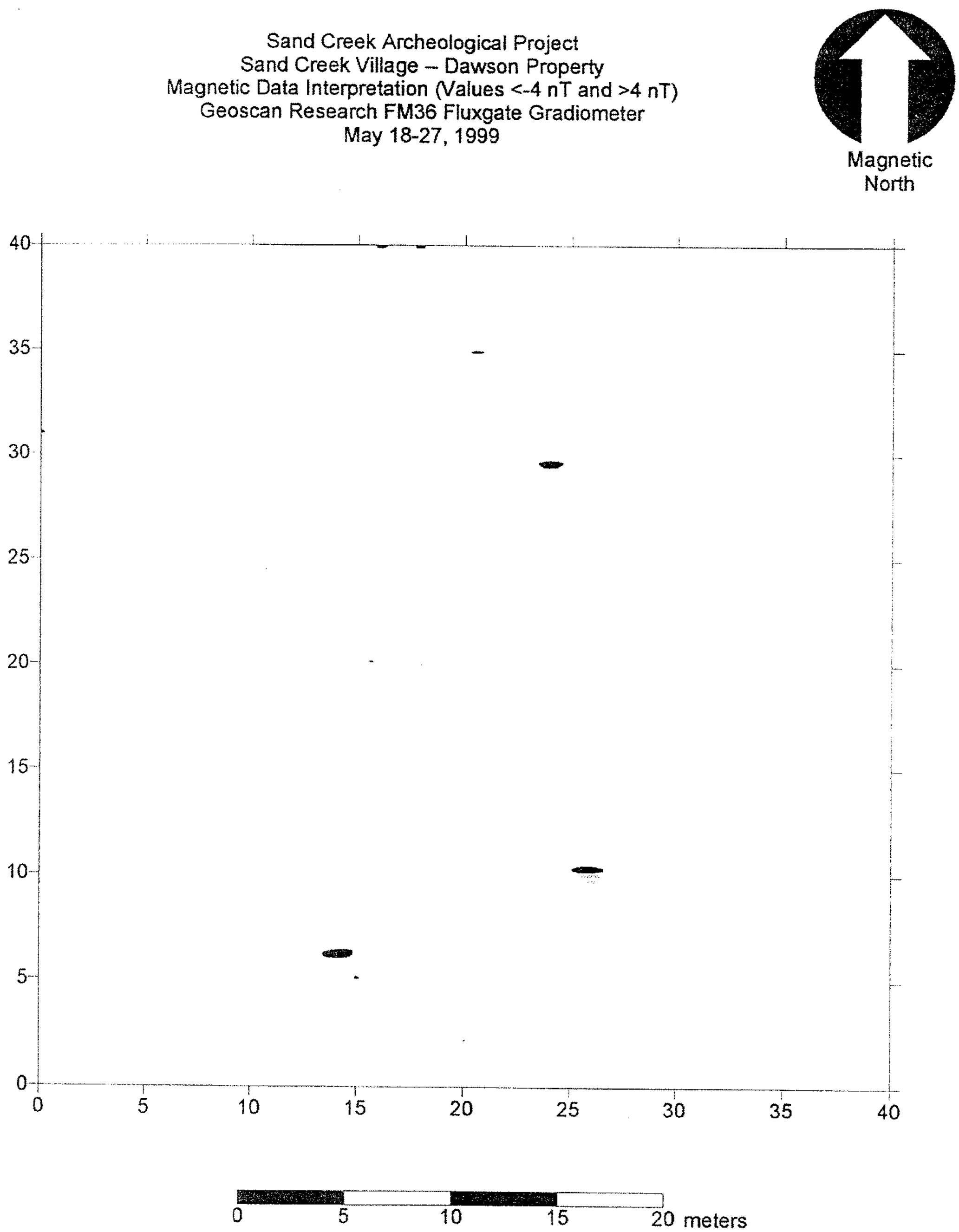

Figure 15. Image Plot of Magnetic Gradient Data Less Than -4 nT and Larger Than 4 nT.

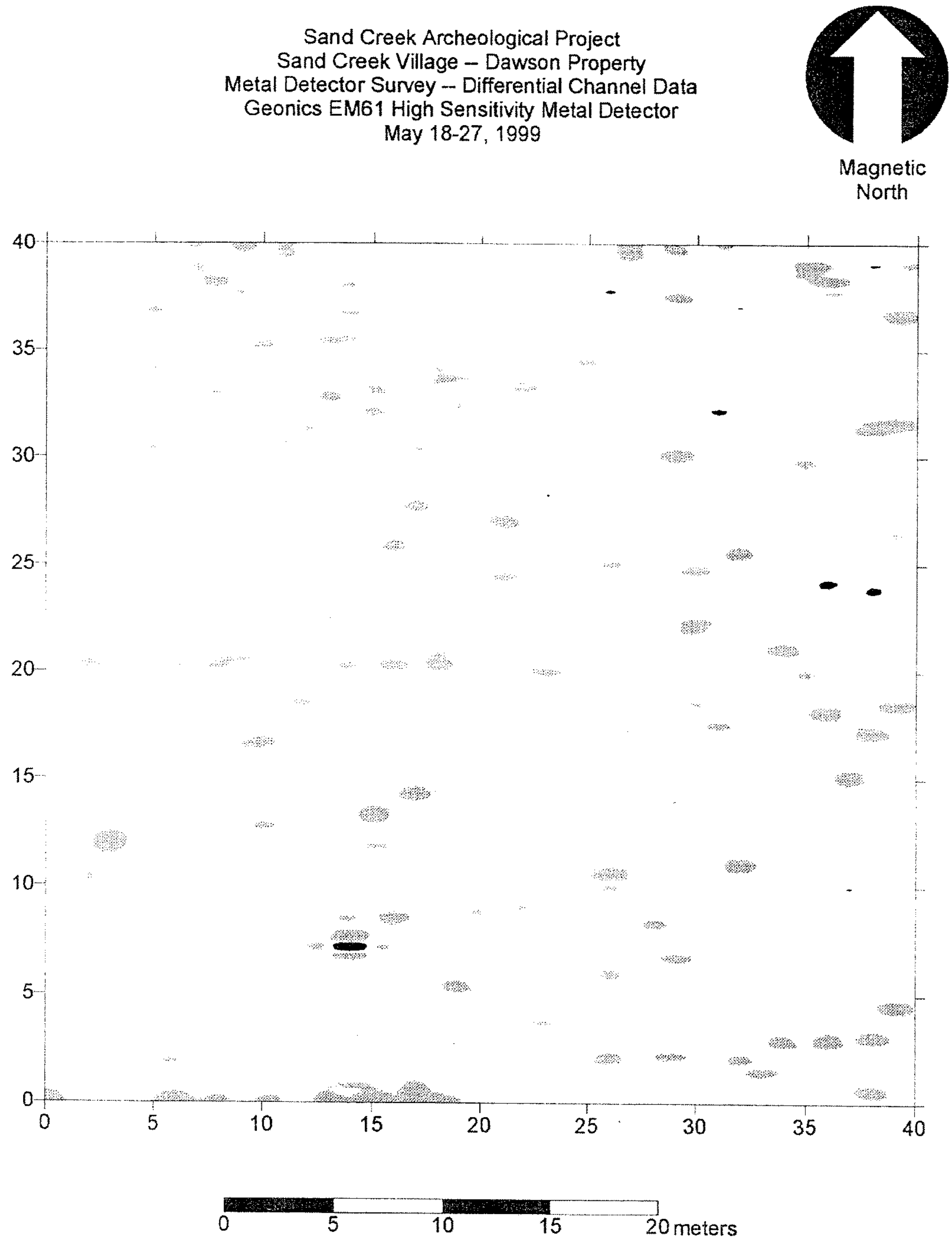

Figure 16. Image Plot of Differential Channel Data from EM61.

The folders on this CD contain the geophysical data collected at the Sand Creek massacre Site during the investigations in 1999. The Word97 folder contains the text file for the report on the investigations. The Illustrations folder contains the tiff file fort he figures in the report. The Geoplot folder contains the grid files (raw data filed for the FM36 gradiometer, the comp files of the processed data, and the mesh file templates. In the EM61 folder are the raw data files and processed DAT61 files. Surfer7 folder contains the data files from GEOPLOT (Magnetics), DAT38 (Conductivity), and DAT61 (HD metal detection) that were used in generating the mapps for the report.