National Park Service
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Midwest Archeological Center
Lincoln, Nebraska

GEOPHYSICAL EVALUATION OF FOUR AREAS WITHIN THE TRADE FAIR LOCALITY AT PECOS NATIONAL HISTORICAL PARK, SAN MIGUEL COUNTY, NEW MEXICO

BY
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ARCHEOLOGICAL REPORT 9

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This report has been reviewed against the criteria contained in 43CFR Part 7, Subpart A, Section 7.18 (a) (1) and, upon recommendation of the Midwest Regional Office and the Midwest Archeological Center, has been classified as

Available

Making the report available meets the criteria of 43CFR Part 7, Subpart A, Section 7.18 (a) (1).

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ABSTRACT

The geophysical survey of the four selected areas within the Trade Fair Locality at Pecos National Historical Park was conducted between June 24 and 30, 2012. The Midwest Archeological Center provided technical assistance for the geophysical investigations of the four geophysical project areas. The geophysical investigations consisted primarily of a magnetic survey with a dual fluxgate gradiometer. A limited conductivity survey with an electromagnetic induction meter was also conducted on two of the four geophysical project areas. An area equal to 8,876 m2 or 2.19 ac was surveyed during the geophysical investigations of the four geophysical project areas. The geophysical survey resulted in the identification of numerous subsurface archeological features associated with the Pecos Pueblo occupation, historic Spanish and American activities, and the modern National Park Serv ice use of the property.

PURPOSE OF ARCHEOLOGICAL WORK PER SOW AND PROJECT DESIGN

The Intermountain Regional Office's Heritage Partnership Programs (IMRO-SF) staff in Santa Fe, New Mexico, requested archeological assistance from the Midwest Archeological Center (MWAC) to conduct a geophysical survey of the Trade Fair Locality within Pecos National Historical Park (Figure 1). The purpose of the geophysical project was to identify and evaluate buried archeological resources within selected areas at Pecos National Historical Park (Haecker 2012a). The geophysical survey techniques consisted of a magnetic survey of Areas A, B, C, and D with a dual fluxgate gradiometer and limited conductivity surveys in Areas A and C with a ground-conductivity meter set in the quadrature phase (De Vore 2012). These techniques offered an inexpensive, rapid, and relatively non-destructive and non-invasive method of identifying buried archeological resources and site patterns that were detectable and also provided a means for sampling relatively large areas in an efficient manner (Roosevelt 2007:444-445; Von Der Osten-Woldenburg 2005:621-626).

ARCHEOLOGICAL PROJECT LOCATION AND AREA OF INVENTORY OR EXTENT OF TESTING

Pecos National Historical Park was established for its exceptional historic and archeological importance. The park contained the remains of a 17th-century mission and an ancient Indian pueblo. The monument was originally established in 1965 by President Lyndon Johnson (P.L. 89-54). The park was designated a National Historical Park in 1987 (P.L. 100-225) and expanded to include the Glorieta Battlefield unit to commemorate the Civil War Battle of Glorieta Pass (P.L. 101-536) in 1990. The present geophysical project is located within the Pecos unit.

The Trade Fair Locality contained an estimated 20-ac open expanse located immediately east of the Pecos Pueblo-Mission Complex. The geophysical project Area A within the Trade Fair Locality was located approximately 40 m east of the Mission and Convento (Figure 2). Area A consisted of grasses mixed with cacti and brush.

The geophysical project area was located on the east-facing slope below the Mission and Convento complex. Area B was located approximately 200 m northwest of the park's visitor center. The area is located at the base of the ridge in the valley between the Visitors Center and the Pecos Pueblo-Mission Complex (Figure 3). The vegetation included mixed grasses and juniper. Area C contained a rock concentration that has been identified as a Jicarilla Apache tipi ring (PECO 65/LA 14148). It was located approximately 100 m southwest of park headquarters in a stand of juniper (Figure 4). Area D was located approximately 160 m southeast of the park headquarters. Area D consists of open grasslands along an arroyo (Figure 5). The Santa Fe Trail swale is located on the west side of the geophysical project area.

ARCHEOLOGICAL PROJECT PERSONNEL

MWAC archeologist Steven L. De Vore directed and conducted the magnetic and conductivity surveys. Jacque Miller, Bailey Lathrop, Kasey Mathieson, Jessica Albertz, and Carl Haberstick of the University of Nebraska-Lincoln (UN-L) archeological field school through the Volunteers-In-Park (VIP) program assisted during the geophysical grid stakeout and global positioning system mapping, and geophysical data collection of the four geophysical project areas. During the course of the project, the UN-L volunteers provided 64 hours towards the geophysical investigations at the park.

ENVIRONMENTAL DESCRIPTION OF PROJECT AREA

Pecos National Historical Park in San Miguel County, New Mexico, is located within the transition zone between the Southern Rocky Mountains province of the Rocky Mountain System division (Fenneman 1931:92-132), the Raton and the Pecos Valley sections of the Great Plains province of the Interior Plains division (Fenneman 1931:37-50), and the Sacramento section of the Basin and Range province of the Intermontane Plateau division of the North American continent (Fenneman 1931:393-395). The region is part of the Southern Rocky Mountain Foothills major land resource area (USDA 2006:132-134) of the Rocky Mountain Range and Forest land resource region (USDA 2006:113-114). The region consists of broad, elevated, complex strips of north-south trending mountains with steeply dipping intermountain sedimentary basins. The Pecos River and its tributaries, including Glorieta Creek, drain the project area. The upper Pecos River valley is bordered by the Sangre de Cristo Mountains on the north, the Tecolote Range on the east, and Gloria Mesa to the west (Johnson et al. 2011:5). Bedrock consists of Pennsylvanian and early Permian conglomerates, limestones, sandstones, shales, and siltstones of the Sangre de Cristo Formation (Johnson et al. 2011:5; USDA 2006:133). The limestone Magdalena group underlies the Sangre de Cristo Formation and outcrops along the Pecos River. Igneous and metamorphosed Precambrian rocks outcrop along Glorieta Creek. The Pecos River valley is covered with Pleistocene and Holocene alluvium.

The dominant soils in the region are mollisols, alfisols, inceptisols, and entisols (Foth and Schafer 1980; USDA 2006:133-134). The soils are dominated by a mesic or frigid soil temperature regime with an ustic soil moisture regime. The soils typically have a smectitic or mixed mineralogy. The soils of the Pecos National Historical Park lie within the Laporte-Rock outcrop soil association of "shallow, moderately undulating to hilly, well drained soils that formed in material weathered from limestone, and Rock outcrop on hills and ridges" (Hilley et al. 1981:9-10) and the Vibo-Tapia soil association of "deep, moderately undulating to moderately rolling, well-drained soils that formed in mixed material and in alluvial and eolian material on fans, valley sides and uplands" (Hilley et al. 1981:10). Soils within the Pecos unit of the park include the undulating Vibo-Ribera association, the moderately sloping Ribera-Sombordoro-Vibo association, the moderately sloping Tuluso-Sombordoro-Rock outcrop complex, and the steep Laporte-Rock outcrop complex (Johnson et al. 2011:5-6). Areas A, C, and D are located within the moderately sloping Ribera-Somboro-Vibo association, which is located on uplands and valley sides (Hilley et al. 1981:32, 72-74, 78-79). The Ribera soil is moderately deep and well drained, the Somboro soil is very shallow and well drained, and the Vibo soil is deep and well drained. The Ribera soil is a fine sandy loam that formed in sandstone- and shale-derived alluvial and eolian deposits, which has a moderate permeability with a moderate available water capacity, and a neutral to moderately alkaline pH. The Somboro soil is a very stony, fine sandy loam that formed in material derived from sandstone, which has a slow permeability with a very low available water capacity, medium runoff, and a mildly to moderately alkaline pH. The Vibo soil is a fine sandy loam that formed in alluvial and eolian sediments, which have a moderate permeability with a high available water capacity, medium runoff, and a neutral to moderately alkaline pH. Area B is located within the undulating Vibo-Ribera association, which is located on fans with one to nine percent slopes (Hilley et al. 1981:40-41,72,78-79). The hazard of water erosion ranges from moderate to high, while wind erosion ranges from slight to high in the park.

The area also lies within the Navahonian biotic province (Dice 1943:39-42). The Pecos River valley lies within the Rocky Mountain conifer vegetation zone (Johnson et al. 2011:8-9). Stands of pinyon and juniper occur across the park with ponderosa pine and Douglas fir found at higher elevations. Open grasslands and juniper grasslands occur below the timber stands containing a mixture of short grasses along with a variety of shrubs, forbs, yucca, and cacti. Cottonwoods are found along Glorieta Creek and the Pecos River. Native grasses include blue grama, Indian ricegrass, sand dropseed, threeawn, hairy grama, broom snakeweed, pinyon ricegrass, little bluestem, and sideoats grama (Hilley et al. 1981:22, 32, 38, 41; Johnson et al. 2011:8-10, 82-85). Cottonwoods are the dominant forest species along the streams. The major wildlife species in the region include mule deer, bighorn sheep, elk, black bear, mountain lion, jackrabbit, cottontail rabbit, rodents, turkey, and mourning dove, as well as several species of songbirds, owls, and raptors (Britton and Ferrell 2006; Johnson et al. 2011:6-8; USDA 2006:134). Waterfowl can be found along lakes and perennial streams. Numerous reptiles, amphibians, fish, and insects are also present in the region (Britton and Ferrell 2006; Johnson 2011:7,92-124; Parmenter and Lightfoot 1996).

The climate in the region is a middle-latitude dry climate with warm summers and cold, dry winters (Dice 1943:39-40; Houghton 1981:1-2,80; Trewartha and Horn 1980:360-364). The average yearly temperature ranges from an average daily minimum of 1.6° C to an average daily maximum of 17.78° C. Temperatures can range from below -20° C in the winter to over 43 ° C in the summer. Precipitation averages 36.8 cm with the majority of it falling in summer thunder storms. The growing season is approximately

150 frost-free days. Prevailing winds are generally out of the southwest. These resources provide the basis of the aboriginal subsistence of prehistoric times and the historic and modern ranching economy.

GENERAL DESCRIPTION OF THE GEOPHYSICAL PROJECT AND METHODS:

Overall Research Design

The present geophysical inventory project is designed to provide a baseline geophysical data set for the evaluation of buried archeological resources within four areas of the Trade Fair Locality at Pecos National Historical Park (Haecker 2012a). The geophysical investigations were part of an intensive remote-sensing investigation of the Trade Fair Locality and other selected locations within the park. The investigations were to identify and define historic activities that occurred within the project area, which were described in written accounts and oral histories concerning the Pecos Pueblo.

Previous Work

The project area lies within the Anasazi sub-region of the Southwest archeological culture area (Willey 1966:178-245). Historic contexts have been identified for the region in David Stuart and Rory Gauthier's (1981) compilation of the state's prehistoric resources. Genevieve Head, Janet Orcutt, and Robert Powers (2002:2-13) also provide a detailed review of the Upper Pecos Valley cultural history.

Archeological investigations of Pecos National Historical Park began in the late 1800s. Adolph Bandelier compiled a set of notes and archeological drawings of the Pecos Pueblo and the Mission complex during his archeological investigations of the upper Pecos River valley in 1880 (Bandelier 1881,1892:127-138). Edgar Hewett continued the work of Bandelier in the early 1900s (Hewett 1904:426-439). From 1915 to 1929, A. V. Kidder conducted systematic archeological excavation within the boundary of today's Pecos National Historical Park. Kidder's excavations and analyses of the ceramics provided a basis for the chronological framework and the development of a regional synthesis (Kidder 1916a, 1916b, 1917a, 1917b, 1921, 1922, 1924, 1925, 1926a, 1926b, 1932, 1951, 1958). The Pecos State Monument was established in 1935. In the years to follow, archeological work at the Pecos Pueblo concentrated on ruins stabilization or smaller sites around the periphery of the main complex (Hayes 1974:19; Ivey 2005; Metzger 1990; Stubbs et al. 1957). With the establishment of the Pecos National Monument in 1965, emphasis was directed to site display, interpretation, and ruins protection (Eininger 2002:28-34). Archeological activity then shifted back to the Pecos Pueblo and Mission complex on the mesilla (Hayes 1970; Matlock 1974; Metzger 1990, Nordby 1990, Nordby et al. 1975, Oinkley 1968, White 1993,1994). Although most of the NPS archeological activities focused on the mesilla, James Gunnerson conducted archeological investigations searching for Apache sites near the Pecos Pueblo (Gunnerson 1969, 1970; Gunnerson and Gunnerson 1970). During the course of three field seasons, Gunnerson identified at least nine Apache sites within the park. The archeological investigation of the park has continued to the present. Many of the projects represented small-scale investigations associated with park undertakings while a Systemwide Archeological Inventory Program (SAIP) inventory was undertaken in the mid to late 1990s (Head and Orcutt 2002).

The park staff has incorporated archeological prospection investigative techniques into the park's archeological research, beginning in 1998 with the hosting of the National Park Service's Non-destructive Investigative Techniques for Cultural Resource Management workshop (De Vore 1998a). Magnetic, resistance, conductivity and magnetic susceptibility, and ground-penetrating radar (GPR) surveys were conducted in an area south of the park's headquarter building (Bevan 1998a; McNeil 1998). A pit structure was identified in the conductivity/susceptibility data (McNeil 1998). In 1998, geophysical investigations were conducted at the location of the Civil War's Union encampment of Camp Lewis (Haecker 1998; De Vore 1998b). The investigations included a metal-detector survey, a magnetic survey with a fluxgate gradiometer, and the analysis of aerial photographs. Metal-detector surveys of the Civil War's Glorieta Battlefield and the Pigeon's Ranch site were conducted in 2005 (Scott 2005). Metal-detector surveys have also been used within the Trade Fair area and the adjacent uplands in 2011 (Haecker 2012b).

For additional information on the National Park Service archeological investigations see the summary of archeological investigations by Susan Eininger (2002:28-37). Besides the archeological resource investigations, an ethnographic overview (Levine et al. 1994) and a cultural landscape overview (Cowley et al. 1998) have been completed. The ethnographic overview identified several ethnic groups that were traditionally associated with the park and provided information on the traditional land use by these groups within the park. The cultural landscape overview examined the cultural and natural forces that have affected the park's landscape features.

Description of Investigations

Geophysical prospection techniques available for archeological investigations consist of a number of techniques that record the various physical properties of the earth, typically in the upper couple of meters; however, deeper prospection can be utilized if necessary (David 1995). Geophysical techniques are divided between passive and active techniques. Passive techniques are primarily ones that measure inherently or naturally occurring local or planetary fields created by earth-related processes (Heimmer and De Vore 1995:7, 2000:55; Kvamme 2001:356). The primary passive method utilized in archeology is magnetic surveying. Other passive methods with limited archeological applications include self-potential methods, gravity survey techniques, and differential thermal analysis. Active techniques transmit an electrical, electromagnetic, or acoustic signal into the ground (Heimmer and De Vore 1995:9, 2000:58-59; Kvamme 2001:355-356). The interaction of these signals with buried materials produces alternated return signals that are measured by the appropriate geophysical instruments. Changes in the transmitted signal of amplitude, frequency, wavelength, and time-delay properties may also be observable. Active methods applicable to archeological investigations include electrical resistivity, electromagnetic conductivity (including ground-conductivity and metal detectors), magnetic susceptibility, and ground-penetrating radar. Active acoustic techniques, including seismic, sonar, and acoustic sounding, have very limited or specific archeological applications. In order to identify any buried archeological resources at the Pecos National Historical Park, the National Park Service's MWAC and IMSF-SF staffs, along with student volunteers from the University of Nebraska-Lincoln archeological field school, applied magnetic and conductivity survey techniques to investigate and identify the nature, extent, and the location of possible archeological features associated with historic Native American, Spanish, and American occupations and activities within the four geophysical project areas.

Field Methods

Using an Ushikata S-25 TRACON surveying compass (Ushikata 2005) and a 100-m tape measure, the four geophysical grids were fitted to the landforms in the four geophysical project areas (Figure 6). Wooden 2-in-by-2-in hub stakes were placed at the grid unit corners or at points along the edges of the grid units at a specified meter interval where access was not obstructed by natural (e.g., trees, bushes, arroyos) or cultural (e.g., buildings, fences, pavement) features.

Area A consisted of 12 complete 20-m-by-20-m grid units measuring 60 m east-west by 80 m north-south, oriented on magnetic north. The total survey area measured 4,800 m2 or 1.19 ac. Area B consisted of two complete 20-m-by-20-m grid units measuring 40 m east-west by 20 m north-south, oriented 42 degrees east of magnetic north. The total survey area measured 800 m2 or 0.20 ac. Area C, the potential Apache stone circle site, consisted of one partial 20-m-by-20-m grid unit measuring 20 m east-west by 10 m north-south, oriented 24 degrees west of magnetic north. The total survey area measured 156 m2 or 0.04 ac. Area D consisted of seven complete and one partial 20-m-by-20-m grid units measuring 80 m east-west by 40 m north-south, oriented 8 degrees west of magnetic north. The total survey area measured 3,120 m2 or 0.78 ac. An area totalling 8,876 m2 or 2.19 ac was surveyed during the geophysical investigations of the four geophysical project areas.

During the establishment of the grid units of the four PECO geophysical project areas, the grid corners of the project areas were recorded with a global positioning system (GPS) unit (Figure 7). The GPS unit consisted of a Trimble GeoXH handheld receiver and external antenna (Trimble 2007a). The GPS readings at stationary points (i.e., grid unit corners and individual surface features) were collected with 30 readings from five or more satellites. The field GPS data were collected in the Universal Transverse Mercator (UTM) projection for the Zone 13 North coordinates using the North American Datum of 1983 (NAD83) horizontal datum. The data were transferred to a laptop computer via the Trimble TerraSync software (Trimble 2007b,2007c). The data were then differentially corrected with the Trimble Pathfinder Office software (Trimble 2007d) using the continuously operating reference station, CORS Santa Fe (NMSF), located 28 km away in Santa Fe, New Mexico. After the raw survey data in the standard storage format (SSF) were post processed, the corrected data were exported to Excel data files. The data were then imported into the SURFER 10 contouring and 3D surface mapping program (Golden Software 2011) for the generation of the UTM project map (Figure 8). One thousand eight hundred forty-seven (99.95%) of 1,848 selected positions were code corrected by post-processing against the two base providers. One thousand eight hundred forty-six (99.89%) of 1,848 selected positions were carrier corrected by post-processing against the two base providers. The estimated accuracy for the 1,847 corrected positions resulted in 99.95% percent of the corrected positions for points within 5-15 cm of the actual landscape position and 0.05% within 0.5-1.0 m of the actual position.

Twenty-meter ropes were placed along the base lines connecting the grid unit corners. These ropes formed the traverse boundaries of each grid unit during the GPR profile data collection phase of the survey (Figure 9). The ropes were marked with different color tape at half-meter and meter increments, which were designed to help guide the survey effort. In addition to the survey ropes at the ends of the project grid units, traverse ropes were placed perpendicular to the baseline ropes at the 2-m intervals to serve as additional guides during the data collection along each traverse. The survey ropes were moved to the next grid unit once the data collection was completed for each traverse line. The first traverse was oriented towards the north during the magnetic survey of the four geophysical project areas. The magnetic data were acquired across the grid units beginning in the lower left hand corner of grid facing the direction of travel along the first traverse. In addition to the GPS mapping of the geophysical project area, sketch maps of the above ground features were made during the magnetic survey when the survey ropes were placed on the grid units for each geophysical project area (Figures 10 through 13 for Areas A through D, respectively).

Magnetic Survey—Dual Fluxgate Gradiometer

Instrument: Bartington Grad601-2 Magnetic (Fluxgate) Gradiometer (Bartington 2007)

Specifications: dual system with two sensor tubes spaced 1 m apart, 1-m sensor spacing between sensors on individual sensor tubes, 0.05 nT (nanotesla) resolution, 0.1 nT absolute accuracy

Survey type: magnetic

Operator: Steven De Vore

A magnetic survey is a passive geophysical survey technique used to measure local changes in the earth's magnetic field (see Aspinall et al. 2008; Bevan 1991, 1998b:29-43; Breiner 1973,1992:313-381; Burger 1992:389-452; Clark 2000:92-98, 174-175; David 1995:17-20; Davenport 2001:26, 50-71; Dobrin and Savit 1988:633-749; Gaffney and Gater 2003:36-42, 61-72; Gaffney et al. 1991:6, 2002:7-9; Hanson et al. 2005:151-175; Heimmer and De Vore 1995:13, 2000:55-56; Kvamme 2001:357-358, 2003:441, 2005:434 436, 2006a:205-233, 2006b:235-250; Lowrie 1997:229-306; Milsom and Eriksen 2011:65-84; Mussett and Khan 2000:139-180; Neubauer et al. 1996; Nishimura 2001:546-547; Oswin 2009:43-54, 126-135; Robinson and Çoruh 1988:333-444; Scollar et al. 1990:375-519; Sharma 1997:65-111; Telford et al. 1990:62-135; Weymouth 1986:343; and Witten 2006:73-116 for more details on magnetic surveying). Magnetometers depend upon sensing subtle variations in the strength of the earth's magnetic field in close proximity to the archeological features being sought. Variation in the magnetic properties of the soil or other buried material induces small variations in the strength of the earth's magnetic field. Its application to archeology results from the local effects of magnetic materials on the earth's magnetic field. These anomalous conditions result from magnetic materials and minerals buried in the soil matrix. Iron-based materials have very strong effects on the local earth's magnetic field. Historic iron artifacts, modern iron trash, and construction material, like metal fence posts, woven and barbed fencing wire, and fencing staples, as well as agricultural machinery parts, can produce such strong magnetic anomalies that nearby archeological features are masked by the strong magnetic fields of these materials and are therefore not detectable. Other cultural features that affect the earth's local magnetic field include fire hearths and soil disturbances (e.g., pits, mounds, wells, pithouses, and dugouts), as well as, geological strata.

Magnetic field strength is measured in nanoteslas (nT; Sheriff 1973:148). In North America, the earth's magnetic field strength ranges from 40,000 to 60,000 nT with an inclination of approximately 60° to 70° (Burger 1992:400; Milsom and Eriksen 2011:68; Weymouth 1986:341). Magnetic anomalies of archeological interest are often in the ±5 nT range, especially on prehistoric sites. Target depth in magnetic surveys depends on the magnetic susceptibility of the soil and the magnetic mass associated with buried features and objects. For most archeological surveys, target depth is generally confined to the upper 1-2 m below the ground surface with 3 m representing the maximum limit (Clark 2000:78-80; Kvamme 2001:358). Magnetic surveying applications for archeological investigations have included the detection of architectural features, soil disturbances, and magnetic objects.

The Bartington Grad601-2 magnetic gradiometer is a fluxgate gradiometer that uses a dual fluxgate sensor system for the recordation of two lines of data for each traverse walked during the collection of magnetic data (Figure 14). It is a vector magnetometer, which measures the strength of the magnetic field in a particular direction (Bartington 2007). The two magnetic sensors in each gradiometer sensor tube on the fluxgate gradiometer are spaced 1.0 m apart. The sensor tubes are carried on a bar with a meter separation between the two sensor tubes. The instrument is carried so the two sensors are vertical to one another with the bottom sensor approximately 30 cm above the ground. Each sensor reads the magnetic field strength at its height above the ground. The gradient or change of the magnetic field strength between the two sensors is recorded in the instrument's memory. This gradient is not in absolute field values but rather voltage changes, which are calibrated in terms of the magnetic field. The dual fluxgate gradiometer provides a continuous record of the magnetic field strength across each traverse. The sensors must be accurately balanced and aligned along the direction of the field component to be measured. The reference point for balancing and aligning the dual gradiometer for the survey of all four PECO geophysical project areas is located at N0/E0 in Area A. The gradiometer was aligned on magnetic north.

The magnetic survey was designed to collect eight samples per meter along 1.0-m traverses or 8 data values per square meter. The data were collected in a zigzag fashion with the surveyor alternating direction of travel for each traverse across the grid. Thirty-two hundred data measurements were collected during the survey of a complete grid unit. The magnetic data were recorded in the memory of the gradiometer and downloaded to a laptop computer after the completion of survey effort. The magnetic data were directly imported into DW Consulting's ArcheoSurveyor software (DW Consulting 2012) for processing. The grid files for individual grid units were combined into a site composite file (DW Consulting 2012:3-4). Both shade-relief and trace-line plots were generated in the field before the instrument's memory was cleared.

Upon completion of the magnetic survey at each area, the data were processed in ArcheoSurveyor. After the grid data files were assembled into a composite file, the destripe processing routine was applied to remove any traverse discontinuities or striping effects that may have occurred from operator handling, heading errors, instrument setup, or instrument drift during the survey (DW Consulting 2012:69-70). Upon completion of the destripe function, the data were interpolated by expanding the number of data points in the traverse direction and by reducing the number of data points in the sampling direction to provide a smoother appearance in the data set and to enhance the operation of the low-pass filter (DW Consulting 2012:71). This changed the original 8-x-1 data point matrix into 4-x-4 data point matrix for the survey area. The low-pass filter was then applied over the entire data set to remove any high frequency, small scale spatial detail (DW Consulting 2012:81). This transformation resulted in the improved visibility of larger, weak archeological features. The data were then exported as an ASCII dat file (DW Consulting 2012:41) and placed in the SURFER 10 program (Golden Software 2011) for final the display (Oswin 2009:86-95).

The dual fluxgate gradiometer data from the Area A, after the application of the destriping traverse function, ranged from -100.0 nT/m to 100.0 nT/m with a mean of -0.17 nT/m and a standard deviation of 7.659 nT/m. Image and contour plots of the magnetic data were also generated for Area A in Surfer 10 (Figure 15). The dual fluxgate gradiometer data from the Area B, after the application of the destriping traverse function, ranged from -10.6 nT/m to 12.9 nT/m with a mean of -0.01 nT/m and a standard deviation of 0.996 nT/m. Image and contour plots of the magnetic data were also generated for Area B in Surfer 10 (Figure 16). The dual fluxgate gradiometer data from the Area C, after the application of the destriping traverse function, ranged from -53.8 nT/m to 89.0 nT/m with a mean of -0.23 nT/m and a standard deviation of 5.721 nT/m. Image and contour plots of the magnetic data were also generated for Area C in Surfer 10 (Figure 17). The dual fluxgate gradiometer data from the Area D, after the application of the destriping traverse function, ranged from -98.2 nT/m to 99.7 nT/m with a mean of 0.07 nT/m and a standard deviation of 6.351 nT/m. Image and contour plots of the magnetic data were also generated for Area D in Surfer 10 (Figure 18).

Electromagnetic Induction Survey—Conductivity:

Instrument: Geonics EM38 ground conductivity meter (Geonics 2006a) with an Archer ultra-rugged Field PC (Geonics 2006b; Juniper Systems 2009)

Specifications: apparent conductivity of the ground in millisiemens per meter (mS/m); measurement precision ±0.1% of full scale deflection; 100 and 1000 mS/m conductivity ranges (4 digit digital meter).

Survey type: conductivity in the quadrature phase operating mode

Operator: Steven De Vore

The electromagnetic induction (EM or EMI) survey in the conductivity or quadrature phase is an active geophysical technique that induces an electromagnetic field into the ground (see Bevan 1983, 1998:29-43; Clark 2000:171; Clay 2006:79-107; Dalan 1995; Davenport 2001:72-88; David 1995:20; Dobrin and Savit 1988:773-837; Fitterman and Labson 2005:301-355; Gaffney and Gater 2003:42-44; Gaffney et al. 1991:5, 2002:10; Heimmer and De Vore 1995:35-41, 2000:60-63; Klien and Lajoie 1992:383-535; Kvamme 2001:362-363, 2003:441-442; Lowrie 1997:222-228; Mussett and Khan 2000:210-219; Nishimura 2001:551-552; Robinson and Çoruh 1988:490-500; Scollar et al. 1990:520-590; Sharma 1997:265-308; Telford et al. 1990:343-521; Weymouth 1986:317-318, 326-327, and Witten 2006:147-213 for more details of electromagnetic induction conductivity surveys). This survey technique measures the apparent soil conductivity, which is in millisiemens per meter (mS/m: Sheriff 1973:197). Conductivity is also the reciprocal of resistivity.

An electromagnetic field is induced into the ground through the transmitting coil. The induced primary field causes an electric current flow in the earth similar to a resistivity survey. In fact, a conductivity survey is the inverse of a resistivity survey. High conductivity equates to low resistivity and vice versa. The materials in the earth create secondary eddy current loops that are picked up by the instrument's receiving coil. The interaction of the generated eddy loops or electromagnetic field with the earthen materials is directly proportional to terrain conductivity within the influence area of the instrument. The receiving coil detects the response alteration (secondary electromagnetic field) in the primary electromagnetic field. This secondary field is out of phase with the primary field (quadrature or conductivity phase). The in-phase component of the secondary signal is used to measure the magnetic susceptibility of the subsurface soil matrix.

Changes result from electrical and magnetic properties of the soil matrix. Changes are caused by materials buried in the soil, differences in soil formation processes, or disturbances from natural or cultural modifications to the soil. EM instruments are also sensitive to surface and buried metals. Due to their high conductivity, metals show up as extreme values in the acquired data set. On occasion, these values may be expressed as negative values since the extremely high conductivity signal of the metals cause the secondary coil to become saturated.

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 are affected by the water saturation in the soil (Clark 2000; Heimmer and De Vore 1995:35-41). Its application to archeology results from the ability of the instrument to detect lateral changes on a rapid data acquisition, high resolution basis, where observable contrasts exist. Lateral changes in anthropogenic features result from compaction, structural material changes, buried metallic objects, excavation, habitation sites, and other features affecting water saturation (Heimmer and De Vore 1995:37). The conductivity survey can sometimes detect the disturbed soil matrix within a grave shaft. It can also locate large metal objects. Metallic trash on the surface and other small objects buried in the upper portion of the soil can degrade the search of the buried archeological resources, including graves (Bevan 1991:1310).

The present EMI survey is conducted with a Geonics EM38 ground conductivity meter (Geonics 2006). The instrument is lightweight and 1.45 m in length (Figure 19). The self-contained dipole transmitter (primary field source) and self-contained dipole receiver (sensor) coils are located at opposite ends of the meter. The intercoil spacing is 1 m. The meter was connected to the Archer ultra-rugged Field PC for digital data acquisition (Geonics 2006a, Juniper Systems 2009). The conductivity survey was designed to collect in the continuous or automatic mode with readings collected every quarter of a second resulting in four samples per meter. The data were collected in a parallel fashion or unidirectional mode with the surveyor conducting the data acquisition in the same direction of travel for each traverse across the grid. The conductivity data were collected along 1.0-m traverses at a sampling density of four samples per meter. Sixteen hundred data measurements were collected in a complete grid unit. The data and header files stored in the polycorder were downloaded into the laptop computer at the end of the survey. The survey of the grid unit began in the lower left hand or southwest corner of the grid. The EM38 was used in the quadrature or conductivity phase, the vertical dipole mode, and one orientation parallel to the direction of travel along the traverses. It provided an exploration depth of approximately 1.5 m with its effective depth around 0.6 m in the vertical dipole mode. The instrument was nulled and calibrated before the start of the survey at the same reference point that was used to balance and align the dual fluxgate gradiometer in Area A. A single grid unit, located at N40/E20 in Area A, was surveyed using the conductivity meter. The conductivity survey was also conducted at Area C. The conductivity surveys were conducted to provide complementary data in the two areas and to check on the possibility of using it on sites within PECO in the future.

The data were downloaded to a laptop computer at the end of the survey of the geophysical project area. The data were processed using the DAT38W software (Geonics 2002). After the transfer of the data and header files to the laptop computer, the files were automatically converted from the raw EM38 format to DAT38 format with the extension name of G38 (Geonics 2002:12-14). The data were then displayed as data profile lines (Geonics 2002:14-15). The individual EM38 data file was then converted to XYZ coordinate file in the Surfer data format. To create the XYZ file, the orientation or direction of the survey line was selected in the DAT38W program along with the data type and format (Geonics 2002:20-23). The resulting XYZ data file was transfer to the SURFER 10 mapping software (Golden Software 2011). The conductivity data were reviewed and an image plot was generated in SURFER 10.

To process the conductivity data further, it was transferred to GEOPLOT (Geoscan Research 2003). The conductivity data were stripped of the X and Y coordinates and then the Z values (measurements) were imported into GEOPLOT for further processing (Geoscan Research 2003:4/1-4/29). The resulting grid was formatted to form a composite file in GEOPLOT. A zero-mean traverse was then applied to remove any traverse discontinuities that may have occurred from operator handling or heading errors (Geoscan Research 2003:6/107-6/116). The interpolation routine was applied to the data set to arrange the data from the 4-x-1 data matrix to an equally spaced 4-x-4 square matrix (Geoscan Research 2003:6/53-6/56). A high-pass filter was then applied over the composite data set (Geoscan Research 2003:6/49-6/52). The high-pass filter was used to remove low frequency, large scale spatial detail such as a slowing changing geological 'background' trend. The data were then exported as an ASCII data file (Geoscan Research 2003: 5/4-5/7) and placed in the SURFER 10 mapping program (Golden Software 2011), then exported as an ASCII dat file and placed in the SURFER 10 mapping program. The conductivity data from Area A, before additional processing, ranged from -8.3 mS/m to 16.0 mS/m with a mean of 11.92 mS/m and a standard deviation of 1.713 mS/m. The image and contour plots of the conductivity data from Grid Unit N40/E20 in Area A were generated for the survey area in SURFER 10 (Figure 20). The conductivity data from Area C, before additional processing, ranged from 6.8 mS/m to 11.8 mS/m with a mean of 8.22 mS/m and a standard deviation of 0.657 mS/m. Image and contour plots of the conductivity data from Area C were also generated for the survey area in SURFER 10 (Figure 21).

DESCRIPTION OF GEOPHYSICAL INTERPRETATION OF CULTURAL RESOURCES LOCATED

Andrew David (1995:30) defines interpretation as a "holistic process and its outcome should represent the combined influence of several factors, being arrived at through consultation with others where necessary." Interpretation may be divided into two different types: the geophysical interpretation of the data and the archaeological interpretation of the data. At a simplistic level, geophysical interpretation involves the identification of the factors causing changes in the geophysical data. Archeological interpretation takes the geophysical results and tries to apply cultural attributes or causes. In both cases, interpretation requires both experience with the operation of geophysical equipment, data processing, and archeological methods; and knowledge of the geophysical techniques and properties, as well as known and expected archeology. Although there is variation between sites, several factors should be considered in the interpretation of the geophysical data. These may be divided between natural factors, such as geology, soil type, geomorphology, climate, surface conditions, topography, soil magnetic susceptibility, seasonality, and cultural factors, including known and inferred archeology, landscape history, survey methods, data treatment, modern interference, etc. (David 1995:30). It should also be pointed out that refinements in the geophysical interpretations are dependent on the feedback from subsequent archeological investigations. The use of multiple instrument surveys provides the archeologist with very different sources of data that may provide complementary information for comparison of the nature and cause (i.e., natural or cultural) of a geophysical anomaly (Clay 2001; Kvamme et al. 2006). Each instrument responds primarily to a single physical property: magnetometry to soil magnetism, electromagnetic induction to soil conductivity in the quadrature phase component and magnetic susceptibility in the in-phase component, resistivity to soil resistance, and ground-penetrating radar to dielectric properties of the soil (Weymouth 1986:371).

Interpretation of the magnetic data (Bevan 1998:24) from the project requires a description of the buried archeological feature or object (e.g., its material, shape, depth, size, and orientation). The magnetic anomaly represents a local disturbance in the earth's magnetic field caused by a local change in the magnetic contract between buried archeological features, objects, and the surrounding soil matrix. Local increases or decreases over a very broad uniform magnetic surface would exhibit locally positive or negative anomalies (Breiner 1973:17). Magnetic anomalies tend to be highly variable in shape and amplitude. They are generally asymmetrical in nature due to the combined effects from several sources. To complicate matters further, a given anomaly may be produced from an infinite number of possible sources. Depth between the magnetometer and the magnetic source material also affect the shape of the apparent anomaly (Breiner 1973:18). As the distance between the magnetic sensor on the magnetometer and the source material increases, the expression of the anomaly becomes broader. Anomaly shape and amplitude are also affected by the relative amounts of permanent and induced magnetization, the direction of the magnetic field, and the amount of magnetic minerals (e.g., magnetite) present in the source compared to the adjacent soil matrix. The shape (e.g., narrow or broad) and orientation of the source material also affects the anomaly signature. Anomalies are often identified in terms of various arrays of dipoles or monopoles (Breiner 1973:18-19). A magnetic object is made of magnetic poles (North or positive and South or negative). A simple dipole anomaly contains the pair of opposite poles that are relatively close together. A monopole anomaly is simply one end of a dipole anomaly and may be either positive or negative depending on the orientation of the object. The other end is too far away to have an effect on the magnetic field. Complex magnetic anomalies are combinations of dipoles and/or monopoles. In addition to the physical properties of the geophysical anomalies (shape size, strength, etc.), pattern recognition is an important component in the interpretation and potential identification of archeological features. The grouping of anomalies in circular, square, rectangular, or linear patterns may suggest the location of buried building foundations, wells, cellars, privies, room blocks, kivas, pit houses, stone circles or teepee rings, fence lines, utility lines, roads, earthworks, mounds, and other cultural features.

Magnetic anomalies of archeological objects tend to be approximately circular in contour outline. The circular contours are caused by the small size of the objects. The shape of the object is seldom revealed in the contoured data. The depth of the archaeological object can be estimated by half-width rule procedure (Bevan 1998:23-24; Breiner 1973:31; Milsom 2003:67-70). The approximations are based on a model of a steel sphere with a mass of 1 kg buried at a depth of 1.0 m below the surface with the magnetic measurements made at an elevation of 0.3 m above the ground. The depth of a magnetic object is determined by the location of the contour value at half the distance between the peak positive value of the anomaly and the background value. With the fluxgate gradiometer, the contour value is half the peak value since the background value is approximately zero. The diameter of this contour (Bevan 1998:Fig. B26) is measured and used in the depth formula where **depth = diameter – 0.3 m** (Note: The constant of 0.3 m is the height of the bottom fluxgate sensor above the ground in the Geoscan Research FM36 where I carry the instrument during data acquisition. This value needs to be adjusted for each individual that carries the instrument.). The mass in kilograms of the object (Bevan 1998:24, Fig. B26) is estimated by the following formula: **mass = (peak value - background value) * (diameter)3/60**. It is likely that the depth and mass estimates are too large rather than too small, since they are based on a compact spherical object made of iron. Archeological features are seldom compact but spread out in a line or lens. Both mass and depth estimates will be too large. The archaeological material may be composed of something other than iron, such as fired earth or volcanic rock. Such materials are not usually distinguishable in the magnetic data collected during a survey (Bevan 1998:24). The depth and mass of features composed of fired earth, like that found in kilns, fireplaces, or furnaces could be off by 100 times the mass of iron. If the archeological feature were composed of bricks (e.g., brick wall, foundation, or chimney), estimates could be off by more than a 1,000 times that of iron. The location of the center of the object can also be determined by drawing a line connecting the peak positive and peak negative values. The rule of thumb is that the center of the object is located approximately one-third to one-half of the way along the line from the peak positive value for the anomaly. One should also be cautious of geophysical anomalies that extend in the direction of the traverses since these may represent operator-induced errors. The magnetic gradient anomalies may be classified as three different types: linear, dipole, and monopole.

Analyses of the geophysical data from the four PECO geophysical project areas indicate the presence of numerous magnetic anomalies. Complementary data from the limited complementary conductivity surveys provide additional data on the nature or source of the geophysical anomalies. The geophysical anomalies appear to be associated with the Native American occupation of the Pecos Pueblo, the Spanish occupation of the Mission and Convento, historic Apache campsites, and the Santa Fe Trail along with historic ranching activities, historic State park activities, and modern National Park Service operations.

Area A contains numerous individual dipole and monopole anomalies along with several clusters of magnetic anomalies across the grid area (Figure 22). Two linear magnetic anomalies in the southwestern section of Area A appear to represent roads/trails to the mission site. They are also represented as swales on the landscape. These may be associated with the Santa Fe Trail or with park visitor access for parking and/or stabilization activities at the mission ruins. A series of strong dipole anomalies extend across the center of the grid in a northerly direction. It is possible that they represent fence post locations or other archeological features. One anomaly located near N55/E30 may be a fire-related feature such as a fire hearth. Several clusters of magnetic anomalies appear square or rectangular in shape. The anomaly outlines are represented by clusters of dipoles or monopoles along with relatively strong linear anomalies adjacent to weaker anomalies. It is possible that these clusters represent rectangular Puebloan room blocks or square Spanish houses (Charles Haecker, personal communication 2012). It is also possible that the four identified rectangular/square areas in the northeastern part of the geophysical project area may be excavation units from the 1970 excavations east of the Mission Church (Gunnerson 1970). The excavation uncovered the remains of a burned structure in association with Puebloan and Apache pottery (Eininger 2002:31).

The magnetic data from Area B contains one relatively strong dipole anomaly (Figure 23). It ranges from approximately -10 to 10 nT/m. It is probably a ferrous metal object. The area is relatively quiet with a range of -3 to 3 nT/m.

Area C contains the possible Apache stone circle (Figure 24). In the area of the exposed rocks in the southwestern part of the grid, there are several relatively weak dipole anomalies ranging between -5 and 8 nT/m. These anomalies appear to be associated with the rocks. Three relatively strong or strong dipoles have ranges of -15 to 10 nT/m, -43 to 8 nT/m, and -47 to 45 nT/m. The two stronger dipoles may represent ferrous metal objects, rocks, or fired adobe brick fragments. The two strongest anomalies may be the wire from pin flags. Pin flags are made from high tensile steel with a very strong magnetic field. The magnetic field associated with a pin flag can obscure an area from 1 m to 5 m in diameter.

Area D contains a swale associated with the Santa Fe trail in the southwestern corner of the grid (Figure 25). The outside edges of the swale are represented by relatively weak positive linear anomalies. In the southwest corner of the grid, a linear magnetic anomaly with alternating strong positive and weak negative values represents a buried utility line or buried wire. The alternating strong positive and weak negative bead like magnetic anomaly represents the cooling of the ferrous wire or pipe and the formation of connected bar magnets (North/ positive – S/negative) in the earth's magnetic field during its manufacture.

Interpretation of the conductivity data results in the identification of lateral changes in the soil matrix. The conductivity data may be divided into three classes of anomalies including linear anomalies, point anomalies, and broad anomalous areas. Linear anomalies may represent foundations of buildings, trenches, buried utility lines, paths, trails, or roads that are longer than they are wide. Point anomalies tend to represent buried objects or vertical structures such as cisterns, wells, or storage pits. Occasionally, these anomalies may have negative values resulting from the saturation of the receiving coil by the overwhelming conductive metal response of buried metals to the generated electromagnetic field. Comparisons between these negative conductivity anomalies and the magnetic anomalies can elucidate the nature of the buried object. If the magnetic and conductivity point anomalies coincide, it is assumed that the buried object is made from ferrous material. The presence of a magnetic anomaly and the lack of a corresponding conductivity anomaly suggest that the magnetic anomaly is composed of non-metallic material such as fired clay typically found in fire-related features (i.e., fire hearths or pits, concentrated areas of ceramics, or bricks). The presence of a negative conductivity anomaly and the absence of a corresponding magnetic anomaly strongly suggest that the buried object is some type of non-ferrous metal (e.g., brass, copper, lead, etc.). Broad anomalous areas typically represent large areas of soil disturbances or compaction often found associated with gardens, basements or cellars, parking pads, compacted dirt floors, or areas of concrete or asphalt.

The conductivity data from Grid Unit 8 located at N40/E20 in Area A contains five conductivity anomalies (Figure 26). Four conductivity anomalies have the metal signature where the receiving coil has been overwhelmed by the eddy signal. A fifth conductivity anomaly near N47/E28 appears similar to a dipole with a strong and weak side. Comparing the magnetic and conductivity data from Grid Unit N40/E20, the four conductivity anomalies appear to be associated with four magnetic dipole anomalies in the same locations (Figure 27). It is highly probable that both types of anomalies are associated with ferrous metal objects. One conductivity anomaly does not appear to have a corresponding magnetic anomaly, which suggests that the source of the anomaly is non-ferrous metal. Four magnetic anomalies do not have corresponding conductivity anomalies suggesting that the sources for these anomalies are fire-related features, such as fire hearths, ovens, or burned adobe bricks, or soil disturbances such as post holes or refuse/cache pits.

A different way of looking at the geophysical data collected during the investigations of the geophysical project area is to combine the complementary data sets into one display. Several of the different geophysical anomalies overlap, suggesting a strong correlation between the geophysical data and the buried archeological features (Ambrose 2005; Kvamme 2007:345-374). These areas of overlap would be considered areas of high probability for ground-truthing and the investigations of buried archeological resources. While these correlations are important, individual isolated occurrences also need ground-truthing in order to determine their unique nature, as well. Complementary data (Clay 2001) from the conductivity and associated magnetic survey area at Area A (Figure 28) indicate the locations of foundation remnants, ferrous and non-ferrous metal objects, fire-related features, and possible refuse and/or cache pits. The combined conductivity and magnetic data from Area C indicate a possible Apache stone circle and more recent ferrous objects related to the archeological investigations at the site and park activities.

NATIONAL REGISTER EVALUATION OF CULTURALRESOURCES LOCATED

The geophysical survey of the four PECO 2012 geophysical project areas was conducted as part of the National Park Service's archeological investigations of the Trade Fair Locality within Pecos National Historical Park (Haecker 2012a). The MWAC staff provided technical support for the geophysical investigations of the four geophysical project areas with volunteers from the University of Nebraska-Lincoln archeological field school. The geophysical inventory of the four geophysical project areas consisted of a dual fluxgate gradiometer survey of all four areas and limited conductivity surveys of Grid Unit N40/E20 in Area A and the partial grid unit in Area C. The total area investigated at the geophysical project area consisted of 8,876 m2 or 2.19 ac. The surveys resulted in the identification of numerous subsurface anomalies. The magnetic and conductivity data collected at the four Trade Fair geophysical project areas provided information on the physical properties (magnetic and soil conductivity properties) of the subsurface materials. Standard methods for conducting geophysical investigations were used with standard 20-m-by-20-m grid sizes where it was feasible. The geophysical survey of the site resulted in the identification of numerous subsurface anomalies associated with the historic Pecos Pueblo occupation, the historic Spanish occupation connected with the Mission and Convento, the historic Apache use of the area, the commerce along the historic Santa Fe trail, and modern National Park Service activities.

This report has provided a review and analysis of the geophysical data collected during the geophysical investigations of four PECO geophysical project areas. The use of geophysical survey techniques at PECO indicates the usefulness in collecting basic background geophysical data concerning the nature and extent of the buried archeological resources. Based on the information provided by the geophysical survey methods, it is apparent that the geophysical data set yielded useful information for the determination of the integrity and significance of the buried archeological resources associated with the historic Native American, historic Spanish, and historic American periods, as well as the National Park Service use of the project areas. While the magnetic and conductivity surveys results provided data on the nature of the buried archeological resources, ground-truthing through archeological excavation will provide definitive information on the nature of these geophysical anomalies.

Finally, refinement of the geophysical interpretation of the survey data is dependent on the feedback of the archeological investigations following geophysical survey (David 1995:30). Should additional archeological investigations occur at the four PECO geophysical project areas investigated during this project, the project archeologist is encouraged to share additional survey and excavation data with the geophysical investigator for incorporation into the investigator's accumulated experiences with archeological problems. Throughout the entire geophysical and archeological investigations, communication between the geophysicist and the archeologist is essential for successful completion of the archeological investigations. It is also important for the investigators to disseminate the results of the geophysical survey and archeological investigations to the general public. It is through their support in funds and labor that the National Park Service will continue to make contributions to the application of geophysical techniques to the field of archeology.

National Register Recommendations with Justifications for Eligible, Not Eligible, Need More Information from Testing, Etc

The geophysical survey of four PECO 2012 geophysical project areas yielded baseline data for the evaluation of the archeological deposits and modern activities. Areas A, C, and D have the potential to yield information on the Native American, Spanish, and American use of the Trade Fair area under Criterion D of the National Register of Historic Places. The three geophysical project areas have the potential to answer research questions related to chronology, subsistence, environmental change, regional interaction and trade, and technological change (Orcutt and Head 2002:421-433). The geophysical investigations have provided potential information on the integrity of the buried archeological resources at Area A, B. C, and D.

Site Integrity and Conservation/Stabilization/Avoidance Recommendations

The geophysical project areas contain archeological remains associated with occupation of the historic Pecos Pueblo, the Spanish missionary use of the area, and 19th- and 20th-century American activities, as well as more recent National Park Service stabilization activities. The resulting archeological integrity of buried archeological resources is good and the historic features represent significant resources associated with local, regional, and national historic contexts. Additional archeological investigations are needed to ground-truth the geophysical anomalies to determine their shape, nature, extent, and chronological placement.

EFFECTS OF PROJECT ON RESOURCES

The application of geophysical survey techniques at the PECO Trade Fair Locality indicates the usefulness in collecting basic background geophysical data concerning the nature and extent of the buried archeological resources. These techniques should be applied to future archeological investigations conducted by the Pecos National Historical Park archaeological staff at other archeological sites within the national park unit. Based on the information provided by the geophysical survey methods, it is apparent that the geophysical data set yielded useful information for the determination of the integrity and significance of the buried archeological resources associated with the use of the site during the Native American, Spanish, and American historic occupation of the Trade Fair Locality. This information will be used by the Midwest Archeological Center, the Pecos National Historical Park, and the Intermountain Regional Office's Heritage Partnership Program staffs to guide further archeological inquiry into the nature of the archeological resources of the Trade Fair Locality at PECO and help direct future National Park Service geophysical surveys and archeological excavations at other archeological sites across the Nation.

LOCATION OF ARTIFACTUAL MATERIALS AND RECORDS FROM THE WORK

No artifacts were collected during the geophysical investigations of the four project areas. The geophysical data and associated documentation are part of the PECO accession number 641. The materials are also temporarily curated under MWAC accession number 1514 until the entire collection is returned to PECO.

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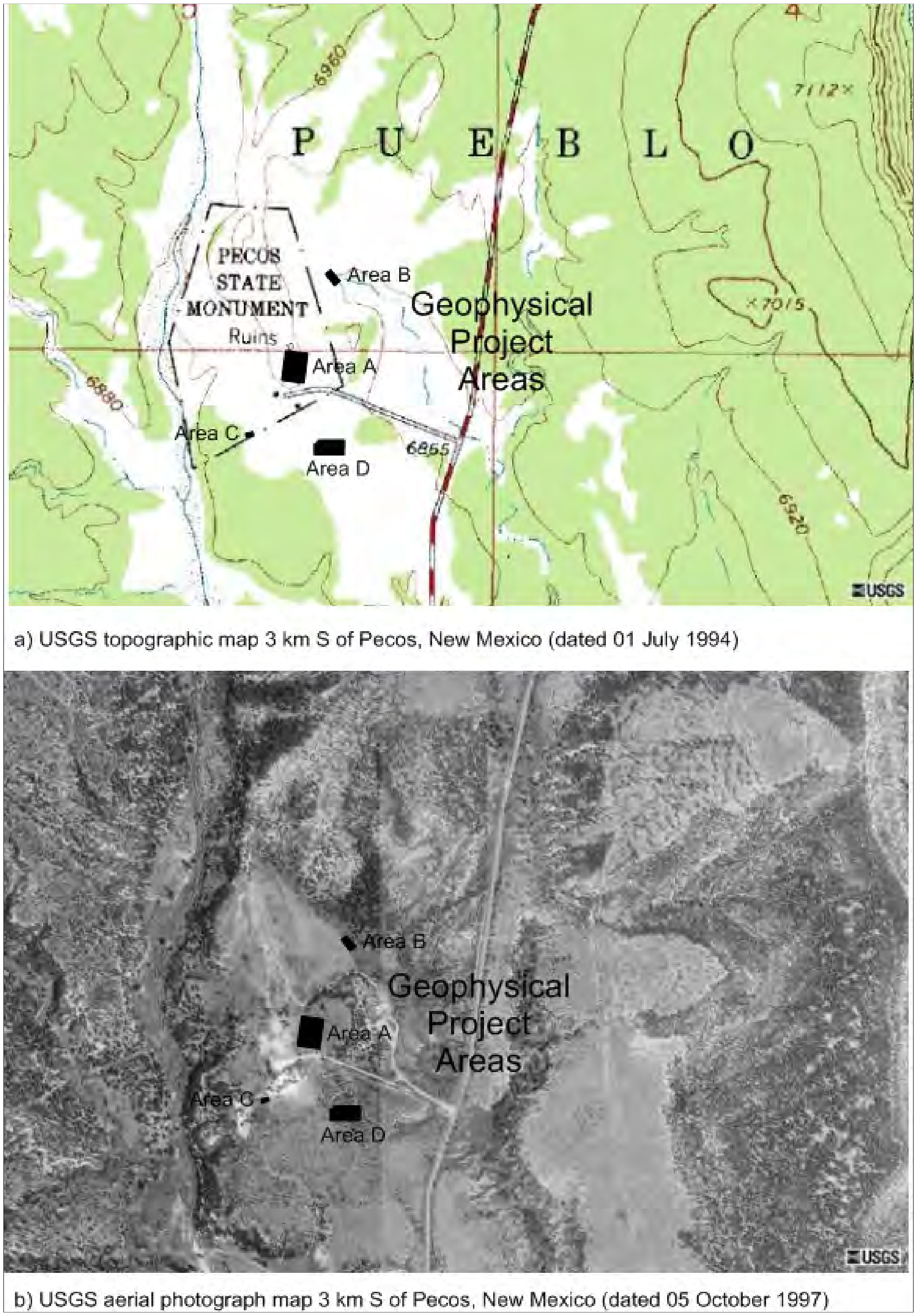
FIGURES



a) USGS topographic map 3 km S of Pecos, New Mexico (dated 01 July 1994)

b) USGS aerial photograph map 3 km S of Pecos, New Mexico (dated 05 October 1997)

Figure 1. Location of the geophysical project areas within Pecos National Historical Park, San Miguel County, New Mexico.

Figure 2. General view of the Area A (view to the north northwest).

Figure 3. General view of Area B (view to the north).

Figure 4. General view of Area C (view to the northeast).

Figure 5. General view of Area D (view to the north northwest).

Figure 6. Laying out Area A with a surveying compass and 100-m tape (view to the northwest).

Figure 7. Collecting grid coordinate locational data with GPS unit and external antenna (view to the south southwest).

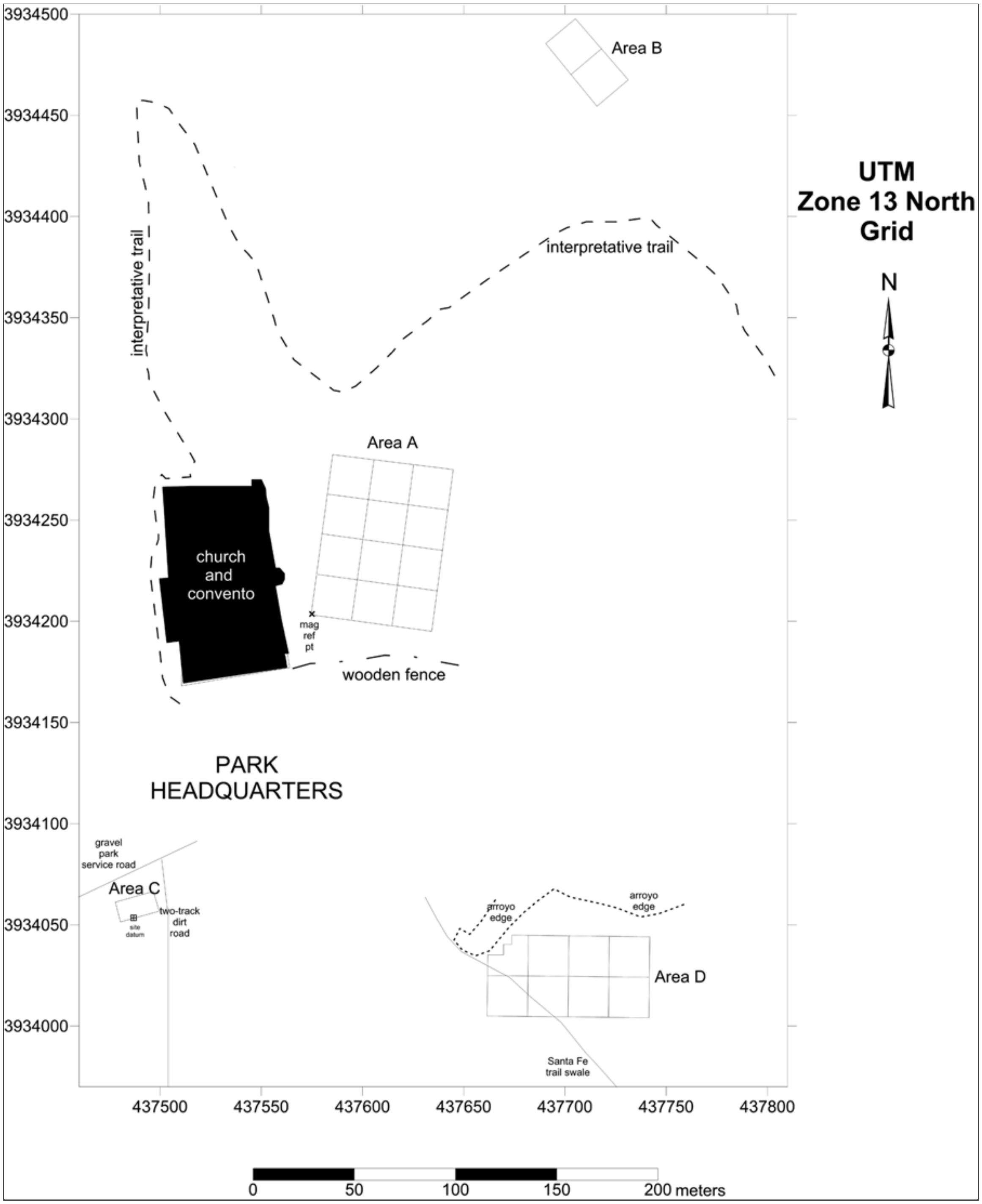


Figure 8. UTM grid of the PECO geophysical project areas.

Figure 9. Laying out the geophysical survey ropes (view to the northeast).

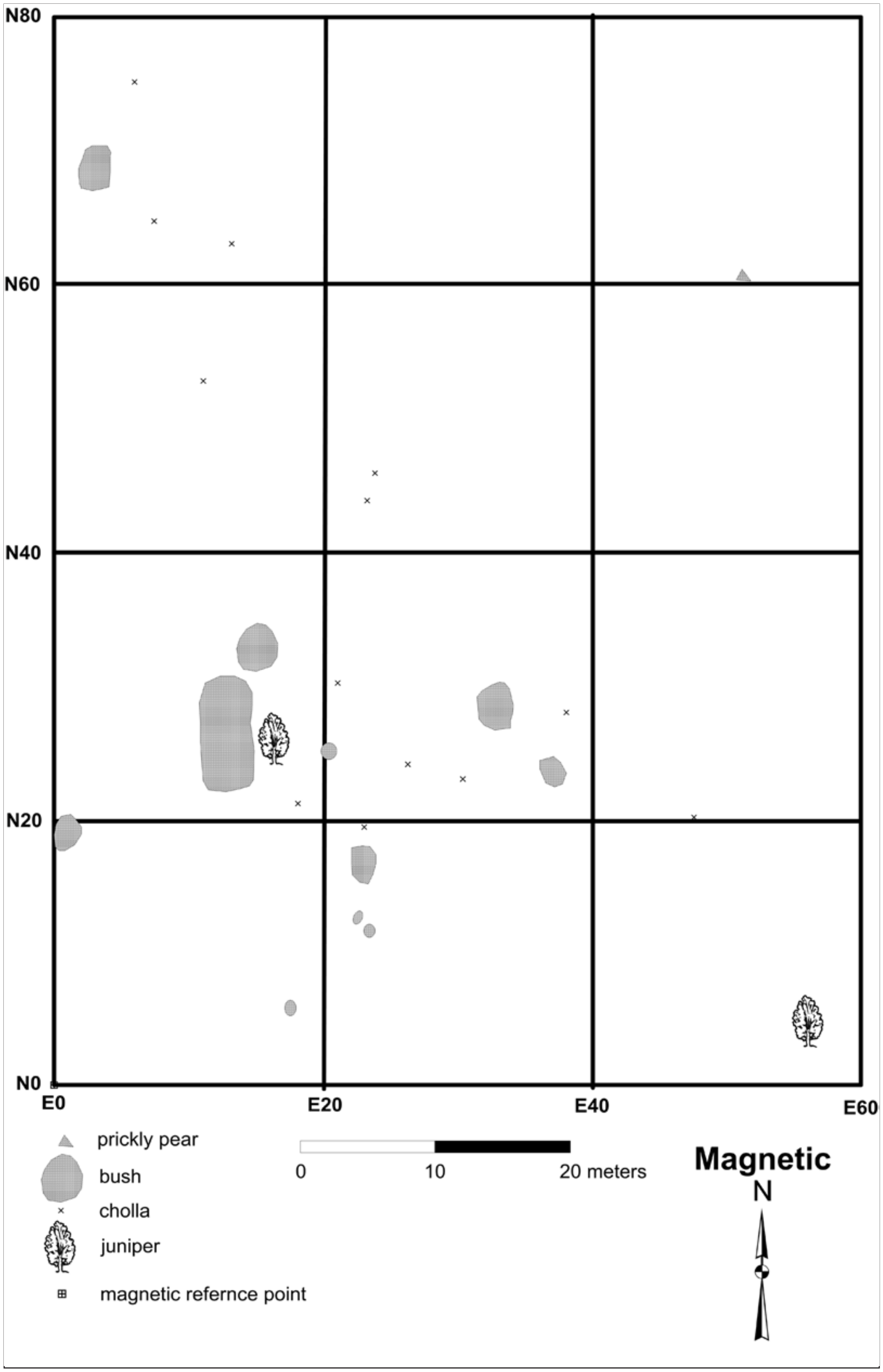


Figure 10. Sketch map of Area A.

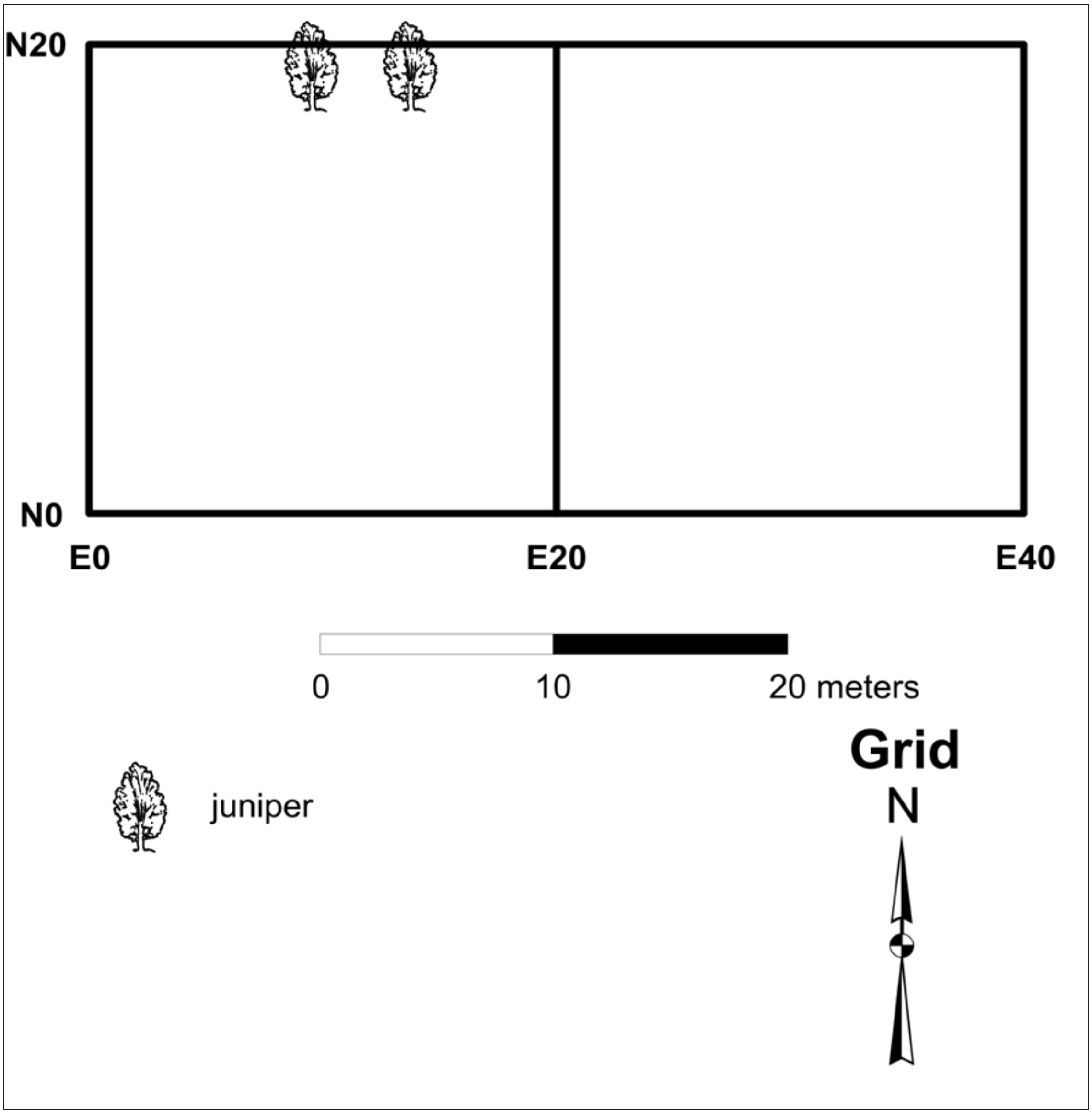


Figure 11. Sketch map of Area B.

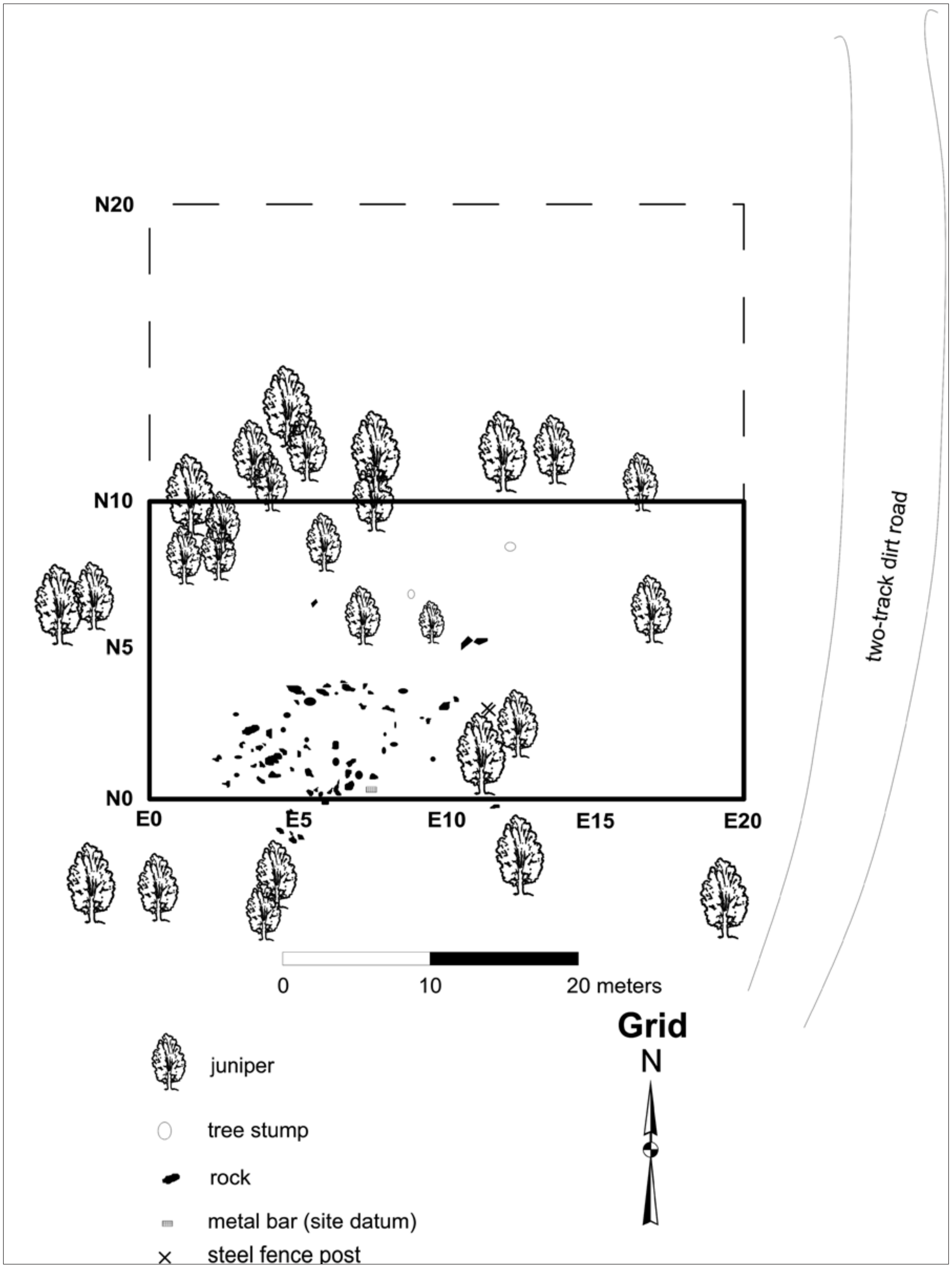


Figure 12. Sketch map of Area C.

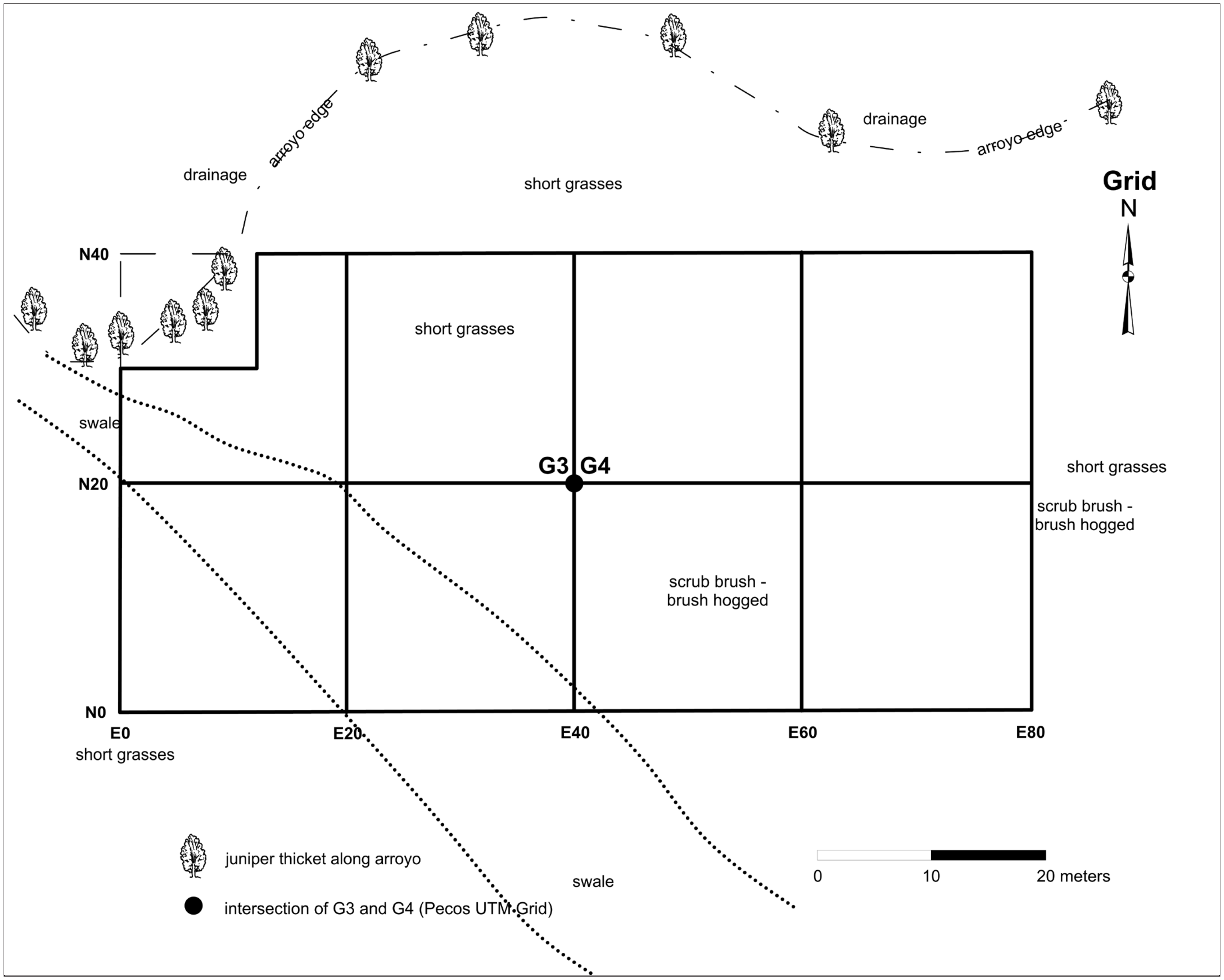


Figure 13. Sketch map of Area D.

Figure 14. Conducting the magnetic survey with the dual fluxgate gradiometer (view to the west southwest).

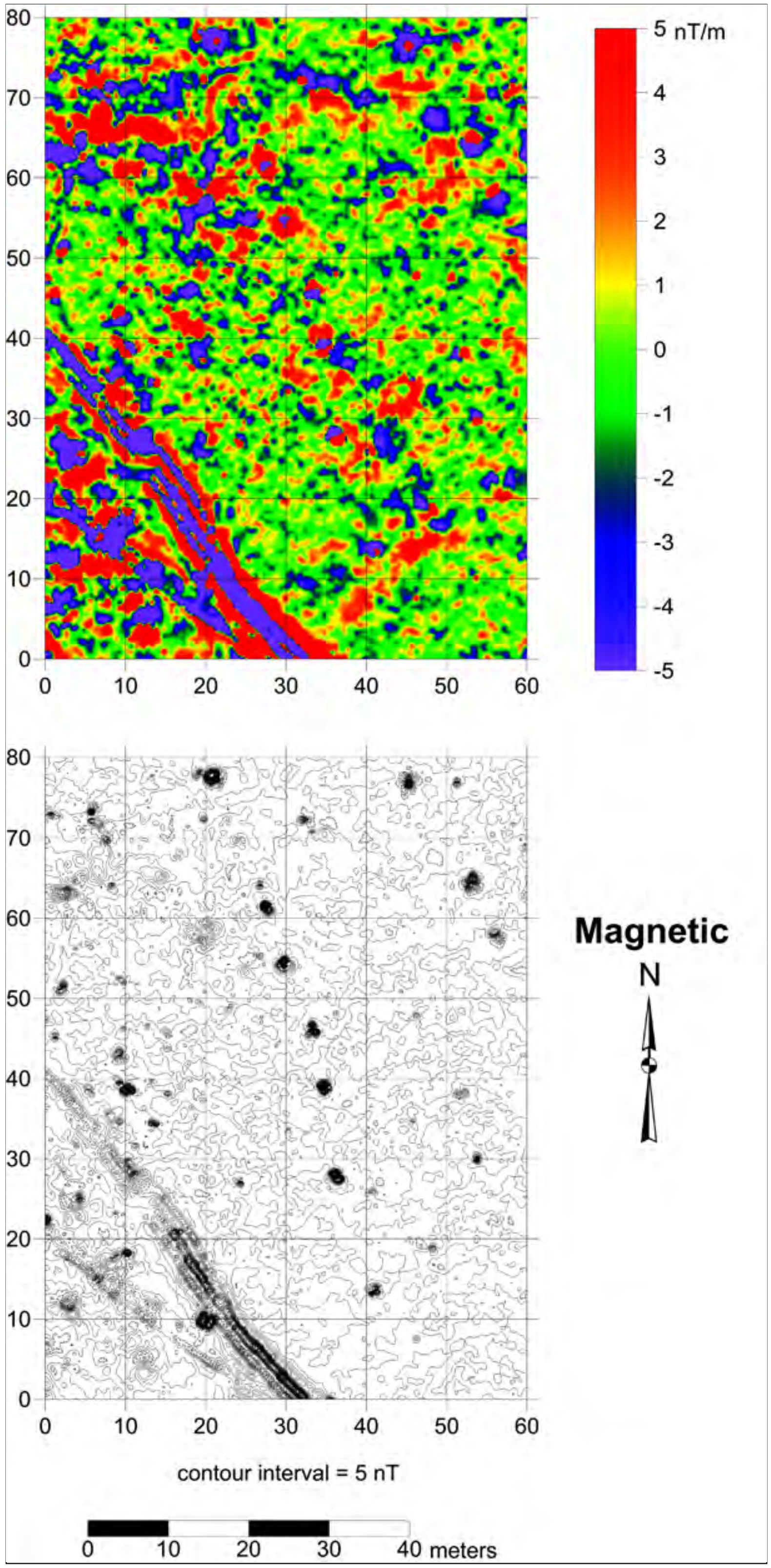


Figure 15. Image and contour plots of the magnetic data from Area A.

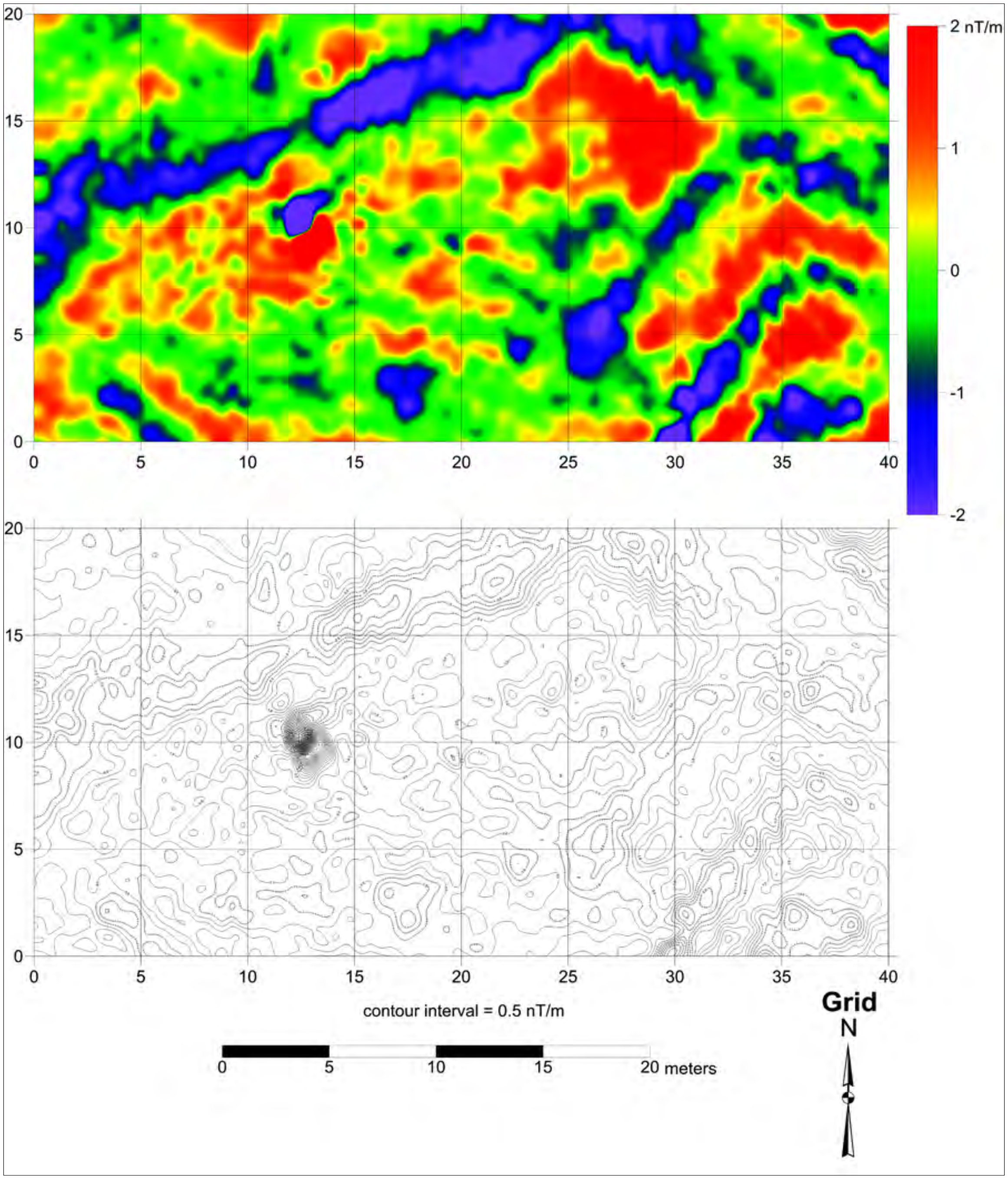


Figure 16. Image and contour plots of the magnetic data from Area B.

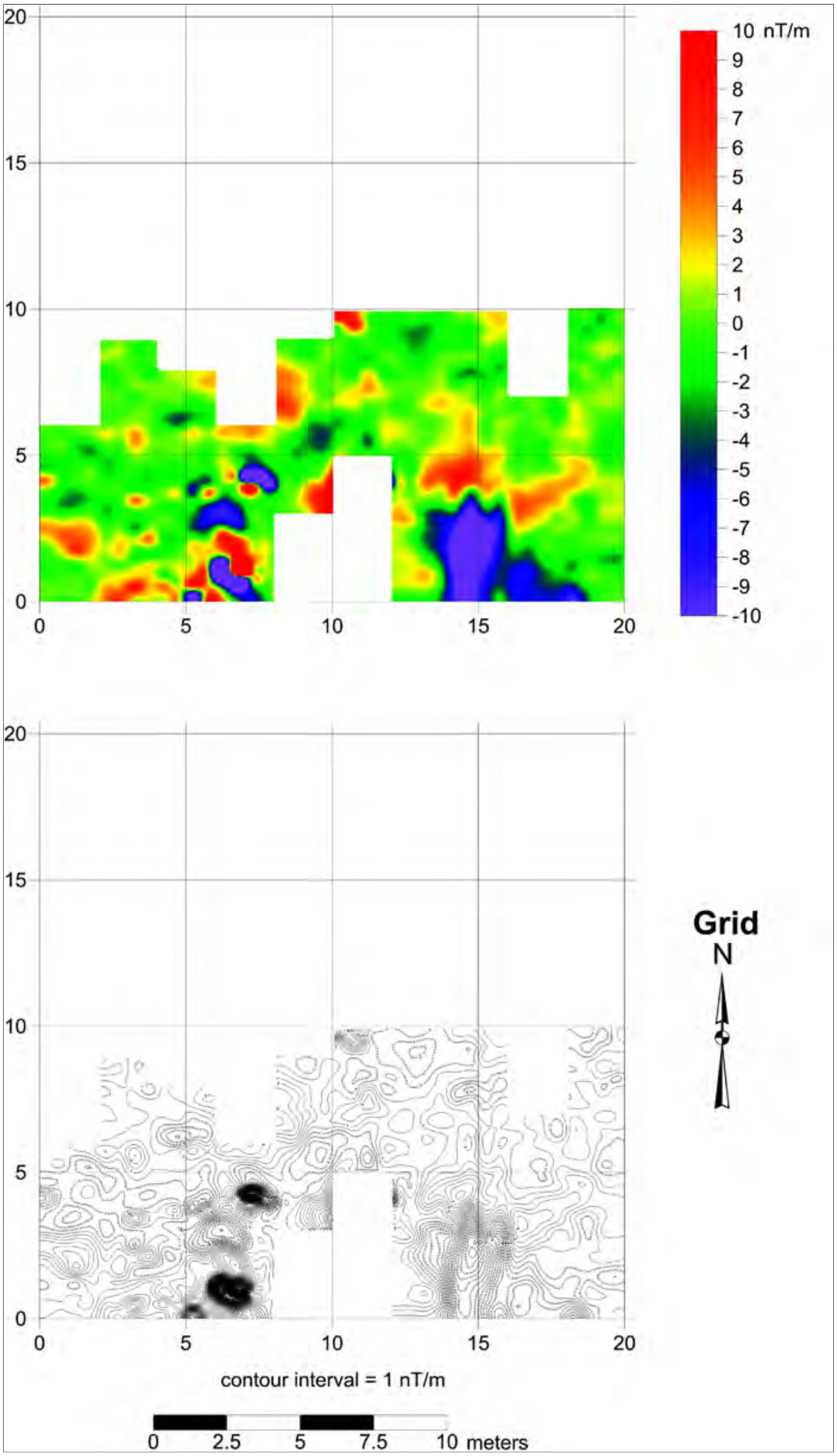


Figure 17. Image and contour plots of the magnetic data from Area C.

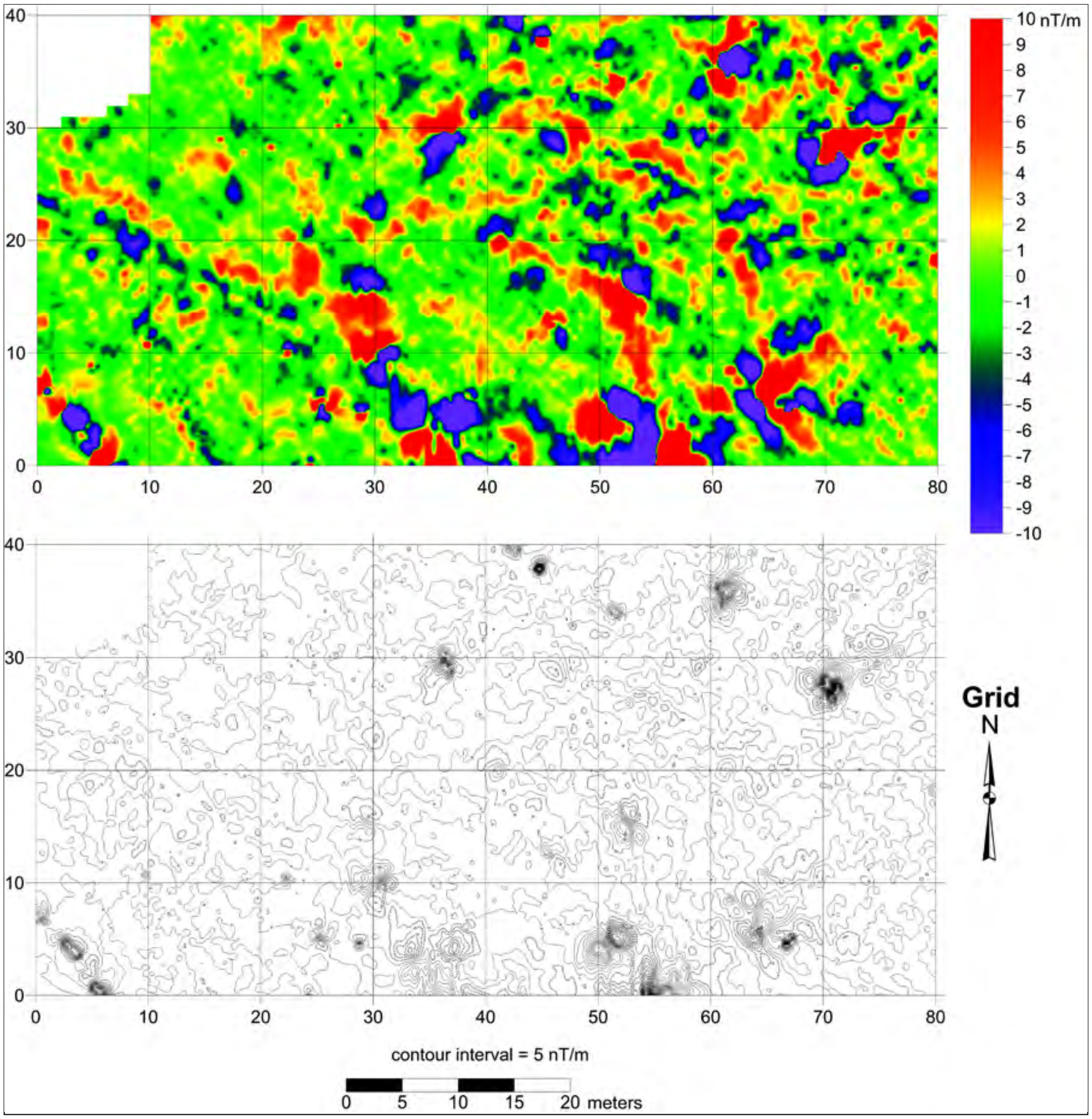


Figure 18. Image and contour plots of the magnetic data from Area D.

Figure 19. Demonstrating the use of the electromagnetic induction meter for conductivity surveying (view to the north).

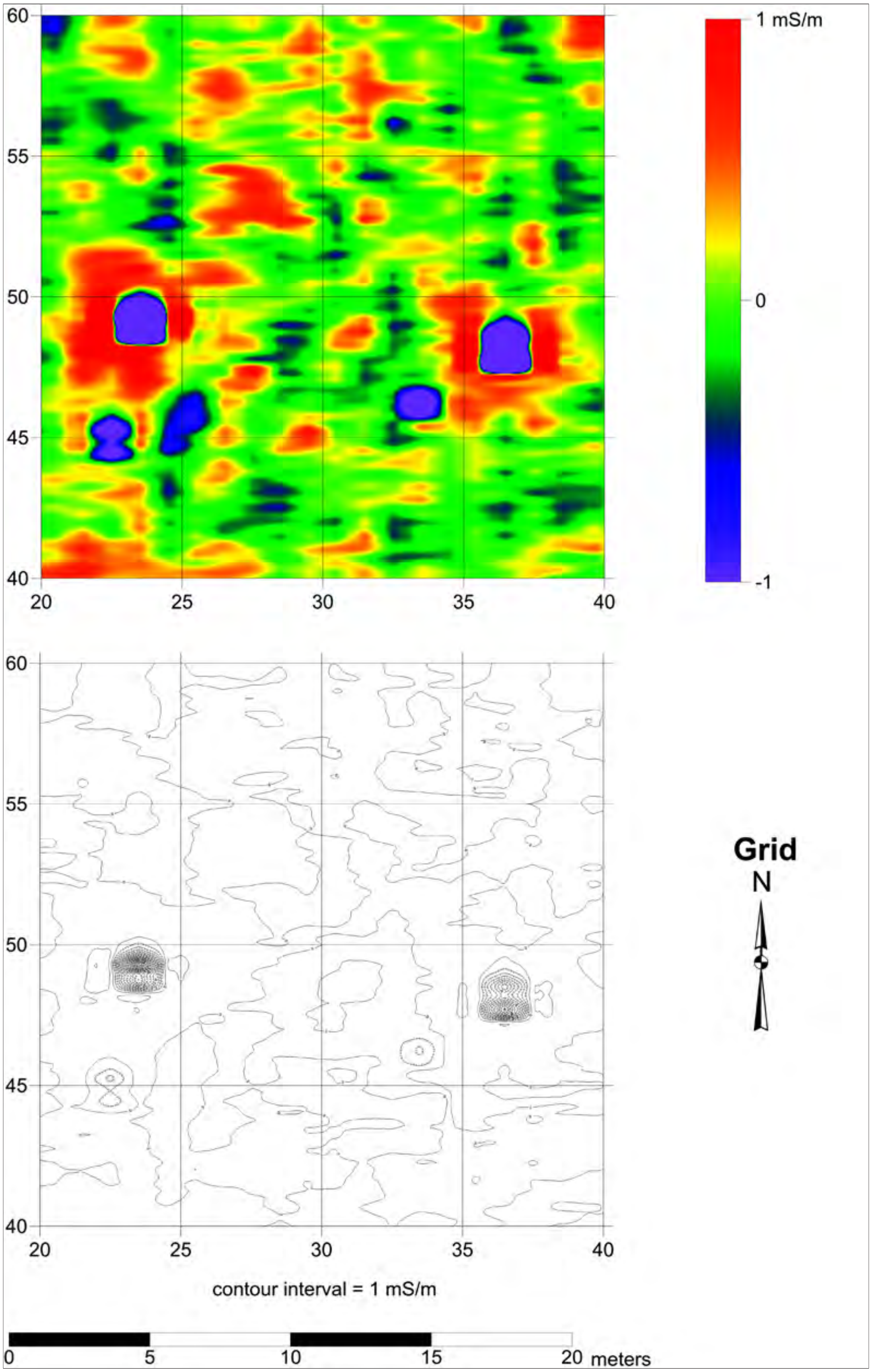


Figure 20. Image and contour plots of the conductivity data from Grid Unit N40/E20 in Area A.

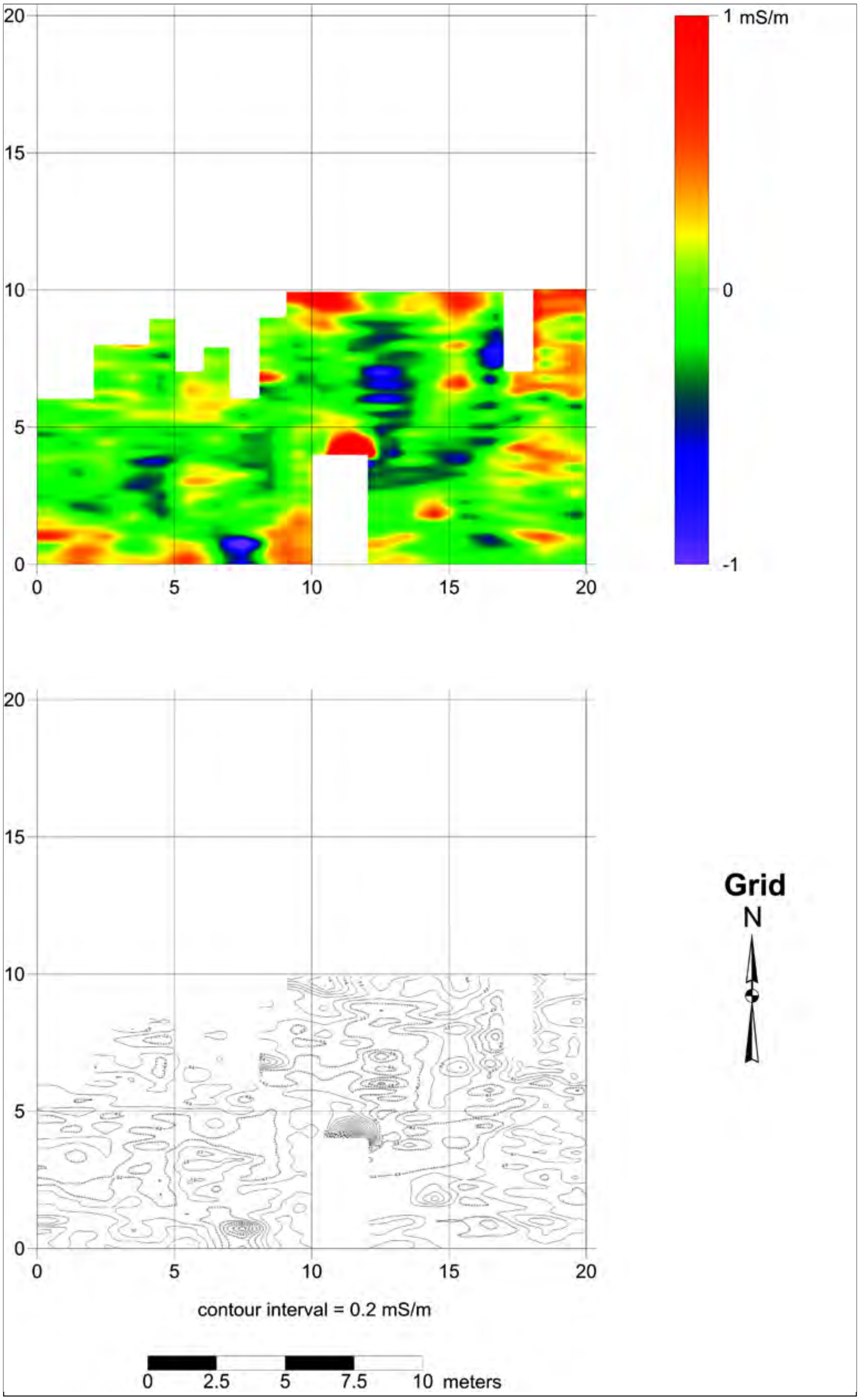


Figure 21. Image and contour plots of the conductivity data from Area C.

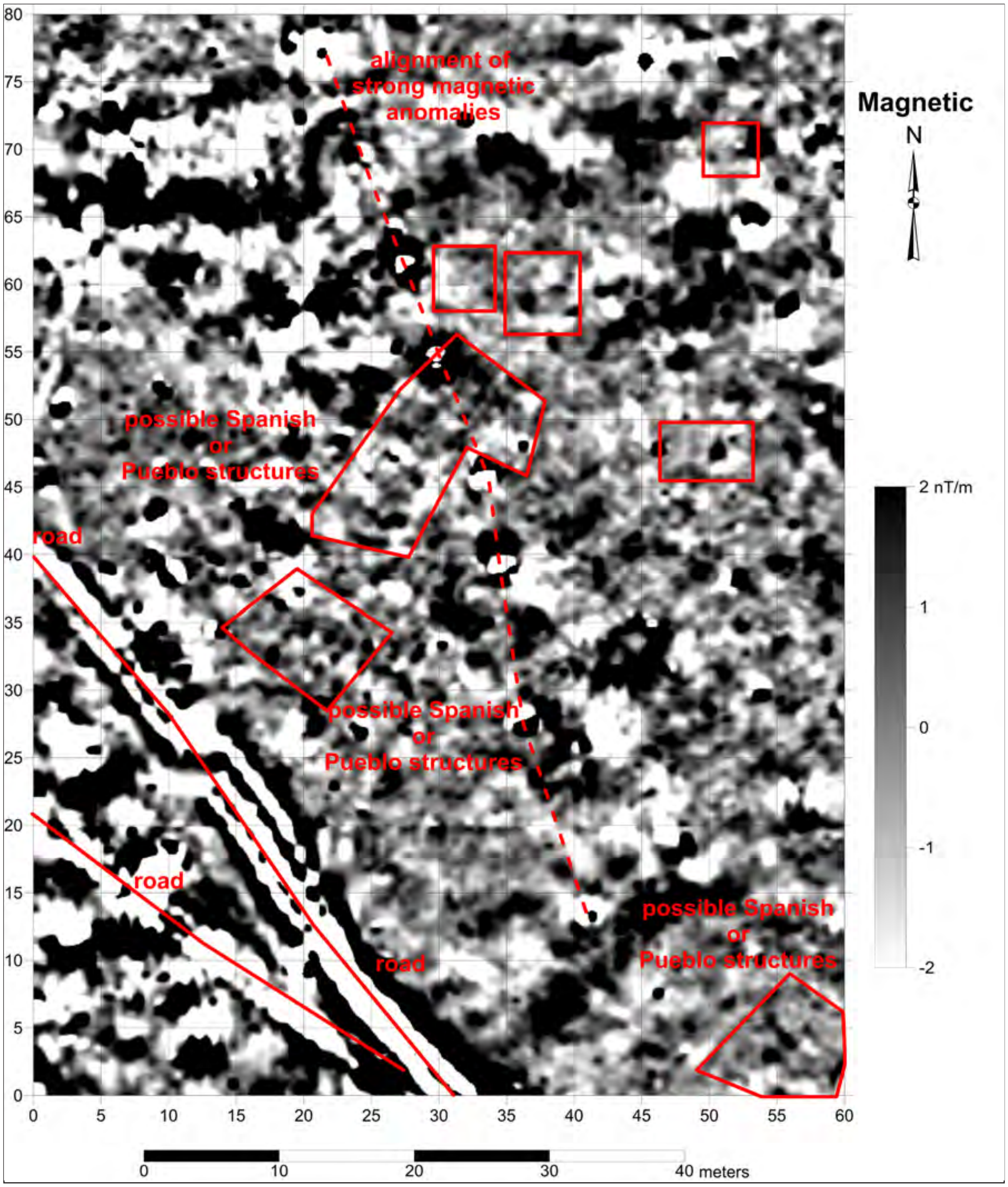


Figure 22. Interpretation of the magnetic data from Area A.

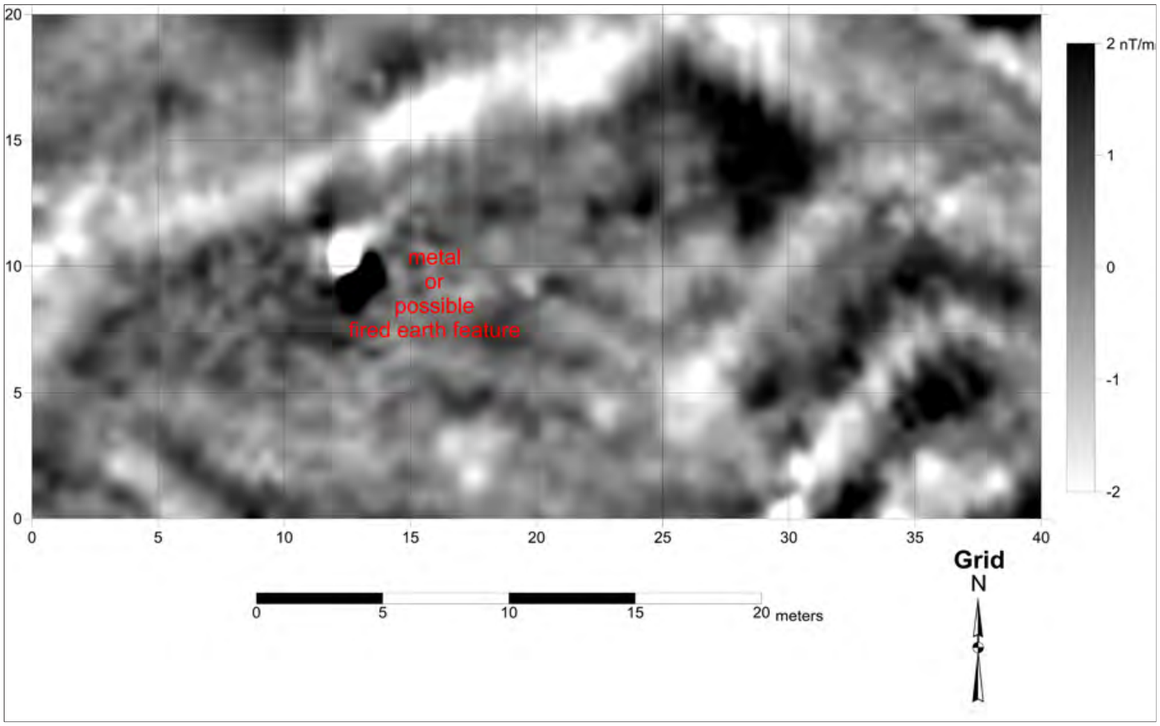


Figure 23. Interpretation of the magnetic data from Area B.

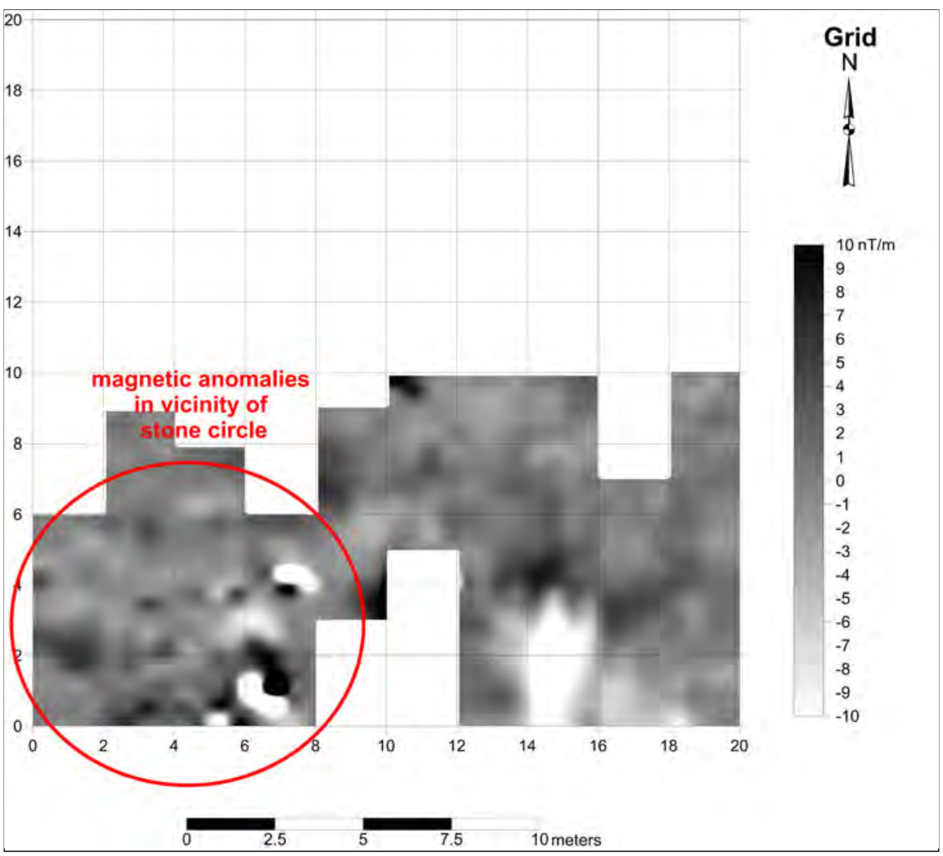


Figure 24. Interpretation of the magnetic data from Area C.

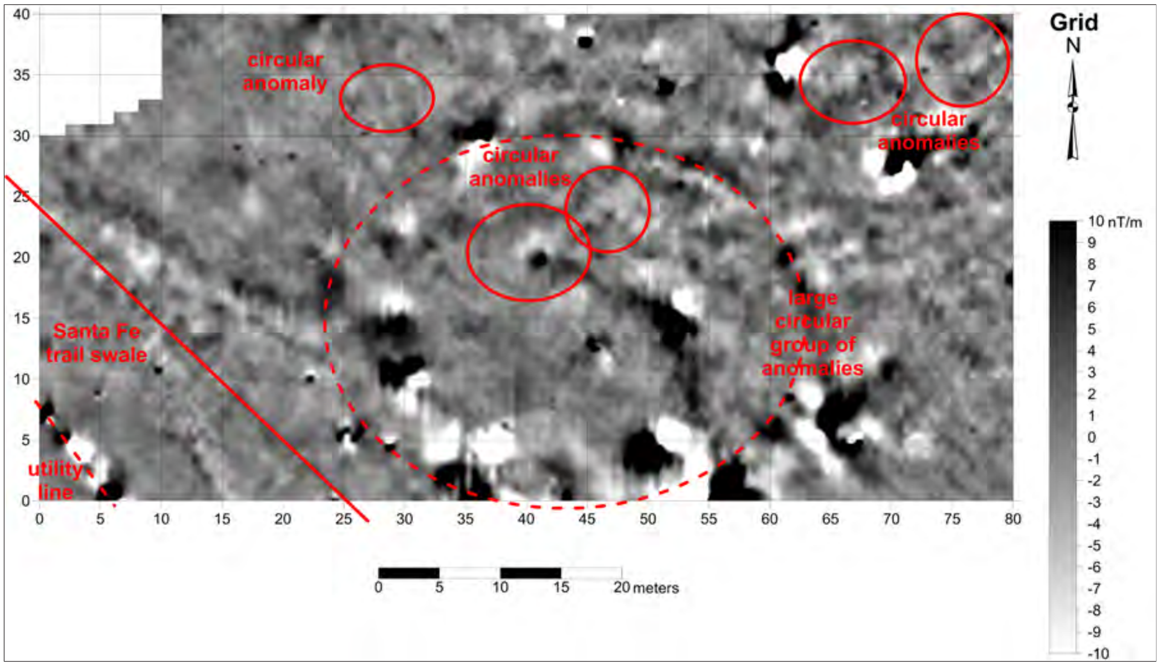


Figure 25. Interpretation of the magnetic data from Area D.

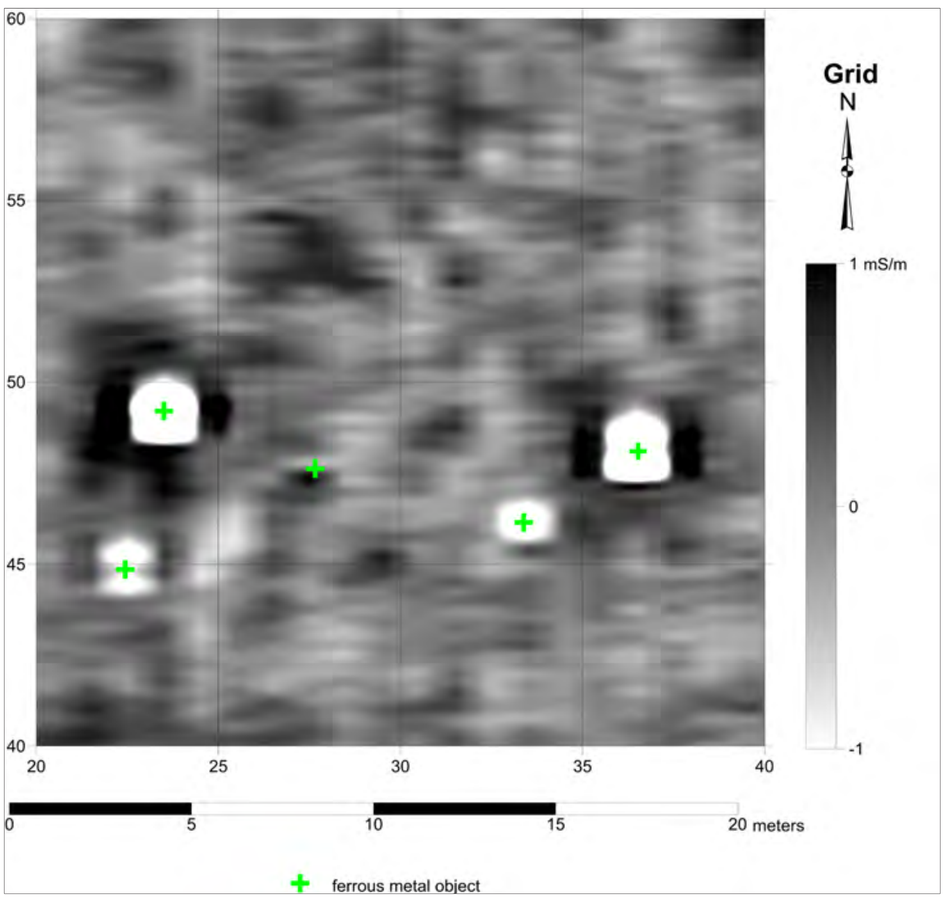


Figure 26. Interpretation of conductivity data from Grid Unit N40/E20 in Area A.

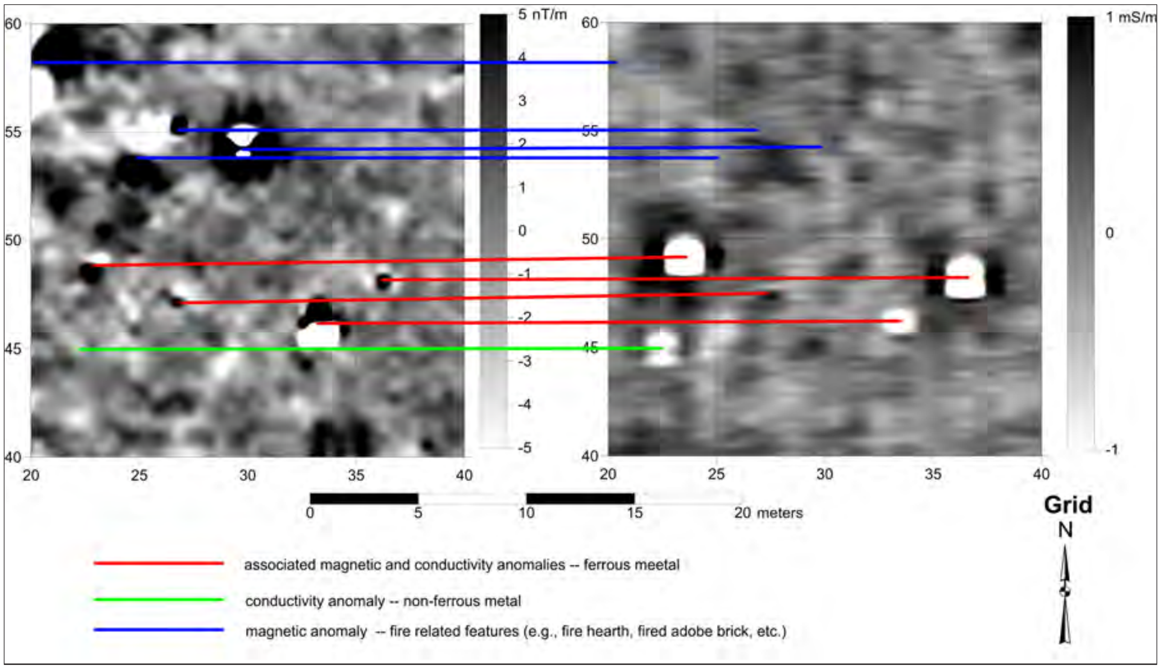


Figure 27. Comparison of magnetic and conductivity data from Grid Unit N40/E20 in Area A.

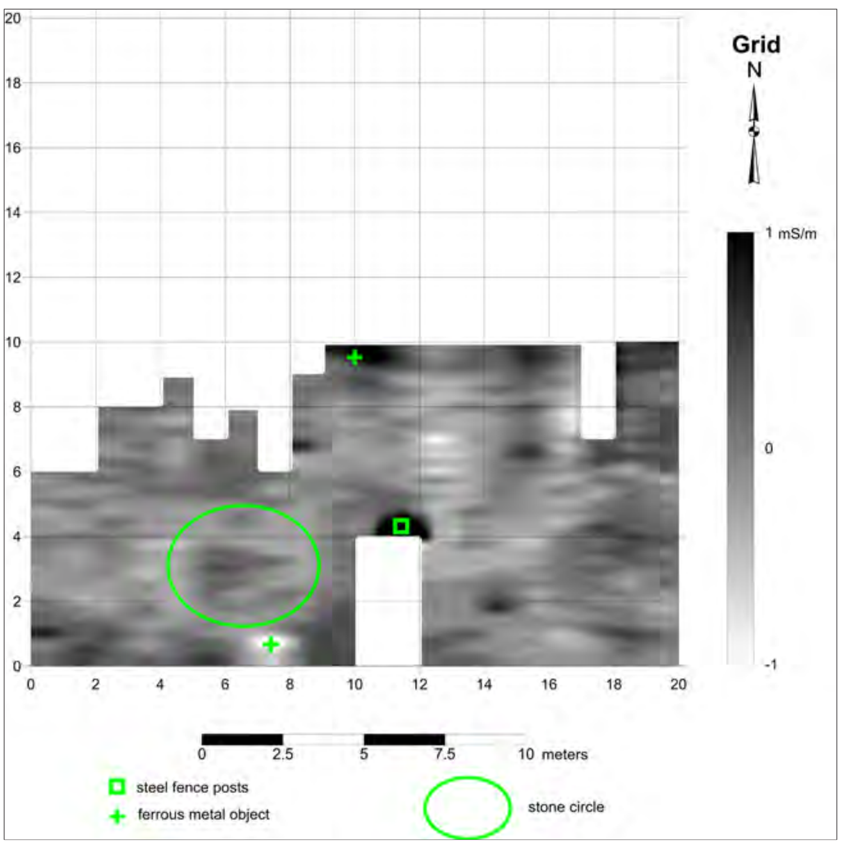


Figure 28. Interpretation of conductivity data from Area C.

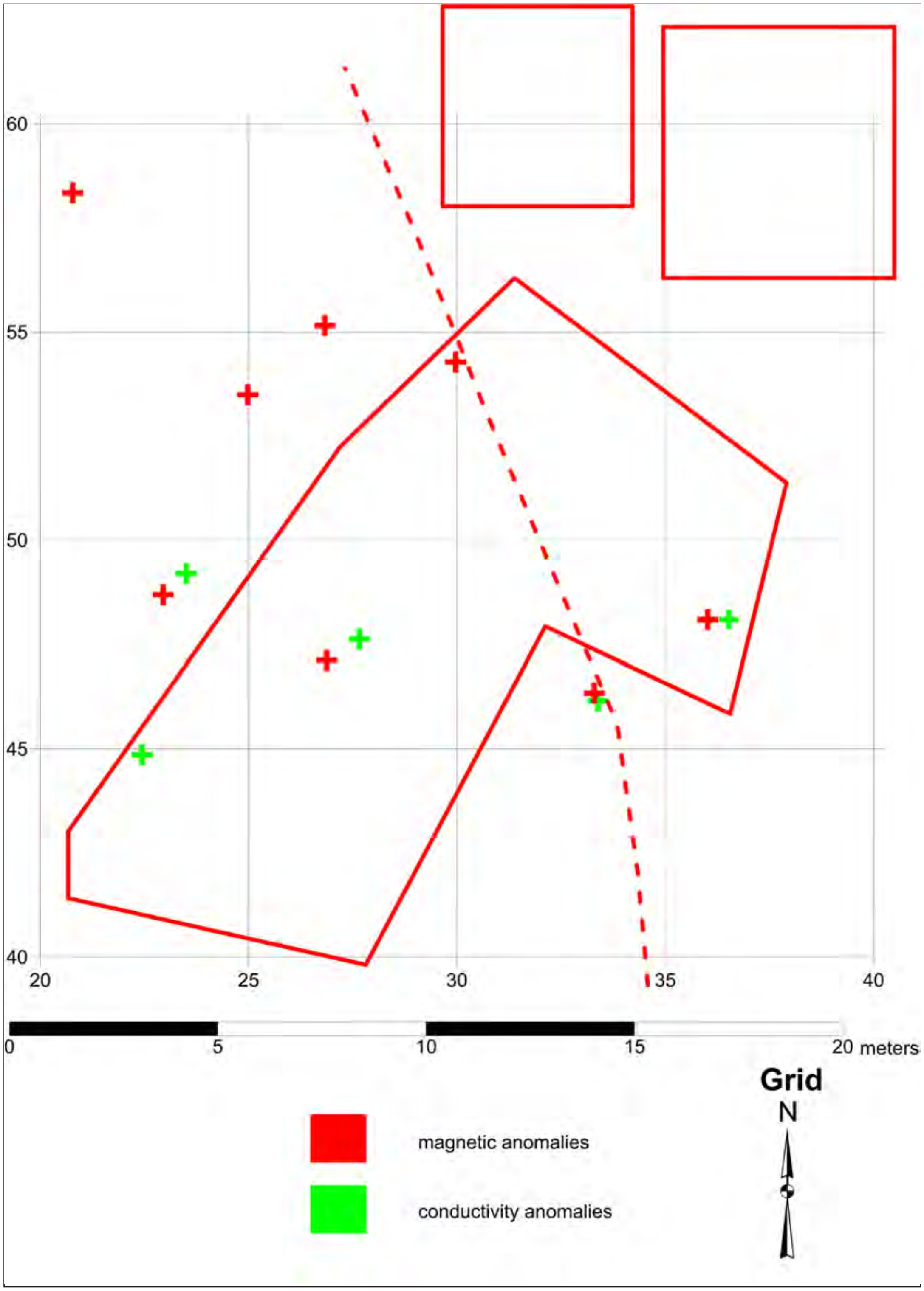


Figure 29. Combined geophysical survey data from the Grid Unit N40/E20 in Area A.

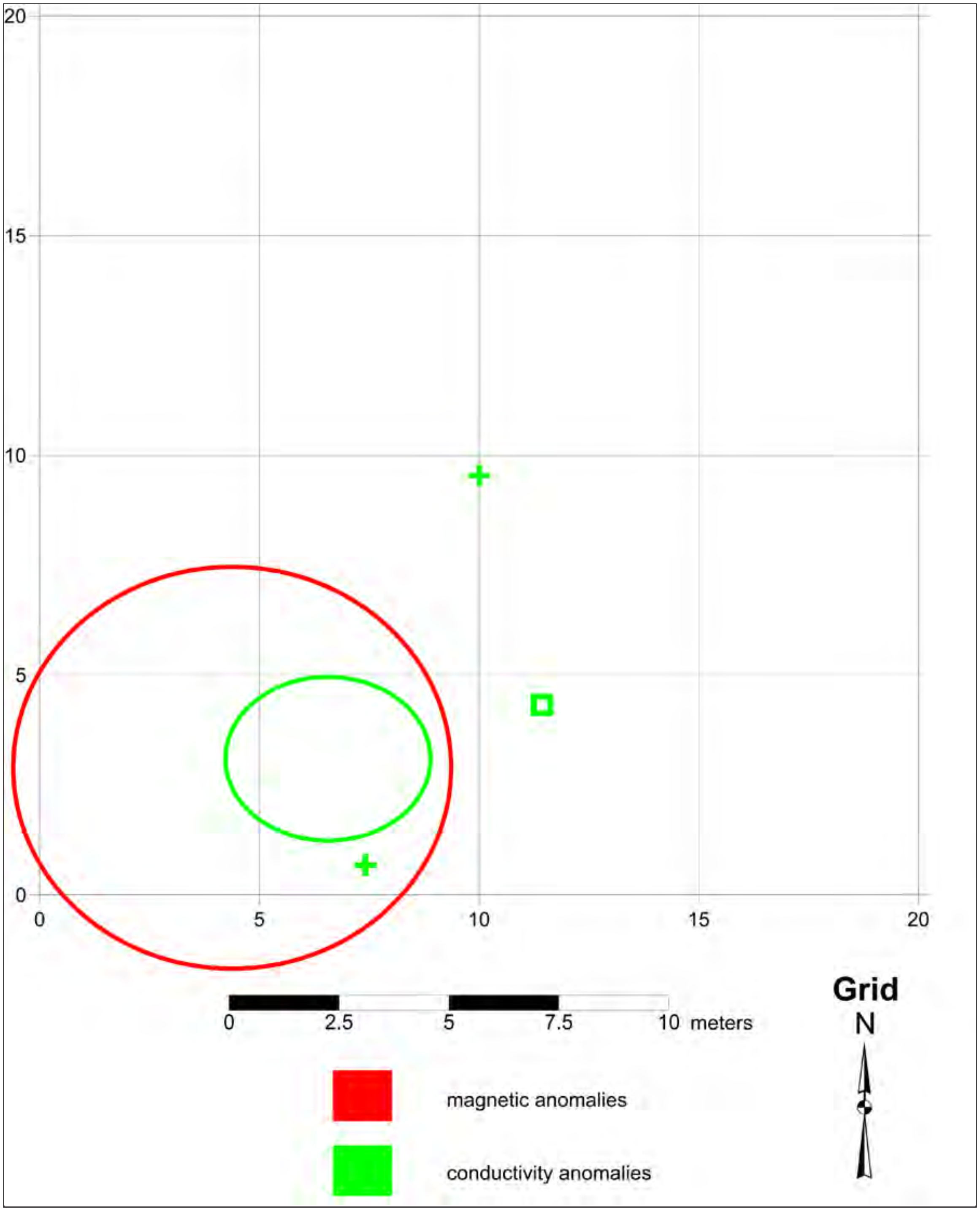


Figure 30. Combined geophysical survey data from Area C.