

SPECIAL THEMATIC SECTION

GEOPHYSICAL INVESTIGATIONS OF LATE PREHISTORIC SITES PART II: MISSISSIPPIAN CENTERS

GEOPHYSICAL SURVEY OF COMPLEX DEPOSITS AT RAMEY FIELD, CAHOKIA

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Located at the Cahokia site, immediately east of Monks Mound, the western portion of Ramey Field is known to include several mounds, a stockade that was rebuilt three times, numerous Late Woodland and Mississippian houses and pits, and more than a meter of sub-plow-zone cultural midden. A portion of Ramey Field was surveyed in 2003–4 using magnetic field gradiometry (43,600 m²) and electrical resistance (29,200 m²). Survey goals were to identify large-scale public or ritual architecture and to assess the usefulness of near-surface geophysical surveys in an area of deep, complex deposits. Very few typical features such as structures and pits could be identified. At least five construction episodes and a circular structure measuring 20 m in diameter were identified in Mound 36. A massive complex of resistance and magnetic anomalies overlooking Cahokia Creek may represent a previously unknown mound, constructed surface, reclaimed borrow pit, or facility associated with possible stockade entryways.

Research Goals

Archaeologists in the Southeast United States have found that near-surface, high-resolution geophysical surveys (Heimmer and De Vore 1995) can benefit investigations of large late prehistoric sites in two important ways. Large-area magnetic field gradient surveys, for example, can provide a more nuanced understanding of a site's overall settlement plan (Hargrave 2005; Kvamme 2003), particularly the distribution of subsurface defensive, residential, and public or ritual facilities relative to plazas and mounds that are visible on the surface. Geophysical surveys can also allow small-scale excavations to be targeted on selected features, greatly improving the ratio of information return to cost and site damage (Butler et al., this volume; Hargrave 2006; Kvamme et al. 2006).

One characteristic of large, complex sites that can limit the usefulness of geophysics is the presence of rich midden. Each data value recorded by many geophysical

techniques (ground-penetrating radar is an exception) is influenced by all deposits within the sensor's effective range. Where features are closely spaced, occur at various depths, below or within a stratum of rich midden, it may be impossible to resolve individual features such as pits, house walls, or floors. Given this, is the use of near-surface geophysical techniques at such sites or site areas a wise use of one's limited resources? This paper explores the benefits and limitations of magnetic field gradient and electrical resistance surveys at Ramey Field, a portion of the Cahokia site that was known to have deep, rich deposits as well as a potential for large-scale architectural remains.

Ramey Field

Located immediately east of Monks Mound, Ramey Field is bounded on the north by Cahokia Creek, and on the south by Collinsville Road (Route 40) (Pauketat and Koldehoff 2002) (Figure 1). The stockade marks the approximate eastern limit for this study, although Ramey Field extends well beyond it. The survey area occupies one of the higher elevation portions of the site. It is situated on a natural levee of the Edelhardt meander scar (Kelly 1982:6). Early historic observations indicate that Cahokia Creek was much wider and deeper than one might suppose based on its current heavily silted channel (Brackenridge 1868:254; Dalan et al. 2003:90; Tucker 1942:46).

The survey area is located within Cahokia's Central Precinct, an area that was architecturally and symbolically delimited in several ways. Monks Mound and the paired Round Top and Fox mounds (numbered 38, 59, and 60, respectively) occupy opposite ends of the Grand Plaza (Dalan et al. 2003; Fowler 1997). Geophysical and archaeological investigations by Dalan (1991, 1993) and her co-workers (Holley et al. 1993) demonstrated that the naturally undulating site of the Grand Plaza was first used as a source of soil for mound construction then reconstructed as a level, massive anthropogenic feature. That landscape transformation began at the end of the Late Woodland period (ca. A.D. 900), with the Grand Plaza and Monks Mound in place by the end of the Lohmann (A.D. 1050–1100) phase (Pauketat 2004:11). The first of four stockades was

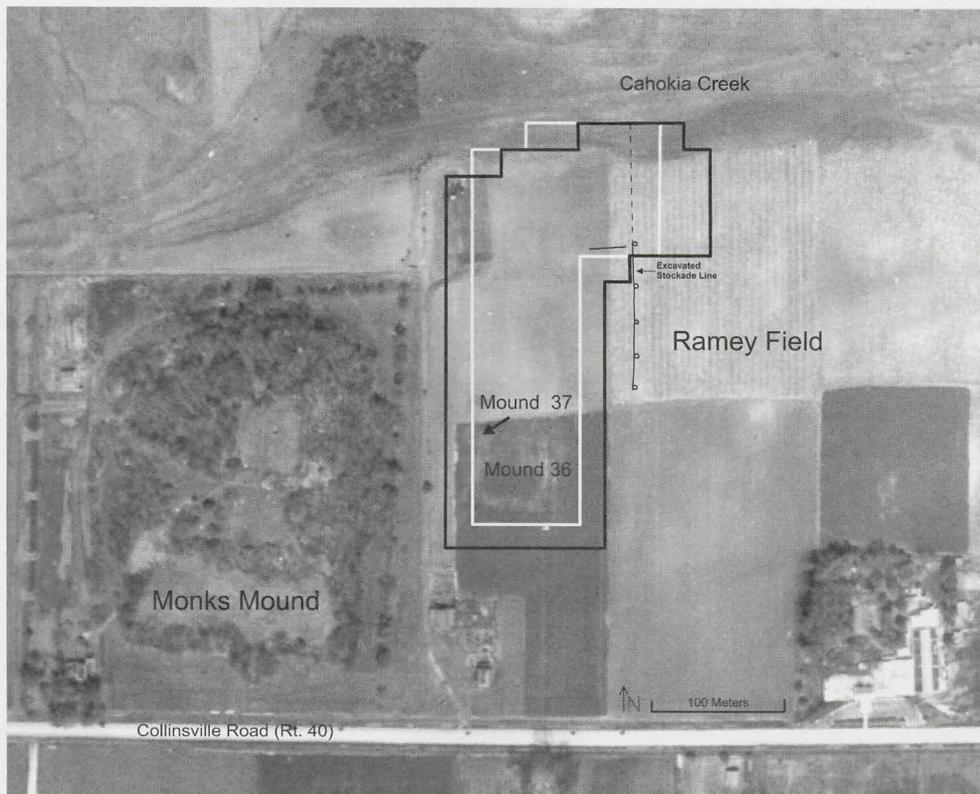


Figure 1. Outlines of magnetic (black) and resistance (white) survey areas at Ramey Field atop a 1933 aerial photograph.

constructed during the Stirling (A.D. 1100–1200) phase, surrounding at least 18 mounds and an area of from 60 to 160 hectares (most of the western and northern stockade alignments have not been located) (Iseminger et al. 1990:31; Milner 1998:112).

Other major plazas, defined by the mounds that surround them and surface artifact density, were located outside the stockade on the east, north, and west in a cross-like configuration, with Monks Mound at the center (Kelly 1997:143, 145). This quadripartite arrangement of plazas may not be cause to expect symmetry in the distribution of other feature types. Kelly (1997) notes, for example, that the western plaza is defined by a small number of mounds that vary greatly in size, whereas the east plaza is defined by numerous mounds of far less disparate proportions. While Cahokia has long been thought to be laid out relative to several axes (Dalan et al. 2003; Fowler 1975), it is also an aggregate of numerous mound clusters that may be associated with subcommunities (Fowler 1997:194). Many aspects of the site's layout were influenced, to varying degrees, by topography, drainage, group identity, and the site's developmental history—particularly its rapid growth during the Lohmann phase (Dalan et al. 2003:108; Pauketat 1994:171–174).

Large-area mechanized excavation was conducted in Tracts 15A, Dunham, and 15B west of the western

plaza, and in the ICT-II Tract southeast of the Grand Plaza (Collins 1990; Pauketat 1994, 1998). Less extensive hand excavation occurred in the Merrell Tract (just west of Tract 15B) and along a section of the east stockade (Iseminger et al. 1990; Kelly 1982). All of these tracts were (at one time or another) residential areas. Tract 15A included five massive circles or arcs of large posts referred to as “wood henges” or “post circle monuments” constructed during the Stirling phase, and Tract 15B included a large (25 m in diameter) circular rotunda and stockaded compounds (Iseminger 2010:131; Pauketat 1994; Pauketat and Emerson 1997:2). All of these massive architectural features were located outside the stockade, west of Monks Mound. Other large architectural complexes and facilities are likely to be present elsewhere at the site (Fowler et al. 1999:161; Pauketat 1994:87–92). One reason for selecting Ramey Field as a survey area was the possible presence of other elite, public, or ritual facilities at this location within the Central Precinct, near Monks Mound and the Grand Plaza.

The survey area includes two definite mounds (numbered 36 and 37). Mound 36, located immediately east of Monks Mound, was depicted on early maps and interpreted by Fowler as a square, flat-topped platform (Fowler 1997:84). Like Monks, Mound 36 is oriented a little east of north. It now measures 48 m north-south by 68 m east-west, and the latter dimension is likely the

effect of predominantly east-west plowing. Based on the 1922 Goddard aerial photographs, Fowler (1997:99, Figure 5.10) interpreted Mound 36 as having two terraces, the south one higher than the north. Mound 36 is in rough north-south alignment with mounds 50, 51, 54, and 55, which define the east side of the Grand Plaza (Dalan et al. 1994:21; Fowler 1997:55). Fowler (1997:195) described Mound 37, a small conical construction, as contiguous with the northwest corner of Mound 36. A third mound (number 17) is shown on early maps to have been located just off the northeast corner of Monks. The early maps differ in Mound 17's exact location as well as its height (ranging from 3.1 to 6.2 m). It is unclear whether Mound 17 was severely impacted or entirely destroyed by flood waters or for use as borrow during the late nineteenth or early twentieth century (Fowler 1997:72). Its exact location is not certain.

Previous Investigations

Previous investigations provide important information about the nature of archaeological deposits in the survey area that can help interpret the geophysical data. Gregory Perino was one of many individuals who surface collected and dug features and burials in Ramey Field (Perino 1980). Of great importance to our interpretation of certain aspects of the geophysical data is his oblique reference to the use of a bulldozer or road grader to expose pits. He (1957:85) mentions this approach in the context of his findings at a location about 1,000 yards (914 m) east of Monks Mound, far outside the present survey area (cf. Benchley 1981). It remains unclear where the stripped area was located or if he used mechanized excavation in more than one location. Bareis (1975) excavated east of Mound 17, but his work involved hand excavation and would thus not explain any of the massive anomalies (discrete areas characterized by geophysical values distinct from their immediate surroundings) discussed below.

The University of Wisconsin at Milwaukee conducted a controlled surface collection (CSC) in a 41,100 m² portion of Ramey Field in 1967 (Vander Leest 1980) and an additional area of 10,987 m² in 1978 (Benchley 1981). Those data provide an independent basis for evaluating inferences based on the geophysical data about spatial variation in the intensity of occupation. Similarly, the geophysical data provide a unique opportunity to reexamine several of the more intriguing interpretations of the CSC data.

Excavation of a portion of the east stockade between 1977 and 1981 revealed a palimpsest of deep basin, single post, Late Woodland houses. Many of these were superimposed by other Late Woodland and Mississippian pits. Some features were defined at the base of the

plow zone, but because of the sub-plow-zone midden, most were initially identified at deeper levels (Iseminger et al. 1990:6).

Field schools conducted at Cahokia in 1992 and 1993 used topographic mapping, electromagnetic conductivity, soil coring, and soil analyses to investigate the processes of mound construction. Dalan and her co-workers (1994) found that soil used to construct a number of mounds (36, 37, 49, 56, and 57) was derived from locations very near those mounds. Dalan et al. (1994:33) also note that, while borrows elsewhere at the site were left open, those within the Central Precinct were carefully reclaimed. Bareis (1975:11) identified in 1966 a reclaimed borrow pit below Mound 51, located just south of Collinsville Road (Chmurny 1973; Fowler 1997:116; Pauketat et al. 2002:258). While the investigated portion is located a little south of the survey area, this borrow may extend north into Ramey Field. Other filled borrows not discernable on the surface may contribute to variability in both the density of surface artifacts and geophysical anomalies.

Perino described flooding in 1946 and 1956 that had severe impacts on deposits at Ramey Field, including the removal of two or three feet of soil just northeast of Monks Mound (Fowler 1997:96; Pauketat and Koldehoff 2002; Perino 1957). No evidence for flood deposits was observed during excavations of the east stockade (Iseminger et al. 1990), but it is likely that cultural deposits in some portions of the survey area have been truncated. For example, excavations in 1974 found that only the lower portions remained of the east stockade trenches that extended northward, over Cahokia Creek's terrace (Vermillion and Iseminger 2008).

Finally, relatively recent land uses contribute to some aspects of the geophysical data. Examples include current and previous pedestrian pathways, baseball fields, small excavation units, and grid datums that contributed to the loss or discard of ferrous items in particular areas. Historic aerial photographs dating from 1922 to the late twentieth century provide useful information on agricultural land use, farm lanes, ditches, and other possible sources of geophysical anomalies (Fowler 1997:22–23, Figures 2.5 and 2.6).

Data Collection and Interpretation

The geophysical data discussed here were collected by the author during a number of brief visits in 2003 and 2004. The magnetic data were recorded using a single Geoscan Research FM36 fluxgate gradiometer. Eight readings per meter were recorded along transects spaced at 1-m intervals. A Geoscan Research RM15 with MPX multiplexer equipped with three mobile probes was used to collect four evenly spaced resistance values per m². The magnetic survey covered



Figure 2. Results of the magnetic survey at Ramey Field.

an area of 43,600 m², whereas resistance survey (which is much slower) covered 29,200 m². Information about how these instruments work can be found in a number of publications and will not be reiterated here (Clark 2001; Dalan 2006; Ernenwein and Hargrave 2007; Gaffney and Gater 2003; Hargrave et al. 2007; Kvamme 2006; Somers 2006).

The magnetic and resistance data are presented here as continuous gray-scale image maps (Figures 2, 6–10; exceptions include Figures 3–5, and 11 described below). The magnetic data have a mean of approximately zero, plotted as 50 percent gray. Stronger

negative values are lighter, whereas stronger positive values are increasingly dark. The resistance values are all positive. Relatively moist soils with low resistance are lighter, whereas coarser or less compact soils that are better drained are darker. Displaying the geophysical data atop an early (1933) aerial photograph provides a spatial context and allows some of the anomalies to be explained based on landscape and modern cultural features.

Fundamental goals of archaeo-geophysical survey are to detect anomalies associated with features or other archaeological deposits, differentiate them from

anomalies caused by natural or recent cultural processes, and assign archaeologically relevant anomalies to meaningful feature categories (e.g., houses, pits, hearths, etc.) (Gaffney and Gater 2003:110–111). Several factors make it difficult to accomplish these goals. Difficulties in detection and categorization caused by the palimpsest of features at Ramey Field are this paper's main theme. Most of the seemingly discrete magnetic anomalies seen in Figure 2 are likely influenced by multiple sources (features and other deposits) (Kvamme 2006:222). Magnetic anomaly characteristics (e.g., positive and negative amplitudes, apparent shape) are the product of multiple factors, including a subsurface feature's composition, orientation, and depth. Weak magnetic anomalies often provide some basis for inferring the size and shape of subsurface features (allowing, for example, the recognition of prehistoric houses at many sites), but stronger magnetic anomalies typically do not. Together these factors make it very difficult to reliably interpret the numerous small, amorphous anomalies seen in the Ramey Field magnetic data. For example, rectangular magnetic anomalies that might be confidently interpreted as late prehistoric houses at other sites (Butler et al., this volume) could be the misleading result of multiple non-architectural features or other deposits.

Factors that contribute to the characteristics of resistance anomalies include moisture contrasts, a feature's composition, depth, and so on. The area between N260 and N300 (Figure 7) was surveyed under extremely dry conditions, giving the resistance data a distinct appearance and making it more difficult to interpret subtle anomalies than the data collected under more favorable conditions to the north and south.

Pattern recognition typically plays an important role in archaeological interpretations of geophysical data (Kvamme 2006). Symmetrical shapes and linear anomalies that are relatively straight or intersect at right angles are likely to be cultural rather than natural. Survey of large areas increases that likelihood that repeated occurrences of similar anomalies can be detected and interpreted in cultural terms. In the Ramey Field data, linear anomalies are less numerous and much more reliably associated with a particular source or event (e.g., the excavation or filling of a trench) than are the innumerable amorphous anomalies.

Positive linear magnetic anomalies can be explained, at least in general terms, as natural or cultural features (erosion gullies, drainage ditches, stockade trenches, etc.) that were filled using material with a higher magnetic susceptibility than the surrounding deposits. The occurrence of a positive linear anomaly in an area of rich midden suggests that the associated feature was filled using a greater proportion of organic (perhaps from processing plant and animal resources) or fired material (sherds and fired clay) (Clark 2001:101; Dalan

2006:165; Kvamme 2006:216–221). Such fill might characterize an open feature that was systematically used as a refuse receptacle by nearby households. Unfortunately, a positive linear anomaly could also occur when an open feature was filled gradually by a high percentage of topsoil (Kvamme 2006:219).

Negative linear magnetic anomalies are presumably associated with features that were filled with soil that has a lower magnetic susceptibility than surrounding deposits. This could occur when less enriched soil was imported to fill relatively quickly an open feature in an area of rich midden. Such features could also have been filled more gradually using discarded materials that were at least somewhat less rich in organic and fired material than those deposited during previous occupations. These alternatives—all seemingly logical—exemplify how equifinality complicates the interpretation of individual anomalies. Fortunately, the interpretation of linear anomalies at Ramey Field can be enhanced by using information about their location and orientation relative to known features (e.g., the stockades), other major anomalies, topography, and drainage patterns.

Strong Magnetic Anomalies and Intensity of Occupation

Based on the abundance of surface artifacts (Benchley 1981; Vander Leest 1980) and density of features encountered during the stockade excavations (Iseminger et al. 1990; Vermillion and Iseminger 2008), it is reasonable to speculate that hundreds of houses and pits may be present in the geophysical survey area. Individual late prehistoric houses have been identified in magnetic surveys at numerous sites in the Southeast and Midwest (Butler et al., this volume; Hargrave 2005, 2006:286–287, 2009; Kvamme et al. 2006; Lockhart and Green 2006; NADAG 2010). Our inability to *confidently* identify more than a few such features in the Ramey Field magnetic and resistance data is attributable to the layer of rich midden throughout much of the survey area. During excavation, midden precluded visual detection of the east stockade walls and many houses until depths of 10 to 20 cm below the plow zone (Anderson 1973:92), and of one of the north stockade walls until 70 cm below surface (Vermillion and Iseminger 2008). Other evidence for the presence of thick midden is provided by two soil cores excavated in the east-central portion of the survey area (both revealed ca. 130 cm of midden) (Dalan et al. 1994:28) and Dalan's (2003) report of about 1 m of cultural fill in a soil core located at the north end of Ramey Field.

The Ramey Field magnetic data provide useful information even where individual features cannot be

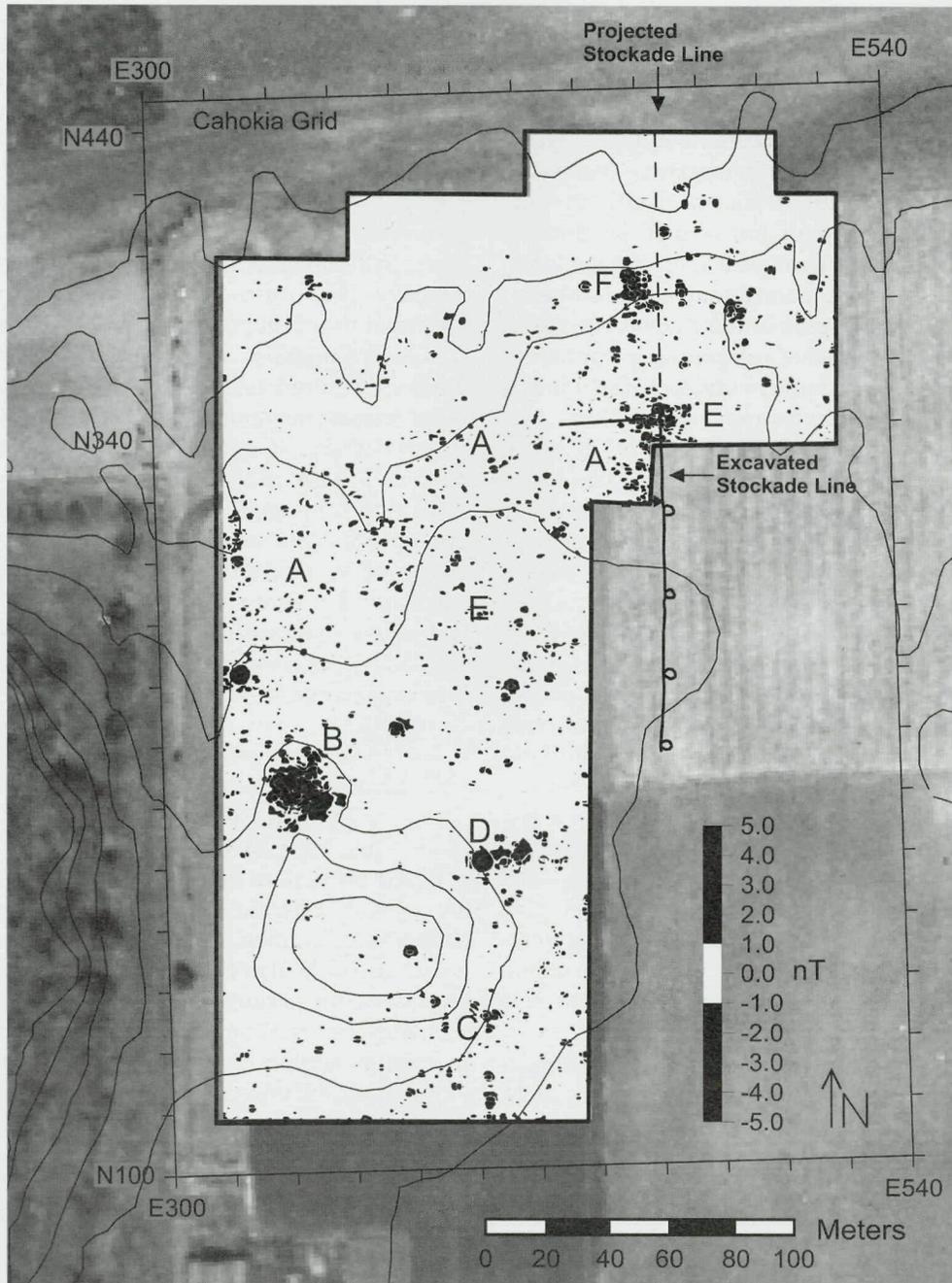


Figure 3. Map showing only the strongest positive and negative magnetic values in black. All other values are shown in white.

discriminated. Figure 2, a continuous gray-scale map of magnetic values, conveys a great deal of information but is difficult to interpret in terms of intensity of occupation, particularly for nonspecialists. One is easily distracted by the presence of both positive (dark gray or black) and negative (white or light gray) anomalies, by the continuous gradation of tones, subtle lines, and possible patterns. Figure 3 shows only the strongest magnetic values (positive values greater than 1.0 nanoTesla and negative values smaller than -1.0 nT are both shown in black). These exceptionally small

values indicate that, at Ramey Field, features and other cultural deposits exhibit a very low magnetic contrast with their surroundings. Raising the threshold from 1 to 2 nT above and below zero produces a map that shows almost no anomalies other than those likely to be associated with historic metal.

The relatively strong (but in absolute terms, very weak) magnetic anomalies shown in Figure 3 depict spatial variability in intensity of occupation much like archaeologists use the count or weight of artifacts recovered on the surface (Benchley 1981; Vander Leest

1980). Many of the anomalies are presumably associated with one or more subsurface features; concentrations of pottery, daub, or other fired clay; or localized areas where the midden is particularly rich in organic content. A minority of the anomalies probably relate to historic ferrous objects. In general, magnetic anomalies associated with prehistoric materials are more abundant and/or characterized by stronger values in areas of relatively intensive domestic activity and less abundant and/or exhibit lower values in areas that were unsuitable for occupation (e.g., low, poorly drained areas), used predominately for nondomestic purposes, or may represent borrow areas that were reclaimed relatively late in the site's occupational history.

Comparisons with Controlled Surface Collection

The geophysical survey area substantially overlaps a 52,087-m² tract where controlled surface collections (CSC) were conducted by the University of Wisconsin at Milwaukee in 1967 and 1978. The CSC and magnetic data provide independent but complementary information about some aspects of activity patterning at Ramey Field. The focus here is on implications of the geophysical data for two of the most intriguing results of the CSC: the postulated existence of a north-south wall that restricted the distribution of shell-tempered pottery and indications of 10 or 11 east-west rows of Late Woodland structures (Benchley 1981:67; Vander Leest 1980:182). The artifact distributions shown in Figures 4 and 5 are based on Benchley's 1981 data, but counts are collapsed into a single category in order to simplify the maps.

A number of linear anomalies, some of them 50 m or more long, are visible in the geophysical data (Figure 4). Most of the linear magnetic anomalies are oriented northwest-southeast (a few are northeast-southwest). Most are positive anomalies, meaning that they are associated with deposits that exhibit higher magnetic values than their surroundings (see Dalan 2006:162–168 and Kvamme 2006:217–218, for discussions of magnetic formation processes).

Benchley (1981:65) identified two possible explanations for the very sharply defined western edge (at ca. E370) of the northernmost concentration of shell-tempered pottery: the presence of a north-south wall that restricted the western extent of pottery discard or the effects of relatively recent flood scouring (Pauketat and Koldehoff 2002; Perino 1957). John Weymouth (1985), a pioneer in the application of geophysics to U.S. archaeology, conducted a small area magnetic survey in Ramey Field in 1984. He (Weymouth 1985:3, 8) found a west-to-east trend toward higher magnetic values that corresponded to increases in artifact abundance at the western edge of the shell-tempered

pottery concentration and interpreted a north-south row of anomalies as possible evidence for the postulated wall (shown here in Figure 4). Weymouth's (1985: Figure 4b) alignment is oriented slightly northwest-southeast and extends across his survey area from N280 to N320. Several linear anomalies can be seen in the 2003–4 data near but not at the location of the postulated wall. One of those anomalies could represent a continuation of Weymouth's alignment, but it occurs well south of the CSC shell-tempered pottery concentration (Figure 4).

Figure 4 identifies a number of locations (labeled A–K) where contour lines abruptly protrude to the south, indicating drainage routes from the southeast down to the northwest. One of these (noted by Benchley 1981:65) is located at the abrupt western edge of the shell-tempered pottery concentration (Figure 4 G), and two others (labeled B and C) are very near the concentration's north edge. Most of the linear magnetic anomalies are located within, just west, or north of the pottery concentration. Given their predominately southeast-northwest orientation, these anomalies are also likely to be drainage features (natural gullies or intentionally excavated ditches). Evidence for drainage routes in the topographic and magnetic data characterize much of the survey area between N260 and N400, making the ongoing (if episodic) process of erosion a more plausible explanation for the western limits of the pottery distribution than the existence of a single wall. It is likely that other aspects of the CSC artifact distributions—like the distribution of magnetic anomalies—are also the result of erosion.

The positive linear resistance anomalies shown in Figures 4 and 5 do not appear to represent prehistoric features or gullies. A number of those anomalies are widely spaced but oriented parallel to one another, running north-south only (not southeast-northwest). They do not coincide with the intersection of data collection units (so are not artifacts of data processing). The high-resistance anomalies (plotted as dark gray or black in Figures 6 and 7) indicate coarser, drier soils, and they do not seem to follow the drainage routes just described (although several low-resistance linear anomalies occur at location G (Figure 5)). A number of the high-resistance anomalies occur in the relatively level area just south of Mound 36 but disappear before they reach the steeper slopes bordering Cahokia Creek. They are too wide and too widely spaced to represent typical plow furrows or ridges, but they are still likely to result from twentieth-century agriculture. Dark (more moist) lines with similar spacing can be seen in aerial photographs of Ramey Field and Mound 42 (Fowler 1997:99, 108).

A second interesting pattern in the CSC data is 10 or 11 east-west rows of small, discrete concentrations of grit-tempered and grog-tempered sherds, interpreted as

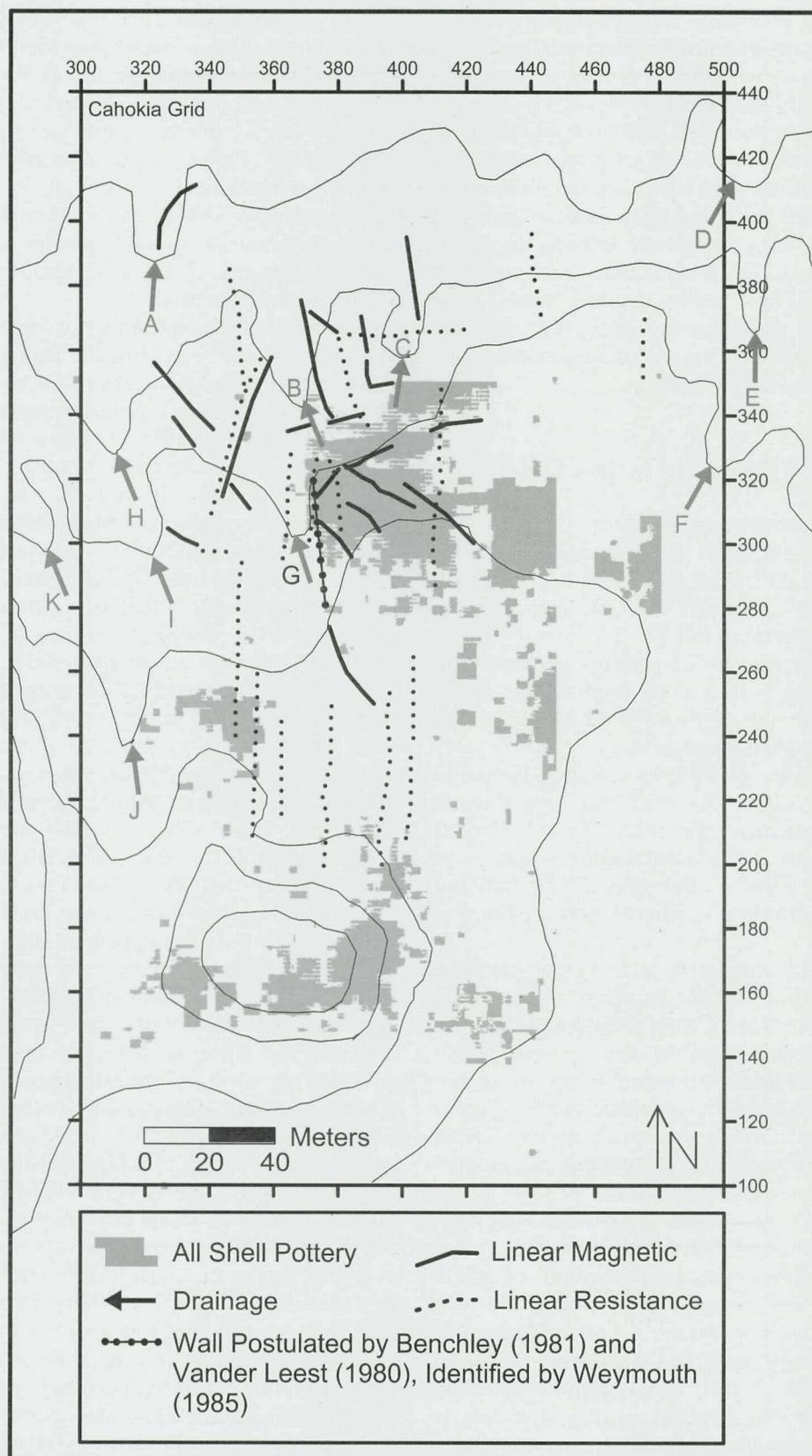


Figure 4. Location of linear magnetic and resistance anomalies relative to all shell-tempered pottery in the CSC data (adapted here based on Benchley 1981:24, Figure 5).

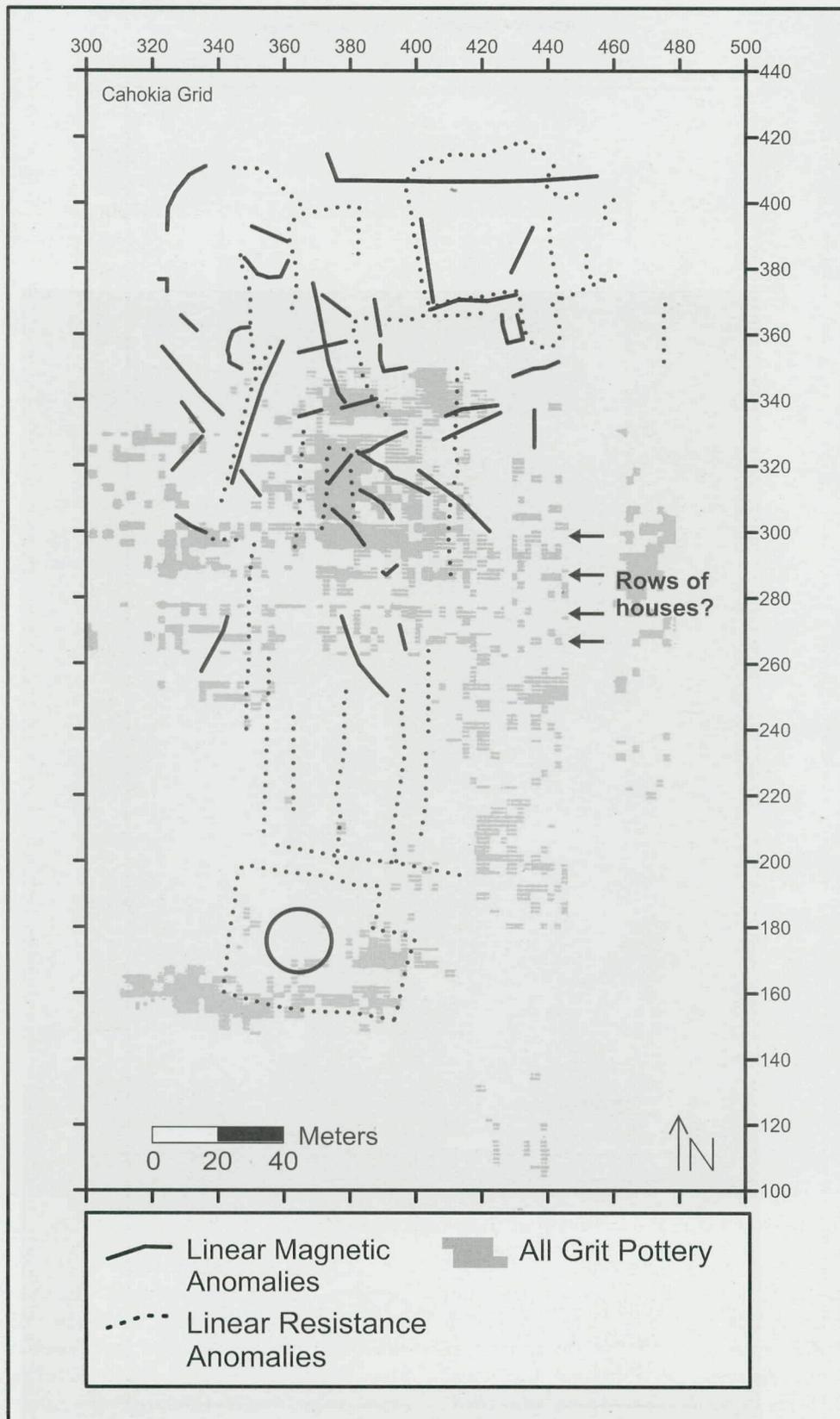


Figure 5. Location of linear magnetic and resistance anomalies relative to all grit-tempered pottery in the CSC data (adapted here based on Benchley 1981:26, Figure 6).

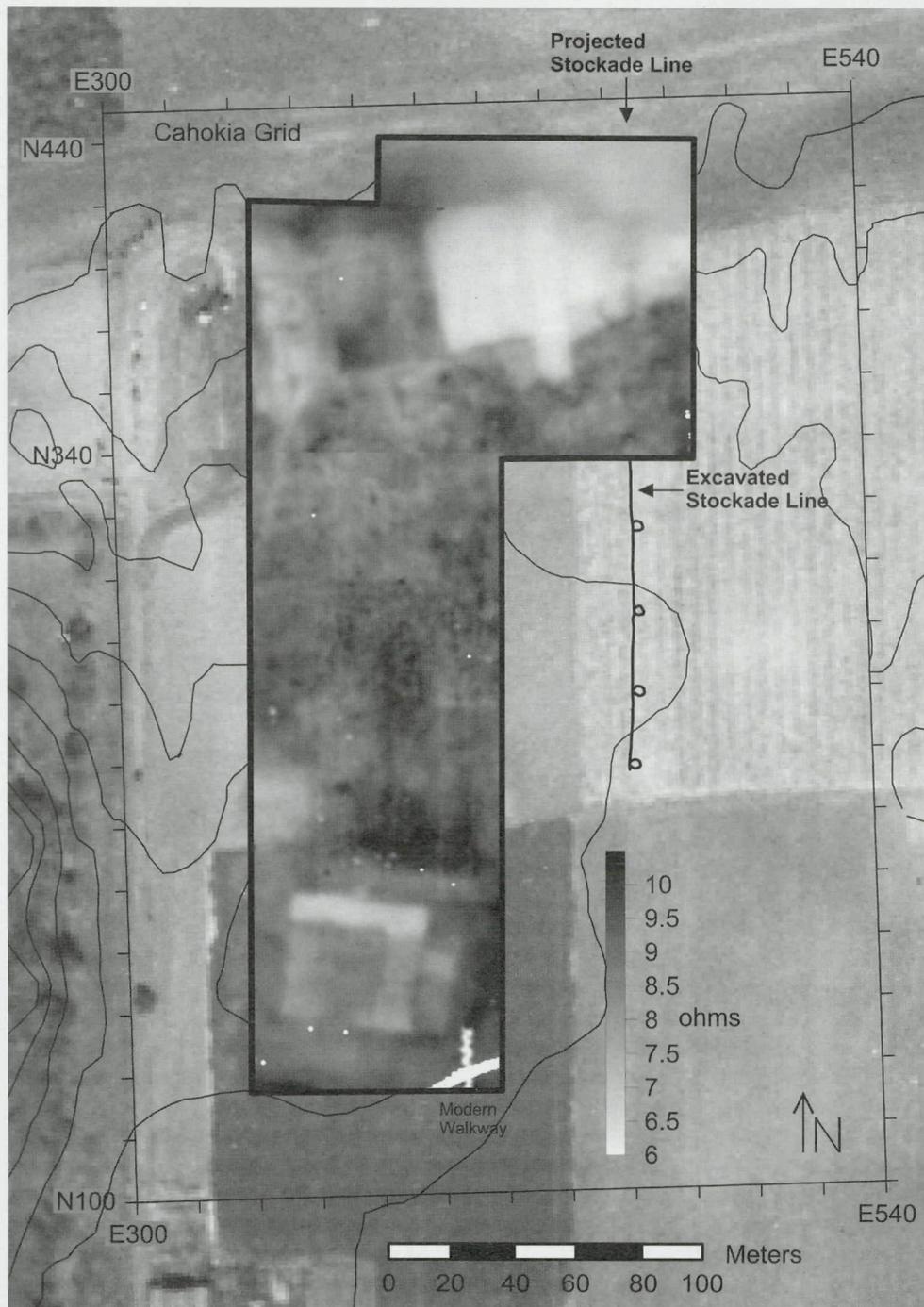


Figure 6. Results of the electrical resistance survey without high pass filtering.

evidence for rows of Late Woodland houses (Benchley 1981:67; Vander Leest 1980:182). Since later prehistoric occupations, natural processes, and historic agriculture apparently did not disperse or obfuscate the sherd surface concentrations, one would expect the corresponding subsurface house basins and pits to also be preserved. At a site with no sub-plow-zone midden, such features might well be detected in a gradiometer survey. There is some evidence for northeast-southwest and,

perhaps, northwest-southeast alignments among the relatively strong magnetic anomalies (Figure 3), but no indication of the east-west rows seen in the CSC data. Magnetic anomalies associated with the rows of houses may be obscured by other features and midden. One also cannot rule out the possibility that the rows in the ceramic data stem from data collection biases in the CSC. Unfortunately, the geophysical data do not resolve the possibility of rows of houses in Ramey Field.

Major concentrations of surface artifacts were found in three areas: Mounds 36 and 37 and across the northern one-third of the CSC Tract (Benchley 1981). Concentrations of strong magnetic values occur at all three of these locations (Figure 3 C, B, and A, respectively), as well as at those labeled D, E, and F. Field observations suggest that some of the strong magnetic anomalies at D may be associated with lost or abandoned metal pin flags used to mark a datum point (N200E400), but much of this anomaly concentration presumably relates to spatially discrete and potentially important prehistoric deposits. This area is at the northeast edge of the surface artifact concentration associated with Mound 36 but does not stand out in the CSC data as an area of particular interest (Benchley 1981:19, 56).

Magnetic concentrations E and F are located on the projected alignment of the east stockades. Concentration F is located north of the CSC area (Figure 3). Magnetic concentration E co-occurs with a concentration of historic artifacts that includes brick, nails, ceramics, clay pipe fragments, and gun flints (Benchley 1981:55). Historic artifacts may well contribute to magnetic concentration E, but it is also possible that anomalies E and F both relate to the prehistoric stockades.

East and North Stockades

Locating the alignments of the stockades that surrounded the central precinct has long been a high-priority research objective for Cahokia researchers. It was not one of the geophysical survey's original goals, largely because portions of the east stockade adjacent to the survey area had long since been identified in aerial photographs and verified by extensive excavations (Anderson 1973; Dalan 1989; Iseminger et al. 1990). Elsewhere at the site, Dalan (1989) had identified portions of the stockade south of Fox and Round Top mounds (far south of the survey area) using electromagnetic induction, and Susan Lowry (2001) continued that work using electrical resistance. As the Ramey Field survey area expanded, however, it eventually included unexcavated areas where one or more of the east stockades may be located (identified in Figures 1–3, 6–7, and 9–11 as the projected stockade line), as well as areas where recent excavations have identified the northeast-most portions of at least one of the north stockades (Vermillion and Iseminger 2008).

Neither the resistance nor the magnetic data provide clear evidence for the east stockade's curtain wall. A potentially important semicircular or hook-shaped positive resistance anomaly (Figure 7 A) is located on or very near the projected east stockade line but is much larger (roughly 10 m in diameter) than the ca. 3.5-m-diameter circular bastions associated with the earliest of the four stockades. Furthermore, the resistance anomaly

would project inward (west) from the east stockade and is open on the north, whereas circular bastions on the earliest east stockade project outward (east) from the curtain wall (Iseminger et al. 1990:31). A very similar but smaller (ca. 7 m in diameter) and lower contrast (visually fainter) positive resistance anomaly (Figure 7 B) is also on or near the east stockade line. Like its larger counterpart, the smaller anomaly appears to project inward from the east stockade and is much too large to be a typical bastion. A third resistance anomaly is even fainter (Figure 7 C). It too is roughly 7 m in diameter, open on the east, and appears to project inward (south) from a location near the north edge of a massive low-resistance anomaly (described below).

One possibility is that these large, semicircular resistance anomalies are associated with stockade entryways. Anderson (1973:95) described a suspected entryway as being configured much like an open gorge bastion, projecting outward from the wall but with its south and west sides open. The few post holes that were detected were not particularly deep. Iseminger et al. (1990:32) describe the entryway as being L-shaped and projecting out from the curtain wall between bastions. Like the hook-shaped resistance anomalies, it was much larger (6.5 m east-west) than that stockade's bastions (ca. 4 m east-west) (Anderson 1973:94–95).

Another possibility is that these hook-shaped anomalies represent unusually large bastions or similar structures. Despite their odd orientations, it seems highly unlikely that the location of two of these three resistance anomalies (Figure 7 A and B) along the projected alignment of the east stockade is coincidental. If these anomalies are associated with the stockades, then the location of anomaly C (Figure 7) suggests the approximate location of one of the north (east-west oriented) stockades. The largest resistance anomaly (Figure 7 A) occurs at or very near a concentration of historic artifacts, but it is difficult to suggest a historic feature that would exhibit that hook-like shape. These three resistance anomalies clearly warrant additional investigation, beginning with electromagnetic induction survey or resistance survey with the probes set more widely to collect data at greater depth.

Houses

The presence of a layer of rich midden makes it nearly impossible to confidently differentiate individual houses and pits from their immediate surroundings in the Ramey Field magnetic data. A number of elongate but otherwise amorphous high-resistance (black) anomalies are seen in the resistance data (Figures 7 and 9), particularly at the north end of the survey area. These could conceivably represent houses, although that interpretation has not been verified by



Figure 7. Results of the electrical resistance survey using high pass filtering.

ground truthing. Most of these anomalies measure roughly 5 m in length, which is at the high end of the range for terminal Late Woodland through Late Lohmann phase structures (which average 3.4 to 5.4 m, respectively, for the 15A Tract [Pauketat 1998:77-79]). Some of the resistance anomalies that are up to 10 m long could represent situations where two adjacent structures are arranged end to end, but it is also very possible that these anomalies represent some other kind of deposit.

Mound 36

In the resistance data, one can see that Mound 36 includes at least five (probably six) distinct rectangular segments (labeled A-F in Figure 8). Their differences in color (ranging from nearly white to medium gray) reflect variation in resistance that is, in turn, attributable to construction using soils with different textures and moisture retention properties. Four of the major segments (all but C and F) may each represent a

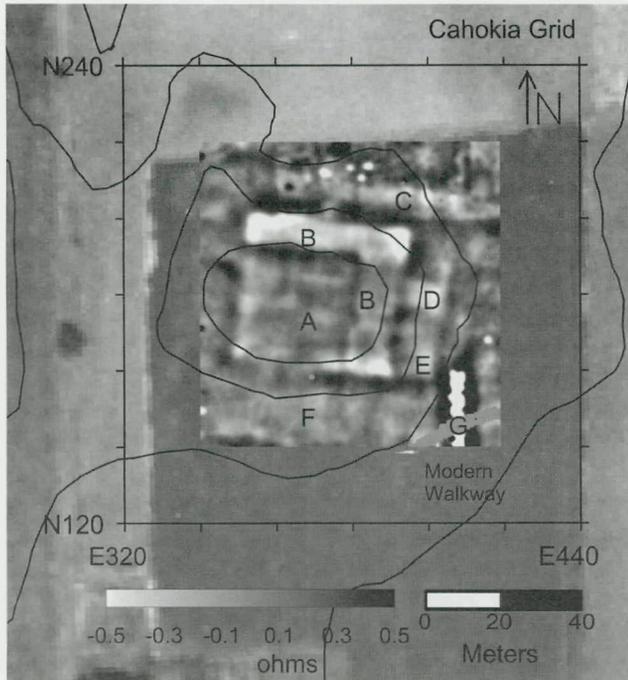


Figure 8. Close-up of high pass filtered electrical resistance data for the Mound 36 area.

distinct construction episode. The inner, southwestern segment (A) is nearly square, measuring about 32 m on a side. Segment B extends to the north and east an additional 8 m. D and E extend another 8 m to the east. D differs markedly from E in terms of resistance and its proportions are suggestive of a ramp, although its long axis appears to curve slightly to the south. Segment F adds 20 m to the south, but its identification as a construction episode rather than redeposited mound fill is problematic because the resistance survey did not extend far enough to provide a reliable indication of its presence or width on the other three sides.

Dalan et al. (1994) reported variability in soil texture in three cores excavated in Mound 36. Unfortunately, all of these were located in Component A, and so provide no information about the degree to which that central portion of the mound differs in texture from the other components. Her analysis of a fine-scale contour map provided no evidence for two tiers. What Fowler (1997:95, Figure 5.10) interpreted as a lower northern tier in the 1922 Goddard oblique aerial photograph of Mound 36 may, in fact, be Segment B. Differential drying and vegetation associated with differences in soil type may allow components A and B to be distinguished in that image.

The resistance image of Mound 36 is visually compelling, but it still provides a highly generalized view of the mound's internal structure. Resistance data were collected with the probe spacing set at 50 cm, with the result that most of the data pertain to the uppermost 50 cm. Today the mound is about 1.7 m

high, and we assume that it was originally much taller, with much steeper sides. Decades of plowing removed the outermost, upper portions of the mound, redepositing that material around its base (Dalan 2006: Figure 8.16). Dalan's (2006:192) magnetic susceptibility study suggested that the preserved portion of Mound 36's platform is only about 17 m east-west. Reference to a preserved portion of the platform does not mean that the last occupational surface is still present, only that the susceptibility of the topsoil was enhanced by natural processes faster than it was removed by deflation. Not only were segments A, B, D, E, and F horizontally more extensive prior to the effects of plowing, but other, deeper segments not visible in the resistance data are almost certainly present.

Looking only at the magnetic data, an individual unfamiliar with the site would almost certainly not recognize the presence of Mound 36. A careful examination of the magnetic data in the vicinity of N180E370 reveals the presence of a circular magnetic anomaly about 20 m in diameter (Figure 2). The interpretation favored here is that this magnetic anomaly is associated with a circular structure that stood atop Mound 36. The fluxgate gradiometer used in this survey would probably not have detected an anomaly located on the premound surface. Circular structures have been identified on Mounds 10/11 at Cahokia (Pauketat 1993) and Mound A at Kincaid (Butler et al., this volume). The circular structure identified in the magnetic data is likely just one of a number of structures associated with various episodes of Mound 36. Holder identified at least 17 distinct structures in his excavations of Mound 10/11, which is roughly comparable to Mound 36 in size (Fowler 1997:67, 84; Pauketat 1993:140).

North Ramey Field Anomaly Complex

The single most intriguing result of this study was the identification of a complex of anomalies at the north end of Ramey Field (hereafter abbreviated as the NRF anomalies). Most notable is a massive resistance anomaly centered at approximately N400E430 (Figures 6 and 7). Three sides of this rectangular anomaly are so symmetrical as to preclude any noncultural origin. Its east end is irregularly shaped, perhaps as a result of natural or cultural impacts. A ramplike projection off its south side (Figures 6, 7, and 9) results in a plan that is reminiscent of Monks Mound and Mound 36. In terms of resistance values, the anomaly is relatively homogeneous, although one can see some very low contrast internal linear anomalies. Potentially important to an assessment of this massive anomaly's age is the fact that it appears to be superimposed by the semicircular resistance anomalies described previously

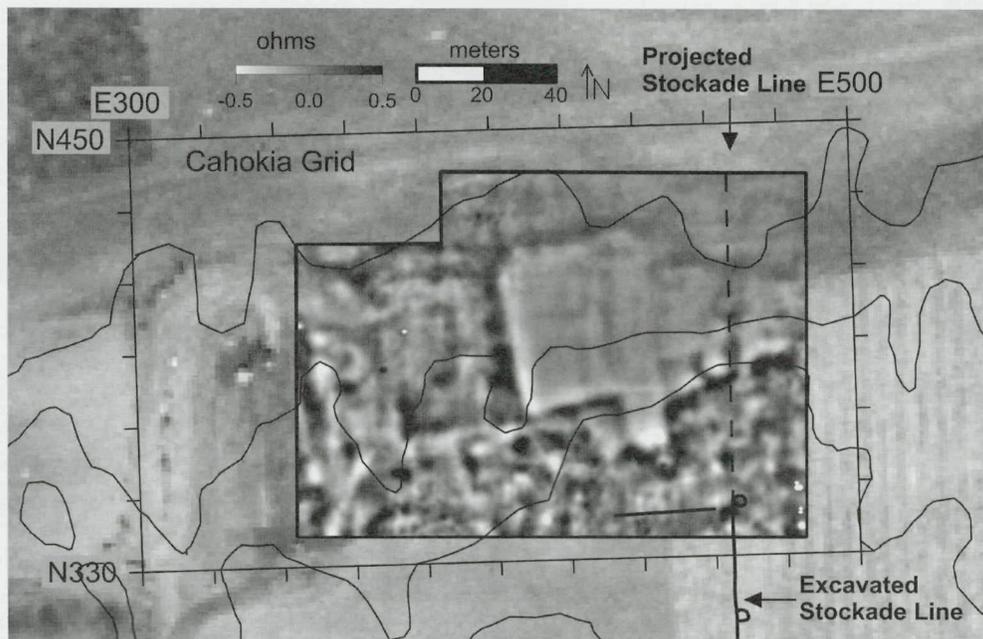


Figure 9. Close-up of high pass filtered electrical resistance data showing the North Ramey Field (NRF) anomaly complex.

(Figure 7 A–C). Unfortunately, the CSC did not extend north far enough to provide artifact evidence for the NRF anomaly’s relative age.

Figures 9 and 10 (respectively) show the NRF resistance anomaly with and without high pass filtering. That processing technique removes spatially broad variation in resistance that is likely to be associated with soil, drainage, and so on. Often the use of a high pass filter allows the identification of

discrete, smaller anomalies likely to be associated with archaeological features. Without high pass filtering, the NRF anomaly appears as a homogeneous area of very low resistance (plotted as nearly white) (Figure 10). This indicates that the anomaly holds moisture better than its surroundings, probably because it has a high clay and silt content. One result of using Geoscan Research’s Geoplot 3.0 software’s high pass filter is the creation of a positive (black) halo around the edges of

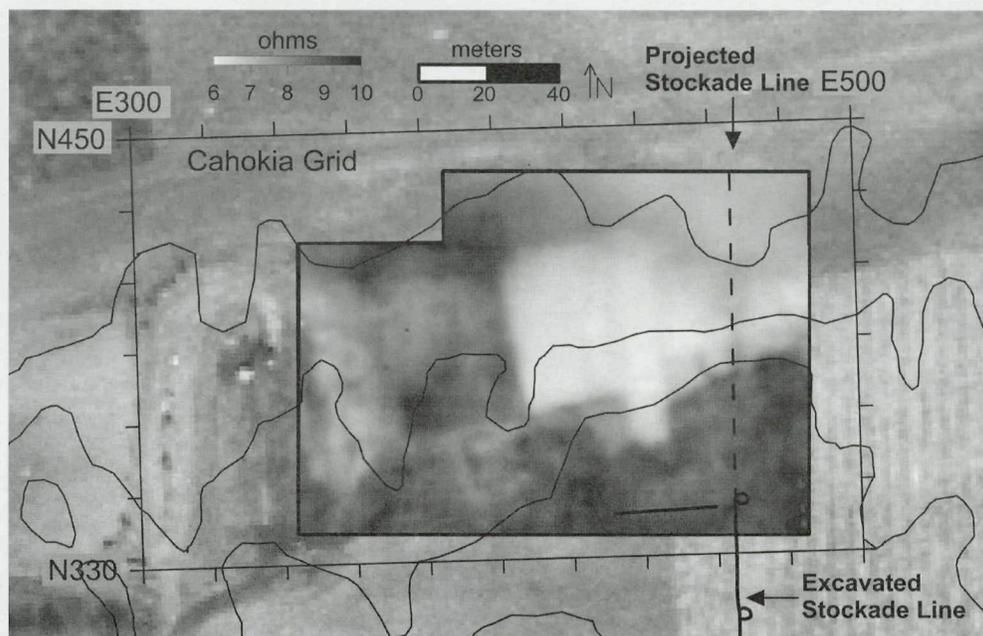


Figure 10. Close-up of electrical resistance data without high pass filtering showing the North Ramey Field (NRF) anomaly complex.

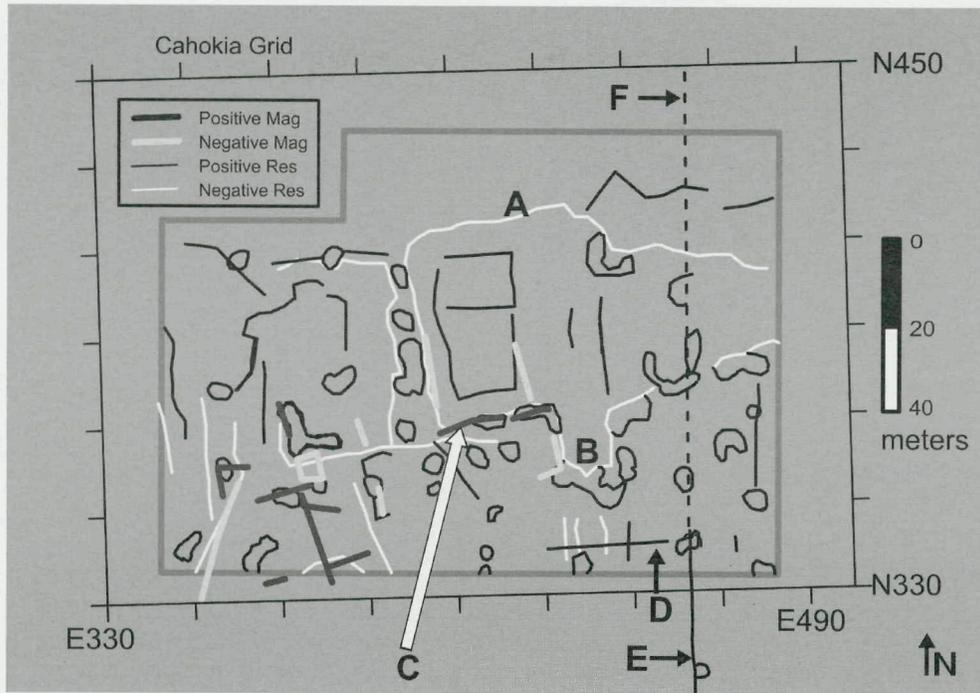


Figure 11. North Ramey Field (NRF) anomaly complex showing major resistance and magnetic anomalies.

lower resistance areas (Figure 9). Knowing that it is an artifact of processing, those strong values can safely be ignored. It may be important to note, however, that several very slightly darker (higher resistance) anomalies can be seen on the west edge of the NRF anomaly prior to high pass filtering (Figure 10). This implies that at least several of these small protuberances, as seen much more clearly in the filtered data, are likely to be distinct deposits or features, not solely the results of using the high pass filter.

A complex of positive and negative linear magnetic anomalies partially overlaps with the NRF resistance anomaly just described (Figure 11). The former includes several positive linear anomalies that are oriented northeast-southwest, the easternmost of which runs along the southwest edge of the NRF resistance anomaly. The magnetic anomaly complex also includes several linear anomalies (some positive and others negative) oriented perpendicular to those just described. The massive NRF resistance anomaly is clearly very different in character from the complex of linear magnetic anomalies to its southwest. However, the two complexes share at least one well-defined anomaly (Figure 11 C), indicating that they are structurally, chronologically, and perhaps functionally related. Overall, these anomalies are oriented relative to the Cahokia Creek terrace, which runs northeast-southwest.

In conjunction with the National Park Service's course in geophysical methods held at Cahokia in May 2003, Dr. R. Berle Clay (2003) resurveyed the area of the NRF

anomaly using a Geonics EM38 electromagnetic conductivity meter. As expected, the NRF anomaly appeared as an area of high conductivity but exhibited essentially the same shape as shown here in Figure 10. Dr. Rinita Dalan (2003) collected down-hole magnetic susceptibility profile data at two locations within and one location near but outside the NRF resistance anomaly using a prototype Bartington MS2H down-hole sensor. She found that the two tests inside the anomaly were characterized by clayey, gleyed soils. The soil core outside the anomaly was characterized by coarser, looser soil, which she interpreted as cultural fill (Dalan 2003).

In the absence of ground-truthing excavations, interpretations of the NRF resistance and magnetic anomaly complexes are speculative. The NRF resistance anomaly could be the base of a relatively early mound that was removed when the stockade was constructed. This assumes that at least one of the east stockades continues north beyond the northernmost portion that has been verified by excavation. The semicircular resistance anomalies (Figure 7 A and B) are visible in the irregularly shaped eastern end of the possible mound, suggesting that they postdate it.

Rather than a mound, the NRF resistance anomaly could represent a relatively early (pre-stockade) constructed level surface that was suitable for use as a small plaza or courtyard. Use of this area, which today slopes down to the north, may have become desirable as space within this part of the site became limited. A related possibility is that the semicircular resistance

anomalies (Figure 7 A and B) represent some type of entryways or specialized bastions, and that the constructed surface was functionally related to them.

The NRF resistance anomaly may also represent a reclaimed borrow. Dalan et al. (1994) have demonstrated that the soil used to construct Mound 36 (as well as several other mounds) was acquired in the immediate area. Borrow pits outside the Central Precinct were often left unfilled and exhibit shapes far more irregular than the NRF anomaly. Borrow pits located within the Central Precinct were always reclaimed (Dalan et al. 2003:163). Its proximity to and visibility from Monks Mound could conceivably account for this borrow's regular shape. If the NRF resistance anomaly is a borrow pit, the protuberance off the south side of the large resistance anomaly could represent a ramp that provided access in to and out of the pit.

A final possibility (Clay 2003) is that the large NRF resistance anomaly may result from historic or modern actions. As noted above, Perino (1957) referred to using a bulldozer or grader to expose features while discussing an area 1,000 yards northeast of Monks Mound (far from the NRF anomalies), but it is unclear whether he might have used that approach elsewhere at Cahokia. Stripping the topsoil from the NRF area might expose a more clayey soil characterized by lower resistance but would leave a noticeable depression. Backfilling the stripped area would leave a layer of less compact soil that would be characterized by higher resistance. On balance, mechanized excavation does not provide a satisfying explanation for the NRF resistance anomaly.

Historic aerial photographs dating from 1922 to the present reveal no explanation for the NRF anomalies. Two of the 1922 Goddard oblique aerial images (Fowler 1997:22–23, Figures 2.5 and 2.6) show that a farm lane running east from the north edge of Monks Mound curved around some large, elongate, northwest-southeast oriented, unidentifiable object. When transposed onto the geophysical data, it is clear that object is much smaller than—and does not overlap—the massive NRF resistance anomaly.

The NRF magnetic anomalies are also difficult to interpret. The same Goddard aerial photos indicate the presence of several small fields in that area, but they are oriented relative to the cardinal directions, whereas the linear magnetic anomalies are oriented relative to the Cahokia Creek terrace that runs northeast-southwest. Drainage ditches could conceivably explain linear anomalies running down toward the creek channel but would not explain those running parallel to it.

The NRF linear magnetic anomalies delimit areas that are too large to be roofed structures. Given their orientation, it would be surprising if they are associated with the stockades that surrounded the Central Precinct, but they could conceivably represent the walls of compounds or less substantial stockades. The darker

(higher resistance) small anomalies that occur along the western edge of the NRF resistance anomaly bear some resemblance to the bastions fringing the Tract 15B compound (Pauketat 1994:87–92). Even disregarding its extended, irregular eastern end, the NRF resistance anomaly is much larger than the Tract 15B compound.

Discussion

Cahokia is widely recognized as the largest, most complex prehistoric site in North America. Excavations that have thus far exposed less than 1 percent of the site (Dalan et al. 2003:48) have revealed massive post circle monuments, large circular rotundas, compounds surrounded by walls and bastions, and extravagant elite burials (Fowler et al. 1999). Within the limits of the Mississippian culture's built environment, virtually anything could be present at Cahokia. The potential benefits of low cost, non-invasive, investigation of large areas offered by geophysics are as great here as nearly anywhere. But Cahokia's complex deposits, soil characteristics, historic impacts, and poorly documented early investigations also create limitations and challenges, at least in some areas.

Relatively deep, rich midden and a palimpsest of features at Ramey Field largely precluded a confident detection in the magnetic gradient data of individual houses and pits. Plotting only the strongest (in relative terms) positive and negative values simplified the magnetic map and provided a useful indication of spatial variability in intensity of occupation. This approach allows the magnetic data to be used much like the distribution of counts or weights of ceramics or other artifact categories. The magnetic data provide no chronological information but can be collected across large, unplowed areas at far less cost than a controlled surface collection of artifacts. The geophysical data do not support or deny the possible existence of east-west rows of Late Woodland houses. In conjunction with topographic data, the magnetic data suggest that erosion provides a better explanation for the abrupt western edge of the shell-tempered pottery concentration than does the existence of a postulated wall (Benchley 1981; Vander Leest 1980; Weymouth 1985).

Only a few typical features (interpreted as possible house basins) were identified in the resistance data. Resistance survey is relatively slow and costly, although prototype cart-mounted resistance systems—already tested at Cahokia with positive results (Hargrave and Burks 2007)—will soon narrow or close the gap between resistance and other widely used techniques. The resistance survey provided new information about Mound 36, including identification of distinct segments of the overall resistance anomaly that are interpreted here as construction episodes. The

magnetic survey revealed a circular anomaly about 20 m in diameter (314 m²) representing a structure that stood atop Mound 36 at one point in its use. While these data are useful and provide a visually compelling image, the excavation of several other mounds at Cahokia reminds us that Mound 36 is almost certainly far more complex than suggested by these results (Pauketat 1993).

A complex of massive resistance and magnetic anomalies at the north end of Ramey Field (NRF) may represent the remains of an unknown mound or a prehistoric constructed surface. Perpendicular linear magnetic anomalies located nearby could indicate the presence of a walled compound or stockades unlike those identified in previous excavations. Other explanations for the NRF anomalies include a reclaimed borrow pit or area of undocumented mechanized excavations. These diverse alternatives exemplify one of the important realities of large-scale geophysics at complex sites. Ground-truthing investigations are nearly always needed to confidently interpret anomalies, particularly unusual anomalies that could represent important feature complexes.

Thus far, ground truthing the results of the Ramey Field survey has been restricted to the use of historic and recent aerial photographs to attempt to reject at least some explanations for large-scale anomalies (Hargrave 2006). Hand excavation is always desirable, but in complex deposits like those at Ramey Field, the excavation of even small units requires a substantial investment. Future investigations at Cahokia and other complex sites will benefit from an increasingly sophisticated integration of geophysical methods, including landscape-scale coverage using the techniques reported here as well as the approach pioneered by Dalan et al. (2003) that focuses on formation processes and site history (Dalan 1991). In the near future, LiDAR data will probably play an important role in identifying very subtle topographic indications of earthworks, borrow areas, and drainage channels.

Is the use of near-surface geophysical techniques in an area of deep, complex cultural deposits worthwhile? Certainly the answer is yes in the case of Ramey Field. This survey area was selected based on an expectation that large-scale public or ritual architecture might be present. Cahokia is in some ways unique, but most or all sites that include mounds also include borrow pits, and many large, late prehistoric sites may include stockades and plowed mounds with no topographic expressions. Information about the location, dimensions, and chronology of these large-scale features is important to an understanding of a site's layout and unique developmental history. In some cases, such large features can be detected despite the presence of midden and abundant smaller features. In contrast, near-surface geophysical surveys of Archaic habitation

sites in the Midwest characterized by deep midden and numerous features (Jefferies and Butler 1982) might detect little more than the horizontal extent of the midden. As geophysical techniques become a more established part of archaeological investigation, archaeologists will develop a more sophisticated understanding of when, where, and how geophysics can be useful, as well as when one should rely on traditional methods like controlled surface collection, hand excavation, and mechanized stripping.

Notes

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