REMOTE SENSING AS COMMUNITY SETTLEMENT ANALYSIS AT MOUNDVILLE

Jera R. Davis, Chester P. Walker, and John H. Blitz

Remote sensing has revolutionized procedures for locating buried features at archaeological sites in eastern North America. However, the potential of instruments such as gradiometers to shape innovative research in ways that move beyond survey and testing is not always realized in practice. At the Mississippian site of Moundville, Alabama, we conducted a landscape-scale geophysical survey to serve as the guiding method of community settlement analysis. First, we mapped the distribution of magnetic anomalies across the site. Next, we defined the variability of anomalies and selected a sample for test excavations to correlate specific anomaly shapes and amplitudes with specific cultural features. Once confirmed as cultural features, we extrapolated sample results to identify unexcavated anomalies as specific building forms and other features with a higher degree of probability than would have been possible without confirmation by test excavation. Results include the identification and mapping of over 450 unexcavated probable buildings, nearly five times the number previously discovered in decades of traditional excavation. Because the buried probable buildings have different forms, sizes, distributions, and chronological spans, the interpreted gradiometer map is transformed through interpretation from a static palimpsest of anomalies to a picture of changing community settlement organization.

La teledetección ha revolucionado los procedimientos usados para la localización de estructuras enterradas en los sitios arqueológicos del este de Norteamérica. Sin embargo, el potencial de algunos instrumentos para modelar la investigación innovadora de formas que van más allá de los sondeos y pruebas no siempre ha sido apreciado. En el sitio de Moundville, en Alabama, hemos llevado a cabo un estudio geofísico a nivel de paisaje que nos sirva como método de guía para el análisis de asentamientos comunales. En primer lugar, hemos mapeado la distribución de las anomalías magnéticas a lo largo del sitio . A continuación, hemos definido la variabilidad de las anomalías y seleccionado una muestra sobre la que realizar excavaciones de prueba para correlar las formas y amplitudes de las anomalías con características culturales específicas . Una vez confirmadas como rasgosculturales, hemos extrapolado unos resultados de muestra para identificar las anomalías no excavadas como formas edificadas específicas y otrascaracterísticas, con un grado de acierto mayor del que hubiera sido posible sin la confirmación por excavaciones de prueba. Los resultados incluyen la identificación y el mapeo de más de 450 probables edificios no excavados, casi cinco veces más de lo descubierto durante décadas de excavación tradicional. Debido a que los edificios probables enterrados tienen distintas formas, tamaños, distribuciones, y representan períodos cronológicos diferentes, el mapa gradiométrico interpretado se transforma, a través de la interpretación, de un palimpsesto estático de anomalías, auna imagen de la organización del asentamiento comunal cambiante.

Recent approaches to understanding archaeological sites as settlements with complex histories require large databases. Generating these data makes high demands on the archaeologist's time and resources. Identification, evaluation, and interpretation of landscape modification, social memory shaped by building and rebuilding, social and cultural variability in residential groups, and degrees of hierarchy or corporatism manifest in community organization all require extensive mapping, excavation, and dating of site features. At places where the remains of ancient architecture are visible on the ground surface, some aspects of community organization may be perceived in the spatial layout of the site plan. Elsewhere, the location and dis-

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tribution of cultural features may remain invisible until exposed by laborious excavation or mapped with subsurface survey made possible by geophysical remote sensing.

Over the last decade, ground-based geophysical remote-sensing surveys of sites have evolved from a revolutionary technique to a widespread method to discover and map buried features without excavation (Gaffney 2008; Kvamme 2003). In the U.S. Southeast and other regions where ancient sites exhibit similar kinds of archaeological features, common use of geophysical instruments like gradiometers has made it possible to identify, without excavation, subsurface anomalies such as buried houses, hearths, storage pits, palisade walls, and ditches, with varying degrees of confidence (Bigman et al. 2011; Butler et al. 2011; Haley 2014; Horsley et al. 2014; Johnson et al. 2000; King et al. 2011; Nelson 2014; Thompson et al. 2014; see also contributors to Johnson 2006). Nevertheless, the results of geophysical surveys vary somewhat by site as a result of differences in local soil properties and conditions, site formation processes, and other factors. Thus, results are more confidently interpretable when archaeologists sample anomalies via excavation. This confirmation problem creates a dilemma because remote sensing's greatest asset to archaeology is rapid discovery without destructive excavation, but excavation is not always feasible, desirable, or possible. This situation can lead to acceptance of anomalies as de facto cultural features without the prerequisite step of confirmation by excavation. Without test excavations to independently confirm that mapped anomalies are cultural features, it may be impossible to evaluate the accuracy of the correlation.

Moreover, remote sensing is typically used at sites in the U.S. Southeast to define site boundaries and guide placement of excavation units, but the data is not developed into a systematic analysis of site settlement patterns to shed light on spatial organization and how it may have changed through time (Aspinall et al. 2008; but see recent efforts described in Barrier and Horsley 2014; Haley 2014; Horsley et al. 2014; Nelson 2014; Thompson et al. 2011; Thompson et al. 2014; Thompson and Pluckhahn 2010). The challenge here is to construct a research plan that resolves the confirmation dilemma by limiting the scale of excavation to a sample of magnetic anomalies and then extrapolating the confirmed interpretations to the entire site. In this paper, we report on our efforts to do this at the Mississippian site of Moundville, Alabama, where we conducted a landscape-scale gradiometer survey to serve as the guiding method of community settlement pattern analysis. First, the gradiometer was used to map the distribution of magnetic anomalies across the site. Next, we defined the variability of anomalies before selecting a sample for ground-truth excavation to correlate specific anomaly shapes and amplitudes with specific architectural feature types. Once the correlations were confirmed, we extrapolated the ground-truthing results to identify unexcavated anomalies as specific building forms and other features with a much higher degree of probability than possible prior to the systematic testing. The first phase of work was the Moundville geophysical survey.

The Moundville Geophysical Survey

Moundville is a large Mississippian site in west-central Alabama (Figure 1). Owned and protected by the University of Alabama, the site covers 75 hectares and includes palisade remains, habitation areas, cemeteries, and 29 mounds, 16 of which form a core arrangement ordered around one of the largest prehistoric plazas north of Mexico (Blitz 2008). Knowledge of the site's history and organization has benefited from decades of research and excavation (Knight 2010; Knight and Steponaitis 1998). Much is also known about house forms, residential groups, and artifact distributions (Thompson 2011; Wilson 2008). But the majority of excavations have focused on the mounds and areas impacted by road construction, about 18 percent of the site area. Meanwhile, recent systematic shovel, auger, and small unit tests have revealed artifacts, midden, and construction fill deposits in poorly understood locations such as the plaza (Steponaitis et al. 2009; Thompson 2011). Because the distribution and age of habitation features was unknown for much of the protected site, we implemented a low-impact research plan with a gradiometer survey as the guiding strategy to (1) map the distribution and density of ancient buildings and other buried features; (2) document the sizes, architectural forms,

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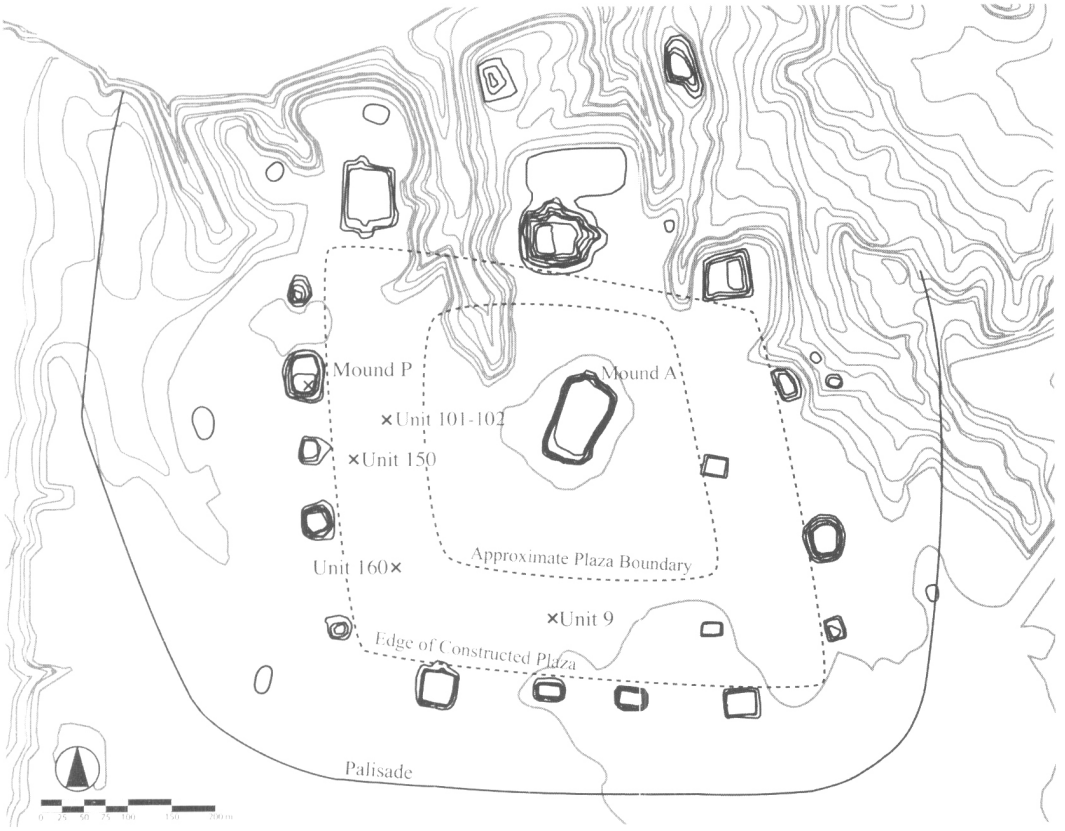


Figure 1. Outline map of Moundville with blocked and labeled locations of excavation units mentioned in the text.

and spatial arrangements of buried buildings, on mounds and in residential areas; (3) determine the occupational history of plaza; and (4) locate palisade walls. Once the gradiometer map was created, a sample of anomalies could be chosen for ground-truth excavations in order to correlate anomaly types with specific kinds of features and produce a site map of probable unexcavated buildings and other features. We also hoped to use what is currently known of diachronic changes in the construction and placement of architecture to assign probable unexcavated structures to historically relevant time spans: initial centralization (A.D. 1120–1200), regional consolidation (A.D. 1200–1300), entrenched paramountcy (A.D. 1300–1450), and collapse and reorganization (A.D. 1450–1650) (Knight 2010; Knight and Steponaitis 1998).

Over the course of 10 days in the spring and fall of 2010, Walker used a Bartington Grad 601 Fluxgate Gradiometer towed by an all-terrain vehicle or pulled by hand to survey and map 43 hectares of the site, including the tops of the massive earthen mounds. The instrument was passed along a 1-m traverse interval and a 10-Hz sample interval. An RTK GPS system was used to position the readings and guide the survey. Survey results were then imposed over a GIS map of the site, thus mapping the finds with high precision (Figure 2). The result is one of the most extensive, ground-based, geophysical surveys ever made of a prehistoric site in the United States. Survey procedures, technical requirements, and data processing issues are discussed in detail elsewhere (Davis 2014; Walker et al. 2013).

Ground Truthing Anomalies

The gradiometer site map was searched to identify possible cultural features recognized by geometric

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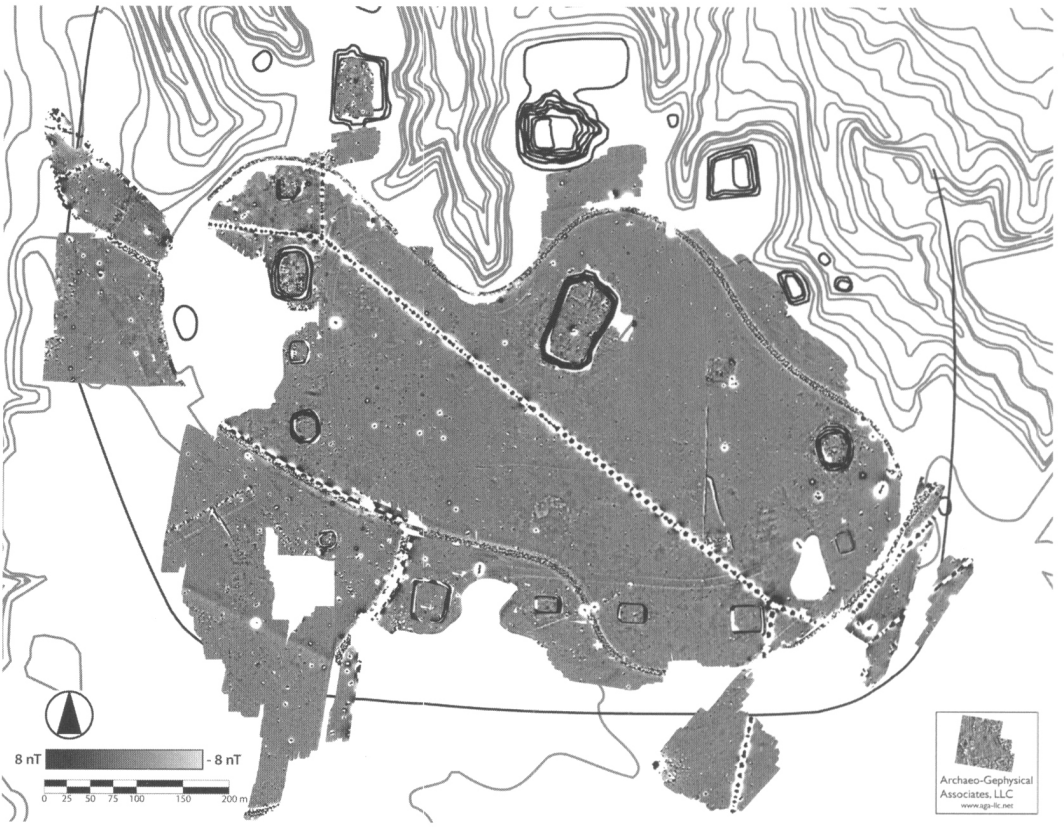


Figure 2. Map of the geophysical survey imposed over outline map of Moundville.

shapes unlikely to occur naturally and by variations in the amplitude of magnetic signals. Because our goal was to analyze community settlement patterns, we prioritized anomalies suspected to be buildings and hearths associated with buildings. Prior knowledge of Moundville architecture and variation in magnetic signals at other Mississippian sites created expectations about correlations of anomalies and features. Based on these criteria, we classified anomalies and proposed expected feature correlations. Type 1 anomalies are rectilinear moderate and high amplitude surrounding solid magnetic low amplitude with the expectation of an undaubed structure; the magnetic low interiors are interpreted as basin floors. Type 2 anomalies are rectilinear magnetic highs interpreted as daubed structures. Type 3 anomalies are rectilinear complex dipole clusters interpreted as burned/daubed structures. Type 4 anomalies are small, circular, magnetic highs at or near the center of a Type 1, 2, or 3 anomaly and interpreted as clay-lined or puddled clay hearths. Many other visible anomalies were ambiguous in outline or variable in amplitude such that we had no prior expectation about their correlations with cultural features. Our sampling strategy was not probabilistic but intuitive, with the goal of sampling a range of classified anomaly types and several of the ambiguous anomalies. In choosing the locations for the anomaly test excavations, we concentrated on anomalies in the mostly unexcavated plaza. We have no reason to believe that anomalies in the plaza manifested differently than anomalies in other areas of the site. With the exception of excavations on the summit of Mound P, we avoided tests on mounds and of magnetic low "pill-shaped" anomalies that might represent burials.

Forty-one test units were dug over three seasons to ground-truth anomalies. Twenty-seven of these were designed to correlate anomaly types with cultural feature types. Test units were posi-

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Table 1. Numbered Units as Cases by Anomaly Type, Unit Dimensions, and Results. Excludes Units Not Involved in the Effort to Correlate Anomaly Types with Cultural Feature Types.

Unit Name	Unit Dimensions	Result	Source (if negative)
Type 1 Anomalies			
Unit 21	1 x 2 m	+	
Unit 22	1 x 2 m	+	
Unit 100	1 x 2 m	+	
Unit 171	1 x 2 m	-	Unknown
Unit 172	1 x 2 m	-	Large posthole
Unit 175	1 x 2 m	+	
Unit 176	1 x 2 m	-	Unknown; posthole present
Type 2 Anomalies			
Unit 101-102	1 x 3 m	-	Undaubed monumental structure
Unit 133	1 x 2 m	-	Burned taproot at edge of Large, flat-bottomed pit
Unit 150	1 x 2 m	+	
Unit 160	1 x 2 m	+	
Type 3 Anomalies			
Mound P Summit	unit block	+	
Type 4 Anomalies			
N1658E1080	unit block	-	Large midden pit containing charcoal
N1669E1080	1 x 2 m	+	
N1693E1108	1 x 1 m	+	
N1699E983	1 x 1 m	-	Metal tent stake
N1707E1004	1 x 1 m	-	Unknown
N1708E1081	1 x 1 m	-	Metal wire
N1718E1056	1 x 1 m	-	Metal tent stake
Unit 9	1 x 1 m	+	
Unit 132	1 x 1 m	-	Unknown
Unit 173	1 x 1 m	-	Metal wire
Unit 174	1 x 1 m	-	Metal wire
AT-N1630.5E962.65	Auger test	-	Unknown
AT-N1660.69E836.65	Auger test	+	
AT-N1760.72E886.58	Auger test	-	Unknown
AT-N1833.36E907.74	Auger test	+	

tioned over sample anomalies with the aid of a total station, referenced to Moundville master grid coordinates, and georeferenced to the site GIS map. Table 1 presents anomaly test excavation results and correlations between anomaly type and cultural feature. Here we briefly summarize five examples of tested anomalies and the features that produced them.

Example 1, Units 101–102, tested a Type 1 anomaly at the northwestern plaza edge. Units 101–102 exposed a deep wall trench enclosing the clay-lined floor of a 100 m^2-building (Figure 3a–b). Example 2, Unit 160, tested a Type 1 anomaly at the southwestern plaza edge. Excavation encountered the midden-filled basin floor of a single-set post structure (Figure 3c–d). Example 3, Unit 150, tested a Type 2 anomaly at the western plaza edge. Excavation uncovered a clay-packed wall of a razed building encountered under plaza fills, intruded by a wall trench (Figure 3e–f). Example 4 tested a Type 3 anomaly that covers the upper terrace of Mound P. Excavations revealed an occupation surface littered with daub, the apparent collapsed wall remains of a razed monumental structure that once occupied the entire south end of the mound summit (Figure 3g–h; Porth 2011). Example 5, Unit 9, tested a Type 4 anomaly. Excavations penetrated a prehistoric fill layer to expose the clay-lined hearth of a square building (Figure 3i–j).

The Interpretive Site Map

With correlations between specific anomaly types and cultural features confirmed by the anomaly test excavations, the final step in the research plan was to extrapolate the correlations to unexcavated anomalies and create an interpretive map

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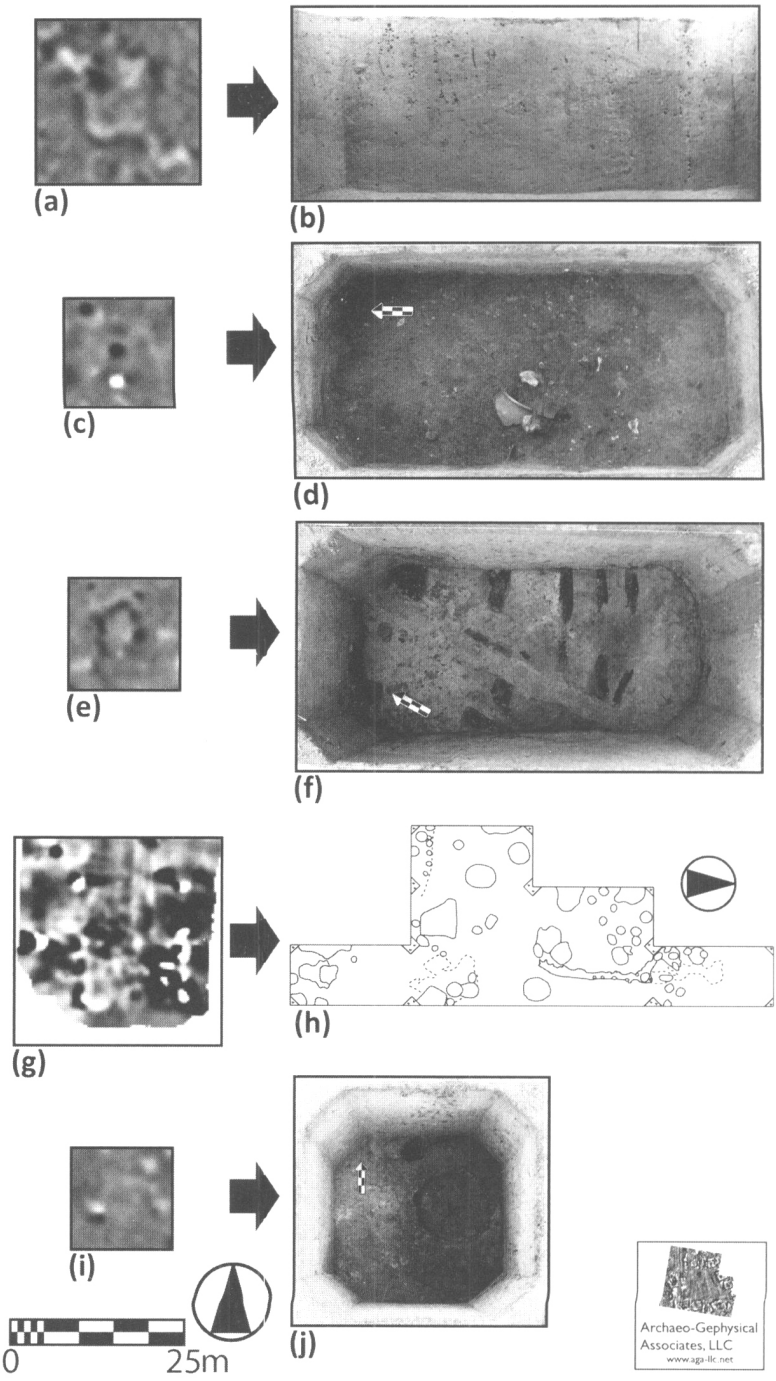


Figure 3. Examples of tested anomalies and the features that produced them: (a) section of gradiometer survey map showing Type 1 anomaly tested by Units 101–102; (b) Units 101–102 profile view of anomaly source; (c) section of gradiometer survey map showing Type 1 anomaly tested by Unit 160; (d) Unit 160 plan view of anomaly source; (e) section of gradiometer survey map showing Type 2 anomaly tested by Unit 150; (f) Unit 150 plan view of anomaly source; (g) section of gradiometer survey map showing location Type 3 anomaly tested atop Mound P; (h) line drawing of features associated with Mound P summit anomaly (from Porth 2011); (i) section of gradiometer survey map showing Type 4 anomaly tested by Unit 9; (j) Unit 9 plan view of anomaly source.

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Figure 4. Interpretative site map of Moundville based on results of geophysical survey.

that we hoped would reveal site settlement pattern changes over time. This procedure required detailed inspection of the gradiometer map to identify unexcavated anomalies that corresponded to an anomaly classification type and the associated form of cultural feature. Once identified, feature symbols in the size and shape of the anomaly were placed to mark the anomaly location on an interpretive site map. Because our primary research goal was to understand community settlement patterns, we decided to limit our coding of features on the interpretive map to structures and hearths. We found that we could identify two basic kinds of buildings: daubed structures and undaubed structures. These buried structure remains produce magnetic signals as a result of thermal and/or cut-and-fill events. Daubed structures are those buildings covered with a clay-and-straw plaster; the daub clay has a high ferric content and is often found burned to a brick-like consistency. Undaubed structures lack the clay plaster and are often constructed with wall trenches and/or basin floors. Daubed and undaubed structures represent distinct architectural forms that have different chronological spans at Moundville; undaubed wall-trench structures are common in the earlier part of the site's history, and daubed structures appear later in the later third of the sequence (Wilson 2008). We also identified anomalies as clay-lined hearths, which are positioned at or near the center of most structures.

Due to local variation in magnetic amplitude and other factors caused by variation in soil conditions, characteristics of nearby magnetic anomalies, and site formation processes, gradiometer images of anomalies are not always detailed or distinct. Thus, not all structures and hearths could be identified with confidence. As a result, features on the interpretive site map are divided into "probable" (the magnetic image is distinct) and

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"possible" (the magnetic image is less distinct). These feature variations are coded on the interpretive site map (Figure 4). Not shown on the interpretive site map are a multitude of anomalies that likely represent unidentified cultural features: pits, isolated posts, middens, burials, and even truncated mounds.

In the interest of making statements about diachronic changes in settlement configuration, the structures can be sorted into three chronological categories. Undaubed structures, coded yellow, date to the first three centuries of Moundville's history. Because available evidence suggests that the Moundville people began orienting their homes and other buildings to the cardinal directions only following the construction of the mound-and-plaza complex around A.D. 1200–1250 (Wilson 2005:25), we have separated the otherwise undifferentiated hundreds of undaubed structures into two more categories: non-cardinally oriented structures to the period of initial consolidation, ca. A.D. 1120–1200, and cardinally oriented structures to the regional consolidation phase and majority of the paramountcy entrenched phase, ca. A.D. 1200–1400. Daubed structures, coded red, predominated from A.D. 1400 to the site's final abandonment, ca. A.D. 1650 (Lacquement 2007). We believe that these categories provide an exciting starting point for ongoing interpretations and future research.

Conclusions

The geophysical survey, gradiometer map, ground-truth excavations, and the resulting interpretive site map confirm the utility of remote sensing for community settlement analysis. The investigation has significantly changed our understanding of Moundville's history and community organization. Approximately 450 probable structures have been located, almost five times the number discovered by traditional excavation at Moundville. The number of newfound structures is nearly doubled if possible structures are included in the count. The majority are domestic house forms that cluster in residential groups, a residential pattern known previously from excavations (Wilson 2008). However, domestic structures extend over a much larger area than previously documented, and this suggests a larger residential population than earlier estimates. Other structures, some quite large and with distinctive shapes, have no known excavated examples at Moundville, though they are known from other Mississippian sites.

Perhaps the most revelatory, though not entirely unexpected, finding of Moundville geophysical survey and the ensuing efforts to correlate anomalies with archaeological feature types is the sheer number of structures in the central plaza area. The vast majority date to the initial settlement of the site, dismantled and buried in the process of plaza construction. That area was *mostly* cleared of structures during the following centuries, its margins defined not by the surrounding mounds, but by a dense band of encircling domestic and nondomestic architecture. Late-phase daubed structures are found mostly on the western half of the settlement, such as south of Mound R and on and around a probable truncated mound, also previously undocumented, in the southwest section of the site, locations where previous auger and small test excavations found thick midden deposits dating to the late Moundville II through Moundville III phases, A.D. 1350–1520 (Thompson 2011). This finding is significant because during this time span Moundville is interpreted as a depopulated ceremonial center (Knight and Steponaitis 1998). As a result of the survey, we have evidence that there was a substantial residential population at this time, although apparently reduced in number from the earlier interval, as can be seen by the greater number of undaubed probable structures. The interpretive map is a research and planning tool; it achieves the goal of aiding community settlement analysis, permits problem-oriented, low-impact excavations to target specific features and locations, and can help archaeologists and site managers to avoid disturbing ancient remains at this protected site.

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