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Discovering Rock Features with Geophysical Exploration and Archaeological Testing at the
Mississippian Pile Mound Site, Upper Cumberland Plateau, Tennessee

A thesis

presented to

the faculty of the Department of Geosciences

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Master of Science in Geosciences

by

Jeremy G. Menzer

May 2015

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Keywords: Pile Mound, Archaeological Geophysics, Ground Penetrating Radar, Magnetometry,

Mississippian Mound

ABSTRACT

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The Pile Mound survey includes magnetometry paired with targeted ground-penetrating radar (GPR) and electromagnetic induction (EMI) surveys of the mound and testing of associated features over the ca. 6.5 ha site. The GPR survey discovered six rock features (five large rock features within the mound and one marking the outside of the mound). Knowledge of mounds in the Upper Cumberland Plateau (UCP) is lacking—the closest other studied sites are at the Corbin Site, Croley-Evans, Bell Site, and Beasley Mounds, approximately 75 – 100 km away. However, the most similar mound construction is found at Corbin and Cherokee sites, some 175 – 275 km away. In addition, the associated ceramic assemblage appears to reflect more similarity to the East Tennessee Valley rather than the Middle Cumberland region. These data provide a unique opportunity to better understand the Mississippian occupation in the UCP of Tennessee.

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CHAPTER 1

INTRODUCTION

Humankind has long been curious of the past. Either through oral or written history people have continuously yearned for knowledge of their own and other cultures' history. Aside from historians, archaeologists provide history books with prehistoric and historic information when it is lost or misconstrued through time. They dig, prod, and scour landscapes looking for evidence to build the ideas that populate these books. In this manner, this thesis is a result of a desire to understand a prehistoric culture. Its goal, albeit preliminary, is quite simple—to learn about the prehistoric peoples that once inhabited Pile Mound. Outside of the classic archaeological method of digging to discover what lies beneath the ground, this project employs the use of near-surface geophysics. These techniques, ground penetrating radar (GPR), magnetometry, and electromagnetic induction (EMI), allow for subsurface features to be detected and mapped before any trowel or shovel strips away the earth. From these geophysical data, inferences and archaeological interpretations can be made, but often features still need to be unearthed for a better understanding of the archaeological record.

Pile Mound History

Pile Mound is a Mississippian mound on the Upper Cumberland Plateau (UCP) near the three forks of the Wolf River in Fentress County, Tennessee (Figure 1). It was originally recorded by Myer (1924:38) as a single unexplored mound 100 feet in diameter and 5 feet high. The land encompassing the site has been in the same family for many generations dating back to before Myer's recording. Many prehistoric mound sites in North America have been demolished by construction or agriculture. It is through this family's respect for ancient peoples that the mound is able to be studied today. The family has not plowed the mound for at least eight generations,

and the landowner believes plowing never occurred. The landowner does report that his grandfather and friends dug into the mound and stopped when they hit “bricks” (Personal Communication Landowner). More recently, a shovel test pit was placed atop the mound by Alexander Archaeological Consultants in 1996 (Tennessee Division of Archaeology 2014). In 2005 a fence row was placed across the mound dividing it between two landowners (Figure 2). During this project access to the western side of the mound was not granted. Otherwise no accounts of other archaeological testing or disturbance was recorded prior to this project. The elevation change between the current mound top and base of the eastern slope is 2.225 m (7.3 ft.) (Figure 3), thus it stands to reason that no destruction of the mound has occurred since Myer's first recording.

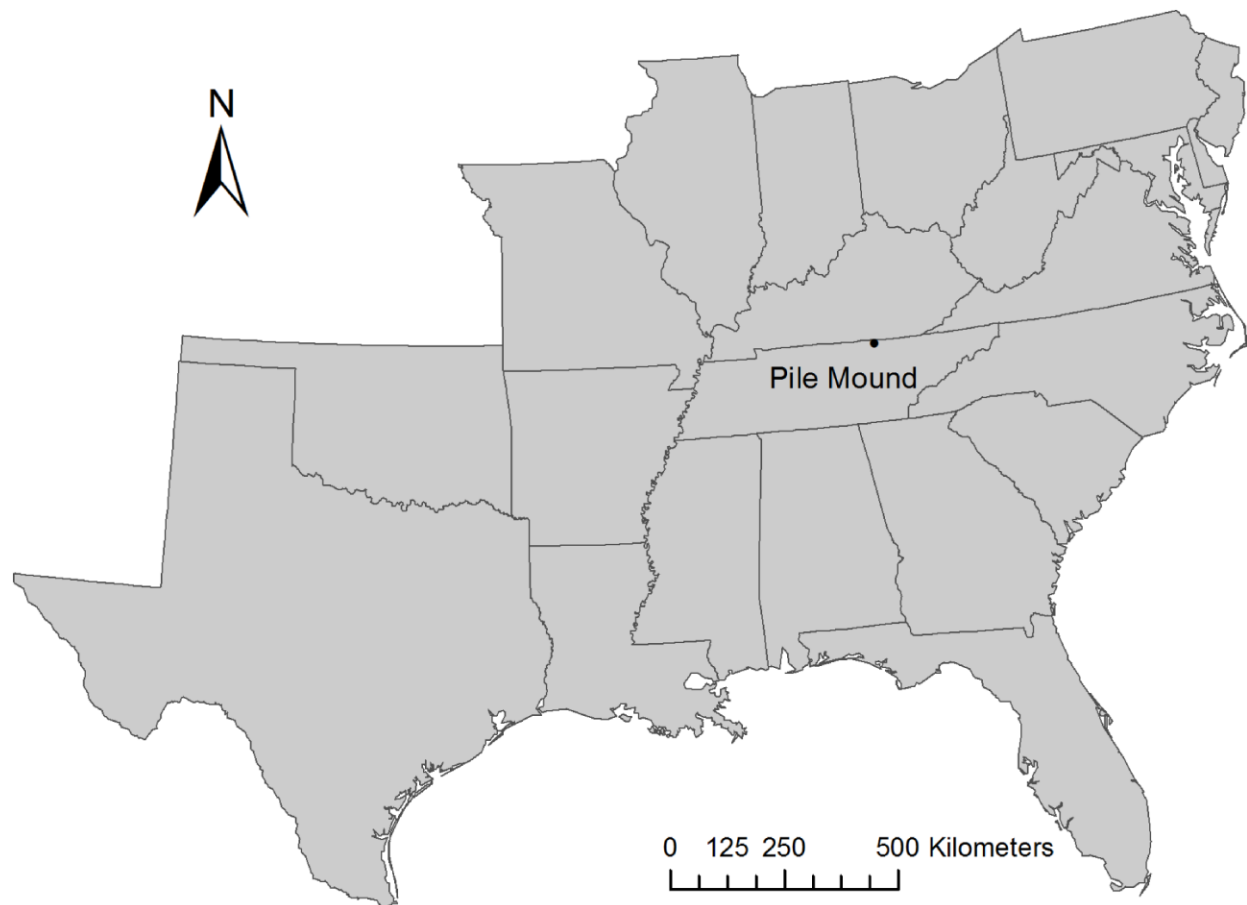


Figure 1. Site Location. Pile Mound's location in the southeastern United States.



Figure 2. Pile Mound. Photograph looking Northwest showing Pile Mound bisected by fence row. Photographed 03/01/2014.

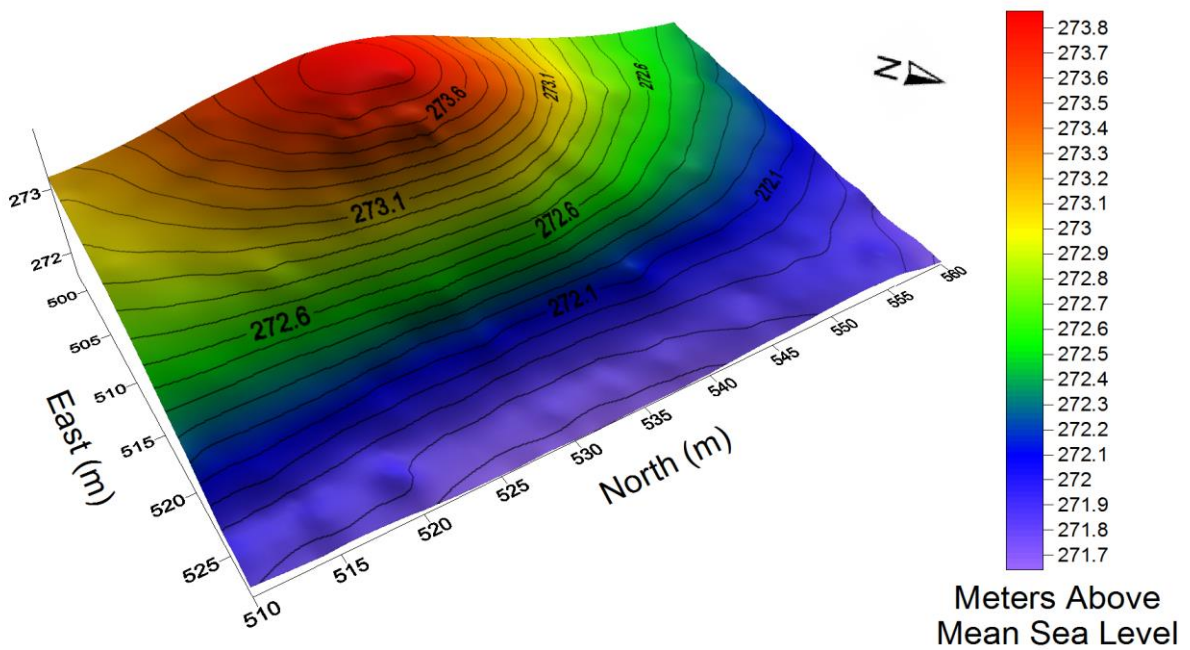


Figure. 3. Mound Topography. Three dimensional surface of Pile Mound.

The site sits on the western edge of the Cumberland Plateau in an upland environment where Mississippian mounds are scarcely documented. This may be more an artifact of archaeological sampling bias, however. Franklin (2002) discusses how this region of the UCP has been viewed as a marginal zone in comparison to more prominent lowland regions, and his work represents the first large area survey of the region. He goes on to show through mainly rock-shelter and cave sites that this area should not continue to be viewed as a marginal zone. Similar to Franklin's 2002 work, Pile Mound is the first Mississippian mound site to be studied and well-documented in an approximately 75 – 100 km radius—showing the broader region's Mississippian component has been understudied. Additionally, it is the first site in the region to be studied with geophysical techniques.

Objectives

This project is a combination of multiple field excursions in 2014. Two short excursions occurred in March and May 2014, both concentrated on geophysical data collection (magnetometry and GPR, respectively). These data assisted in directing further geophysical data collection, archaeological testing, and excavations at an archaeological field school in July 2014. The field school was directed by Dr. Jay Franklin, East Tennessee State University, Department of Sociology and Anthropology. Subsequent GPR data collected in November 2014 aimed to answer research questions based on preliminary data interpretations. This thesis is the result of an interdisciplinary project combining near-surface geophysics and archaeology. It focuses on the geophysical aspect of the project, however, archaeological background and excavation data are provided and discussed as needed.

First, Chapters 2 and 3 provide general background information. Chapter 2 summarizes the four prehistoric periods of the Southeast: Paleoindian, Archaic, Woodland, and Mississippian,

with particular focus on the Mississippian. Chapter 3 introduces the concepts of three near-surface geophysical techniques: magnetometry, electromagnetic induction, and ground penetrating radar. Next, context to the application of geophysics to archaeology is provided.

Chapter 4 outlines the field and data processing methods of this project. An explanation of geophysical data collection and data processing is provided. In addition, the specific methods used at Pile Mound are provided. Then, the classic archaeological methods used are described. Due to the amount of data collected for the project only a subset is provided in Chapter 5, as the rest is beyond the scope of this thesis.

The geophysical and archaeological results are then discussed in Chapter 6. Comparative sites are identified and compared to Pile Mound, and an archaeological interpretation of Pile Mound is provided. Finally, the ideas presented throughout this thesis are concluded and future work is provided in Chapter 7.

CHAPTER 2

CULTURE HISTORY

Due to the interdisciplinary nature of this thesis, combining the fields of archaeology and near-surface geophysics, background information is given for both. This chapter provides introductory information for a somewhat diverse audience of archaeologists and geoscientists. The prehistory of the Southeast is summarized including the Paleoindian, Archaic, Woodland, and Mississippian time periods, with a more in-depth discussion of the Mississippian because this time period encompasses the main occupation at Pile Mound.

The Southeast

All of the archaeological background provided herein is in regards to the “Southeast Culture Area”. This term varies through time and between scholars (Figure 4), but in general the area is bounded to the West near the Mississippi river and to the North near the middle of Missouri following a line East to Delaware. By defining regions as culture areas, classification of social groups can be made based on their cultural traits (e.g. architecture, ceramics, mythology, rituals, social grouping, and tools) (Wissler 1938:vii-viii, 219-220). This allows anthropologists to categorize similar peoples and regions.

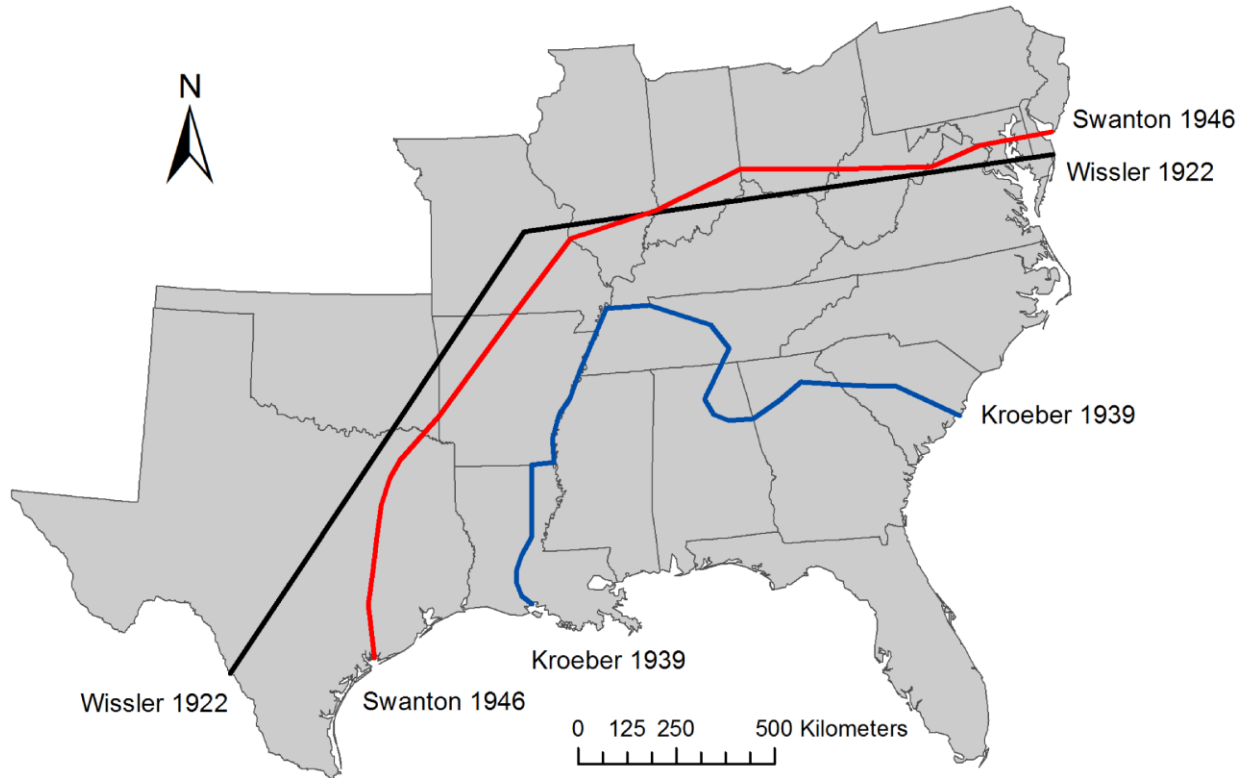


Figure 4. The Southeast. Culture Area as defined by Clark Wissler in 1922, A.L. Kroeber in 1939, and John R. Swanton in 1946. These boundary lines show just a few of the “Southeast boundaries” and in general the boundary lies somewhere in between these bounding units. Adapted from Wissler 1938:221; Kroeber 1947:66; Smith 1986:2

The Paleoindian Period

The archaeological record shows that humans arrived in the Southeast after the last glacial maximum ca 21,000 cal year B.P. The time between the first arrival of Native Americans during the Pleistocene until around 11,500 cal year B.P. is known as the Paleoindian period (Anderson and Sassaman 2012:36). During this time people most likely congregated into highly mobile bands of hunter-gatherers that could move across the landscape and would occasionally aggregate into larger groups for one to two weeks throughout the year (Anderson and Sassaman 2012:52).

The end of the Younger Dryas, which occurred approximately 200 years before the Holocene, marked a change from the cold Pleistocene environment to Holocene like conditions (Anderson and Sassaman 2012:38-39). The diverse fauna in the Pleistocene Southeast included many species present today (bears, rabbit, opossum, raccoon, white-tailed deer, turtles, and common fish) along with now extinct late Pleistocene fauna including mammoths, mastodons, and saber-toothed cats (Anderson and Sassaman 2012:40-41). The warming climate also pushed many cold-adapted plants north or to higher elevations, while those that were unable to do so disappeared locally (Anderson and Sassaman 2012:44).

Around this time, approximately 13,000 years ago, the southeastern archaeological record shows a stark increase in sites and artifacts, which suggests a rise in population. The Clovis spear point, a very distinct style of lithic technology, is introduced and becomes widespread (Anderson and Sassaman 2012:47). There are high concentrations of Paleoindian sites and artifacts in parts of Florida, the Atlantic Coastal Plain, and near major rivers including the Ohio, Tennessee, and Cumberland in the Southeast (Anderson and Sassaman 2012:50). The Paleoindian period spans over 10,000 years of human history and culture, though most of what is known is concentrated towards the end of that time period. Formerly, archaeologists envisioned a striking difference between the material culture and settlement patterns of Paleoindian and the following Early Archaic peoples. A fluid transition between these periods is now becoming evident (Anderson and Sassaman 2012:64).

The Archaic

The Archaic period spans over 8,000 years in the Southeast. This time is often divided into Early (11,500-8,900 cal years B.P.), Middle (8,900-5,800 cal years B.P.) and Late (5,800-

3,200 cal years B.P.). These divisions are primarily based on differences between subsistence technologies such as hafted bifaces and environmental and population changes (Anderson and Sassaman 2012:66). In general the Archaic is thought of as a transition between the less organized and less populated Paleoindian period and the subsequent Woodland and Mississippian (Anderson and Sassaman 2012:66).

Early Archaic

The Early Archaic is categorized by a global warming trend associated with the beginning of the Holocene and the expansion of hardwood forests out of the Southeast to the North (Delcourt and Delcourt 1987:20-23). After the introduction and disappearance of Clovis culture during the end of the Paleoindian period, a change in culture and technology took place that carried over into the Early Archaic (Anderson and Sassaman 2012:72). An example of adaptation to the environmental and cultural changes is the intensified use of rock shelter and cave sites in the Southeast during the Early Archaic (Walthall 1998; Anderson and Sassaman 2012:71). Another trademark of the Early Archaic in the Southeast is the variety of changes and adaptations seen in lithic technologies (Anderson and Sassaman 2012:72). This change in lithic technology along with a transition in the style of projectile points is viewed by some as evidence for a shift from intermittent big game (e.g. mammoth and mastodon) hunting to more frequent hunting of smaller game (Anderson and Sassaman 2012:72). Also during this time, a fallout of formal “toolkits”, a set of high quality stone tools that could be modified when needed and were easily carried across a landscape, and an increase in the frequent use of local raw materials for tools can be seen (Anderson and Sassaman 2012:72). Although there is a change in technologies and subsistence strategies during this time, the Early Archaic peoples were still organized into

mobile bands. These bands tended to stay in a somewhat localized region such as a river drainage system or some other physiographic environment, presumably with access to water and raw materials (Anderson and Hanson 1988; Dunbar 1991; Daniel 1998, 2001). Even though these groups were localized, they were a part of loose affiliations with other bands for partner and information exchange (Anderson and Hanson 1988; Anderson 1996:39-45).

Middle Archaic

The Middle Archaic coincides with the general warming trend known as the Hypsithermal, Altithermal, Atlantic Optimum, or Climatic Optimum. This period, ca 8,900-5,800 cal years B.P., is characterized by much greater extremes in temperature and precipitation compared to today (Anderson and Sassaman 2012:73). Similar to many periods the Middle Archaic is often recognized by the introduction of an adaptation to lithic technology, specifically stemmed bifaces, represented by a distinct stem or solid protrusion at the base of a projectile point (Anderson and Sassaman 2012:73). Also during this time there is evidence for an expansion of cultures and societal complexity based on: (1) large freshwater shellfish middens in the Midsouth and Florida, (2) introduction of earthen mounds in the Mississippi Valley and then in Northeast Florida, (3) an expansion of long-distance trade networks, (4) new technologies such as bannerstones being combined with rituals, and (5) evidence of warfare or violence is (Anderson and Sassaman 2012:73).

Late Archaic

By the beginning of the Late Archaic around 5,800 cal years B.P., the climate was similar to modern times (Anderson and Sassaman 2012:74). Cultural designations during the Late Archaic rely on changes or variations in lithic technology, but after 5,000 cal years B.P. pottery

was introduced in the South Atlantic Slope and then the lower Midsouth, Gulf Coast, and Lower Mississippi Valley (Saunders and Hayes 2004:1-3). Similar to the Middle Archaic, expansive trade networks existed during the Late Archaic. The terminal Archaic Poverty Point culture located in Northeast Louisiana is a case in point (Anderson and Sassaman 2012:75).

The Woodland Period

Like the Archaic, the Woodland period is separated into three time periods, Early, Middle, and Late. Broadly speaking, these occur at 700-100 B.C.E., 100 B.C.E.-500 C.E., and 500-1000 C.E. (Jefferies 2004:115). During the Archaic, especially the later portion, there was the introduction and increased use of specific cultural features such as pottery and earthen mounds. These cultural traits truly become widespread and important throughout the Woodland period in the Southeast (Jefferies 2004:115).

Early Woodland

The beginning and duration of the Woodland period varies throughout the Southeast, but the Early Woodland roughly spans between 700-100 B.C.E. (Jefferies 2004:115). In general, this time period is marked by an increase in the use of and diversification of ceramics, horticulture, aquatic resources, and burial mounds (McNutt 1996:169). Ceramic temper shifts from fiber to clay, sand, and varieties of crushed rock (McNutt 1996:169-170). There is a notable shift around 500 B.C.E. in the Tennessee River drainage system from various tempers to specifically crushed limestone (Hally and Mainfort 2004:265). Domestication of plants began before this period, but an expansion of native plant horticulture increased throughout the Early Woodland with a focus on squash, goosefoot, marsh elder, maygrass, knotweed, and sunflower (Fritz 1997; Gremillion 1998:148; Jefferies 2004:117). The use of burial mounds became much more prominent during

the Early Woodland not just in the heart of the Southeast, but is also found along the northern boundary of the Southeast culture area (Jefferies 2004:118). These mounds were constructed of earth and stone and were generally associated with ceremonial activities. Although burial mounds are more common in the Early Woodland than previous periods, they are not indicative of the Early Woodland and little is known about the mortuary practices of the many Early Woodland groups that did not use burial mounds (Hally and Mainfort 2004:267 and Jefferies 2004:118).

Middle Woodland

The Middle Woodland period began around 200-100 B.C.E. and lasted until 300-500 C.E. depending on the region (Anderson and Mainfort 2002:9; Jefferies 2004:119). Like most of the Early Woodland, changes in pottery, mostly surface treatments, are the most diagnostic characteristics linking native peoples and the archaeological sites to a specific culture (Hally and Mainfort 2004:268; Jefferies 2004:119). Other than variations in ceramics, data describing subsistence can be sparse, though white-tailed deer were surely an important food source (Jenkins 1982:71-72; Jefferies 2004:119). Peoples were still living in dispersed groups during this time period, but had begun to occasionally congregate into small villages (Jefferies 2004:120). These villages or homesteads were made up of small round or oval domestic structures measuring between 6.5 and 8 m in diameter. The houses utilized bent pole construction, where wooden poles are placed vertically in the ground and bent over at the top to form the wall and roof, and had a few associated storage pits (Hally and Mainfort 2004:268). These small groups most likely came together for ceremonial purposes often associated with a burial or platform mound (Jefferies 2004:121). Middle Woodland platform mounds differ from

those of the later Mississippian societies in that they were strictly used for rituals and no domestic purposes were associated with them (Hally and Mainfort 2004:270). The greatest concentration of these Middle Woodland mounds in the Southeast occurs in northern Alabama within the Tennessee River Valley where over 50 mounds are associated with what is called the Copena mortuary complex (Beck 1995:172-173). These mortuary complexes were not uncommon throughout the Southeast and by 1 C.E. there is a clear increase in social and political network complexity throughout the region (Jefferies 2004:122). Although infrequent in Southeast assemblages, much of the Middle Woodland in other regions is characterized by the presence of Hopewell culture artifacts (Seeman 1979).

Late Woodland

Varying throughout the Southeast, the Late Woodland period occurs between 300-1,000 C.E. (Anderson and Mainfort 2002:15; Jefferies 2004:124). Like previous periods ceramic temper is quite variable by region and is most often limestone or some other crushed rock—there is however a decrease in decorative surface treatments, with most pottery being cord-marked or plain (Hally and Mainfort 2004:271). One major distinction in the Late Woodland is clear evidence of bow and arrow technology. This is distinguished by small triangular and notched points around 700 C.E. (Railey 1996:111; Nassaney and Pyle 1999). In contrast to the Middle Woodland, there seems to be less evidence of exchange networks during the Late Woodland and in some regions a decrease in mound construction (Hally and Mainfort 2004:272). This decrease is not universal and in a few areas an increase in mound construction occurred (Hally and Mainfort 2004:272). Overall the Late Woodland mounds were used specifically for burials and

rituals, and therefore systematically differ from the Mississippian mounds that follow (Hally and Mainfort 2004:273).

Mississippian

Mississippian Culture: Basics

The Mississippian period began at the close of the Late Woodland around 1000 C.E. The beginning of its closure is marked by European contact in the mid-sixteenth century, although a Mississippian way of life persists throughout parts of the Southeast until much later (Anderson and Sassaman 2012:152). Mississippian culture spans across the Southeast and is bound in the north by the headwaters of the Tennessee River in present day Southwest Virginia and the Cumberland River in Southeast Kentucky (Jefferies et al. 1996; Hally and Mainfort 2004:274). Unlike previous cultures, few lithic tools are recovered from Mississippian sites (Roberts 1987; Smith 1994:139; Lewis and Lewis 1995). Corn agriculture increased during the Mississippian due in part to the limit of Late Woodland subsistence strategies to sustain increasing populations (Ambrose 1987; Boutton et al. 1991; Buikstra 1992; Hally and Mainfort 2004:273). Secondary sources of food were cultivated or foraged including beans, squash, white-tailed deer, turkey, fish, and hickory nuts and some animals, particularly turtles, were possibly collected for ritual or ornamental use (Hally 1981; Hally and Mainfort 2004:278). Out of the animals hunted, white-tailed deer were by far the most targeted with various types of bear often being second, depending on region (Hally and Mainfort 2004:278). Though most sites show a strong focus on maize agriculture, some sites (notably the Croley-Evans site in Southeast Kentucky) have high yields of nutshell compared to maize, (Jefferies et al. 1996; Hally and Mainfort 2004:278).

Early Mississippian pottery is characterized by plain and smoothed surfaces and predominantly shell, but sometimes limestone or other temper, is distributed throughout most of the Southeast except the eastern edge (Piedmont and Blue Ridge) (Hally and Mainfort 2004:273-274). The changes from Woodland to Mississippian ceramic form indicate that Woodland peoples transformed into Mississippian and the Mississippian culture was not derived from an immigrant population (Schroedl et al. 1985:247). Hally and Mainfort (2004:274) discuss that by creating pottery typologies, cultural phase sequences have been developed for specific regions and that change from one cultural phase to another can be determined via pottery typologies. The individual cultural phase sequences last anywhere from 50-300 years and their chronology is more easily determined when the pottery typologies are well documented.

Unlike any of the previous time periods and native cultures, the Mississippian has been documented by Europeans. Early Spanish colonies in Florida and the expeditions of de Soto, de Luna, and Juan Pardo produced written accounts, if only minimal, of the Mississippian way of life (Hudson 1990:3-18). Hally and Mainfort (2004:273-274) describe seven key features of Mississippian culture gathered from early accounts: (1) individual chiefdoms were made up of communities, but controlled by one leader, (2) the leaders were a single individual usually male, but could be female, and they were thought to be semidivine and possibly descended from the sun, (3) the chief's divinity was supported by a cult of the chief's direct ancestors and the rules that allowed the chief to control food and other items, (4) chiefdoms were controlled from a town that had one or more platform mounds, (5) platform mounds were an integral part of the political and religious aspects of Mississippian society—the chief's house, and a temple with the chief's ancestor's bones, and a sacred fire were located atop a mound, (6) successive mound building

events occurred when the chief died and involved the destruction of the chief's house and most likely the temple—then a layer of earth was added to the mound before the successor's house and probably temple were constructed, (7) a chief had control, even if minimal, over food and wealth items. Although these features, and other aspects of Mississippian life are in some ways unlike those of their predecessors, there was surely no one process or factor that caused the development of Mississippian culture (Smith 1990).

With the transition to Mississippian culture, many if not all of the native groups in the Southeast increased in social and political complexity forming into chiefdoms (Earle 1987). The degree of occupation in Mississippian chiefdoms throughout the Southeast is determined by the density and number of platform mounds found (Hally and Mainfort 2004:274). One or more towns with a platform mound would make up a chiefdom—towns being usually within a 20 km range, relating to the approximate distance people could travel by foot to other towns in a single day (Hally and Mainfort 2004:281).

Mounds

Earthen mounds may be the most publicized and well-studied aspect of Mississippian culture, due in part to their easy identification compared to other sites and countless depression era excavations through the Works Progress Administration (WPA), Tennessee Valley Authority (TVA), and Civilian Conservation Corps (CCC). During the Archaic and Woodland periods mounds were associated with religious events or burials, but they were not domestic sites—this changes in the Mississippian. Throughout the Mississippian, towns increased in size and some became fortified. Towns with platform mounds were now political and economic centers. The one or more structures located atop the mounds represented the political and economic powers of

the town or chiefdom (Webb 1938; Kelly and de Ballion 1960; Kelly and Neitzel 1961; Dickens 1976; Polhemus 1987; Smith 1994:25; Hally and Mainfort 2004:273). Some small single mound centers which were often located at the edge of the Mississippian region only had one or two structures at the summit (Jefferies et al. 1996; Hally and Mainfort 2004:280). Hally and Mainfort (2004:280) outline why these mounds and the structures at their summit were built in three different time frames. The shortest occurring approximately every 10 years when structures were rebuilt due to natural decay or accidental fire. Next, the demolition of structures and then addition to the mound and rebuilding of new structures marked the transition between chiefs, and simple mound additions added about every 20 years (Polhemus 1987; Hally 1996).

Mound centers also had a plaza and often some kind of defensive structures including a palisade, ditch, embankment, or some combination of these (Larson 1972; Butler 1981; Blitz 1993; Lewis and Lewis 1995). Because the components of mound centers (architecture, burial or non-burial use of mounds, and overall town layout) were extremely similar throughout the Mississippian world, it is believed they were built following commonly shared plans (Hally and Mainfort 2004:280). The plaza was often placed next to a single mound or between or encircled by multiple mounds which at some sites ranged from 1 to 29 mounds (Hally and Mainfort 2004:280). Sometimes the plaza surface was outlined with a wooden palisade (Blitz 1993:57-58). Most often a mound center (mound or mounds and an adjoined town) would span a few hectares (2-5), but in some cases (e.g. Moundville and the Macon plateau) they are larger than 70 hectares (Hally and Mainfort 2004:280). Mound sites generally occur near or within large river valleys and the highest concentrations of mounds are found on expansive floodplains (Hally and Mainfort 2004:274). There are sites located in higher elevation regions however, specifically in

the Oconee and Middle Cumberland river systems and the Black Belt district of Alabama (Butler 1981; Johnson and Sparks 1986; Kowalewski and Hatch 1991; Hatch 1995).

Settlement Pattern

The movement from dispersed homesteads or small villages in the Woodland period to larger settlements in the Mississippian could be a response to increased population during this time, especially because Mississippian settlements were often fortified possibly due to competition with other chiefdoms over resources (Hally and Mainfort 2004:273). Commonly, Mississippian settlements were nucleated towns with or without a mound or mounds, otherwise they were scattered farmsteads (Hally and Mainfort 2004:279). A Mississippian household consisted of paired summer and winter houses. A household makes up the basic economic and social unit within a town and chiefdom. Often summer houses are not seen in the archaeological record, partly due to their light construction, but there are European accounts of the two types of homes (Faulkner 1977 and Hally and Mainfort 2004:278). Winter houses were constructed in two ways: small or large post. Small post construction occurred earlier and were often square or oblong with sides ranging from 4 – 7 m. These could be constructed with wall trenches or single set poles and were sometimes built in shallow basins (Lewis and Kneberg 1946:49-79). In contrast large post structures were square with 5 – 8 m sides and utilized single set poles. A steeply pitched roof was supported by 4 interior posts (Adair 1930:451). In either type of structure hearths were commonly located in the center (Hally and Mainfort 2004:276). Remains of some of the more lightly constructed summer houses have been documented in late Mississippian sites in northern Georgia, East Tennessee, and central Alabama (Polhemus 1987; Sullivan 1987; Hatch 1995; Hally and Kelly 1998:54-56). Summer houses were built very lightly

and were open possibly without walls—they were most likely used as a covered workspace to shelter people from the sun and rain and may have also doubled as corn cribs (Polhemus 1987; Hally and Mainfort 2004:277).

Upper Cumberland Plateau

The Cumberland Plateau like other upland regions has long been considered an archaeological black hole or terra incognita (Faulkner 1968:54). The main factors for this idea can be drawn from a historic bias about mountain peoples and lack of archaeological interest in the region. The idea that these peoples are backwards or in some sense not connected to the greater society can be documented in the Appalachians through historic time and is still present today. This idea has sometimes been projected onto the prehistoric peoples of the region. Also, the general sense of upland regions, specifically the UCP, was that native peoples used this area only for hunting grounds (Franklin 2002:2). Due in part to these biases, many lowland regions have been documented while upland regions were neglected by southeastern archaeologists (Franklin and Bow 2009:145). Also, simply because today there are lower population densities in many upland regions, less development and related archaeological work has occurred.

The first large archaeological survey on the UCP of Tennessee did not occur until Franklin (2002). Franklin's (2002) initial work showed consistency with this upland environment, a combination of karst and other sedimentary rocks, because the majority of sites surveyed were rock shelters, found in sandstone bluffs, and caves, in local limestone. In fact this study region has hundreds of caves and likely thousands of rock shelters making it markedly different from surrounding regions (Franklin and Bow 2009:145). Franklin and colleagues' work (Franklin 2002, 2008a, 2008b; Franklin and Bow 2009; Franklin et al. 2012) have shown the

UCP, although a different physiographic province, was not excluded or marginally used throughout prehistory. The above studies show continuous occupation from mostly Late Archaic (some Paleoindian) through Mississippian times. Although, the majority of the work has been in rock shelters and caves there is a clear Mississippian component. Also from part of this work more information has been gained about Jaguar Cave —a site with a Mississippian component (Franklin 2002, 2008) approximately 600 m south of Pile Mound. This adds to the necessity of the current study by the author, as it is the first archaeological survey of a Mississippian mound in the region.

CHAPTER 3

GEOPHYSICS

Geophysics is a remote sensing technique that aids in understanding the subsurface of the Earth. Where other remote sensing techniques (e.g. aerial photography, satellite imaging) typically view only the surface of the Earth, geophysical techniques detect variations in the physical and chemical properties underground. Simply, geophysics is used to map, characterize or “see” through the surface and into the ground (Witten 2006:1). Geophysical applications vary widely from environmental issues, hazard detection (earthquakes), mineral and petroleum detection, and archaeological prospection, with petroleum exploration being the most common (Witten 2006:1-2). While many of these uses lead to deep exploration of the Earth, archaeological applications focus on combining multiple techniques to measure aspects of and produce maps and profiles of cultural remains within the near-surface, usually the top 1-2 m (Conyers 2010:1 and Kvamme 2003:439). The four most commonly used techniques are magnetometry, electrical resistivity, ground penetrating radar (GPR), and electromagnetic conductivity (Kvamme 2003:439). This thesis uses magnetometry, magnetic susceptibility, and GPR. Each technique has the ability to map the subsurface, but GPR is the only technique that can precisely measure depth (Conyers 2010:3). Because most, if not all, of these methods were developed for environmental or geological applications, the earliest archaeological geophysics users were physicists, geologists, or from some other “hard science” discipline and not from anthropology or archaeology (Bevan 1983; Scollar et al. 1990:xiii, 2; Ovenden 1994; Clark 2001; Hildebrand et al. 2002).

Multiple factors determine the success of an archaeogeophysical survey, but the most important is “contrast”. Because geophysical detection works by measuring one or more electromagnetic properties of the subsurface, some level of contrast between archaeological features and the surrounding matrix must be present (Kvamme 2003:439-400, 2006:206; Aspinall et al. 2008:27; Conyers 2013:27; Goodman and Piro 2013:15). Since archaeological features do not always exhibit both electrical and magnetic contrast with the surrounding matrix, it is always best to use multiple methods of detection (preferably those that measure different properties) (Piro et al. 2000; Clay 2001).

Even with the use of multiple methods measurement, sampling must be dense enough to resolve archaeological features of interest (Kvamme 2003:400). For simplicity a scenario is presented: five 10 x 10 m houses are buried in a 100 x 50 m area (about the size of a football field) and the area is flattened so that there is no surface evidence of the house locations. One is tasked with finding these houses and the area is gridded into 10 x 10 m sections following the scientific process. Now, one 1 x 1 m unit is dug in each section at random. It is clear that the probability of digging inside a house, much less digging into a house wall, is minimal (Figure 5).

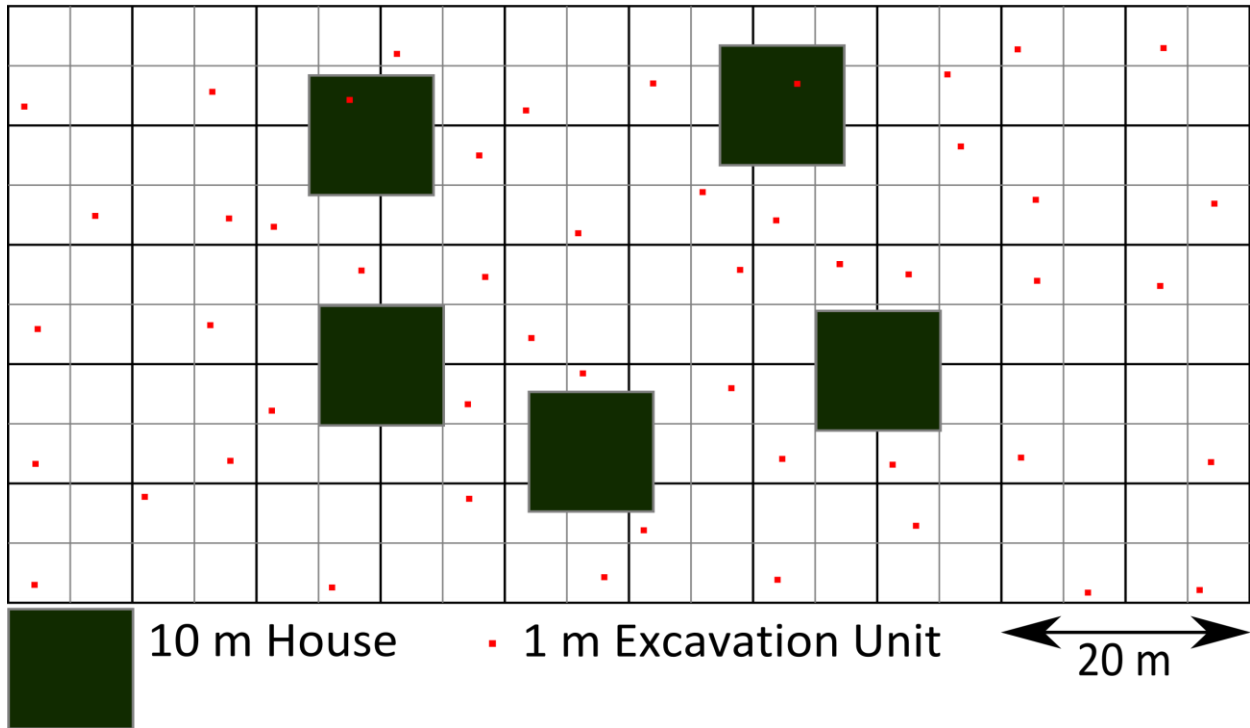


Figure 5. Archaeological Testing. A representative map of a site 50 x 100 m (approximate size of a football field) with five 10 x 10m houses located throughout. The site is divided into a 10 x 10 m grid system with a 1 x 1 m excavation block placed at random in every grid block.

The above scenario represents the most common archaeological practice in the United States (shovel test pits). Much akin to this scenario geophysical readings sampled at low density do not easily resolve features. Even with a high density of measurement, discovering small artifacts is extremely uncommon and large features (e.g. large post holes, hearths, middens, storage pits, ditches, and architecture) are the primary target of archaeological geophysical surveys (Kvamme 2003:400). It follows that surveys of large contiguous areas present a higher likelihood of detecting features and patterns throughout a landscape (Kvamme 2003:438, 2006:206). Although humans have shaped the landscape in a way that many times does not allow for archaeologists to visually see a change at the surface, sensitive geophysical techniques can discern patterns due to the subtle changes left behind in the physical properties of the subsurface (Clark 2001:64).

Magnetics

Understanding magnetism has influenced people since the first prehistoric peoples discovered the lodestone (magnetite) and used it to navigate over land and sea hundreds of years ago (Aspinall et al. 2008:1). In recent history, physicists devoted much time and experimentation to the understanding of magnetism and more properly electromagnetism, as the properties surrounding electricity and magnetism are interrelated. Today, the general understanding that the earth has its own magnetic field is common knowledge, but an in-depth understanding of magnetism is not. More directly the use of magnetism to detect minerals and archaeological sites is not widely known even though the first recorded use of magnetism as a prospecting method to look below the earth's surface was in the seventeenth century in Scandinavia (Aspinall et al. 2008:2). Developments in electromagnetics throughout the early twentieth century have led to the expansion and use of magnetics as a common geophysical tool for geologists and archaeologists. The first archaeological features to be surveyed with magnetic methods were kilns (Aitken 1958). After this survey, continued research led to the development of a continuously reading fluxgate gradiometer (an instrument discussed below) specifically for archaeological use by John Aldred in 1964. Magnetic methods can be separated into two distinct but interrelated techniques: magnetometry and magnetic susceptibility. Both rely on magnetic properties of minerals, soils, and artifacts left behind by humans. These methods work well for mapping and discovering evidence of past peoples, but surveys can be negatively affected by aspects of modern life such as magnetic metal and trash scattered throughout fields (Aspinall et al. 2008:25). Even with these complications, Kvamme (2006:205) describes magnetometry as

“nature's gift to archaeology,” serving as a testament to the usefulness of magnetic prospecting methods to archaeology.

Theoretical Background

William Gilbert in 1600 is credited with the idea that the world is a magnet creating a field (Aspinall et al. 2008:2). This geomagnetic field (Figure 6) is created by the rotation and convection of the Earth's liquid outer core (Clark 2001:64; Witten 2006:82; Reynolds 2011:91).

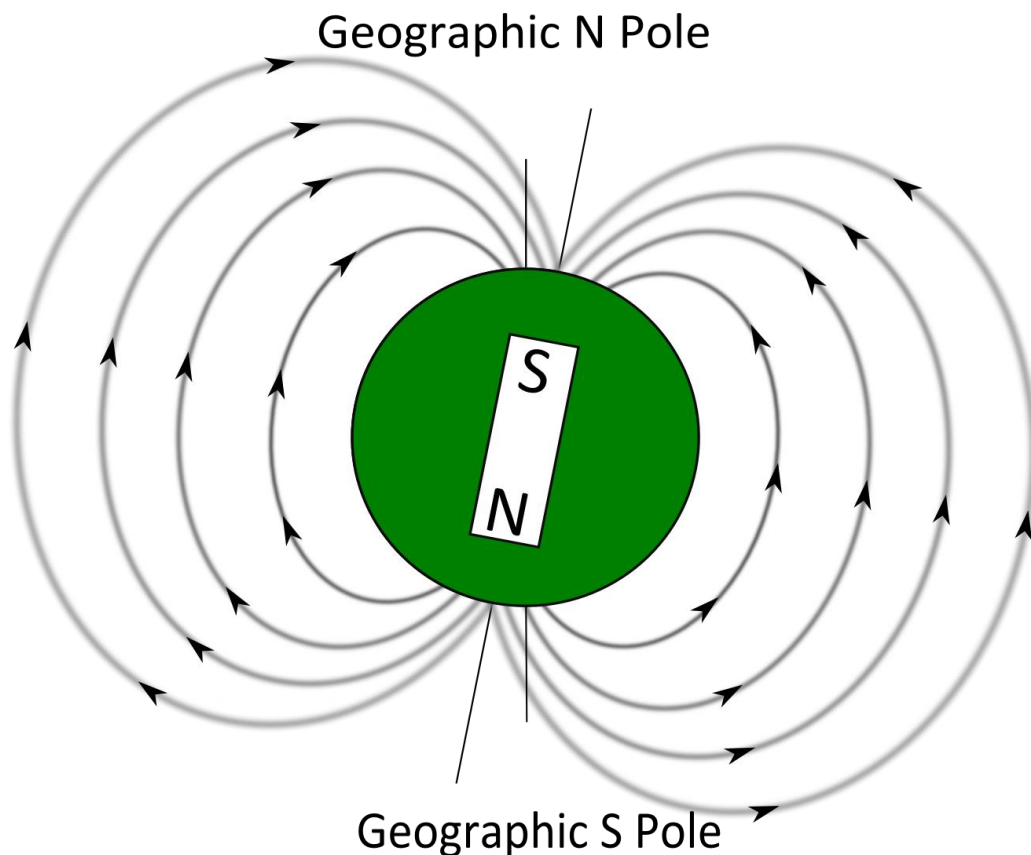


Figure 6. Earth's Magnetic Field. A simplified representation of magnetic flux lines surrounding the Earth.

Lines of magnetic flux show the strength and direction of the magnetic field, an idea originally presented by James Clark Maxwell (1831-1897) (Aspinall et al. 2008:4). With the designation of a north and south pole (Figure 6), the poles will have the strongest magnetic flux (the strength of

the magnetic pull or repulsion). If one holds a magnetic object near a bar magnet (representing the Earth's magnetic field) it will be pulled to or pushed away from either pole, showing that the Earth's high latitudes have a stronger magnetic flux compared to the middle latitudes (Witten 2006:82; Aspinall et al. 2008:3-4). In a bar magnet the magnetic poles are fixed but because the Earth is a dynamic system, the Earth's magnetic poles wander over time and periodically reverse (Kvamme 2006:209; Reynolds 2011:91). The measure of the ambient magnetic field also changes throughout the day as the Earth rotates on its axis referred to as a “diurnal cycle” (Kvamme 2006:209; Witten 2006:86; Aspinall et al. 2008:31; Reynolds 2011:95). This variation is caused by solar wind which is the output of charged particles from the sun (Witten 2006:86; Aspinall et al. 2008:31). These particles are then attracted by the Earth's magnetic field and produce a separate magnetic field that varies with the rotation of the Earth (Witten 2006:86; Reynolds 2011:95). The variance of the solar wind's magnetic field averages 30-50 nT from day to night causing mid-day to be the strongest and night-time to be the calmest (Witten 2006:86; Reynolds 2011:95). In addition to solar wind, magnetic storms produced by the sun can cause rapid changes (on the order of minutes to days) in the Earth's ambient magnetic field (Kvamme 2006:209; Witten 2006:86; Aspinall et al. 2008:31; Reynolds 2011:95). These storms can cause changes in upwards of 1,000 nT within a data set and therefore the effects must be removed from or accounted for in surveys (Witten 2006:86; Aspinall et al. 2008:31; Reynolds 2011:95). During extremely strong storms it may be necessary to avoid data collection when using total field or slow sampling rate magnetometers (Reynolds 2011:95).

Magnetic flux is measured in webers (Wb) which when represented over an area is called flux density, denoted as webers per square meter (Wb/m^2), which is equal to 1 tesla ($1 \text{ Wb/m}^2 =$

1 T). Due to the lesser strength of the Earth's magnetic flux ranging from approximately 70 to 20 micro tesla, flux measurements are made in micro- 10^{-6} , nano- 10^{-9} , or pico- 10^{-12} tesla (Aspinall et al. 2008:4-5 and Reynolds 2011:83-84). Archaeological applications typically use nanotesla (nT) as most prehistoric archaeological features, including the background field strength, range from positive to negative 5 nT, some being differentiated by .5 nT (Kvamme 2006:209).

Although the Earth produces an ambient magnetic field, in general there are only two sources for a magnetic field, a permanent magnet or an electrical device (Aspinall et al. 2008:3). Outside of these, common iron oxide minerals can become magnetized either through remanence or because they are magnetically susceptible (Aspinall et al. 2008:23).

Thermoremanence

Although the Earth constantly creates a magnetic field, in its absence very few materials have their own permanent, or remanent, magnetic field (Kvamme 2006:207). There are multiple types of remanent magnetism, but the most useful to archaeology is thermoremanence, the magnetization of a material by virtue of heating followed by cooling in the presence of an ambient magnetic field. When magnetic materials are heated past the Curie point (approximately 600 degrees C) the bonds controlling the magnetic alignment begin to break down and the magnetic components align with the inducing magnetic field, commonly the Earth's (Figure 7). Upon cooling, the magnetic moments are aligned and a permanent increase in magnetism of the material results (Clark 2001:64-65; Kvamme 2006:207; Aspinall et al. 2008:14, 21).

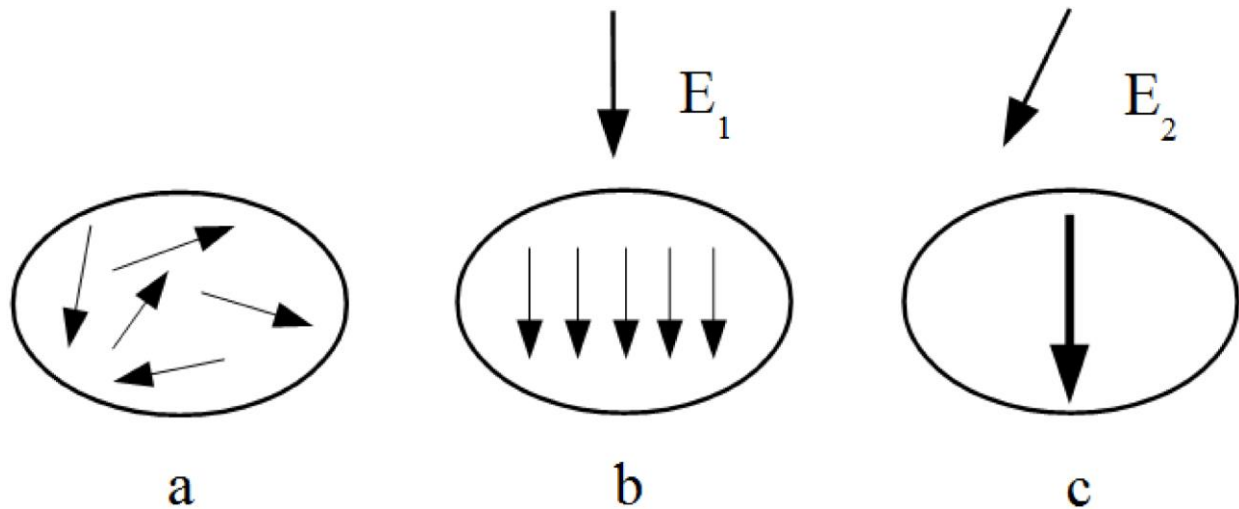


Figure 7. Thermoremanent Magnetization. The process of aligning magnetic moments of a material when heated beyond the Curie point. (a) Before heating, random orientation. (b) During heating, alignment of magnetic moments with the present magnetic field (E_1), usually the earth's. (c) After cooling, all magnetic moments are aligned giving a strong magnetism unaffected by change in the ambient magnetic field (E_2). E_1 represents the ambient magnetic field during the heating process. E_2 represents any and all changes in the ambient magnetic field after heating has occurred. Adapted from Aspinall et al. (2008:22), Figure 1.11.

Thermoremanence is most common in igneous rocks, whose magnetic constituents align with the Earth's magnetic field upon cooling. In the early studies of the Atlantic Ocean, it was determined that the polarity of the ocean floor (oceanic basalt) varied. Once mapped, it was clear that the changes in polarity were the same on both sides of the Mid Atlantic Ridge. Through dating techniques, scientists determined the time ranges for the polarity intervals. Similarly, archaeologists use these principles to determine the time at which objects were last fired (Tite 1972:11).

Heating beyond the Curie point increases magnetism the most, but any increase in temperature will cause some thermoremanence (Tite 1972:11). Archaeologists often see thermoremanence in igneous building material along with fired clay pottery and mud bricks, but even unfired bricks can acquire minimal remanent magnetization when they are packed or

slammed with great force into a mold—this is called shear remanent magnetization (Games 1977:317). Other forms of remanent magnetization occur when the chemical composition of a material is changed or when an intense short change in the magnetic field occurs (e.g. lightning strike) (Jones and Maki 2005:191; Aspinall et al. 2008:17).

Magnetic Susceptibility

Thermoremanent materials have a permanent magnetism, but materials that are magnetically susceptible are only magnetized when an inducing magnetic field is present (Clark 2001:65). Magnetic susceptibility is a measure of a substance's ability to become magnetized, which is directly related to the magnetizable minerals present (Dalan 2006:161; Kvamme 2006:208). Magnetic susceptibility is a quantification of how a material responds to a magnetic field and is defined as a ratio between the level of magnetization in a material to the strength of the magnetizing field (Dalan 2006:161-162). Because this measurement is a ratio of the magnetic moment and the magnetic field strength, which have the same units, it is dimensionless (Aspinall et al. 2008:9-10; Reynolds 2011:84). It is often expressed as parts per thousand (ppt).

The magnetic susceptibility of a material is directly related to its atomic structure and the orbit of electrons around the nucleus of an atom (Reynolds 2011:85). At the atomic level whether a material has paired or unpaired electrons corresponds to a very weak negative (diamagnetic) or weak positive (paramagnetic) magnetic susceptibility (Aspinall et al. 2008:12-13; Reynolds 2011:85-86). Because elements in the transition series or transition metals (e.g. iron, cobalt, and nickel) have many sets of unpaired electrons, they produce strong magnetic susceptibilities (Aspinall et al. 2008:12-13). The variation of structure within ferrous minerals causes the strength of magnetic susceptibility to change. Aspinall et al. (2008:11-14) explains if a mineral's

structure results in the total alignment of all magnetic components it is deemed ferromagnetic (Figure 8a) and has the strongest magnetism (e.g. iron) while opposing magnetic components (equal number in two directions), denoted antiferromagnetic (Figure 8b), cause a cancellation and no magnetism is present (e.g. hematite). If impurities are introduced into hematite the crystalline structure can be interrupted. When this occurs some of the angles of the magnetic moments in hematite are changed. This causes an unequal distribution of the magnetic components (Figure 8c) allowing for moderate magnetism, called parasitic antiferromagnetism (e.g. magnetic hematite). When there are magnetic components in both directions, but at an unequal number, the resulting mineral is deemed ferrimagnetic (Figure 8d) and is strongly magnetic (e.g. magnetite). See Table 1 for a summary of magnetisms.

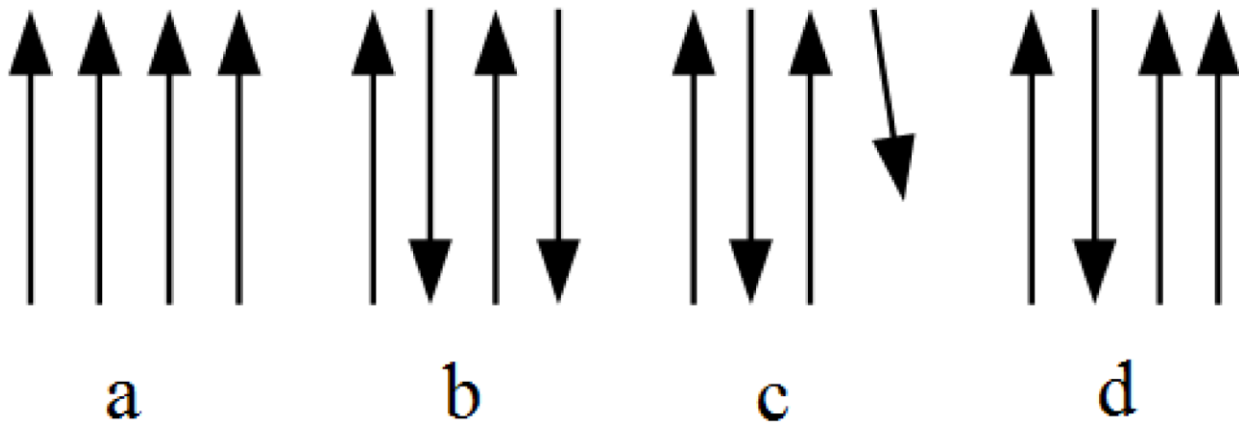


Figure 8. Magnetic Component Direction. Magnetic components combined in different directions showing various scenarios found in ferrous minerals. (a) Ferromagnetic, (b) Antiferromagnetic, (c) Parasitic Antiferromagnetic, (d) Ferrimagnetic. Adapted from Aspinall et al. (2008:13), Figure 1.5.

Table 1. Magnetic Differences. Common magnetic differences with respective strength and common example. Adapted from Aspinall et al. (2008:13), Table 1.1.

Type	Ferromagnetic	Antiferromagnetic	Parasitic Antiferromagnetic	Ferrimagnetic
Strength	very strong	zero	moderate	strong
Example	iron	hematite	magnetic hematite	magnetite

As previously stated fires or heating of substances beyond the Curie point cause thermoremanence. In addition, natural or anthropogenic fires create a reducing environment in soils—this causes hematite in soils to convert to magnetite and upon cooling and re-oxidation some magnetite converts to maghemite, which increases the magnetic susceptibility and is known as the “Le Borgne effect” (Le Borgne 1955, 1960; Tite and Mullins 1971:209; Tite 1972:9-13; Dabas and Tabbagh 2000:335-336; Aspinall et al. 2008:24). Although the three iron oxides hematite, magnetite, and maghemite are important to archaeology, the latter two are the most important because they are ferrimagnetic having a 1,000 times greater magnetic susceptibility than hematite, an antiferromagnetic mineral (Tite and Mullins 1971; Clark 2001:100; Aspinall et al. 2008:23).

In addition to fire, natural soil development enhances magnetism due to accumulation of fine-grained magnetite and maghemite (Dalan 2006:162-163). This enhancement occurs through low-temperature chemical reactions, magnetotactic bacteria, iron-reducing bacteria, and bacteria-induced chemical reactions (Evans and Heller 2003:189-196). Human-created organic waste in trash piles, middens, or scattered throughout a site is home to microorganisms—bacteria found throughout these locations create reducing and oxidizing conditions for digestion, which can convert magnetic minerals and produce tiny magnetite crystals inside their bodies (Fassbinder et al. 1990; Evans and Heller 2003:189-196; Aspinall et al. 2008:24-25). In addition, humans often add magnetically enhanced material (e.g. broken pottery, charcoal, brick fragments, metal working debris, slag, hammer scale, and other metal or fired material) to the topsoil layer of a site (Fassbinder et al. 1990; Weston 2002:211; Dalan 2006:165; Aspinall et al. 2008:25). As a

result, measurements of soil magnetic susceptibility are often used to indicate the presence or absence of human occupation on the landscape (Clark 2001:99).

Magnetometry

Magnetometry is a geophysical method that measures the local variation in the earth's magnetic field and is one of the most useful prospecting methods used by archaeologists (Kvamme 2006:205-206). Magnetometers passively measure in nanotesla (nT) the sum of any remanent magnetism plus magnetic susceptibility induced by the Earth's magnetic field, or any other local magnetic field (Aspinall et al. 2008:29 and Kvamme 2006:208). A magnetometer does not differentiate between either source of magnetism: magnetic susceptibility or remanent magnetism (Clark 2001:65; Kvamme 2006:208). Due to this, a single magnetometer can be limited in its usefulness because it is simultaneously measuring the magnetic flux density of the near surface with archaeological features, any underlying geological features, and the earth's ambient field (Aspinall et al. 2008:31). There are multiple types of magnetometers (fluxgate, SQUID, proton, Overhauser, and alkali-vapor), but fluxgate instruments are most commonly used in archaeology and placed in a gradiometer configuration. In this arrangement measurements are made by two sensors separated vertically by a fixed distance usually 0.5 or 1 meter (Figure 9) allowing for the earth's field and broad underlying geological features to be subtracted and measurements of only the near surface remain (Kvamme 2006:210; Aspinall et al. 2008:29). This type of instrument has an effective depth of approximately 1-2 meters, but only an estimation of the depth to anomalies is possible (Kvamme 2006:222-223). Although in practice depth information is rarely gained, these measurements can be made at high speeds with

significant spatial resolution making magnetometry one of the most efficient ground-based near surface geophysical techniques (Kvamme 2006:205).

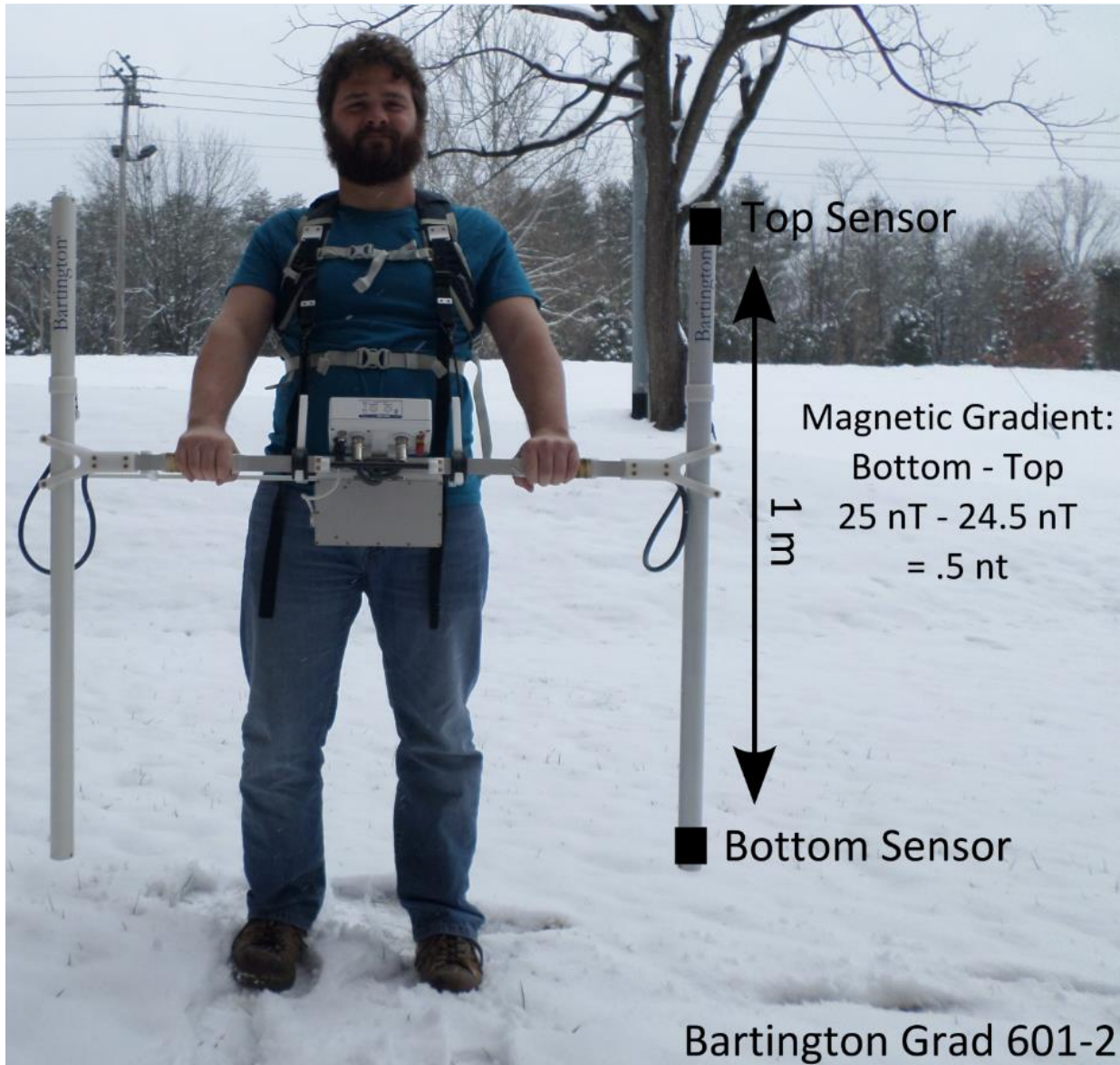


Figure 9. Magnetic Gradiometer. Bartington Grad 601-2 with representative top and bottom sensor markers showing 1 meter separation. Gradiometer format removes ambient magnetic field and readings of only the near surface are recorded.

Magnetic Susceptibility

Magnetic susceptibility surveys are different from magnetometry surveys because they

only measure the induced portion of a magnetic field (Dalan 2006:162). This is done by creating a local primary electromagnetic field which induces a secondary magnetic field in the sub-surface (Figure 10). By using a locally induced field, magnetic susceptibility instruments are deemed active as the instruments create their own electromagnetic field and do not use the Earth's ambient field (Aspinall et al. 2008:29-30). These instruments are split into two categories: single- and dual-coil types. Single-coil instruments have effective depths of approximately 1 – 10 cm and are used to measure single points at a time making data collection tedious and slow (Dalan 2006:168,172). Dual coil or slingram instruments contain a separate transmitter and receiver coil (Dalan 2006:17). These can be set to take readings at a constant speed and therefore can survey a much larger area in a shorter amount of time. These instruments also have deeper penetration into the sub-surface, averaging a maximum depth of 50 cm (Dalan 2006:167).

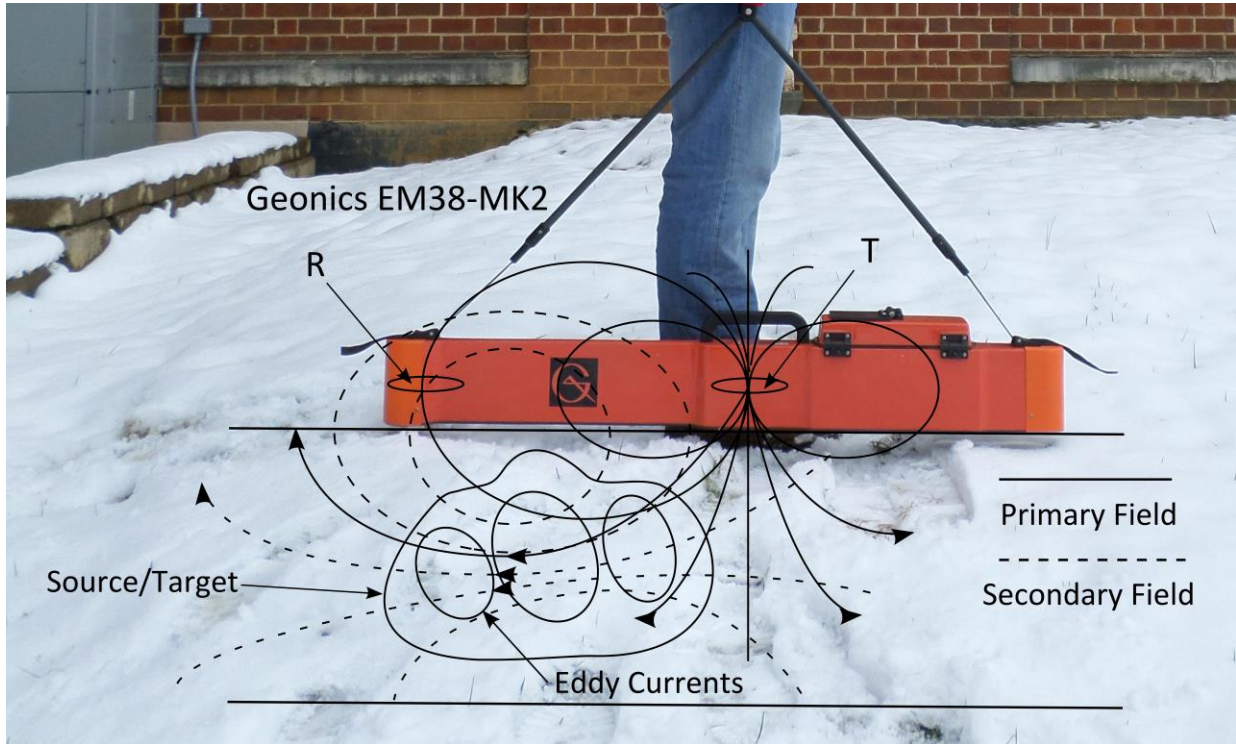


Figure 10. Induced Magnetic Fields. Geonics EM38-MK2 with representative primary and secondary electromagnetic fields. Transmitter (T) and receiver (R) spaced at .5 m. Primary field induces a secondary field and the strength of the secondary field is the magnetic susceptibility of the sub-surface.

Ground Penetrating Radar

Ground-penetrating Radar (GPR) is one of the most widely used near surface geophysical techniques in the United States. The GPR method as we know it today developed in the 1970s, but radar technology has been in use since the early twentieth century. In many cases the first GPR users were seismic scientists studying seafloor and petroleum geology because both data types are wave-based and only differ in their energy source (radio waves or sonic waves) (Hildebrand et al. 2002, Ovenden 1994). The many processing techniques used for seismic data were easily adapted to processing GPR. Unlike seismic however, GPR has a much shallower maximum penetration depth of approximately 100 m (in optimal conditions) and in most

archaeological applications a maximum depth of about 6 m. An early archaeological use of GPR in the United States was at Chaco Canyon where the buried remains of prehistoric structures were discovered (Vickers et al. 1976). Early systems were analog, making data collection and processing cumbersome, taking a full day to survey a small area and then two to four days to process the data (Conyers 2013:5-6). Because of this time commitment, GPR did not become widespread until computer technology drastically improved in the 1990's. By this time, GPR systems utilized digital technology and the development of new GPR processing software improved the efficiency and reliability of data analysis. Essentially, mapping of the near surface with GPR allowed for users to analyze and interpret archaeological sites in a quick and thorough manner formerly not possible (Conyers 2013:3).

Theoretical Background

GPR uses the same form of radiation that is emitted every day from the sun: electromagnetic radiation. Radio waves are a sub-set of the electromagnetic spectrum ranging from 10 KHz – 100 GHz, although most archaeological applications use the 0 – 10 GHz range (designated “radar waves” herein). Electromagnetic waves can be imagined as a composite of two sinusoidal waves, the electrical and magnetic portions normal to each other (Figure 11), and if either portion is destroyed the propagation or motion of the wave stops (Conyers 2013:24). The frequency of the electromagnetic wave directly relates to the size of the wavelength—higher frequencies have shorter wavelengths and lower frequencies have longer wavelengths. These radar waves are similar and in some cases overlap with many everyday technologies including cell phones, FM radio, TV, and microwave ovens (Figure 12). Similar to most of these

technologies, GPR units have transmitting and receiving antennas that allow for the radar signal (wave) to be sent and received.

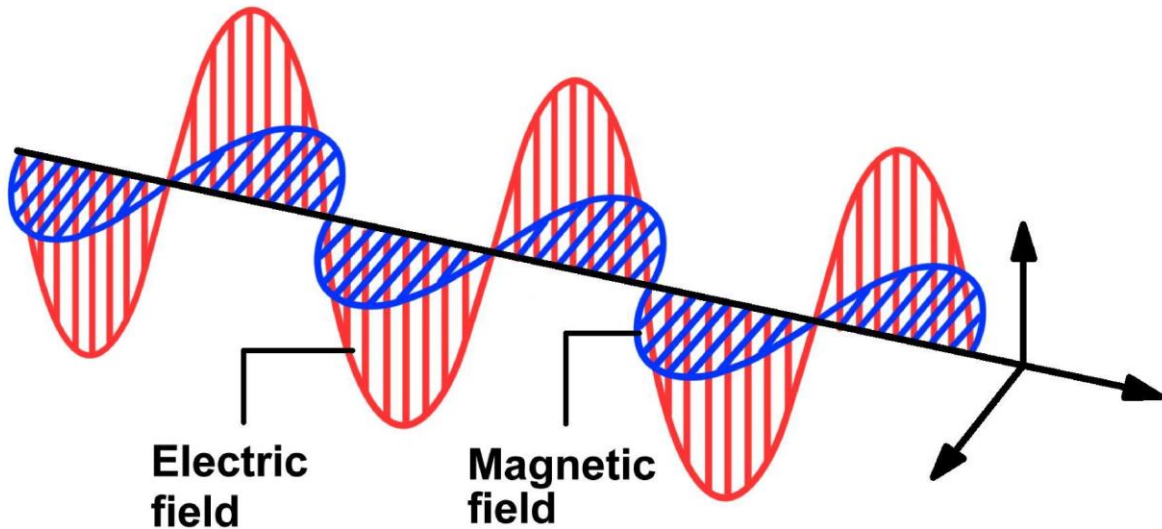


Figure 11. Electromagnetic Wave. Model of an electromagnetic wave broken into two components, the electrical (red) and magnetic (blue) fields. Adapted from Conyers (2004a:24), reprinted with permission.

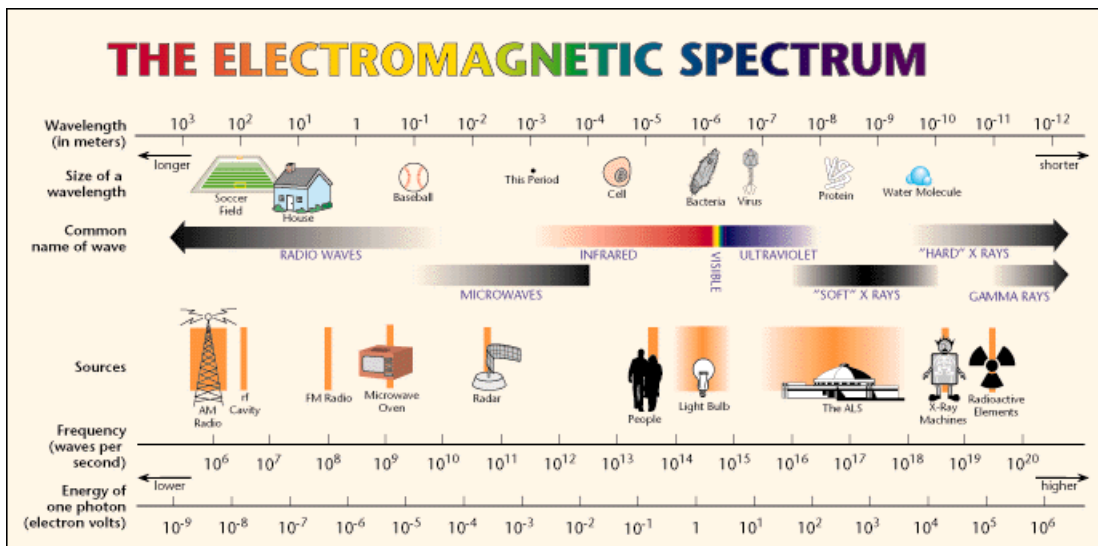


Figure 12. Electromagnetic Spectrum. Representative image of the electromagnetic spectrum showing various wave sizes, frequencies, and energy. Waves per second is equivalent to Hertz. Adapted from Lawrence Berkeley National Laboratory (2014).

Hardware

GPR instruments have two main components: (1) antennas and (2) a control unit (Figure 13). There are multiple systems available, but in general the control units allow for data collection settings to be adjusted and to digitally record the signal received. Unlike the electromagnetic waves emitted from the sun to the earth, a GPR system uses separate transmitting and receiving antennas, although some systems use only one antenna for both purposes (Conyers 2013:30). The antenna in its most basic form is a short piece of metal (often a copper wire or plate) to which an oscillating electrical current is applied. The frequency of the oscillations directly determines the frequency of the radar waves produced (Conyers 2013:24). Although antenna sizes are commonly named with a single center frequency (e.g. 400 MHz), the transmitting antenna does not produce waves of only one frequency, rather, it produces a range of waves from approximately one half to double the center frequency (Conyers 2013:42). Waves emanate from the antenna in many directions including into the sub-surface and the air, so antennas are often shielded to direct waves only into the ground (Conyers 2013:46).



Figure 13. GPR System. Geophysical Survey Systems Inc. (GSSI) SIR 4000 control unit paired with a 400 MHz antenna and a survey wheel.

Wave Propagation

The amount of any individual wave that is transmitted into the sub-surface and then travels back to the receiving antenna is affected by (1) the frequency of the initial wave, (2) the level of coupling with the ground surface, and (3) the physical and chemical properties of the sub-surface. Depending on the frequency, high or low, of a wave, it will be short or long and travel faster or slower through a given matrix. GPR antennas produce a range of frequencies that

transmit a collection of waves into the sub-surface. This grouping is dispersed in a conical shape called the “cone of transmission” and the size of the area illuminated or the “footprint” (Figure 14) can be calculated from the antenna frequency and the relative dielectric permittivity of the matrix (a property discussed below) (Conyers 2013:65-66).

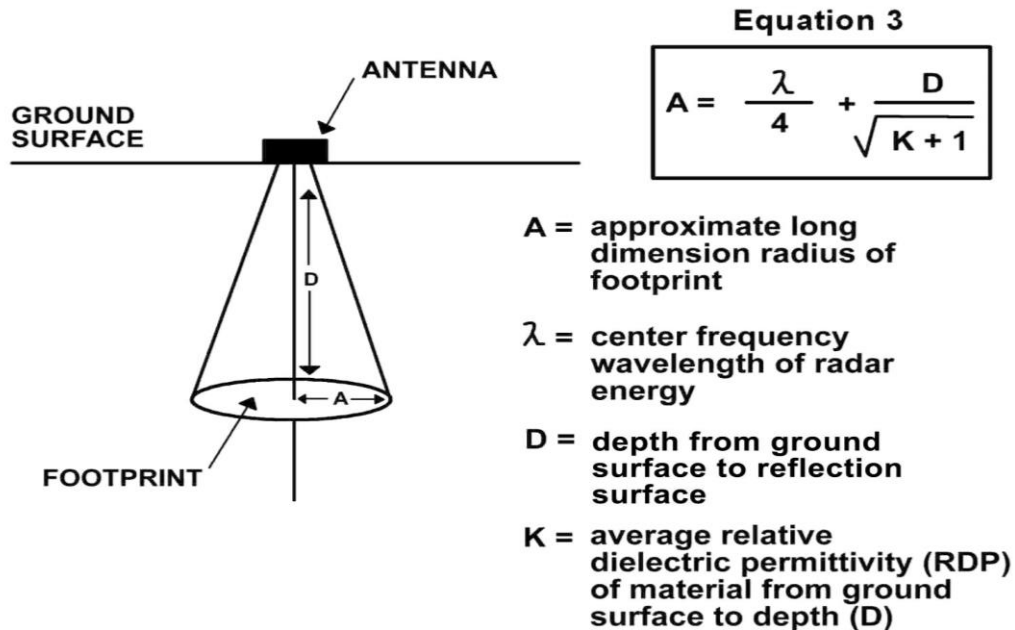


Figure 14. GPR Cone of Transmission. Represents the conical footprint of radar energy in the sub-surface. The accompanying equation can be used to determine the area or size of the footprint given a known antenna frequency, relative dielectric permittivity, and depth to target surface. Adapted from Conyers (2013:66), reprinted with permission.

Antennas are commonly placed directly on the ground. This is done in part to focus the radar on an area of interest, but more importantly if an antenna is located too far above the surface it does not couple correctly with the ground (Conyers 2013:31-32). Coupling allows for more of the initial radar energy to be propagated into the subsurface instead of being reflected by the air-ground interface (Conyers 2013:31-32). During the coupling process the initial frequency is decreased so that the group of waves has a lower center frequency traveling through the

ground than it did in the air (Reynolds 2011:545). Lastly, the energy that does enter the sub-surface must pass through it and back to the receiver exposing the waves to the multitude of variables present below ground.

Dielectric Permittivity and Conductivity

A primary property affecting GPR is the dielectric permittivity or dielectric constant (terms used interchangeably) for a particular matrix (e.g. soil). In short, this property is a measurement of the amount of electrical energy that a soil can accept into and store in its structure. This can account for how much energy is dissipated into the soil (held by the soil) and how much energy is allowed to pass through the soil (after it has accepted all the energy it can hold in its structure) (Goodman and Piro 2013:12). Electrical properties differ between soil types and can even differ greatly throughout a homogeneous soil or mixture such as concrete (Reynolds 2011:552). This variation makes determining the dielectric constant difficult. Most often this can be done in the lab, but in the field the use of relative dielectric constants is used instead.

The relative dielectric permittivity (RDP) of materials ranges from 1 in air to 81 in water (Reynolds 2011:547) (Table 2). The greater the RDP of a substance the slower a radar wave propagates through it (Conyers 2013:48) and the opposite is true of RDPs approaching 1 where radar waves travel at the speed of light in a vacuum (Reynolds 2011:547). When there is a considerable change in RDP between two layers radar energy will be reflected (Conyers 2013:51).

Table 2. RDP of Common Materials. Common geologic materials and their respective relative dielectric permittivities (RDP). Adapted from Davis and Annan (1989) and Geophysical Survey Systems, Inc. (2001).

Material	RDP	Material	RDP
Air	1	Clay	5-40
Dry Sand	3-5	Concrete	6
Dry Silt	3-30	Saturated Silt	10-40
Ice	3-4	Dry Sandy Coastal Land	10
Asphalt	3-5	Average Organic-rich Surface Soil	12
Volcanic Ash/Pumice	4-7	Marsh or Forested Land	12
Limestone	4-8	Organic-rich Agricultural Land	15
Granite	4-6	Saturated Sand	20-30
Permafrost	4-5	Fresh Water	80
Coal	4-5	Sea Water	81-88
Shale	5-15		

Although the RDP in general accounts for the variation in signal loss, if materials are conductive the electrical conductivity must also be accounted for when determining the propagation of a radar signal through the sub-surface (Reynolds 2011:547). GPR simulations show that if the RDP is constant throughout a matrix and the conductivity changes significantly and abruptly, the change in conductivity will also produce reflections or changes in the radar wave propagation (Goodman and Piro 2013:23). This shows that changes in RDP and/or conductivity, properties directly affected by water content, cause reflections or changes in radar propagation (Conyers 2004b, 2012, 2013; Reynolds 2011; Goodman and Piro 2013). Conyers (2012:34-40) has definitively shown that water is the controlling factor that causes a change in the RDP of most materials. Even very conductive materials such as clay have low conductivity when completely dry (Conyers 2012:34-40; Goodman and Piro 2013:21). Water is therefore what dictates how radar energy propagates through the ground. Given that water is the primary factor, it follows that soil properties that control water movement are also important.

Soil Effects

The chemical and physical composition of soils in part determines the speed of radar

wave propagation and partially controls water content. Combined these are the primary controls of electromagnetic wave attenuation (Reynolds 2011:539). The type of chemical structure (i.e. mineralogical structure usually related to clay types) can be more electrically resistive or conductive (Reynolds 2011:544). Soils that are more conductive will attenuate or dissipate more energy while more resistive soils will transmit the waves more readily through a matrix. Porosity, permeability, and grain size are also major factors in how energy travels through a matrix because they govern the movement and retention of water in a soil. Since water affects the conductivity and dielectric permittivity of a soil, it is essential to how radar energy will propagate through a soil (Reynolds 2011:539; Conyers 2012:34-40). These varying soil properties are the cause of radar waves either being attenuated, reflected, or refracted by the sub-surface.

Attenuation

Attenuation (dissipation) is simply the loss of radar energy as the waves travel through a medium. Attenuation is a function of the magnetic, electric, and dielectric properties of a substance or matrix and the frequency of the radar signal (Reynolds 2011:540). Because electromagnetic waves are comprised of a magnetic and electrical component, the wave needs both portions to propagate. More often conductivity (the electrical component) is the first to be attenuated and therefore is the controlling factor in wave attenuation (Goodman and Piro 2013:52-53). If a medium is more conductive it will disperse a radar wave faster and it will attenuate at a shallower depth (Conyers 2013:52-53; Goodman and Piro 2013:19). Conyers (2012:34-40) and Goodman and Piro (2013:21) state that the inclusion of even a small amount of water drastically changes the conductivity and RDP of a material resulting in a radar wave

velocity change, thus, the inclusion of water results in the attenuation of radar waves at a much faster rate. These changes can be used for or against GPR users, depending on the nature of the GPR target feature or layer. If the target layer causes vast attenuation its location may be determined by the decrease in or complete lack of waves returned from that depth. In contrast, if a target feature is below a highly conductive layer, radar waves may never reach or return from the target feature because they have been attenuated by the overlying conductive layer. The waves that are not initially attenuated are either reflected or refracted, before being finally attenuated or returned to the surface.

Reflection and Refraction

As waves pass through a medium or soil layer they may encounter a boundary between two layers. If there is no contrast (or extremely little) the wave will simply continue to transmit, however, more often a boundary between two contrasting layers is encountered. When this occurs the wave can either reflect (bounce back towards the surface) or refract (change angles while still moving downward into the earth). After a wave does either of these, it can then attenuate, transmit through another boundary, or reflect or refract off another boundary and proceed to repeat any of these or reach the surface and sometimes the receiving antenna. This can become quite complex and further explanation of a radar wave's path is beyond the scope of this thesis. However, a basic understanding of the principles that govern these processes must be addressed which starts with Snell's Law (Figure 15).

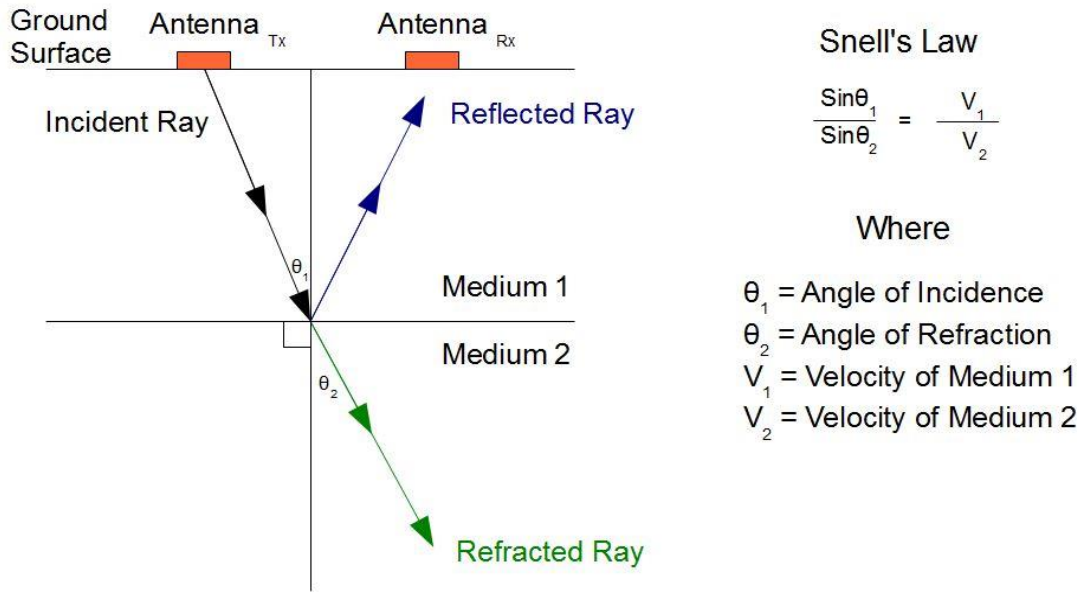


Figure 15. Snell's Law, Refraction and Reflection. Snell's Law is a common physics equation describing the reaction of waves when encountering a boundary of two mediums. This example shows a simplified radar wave's path through the sub-surface. The initial wave (Incident Ray) passes from the transmitting antenna (Tx) to a contrasting layer boundary. If the contrast is minimal, the wave will refract and continue through the sub-surface at a different angle (shown in green). If the contrast is greater the wave will reflect (shown in blue) and be directed to the surface and possibly the receiving antenna (Rx).

Goodman and Piro (2013:17) state that a microwave will behave according to Snell's Law and refract when it passes through a buried archaeological structure or in most cases a contrasting layer boundary. The larger the contrast between the two material's velocities (a function of the electrical properties and RDP) the greater the refraction angle of the propagating wave. When the contrast between two layer's RDPs is great enough the wave will be reflected rather than refracted. The strength of the reflection is in direct relation to the level of contrast on either side of the boundary (Reynolds 2011:539; Goodman and Piro 2013:15).

Archaeological Geophysics

Classically, archaeology involves digging shovel test pits and excavation units to discover

and understand a site. Such excavations only reveal a very small portion of a site, yet are used to make broad interpretations. What lies in the vast expanses between excavation units remains a mystery. To solve this problem some archaeologists have and continue to employ geophysics as an exploration tool, simply to map the subsurface to better guide excavations or to avoid damage from impending cultural development (Conyers 2010:2). Kvamme (2003:435) explains that using geophysical surveys as only exploratory tools is an under-utilization because they can be used as primary data of cultural structures and features and their spatial layout within an individual site or across an entire landscape. In addition to the primary cultural data produced, geophysical techniques, specifically GPR, have led to a better understanding of a site as the geophysical method was able to map archaeological features (contrasts of the physical and chemical properties) that excavators were unable to see (Conyers 2010:1; Goodman and Piro 2013:3). Conversely, sometimes archaeologists discover easily defined features where the GPR has detected nothing, because there was no electrical contrast between the feature and the matrix (Conyers 2010:1; Goodman and Piro 2013:3). The addition of these “non-visible” features to a data set and the formerly stated additions of primary cultural data and spatial layout information to archaeological sites by geophysical techniques have fostered new interpretations of history and prehistory (Kvamme and Ahler 2007; Conyers 2010:1). A notable example is Kvamme and Ahler's (2007) work at Double Ditch State Historic Site in North Dakota. The site was originally investigated in 1905 by Will and Spinden (1906) and through continued archaeological testing the site was given the name Double Ditch for its topographically visible two-ditch fortification system. It was not until Kvamme and Ahler's (2007) work beginning in 2001 that two more outer ditches were discovered by magnetometry. This discovery dramatically changed the nearly 100-

year long assumption that the site was defined by the second ditch. The additional outer ditches more than quadrupled the site size, population, and length of occupation.

All of the benefits brought to archaeology by geophysics would not have been possible without the substantial advances in technology and methodology which have allowed geophysical instruments to produce precise and accurate high resolution data very rapidly (Kvamme 2003:436). These advancements have allowed archaeogeophysical surveys to provide knowledge formerly unattainable by traditional methods, due to the high costs of labor and time surrounding a large scale excavation (Kvamme 2003:443). Kvamme (2003:436) elaborates to the use of archaeological geophysics for more than just a prospecting method and the necessity of its use for understanding and studying aspects of past culture. Conyers (2010) provides excellent examples where GPR was used in conjunction with standard excavation to test hypotheses about human culture. Many users within the archaeogeophysical community can attest to its usefulness as a prospecting method as well as a way to answer anthropological questions.

CHAPTER 4

METHODS

This study employed standard archaeological excavations in conjunction with three near-surface geophysical techniques: magnetometry, EMI, and GPR. Field work was conducted at Pile Mound on four occasions between March and November 2014. Magnetometry survey in March indicated several potential archaeological features within and surrounding the mound, and GPR survey two months later showed additional features. These two data sets were used to guide excavations during the July 2014 archaeological field school. The magnetometry survey was expanded as part of the field school and EMI data were collected in select locations to further understand the magnetometry results. In total, 6.5 ha of magnetometry and .48 ha of EMI data were collected. This thesis focuses on geophysical data and excavations on the mound proper and immediate surroundings (.84 ha). Magnetometry and EMI data collected in the surrounding area are beyond the scope of this thesis but are reported in the Appendix.

Six of the 10 archaeological test units excavated during the field school were placed to better understand selected geophysical anomalies. Artifacts were processed by archaeology students at East Tennessee State University under the direction of Dr. Jay Franklin, Department of Sociology and Anthropology, and the results were made available to aid in the overall interpretation for this thesis. Similarly, radiocarbon dates obtained by Dr. Franklin are used here with permission. These results will be presented and discussed as needed in the discussion chapter. A final visit to Pile Mound in November 2014 was made to collect GPR data in a larger grid at a higher spatial resolution to address unanswered questions.

Geophysical Field Methods

All geophysical surveys followed standard data collection procedures. This includes setting a site datum point and local coordinate system. Then, a grid system with grid blocks, usually 20 x 20 m, is established. A total station transit is placed over the datum and used to accurately place a plastic stake or marker at each grid block corner. If a transit is not used, measuring tapes can be used to lay out the grid system, but this is often less accurate.

Geophysical data are generally collected by carrying or pulling an instrument multiple times across each grid block. This can be done in a unidirectional manner—collecting data while walking from one end of the grid block to the other then walking back to the starting side and repeating the process. More typically a zig-zag pattern is used—collecting data while walking from one end of the grid block to the other and then turning around and collecting data while walking back. Lines or measuring tapes marked at every meter are used to guide the surveyor in walking accurately and collecting data at precise locations. These lines are stretched across the grid block at equal lateral spacing, typically .5 m. See Figure 16

At Pile Mound a local coordinate system was established, the datum being 500, 500 m located 4 m from an existing fence row. The grid was oriented parallel to the fence to make the grid set up and data collection easier so the crew avoided running into the fence. All coordinates and cardinal directions herein are in reference to the grid system unless otherwise noted. Corner stakes were placed with the assistance of a total station (Trimble model 3305). Next, the grids were laid out using marked fiberglass guide ropes placed at .5 m interval. A high accuracy GPS receiver (Trimble GeoExplorer GeoXT) was used to calculate geographic coordinates of the datum.

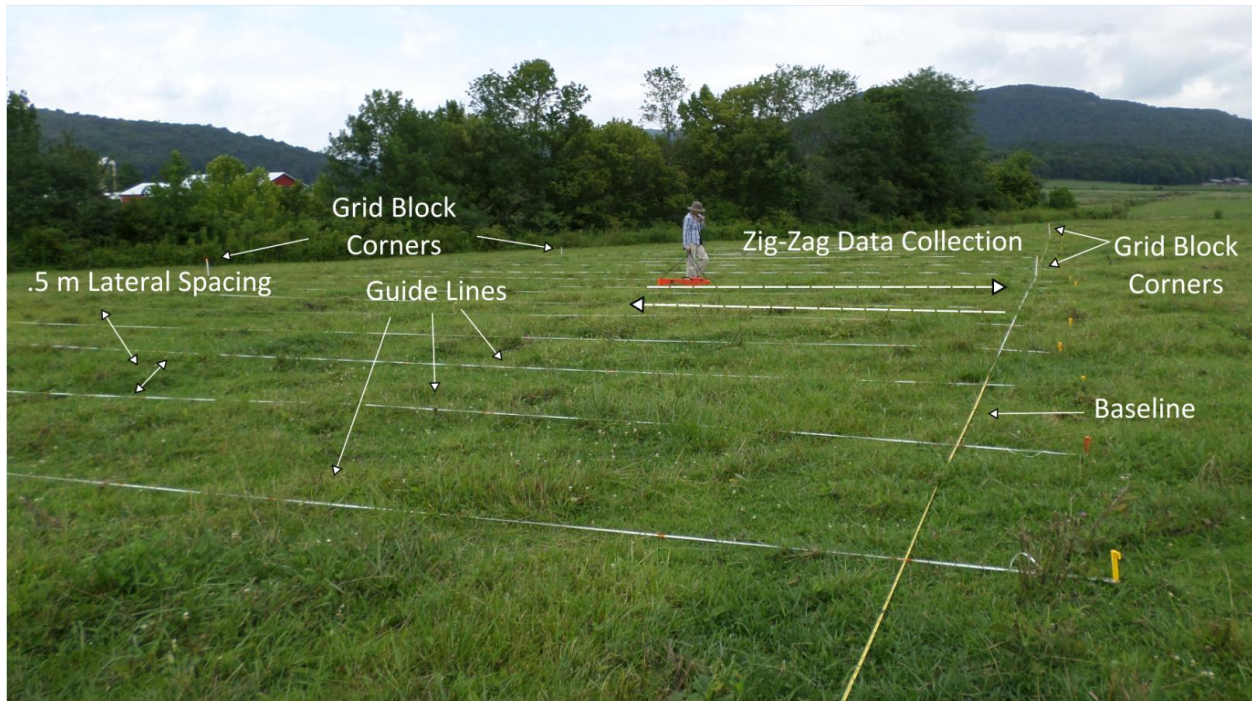


Figure 16. Geophysical Survey. General geophysical survey method with grid blocks and guide lines to assist the surveyor in data collection. Photographed 07/24/2014.

Magnetometry

The magnetometry survey was conducted during the first week of March 2014. Once on site, the Bartington Grad601-2 fluxgate magnetic gradiometer, hereafter called magnetometer, was turned on and allowed to “warm-up”. Subsequently, the instrument was tuned following the protocol presented in the instrument manual. Tuning involves finding a magnetically “quiet” spot and elevating the instrument approximately 1 m above the ground to zero the magnetometer in the absence of localized magnetic fields in the ground. This was done while other members of the crew set up the grid system, including 24 20 x 20 m grids blocks, one partial 20 x 20 m grid block, and five 4 x 20 m grid blocks (Figure 17). With the exception of Grid 21, each grid block was collected in a zig-zag pattern starting in the southwest corner and heading north. Grid blocks on top of the mound along the western baseline (500 m East) were surveyed first and then data

collection proceeded east, north, and south. The grid was placed 4 m away from the fence row to eliminate magnetic interference. Each grid block was numbered by order of collection and data were collected at .5 m line spacing. Because the instrument collects data in readings per second, the surveyor must walk at a constant speed over an equal distance for correct data sampling. During survey, the instrument was set at 1 m per second allowing 8 readings per meter. This equates to a sampling density of .5 x .125 m for each grid block. Of the 24 20 x 20 m grids, three were collected twice (1, 2, and 3 later recollected 10, 11, and 12) due to an operator error known colloquially as “cell-phone-in-pocket.” The one partial 20 x 20 m grid block (Grid 21) was collected in a unidirectional manner so that the operator could stop short of a fence row to eliminate magnetic interference. The five 4 x 20 m grid blocks were collected between the North-South running fence row and to the west of the 20 x 20 m grid blocks. These grid blocks (28-32) were intentionally collected separately to fill in the gap between the main survey area (which was located far enough away from the fence to avoid interference) and the magnetically compromised area adjacent to the fence.

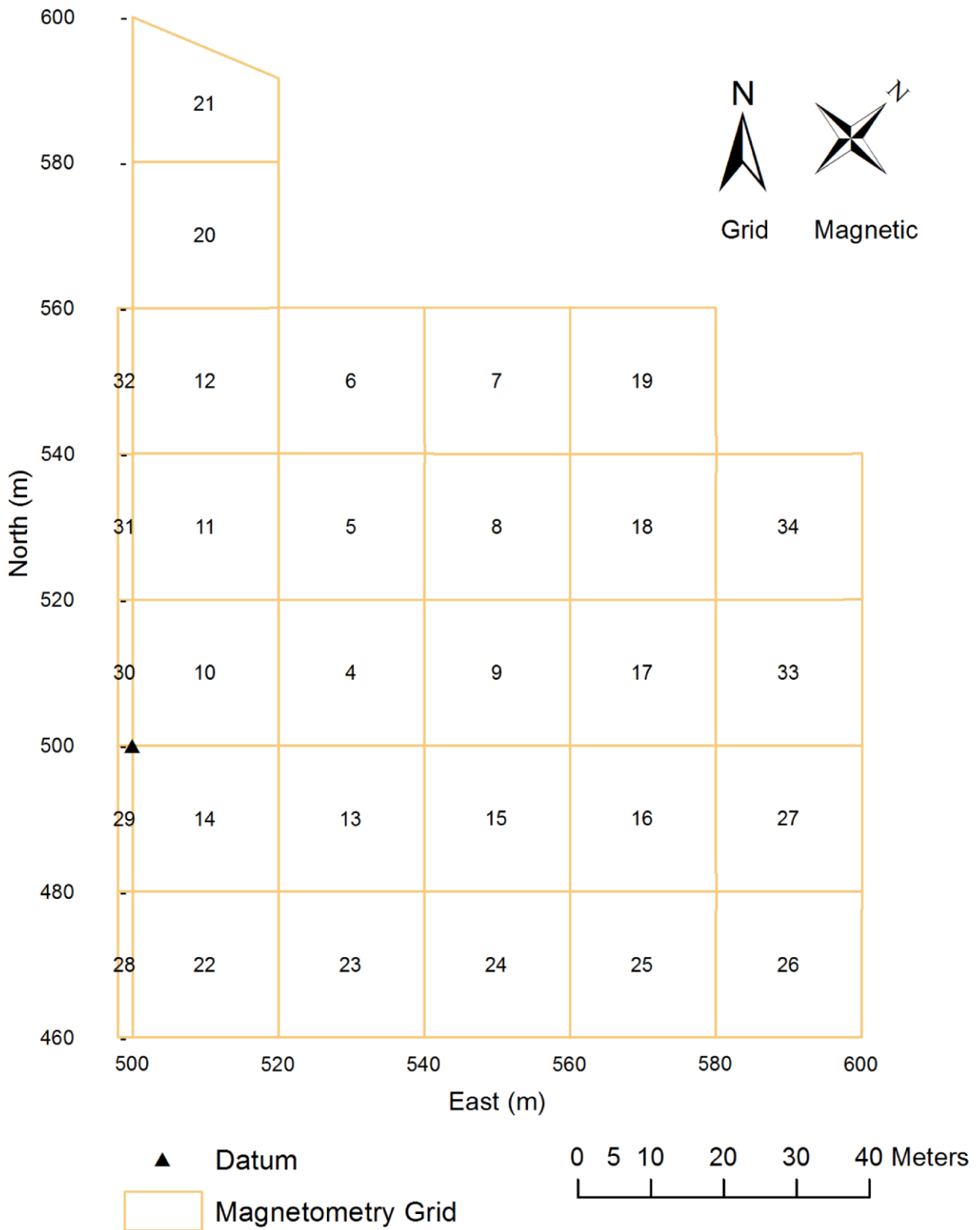


Figure 17. Magnetometry Grid. March 2014 magnetometry grid system with datum location.

Electromagnetic Induction

The one grid block of EMI data used for this thesis, situated directly on top of the mound, was collected at the start of the July 2014 archaeological field school prior to excavations. Following standard practice, the Geonics EM 38-MK2 was first tuned or “zeroed” in an electrically and magnetically “quiet” spot following guidelines in the instrument manual. Then the EMI data were collected in a 20 x 20 m grid block corresponding exactly with magnetometry Grid 11 (Figure 18). Data collection started in the southwest corner and moved north in a zig-zag pattern. As with magnetometry survey, EMI data were collected along lines spaced .5 m apart at a rate of 8 readings per second per meter, resulting in a sampling density of .5 x .125 m. The EM 38-MK2 employs the use of a separate data logger or data acquisition system. An Archer 2 hand held computer was used with DAS70-AR/MX software for this. Because this software has the surveyor manually start and stop data collection for each line, excess data are collected at the end of every line, which must be deleted later.

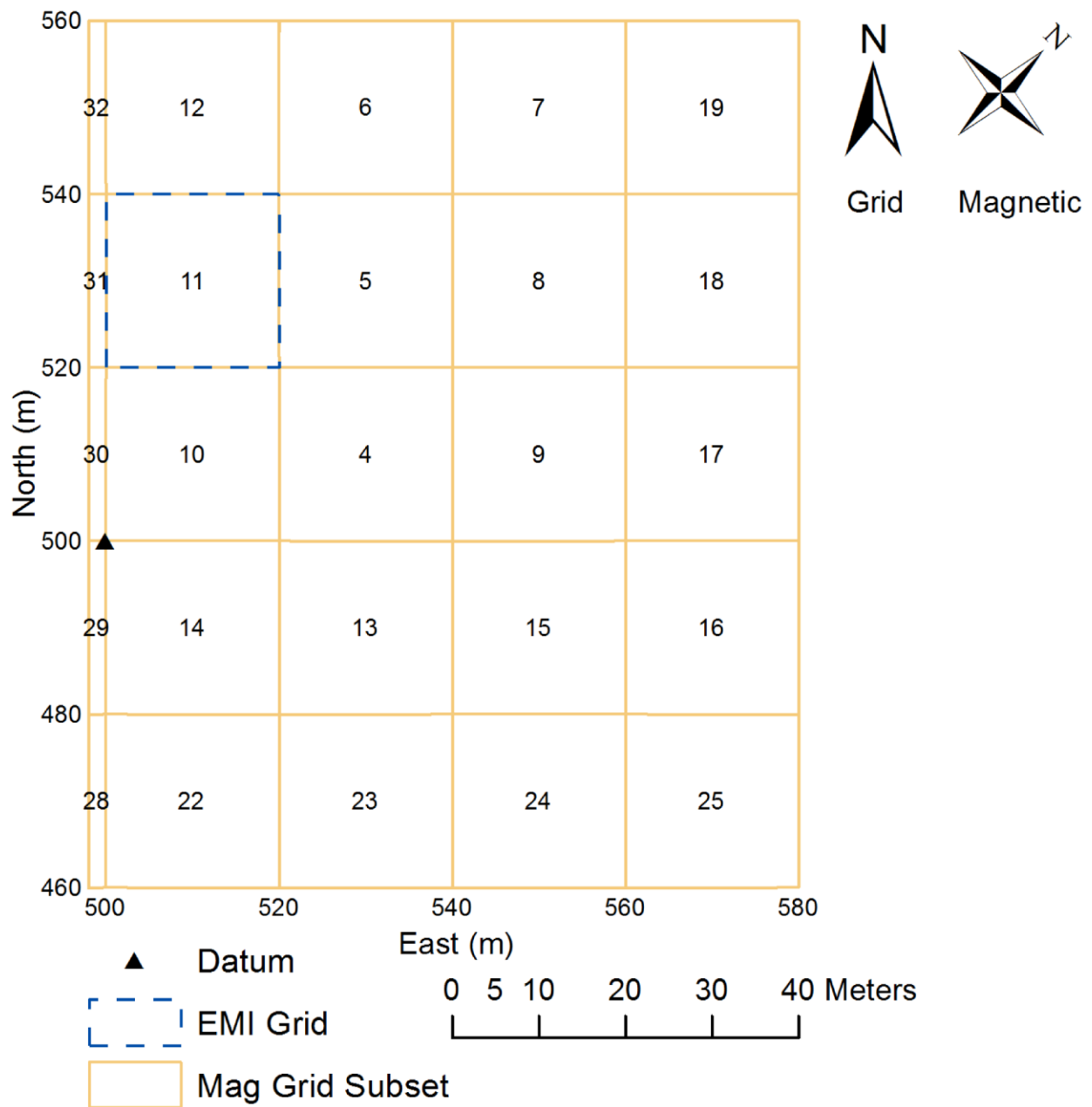


Figure 18. EMI Grid. July 2014 EMI grid block overlaid on the March 2014 magnetometry grid system.

Ground Penetrating Radar

GPR data were collected during two separate field excursions. The first, in May 2014, used .5 m lateral spacing with a Geophysical Survey Systems, Inc. (GSSI) SIR 3000 control unit paired with 270 MHz and 400 MHz center frequency antennas. This survey included the

collection of three different-sized grid blocks. Unlike magnetometry and EMI, GPR requires a detailed calibration process for each antenna, with many parameters to set. These parameters are reported for each survey in the Appendix. Once calibrated, the 400 MHz antenna was used with the GSSI 3-wheel cart (Figure 19) to survey a 42 x 40 m grid block. The cart system was pushed in a zig-zag fashion starting in the southwest corner and moving north. Next, the 270 MHz antenna was used in a similar fashion to collect a 24 x 40 m grid block. This survey also started in the southwest corner and moved north. Because a survey wheel was not paired with the 270 MHz antenna, the data collection of this grid employed the user mark feature which entailed manually inserting a mark in the data every meter along each transect. The next day portions of the same 270 MHz survey were recollected in a unidirectional pattern (all lines collected from east to west). Data collection started in the southwest corner and a 30 x 37 meter grid was surveyed.



Figure 19. GPR Cart System. GSSI SIR 3000 control unit with three wheel cart and 400 MHz antenna. Photographed 05/02/2014.

The second set of GPR data were collected in November 2014. This survey used .25 m lateral spacing with a GSSI SIR 4000 control unit paired with 270 MHz and 400 MHz center frequency antennas. The same 30 x 50 m grid block (Figure 20) was collected with both antennas. The parameters for each antenna's calibration are provided in the Appendix. First the 270 MHz antenna was pulled in a zig-zag fashion starting in the southwest corner and moving north. The next day, the 400 MHz antenna was dragged in a zig-zag fashion starting in the

northwest corner moving south. Both surveys employed a survey wheel to calculate the distance of each 30 m transect.

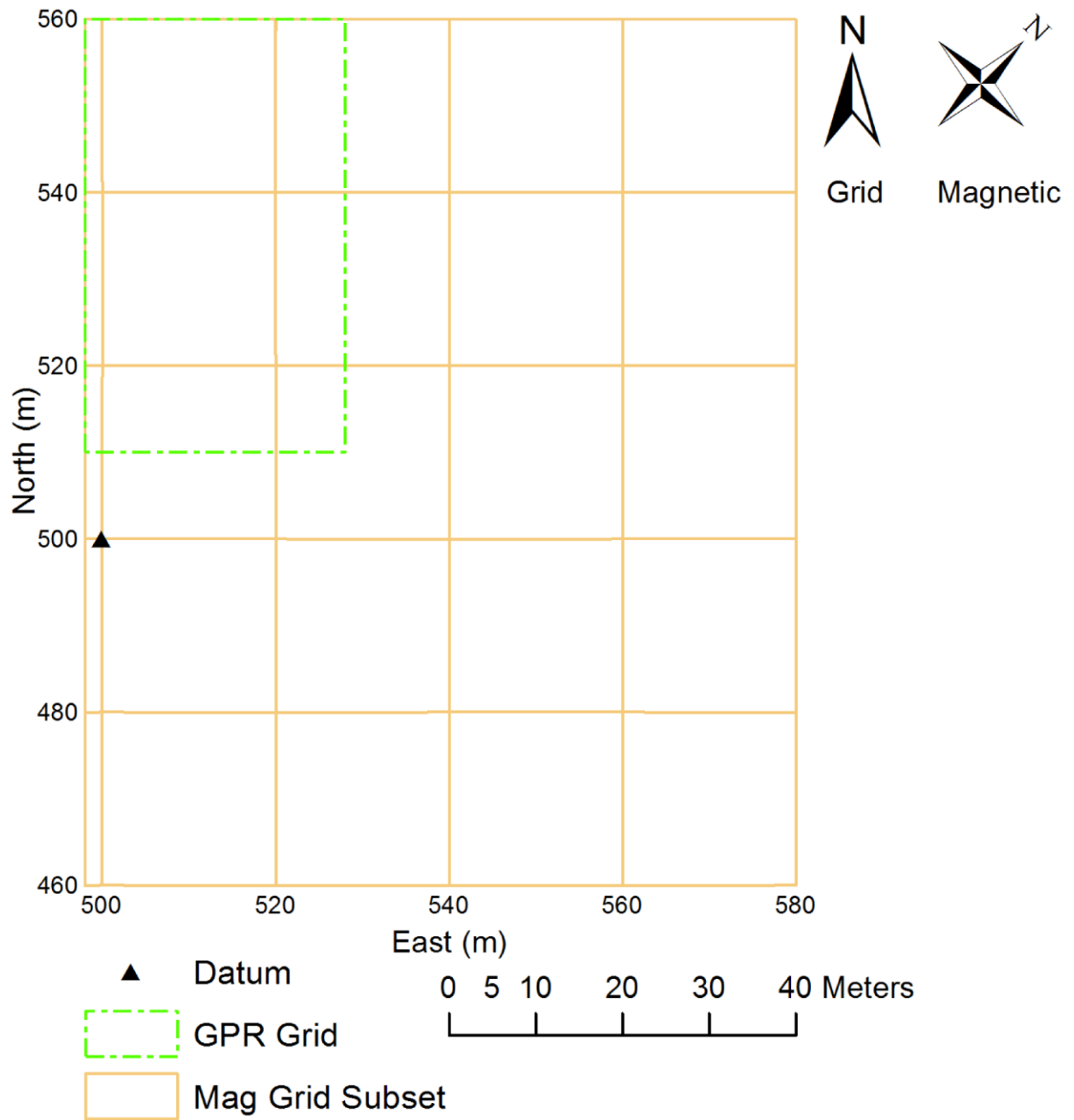


Figure 20. GPR Grid. November 2014 GPR grid block overlaid on March 2014 magnetometry survey.

Geophysical Data Processing

After data collection, data are first downloaded from the instrument or data logging device to a computer. Some instruments transfer files directly from the geophysical unit to a computer via a cable or flash drive while others (e.g. magnetometer) require special software to transfer data. The data are imported into a geophysical data processing software—many are available, but ArchaeoFusion and GPR-SLICE were used for this project (ArchaeoFusion 2010; Goodman 2014). Geophysical data are a series of instrument readings assembled into a computer file. Although there are many file formats, essentially, they all contain the horizontal (x), vertical (y), and, if applicable the depth (z) locations along with the instrument readings. Each reading is gridded according to the spatial location and assembled into a raster image file—a file format where each pixel represents an instrument reading. If instrument readings occur at a low sampling density, interpolation may occur between data points to create a complete image of a grid block. Each grid block is assembled and placed in the correct spatial location. This often requires grid blocks to adjoin other blocks on one or more sides, creating a mosaic of all the grid blocks for a survey area.

This above process will make a display image for geophysical users, but frequently further raster image processing is required. Processes can be applied to the entire data set, individual grid blocks, or selected portions of the raster image. The images are processed to remove instrument and user errors such as stagger, striping, and spikes. Similarly, other processes (e.g. clipping, high or low pass filters) are used to enhance or diminish aspects of the data set. The following processes were used on the project's data and process explanations are derived from the ArchaeoFusion (2010) user's manual.

- *Destagger* shifts lines of data within a grid block to correct spatial offset. This usually occurs during zig-zag surveys where lines of data do not match up next to each other. Also, this can occur from instrument lag—meaning the instrument collects readings at a delayed time.
- *Zero Mean Traverse (ZMT)* removes striping within a data set. This usually occurs when collecting in a zig-zag pattern, but is related to minor differences between sensors, often in magnetometry, that causes one sensor to have consistently higher or lower readings than the other. This process has three different settings (mean, median, or mode) allowing the “M” to stand for any of these settings.
- *Spatial Filter* applies either a low or high pass filter to the data set. A low pass filter will smooth an image while a high pass filter will sharpen the image.
- *Mean Profile Filter (MPF)* is a combination of a low and high pass filter to further remove striping effects within a grid block. The low pass filter first enhances the striping effects and then the high pass filter isolates the stripes which are then subtracted from the grid block.
- *Clip* removes all data outside of a specified range and replaces those data with the highest or lowest values specified.

Magnetometry

At the end of each day, all magnetometry data were downloaded to a laptop computer using the Bartington Grad 601 software. This enables the magnetometer to be connected to a computer via serial port and then guides the transfer of data files to the computer. After this, all grids were renumbered corresponding to their designated grid block number because the

magnetometer automatically numbers the grids one through (n) without any prefix. Also, the instrument has a limited data capacity, holding a maximum of 16 full grids worth of data, which creates multiples of grid block numbers when doing large surveys.

ArchaeoFusion was used to grid and process the magnetometry data. All grid blocks were destaggered, de-striped using Zero Median Traverse (ZMT) and a Mean Profile Filter, and then clipped to improve contrast. Finally, a low pass filter was employed to smooth the final image. For the exact settings used during processing see the Appendix.

Electromagnetic Induction

EMI data were transferred directly from the Archer 2 hand held system to a laptop computer. Upon importing the file into ArchaeoFusion each line of data or transect was edited for the removal of excess data caused by the continuous data collection mode. Next, the data were gridded and standard data processing techniques were employed. The Geonics EM 38-MK2 actually produces four data sets (magnetic susceptibility and conductivity at .5 m and 1 m spacing) and all were processed using Destagger, Mean Profile Filter, and finally a high pass filter. To see the detailed settings of each process see the Appendix.

Ground Penetrating Radar

After data acquisition, processing was done with the GPR-Slice software program. This software allows for the viewing and processing of 2 dimensional (2D) radargrams (the standard representation of GPR data) and the creation of 2D time slices (a method of interpolating between radargrams to create plan-view image maps) for viewing data in the x, y, and z direction. These slices allow for the creation of 3 dimensional (3D) volumes and isosurfaces—a 3D representation of subsurface features (Figure 21). A variety of processing techniques were

used individually and in combination with each other throughout the project. Some of these methods produced viable results while others were not as effective. For this reason a general overview of the most used and most common processing techniques will be provided here and a detailed description with specific settings is provided in the Appendix.

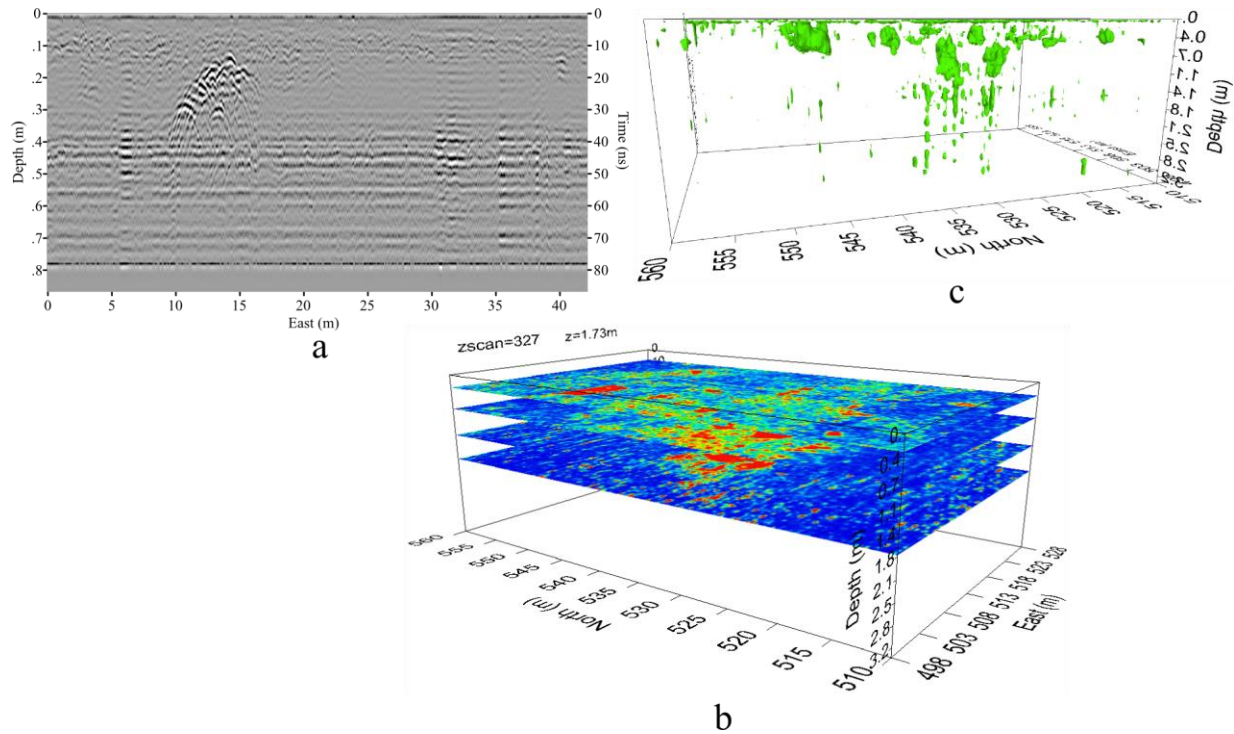


Figure 21. GPR Data. Examples of GPR data in 2D and 3D renderings. (a) Radargram or reflection profile showing GPR data in 2D. (b) A GPR slice showing 2D data in plan or map view. (c) Isosurface showing data in a 3D rendering.

The first phase of GPR data processing is done to individual radargrams. Using these techniques many iterations of filtering and data processing were used to determine what produced the most meaningful results while answering individual questions from the data set. The basic and most used processes are described below.

- *Gain* is first applied to radargrams to amplify the radar signal strength at selected depths. This is done because most systems record raw data with no field gain or processes

applied. Some systems do allow for gain and filtering to be applied to the recorded data, but these usually still require further gaining (Goodman and Piro 2013:37-38).

- *Time Zero* process is used to remove excess data above the surface signal. This is due to the time it takes the radar signal to travel through the air from the antenna to the ground surface. Data removal is usually done by setting *Time Zero* at or near the first strong reflection in a radargram.
- *DC drift* is caused by low frequency noise which becomes amplified at depth. This moves GPR traces away from the center zero line essentially causing positive signals to become negative and vice versa. If data are recorded without field applied filters, then “DC drift” also called “wow” or “wobble” must be removed through different filtering techniques (Annan 2009:34; Cassidy 2009:150; Goodman and Piro 2013:38-40).
- *Bandpass Filtering* removes selected frequencies from the data set. This is done by combining a high and low pass filter. They are used to enhance or diminish aspects of a data set and can remove high and/or low frequency noise (e.g. radio and cell phone transmission) (Cassidy 2009:152-157; Goodman and Piro 2013:40-45).
- *Background Removal* is used to remove horizontal banding or constant noise from individual radargrams. The filter averages the traces along a radargram and then subtracts that average from every trace in the radargram. This works well for removing noise, but it can also remove useful data or create processing artifacts—reflections that are enhanced or introduced strictly from the filter process (Cassidy 2009:154; Goodman and Piro 2013:46-48).
- *Hilbert Transform* is a process that converts the negative portions of the GPR signal to

positive, thus creating a rectified signal. This process simplifies the subsurface reflections into only strong and weak reflections instead of having strong and weak positive or negative reflections (Goodman and Piro 2013:53-54).

- *Migration* is a process used to deconstruct hyperbolas in data and can be used to estimate velocity within a survey. Round objects are recorded as hyperbolas in GPR data and the shape of the hyperbolas can then be used to estimate the velocity of radar transmission into the ground (Goodman and Piro 2013:48-52). If the velocity is known or correctly estimated, migration can be used to turn hyperbolas into point sources at the apex of the original hyperbola (Cassidy 2009:164-165; Goodman and Piro 2013:48-52). This places the point sources in their true position and reorients the position of other reflective surfaces near the hyperbolas (Goodman and Piro 2013:48-52).
- *Velocity Analysis* can be estimated through hyperbola fitting or, when applicable, velocity is calculated manually. This is done when the depth to reflectors (e.g. archaeological features) is known. In the case of archaeological applications, the distance from the ground surface to features can be measured during excavations. GPR data are collected with depth as time in nanoseconds (ns). The known distance to a feature can then be related to the time in ns to a corresponding reflector and velocity can be calculated (velocity = distance/time).
- *Topographic Correction* first requires creating a digital terrain model (DTM) or digital elevation model (DEM) of a site. This can be done in many ways, either through collection of elevation points with a total station, creating elevation from photographs (photogrammetry), or with light detection and ranging (LIDAR). After creating the

topography model, GPR data can be graphically warped to fit the topography or the data can be recreated accounting for topography (Goodman and Piro 2013:121-122). This simple correction can be helpful, but in cases of extreme topographic change correcting for antenna tilt is required. This readjusts the GPR data to fit the angle the antenna was at during data collection (Goodman and Piro 2013:122-126).

Archaeological Field Methods

Ten test units were placed on top of and around the mound proper during the 2014 summer field school (Figure 22 and Table 3). The locations of six of these units were based on the geophysical data while the other units, a trench, were used to determine the stratigraphy of the mound. To better understand the mound stratigraphy, the trench was aligned east-west with two other excavation units, so the stratigraphy of different excavation units could be related to each other. All units were square or rectangular in shape and the outside corners were placed with the aid of a total station. Standard archaeological excavation was employed using shovels, trowels, and other excavation tools. Dirt was then dry screened with one-quarter inch mesh screens. Any artifacts discovered during excavation previous to screening were piece plotted. This entails recording the location with the total station and photographing the artifact *in situ*.

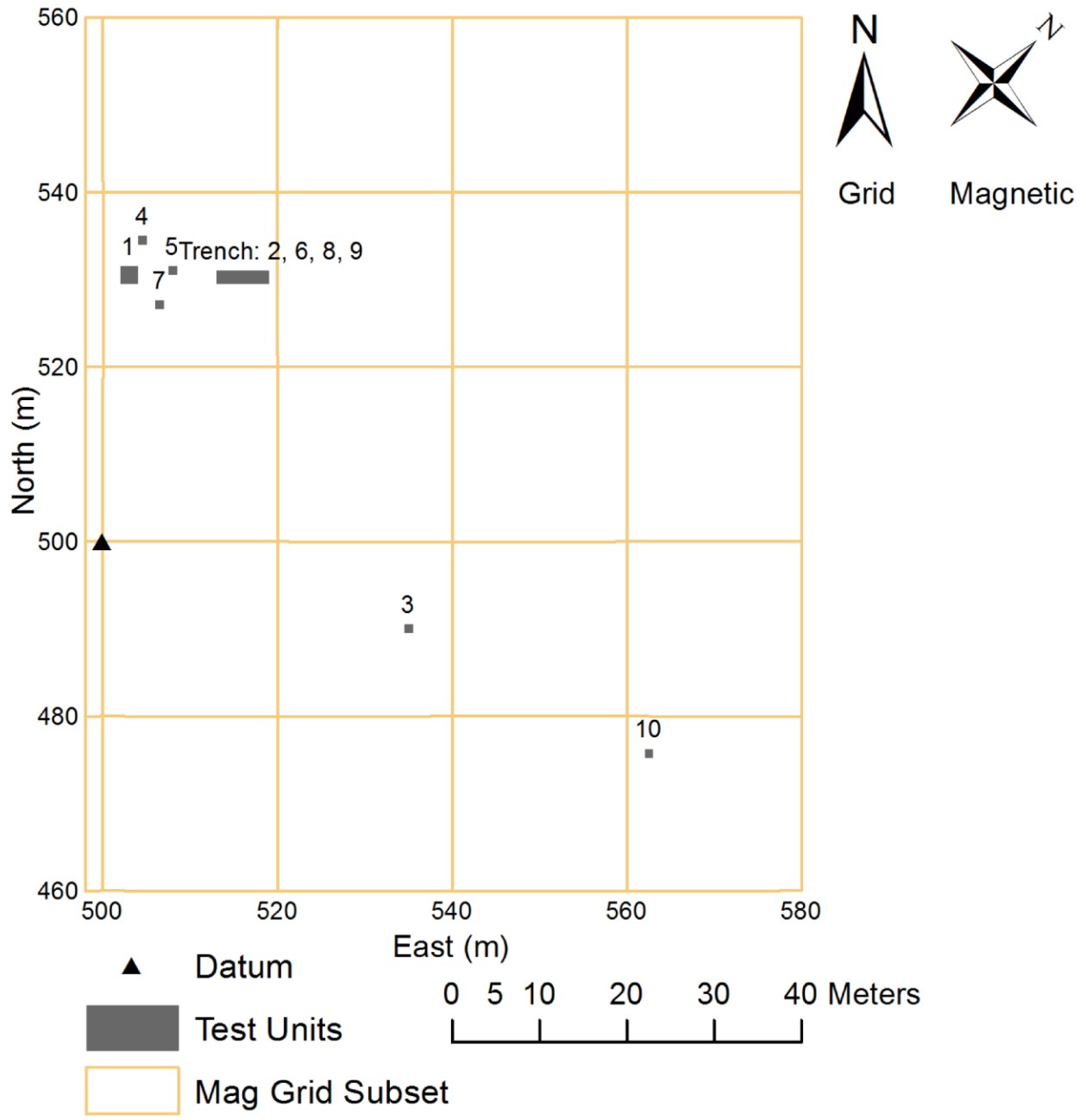


Figure 22. Test Unit Locations. Location of all archaeological test units during the summer 2014 field school overlaid on the magnetometry grid.

Table 3. Test Units. Description of archaeological test units during the summer 2014 field school.

Test Unit #	Dimensions (m)	SW Corner (m)		Starting Elevation (m)	Excavation Depth (m)	Description
		X	Y			
1	2 x 2	501.995	529.502	273.886	.8	Magnetic Anomaly
2, 6, 8, 9	1.5 x 1.5	512.987	529.498	W 273.014 – E 272.252	W 1.2 – E .4	6 x 1.5 m Trench
3	1 x 1	534.494	489.505	272.34	.5	Magnetic Anomaly
4	1 x 1	504.008	534.001	273.768	.8	Magnetic Anomaly
5	1 x 1	507.499	530.503	273.636	.7	GPR Reflection
7	1 x 1	505.999	526.599	273.725	.7	GPR Reflection
10	1 x 1	561.998	475.25	272.471	.4	Magnetic Anomaly

CHAPTER 5

RESULTS

This chapter provides a combination of geophysical results and where applicable the associated archaeological excavation results. Though a great deal of geophysical data were collected throughout the project only a portion of the data, specifically on top of and surrounding the mound, will be presented here. Due to this the magnetometry results shown are only a subsection, however, the full magnetometry data set is available in the Appendix. Table 4 summarizes 17 potential archaeological features. Also to note, some archaeological feature numbers will not be addressed though they were discovered during the field school excavations and so the naming convention reflects their existence in the overall project.

All but two features are on top or surrounding the mound proper. Features 3 and 5 are magnetic anomalies found southeast of the mound. Of the 15 mound features discussed only 13 are presented in Figure 23. Features 17 and 18 are presented separately and they are not shown in Figure 23. Feature 18 (the mound platform) is difficult to display in plan view, so it is only presented in radargrams. Feature 17 consists of multiple posts and would clutter the display of other features, for this purpose it is presented separately.

Fourteen features were detected with the GPR (Figure 24). In GPR, features are recognized as extremely strong to mild reflections. Also, reflections can be flat or hyperbolic—hyperbolic reflections are created from point sources. Point sources are commonly single small objects (e.g. individual rocks), or linear features that behave like point sources in cross-section (Conyers 2013:59). Point sources are recorded as hyperbolas because GPR antennas transmit energy in a conical pattern. This causes reflections to be recorded that are not from directly

underneath the antenna which produces a hyperbolic reflection (Conyers 2013:59). The GPR features include rock features, pits, post holes, a burn feature and a platform. Only GPR provides depth to features which is presented here in elevation above mean sea level (m). The highest elevation on the mound is 273.7867 (m). Nine features were detected by magnetometry (Figure 25) as strong positive and negative anomalies. These include rock features, pits, a burn feature, and a possible structure. Three features were detected by the EMI as strong positive and negative anomalies. These include rock features and a possible structure (Figure 26).

Table 4. Feature Matrix. This table presents the features to be presented here and discussed in chapter six. Features are described as being detected (Y) not being detected (N) or not applicable (-) by a particular geophysical method or archaeological excavation.

Feature Number	Short Feature Description	Methods			
		GPR	Magnetometry	MS	Excavation
1	Large Stone Pile/Entrance Marker	Y	Y	Y	Y
2	Large Stone Pile/Entrance Marker	Y	Y	Y	Y
3	Small Pit	-	Y	-	Y
5	Modern Post Hole	-	Y	-	Y
6	Burn Feature	Y	Y	-	-
7	Structure Corner/Prepared Surface	Y	Y	-	-
8	Pit	Y	N	-	-
9	Pit	Y	N	-	-
10	Prepared Surface/Pit	Y	N	-	-
11	Prepared Surface/Pit	Y	N	-	-
12	Stone Boundary Markers	Y	N	-	-
13	Small Stone Pile	Y	Y	N	-
14	Small Stone Pile	Y	N	N	-
15	Stone Pavement/Altar	Y	Y	-	-
16	Structure	N	Y	Y	Inconclusive
17	Post Holes	Y	N	N	-
18	Platform	Y	N	N	Y

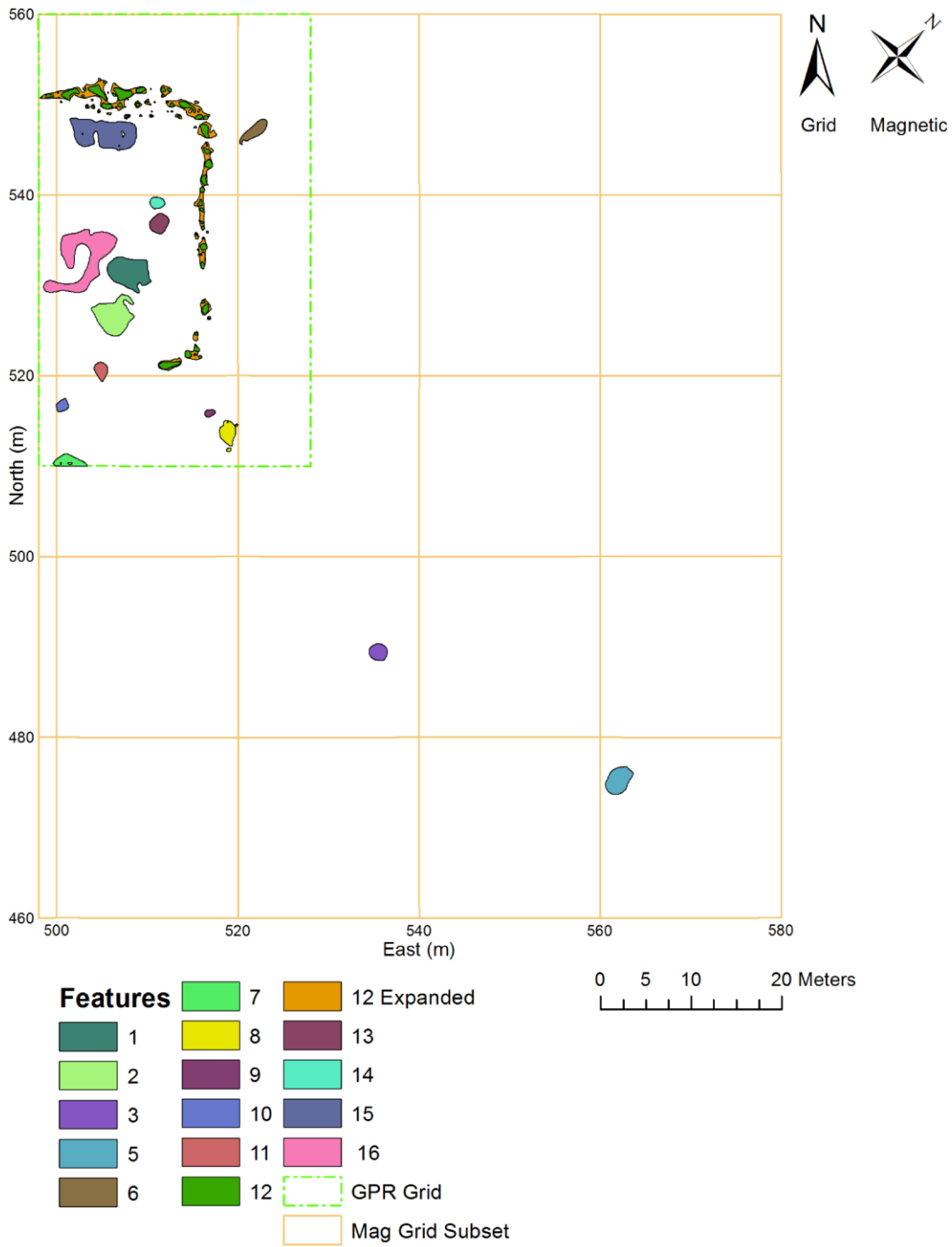


Figure 23. All Features. Polygons created from the original data sets. The best representative data type was used for features detected by multiple techniques. Feature 12 is split into the highest strength GPR reflections (12) and lesser strength (12 Expanded).

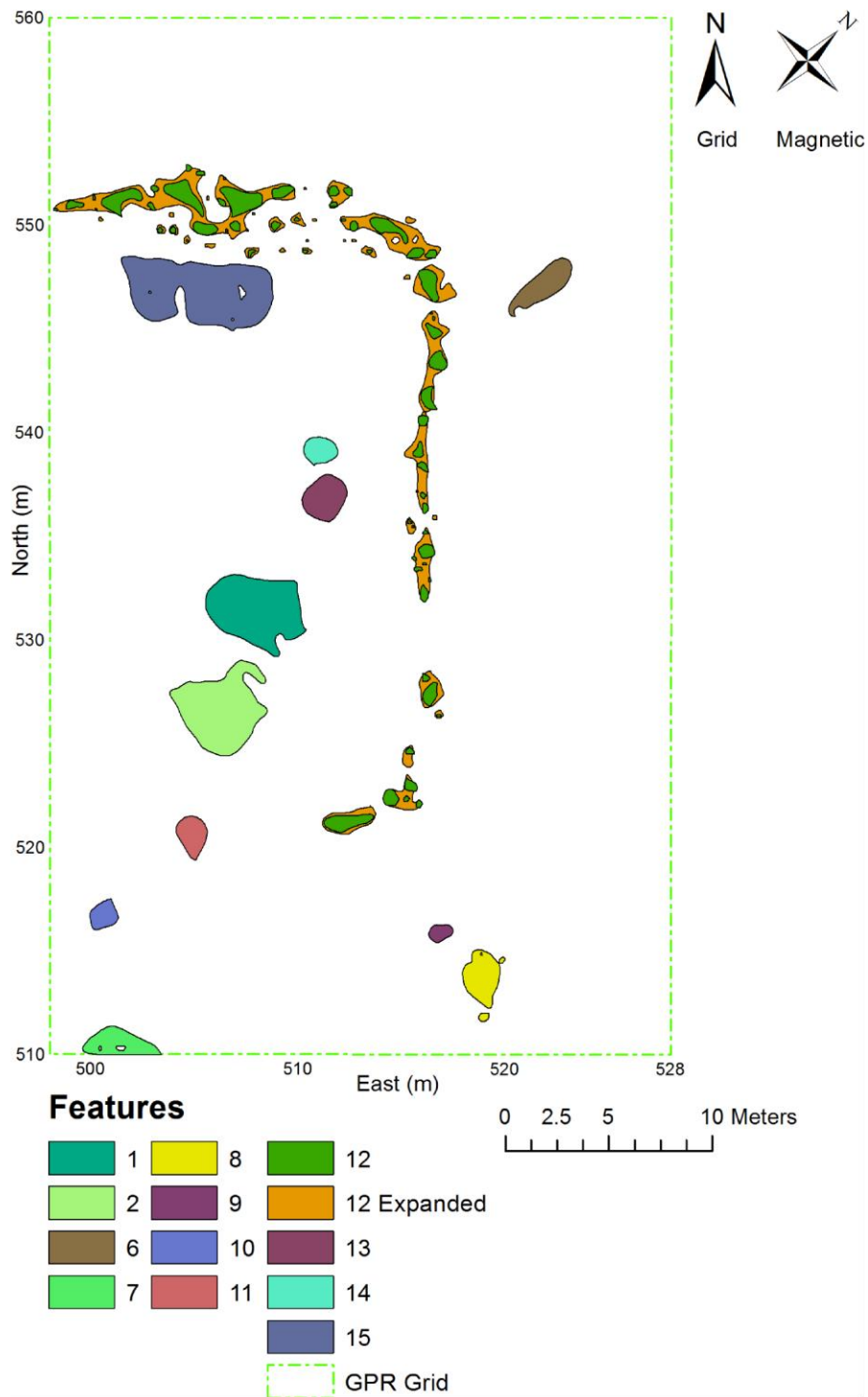


Figure 24. GPR Features. GPR features are found at different depths, but presented on the same plane here for simplicity. Feature 12 is split into the highest strength GPR reflections (12) and lesser strength.

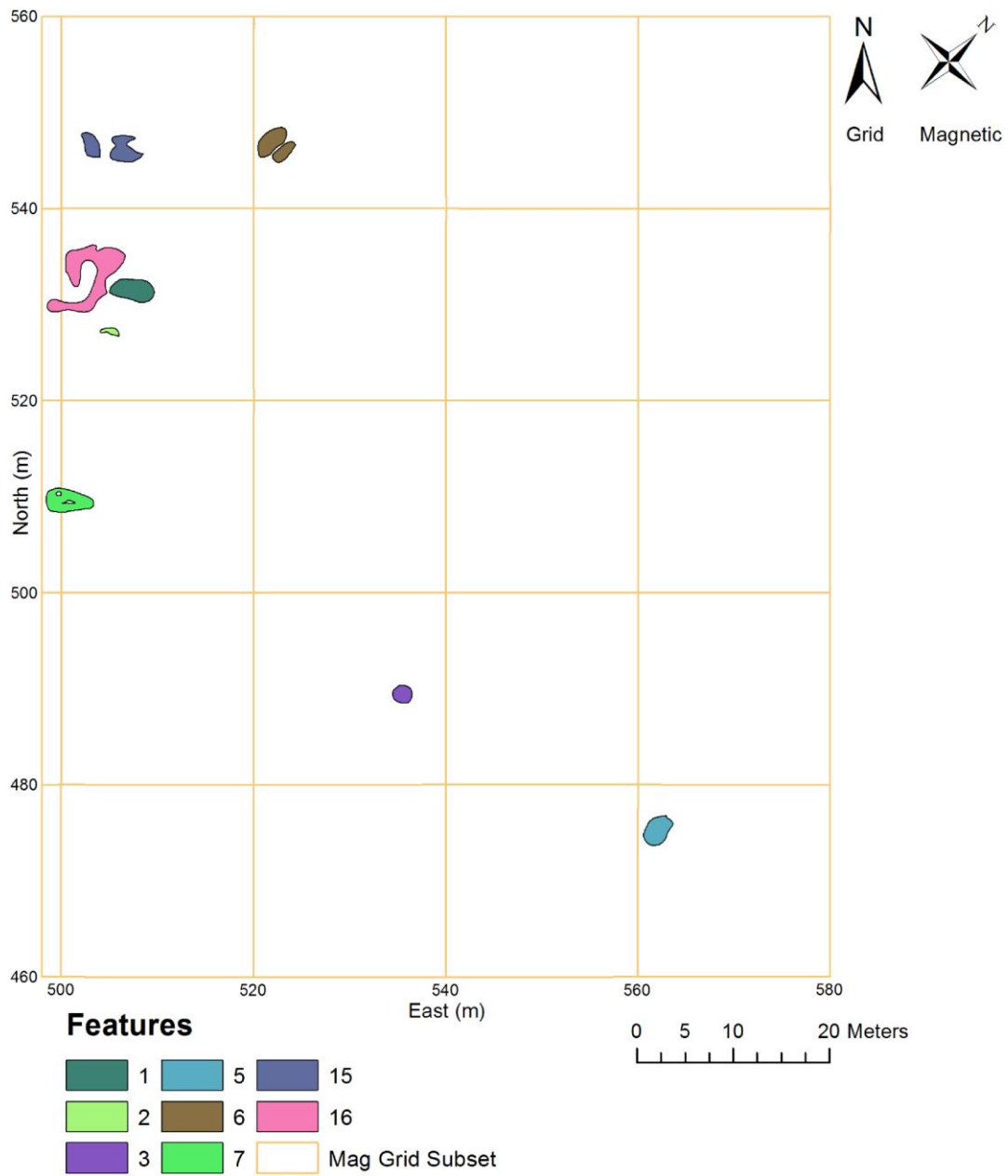


Figure 25. Magnetometry Features. Features shown are not differentiated between positive or negative.

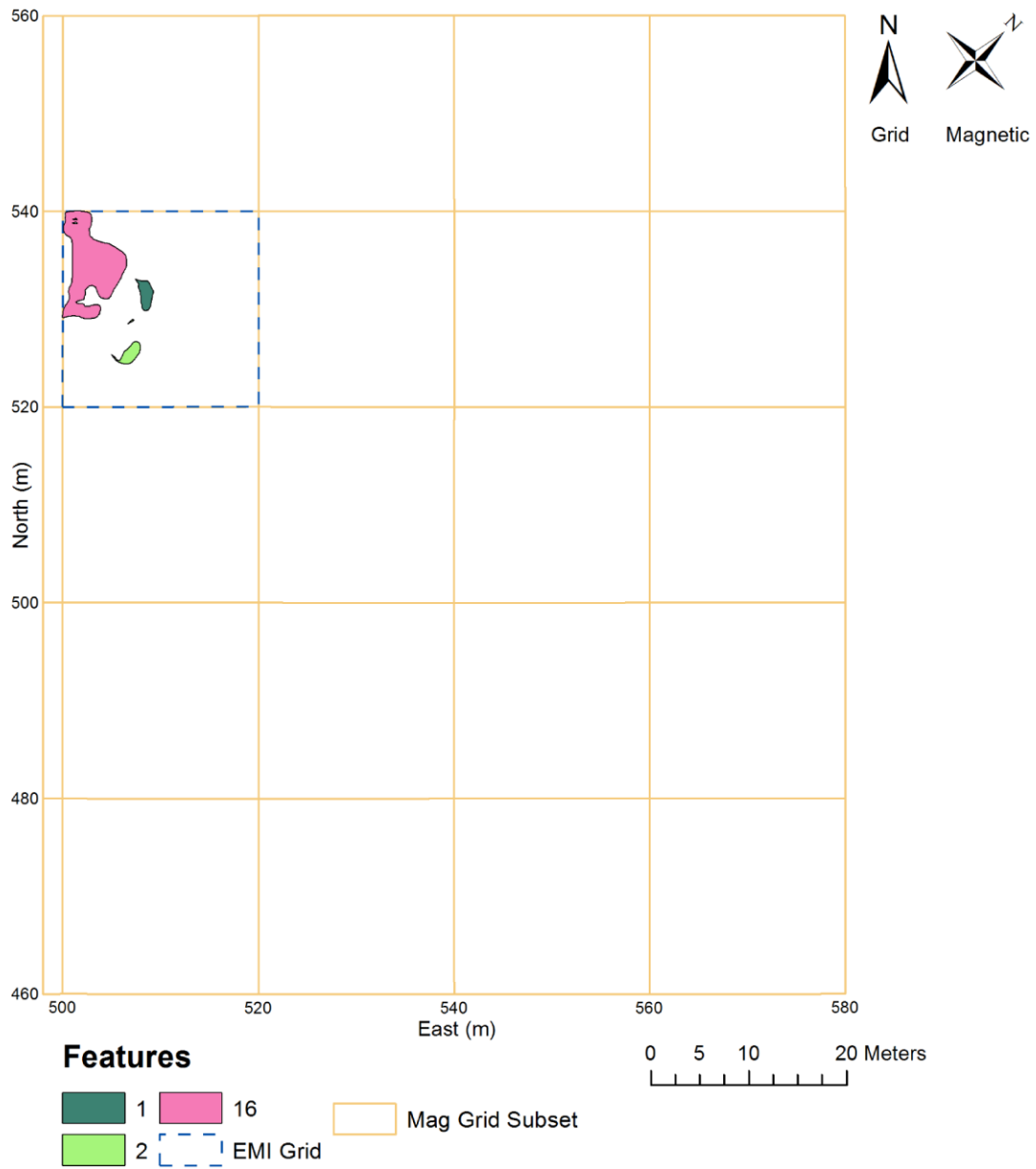


Figure 26. EMI Features. Features shown are not differentiated between positive or negative.

Feature Descriptions

Feature 1

This feature was detected by GPR, magnetometry, and MS (Figure 27). It was best detected by the GPR and in that data set it is centered at 508 m (E) and 531.5 m (N) and is approximately 4 x 3 m at 273.365 – 272.655 (m) elevation (Figure 27b). It consists of strong flat and hyperbolic reflections (Figure 27a). In magnetometry it is represented by a 4.2 x 2 m strong negative anomaly centered at 507.4 m (E) and 531.5 m (N) (Figure 27c). In MS it is represented by a 1.2 x 3.1 m strong negative anomaly centered at 508.5 m (E) and 531.5 m (N) (Figure 27d). Through excavation of TU 5, Feature 1 was determined to be a large pile of local limestone and sandstone (Figure 28a). The individual stones are generally .2 x .3 x .2 m in size.

Feature 2

Similar to Feature 1, Feature 2 was detected by GPR, magnetometry, and MS, being best detected with the GPR (Figure 29). In GPR it is centered at 506.25 m (E) and 526.4 m (N) and is approximately 3.5 x 4 m at 273.365 – 272.865 (m) elevation (Figure 29b). The feature is represented by strong flat and hyperbolic reflections (Figure 29a). In magnetometry it is centered at 505.1 m (E) and 527.25 m (N) and is a 1.8 x .7 m strong negative anomaly (Figure 29c). In MS it is centered at 506.95 m (E) and 525.5 m (N) and is a 1.6 x 2.6 m negative anomaly. Through excavation of TU 7, Feature 2 was determined to be a large pile of local limestone and sandstone approximately .2 x .3 x .2 m in size (Figure 28b). This is similar to Feature 1, however, TU 7 contains one piece of non-local quartzite.

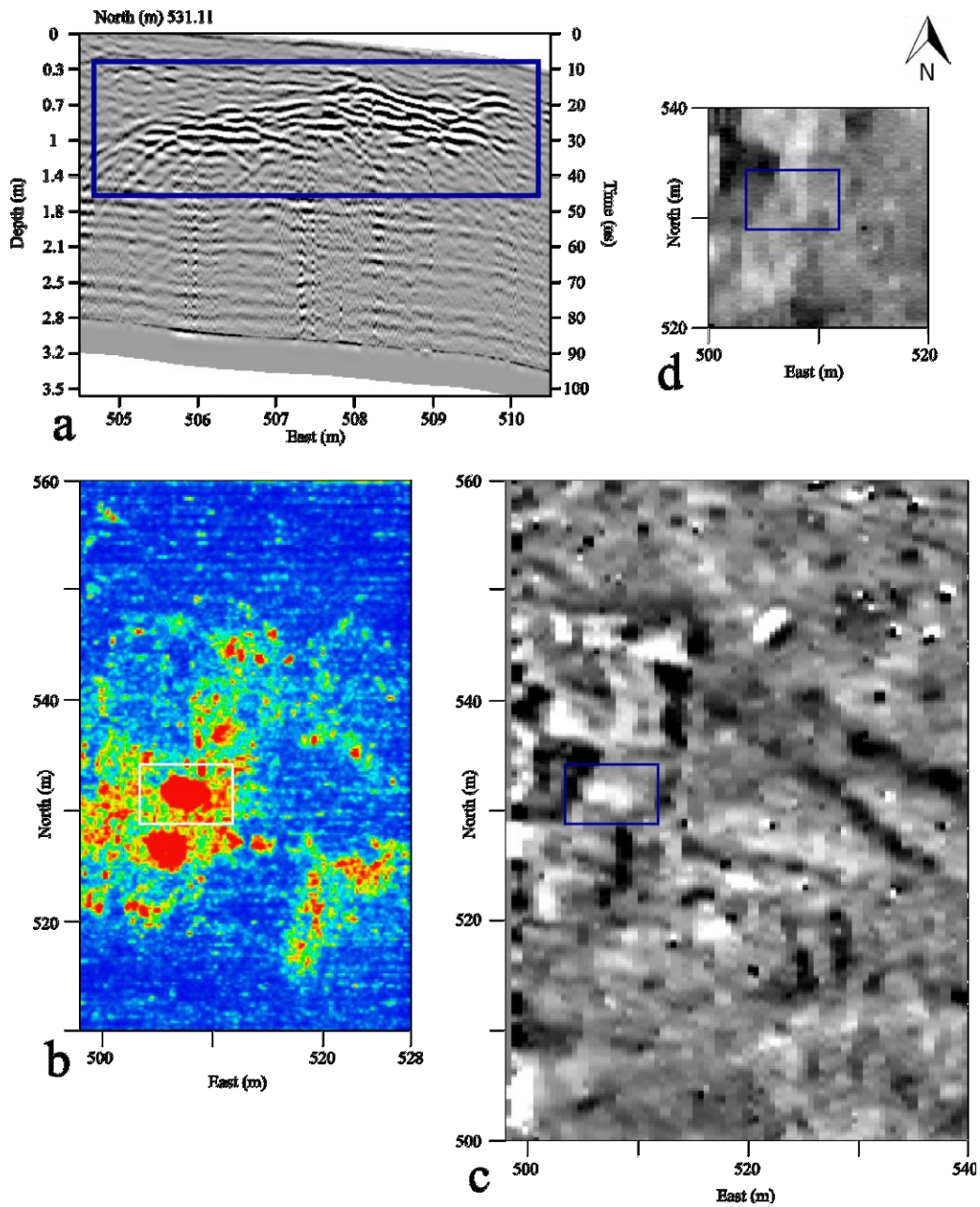


Figure 27. Feature 1. (a) A 6 m subsection of radargram 111. (b) GPR slice at .8 m below ground surface. (c) Negative anomaly in magnetometry. (d) Negative anomaly in MS.

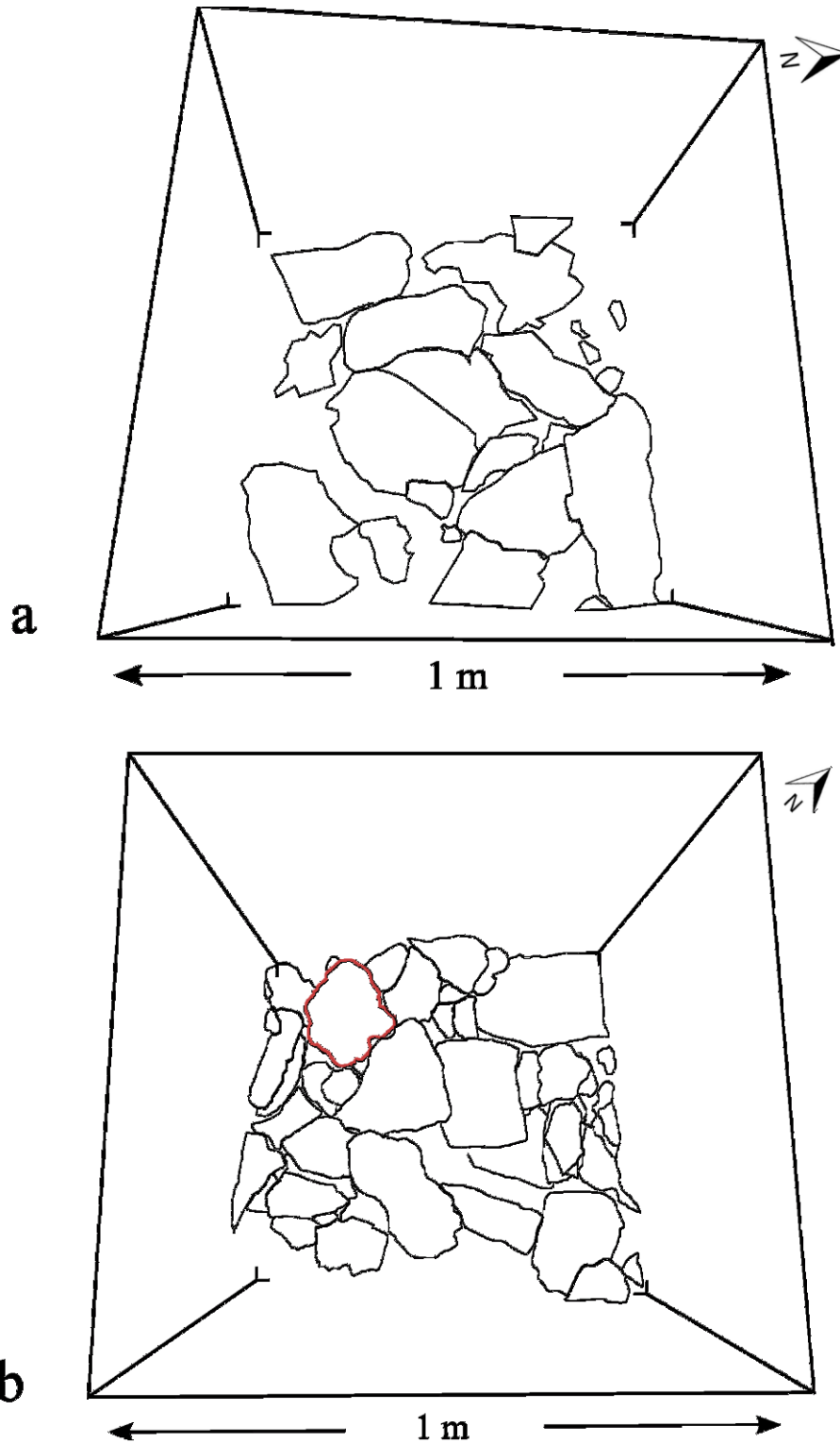


Figure 28. Rock Features 1 and 2. (a) Plan view of rocks in TU 5. (b) Plan view of rocks in TU 7 with a piece of quartzite outlined in red.

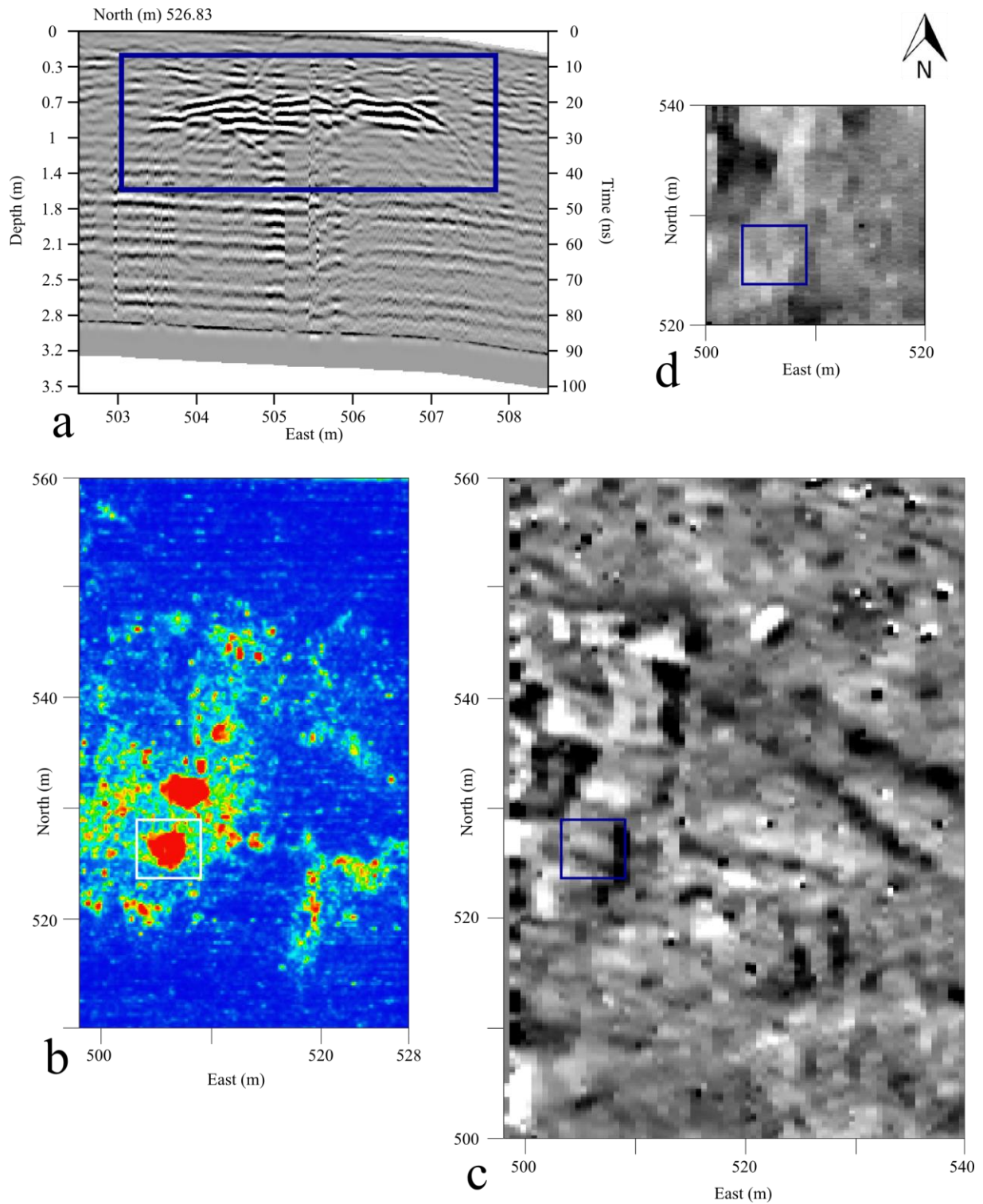


Figure 29. Feature 2. (a) A 6 m subsection of radargram 133. (b) GPR slice at .7 m below ground surface. (c) Negative anomaly in magnetometry. (d) Negative anomaly in MS.

Feature 3

Feature 3 is a small pit feature represented in the magnetometry data set by an approximately 2 m diameter strong positive anomaly centered at 535.5 m (E) and 489.4 m (N) (Figure 30). TU 3 was placed in the northwest portion of this anomaly (leaving over three fourths of the unit within the anomaly) and through excavation a darkened soil layer containing ceramics and fire-cracked rock was discovered in the southwest of the unit (Figure 31).

Feature 5

Feature 5 is represented in the magnetometry data set by an oblong strong positive anomaly centered at 562 m (E) and 475.25 m (N) measuring approximately 3.3 x 2.3 m (Figure 30). TU 10 was placed near the northeast corner of the anomaly. Through excavation, what is likely a modern post hole was discovered along with ceramics and 1 small (6.5 x 5.5 x 2.5 cm) piece of quartzite. Due to the size of the magnetic anomaly it is likely that a prehistoric feature is buried below the modern post hole (extent of excavation) and therefore the modern post hole is not the entire cause of the anomaly.

Feature 6

Feature 6 is presumably an intensely burned feature. It was detected in magnetometry and GPR (Figure 32). In magnetometry it is represented by a dipolar anomaly containing two oblong portions, the negative is centered at 521.8 m (E) and 547.1 m (N) and measures 3.8 x 1.8 m (Figure 32c). The corresponding positive anomaly is centered at 523 m (E) and 545.9 m (N) and measures 2.7 x 1.2 m. In GPR, Feature 6 is characterized by strong flat reflectors centered at 521.8 m (E) and 547.1 m (N) (Figure 32a). Its elevation is 272.015 – 271.215 (m). It is approximately 3.8 x 1.2 m and overlays with the negative magnetic anomaly (Figure 32b).

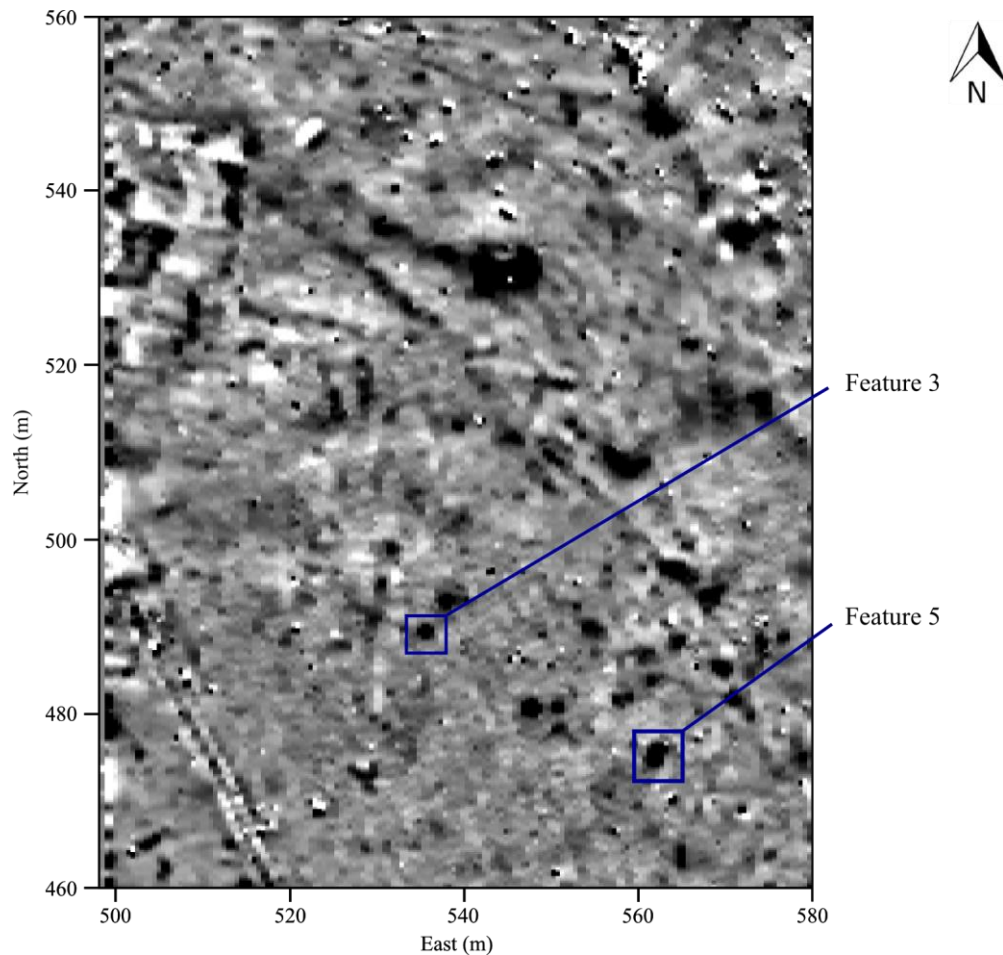


Figure 30. Features 3 and 5. Positive anomalies in black and negative in white. Both Features 3 and 5 are strong positive anomalies in the magnetometry data set.

Feature 7

This feature is found in the GPR and magnetometry data sets, although only a portion of the feature is present in the GPR due to it being at the southern extent of the GPR survey (Figure 33). In GPR, Feature 7 is characterized by a series of strong reflectors centered at 501.25 m (E) and 510.6 m (N) that come to a 90 degree angle moving northward (Figure 33b). The reflections range from 272.8067 – 272.6267 (m) in elevation (Figure 33a). This could be indicative of a structure floor or other prepared surface. In magnetometry a strong positive anomaly measuring 4.9 x 2.5 m is centered at 500.8 (E) and 509.5 m (N) (Figure 33c). Only the northeastern portion

correlates to the GPR reflectors. This feature is extremely close to a fence row, it is possible that the western portion of the magnetic anomaly is due to interference instead of the buried feature.



Figure 31. Test Unit 3. Feature 3 consists of a darkened soil layer and fire cracked rock.

Features 8 and 9

Both Features 8 and 9 are possible pit features detected in the southeast portion of the GPR survey. Feature 8, the larger of the two, is oblong shaped and approximately 2.8 x 1.7 m. It is centered at 518.9 m (E) and 513.5 m (N) and its elevation is 271.1867 – 271.9267 (m) (Figure 34). Feature 9 is roughly .8 x 1.2 m and is centered at 516.85 m (E) and 515.9 m (N) (Figure 35). Its elevation is 272.365 – 272.105 (m). Both are a combination of mostly strong flat reflections and few hyperbolic reflections.

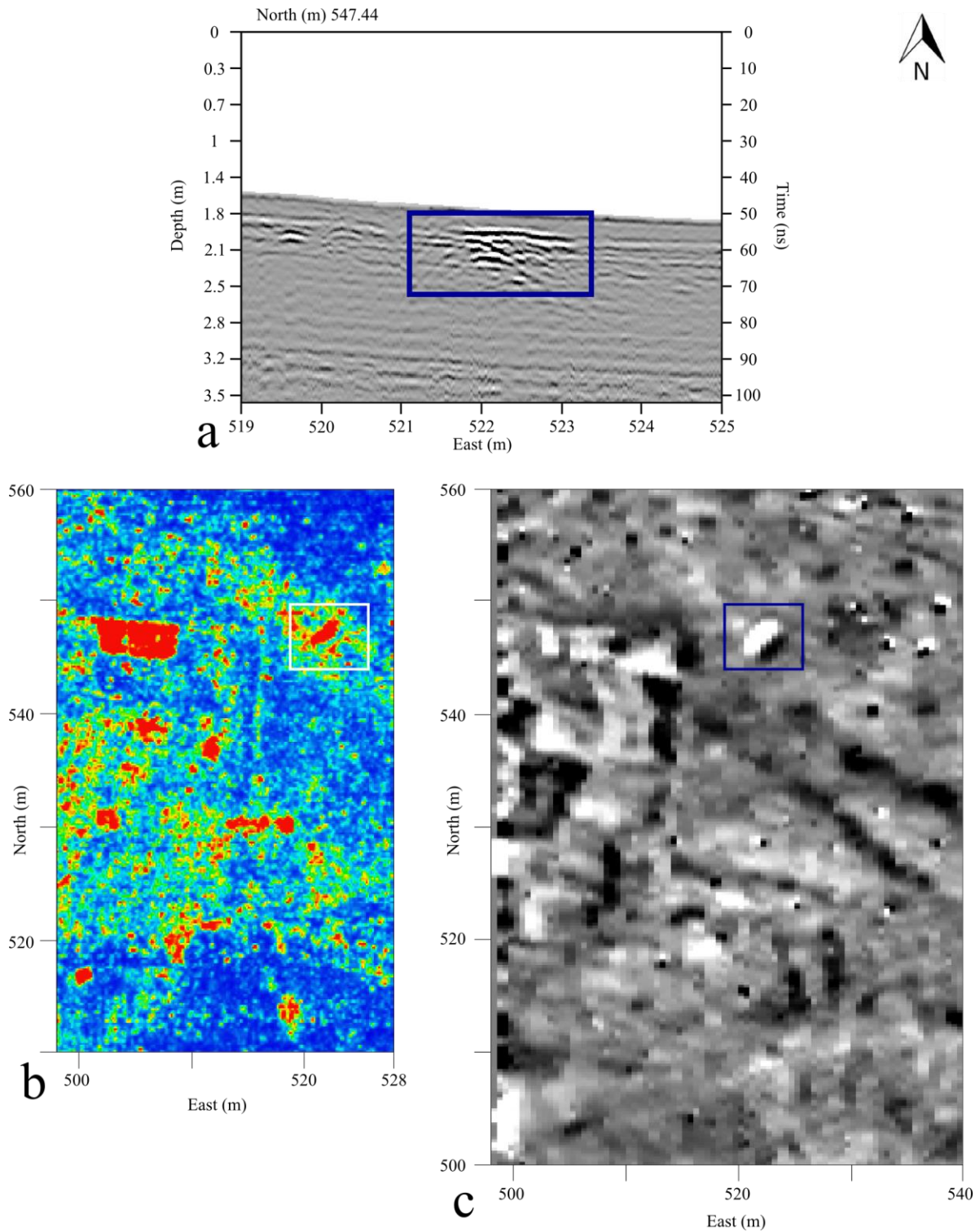


Figure 32. Feature 6. (a) A 6 m subsection of radargram 51. (b) GPR slice at .2 m below ground surface. (c) Corresponding positive and negative anomalies in magnetometry.

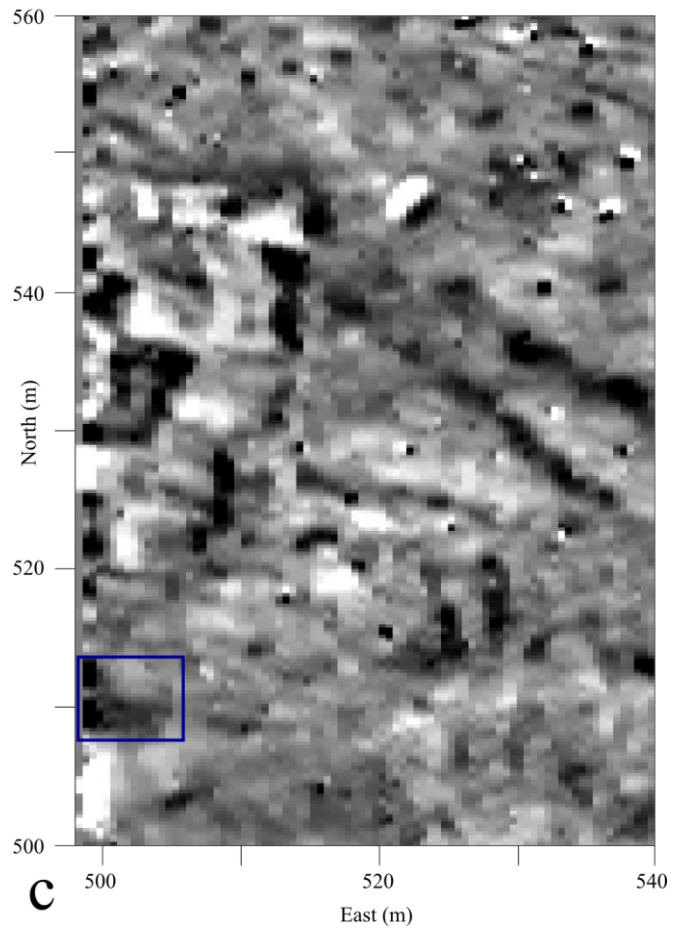
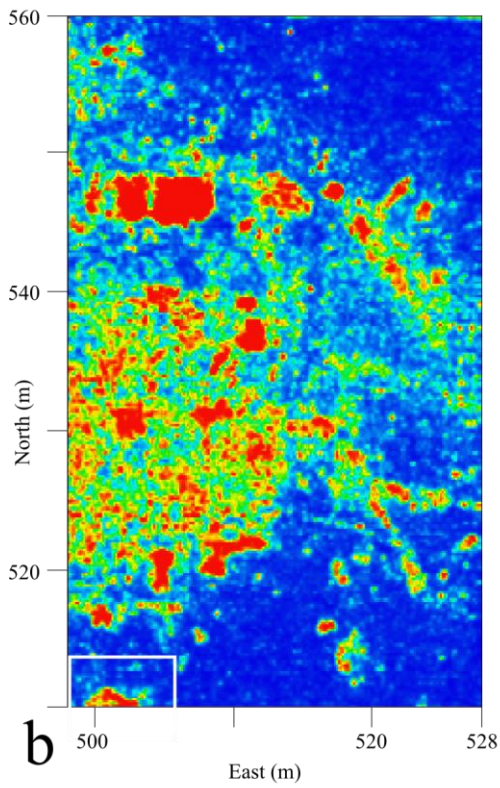
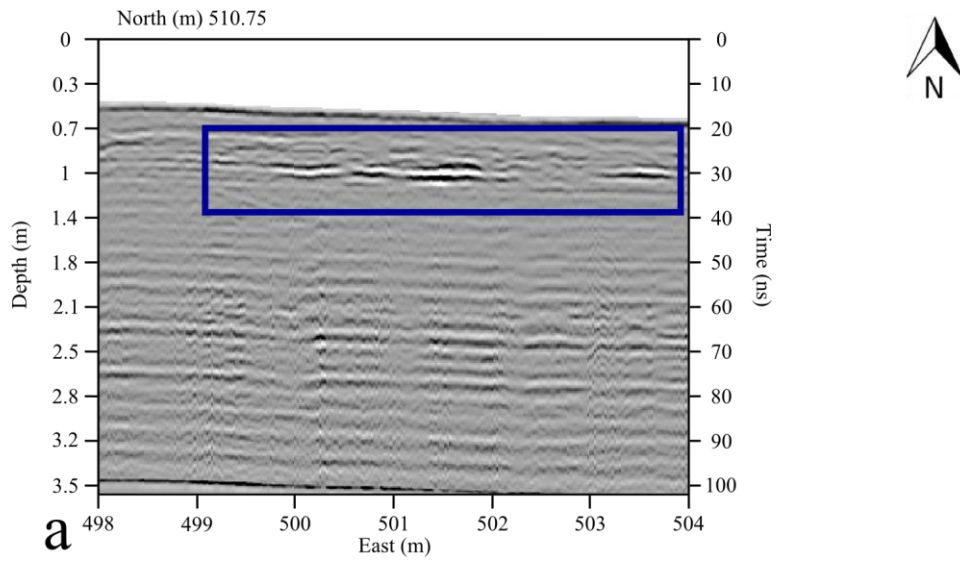


Figure 33. Feature 7. (a) A 6 m subsection of radargram 197. (b) GPR slice at .4 m below ground surface. (c) Positive anomaly in magnetometry.

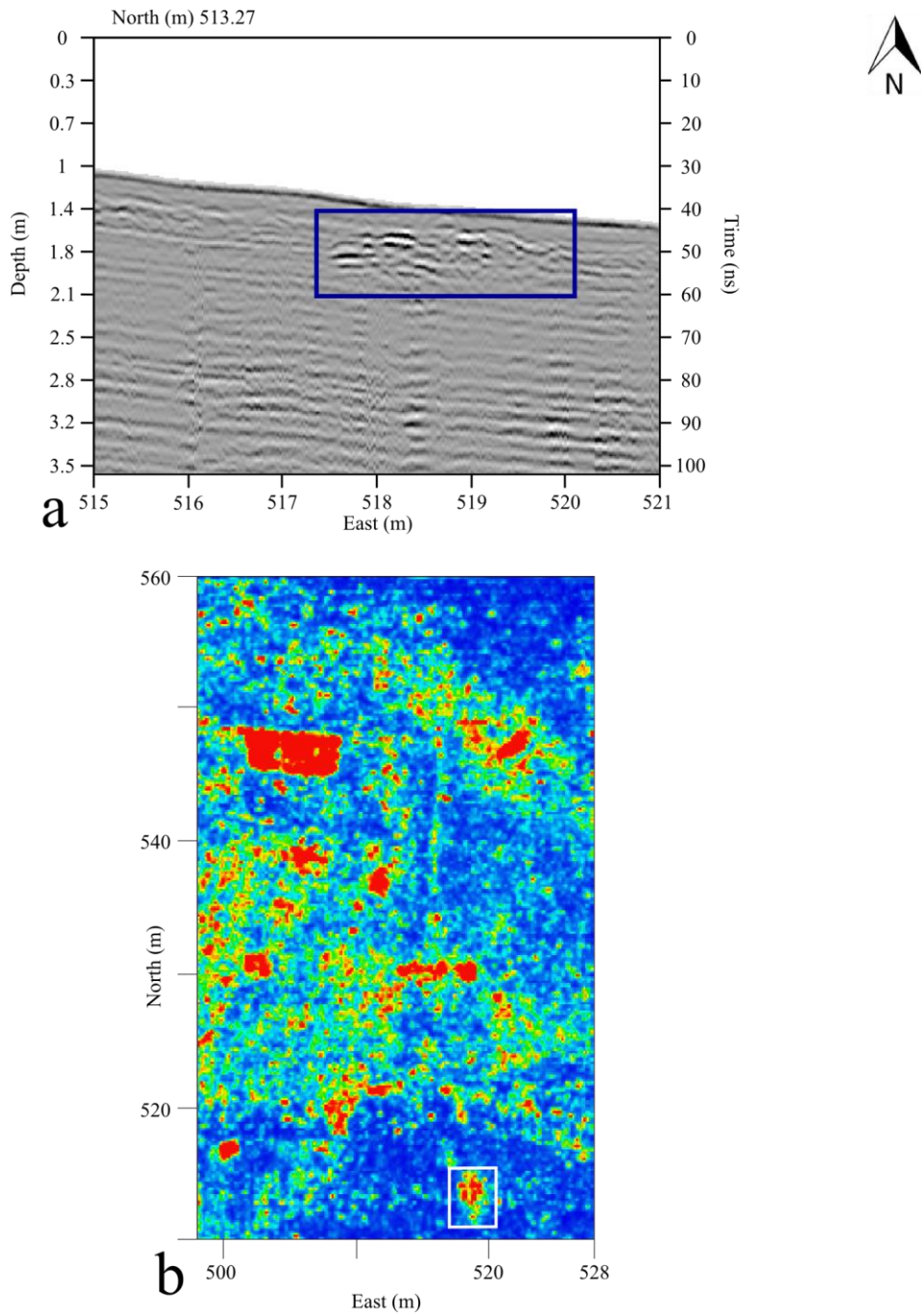


Figure 34. Feature 8. (a) A 6 m subsection of radargram 187. (b) GPR slice at .2 m below ground surface.

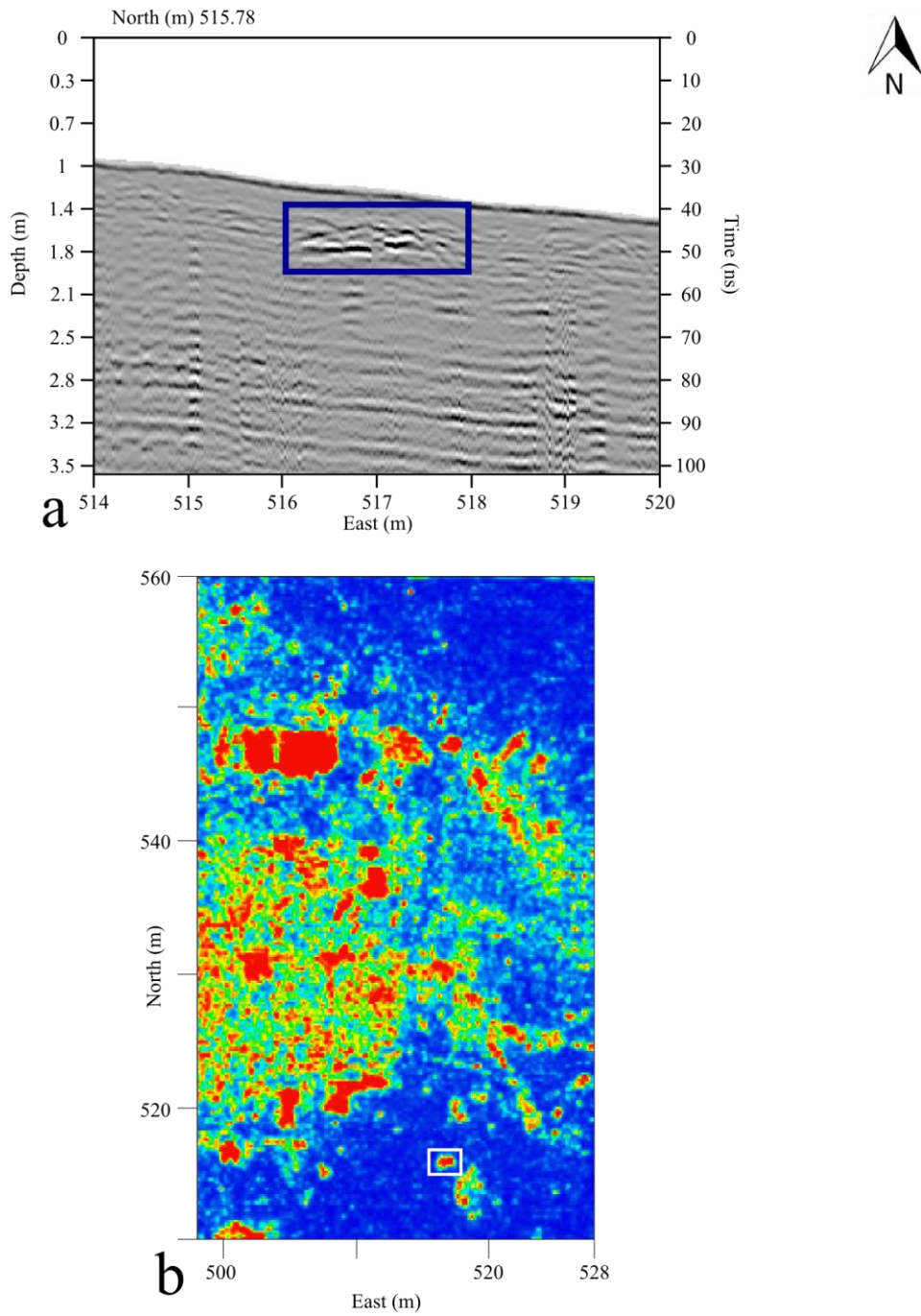


Figure 35. Feature 9. (a) A 6 m subsection of radargram 177. (b) GPR slice at .4 m below ground surface.

Features 10 and 11

Both Features 10 and 11 are present in the GPR survey. Feature 10 is centered at 500.5 m (E) and 516.75 m (N) and measures 1.3 x 1.5 m (Figure 36). Its elevation is 273.365 – 273.045 (m). Feature 11 is centered at 504.9 m (E) and 520.6 m (N) and is slightly oblong measuring 1.4 x 2.1 m (Figure 37). Its elevation is 273.205 – 273.055 (m). Both features roughly align with magnetic north and rock Features 1, 2, 13, and 14. Because both features are a combination of strong flat reflectors and broad hyperbolas (much different than the rock features) they are probably prepared surfaces or possibly shallow pit features.

Feature 12

Feature 12 is a linear feature detected by GPR that outlines the north and east portions of the mound (Figure 38 and 39). It consists of multiple strong and medium strength hyperbolas and some strong and medium strength flat reflections (Figures 38a, 38b, and 39a). The reflections average elevations are 272.6567 – 272.0867 (m). The reflectors trend along a path from 498 m (E) to 516.8 m (E) at approximately 550.1 m (N). The feature then turns south and trends from 548.1 m (N) to 521.7 m (N) at approximately 516 m (E). The pattern continues west from 516 m (E) to 511.1 m (E) at about 521.35 m (N) (Figure 39b). There is a continuation of strong reflectors to the west, but they may be a part of other features and so it is undetermined whether evidence for Feature 12 continues. Due to the strength and shape of reflections it is possible they are buried rocks.

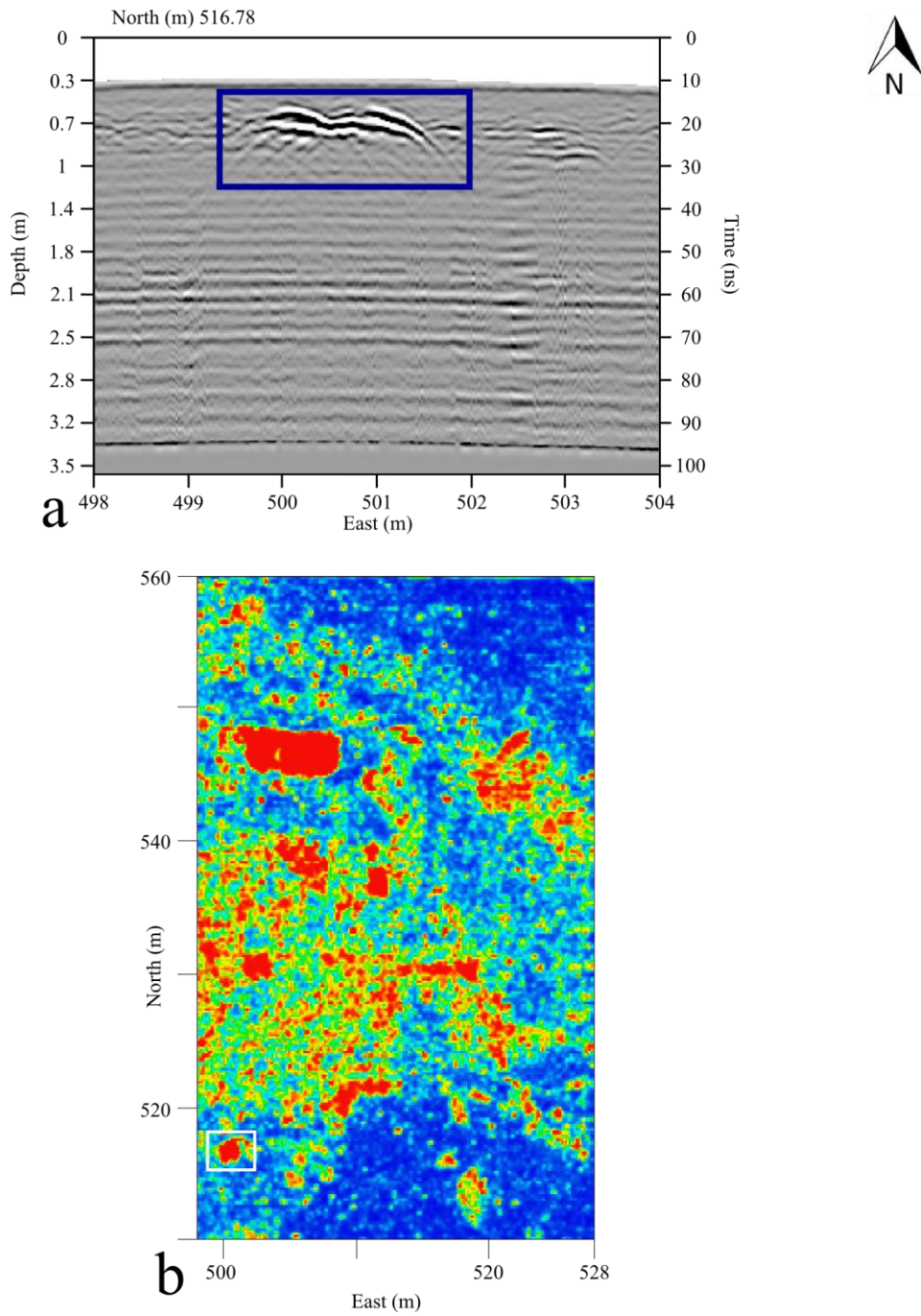


Figure 36. Feature 10. (a) A 6 m subsection of radargram 173. (b) GPR slice at .3 m below ground surface.

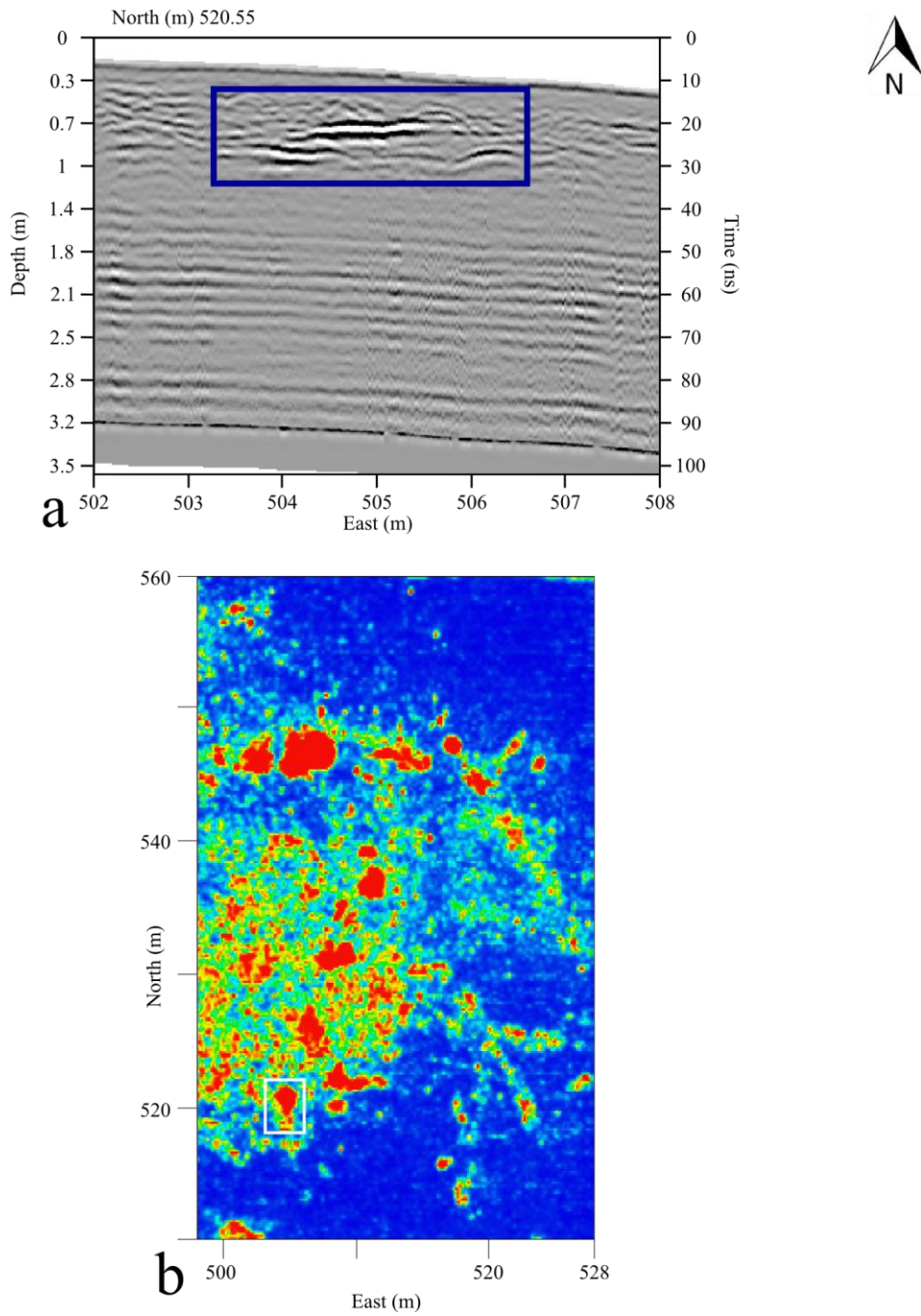


Figure 37. Feature 11. (a) A 6 m subsection of radargram 158. (b) GPR slice at .5 m below ground surface.

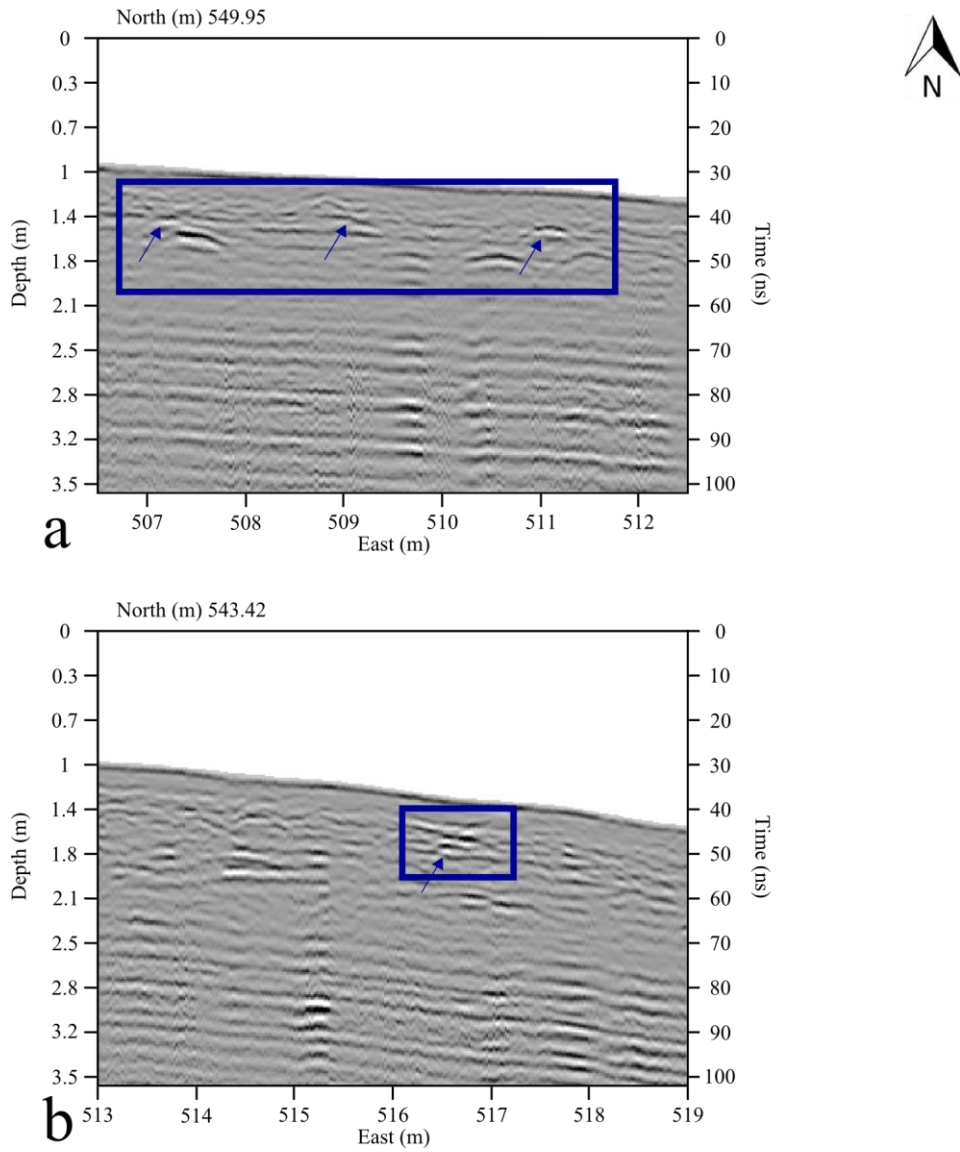


Figure 38. Feature 12. (a) A 6 m subsection of radargram 41 with at least three reflections related to Feature 12. (b) A 6 m subsection of radargram 67 with one reflection related to Feature 12.

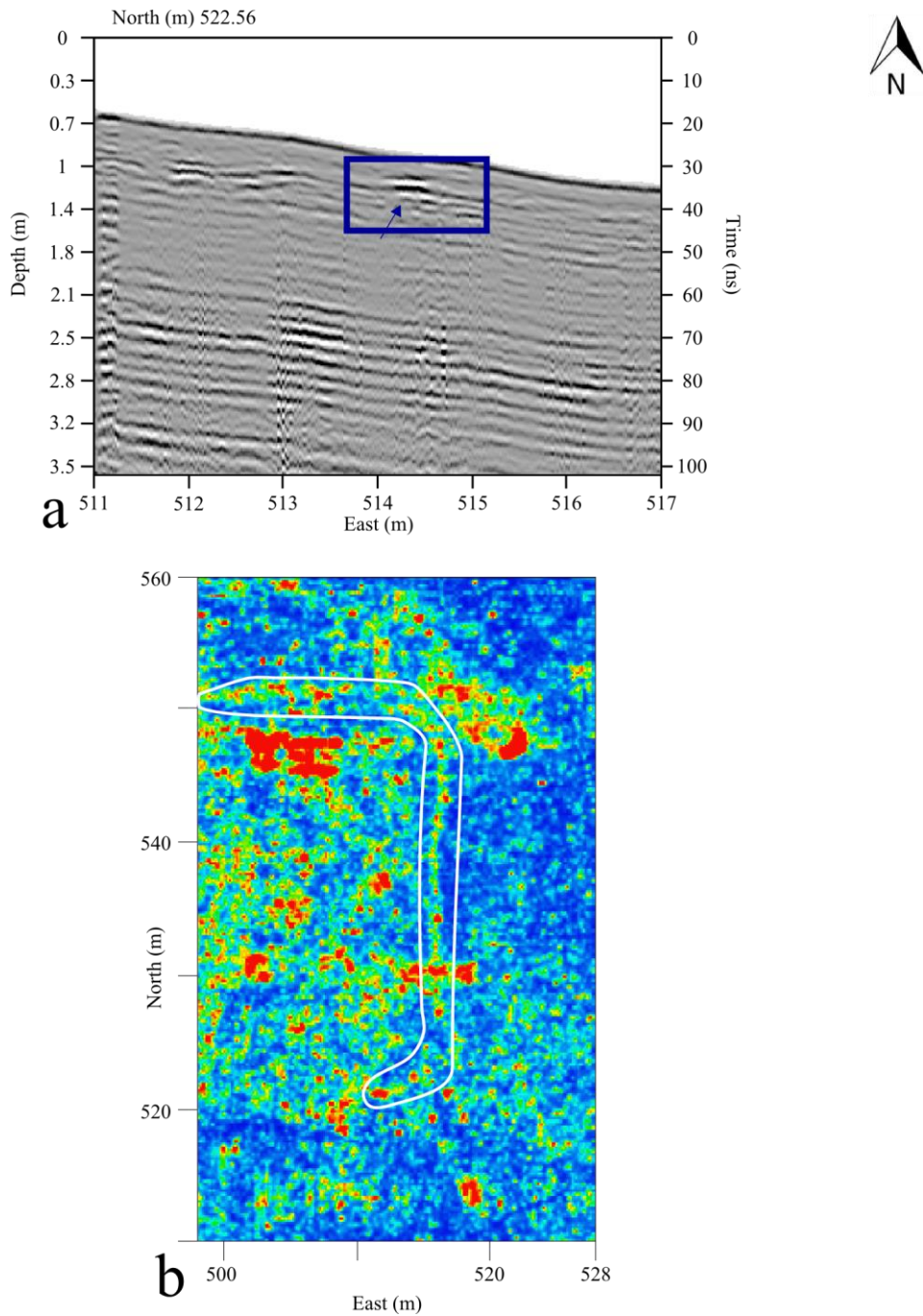


Figure 39. Feature 12 continued. (a) A 6 m subsection of radargram 150 with one reflection related to Feature 12. (b) GPR slice at .2 m below ground surface showing the linear trends of reflections creating the feature.

Feature 13

Feature 13 is present in the GPR and magnetometry data sets (Figure 40). In GPR it is centered at 511.3 m (E) and 538.8 m (N) and is fairly rectangular measuring 1.7 x 2.2 m (Figure 40b). Its elevation is 273.065 – 272.565 (m). The feature consists of strong hyperbolas and flat reflectors which suggest a buried rock feature (Figure 40a). In magnetometry it is represented by a strong negative anomaly centered at 511.1 m (E) and 563.4 m (N) (Figure 40c). It measures 1.8 x .65 m and falls within the southern portion of the GPR reflectors.

Feature 14

Feature 14 is .5 m north of Feature 13 and was detected by GPR (Figure 41). It is centered at 511.05 m (E) and 539.1 m (N) and measures 1.65 x 1.25 m (Figure 41b). Its elevation is 272.905 – 272.565 (m). This feature is represented by strong hyperbolas and flat reflectors suggesting a buried rock pile (Figure 41a), similar to Feature 13.

Feature 15

Feature 15 was detected by GPR and magnetometry (Figure 42). In GPR it is a combination of two sets of strong reflectors separated by approximately .5 m (Figure 42b). It is centered at 505.3 m (E) and 546.7 m (N) and rectangular measuring 6.8 x 2.9 m. The elevation ranges from 272.864 – 272.435 (m). This feature is comprised of strong hyperbolas and flat lying reflectors suggesting flat rock pavement or a rock altar (Figure 42a). In magnetometry it is represented by two strong negative anomalies separated by approximately 1 – 1.7 m (Figure 42c). The anomalies combined are centered at 504.4 m (E) and 546.5 m (N) and span 5.9 x 2.7 m.

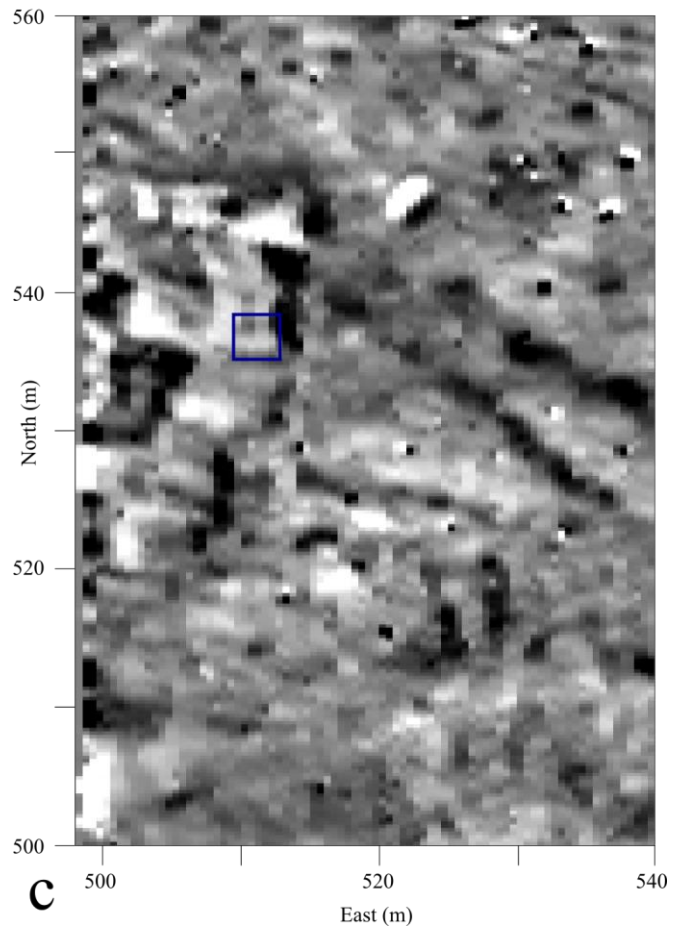
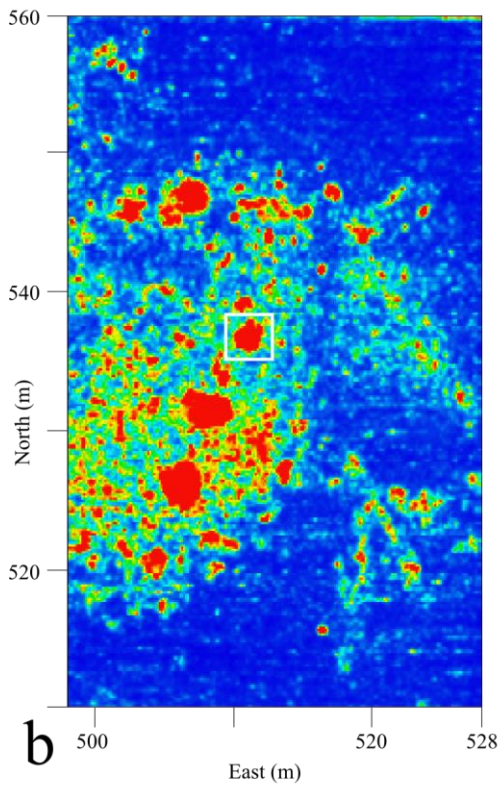
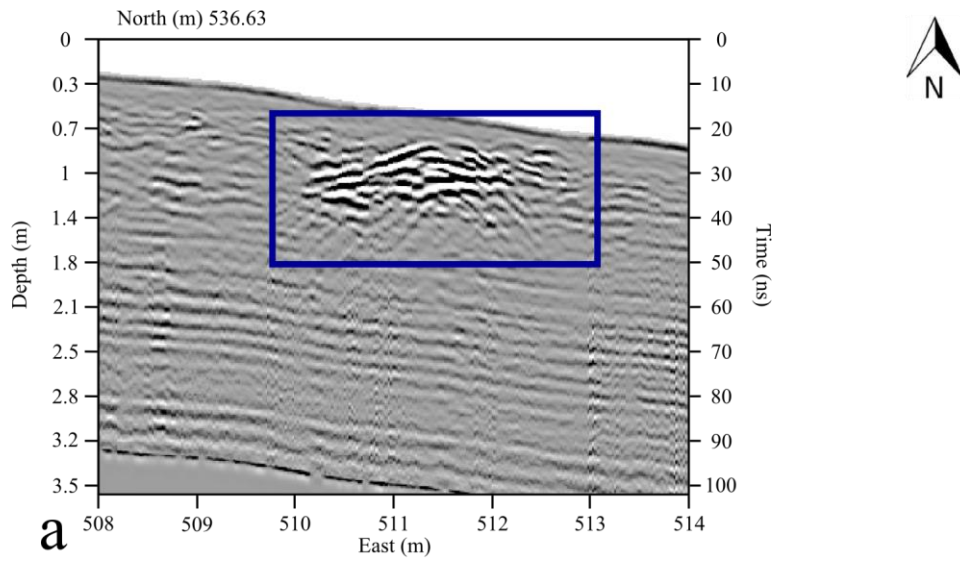


Figure 40 Feature 13. (a) A 6 m subsection of radargram 94. (b) GPR slice at .6 m below ground surface of selected feature. (c) Negative anomaly in magnetometry.

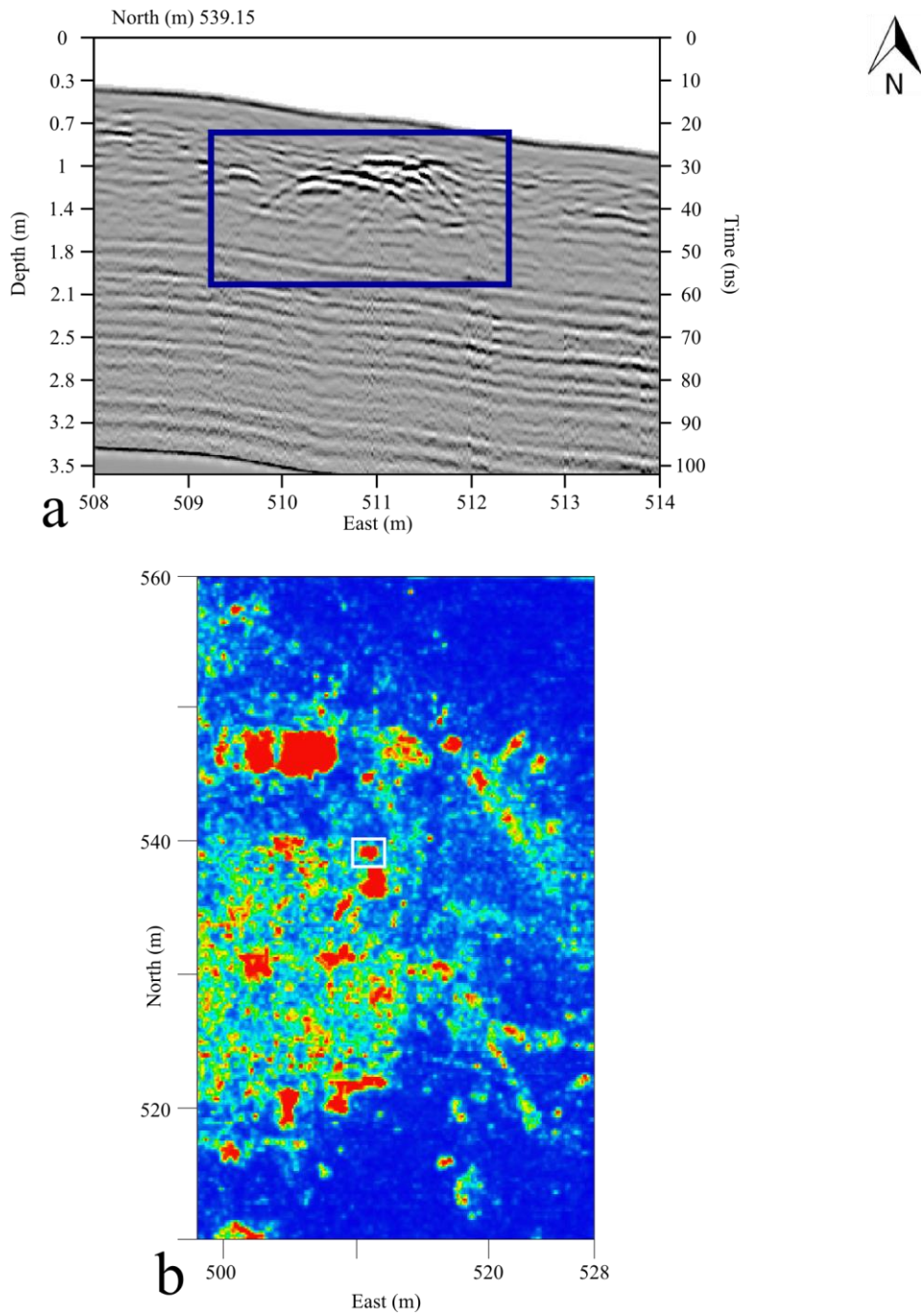


Figure 41. Feature 14. (a) A 6 m subsection of radargram 84. (b) GPR slice at .4 m below ground surface.

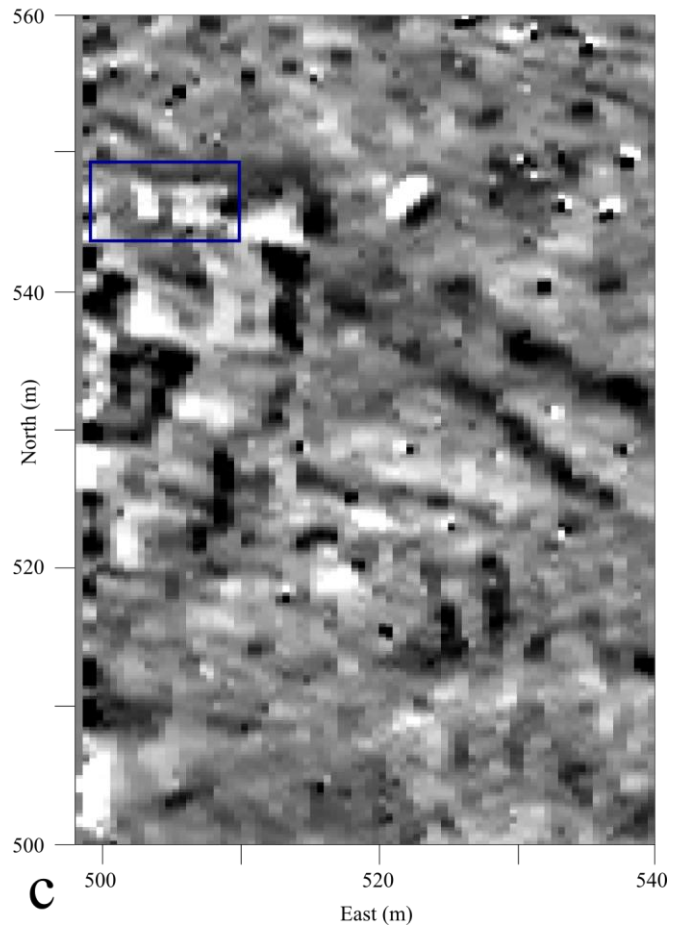
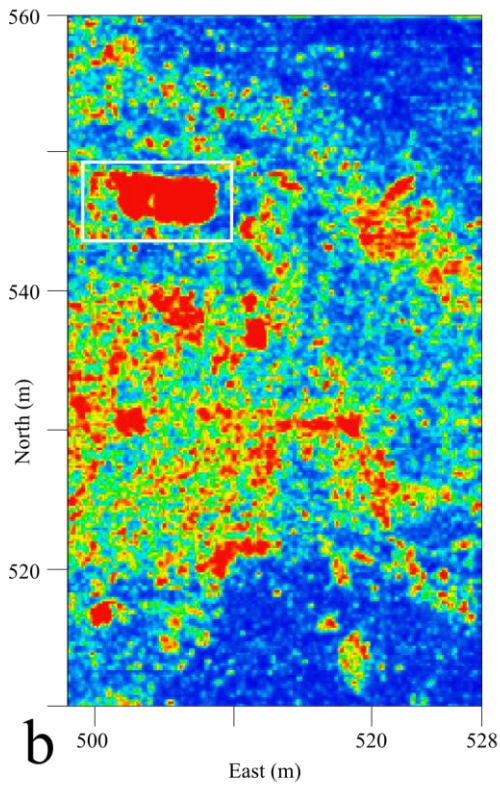
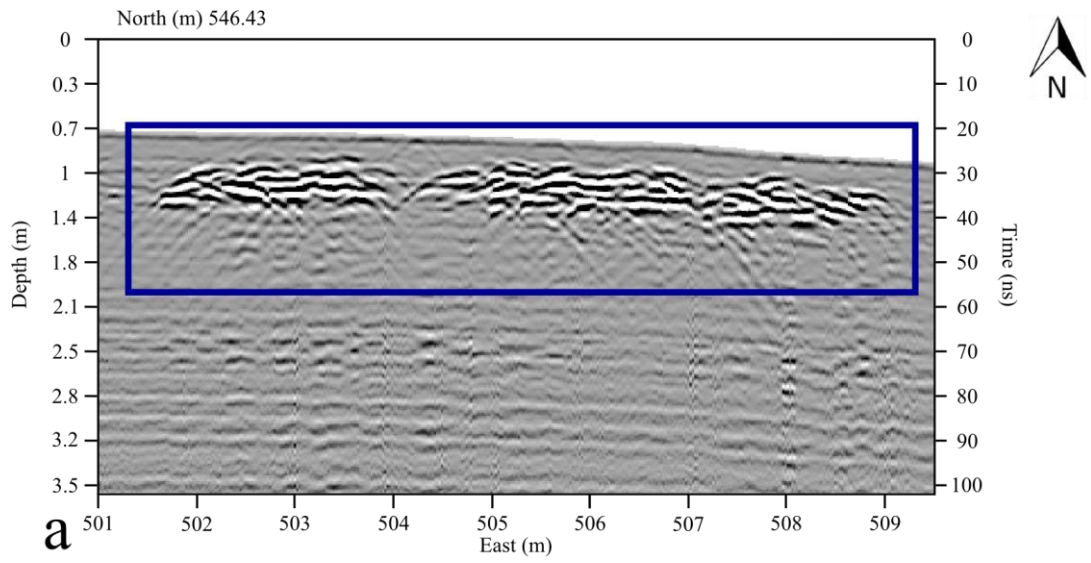


Figure 42. Feature 15. (a) A 8.5 m subsection of radargram 55. (b) GPR slice at .3 m below ground surface. (c) Negative anomalies in magnetometry.

Feature 16

Feature 16 was detected by magnetometry and MS (Figure 43). In magnetometry the feature is rectilinear and represented by three possibly complete and one partial side (Figure 43a). The southern side ranges from 498.57 – 503.36 m (E) centered at 529.82 m (N). The eastern side ranges from 529.24 – 535.8 m (N) centered at 503.9 m (E). The northern side ranges from 500.6 – 506.4 m (E) centered at 535.03 m (N). The partial western side ranges from 535.7 – 531.97 m (N) centered at 501.32 m (E). If completed to a rectangle this feature measures approximately 5 x 7 m and is represented by a strong positive anomaly. In MS this rectilinear feature is represented by a portion of strong positive anomaly (Figure 43b). There is a protrusion on the north side of the MS anomaly that could potentially be a separate or related feature. Excluding the protrusion, the MS anomaly is comprised of three complete and one partial side. The southern side ranges from the western survey boundary 500 – 503.8 m (E) with the southern edge at approximately 529 m (N). The partial eastern side ranges from 529 – 535.65 m (N) with the western edge running from 503.65 – 506.35 m (E). This side has a .8 m gap in the southeast corner. The northern side (excluding the protrusion) runs from 500.9 – 535.6 m (E) with the northern edge ranging from 537.2 – 535.8m (N). The western side (excluding the protrusion) ranges from 529.1 – 537.3 m (N) with the western edge ranging from 500 – 500.9 m (E). If simplified into a rectangle this feature measures approximately 3.8 – 5.8 m x 8 m.

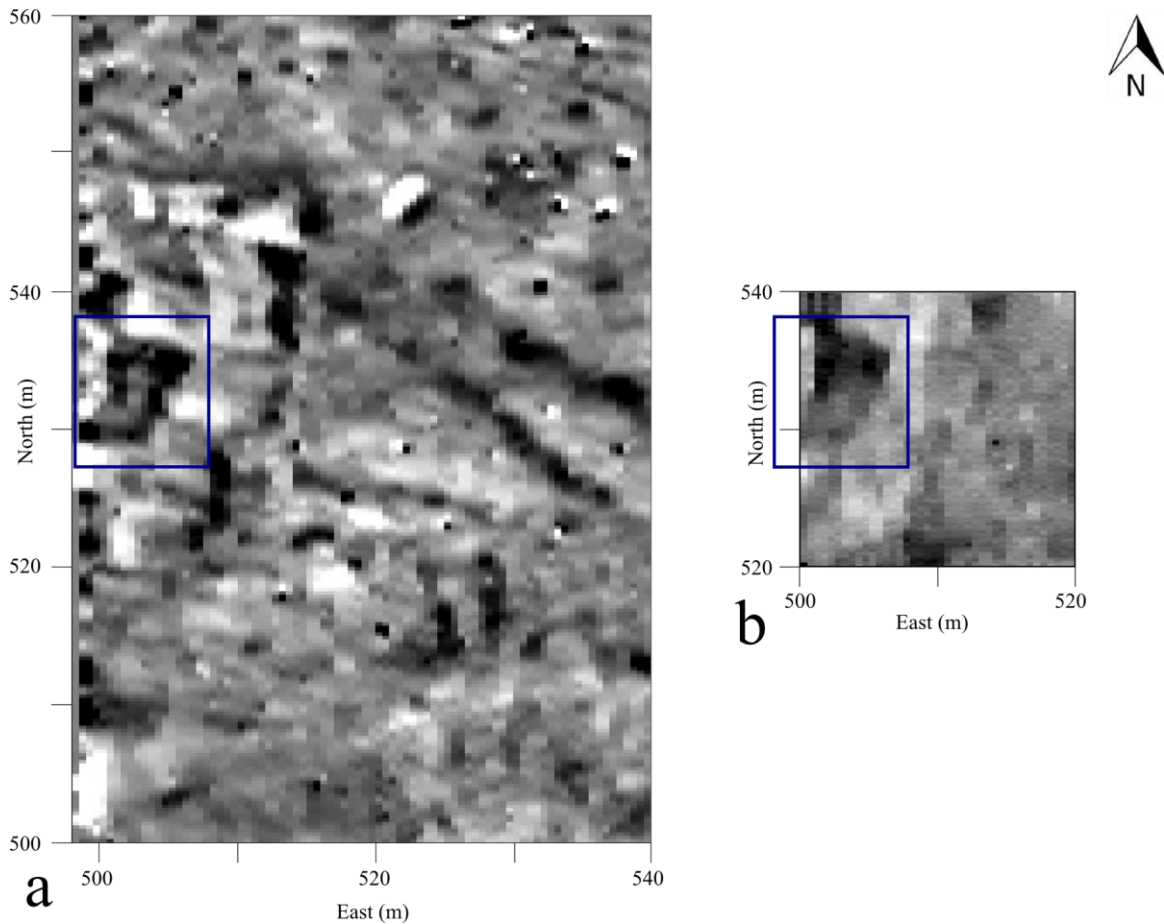


Figure 43. Feature 16. (a) Strong positive anomaly in magnetometry. (b) Positive anomaly in MS.

Feature 17

Feature 17 is a series of post holes detected by GPR (Figure 44). Sixty post hole like reflections were recorded within a 238 m² area (Figure 45). The elevations range from 273.5687 – 272.3867 (m). Although there are some linear trends, many posts do not conform to this and so discerning one or more specific structures is difficult. It is clear however, that evidence for a structure(s) is (are) present. Reflections were considered post-like if they were .1 – .3 m wide and comprised of 2 – 4 wavelets—an individual positive or negative subsection of a wave.

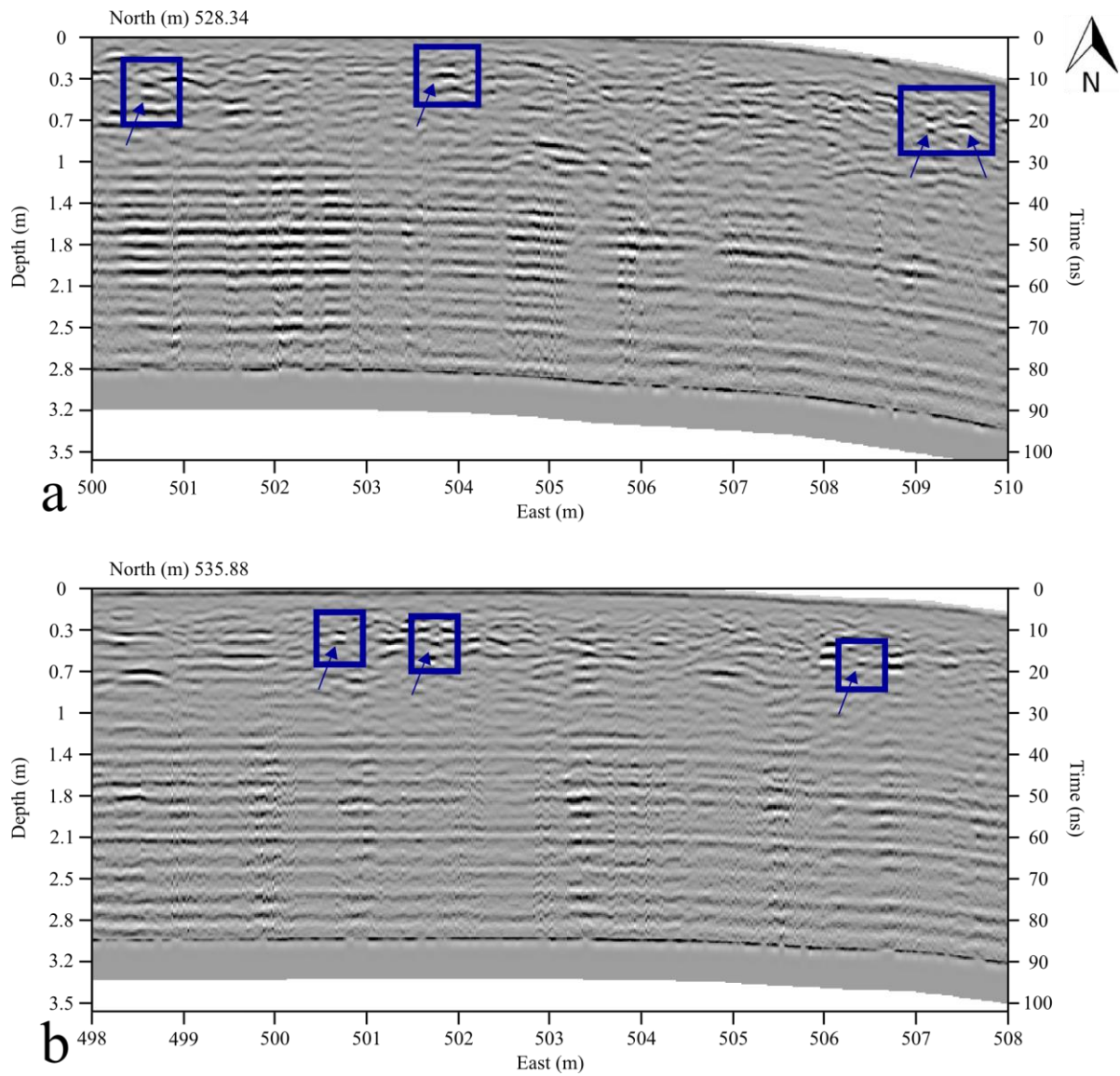


Figure 44. Feature 17. (a) A 10 m subsection of radargram 127 with four post like reflections. (b) A 10 m subsection of radargram 97 with three post-like subsections.

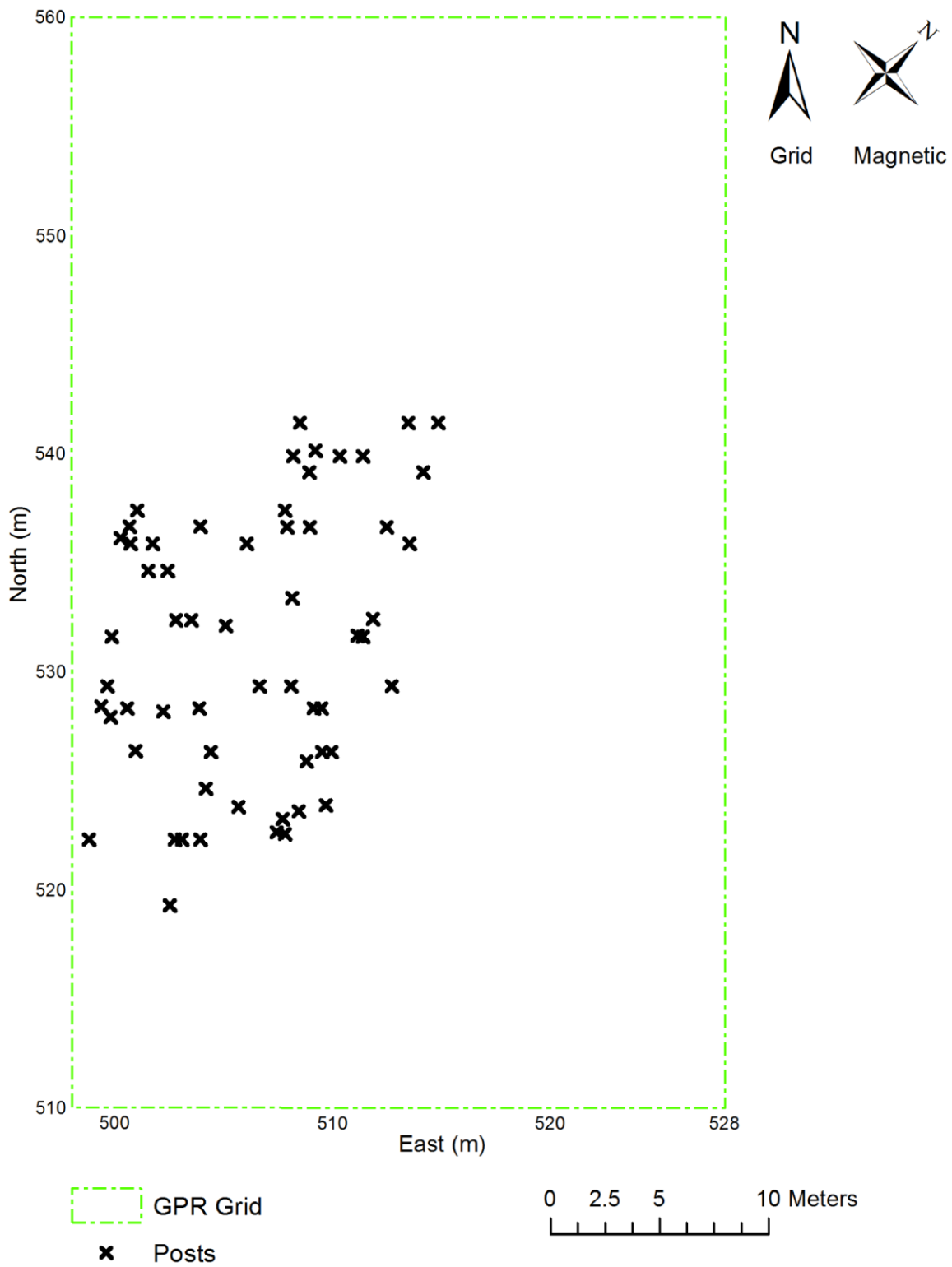


Figure 45. Feature 17 continued. A plan view of all 60 post-like reflections.

Feature 18

Feature 18 was detected in GPR. It is a set of strong to light linear reflectors that represent a package of buried stratigraphic levels or platforms within the mound (Figure 46). The elevation of all reflections ranges from 272.7867 – 271.5467 (m). The depth below the ground surface to the base of the platform changes throughout the site depending on the thickness of the mound, but the basal elevation is consistently about 272.7867 (m). This pattern can be seen in other radargrams, but only two were selected for demonstration.

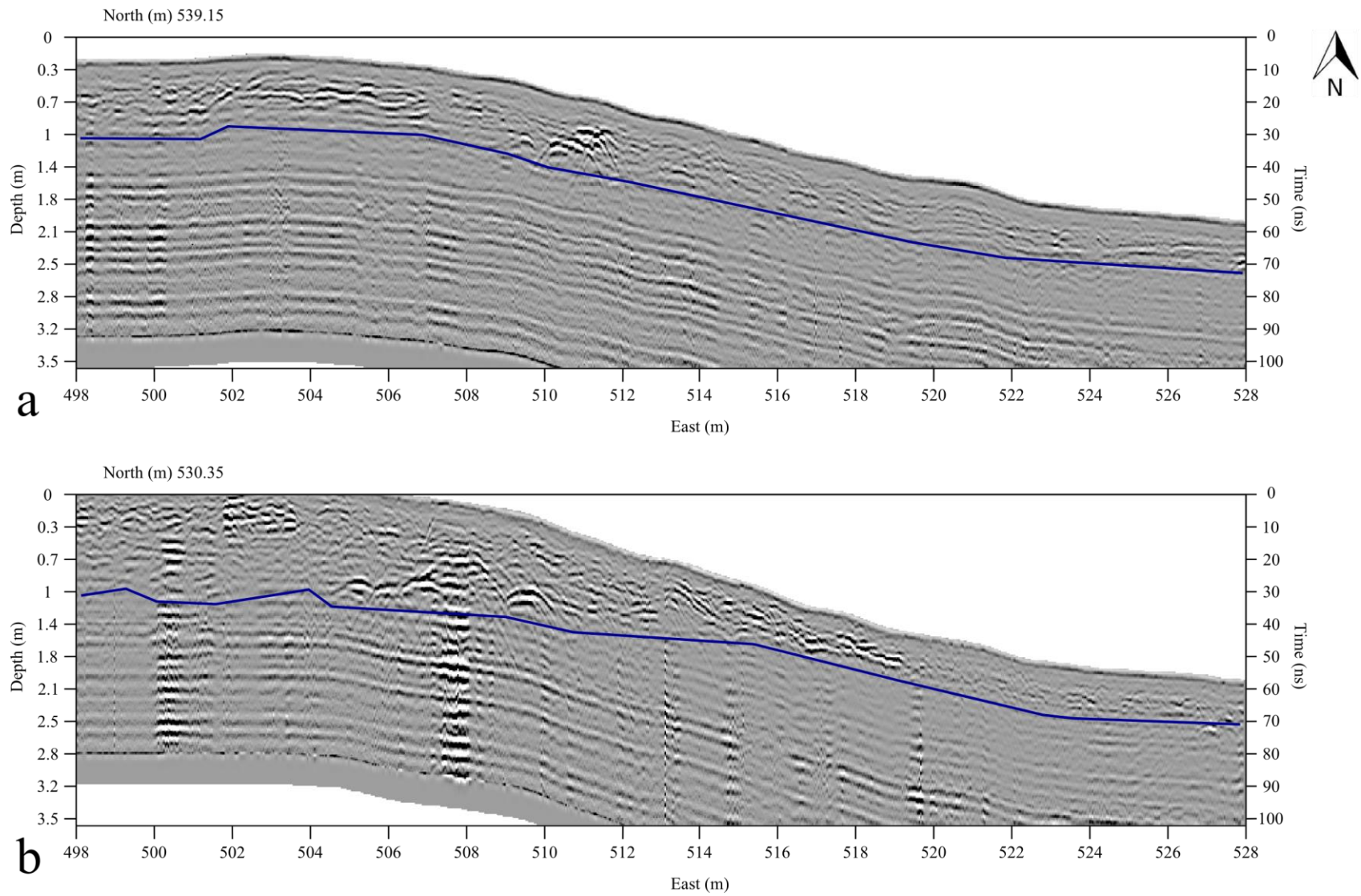


Figure 46. Feature 18 Complete Radargrams. (a) 84 and (b) 119, showing multiple linear reflections indicating the buried platform.

CHAPTER 6

DISCUSSION

Pile Mound is a Middle Mississippian platform mound site located on the Upper Cumberland Plateau, Fentress County, Tennessee. Eleven feature types were identified through geophysical techniques and archaeological testing at the site. The archaeological feature types are: pit, post, structure corner, structure, burned, prehistoric, rock boundary marker, large rock entrance marker, rock pavement/altar, other rock feature, and platform (Table 3). It is believed that Features 3, 8, 9, 10, and 11 are pits. Feature 17 is a series of post molds. Feature 7 is the corner of a structure floor. Feature 16 is a structure or evidence of multiple structures. Feature 6 is a burned feature. Feature 12 comprises a series of rock boundary markers. Features 1 and 2 are large rock entrance markers. Features 13 and 14 are rock features, possibly used for construction or stabilization of the mound (Figure 47). Feature 18 is a series of GPR reflections that provide evidence for Pile Mound being a platform mound.

Pile Mound is uniquely different than most other Mississippian mound sites because rocks are included in mound construction. Rock features are found in Cherokee sites in western North Carolina, northeast Georgia, and northwest South Carolina, sites in the Norris Basin of Tennessee, and the Corbin site in southern Kentucky. Some of the Norris Basin and Cherokee sites have rock inclusions much different than Pile Mound. These include small pebbles in piles, rocks incorporated with graves, or rocks used as supports for posts. Similarly, some Cherokee and Norris Basin sites have rock mantles or pavements similar to Feature 15 at Pile Mound. In general the Cherokee and Norris Basin rock mantles encompass the greater portion of a mound layer while Feature 15 does not. Also, this feature is rectangular—the Cherokee and Norris Basin

mantles are generally irregular. This makes Feature 15 more similar to the smaller square rock mantle or pavement found at the Corbin site (Lathel F. Duffield, personal communication 2015). Some Cherokee sites used rock features for what seems to be a purely structural function. They could have been used to strengthen a weak area within a mound layer (Kelly and Neitzel 1961:17)—these appear the most similar to Features 13 and 14. There seem to be no sites with features comparable to Pile Mound's rock Features 1 and 2, which are plausibly entrance markers to one or more mound structures.

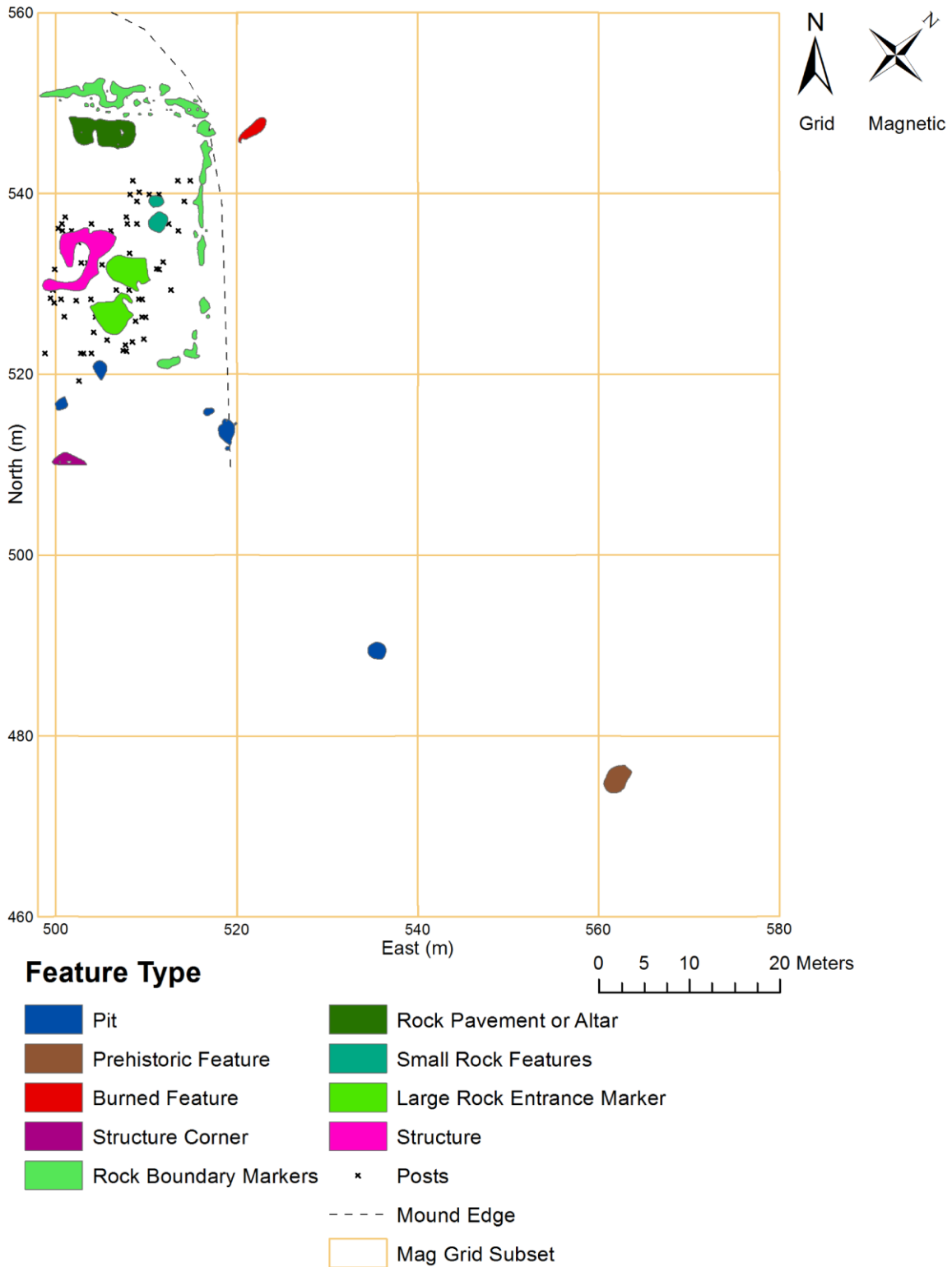


Figure 47. Interpretative Feature Map. Map comprised of all archaeological features, arranged by type, except 18, which cannot be shown clearly in plan view. Mound edge determined by examining terrain and GPR reflection profiles.

Archaeological Features

Of the 17 archaeological features presented in Chapter 5, eight surround the mound and nine are within the bounds of the mound proper. The surrounding eight features will be discussed briefly while the other nine are more important to site interpretation and will be discussed more thoroughly. Only four discussed features have been excavated, so unless noted interpretations are based solely on geophysical data. Following, archaeological data recovered during the 2014 summer field school will be incorporated to enhance the discussion of related archaeological sites.

Surrounding Features

Pit, prepared surface, or other prehistoric features (3, 5, 8, 9, 10, and 11) occur south and southeast of the mound. Features 8, 9, 10, and 11 (Figures 34, 35, 36, and 37 respectively) were detected by GPR and Features 3 and 5 (Figure 30) were detected by magnetometry. The feature types are pit, prepared surface, or other indeterminable archaeological feature. Pit features are commonly used for storage or refuse and are often re-purposed repeatedly. It is difficult to determine the exact nature of pit features, so they are simply classified generically. The pits, possible prepared surfaces, or other archaeological features stand as evidence of cultural activity at the site. Test units 3 and 10 were placed over Features 3 and 5 respectively (Figure 22). Feature 3 was excavated and a small pit consisting of a darkened soil layer with fire-cracked rock, charcoal, and ceramics was discovered (Figure 31). Excavations of TU 10, over Feature 5 revealed a possible modern post hole and below it a small piece of non-local quartzite. The magnetic anomaly comprising Feature 5 is 28 nT and over 3 x 2 m. This strong anomaly and the

amount of area seem too large for only a modern post hole. It is believed a prehistoric feature lies beneath the excavation depth.

Feature 6 was detected in magnetometry and GPR. In magnetometry it is a dipolar anomaly. In many cases a magnetic dipole indicates a metallic object, but this feature ranges from $-19.6 - 7.6$ nT. This weak value more likely corresponds to a prehistoric feature, but could result from a deeply buried metal object. Dipolar anomalies are also consistent with strongly burned features, which if prehistoric would result in a weaker strength anomaly similar to Feature 6 (Aspinall et al. 2008:58-65). In GPR the feature is buried approximately .4 – .7 m below the ground surface. This further suggests the feature is not a deeply buried metallic object, but a prehistoric feature. Also, the nature of the GPR reflection is not consistent with a metallic object. In profile the reflection is approximately 1.8 m long and radar energy is returned from below the feature. If it were metallic, all energy would be reflected (Conyers 2013:57). The combined evidence suggests an intensely burned feature. Possibly an area where pottery was fired or other feature type characterized by repetitive intense burning.

Feature 7 was detected in GPR and magnetometry. In GPR, the reflections are linear and form a 90 degree corner. This and the associated positive magnetic anomaly provide evidence for a possible structure floor. Because the GPR survey does not extend to the full size of the magnetic feature it is difficult to make any further interpretations. Also, the western extent of the magnetic feature is overpowered by interference from the nearby fence row.

Mound Features

Features 1, 2, 12, 13, 14, 15, 16, 17, and 18 are all within the bounds of the mound proper. Feature 18 (Figure 46), continuous linear reflections, shows what is likely the basal layer

of the mound. It shows a flat center and eastern slope of a platform. This provides evidence that the mound was a platform mound and consecutive layers were added through time. It is evident that the basal layer's elevation changes between .1 – .2 m across the mound. This could reflect microtopographic changes over the mound platform. A platform mound is indicative of the Mississippian period and further confirms the age and association of the site (Hally and Mainfort 2004:273-274). In conjunction with the platform, Feature 12 (Figures 38 and 39), which is a linear feature (likely rocks), marks the boundary of the mound. In the GPR data the area enclosed by Feature 12 contains a considerable amount of strong to mild reflections and overall the background level is consistently stronger than the surrounding area (Figure 48). This alludes to the higher density of cultural use in this area which further supports the platform interpretation. Whether Feature 12 is a line of rocks outlining the edge of the mound or some other form of marker, it is clear that it is a divide between the more intensely used space on the platform and the surrounding less affected area.

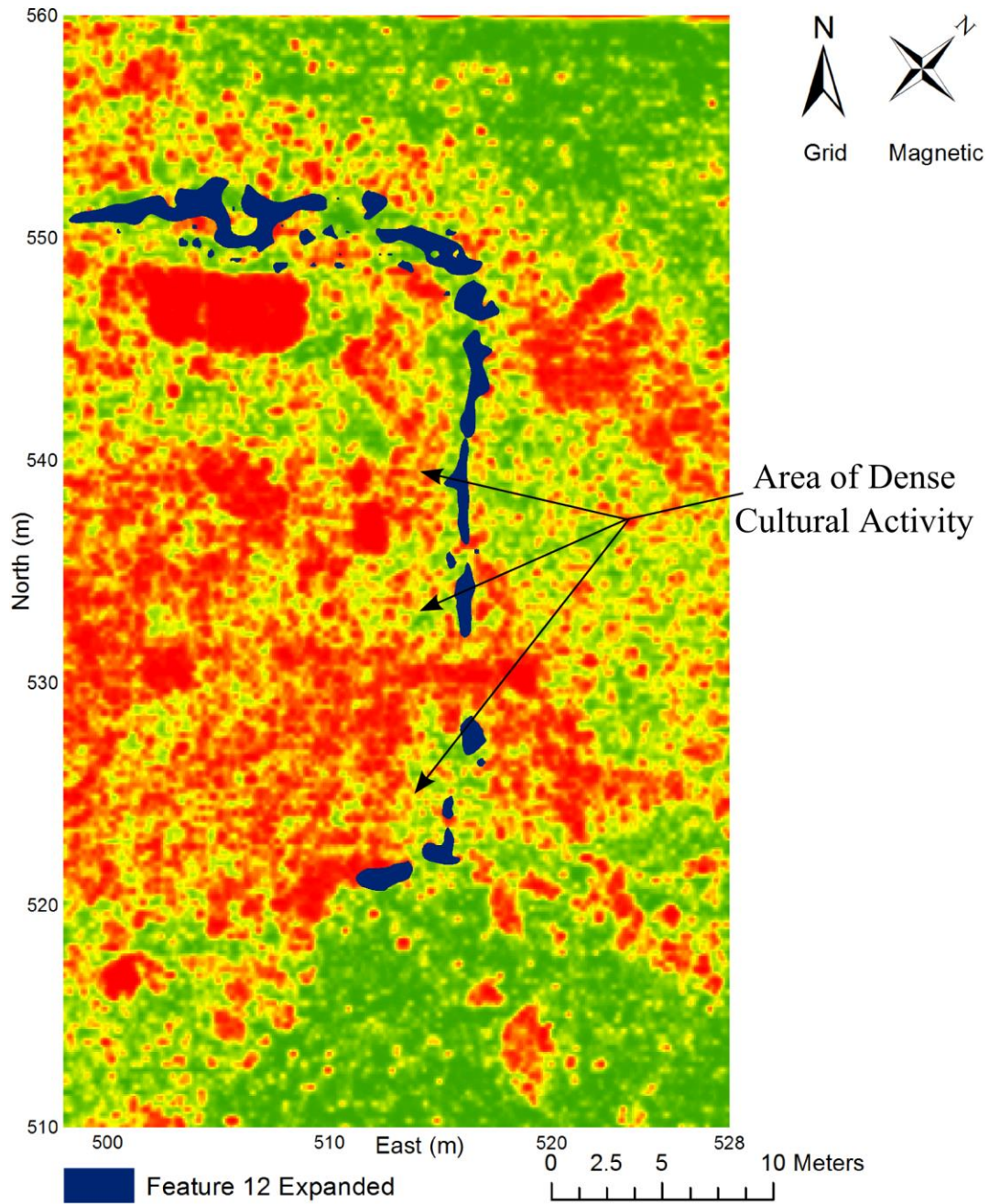


Figure 48. Cultural Activity. Dense area of moderate to strong GPR reflections (red – yellow) compared to weaker or absence of reflections (green) to the south and west of Feature 12. This conforms to an increased cultural enhancement in this area compared to the area outside of Feature 12 surrounding the mound.

Feature 15 (Figure 42), located on the northern edge of the platform, is likely comprised of local limestone and sandstone. It is a set of extremely strong flat and hyperbolic GPR reflections which are similar to the reflections returned from the excavated rock comprising Features 1 and 2. Similar to Features 1 and 2, the area is magnetically negative. Sandstone and limestone are usually magnetically negative compared to developed soils and other igneous or metamorphic rocks (Aspinall et al. 2008; Reynolds 2011:87-88)—thus providing additional evidence that this feature is comprised of local rocks. Feature 15 is roughly a 6.8 x 2.9 m rectangle and could be some form of rock pavement, mantle, or altar. Rock pavements or mantles are found in other mound sites in the Southeast (sites discussed below), but rock altars are not. Generally, rock mantles or pavements comprise a larger area within a mound making Feature 15 different from those found at other sites. The base of this feature sits .22 m and .43 m below the base of Features 1 and 2, respectively. The top of Feature 15 sits .5 m below the tops of both Features 1 and 2. This may seem to suggest the features were created at different stratigraphic levels, but when comparing these data to the basal mound layer, visible in Feature 18, it is evident the top of the mound slopes to the north from the apex. Also, both features occur along the basal platform GPR reflection. This, along with the microtopographical changes of .1 – .2 m, suggests that all three features occur at a similar stratigraphic level and were present and used at the same time by the prehistoric occupants.

Features 13 and 14 (Figures 40 and 41) are both comprised of similar GPR reflections as Features 1, 2, and 15. For this reason and their proximity to Features 1 and 2, they are expected to be comprised of local limestone and sandstone. Feature 13 is roughly rectangular measuring 1.7 x 2.2 m which makes it smaller than Features 1 and 2, but larger than Feature 14. Feature 13

was detected by magnetometry as a negative anomaly while Feature 14 was not detected by magnetometry. It is probable that Feature 14 was not detected in magnetometry because it is smaller (1.65 x 1.25 m) and contains fewer reflections (fewer rocks) than Feature 1—thus not being large enough to produce a strong negative magnetic anomaly. Both Features 13 and 14 occur at the same basal elevation of 272.565 m, which is roughly .1 - .3 m below Features 1 and 2. The distance between these sets of features (approximately 9 m) is less than the distance between Features 1 and 2 and 15 (approximately 15 m). Therefore less topography change is expected—suggesting Feature 13 and 14 were built slightly prior to Features 1 and 2 and then used contemporaneously. The base of Features 13 and 14 occurs .13 m above Feature 15. This suggests, similar to Features 1 and 2, Features 13 and 14 occurred contemporaneously with Feature 15. The distance between Features 13 and 14 is only .5 m. For this reason it is unlikely they were used as entrance markers, similar to Features 1 and 2. It is probable that both Features 13 and 14 were used for construction purposes, possibly strengthening the east side of the mound.

Features 1 and 2 (Figures 27 and 29) are both large rock concentrations 4 x 3 m and 3.5 x 4 m respectively. Both of these features consist of strong linear and hyperbolic GPR reflections and were excavated, which determined they were comprised of mostly local limestone, some local sandstone and one piece of non-local quartzite, located in Feature 2 (Figure 28). These features and Feature 13 roughly align to magnetic North and face magnetic East, current magnetic declination for the area is 5 degrees West. If they are entrance markers to a series of structures (Features 16 and 17), then the structural entrances would be facing East—a prominent

direction for Native American cultures. This would allow the sun to shine into the entrances of the structures at sun rise and could be related to festivals or ceremonies.

Feature 17 (Figures 44 and 45) is a series of GPR reflections found throughout the mound platform that are consistent with post holes—similar reflections related to post holes can be found in Patch and Lowry (2014:92). It is difficult to determine any individual structure, but there is a pattern of posts in close proximity to Features 1, 2, 13, and 14. This suggests that one or more structures were constructed to the west of these rock features (Figure 49). Rebuilding structures in the same place is consistent with Mississippian construction techniques (Hally and Mainfort 2004:276). This repetition of post holes in the same area over time would account for the density of post holes (at least 60) and the inability to link them to a specific structure. Feature 16 (Figure 43) is a strong positive magnetic anomaly found in both magnetometry and MS. It is found west of Features 1 and 2 and further suggests the presence of a structure. Because neither magnetic method can determine precise depth, determination of the feature's depth is improbable without further excavation (Aspinall et al. 2008:60). It is possible that even through excavation this geophysical feature will not be visible, because some properties are not detectable by color or texture change, which is the basis for traditional archaeological feature identification (Conyers 2010:1; Goodman and Piro 2013:3). Also, some posts (Feature 17) lie alongside and to the east of the rock features. This could be related to an awning or some form of entrance that was attached to the structures, hence covering or surrounding the rock features.

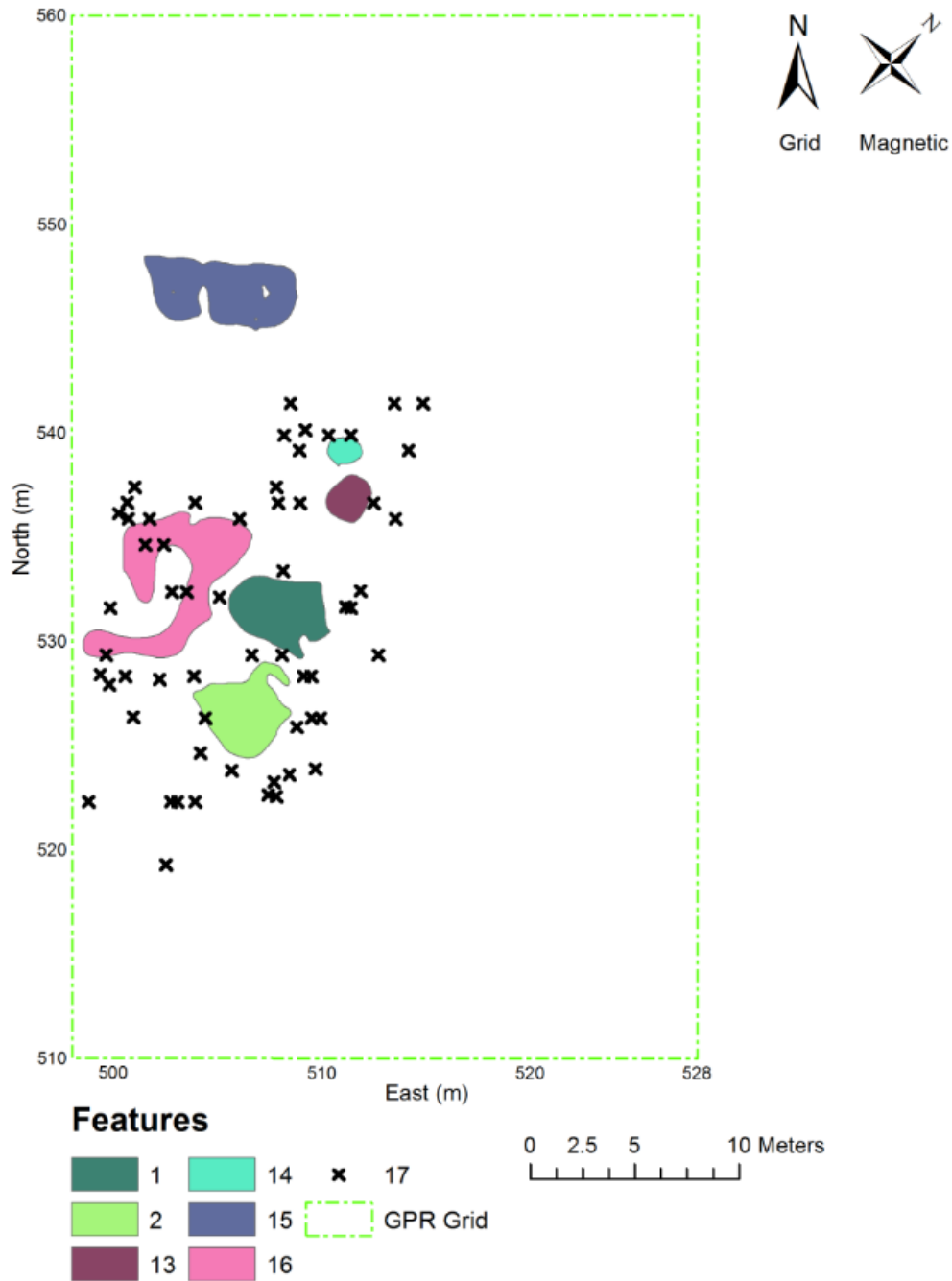


Figure 49. Structural Evidence. Magnetic anomaly, Feature 16, and GPR post reflections, Feature 17, overlaid with rock Features 1, 2, 13, 14, and 15. Evidence of structures on the mound, particularly near or in conjunction with rock features.

Archaeological Materials Analysis

Excavations of TU 3 (over Feature 3) produced an assemblage of Mississippian ceramics

including shell and chalcedony grit tempered plain and cord-marked pottery, and charcoal samples that were C14 dated using Accelerator Mass Spectrometer (AMS) by Direct AMS Radiocarbon Dating Services, Seattle, Washington. One sample (Feature 3) returned a date of 797 ± 21 BP (D-AMS 000170), which equates to 1241 C.E. Trench (TU 2) produced additional ceramics including shell and chalcedony grit tempered check-stamped and zone check-stamped ceramics. Some of the check-stamped ceramics appear to be Wolf Creek Check-stamped—a ceramic type found in areas of Kentucky along the upper Cumberland River (Beahm and Smith 2012:160). A piece of charcoal returned a date of 700 ± 24 BP (D-AMS 007169), 1284 C.E (Franklin et al. 2014).

The radiocarbon dates for the site place it well within the Mississippian time period (1000 C.E. - approximately 1550 C.E.) near the Middle Mississippian (Anderson and Sassaman 2012:152). Also, the ceramic assemblage produced is more similar to East Tennessee and Kentucky than other Mississippian style ceramics, but chalcedony grit temper is a local variation not seen in related Kentucky and East Tennessee sites (Jay Franklin, personal communication 2015). Although recorded in the area by Myer (1924:36-37), stone box graves have not been found at the site. These are common throughout the Upper Cumberland region and are found in the Norris Basin and Cherokee sites (Heye et al. 1918; Webb 1938), but have not been documented immediately surrounding Pile Mound.

Pile Mound

In many ways Pile Mound is a typical Mississippian mound site. First, the radiocarbon samples from the site date it to the time period. Also, the mound is a platform mound—which are different than mounds found prior to the Mississippian period (Hally and Mainfort 2004).

Unlike mounds from previous time periods, Mississippian platform mounds were used as civic ceremonial centers. This resulted in the construction of one to four civic and/or domestic structures on top of the mound (Hally and Mainfort 2004). There is clear evidence, presented in Chapter 5, of one or more structures on Pile Mound (Figures 43, 44, and 45). Also, Mississippian culture is attributed to the wide use of shell tempered pottery—this could be most often plain, with the addition of some cord-marked, check-stamped, or other decorative forms (Hally and Mainfort 2004:274-275). Shell tempered plain, cord-marked, and check-stamped ceramics were recovered from the site. In addition a “Chunkey Stone”, a disc-shaped rolling stone for playing the Chunkey game (Cobb 2003:71; Emerson and Pauketat 2008:176-178), was recovered from an adjacent field. These traits clearly identify Pile Mound as a Mississippian site.

Pile Mound is unique compared to almost all other Mississippian mound sites. It is located on the UCP, which is often described as the northern periphery of the Mississippian world (Jefferies et al. 1996). This is an upland region compared to most other areas in the Southeast and there have been fewer studies of Mississippian mound sites (and all other archaeological sites) compared to other regions of the Southeast (Franklin 2002). Partly due to this, there is an approximately 75 – 100 km buffer between Pile Mound and the closest studied mound sites. This disparity is likely due in part to a recording bias. However, the upland environment of the UCP is different than much of the Southeast. What this means in regards to cultural identity is difficult to interpret until equal research is done between this area and other regions.

The pottery recovered from Pile Mound is also distinct in some ways. Shell tempered plain pottery is found throughout the entire Mississippian world, but shell tempered cord-marked

and check-stamped are more closely related to East Tennessee and western North Carolina than other areas of the Southeast (Jefferies et al. 1996; Beahm and Smith 2012). Also, chalcedony and shell grit tempered pottery was recovered at Pile Mound. This is a local temper type found only in the immediate region surrounding Pile Mound (Jay Franklin, personal communication 2015).

Lastly, various rock features were discovered at Pile Mound. Some comparable rock features are found in the sites discussed below. Many of the uses for rocks are different (e.g. burials, small stone piles, walls) at these sites. In addition, there are few comparative sites (six Cherokee sites, four from the Norris Basin, and one in Kentucky). This makes Pile Mound one of 12 sites with somewhat comparable rock features in the whole Southeast and rock Features 1 and 2 are possibly different from any other site.

Comparative Sites

There are at least four other documented mound sites on the Upper Cumberland Plateau, which are probably Mississippian, however the closest studied sites range from 75 – 100 km away (Figure 50). After field work for this project, the author was made aware of two mounds in close proximity to Pile Mound. One expands the Pile Mound site because it is on a contiguous property. The other, West Mound, is also found downstream along the Wolf River approximately 10 km west of Pile Mound. In addition to these, there is record of three unstudied mounds. The Hassler Mounds are approximately 22 km west of Pile Mound and are inundated by Dale Hollow Lake (Figure 50) (Jay Franklin, personal communication 2014). The Boatland mound was recorded by Myer (1924:37) and is approximately 18 km southwest of Pile Mound. Another unnamed mound site is located along the Obey River approximately 18 km southwest of Pile Mound (Jay Franklin, personal communication 2014). These five mound sites are close enough

in proximity to have been of the same polity group, within approximately 20 km (Hally and Mainfort 2004:281). To date, the most similar studied mound sites are discussed below.

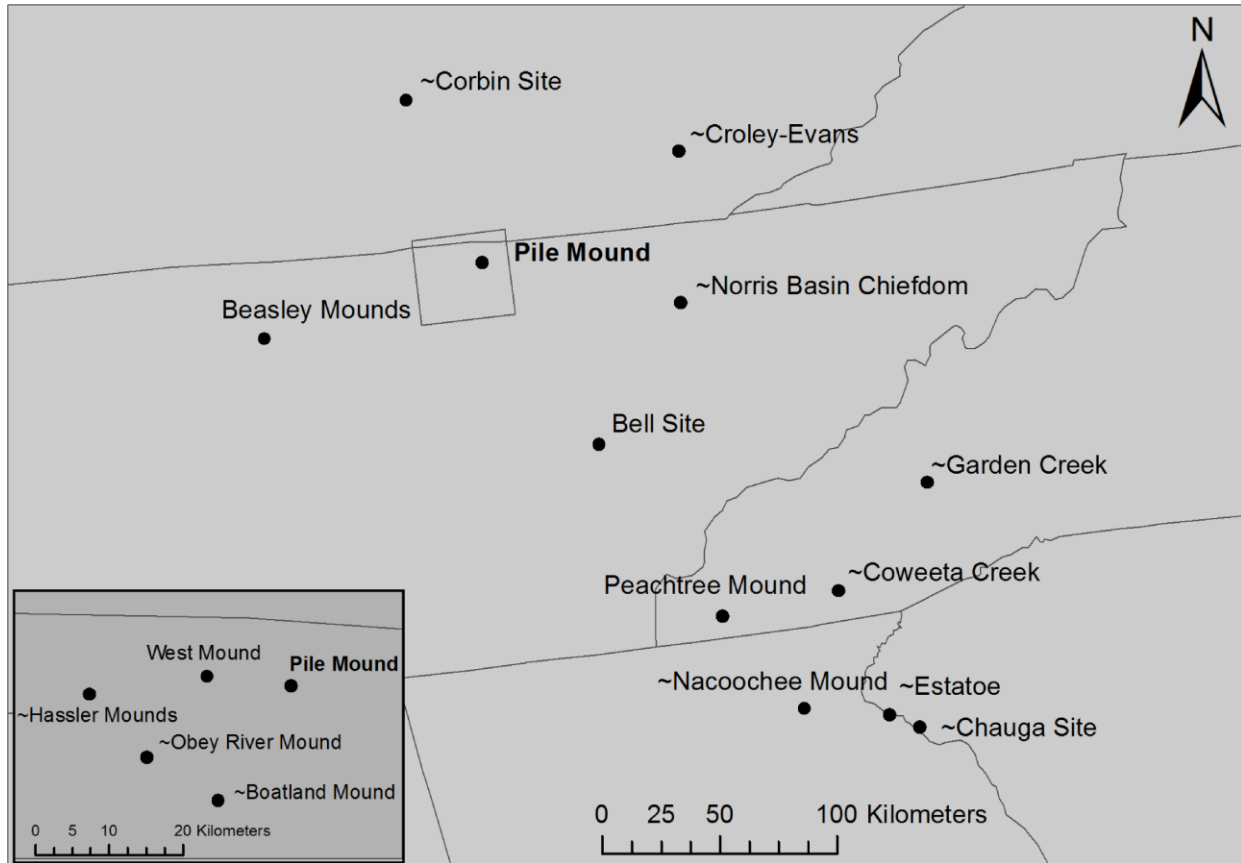


Figure 50. Comparative Sites. A map showing the most similar sites to Pile Mound.

Croley-Evans

The Croley-Evans site is located approximately 100 km northeast of Pile Mound along the Cumberland River in Knox County, Kentucky (Jefferies et al. 1996). Croley-Evans is similar to Pile Mound in that shell tempered plain, cord-marked, and check-stamped ceramics were recovered (Jefferies et al. 1996:14). Also, it is within the Upper Cumberland River drainage basin—the same as Pile Mound (Jefferies et al. 1996:1). Four dates recovered from Croley-

Evans: 1035, 1272, 1281, and 1414 C.E (Jefferies et al. 1996:9) show that the sites are broadly contemporaneous. The Croley-Evans site differs as it is a single mound site (Jefferies et al. 1996:5). Also, black and red painted ceramics and red filmed ceramics were recovered (Jefferies et al. 1996:18). In addition, no rock features have been documented (Jefferies et al. 1996). Croley-Evans was not fully excavated and no geophysical studies have been done (Jefferies et al. 1996).

Beasley Mounds

The Beasley Mounds site is 103 km southwest of Pile Mound along the Cumberland River in Smith County, Tennessee (Beahm and Smith 2012). This site is similar to Pile Mound in that shell tempered cord-marked and check-stamped ceramics were recovered and it is also in the Cumberland River drainage basin (Beahm and Smith 2012:157-158). The site has multiple mounds and no stone box graves have been recorded (Beahm and Smith 2012:149). Both sites are located near the fork of two rivers or streams (Beahm and Smith 2012:157). The sites are contemporaneous based on one radiocarbon date from Beasley Mounds, 1280 C.E. (Beahm and Smith 2012:156). The Beasley Mounds differ from Pile Mound in that unique Tennessee-Cumberland style stone statues were recovered. Also the site consists of five mounds and a separate non-mound earthwork 5 – 6 feet high, although not visible today, was recorded at the site by Meyer in his unpublished notes (Beahm and Smith 2012:150). There was an abundance of freshwater shell recovered, but none has been recovered at Pile Mound (Beahm and Smith 2012:157). Also, no rock features have been discovered at the site (Beahm and Smith 2012). Complete excavation or geophysics have not been conducted at the site.

Bell Site

The Bell Site is 93 km southeast of Pile Mound in Roane County Tennessee within the Watts Bar Reservoir (Patch and Lowry 2014:1). It is quite different than Pile Mound as seven mounds, ranging from large to small, have been recorded (Moore 1915:415). A record of stones being scattered atop a small mound next to the largest mound and a stone grave (with stones set on edge around it) was recorded by Powell (1884:461). Later, Moore (1915:415) described this reference and made notion of a stone grave, not box-shaped, and that stone slabs lay on the surface of a mound. Goodspeed (1887) made note of a stone wall around the summit of a mound, but no further accounts were recorded. Lewis (1935) at mound 51 noted there were limestone slabs below posts and at mound 53 graves were covered with limestone slabs. It is unclear the exact placement and use of stones throughout the site. This site has gone through partial excavation and large amounts of magnetometry and GPR data have been collected. There were no GPR reflections found at the Bell Site similar to those of rock features at Pile Mound (Patch and Lowry 2014). However, the GPR survey did not penetrate the complete thickness of the mounds. Provided that Pile Mound and other sites' rock features (discussed below) are often incorporated at the basal layer of mounds, it is possible there are undetected rock features buried at the base of the Bell Site mounds. This is purely speculative, but it is simply not known what lies at the base of the Bell Site mounds.

Norris Basin Survey

The Norris Basin survey consists of 23 sites formerly along the Clinch and Powell rivers in Tennessee, which have since been inundated to create Norris Lake (Webb 1938:2-3). Due to this, the sites now lie underwater and any future testing of sites that were not completely

excavated is improbable. Of the 23 sites, 11 have stones incorporated within a mound(s) in some way (Webb 1938). Seven of these sites (Heatherly Stone Mounds, Bowman Farm Mounds, Irvin Mound, Ausmus Mounds, Lea Farm Village and Mound, Stiner Farm Stone Mounds, and Freel Farm Mound) have either large stones associated with graves, are burial mounds and likely not Mississippian, have piles of small stones (river pebbles), or the stones were used as chinking or support for posts (Webb 1938). In any case, the stones were used in a manner very different than the rock features at Pile Mound.

McCarty Farm Mounds. At this site, stone piles located on top of Mound 1 were removed for agriculture (Webb 1938:33). Also, at Mound 2 large limestone slabs were removed and stone cists were found inside the mound (Webb 1938:35). It is unclear how the stones were piled on top of Mound 1 or incorporated inside Mound 2, outside of the cists. For this reason it is difficult to assess how similar this site was to Pile Mound, but large stones were incorporated in some manner in the mound construction.

Hill Farm Stone Mounds. This site included three small earth and stone mounds. Limestone slabs were incorporated in the mounds, but cultivation of the area had all but decimated the site prior to archaeological excavations. It is unclear how the stones were incorporated, but Webb (1938:60-63) speculated they were used in burials.

Wilson Farm Mound. A single mound was located at this site that had a pile of large to small stones at the primary floor level (Webb 1938:63). A photograph of the stone pile is provided in Webb (1938:plate 33b), the stone cluster looks to be of considerable size, maybe 5 – 10 m², but no scale is given for the photograph and no dimensions are provided for the stone layer. The use of stones at this site seems more similar to Cherokee sites discussed below.

Cox Mound. This site consists of a single mound (Webb 1938:161). In some areas stones were placed underneath posts as a footer (Webb 1938:165). Also, a pile of 72 limestone and sandstone rocks in a 48 x 16 inch area with no evidence of fire is recorded (Webb 1938:166). Similar to the Wilson Farm Mound site, a layer of stones, over 200, was scattered at the primary floor level with no evidence of fire (Webb 1938:167, plate 112). Again, this looks more similar to Cherokee sites discussed below than Pile Mound.

Of all the Norris Basin sites the above four seem most similar to Pile Mound, but in all cases there is not enough evidence to conclude how the stones were used. Some were incorporated as a basal layer, but they were not in conjunction with a structure(s). This provides evidence of Mississippian peoples incorporating rock features into mounds, but no conclusion can be drawn on their purpose and these examples do not provide similar evidence to the proposed use of rocks at Pile Mound.

Cherokee Sites

There are at least six Cherokee sites throughout southwest North Carolina, northeast Georgia, and northwest South Carolina that have rocks incorporated into the mound construction. These sites have prehistoric components, but were inhabited by historic Cherokees. Most have a single layer of rocks placed across the entire mound or a portion of it. The exact function of this rock layer is undetermined. No radiocarbon dates have been published, but through ceramics and other traits these mounds range from prehistoric to historic Cherokee towns, approximately (1000 – 1300) – 1800 C.E.

Garden Creek. This site is located approximately 220 km southeast of Pile Mound. It is along the Pigeon River near its confluence with Garden Creek in Haywood County, North

Carolina (Dickens 1976:69). It consists of three mounds (Dickens 1976:69). Under Mound 1 a layer of river boulders was uniformly distributed under two thirds of the mound and encompassed the entire limit of the first mound stage (Dickens 1976:79). There were two semi-subterranean earth lodges below the layer of rocks (Dickens 1976:83). Also, Pisgah check-stamped pottery was recovered from the site (Dickens 1976:86). This is a different style of check-stamping, but shows some similarity to the check-stamped pottery recovered from Pile Mound.

Peachtree Mound. The Peachtree mound and village site is located approximately 185 km southeast of Pile Mound near the confluence of Peachtree Creek and the Hiwassee River, Cherokee County, North Carolina. This site contains a single mound with various rock features within it and in the village area located underneath the mound (Setzler and Jennings 1940:1,27). The village area rock features are small piles of little stones randomly placed, very different from Pile Mound (Setzler and Jennings 1940:27). In the northeastern area of this layer a number of stones were placed on top of a prepared floor. This was surrounded by an immense amount of post holes suggesting several structures were built here prior to mound construction (Setzler and Jennings 1940:28).

The mound was distinguished by two distinct stages, primary and secondary. The primary mound was approximately 2 m high and was then encompassed by later additions forming the higher secondary mound (Setzler and Jennings 1940:16). A square structure, 6.7 m interior dimensions, 9.4 m exterior dimensions, made of wood and stone was located at the base of the primary mound (Setzler and Jennings 1940:24). The outer wall was approximately .6 m high and made of large stones. Also, there were stones scattered throughout the center of the structure, but

due to large indentations it seemed these were placed on the roof of the structure and landed in the center when it collapsed (Setzler and Jennings 1940:24). An evenly laid stone floor, approximately 6.4 x 5 x .3 m, of river boulders was placed on the eastern slope of the secondary mound. Some post holes were found in proximity which led Setzler and Jennings (1940:23) to believe they could have been part of a sweat house or stone ramp.

The wood and stone structure appear very different than anything at Pile Mound. However, the stone floor on the eastern slope of the mound may be similar to Features 1, 2, 13, and 14, which are also located on the east side of the mound. The stone pavement located on the northeast of the village was not given dimensions, but the related post holes suggest it is different than the stone pavement, Feature 15, at Pile Mound. In any case, this is an example of a Native American group using stones as pavement and other purposes.

Nacoochee Mound. The Nacoochee Mound is located approximately 235 km southeast of Pile Mound in White County, Georgia. This single mound consists of a distinctly small mound, approximately 1.5 m high, inside of the larger, 6 m high, final mound (Heye et al. 1918:31, 100). There were multiple stone box graves discovered in the lower levels of the mound and other stones, not in a box shape, near other graves (Heye et al. 1918:100). There was an approximately .6 m thick layer of stones in the northeastern section of the mound that extended at least 8 m in one direction (Heye et al. 1918:34). Other than this, there were 5 stone piles located at various levels throughout the mound (Heye et al. 1918:35-38). Two of these were small groupings of rocks near burials and the other three had no burial context. All but one of these was located on the east side of the mound (Heye et al. 1918:35-38). One of these five rock concentrations was 3 x 1.5 m and trended northeast to southwest—a similar trend and size to those at Pile Mound.

The large rock layer near the base of the mound seems possibly similar to Feature 15. Also, the one rock concentration that trends northeast to southwest is of similar size to Features 1 and 2. However, the density of rocks at this feature is not described and there was no photograph in the report. If this rock concentration is of similar density to the two stone piles near graves (not highly concentrated) (Heye et al. 1918:plate xiii), it would not be very similar to Features 1 and 2. This makes it difficult to determine how similar this may be to Features 1 and 2. In all cases except one, the rock features were placed on the east side of the mound. This shows consistency with the other Cherokee sites as the rock features seem to be mostly located on the east side of the mounds.

Chauga Site. This site is located approximately 275 km southeast of Pile Mound in Oconee County, South Carolina. Chauga was a single mound with multiple rock features found throughout its construction. There were multiple large and small water-worn stones located at the basal layer (Kelly and Neitzel 1961:12). Then in the base of the second stage there were three large clusters of water-worn boulders located on the southwest, northwest, and northeast flanks of the mound (Kelly and Neitzel 1961:13). Again rocks were incorporated at the bases of layers three and four of the mound. Their placement varied around the flanks of the mounds (Kelly and Neitzel 1961:16-17). Kelly and Neitzel (1961:17) related this re-occurrence of stone features near the flanks to stabilization of the mound. Due to previous excavations the rest of the mound stages were analyzed by looking at the slope wash, so it was determined there were no more rocks incorporated in these later layers (Kelly and Neitzel 1961:18-20).

This site is similar to Pile Mound in that there were rock features along the flanks of the mound—Pile Mound has Features 1, 2, 13, and 14 along the eastern side and Feature 15 on the

northern edge. It seems that these rock clusters were not as dense as what is found at Pile Mound, but it is difficult to make a direct comparison from the evidence reported by Kelly and Neitzel (1961).

Another two sites (Estatoe and Coweeta Creek Mound) are within relative proximity to the above Cherokee sites and all have records of a rock layer or rock clusters being encompassed in mounds (De Baillou and Kelly 1960; Egloff 1971). These sites are similar as they provide other examples of people incorporating rocks into the building of non-burial mounds and the majority of the features are found on the east side of the mounds. This suggests some importance to this direction and the incorporation of rocks on that side of mounds. However, it is difficult to say exactly how similar these sites are to Pile Mound beyond the inclusion of somewhat similar rock features in the mounds.

Kentucky Site

Corbin Site. This site is located approximately 75 km northwest of Pile Mound along the Green River in Adair County, Kentucky (Duffield 1967:4). The site includes three mounds and in Mound 2 an approximately 7.2 x 7.2 m flat rock pavement of limestone and sandstone was incorporated in the mound (Duffield 1967:16; Fryman 1968:26-33; Lathel F. Duffield, personal communication 2015). This rock pavement may be similar to Feature 15 at Pile Mound. Both sites have clearly defined rectilinear rock features and Feature 15 is likely made of similarly flat stones. The ceramics recovered from Corbin are the most similar to Pile Mound because the majority were shell tempered Wolf Creek check-stamped and some were shell tempered cord-marked, probably Mckee Island (Fryman 1968:12-15, 23-23). The predominance of Wolf Creek

check-stamped and cord-marked ceramics recovered likely makes these sites related through rock features and ceramic types.

Pile Mound Interpretation

The pit and structural features (Feature 16 and post molds) at Pile Mound are common and so are expected at most if not all Mississippian mound sites. The rock features, however, are what make Pile Mound distinctly different from other studied sites. At the moment it is unclear as to the nature or purpose of the rock features, but they are plausibly a rock mantle or pavement (Feature 15), area markers (Feature 12), rock piles used for construction or strengthening of the mound (Features 13 and 14), and structural entrance markers (Features 1 and 2). The work thus far at Pile Mound is preliminary. Half of the mound has been surveyed with geophysics and only minor excavation data (from that half) have been recovered. This makes studying the other side of the mound essential to a complete understanding of the rock features and the site. Also, no work has occurred at the second mound on the contiguous property to Pile Mound. Studying that mound could potentially enhance our understanding of rock features at the site. From these limited data, it is clear however that Pile Mound is distinctly different from most other Mississippian sites while simultaneously sharing some traits with southeastern Kentucky, East Tennessee, and Cherokee sites located in southwest North Carolina, northeast Georgia, and northwest South Carolina. These sites have rock features most similar to Feature 15 (rock mantle or pavement) and Features 13 and 14 (rock piles included for construction purposes).

In addition to the inclusion of rocks and recovery of check-stamped ceramics, non-local quartzite was recovered from Pile Mound. The closest sources of quartzite are in East Tennessee and western North Carolina, approximately 150-300 km away along the Appalachian Mountains.

This shows interaction either through intermediaries or directly between the Upper Cumberland Plateau region and East Tennessee or western North Carolina, specifically prehistoric Cherokee lands. No notion of a sample of quartzite as large as that in Feature 2 has been noted in the comparative sites. This further confirms the connection of these regions and the likeness of pottery styles found throughout sites on the UCP and East Tennessee (Jefferies et al. 1996; Beahm and Smith 2012).

It should be noted that some of the comparative sites were completely excavated, but others (specifically, Beasley Mounds and Croley-Evans) have not been completely excavated nor has geophysical work been conducted. There could be similar rock features at these sites, but evidence of this may never be determined. Also, outside of the sites within an approximately 20 km radius of Pile Mound, there is a 60 km buffer zone where little or no information for Mississippian mound sites is available. This severely limits the inferences and interpretations that can be made between Pile Mound and other sites. In light of this, it seems that the most similar sites are Corbin in Kentucky and the various Cherokee sites—located 75 km northwest and approximately 180 – 270 km east, respectively. The most similar rock features found in the Norris Basin are more similar to Cherokee than Pile Mound, but this does not mean that all of the sites are not related. The Norris Basin sites are located between Pile Mound and the Cherokee sites, traveling through the Norris Basin would possibly be a direct route for trade, specifically the quartzite. Though the similar ceramic types, quartzite, and general use of rocks in mounds links Pile Mound to Cherokee sites, it is difficult to directly compare the rock features. There are multiple sites with similar features to Feature 15 and possibly Features 13 and 14. Survey of the other half of Pile Mound could potentially change this interpretation. At

the moment, the Corbin site has the closest related rock feature, a rock platform or mantle similar to Feature 15, and the closest related ceramics. There appears to be no other sites with similar rock entrance markers, Features 1 and 2, thus making Pile Mound distinctly different than all other Mississippian Mound sites.

CHAPTER 7

CONCLUSION

Pile Mound is a Middle Mississippian (radiocarbon dates, 1241 and 1284 C.E.) mound site with one small platform mound and another untested small mound. To date archaeogeophysical methods (GPR, EMI, and magnetometry) and minimal test excavations have occurred only over the northeast half of Mound 1 and the surrounding area. This is due to the bisection of Mound 1 by a fence row (property line), where access to the other side of the site and Mound 2 was not granted. Therefore, the focus of this thesis is on the area surrounding the northeast half of Mound 1, which is approximately 1.5 m high, 40 m wide and extends 17 m into the surveyed area.

Through archaeogeophysical survey, 17 archaeological features were discovered on the mound proper and surrounding area. These data were used to assist placement of test units during a summer 2014 archaeological field school, which led to testing of four archaeological features. Other units were placed without the assistance of archaeogeophysics, which led to the discovery of other archaeological features. The feature types discovered include: pits, post holes, prepared surfaces, a burned feature, platform layering, a possible structure, rock mantle, rock area markers, small rock piles, and rock entrance markers.

Of all the features, rock Features 1 and 2 are the most unique because similar features have not been documented in any other Mississippian mound. The inclusion of a rock mantle or pavement, similar to Feature 15, is present at sites located in southeast Kentucky (Corbin) and in Cherokee sites in southwest North Carolina, northeast Georgia, and northwest South Carolina (Chauga Site, Garden Creek, Nacoochee Mound, and Peachtree) (Heye et al. 1918; Setzler and

Jennings 1941; Kelly and Neitzel 1961; Duffield 1967; Fryman 1968; Dickens 1976). Some of the Norris Basin and Cherokee sites seem to have a similar rock mantle across the majority of the basal mound layer (Heye et al. 1918; Webb 1938; Dickens 1976). The rock mantle at Corbin seems most similar to Feature 15 as it does not encompass an entire or greater part of a stratigraphic mound layer. In addition, the most abundant ceramic types recovered at Corbin were Wolf Creek check-stamped and some shell tempered cord-marked (Fryman 1968:12-15, 23-23). This is similar to the shell tempered cord-marked and check-stamped ceramics found at Pile Mound—some of which appear to be Wolf Creek check-stamped (Personal Communication Jay Franklin). The ceramic assemblage at Pile Mound is more similar to sites found throughout the UCP, East Tennessee, and western North Carolina than Middle Cumberland or other areas of the Mississippian world. This is due to the presence of shell tempered cord-marked or check-stamped pottery, often not found in other areas of the Southeast. Pile Mound does retain a local ceramic variation (chalcedony and shell grit temper) compared to other sites further away on the UCP and those of East Tennessee and North Carolina (Personal Communication Jay Franklin).

The rock features and ceramic assemblages suggest the above mentioned sites are the most similar to Pile Mound. This furthers the idea that many other sites within the Upper Cumberland Plateau of Tennessee and Kentucky are more similar to East Tennessee and western North Carolina than any other area within the Mississippian world (Beahm and Smith 2012 and Jefferies et al. 1996). Also, the discovery of non-local quartzite (two samples) at Pile Mound shows the prehistoric inhabitants of this site and general area, sometimes described as the northern periphery, interacted on a broad level with the greater Mississippian world (Jefferies et al. 1996). The closest sources of quartzite are approximately 150 – 300 km away along the

Appalachian Mountains of East Tennessee and western North Carolina showing further interaction between the two areas. This promotes the connection between Pile Mound and Cherokee sites because the Cherokee lands are the likely source of the quartzite. Although some 200 km away, there is a clear relationship between Pile Mound and Cherokee sites. It is then likely that the prehistoric Cherokee interacted directly with Pile Mound and the surrounding area. Therefore, UCP sites may be on the northern border of the Mississippian world, but they are clearly connected to it.

This work also stands as another example to the wealth of knowledge gained from applying geophysical exploration to archaeology, especially in the Southeast. The application of geophysics continues to grow within American archaeology and this study was the first to incorporate geophysics within this region of the Upper Cumberland Plateau. Similar to other sites where geophysics has enhanced or even changed longstanding archaeological interpretations (e.g. Double Ditch and Comb Wash) (Kvamme and Ahler 2007; Conyers 2010:3-4), rock features were a surprise at Pile Mound and their connection to Cherokee sites stands as an unexpected relationship. However, there are Cherokee migration stories that state the Cherokee stopped or “rested” at two locations before making their final home in western North Carolina and East Tennessee. The first stop is located somewhere near the headwaters of the Holston, Clinch, and Cumberland rivers (Hicks 1926). This could possibly conform to the Upper Cumberland region where Pile Mound is located, but greater evidence is needed to propose any such claim.

Without the use of geophysical techniques, it is quite possible the rock features would never have been discovered and Pile Mound would appear similar to other understudied sites

throughout the Southeast. As such, Pile Mound seems to be a unique archaeological site surrounded by an ever shrinking shroud of regional archaeological knowledge.

Future Work

As with many preliminary studies, this work has sufficiently raised more questions than have been answered. Moving forward, geophysical work (GPR, EMI, and magnetometry) will be conducted on the other side of Mound 1, the newly discovered Mound 2, and throughout the immediate vicinity. Archaeological testing and excavation will likely continue with another field school planned for summer 2016. In addition, aerial photography of the site via an unmanned aerial vehicle could produce a high resolution DEM of the area. This would allow for a better understanding of the site's micro-topography and provide further archaeological information, such as vegetation or soil differences possibly related to prehistoric activities. In part, the future work at Pile Mound can further define the extent and use of rock features and possibly discover any associated habitation areas to advance our understanding of the site and the region.

Furthermore, geophysical and aerial survey, along with excavations will likely be conducted at the larger (6 m high) West Mound some 10 km downstream from Pile Mound. Studying West Mound could also provide insight into the possible use of rock features in the region. Continued work in this region and a more detailed literature review of Cherokee and Kentucky sites will help to better define the connection between Pile Mound and other sites with rock features.

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APPENDIX

Geophysical Processing and Data

GPR Field Parameters

GSSI SIR 4000: 400 MHz Antenna		Gain Points	Gain Setting
Scans/ Second	92	1	1
Samples/Scan	1024	2	42
Scans/Meter	40	3	54
Meter/Mark	1	4	66
Time Window	100 ns	5	82
Time Offset	-11.00	6	82
		7	82
		8	82

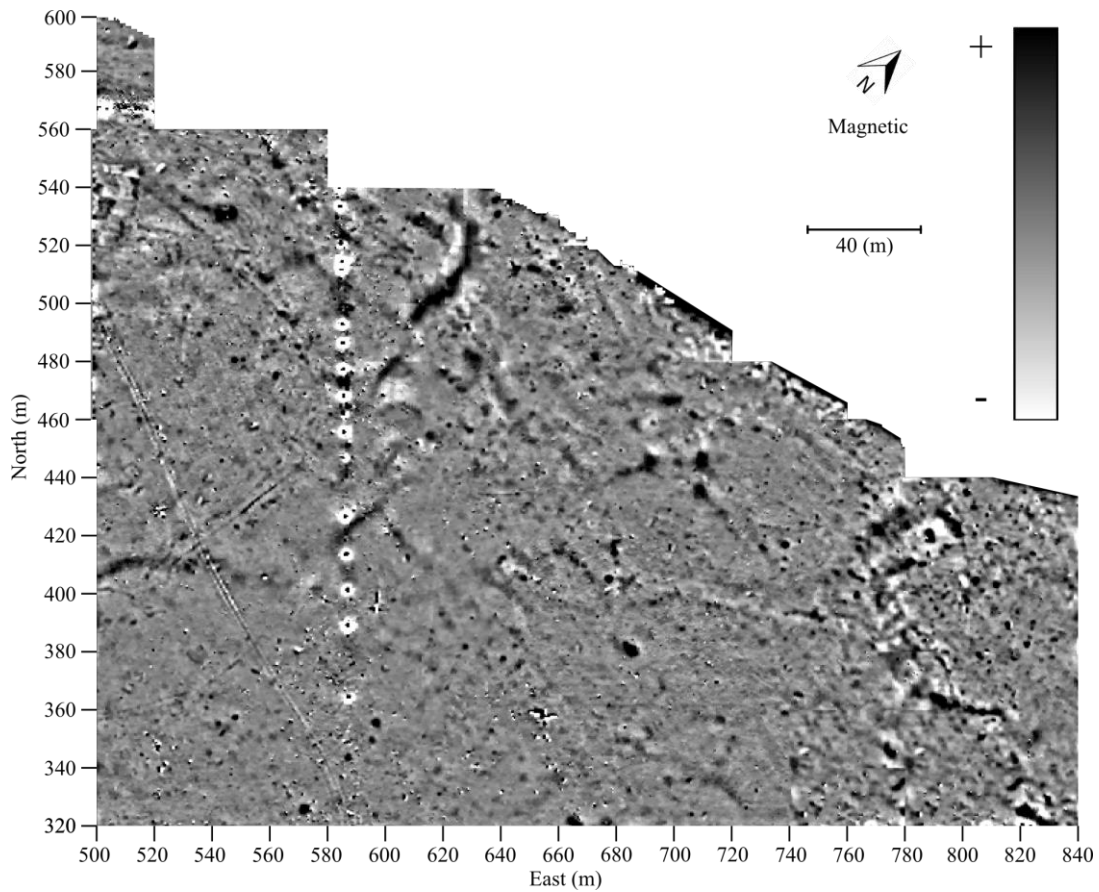
Magnetometry Data Processing Parameters

Process	Tiles Applied To	Parameter 1	Parameter 2
Zero Median Traverse	All	Direction - Along Traverse	Method - Median
Mean Profile Filter	All	Along Stripe Size - 9	Across Stripe Size - 3
Clip	All	Minimum - -35 nT	Maximum - 35 nT
Spatial Low Pass Filter	All	Method - Average	Filter - .5 x .5 meters

EMI Data Processing Parameters

Process	Tiles Applied To	Parameter 1	Parameter 2	Parameter 3
Destagger	All	Rows - All	Number of Shift Rows - 1	Stagger Amount - 1
Mean Profile Filter	All	Along Stripe - 9	Across Stripe - 3	
Spatial High Pass Filter	All	Method - Average	Filter - 10 x 10 meters	

Other Geophysical Data Results



Complete processed magnetometry results. A total area of 6.5 ha. 340 m (x) by 280 m (y). Includes data collected during March and summer 2014.

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