Evaluating Paleochannels Using Interdisciplinary Methods in the Yazoo Basin of Northwest Mississippi

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Abstract

Several paleochannels and oxbows from the Mississippi River surround the Parchman Place Mounds (22CO511) in the Yazoo Basin of Northwest Mississippi. These paleochannels were mapped using aerial photography and bore-hole coring in the middle part of the twentieth century. Advanced technology and minimally destructive interdisciplinary methods such as airborne remote sensing images and geophysical surveys can be used to map paleochannels and their boundaries more accurately. Such methods were used to reevaluate the channels as well as the site, both geologically and archaeologically, for this study. The placement of sites in conjunction with paleochannel boundaries provides information about the paleoenvironment that the prehistoric people of Parchman were utilizing.

1 Introduction

Interdisciplinary applications have been useful for understanding archaeological sites (Dalan 1989, 1991,1993; Herz and Garrison 1998). Many of these applications, like near-surface geophysics or airborne remote sensing, are non-intrusive and sometimes cost-effective methods that can be used to comprehend topographical, geological, and cultural characteristics of the landscape. Landscape studies are often used by archaeologists (Dalan 1996; Dalan and Bevan 2002) and geoarchaeologists (Holliday 1995; Mandel 2001; Waters 2002; Rapp and Hill 1996) as a way to reconstruct past environments of prehistoric sites. Interdisciplinary approaches such as geophysics, soil coring, and airborne remote sensing are just a few methods that can be used to understand and reconstruct the landscape of an archaeological site. These methods can aid in one's understanding of site formations, settlement patterns, and human interaction with the environment. Interdisciplinary studies were used to examine several paleochannels surrounding a Mississippian archaeological site in the Lower Mississippi Valley.

The Parchman Place Mounds (22CO511) is a Mississippian archaeological site located in an area defined as the Yazoo Basin in northwest Mississippi (Figure 1). The actual age of Parchman is unknown, however Phillips et al. (1951:51) suggest that Parchman was a late Mississippi Period site dating to around AD 1450 to 1550. Recent ceramic analysis conducted by Jay K. Johnson and Matthew Reynolds (pers. comm., 2003) indicates an occupation period ranging from about AD 1250 to 1450. The site is situated in Coahoma County and is approximately ten miles north of the city of Clarksdale, two miles southwest of the town of Coahoma and about three miles east of the Mississippi River.

Parchman consists of a village site and ceremonial center that includes one large platform, or temple mound (Mound A), and two smaller platform mounds (Phillips et al. 1951:51). The largest mound, Mound A, is about 10-12 m high and appears to have a terrace located on its western edge (Figure 2). There are only two other mounds that today range from two to five meters high. A grand plaza has been documented by several archaeologists (Brown 1977; Phillips et al. 1951; Starr 1984) who described a well-defined plaza surrounded by several smaller mounds. The plaza and the smaller mounds may have been destroyed by plowing since this area has been heavily cultivated for cotton and none of the small mounds are present today.

A broad, shallow depression that appears more cultural than natural is located southeast of Mound A and is likely to be a borrow pit. This is the only borrow pit known at present; however, recent geophysical data (Lowe 2005) suggest a second and larger borrow pit may be located directly north of Mound A. The majority of the village is located just south of the large mound in what today is an agricultural field. Daub scatters on the plowed surface of the village site were first mapped by Connaway as a way to examine the distribution of potential remains (Star 1984:185). The village area was later defined more clearly in a number of geophysical datasets that were collected at the site prior to excavation of portions of the village, including its structures, in 2002 by the University of Mississippi.

The site is situated next to a series of meandering paleochannels and oxbows of the Mississippi River. Fisk (1944) and Saucier (1994) both mapped the abandoned channel deposits of the Mississippi River in the Lower Mississippi Alluvial Valley using geological data. Fisk used bore-hole coring and aerial photographs from the 1930s to look at the sequential relationships of the channel deposits in the valley (Stein 1986:506) and to compose a chronology of Mississippi River meander belts. Saucier used similar techniques to construct a more recent interpretation of Mississippi Alluvial Valley geomorphology (Figures 3), focusing on particular paleochannels (Saucier 1994:II: Plate 7). Saucier was not interested in determining the stages of the Mississippi River; he was more concerned with mapping the abandoned channels that were present in aerial photographs.

Parchman is located on the natural levees of at least

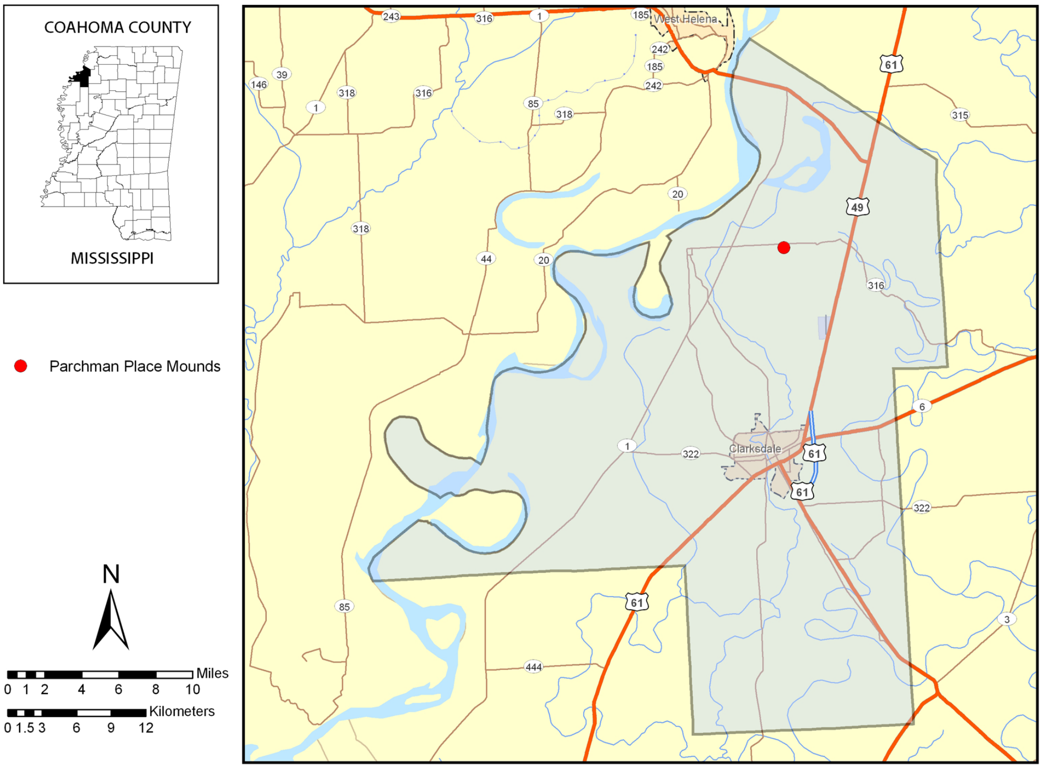

Figure 1. GIS map showing the location of Parchman Place Mounds in Coahoma County, Mississippi (2005).

Figure 2. Aerial photograph of Parchman Place Mounds looking northwest. (Photo courtesy of the University of Mississippi, Center for Archaeological Research 2003).

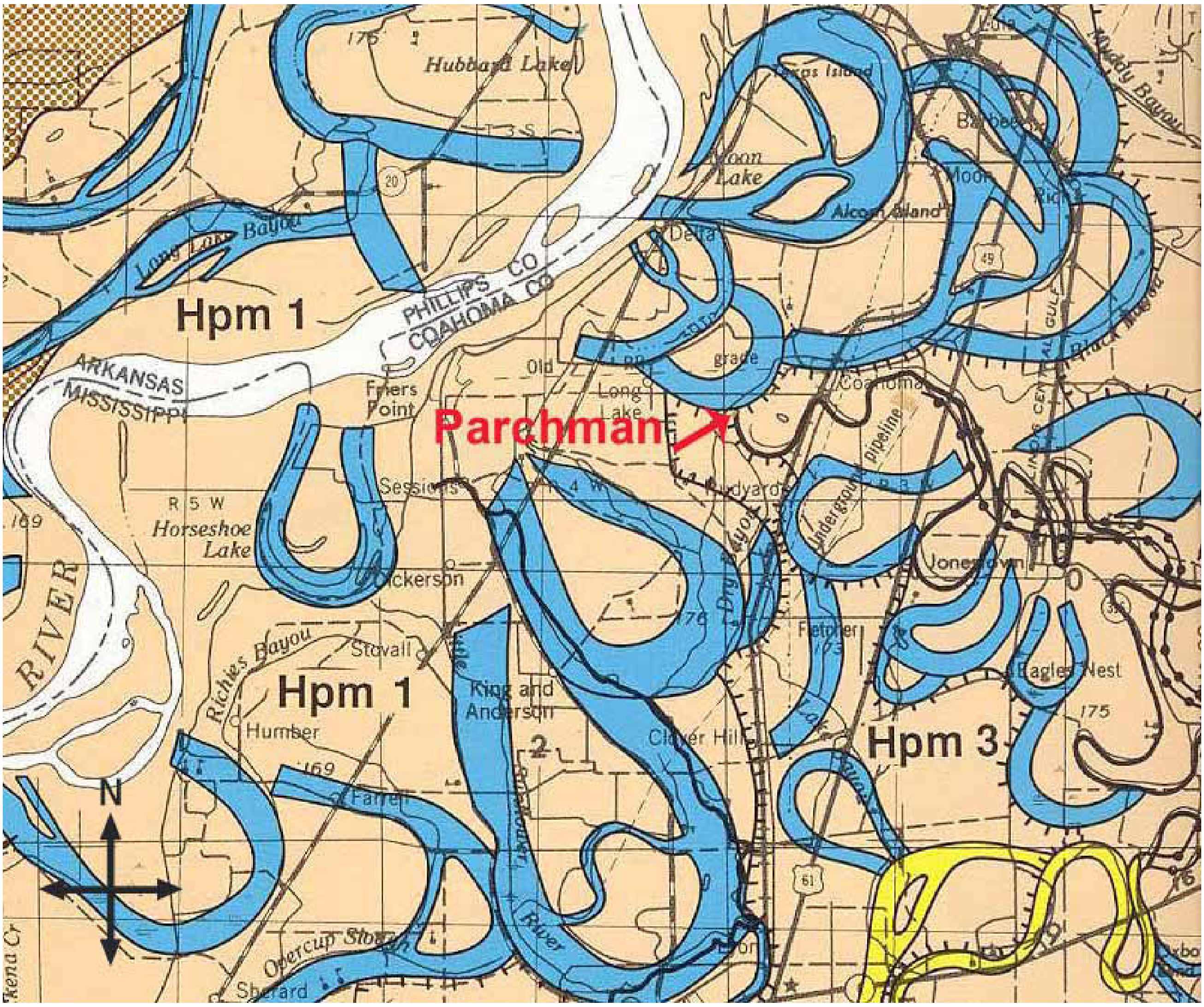

Figure 3. Saucier's (1994: Plate 7) Abandoned Channel Maps of the Lower Mississippi Valley. Army Corps of Engineers.

one, and perhaps two, of the Mississippi River's extinct channels. In the reconstruction of channel stages by Fisk (1944:Plate 22, Sheet 6), Parchman is situated on Channel 11, which overlies the previous extinct Channel 10 (Figure 4). In Saucier's map, Parchman is situated on the natural levee of an extinct channel of Meander Belt Stage 1 (Saucier 1994:II:Plate 7).

1.1 Physiographical Setting and Geomorphology

The Yazoo Basin is located in the Lower Mississippi Alluvial Valley and extends from Memphis, Tennessee to Vicksburg, Mississippi. This area is about 200 miles long and ranges anywhere from 30 to 60 miles wide. Uplands consisting of loess covered bluffs are located to the east side of the basin; the current Mississippi River to the west. About ninety-five percent of the area consists of late Holocene meander belt and backswamp environments; while the other five percent is glacial outwash (Saucier 1994). The Coldwater, Tallahatchie, Yazoo and Sunflower rivers are major tributaries to the Mississippi River within this region. These streams, along with abandoned meanderbelt channels, provide drainage throughout the basin. All drainage in the basin is directed by abandoned Mississippi River meander-belt features.

According to Fisk (1944:47) the landforms and deposits created in the alluvial valley since the last glaciations date back to the early Holocene or about 10,000 B.P. The lower stratum of the basin consists of gravels and sands that were deposited during the Late Tertiary and Early Pleistocene epochs (Saucier 1994); while the top stratum consists of alluvial and colluvial deposits. Continental glaciations were the dominant factor in shaping the alluvial valley.

The geomorphology of the Lower Mississippi Valley is well known and has been extensively studied archaeologically (Arco et al. 2006; Fisk 1944; Kidder 2004; Phillips et al. 1951; Saucier 1994; Weinstein 1981; Williams and Brain 1983). The geoarchaeology of the Parchman area is complex and consists of meanderbelt landforms (including ridges, meander scars, abandoned channels and courses, natural levees, point bars, and back swamps). The meanderbelts have been mapped as a series of stages, with Stage 6 being the oldest and Stage 1 representing the most recent (Saucier 1994). Parchman is located on Saucier's (1994) meander belt Stage 1 which dates back to 2,500 B.P. The

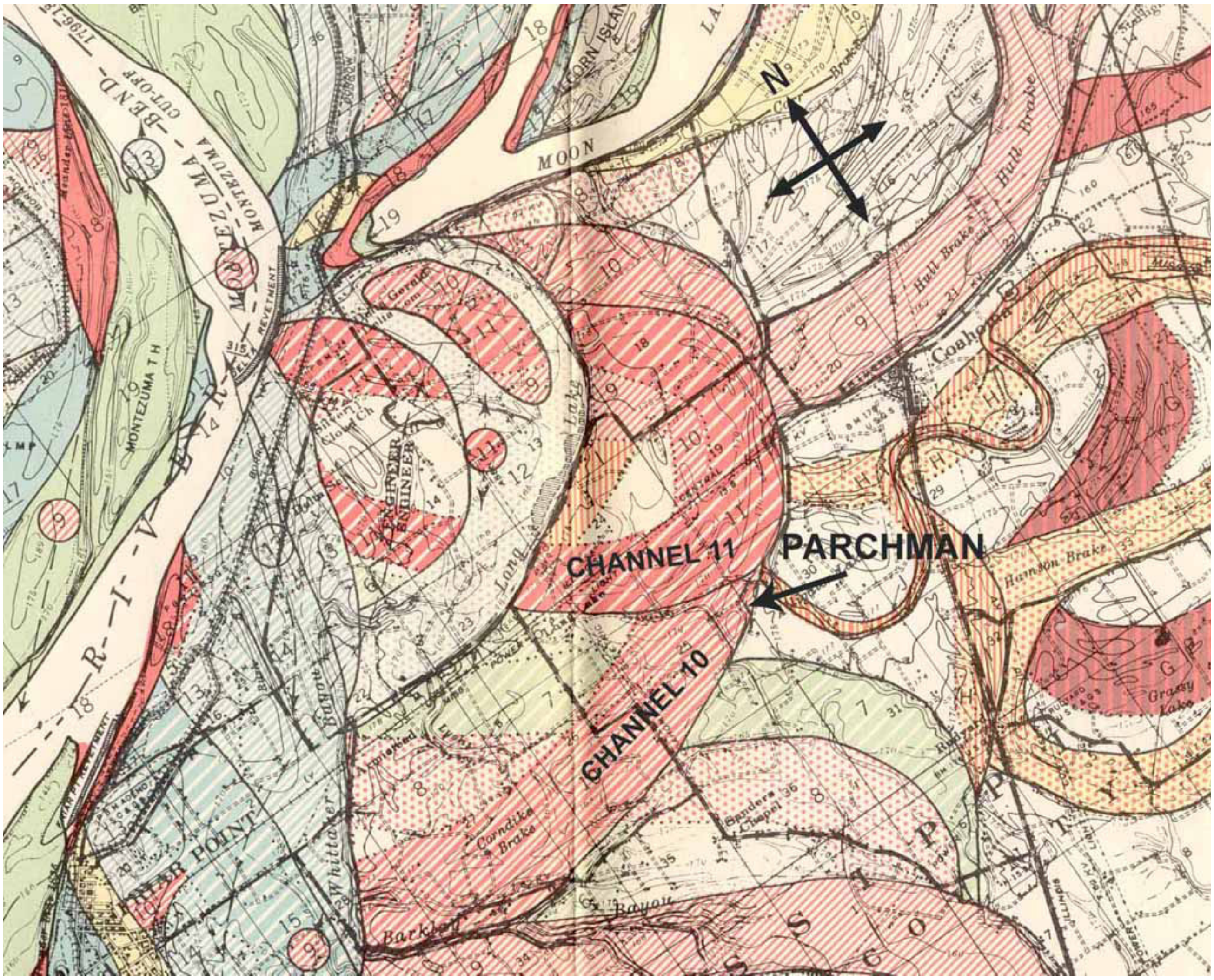

Figure 4. Fisk's (1944: Plate 22, Stage 6) map of Channel Stages 10 and 11.

most visible geological deposits at the site today consist of natural levees and ridges, abandoned channels, and meander scars.

2 Purpose

The primary goal for this project was to use airborne remote sensing and electromagnetic conductivity to map and understand the topographical and geological channel boundaries, in the vicinity of Parchman,.Phillips et al. (1951:296) note that many Mississippian sites are situated on recently formed natural levees. These areas are more desirable for settlement than older levees. Younger levee soils are easier to work and are more fertile than older soils. Parchman's location on two natural levees would be ideal for aboriginal occupation because the locale would provide the prehistoric people of the site with fertile, fairly well-drained land protected from flooding. The collected and processed geophysical data for this project, combined with high-resolution aerial photography, revealed the inaccuracy of the suggested levee boundaries proposed by Fisk and Saucier for these channels. Although they used the best methods possible for their data collection, current research suggests that additional methods such as archaeogeophysics may be a more precise way for one to see channel boundaries.

Fisk's boundaries for Channels 10 and 11 run adjacent to, and north of, Parchman. Saucier acknowledges Channel 11 but does not define Channel 10. His boundaries for Channel 11 are similar to Fisk's except they extend much farther to the northwest in other areas. The boundary differences are a result of the methods they used to map the channels, with less emphasis on detail and bankline precision and more on a channel's general location.

Multiple methods such as airborne remote sensing and geophysics were used in this study to map the paleochannel boundaries of Channels 10 and 11 more accurately and to determine how well these features match up to the boundaries postulated by Fisk and Saucier. The Electromagnetic Conductivity (EM-31) was chosen for this project because of its availability, its success in locating buried channel deposits in previous studies, and as a way to examine different depositional environments of abandoned channels. EM-31 instruments have been used primarily in large-scale geophysical explorations, therefore it was anticipated that it would be an extremely effective method to use for defining deeply buried paleochannel deposits.

3 Methods

3.1 Airborne Remote Sensing

Several minimally destructive and efficient methods were used to reconstruct the past environment of Parchman Place Mounds. Airborne remote sensing was the first method used. Data derived from this method provide archaeologists the opportunity to detect geologic or cultural phenomena that may otherwise be hard to distinguish (Sever 2000:21). It provides a bird's-eye perspective of the landscape, which, as in the case of the Mississippi Alluvial Valley, is beneficial for understanding paleochannel sequences.

Multispectral imagery can be understood as the production of digital "photographs" of the earth's surface that result from the measurement of reflected or emitted electromagnetic radiation (Limp 1993:184). Visible light is the most recognizable part on the electromagnetic spectrum, however other parts of the spectrum, such as near infrared and microwave bands, which one cannot see, are also commonly used in feature detection. The electromagnetic spectrum is used to categorize electromagnetic waves by their wavelength location (Lillesand and Kiefer 1994:9-10). Multispectral sensors allow one to see beyond visible light waves in the electromagnetic spectrum. Multispectral digital images are the product of remote sensing systems that simultaneously measure the spectrally and spatially delimited radiation as it is emitted or reflected from the earth's surface (Kahle and Goetz 1983:27).

Satellite sensors produce a wide variety of available data of a known character that require little preprocessing (Limp 1993:188). The satellite and airborne images can provide information regarding archaeological and geological features that may be a result of human impact on the land. Sometimes, patterns of shadows or sunlight in images reveal earthen features such as roads, mounds, or ditches that are difficult to see when standing at a site. Erosion, vegetation, and even buried deposits make it difficult for the archaeologist to understand the landscape. Remote sensing methods may help one see beyond those difficulties. Differences in soil and vegetation patterns can indicate the presence of archaeological or cultural features.

Airborne remote sensing was used in conjunction with the geophysical data to identify several abandoned channels, their boundaries, and their proximity to Parchman. Mississippi River paleochannels are well defined in the remote sensing images. This is largely due to different soils and soil development, vegetation, and moisture content. While most abandoned channels can be detected from the remote sensing images, others are much more difficult to identify, such as Channel Stage 10 as defined by Fisk (1944).

Images such as the Landsat ETM+ and Digital Ortho Quarter Quad (DOQQ) provide adequate detail for understanding landscape features at Parchman. The University of Mississippi's Center for Archaeological Research provided the DOQQ image for this project. DOQQs have one meter resolution and are typically black-and-white; however, color infrared is available, produced by the United States Geological Survey's National Aerial Photography Program (NAPP) (Giardino and Haley 2006).

3.2 Electromagnetic Conductivity

Electromagnetic conductivity or induction meters (EM-31, EM-34, and EM-38) are used in geology as well as archaeology as a way to detect differences in subsurface materials in terms of their conductivity (Bevan 1998). The EM-31 and EM-34 are used primarily in geological exploration since they measure features at depths from 10 m to 50 m for the EM-34 and 3 m to 6 m for the EM-31. However, there have been cases in which the EM-31 has been used for archaeological purposes (Dalan 1989, 1991; Clark 1996; Gaffney and Gater 2002). Most archaeologists prefer using the EM38 for archaeological surveys since it measures features at much shallower depths, generally less than one meter below the surface.

The EM instruments are non-invasive and non-destructive geophysical tools. They are quick and accurate geophysical methods that do not require electrical contact with the ground. Electrical conductivity measures the ease of current flow in subsurface material. An alternating current in a primary input coil or transmitter located at one end of the instrument produces an alternating magnetic field that induces the flow of eddy currents into the ground through a circular motion or loop (Dalan 1989:11). The transmitter coil is used to generate the primary electromagnetic field, which circulates both above and below the ground (Reynolds 1997). A second magnetic field is produced by the eddy currents and received by a second coil located at the other end of the instrument. The indirect coupling from the transmitter coil through the earth's surface and back to the receiver coils allows the measurement of electrical conductivity (Bevan 1998). These variations in electrical conductivity can be used in data analysis to produce images of differing conductivity values of subsurface deposits over an area.

The receiver coil divides the second magnetic field into two components, the in-phase component (IP) or magnetic susceptibility and quadrature phase component (Q) or conductivity phase. The in- phase component is a measurement of the magnetic component of the electromagnetic wave, while the quadrature component is a measure of the electric component (West and Macnae 1991). The in-phase component is more sensitive to large metallic objects and is often used to located large buried drums in geophysical exploration. For this study, the quadrature phase was used.

Various depths can be used for measuring conductivity. These depths are based on the different intercoil spacing in the transmitter and receiving coils located at both ends of the instrument. The distance between the transmitter and receiver coils for the EM-31 instrument is 3.66 m. When the instrument's intercoils in the transmitter and receiver are in vertical coplanar or normal operating mode, the depth of penetration is six meters; when the instruments coils are horizontal coplanar, or turned on its side ninety degrees, the penetration depth is three meters or approximately half that of the vertical dipole mode (McNeill 1980b). The horizontal resolution of the instrument according to Keller and

Frischknect (1966:354) is approximately equal to the distance separating the two coils. They concluded that the horizontal resolution for the EM-31 was 3.5 m.

Factors that most affect electrical conductivity readings are soil moisture content, soil porosity, water quality, depth and thickness of soil layers, and permeability since most rocks and soil materials are already poorly conductive materials (McNeill 1980a). Various sediments can be either highly conductive, like clays, or poorly conductive, like sands. Conductivity values also vary with the differences in the particle sizes of these materials. The absorption and attenuation of electromagnetic waves into the ground is greater in higher conductive materials or materials with a smaller porosity (Mussett and Khan 2000). In lower conductive materials, the absorption and attenuation of electromagnetic waves lessens due to higher porosity and reduced water content.

The Geonics Limited EM-31 non-contacting terrain conductivity meter was used for this project as one way to locate cultural and natural large-scale anomalies in the Parchman area at depths of three meters (horizontal coplanar) and six meters (vertical coplanar). The instrument is insensitive to material located near the surface in vertical coplanar mode (McNeill 1980b). In horizontal coplanar mode, the sensitivity is much greater to materials located near the surface and decreases with depth. Using both survey modes, the author was able to define the layering of subsurface material and understand changes and features in subsurface materials.

4 Results

The airborne remote sensing data contained in the DOQQ image proved to be useful in locating oxbow deposits (Figure 5). These channels are evident due to the differences in soil types which are reflected by changes in the infrared bands of remote sensing images. Areas used for agriculture also reflected the infrared bands in a distinct way, which made it easier to detect the buried channel deposits.

Fisk's channel sequence map was digitized and superimposed on the DOQQ image (Figure 6). This procedure was repeated with Saucier's channel maps and the DOQQ image (Figure 7). These image comparisons were performed in order to examine the relationships between the documented channels of the Fisk and Saucier maps and the channels apparent in the remote sensing images. Maps such as the Soil Survey Map of Coahoma County were also useful in this project for understanding topographic, landscape, and environmental changes of the Parchman area. The Soil Survey of Coahoma County (1959:13) as well as the National Resource Conservation Services (NRCS) Official Soil Database provided information regarding these paleochannel deposits. Certain soil types are characteristic of the natural levees, channel fills, and point bars that make up meandering stream systems. The soil maps provided another way to identify the boundaries of the abandoned channels.

The EM-31 results proved to be a successful geophysical method for determining the boundaries of Channels 10 and Channel 11. Again, the DOQQ image illustrates what appears to be a well-defined, abandoned, channel deposit just north of the Parchman Mounds. The final EM-31 data confirmed these channel boundary observations, both with the three meter and six meter data (Figure 8). The EM-31 was able to pick up the differences of the subsurface materials surrounding the Parchman area by differentiating the natural levee material from the abandoned channel material. The electrical conductivity values show a remarkable difference in the abandoned channel fill deposits and the natural levee deposits. Sediments in the abandoned channel contained fine silts and clays. High conductivity values, or the areas with purple, blue, and green in the EM31 images, marked these areas with values ranging from 50-70 millisimens per meter (mS/m). Conductivity values were much lower on the natural levees of Channel 10 and Channel 11. These areas on the EM 31 images are marked in yellow, orange, and red and had values from 10-35 mS/m.

The EM Data were brought into Erdas Imagine and combined with the DOQQ image as a way to identify the boundaries of Channel 11 more accurately, especially the natural levee deposits (Figure 9). The EM-31 data also revealed other interesting geological features of meandering stream regimes such as topographic variations. The topographical data collected in this area, combined with the EM-31 results, provided a well-defined image of Channel 11 and its natural levee as well as what may potentially be Channel 10's natural levee. Detailed collection of elevation data was essential for this project. The differences in elevation within the channel were identified by differences in conductivity values. The topographically low areas typically had higher conductivity values. Low areas were characterized by fine silt and clay sediments and generally had higher water content than the surrounding soils. The topographically high areas contained more silt and sand material and had slightly lower conductivity values. The projected channel boundaries of Fisk (white line) and Saucier (yellow line), as well as those proposed by this research (red line), were digitized and superimposed on the DOQQ image (Figure 10).

Both geologists acknowledge the abandoned channel located north of the site, yet they propose different boundaries for this channel. Using the geophysical and topographical data, the soil survey, and airborne remote sensing data, the author suggests a more southern boundary for Channel 11 than previously indicated. The EM-31 data confirmed the existence of Channel 11; however, it also showed that the channel's levees extended farther to the south and much closer to Mound A than either Fisk or Saucier indicated. It appears that Mound A is located directly on the edge of the highest part of the Channel 11 levee. One can even see how the prehistoric people of Parchman altered parts of the natural levee when they borrowed from a portion of the deposit located to the northwest of Mound A. The channel appears to bend southwest where it cuts across Channel 10's deposits. This new paleochannel boundary is also supported by the soil data (Figure 11). Both images show that the levee deposits are less prominent in Channel 11 when it cuts across Channel 10. This is due largely to a change in elevation as well as a change in the depositional material the channel is cutting across. This alteration in depositional features also supports the existence of Channel 10. The data collected for this project show that Fisk and Saucier were

Figure 5. Digital Ortho Quarter Quad (DOQQ) of Parchman Place Mounds and adjoining abandoned channel deposits. (Provided by University of Mississippi, Center of Archaeological Research 2003).

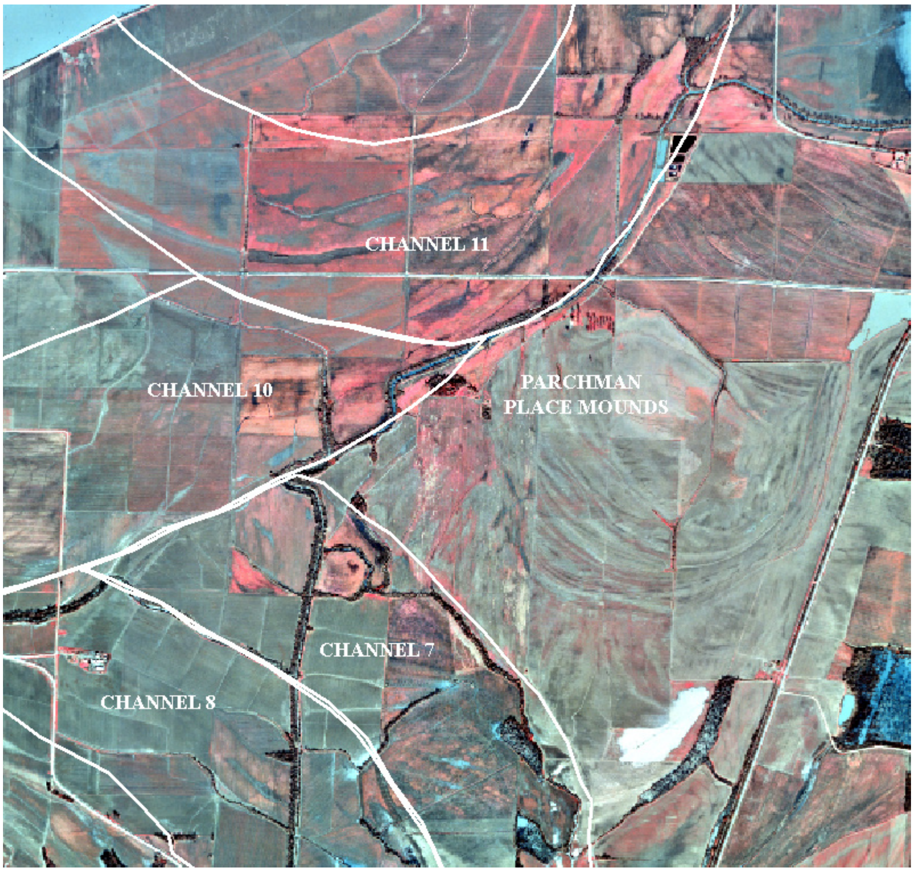

Figure 6. DOQQ image digitized with Fisk's (1944) Channel Stages.

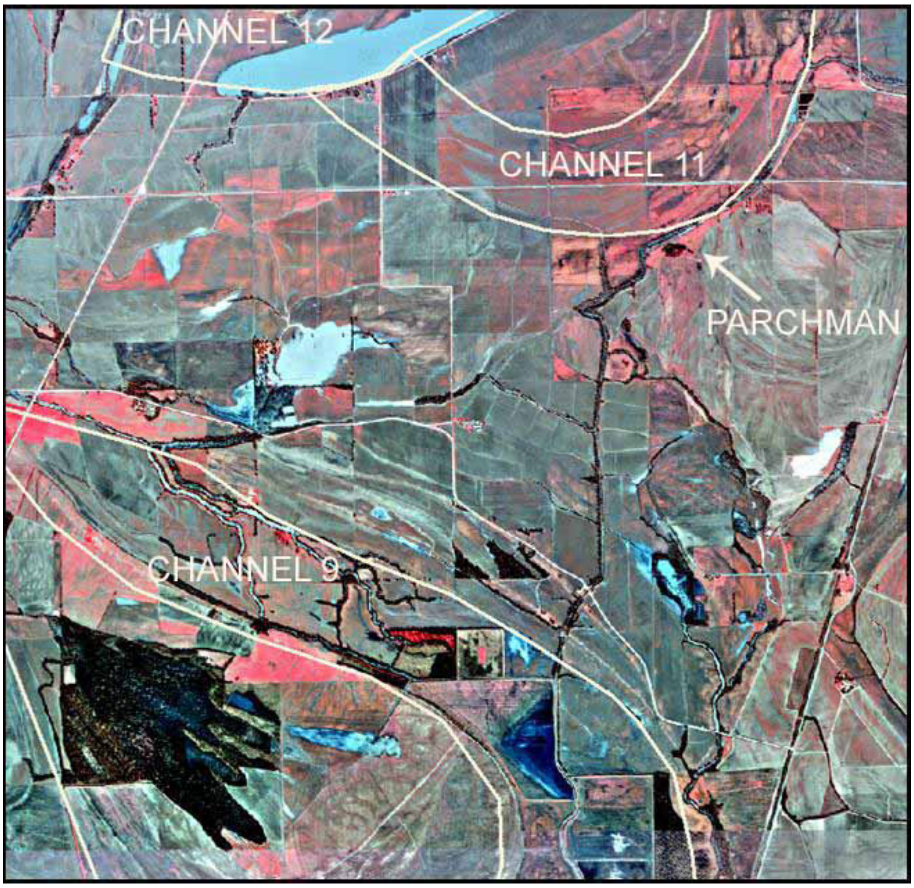

Figure 7. DOQQ Image digitized with Saucier's (1994) Channel Outlines.

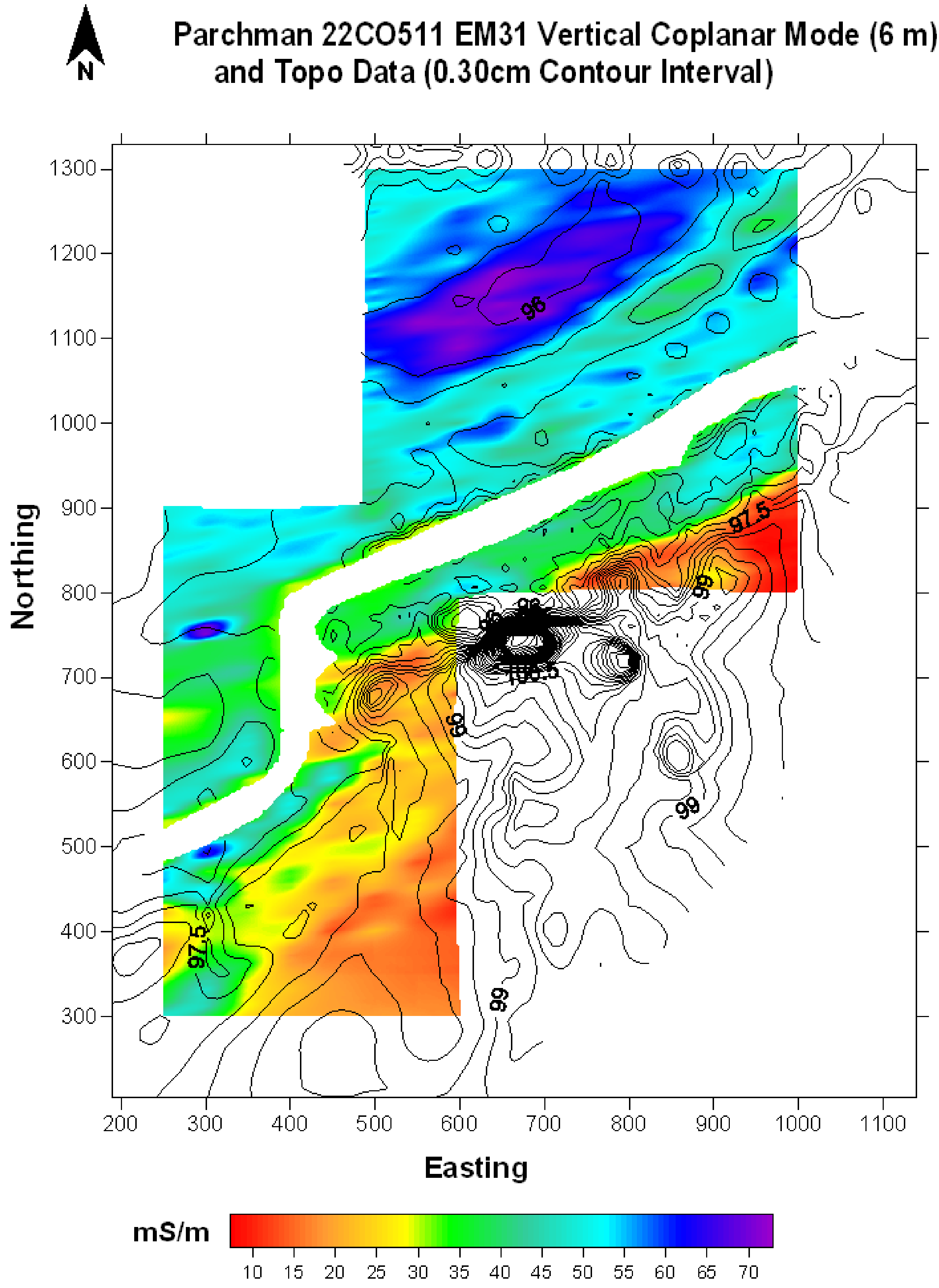

Figure 8. EM-31 Vertical Coplanar results of Channel 11 and possibly Channel 10.

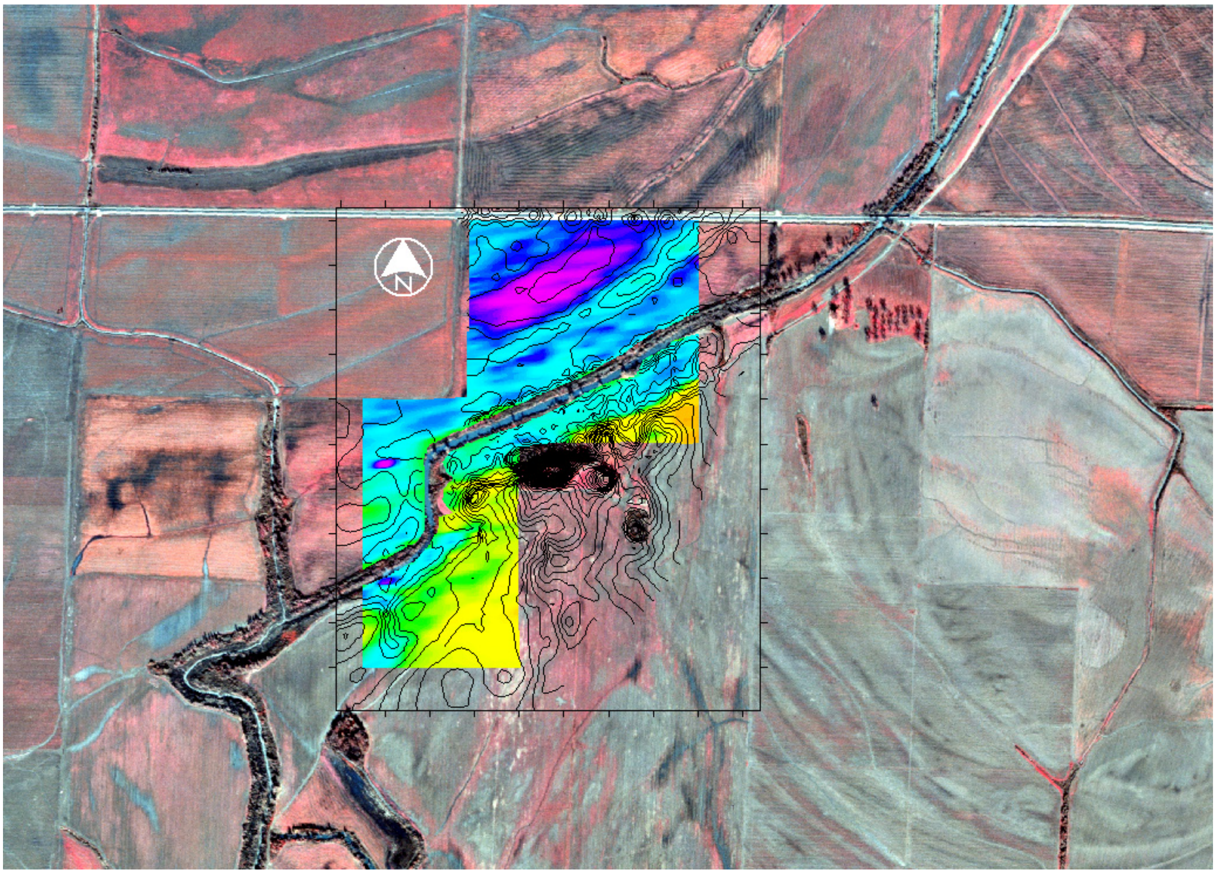

Figure 9. EM-31 Horizontal Coplanar (3 m) with Topographic Data and DOQQ Image.

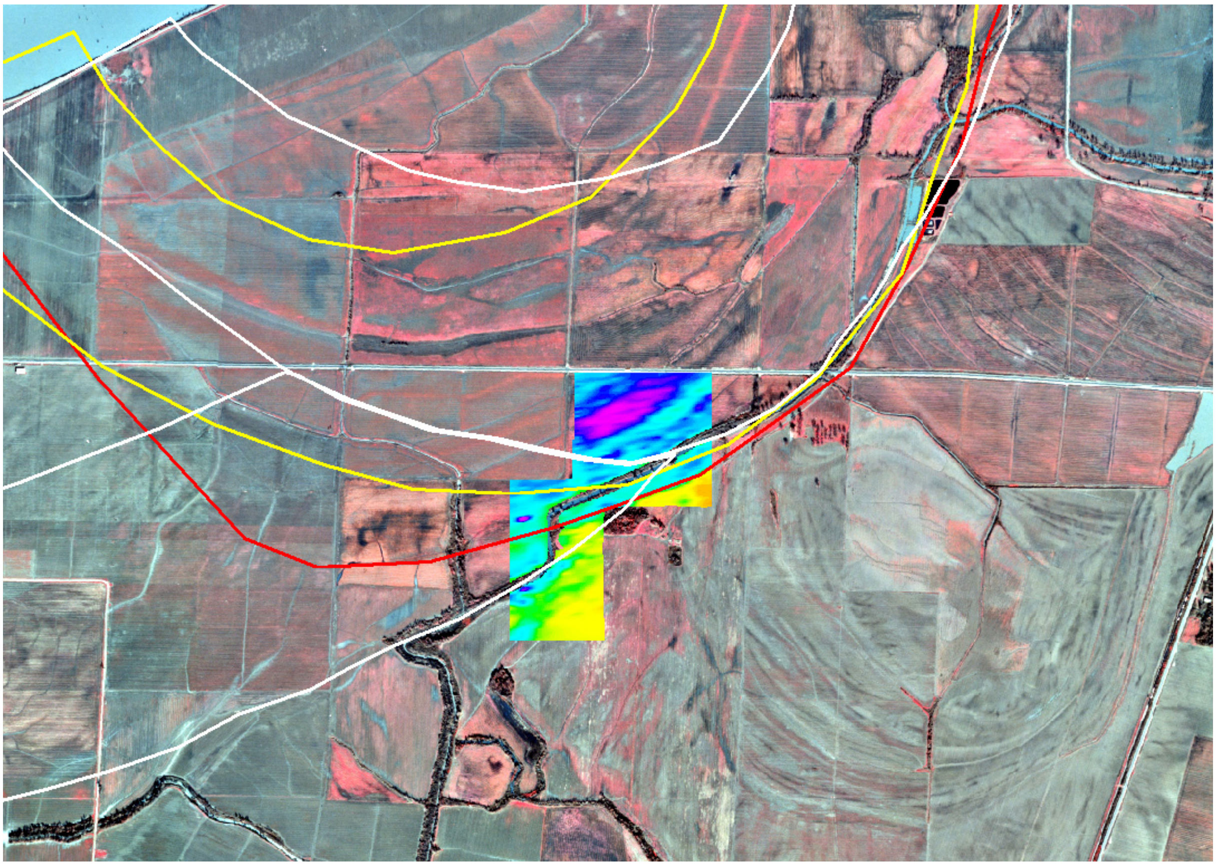

Figure 10. DOQQ Image and EM-31 Horizontal Coplanar (3 m) Data. Outlined with Fisk's (white), Saucier's (yellow), and the author's predicted (red) channel boundary line for Channel Stage 11.

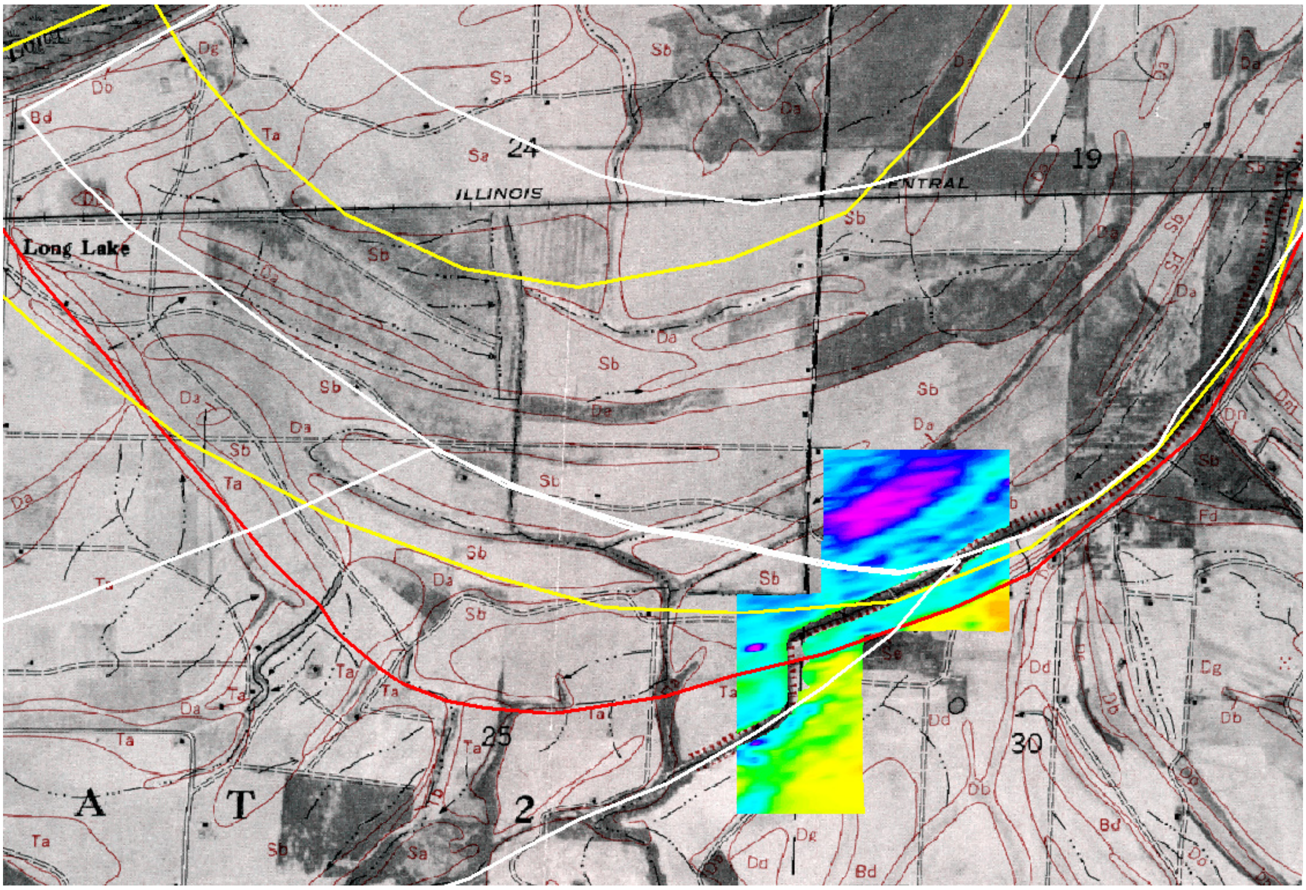

Figure 11. Soil Survey Map of Coahoma County combined with EM-31Vertical Coplanar (6 m) data. Fisk's (white), Saucier's (yellow), and the author's predicted (red) channel boundary line for Channel Stage 11 are displayed.

not completely accurate on there locations of Channel 11's boundaries. Fisk, however, may have been correct about the location of Channel 10 and its boundaries, while Saucier dismissed its existence completely. Although portions of Channel 10 have been modified by recent human activities, there is evidence for its existence. High values in conductivity in the EM-31 data also correspond nicely with Fisk's proposed channel boundaries, suggesting that the channel in fact existed prior to Channel 11.

5 Conclusions

The interdisciplinary methods chosen for this project proved to be successful tools for understanding, mapping, and determining the accurate dimensions of geological features such as the Mississippi River and its extinct channels. This method also provided a brief glimpse of site settlement and site modifications made by the prehistoric people at Parchman. It is understood that Fisk and Saucier were not mapping the Lower Mississippi Valley at such a fine scale as the current research data; however, the fine-scale data provided another approach for determining paleochannel boundaries. Features like ridge/swale topography and levee deposits that were unrecognizable on the United States Geological Survey (USGS) topographic maps used by Fisk and Saucier became apparent when combined with a high-resolution DOQQ image, a topographical map, and the EM-31 images.

The complexity of abandoned channel deposits has been examined in archaeological and geoarchaeological studies for almost a century. Defining channels effectively with more precise methods can provide important evidence when studying archaeological sites in alluvial valleys, especially the placement of sites in conjunction with these abandoned channels. Locations on the banklines of oxbow-lake and relict channel deposits would be the most beneficial places for settlement due to the rich resources, as was the case with Parchman. The lack of biotic resources associated with an active channel and the hazards of periodic flooding caused prehistoric cultures to avoid settling on the natural levees of active channels. The location of the three remaining mounds situated on the topographically highest portion of the natural levees of Channels 10 and 11 suggest that this was one of the few areas suitable for long-term habitation in this active depositional environment. Also, after extensive data collection, the questionable area of the depression located northwest of Mound A was verified to have originally been part of the natural levee of Channel 11 but was altered through cultural modification and borrowing.

Since large-scale geophysics was so successful for defining paleochannel boundaries, additional geophysical surveys with the EM-31 will be conducted in several areas, namely the area southwest of the mounds, to map the remainder of Channel 10's deposits. EM-31 surveys will also be conducted in the area south of the site where the village was located in an attempt to locate cultural features in the village area. The proposed surveys will allow me to determine the existence and approximate location of Channel 10 as well as any cultural features within the site area such as plowed mounds or borrow pits.

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