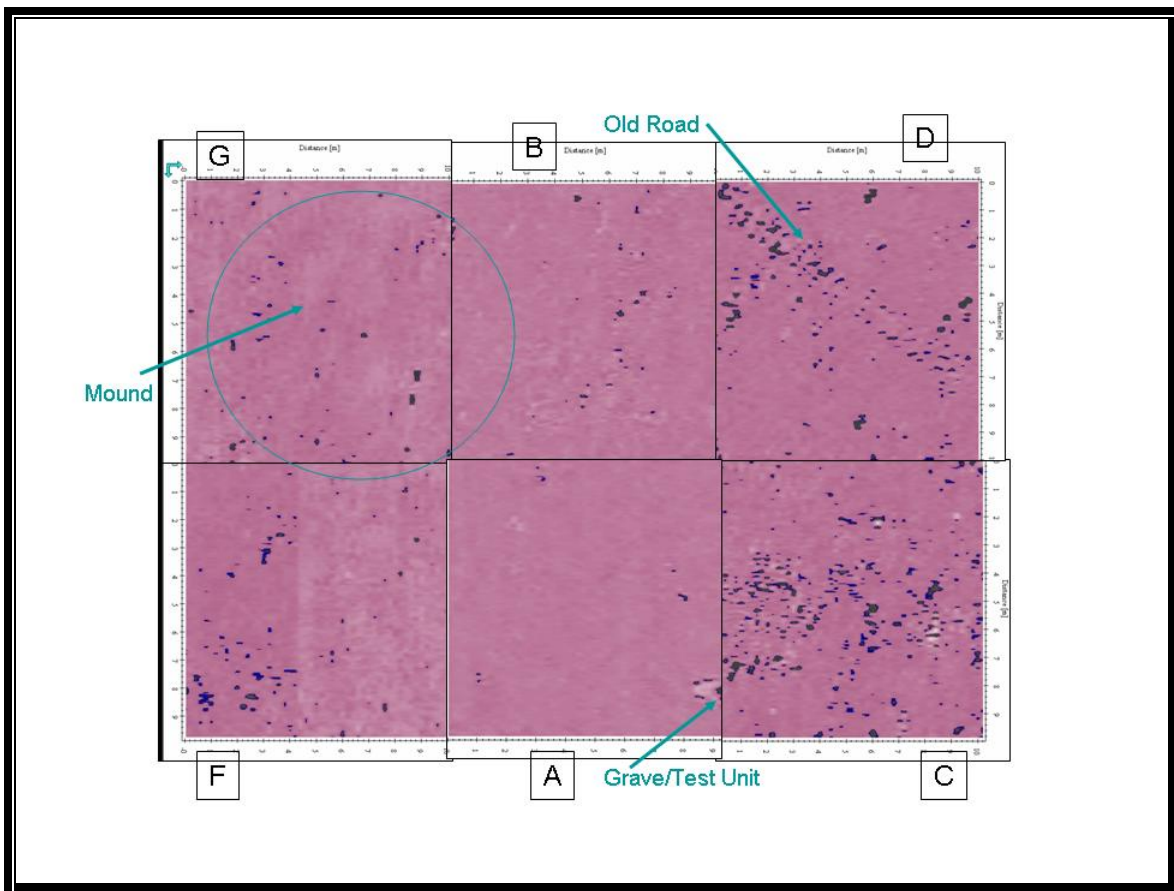


Ground Penetrating Radar Survey at the Woodbine Mound Site

LAMAR Institute Publication Series Report 88



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at the Woodbine Mound Site**

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By Daniel T. Elliott

Submitted to Carolyn Rock
128 Buntin Street
Woodbine, Georgia

LAMAR Institute & Rocquemore Research
P.O. Box 317
Box Springs, Georgia 31801

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Introduction

Archaeological investigations at the Woodbine Mound archaeological site in Camden County, Georgia were provided by the LAMAR Institute, Box Springs, Georgia. This work included topographic mapping of the site and Ground Penetrating Radar survey of a sample of the site. The GPR study was part of a broader archaeological investigation of the cultural resources directed by archaeologist Carolyn Rock. Fieldwork for this project was conducted on January 19, 2004. These results are detailed within.

Background

The Woodbine Mound site is located on a ridge south of the Satilla River in Woodbine, Camden County, Georgia. The site is located in a cattle pasture on the western edge of town (Figure 1). The site contains a single, low burial mound. This mound was explored in the early 20th century by Clarence Bloomfield Moore. Moore excavated approximately one-half of the mound and uncovered 50 human burials. Moore's description of his investigations at the Woodbine Mound are quite brief. In 2003, Carolyn Rock led a field school in a reexamination of the Woodbine Mound. Rock's research determined that, in addition to the Woodland period funerary mound, the site contains a large 19th to early 20th century cemetery. In one test unit, the field school students discovered a historic human grave.

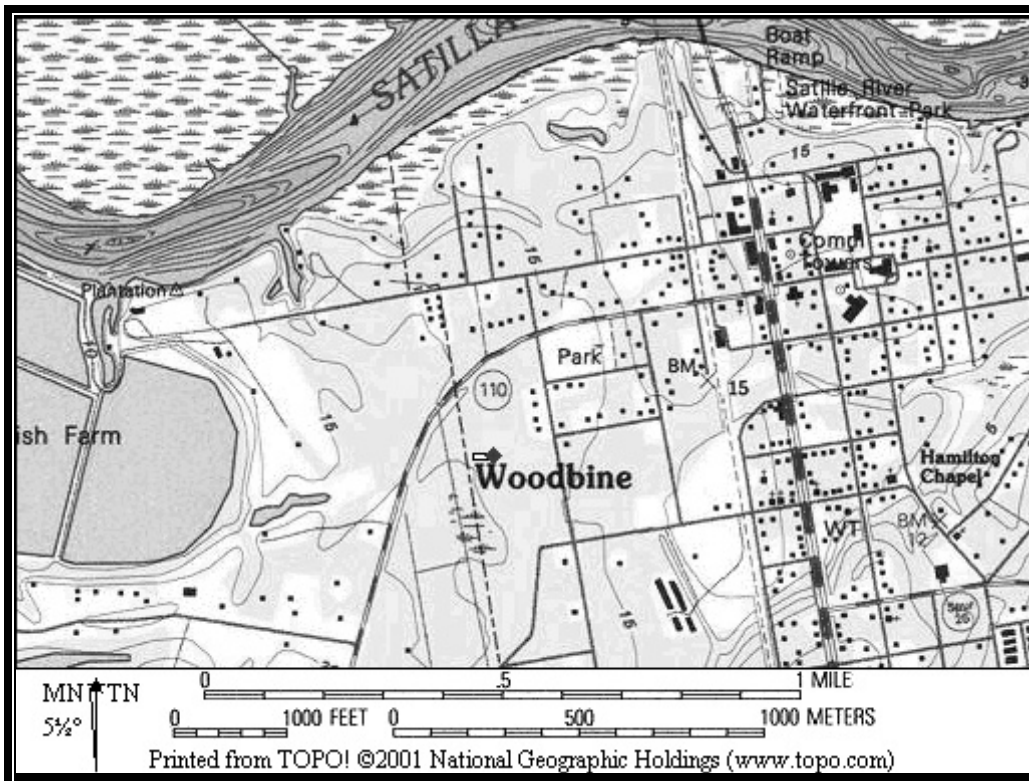


Figure 1. Study Location.

Methods

Topographic Mapping

Mapping of the Woodbine Mound site was accomplished with the aid of a Topcon total station laser transit and TDS data collector (Figure 2). The map was linked to the pre-existing site grid that was established by Carolyn Rock.



Figure 2. Topographic Survey in Progress (Woodbine Mound is visible directly behind the survey team).

Ground Penetrating Radar

Ground Penetrating Radar (GPR) was developed by the U.S. Department of Defense during the Vietnam War as an aid in remotely locating Viet Cong tunnels. Since then the technique has been extensively miniaturized and the technological capability enhanced to a point where today a single individual can conduct a GPR survey with ease.

The GPR device uses high frequency electromagnetic waves to acquire subsurface data (Figure 3). The device uses a transmitter antenna and closely spaced receiver antenna to detect changes in electromagnetic properties beneath them. The antennas are suspended just above the ground surface and the antennas are shielded to eliminate interference from sources other than directly beneath the device. The transmitting antenna emits a series of electromagnetic waves, which are distorted by differences in soil conductivity, dielectric permittivity, and magnetic permeability. The receiving antenna records the reflected waves for a specified length of time (in nanoseconds). The approximate depth of an object can be estimated with GPR, by adjusting for electromagnetic propagation conditions.

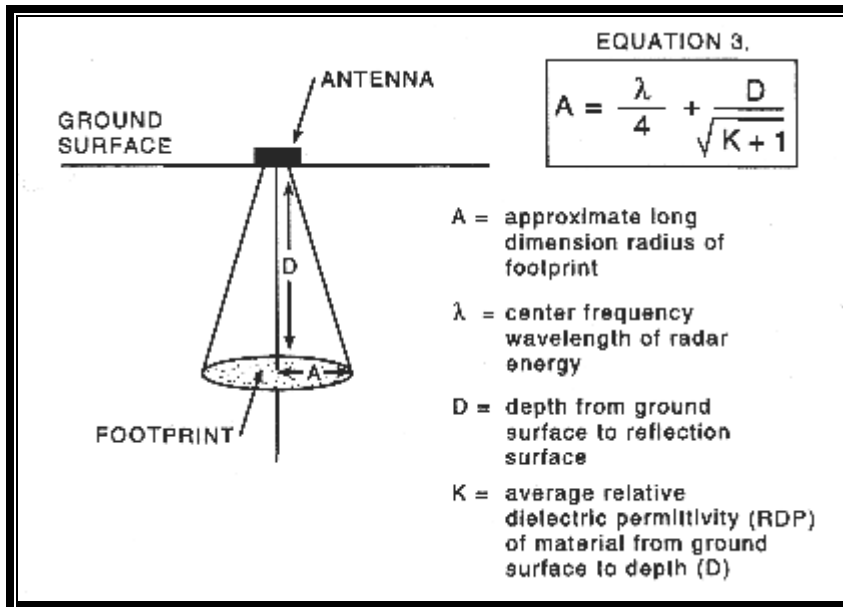


Figure 3. The Elliptical Cone of GPR Penetration into the Ground (Conyers and Goodman 1997: Figure 4, cited in Hodge et al. 2002).

The GPR sample blocks at the Woodbine Mound site were composed of a series of parallel transects, or traverses, which yielded a two-dimensional cross-section or profile of the radar data. This two-dimensional image is constructed from a sequence of thousands of individual radar “pings” or traces. A succession of radar traces bouncing off a large buried object will produce a hyperbola, when viewed graphically in profile. Multiple large objects that are in close proximity may produce multiple, overlapping hyperbolas, which are more difficult to interpret. For example, an isolated historic grave may produce a clear signal, represented by a well-defined hyperbola. A cluster of graves, however, may produce a more garbled signal that is less apparent.

The GPR signals that are captured by the receiving antenna are recorded in array of numerals, which can be converted to gray scale (or color) pixel values. The radargrams are essentially a vertical map of the radar reflection off objects and other soil anomalies. It is not an actual map of the objects. The radargram is produced in real time and is viewable on the laptop computer monitor, which is mounted to the GPR cart.

Ground penetrating radar signals cannot penetrate metal objects and the signals are also significantly affected by the presence of salt water. Although radar does not penetrate metal objects, it does generate a distinctive signal that is usually recognizable, particularly for larger metal objects, such as a cannon or man-hole cover. The signal beneath these objects is often canceled out, which results in a pattern of horizontal lines on the radargram. For smaller objects, such as a scatter of nails, the signal may ricochet from the objects and produce a confusing signal. Rebar-reinforced concrete, as another example, generates an unmistakable radar pattern of rippled lines on the radargram. Conyers notes: “Ground-penetrating radar works best in sandy and silty soils and sediments that are not saturated with water. The method does not work at all in areas

where soils are saturated with salt water because this media is electrically conductive and ‘conducts away’ the radar energy before it can be reflected in the ground” (Conyers 2002).

The effectiveness of GPR in various environments on the North American continent is widely variable and depends on solid conductivity, metallic content, and other pedo-chemical factors. Generally, Georgia’s soils have moderately good properties for its application.

Metal was expected to be present in the Woodbine Mound site vicinity and it was anticipated that metal would have some effect on the data that was gathered. The soils at the Woodbine Mound site were well drained, however, and salt water was not a significant problem at shallower depths.

GPR has been successfully used for archaeological and forensic anthropological applications to locate relatively shallow features, although the technique also can probe deeply into the ground. The machine is adjusted to best probe to the depth of interest by the use of different frequency range antennas. Higher frequency antennas are more useful at shallow depths, which is most often the case in archaeology. Also, the longer the receiving antenna is set to receive GPR signals (measured in nanoseconds), the deeper the search.

GPR has been used to a limited extent on archaeological sites in Georgia yielding mixed results. A study of a Creek habitation site in Muscogee County, which was part of the Upatoi village, circa 1790 to 1825, included GPR as part of a battery of geophysical techniques that were employed to delineate these sites (Elliott et al. 1999; Briuer et al. 1997). These archaeological sites were located in the Red Sand Hills of Georgia’s Fall Line Zone. The sandy soils on these sites were not too dissimilar from the soils at Ebenezer and the approximate ages of the two sites also were fairly similar. Preliminary testing at the site by Elliott and his colleagues had established the existence of Creek burials that were clearly associated with Upatoi. Briuer and his colleagues identified nine EM anomalies that were interpreted as possible human burials. After Briuer’s study was completed, additional test excavations were conducted by Elliott and his colleagues to “ground truth” a number of the anomalies that had been identified by the GPR survey. Most of these anomalies proved to be modern military disturbances, which was understandable given the location of this site on the Fort Benning Military Reservation. Nevertheless, the GPR technique was able to identify disturbed areas of soil, at least some of which were Creek-related phenomena. In the brief time that has elapsed since Briuer and his colleagues conducted this study, the GPR technology and equipment has significantly improved.

Elsewhere in Georgia, Ervan Garrison and his students have conducted numerous GPR surveys, including investigations at a number of aboriginal earthworks, including Little River mounds in Morgan County and Kolomoki mounds in Early County (Wynn 2002, Friends of Scull Shoals 2002). GPR also has been used to map portions of the Old Athens

Cemetery in Clarke County (National Center for Preservation Technology and Training and USDA Forest Service, Southeast Region 2002).

GPR has been used with success in adjacent areas of the South Carolina interior coastal plain to map the stratigraphy of Carolina Bays. Carolina Bays, which are natural wetland features of undetermined origin, typically have deep sand deposits on their rims and these areas often contain deeply buried archaeological deposits (Brooks et al. 2002).

GPR has successfully employed at other 18th century sites in the eastern United States. Investigators at the Nathan and Polly Johnson House, New Bedford, Massachusetts had successful results using GPR (Hodge et al. 2002). Their website provides additional background information on GPR and its archaeological applications.

GPR is particularly well suited for the delineation of historic cemeteries, for example, the Bozeman site in Clark County, Arkansas (Kvamme 2002). Historic graves are often easy to recognize in radargrams, as evidenced by a pronounced hyperbola. When 3-D slices intersect these hyperbolas the graves are usually clearly evident in plan view. When a series of graves are closely spaced, however, the grave radar “signature” is less clear-cut. By slicing the radar data at various depths along the hyperbola, the aerial perspective can be refined for optimal viewing and recognition. Since not all graves were dug to the same depth, 3-D slices at different depths can often yield very different views of graves in plan by varying the slice only a few centimeters.

GPR was employed by the present author, using the same Ramac X3M system as used in the Woodbine Mound site study, to study 18th and 19th century archaeological resources at several sites in coastal Georgia. The first study was at the New Ebenezer town site in Effingham County, Georgia, followed by a GPR survey of the colonial-era Horton House site in Glynn County, Georgia (Elliott 2003a; Rita Elliott et al. 2002). The results of the GPR work at New Ebenezer were quite exciting and included the delineation of a large portion of a British redoubt palisade ditch and the discovery of several dozen previously unidentified human graves. More recently, GPR survey was conducted at several other 18th and 19th century sites in coastal Georgia with satisfactory results (Elliott 2003b, in preparation).

Methods Used in the Present Study

The equipment used for this study consisted of a RAMAC/X3M Integrated Radar Control Unit, mounted on a wheeled-cart and linked to a RAMAC monitor (Figure 4). A 500 megahertz (MHz) shielded antenna was used for all of the data gathering. MALÅ GeoScience’s Windows-based acquisition software program Ground Vision (Version 1.3.6) was used to acquire and record the radar data (MALÅ GeoScience USA 2002). The radar information was displayed as a series of radargrams, or radar profiles of each transect. Easy 3D software (Version 1.2.1), which was developed by MALÅ GeoScience, was used in post-processing the radar data and 3-D imaging. This entailed merging the data from the series of radargrams for each block. Once this was accomplished,

horizontal slices of the data were examined by Mr. Elliott for important anomalies and patterns of anomalies, which were likely of cultural relevance. These data were displayed as aerial plan maps of the sample areas at varying depths below ground surface. These horizontal views, or time-slices, display the radar information at a set time depth in nanoseconds. Time-depth can be roughly equated to depth below ground. This equivalency relationship can be calculated using a mathematical formula.



Figure 4. GPR Survey in Progress.

Various adjustments to the GPR equipment were made in the field during the data collection phase. The time window that was selected allowed data gathering to focus on the upper 1.5 meters of soil, which was the zone most likely to yield archaeological deposits. Meta data for the radargrams are provided in the accompanying CD-Rom. Additional filters were used to refine the radar information during post-processing. These include adjustments to the gain. These alterations to the data are reversible, however, and do not affect the original data that was collected. This same combination of GPR equipment and radar imaging software was used previously at the colonial site of New Ebenezer, Horton House, Sunbury and Fort Morris with very satisfactory results (Elliott 2003a, 2003b, in preparation; Rita Elliott et al. 2002).

Results

Topographic mapping of the Woodbine Mound site was accomplished using a Topcon total station and TDS data collector. These data were processed using TDS Survey Link and Surfer software. [Figure 5](#) shows the archaeological site area. On this map the Woodbine Mound appears as a light oval area in the lower center of the map. [Figure 6](#) shows an enlargement of the mound area. Elevation contours shown on both maps are arbitrary.

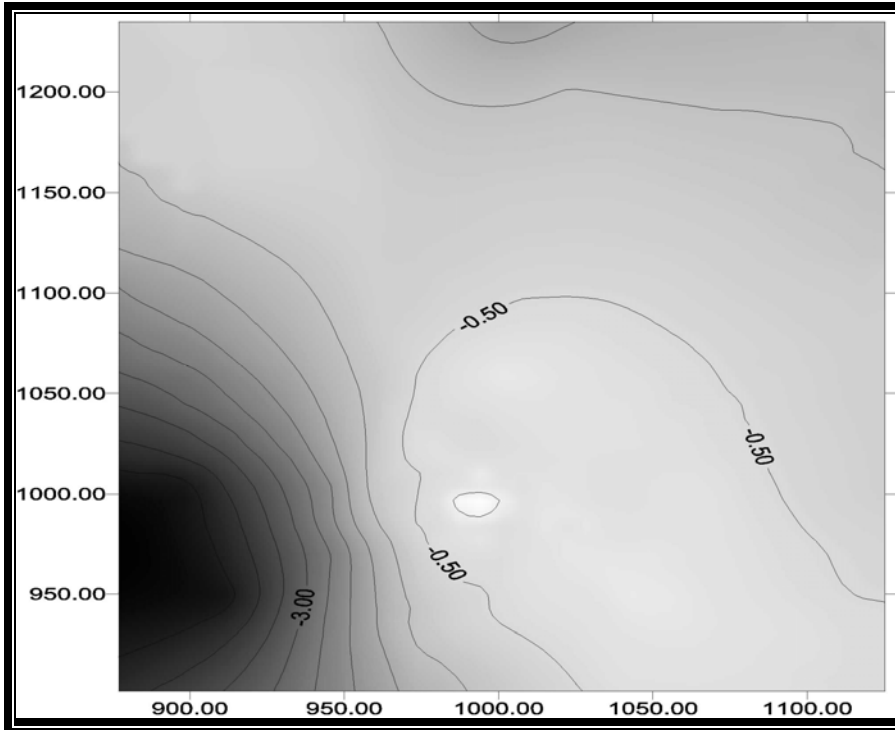


Figure 5. Topographic Map of the Woodbine Mound Site.

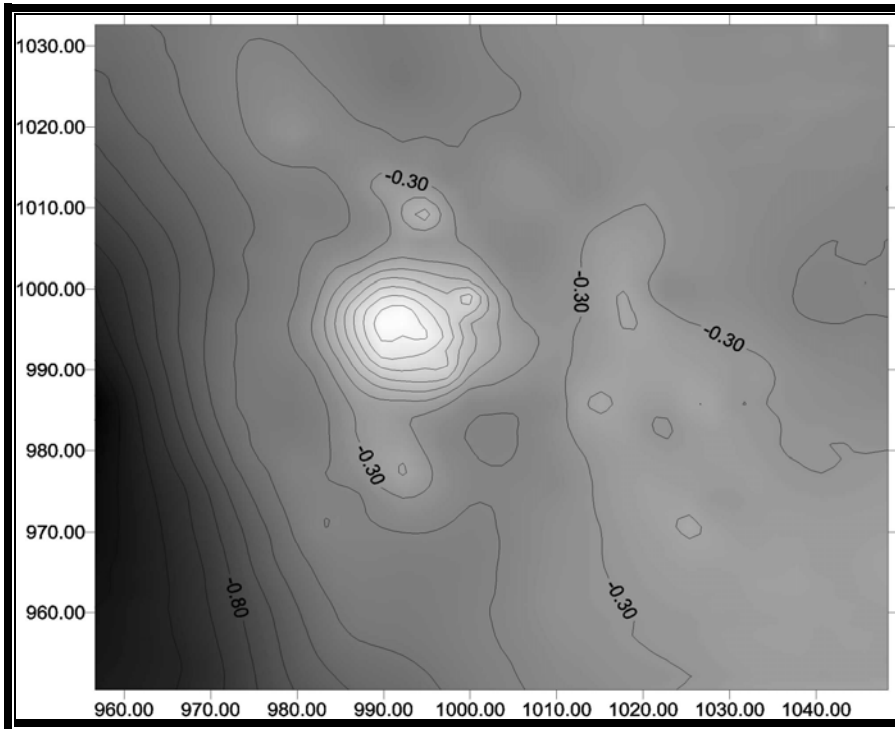


Figure 6. Topographic Detailed Map of the Woodbine Mound.

The ground penetrating radar survey was conducted on January 19, 2004 by Daniel Elliott with post-processing conducted immediately following the field survey. Mr. Elliott was assisted by archaeologists Carolyn Rock, Rita Elliott, Elizabeth Shirk, and two of Ms. Rock’s archaeology students—Marren Porter and Darcy Robins. Tara Fields generously provided some field supplies for the project. Upon arrival at the site, the RAMAC X3M Radar Unit was set up for the operation and calibrated. Several trial runs were made on parts of the site to test machine’s effectiveness in the site’s soils.

The survey examined seven sample areas (designated Blocks A through G) of the Woodbine Mound site, covering an area of approximately 600 m² (Table 1). One additional sample, Block E, was surveyed over some of the same area covered by Blocks A through D, F and G.

Table 1. Summary of Areas Sampled by GPR Survey, Woodbine Mound Site.

Block	Interval (cm)	North	East
A	40	976-986	1000-1010
B	40	986-996	1000-1010
C	40	976-986	1010-1020
D	40	986-996	1010-1020
F	40	976-986	990-1000
G	40	986-996	990-1000

GPR Block A was bounded on the north by Block B, east by Block C, and west by Block F. Block A measured 10 m by 10 m. An archaeological test unit, which revealed a historic human burial was contained within this sample block. This test unit had been backfilled prior to the GPR survey. A strong radar anomaly was evident in the southeastern part of Block A, which corresponded to the archaeological test excavation and known human grave described previously.

GPR Block B was located immediately north of Block A, east of Block G and west of Block D. Block B measured 10 m by 10 m. The east slope of the Woodbine Mound was located in the western part of Block B. Block B contains numerous strong radar anomalies in its central part.

GPR Block C was located immediately east of Block A and south of Block D. Block C measured 10 m by 10 m. When viewed at 50 cm depth, Block C exhibits many strong radar anomalies. These may represent many cultural features.

GPR Blocks D was located north of Block C and east of Block B. Block D measured 10 m by 10 m. An old road trace passes across this sample block on its eastern side. This road is oriented approximately north-northwest to south-southeast. The road is clearly

definable from the GPR image at 50 cm depth. Several other large, strong radar anomalies are present in this block, which may represent cultural features.

GPR Block F was located immediately west of Block A and south of Block G. Block F measured 10 m by 10 m. The extreme southern edge of the Woodbine Mound was located on the northern edge of Block F. Block F contains numerous strong radar anomalies at 50 cm depth, particularly on its western side.

GPR Block G was located immediately north of Block F and west of Block B. Most of the Woodbine Mound was located within Block G. Block G contains several large radar anomalies at 50 cm depth, which are scattered across the block. The mound's structure is not readily apparent from this radar image.

GPR Blocks A, B, C, D, F, and G formed a contiguous polygon, which had a maximum extent of 60 m east-west and 20 m north-south. Odd-numbered transects progressed from east to west and even-numbered transects progressed from west to east. The lines progressed from south to north. The sampling interval used for all of the GPR sample blocks was 40 cm. Figure 7 shows a composite aerial view of the GPR survey at approximately 50 cm below surface.

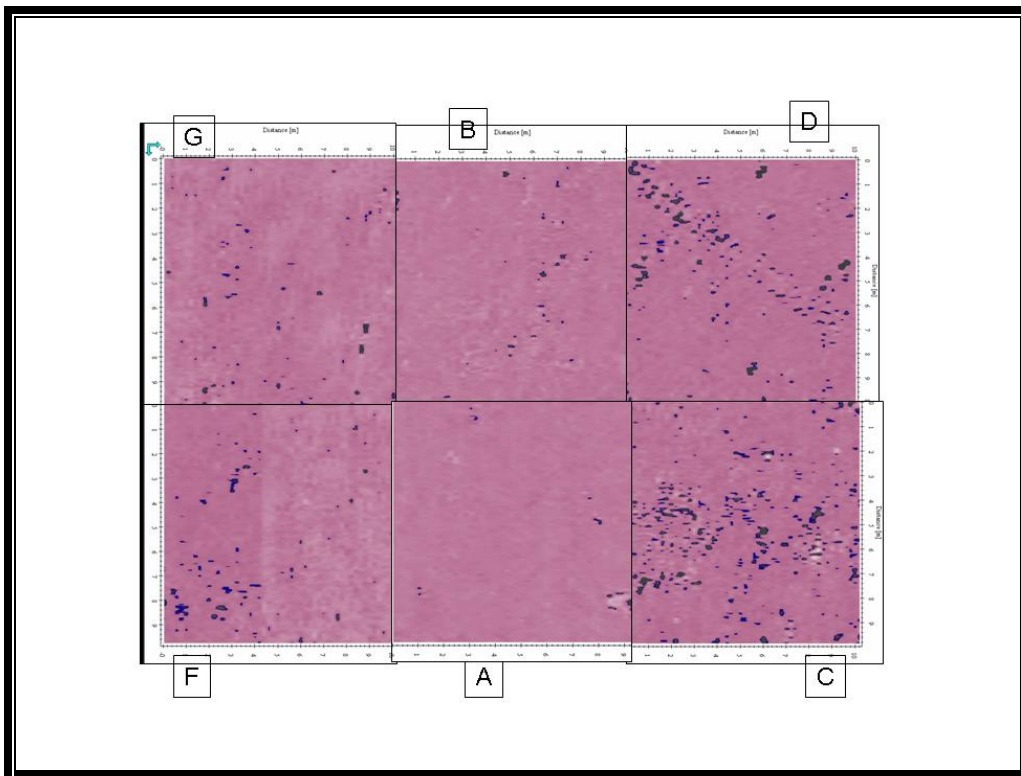


Figure 7. Aerial View of GPR Blocks A, B, C, D, F, and G at 50 cm Below Surface.

Interpretive Summary

Ground Penetrating Radar (GPR) survey of portions of the Woodbine Mound site in Camden County, Georgia was completed in January 2004. The survey examined six sample blocks within a portion of the Woodbine Mound site that extended from grid point 876-996 North, and 990-1020 East, or an area measuring 60 m east-west by 20 m north-south. These sample blocks covered an area of approximately 600 m². The results of this work indicate that this technique has useful application for archaeological sites in the Satilla River watershed. The GPR radargram profiles revealed many anomalies across the site, particularly in the upper 50 cm of soil. Figure 8 shows an annotated version of the composite GPR map at 50 cm below surface with the approximate location of the Woodbine Mound, Rock's test unit excavation and human grave discovery, and an old road trace.

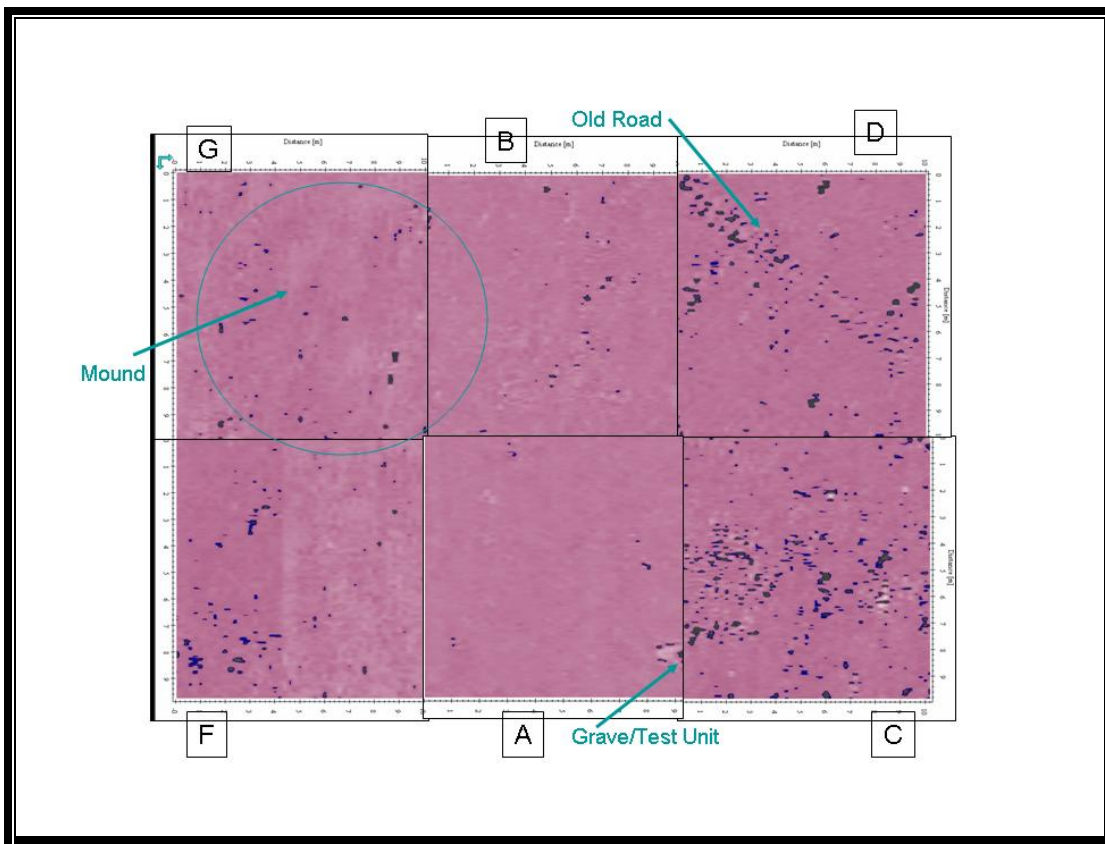


Figure 8. Annotated Aerial View of GPR Blocks A, B, C, D, F, and G at 50 cm Below Surface.

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