Ground Penetrating Radar Survey on Portions of Fort St. Andrews, Cumberland Island, Georgia

LAMAR Institute Publication Series
Report Number 93

The LAMAR Institute, Inc.
2006
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Introduction

Recent archaeological survey by Carolyn Rock, as described in this volume, resulted in the location of the probable remains of Fort St. Andrews on the northwest margin of Cumberland Island, Camden County, Georgia. Although this area was previously officially designated in the 1970s as an archaeological site in the Georgia Archaeological Site File (GASF) as 9Cm113, no formal survey of the site had been undertaken prior to Rock’s recent explorations. Rock’s survey methods followed traditional National Park Service guidelines for archaeological surveys, which included visual reconnaissance of exposed surfaces, artifact scatters, and other potential cultural features, and systematic shovel testing. Rock’s study yielded substantive evidence for the location of Fort St. Andrews.

Remote sensing investigations at the Fort St. Andrews site (9Cm113) in Camden County, Georgia were conducted by the LAMAR Institute, Savannah, Georgia. This work included Ground Penetrating Radar (GPR) survey of a small sample of the suspected fort site. Fieldwork for this project was conducted on August 12, 2006. These results are detailed in this report, which serves as an appendix to Rock’s survey report. The LAMAR Institute’s survey team was led by Daniel T. Elliott. Mr. Elliott was assisted by Rita Folse Elliott and Carolyn Rock. Hopefully, the GPR study will prove helpful as the National Park Service works to protect and interpret what remains of Fort St. Andrews.

Background

Camden County contains many important archaeological vestiges of Colonial Georgia (Rock 2006a). Many of these important historic sites, including Fort St. Andrews, are located on Cumberland Island. Rock’s (2006b) county-wide survey report contains historical background information and
other environmental setting descriptions for the Fort St. Andrews locale.

Fort St. Andrews had a brief but colorful life. It was founded by General James Oglethorpe in 1736 but was the garrison was withdrawn by 1742. Cartographic images of Fort St. Andrews offer few details as to the size and internal organization of the fort. Historical accounts suggest that the fort was constructed relatively quickly and was not occupied for very many years. The fort site is shown on Emanuel Bowen’s 1747 map of Georgia, although the fort was abandoned by the time this map was published. Indeed, Fort St. Andrews appeared as a landmark on Georgia maps well into the Revolutionary War era. Yet, no detailed views of the military fortifications are known to survive. In her Fort St. Andrews survey report, Rock critiqued the most detailed cartographic image of Fort St. Andrews, in which she discounts this version of the fort as merely an unfulfilled plan. Some elements of this plan may have been constructed, so it should not be completely neglected but should be used with certain reservations, as expressed by Rock.

The Fort St. Andrews site may harbour more than just a military occupation. The King’s Surveyor, Wilhelm DeBrahm, briefly described the village of Barrimacké at St. Andrews:

“Near fort St. Andrew on the north-east extremity of Cumberland island grew up the village of Barrimacké, which, about 1740, embraced some twenty-four families. When General Oglethorpe’s regiment was withdrawn from the southern frontier, this town speedily died, and for more than a century all traces of its former existence have been entirely wanting” (DeBrahm 1842).

DeBrahm’s description suggests that Fort Andrews and its immediate surroundings may contain a diversity of archaeological remains from the mid18th century. DeBrahm visited Cumberland Island in the early 1750s and his writing attests that the Fort St. Andrews locale was abandoned by that date.

Some likely features can be predicted for Fort St. Andrews, based on analogs from surviving plans and archaeological study of other Georgia Trustee-era fortifications in Georgia, including Frederica, St. Simons Village, Fort Argyle, and Fort Mt. Pleasant. The fort at St. Andrews probably contained a palisade stockade surrounded by a dry ditch. Projecting angles contained strongly fortified bastions. Buildings within the fort walls would have included dwellings for officers, dwellings for the rank and file soldiers, a kitchen, munitions magazines and storage rooms. The most survivable feature of the fort from an archaeological perspective was probably its ditchwork. The GPR survey team hoped to be able to identify vestiges of this ditchwork.

Rock’s survey data suggests that the area continued to be used into the 19th century after Fort St. Andrews was long gone. The extent and function of this later historic component is poorly defined at present. Rock also identified a thick shell midden at the site, which may be the result of both prehistoric and historic subsistence activity (Rock 2006b).

Rock’s systematic shovel test survey yielded 19 positive shovel tests and surface evidence along the shoreline. Most of the site area is heavily vegetated, which limited the ground
surface visibility. These surface conditions also limited the extent of the GPR survey coverage. No obvious cultural surface features, such as chimneys, military earthworks, cellars, or wells were observed on the bluff. Rock observed a section of displaced early historic brickwork on the shoreline, which had evidently tumbled down from the bluff. Rock also observed remnants of wooden posts or pilings along the shoreline, which may date to the Fort St. Andrews period. Rock’s shovel test information indicates a buried debris zone on the bluff that measures minimally 100 meters by 75 meters. The extent of the site along the shoreline is somewhat longer. This shoreline scatter (and other submerged archaeological deposits) may provide clues to the extent of site loss that has occurred. The GPR survey focused within the site limits defined by Rock’s shovel testing and surface examination (Rock 2006b).

Methods

*Ground Penetrating Radar*

GPR uses high frequency electromagnetic waves to acquire subsurface data. 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, or ns). The approximate depth of an object can be estimated with GPR, by adjusting for electromagnetic propagation conditions.

The GPR sample blocks in this study area were composed of a series of parallel transects, or traverses, which yielded a two-dimensional cross-section or profile of the radar data. These samples are called radargrams. This two-dimensional image is constructed from a sequence of thousands of individual radar 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 as an 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 a laptop computer monitor, mounted on the GPR cart.

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.

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 coastal soils have moderately good properties for its application.

GPR signals cannot penetrate large 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 manhole 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).

GPR has been used to a limited extent on archaeological sites in Georgia yielding mixed results. Thomas and his colleagues employed GPR technology in his study of the Guale Spanish mission on St. Catherines Island, Georgia in the early 1980s (Royce Hayes personal communication May 31, 2006). Recently, the LAMAR Institute team has conducted GPR survey with good results on several of Georgia’s barrier islands, including Jekyll, Ossabaw, Sapelo, St. Catherines and St. Simons islands. In the period since the early GPR work at St. Catherines Island, advances in software imaging have substantially increased the value of this technology in identifying subsurface features.

GPR is particularly well suited for the delineation of historic cemeteries. 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.

Using the same Ramac X3M GPR system as that used in the present study, Elliott has conducted several GPR studies of 18th and 19th century archaeological sites in coastal Georgia. The first study was at the New Ebenezer town site in Effingham County, Georgia (Elliott 2003a). 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 (both within and beyond the known limits of the Jerusalem Lutheran Church cemetery). More recently, GPR survey was conducted by Elliott and his colleagues, at Fort Morris and Sunbury Cemetery (Liberty County), Sansavilla Bluff (Wayne County), Woodbine Plantation cemetery (Camden County), and Garden Homes [Waldburg Street, Savannah] (Chatham County), and the Gould-Bethel Cemetery (Chatham County) and numerous other sites with satisfactory results (Elliott 2003b; 2004; 2006).

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. A 500 megahertz (MHz) shielded antenna was used for the data gathering. A Toshiba Satellite A65 personal computer was used to record the GPR data. MALÅ GeoScience’s *Ground Vision* (Version 1.4.5) software was used to acquire and record the radar data (MALÅ GeoScience USA 2006a). The radar information was displayed as a series of radargrams. *Easy 3D* software (Version 1.3.3), which was developed by MALÅ GeoScience (2006b), 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 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. An estimated soil velocity of 55 (an approximate value for wet sand) was used to generate the GPR maps in this report.

The GPR data from the present study was further processed with more robust imaging software, which was developed by Dean Goodman and called *GPR-Slice* (Version 5.0). Goodman’s *GPR-Slice* program is recognized as the world leader in GPR imaging (Goodman 2006). The output from his software forms the results presented in this report.

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. 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 in coastal Georgia with very satisfactory results (Elliott 2003a, 2003b; Rita Elliott et al. 2002).

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 the machine’s effectiveness in the site’s soils. Machinery settings and other
pertinent logistical attributes included the following:

**Block A**
- Time Window: 75 ns
- Number of Stacks: 4
- Number of Samples: 900
- Sampling Frequency: 11941 MHz
- Antenna: 500 MHz shielded
- Antenna Separation: 0.18 m
- Trigger: 0.02 m
- Radargram orientation: Odd-South; Even-North
- Radargram progress: West to East
- Radargram Spacing: 50 cm
- Number of Radargrams: 15
- Dimensions: 29 m E-W by 7 m N-S
- Grid Coordinates: 997-1004N, 1000-1029E
- Datum Reference: Northwest Corner of Grid is 1004N 1000E

**Block B**
- Time Window: 75 ns
- Number of Stacks: 4
- Number of Samples: 900
- Sampling Frequency: 11941 MHz
- Antenna: 500 MHz shielded
- Antenna Separation: 0.18 m
- Trigger: 0.02 m
- Radargram orientation: Odd-East; Even-West
- Radargram progress: North to South
- Radargram Spacing: 50 cm
- Number of Radargrams: 7
- Dimensions: 40.2 m N-S by 3 m E-W
- Grid Coordinates: 963.8-1004N, 1000-1003E
- Datum Reference: Northwest Corner of Grid is 1004N 1000E

**Block C**
- Time Window: 75 ns
- Number of Stacks: 4
- Number of Samples: 900
- Sampling Frequency: 11941 MHz
- Antenna: 500 MHz shielded
- Antenna Separation: 0.18 m
- Trigger: 0.02 m
- Radargram orientation: Odd-East; Even-West
- Radargram progress: North to South
- Radargram Spacing: 50 cm
- Number of Radargrams: 6
- Dimensions: 7 m E-W by 2.5 m N-S
- Grid Coordinates: 1001.5-1003N, 993-1000E
- Datum Reference: Northwest Corner of Grid is 1003N 993E

**Block D**
- Time Window: 75 ns
- Number of Stacks: 4
- Number of Samples: 900
- Sampling Frequency: 11941 MHz
- Antenna: 500 MHz shielded
- Antenna Separation: 0.18 m
- Trigger: 0.02 m
- Radargram orientation: Odd-South; Even-North
- Radargram progress: West to East
- Radargram Spacing: 50 cm
- Number of Radargrams: 9
- Dimensions: 14 m N-S by 4 m E-W
- Grid Coordinates: 980-994N, 996-1000E
- Datum Reference: Northwest Corner of Grid is 994N 996E

**Block E**
- Time Window: 75 ns
- Number of Stacks: 4
- Number of Samples: 900
- Sampling Frequency: 11941 MHz
- Antenna: 500 MHz shielded
- Antenna Separation: 0.18 m
- Trigger: 0.02 m
- Radargram orientation: Odd-West; Even-West
- Radargram progress: South to North
- Radargram Spacing: 50 cm
- Number of Radargrams: 45
- Dimensions: 22 m N-S by (5 to 12) m E-W
- Grid Coordinates: 980-1002N, 1004-1016E
- Datum Reference: Southeast Corner of Grid is 980N 1004E
- Comments: Block E included resurvey of portions of the site covered by GPR Blocks A and D. The radargrams in Block E were collected from West to East, whereas Blocks A and D were collected bi-directionally.

Grid North for these GPR blocks was approximately 20 degrees West of Magnetic North, or a bearing of 340 degrees. The GPR grids were established by using a hand held compass and a fiberglass metric tape, which reduced the accuracy for the site map somewhat. This factor should be considered by archaeologists returning to the site to investigate any of the GPR anomalies that were identified. Their location is approximate.
Results and Interpretation

Five sample blocks of GPR data from the presumed site of Fort St. Andrews (9Cm113) were collected by the survey team. Their approximate location is shown as an overlay on Rock’s site plan map (Figure 3). The results from each block are discussed separately. A composite GPR site map was created from these data and it is also discussed.

Figure 3. GPR Coverage at Ft. St. Andrews (Shown in Blue).

Block A was placed within the widest open area at the site. It extended from the edge of the bluff to the south. The hiking/jeep trail is located along the central part of this sample block. The topography is highest at the north end of the block and gradually slopes down to the south. The areas immediately east of this block were thickly vegetated but had similar topographic conditions. The area immediately west of this block contained some heavily vegetated areas and one open area, which was covered by GPR Block D. The open areas further south of the block constrict considerably, narrowing to a hiking trail.

Figure 4 shows a plan of Block A viewed at approximately 1 m below ground. GPR anomalies are found mostly on the western side of this sample block and the strongest GPR anomalies occur in the northwestern part. The vertical banding exhibited in Figure 4 is line noise, which sometimes results when data is collected in two directions.

Figure 4. Plan of Block A at 1 m Depth (Grid North is Up).

Block B was a long narrow sample that was located parallel to the bluff and extended from the main datum to a point 40 m east of the datum. The area immediately north of this block contained steep slopes and thick vegetation. The area immediately south of this block was more gradually slope but was also heavily vegetated. The
topography immediately east of the grid block drops suddenly so the sample was terminated at this point. The area immediately west of Block B contained a smaller sample block (Block C). An area of overlap between Blocks A and B exists as both sample blocks have common northwest corners. A walking/jeep trail was located along its course. The topography dips between the two ends of this block. Figure 5 shows a plan of Block B viewed at approximately 1 m below ground.

Strong, deeply buried GPR anomalies were concentrated on the two ends of Block B, corresponding to the topographic highs. These anomalies were more concentrated on the west end of the block. A few small scattered radar anomalies occur along the length of the sample block.

These radar signatures are probably below that created by the roots of the modern forest cover. They may represent older tree stump holes, or cultural features. It should be noted that, although Rock’s shovel test survey was mostly negative within the area covered by this GPR sample block, she found three positive shovel tests just off of the slope crest, immediately north of this area (See Figure 1).
Block C was a small sample block located on the bluff crest, immediately west of Block A. Despite its small size, the survey data revealed a cluster of strong GPR anomalies within it. These are shown in plan view at a depth of about 1 m in Figure 6.

Figure 6. Plan of Block C at 1 m Depth (Grid North is Up).

Block D covered a large rectangular area and was located immediately west of Block A. The topography in this area was gently sloping to the south. Numerous, strong GPR anomalies were observed across this block. These appeared to trend northwest-southeast. Several large nodes were observed along this concentration. A plan of Block D viewed at about 1 m depth is shown in Figure 7.

In Block E the radar data was collected differently than the other four blocks. All of the lines were traversed from east to west. Figure 8 shows a series of plan maps of Block E at increasing depth.

Figure 7. Plan of Block D at 1 m Depth (Grid North is Up).

Figure 8. Series of plan maps of Block E at increasing depth.
A composite plan of GPR Blocks A, B, C and D viewed at approximately 1 m below ground is shown in Figure 9. The pattern of radar anomalies on this map is intriguing and may serve to indicate where the vestiges of Fort St. Andrews are located, namely Blocks C and D, the western half of Block A, and the extreme western end of Block B.

When the data from Block E is added to the data from Blocks A-D, the clustering of radar anomalies is more apparent. This view is shown in Figure 10.
The composite view Blocks A-E attests to a pronounced clustering of GPR anomalies within an area that extends the entire length of the survey area on the north-south axis and is concentrated on the east-west axis from 992-1006E.

Figure 11 shows the area of radar anomaly clustering as a red overlay on Rock’s survey plan map. This concentration is within the approximate center of the site, as defined by shovel test information. While only ground truthing test excavations may be able to determine if the observed radar patterning represents the remains of Fort St. Andrews (or some other cultural occupation period), the independently collected shovel test data lends credence to a cultural interpretation rather than a biotic or geologic interpretation.
Summary

Ground Penetrating Radar (GPR) was employed by the LAMAR Institute team to corroborate Rock’s survey findings at Fort St. Andrews (9Cm113) and to search for subsurface indications of fortification ditches or other buried evidence relating to this important archaeological site. The GPR survey was presented by the LAMAR Institute as an appendix to Carolyn Rock’s study (Rock 2006c).

GPR survey of Fort St. Andrews yielded very promising results. While only a small portion of the site was accessible to the GPR equipment, the survey managed to sample a variety of areas. Areas with few anomalies were observed over large portions of Blocks A and B. Clusters of strong radar anomalies were most concentrated along the western part of the sampled area. They were very pronounced in Blocks C, D, and E. The strongest clusters were located in the heart of the archaeological site, as defined by the shovel test survey.

These radar signatures may indicate a concentration of cultural features and deeply buried artifacts. Many of these radar anomalies may pertain to the historic component at Fort St. Andrews. Some may relate to other occupations on the bluff, including a prehistoric occupation. Some of the signals may be reflections from deeply buried tree stump holes. These radar signals were quite strongly reflected at a depth of approximately 1 m below ground. This depth is below most of the modern-day root disturbance.

This study presents a preliminary and tantalizing glimpse into this important historical site. Our interpretation of the GPR data is that many of the radar signals represent deeply buried cultural features. The exact nature of these features remains to be determined. No obvious fort outline was observed, although some of the anomalies appear to have a linear trend that may be indicative of the fortifications. These anomalies should be investigated by test excavation and/or corroborated by other remote sensing techniques to confirm or deny this interpretation.
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