Ground Penetrating Radar
Reconnaissance on
St. Catherines Island, Georgia

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Ground Penetrating Radar Reconnaissance on St. Catherines Island, Georgia

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By Daniel T. Elliott

The LAMAR Institute, Inc.
Savannah, Georgia

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I. Introduction

The LAMAR Institute provided a brief archaeological investigation on St. Catherines Island, Liberty County, Georgia on May 31, 2006. This work included Ground Penetrating Radar survey of a small portion of the Button Gwinnett plantation site and very limited samples at three other archaeological sites on the island (Figure 1). These results are detailed in this report. The LAMAR Institute’s survey team consisted of Daniel T. Elliott with additional support provided by Royce Hayes and Ian Dutton, both of the St. Catherines Island staff.

Remote sensing technology has been a component of archaeological exploration on St. Catherines Island since the early 1980s (Garrison et al. 1985). Ground Penetrating Radar was included in a battery of techniques in David Hurst Thomas’ landmark study of the Santa Catalina de Guale Mission site. The results of that initial GPR study were not very encouraging. GPR technology has significantly improved since the 1980s, both in terms of hardware and software, and the present study was an attempt to revisit the island and demonstrate these improvements.
Figure 1. St. Catherines Island and GPR Locations.
II. Research Methods

The GPR device 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 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 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.

Ground penetrating radar 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 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.

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 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). The Ebenezer work was followed by a GPR survey of the colonial-era Horton House site (and DuBignon Cemetery) in Glynn County, Georgia (Rita Elliott et al. 2002). 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 [east Savannah] (Chatham County), and the Gould-Bethel Cemetery (Chatham County) with satisfactory results (Elliott 2003b; Elliott 2004; Elliott 2006b).

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. 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).

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 machine’s effectiveness in the site’s soils. Machinery settings included the following:

**Block B—Persimmon Point**
Dimensions: 20 m North-South by 16 m East-West
Time Window: 75 ns
Number of Stacks: 4
Number of Samples: 712
Sampling Frequency: 9605 MHz
Antenna: 500 MHz shielded
Radargram orientation: Odd--North; Even--South
Radargram progress: West-East
Radargram Spacing: 50 cm
Datum: GPR Block’s SW corner is located 45 m West and 15 m South of Concrete Datum Marker
Note: The same machine settings were used for the three other areas visited by GPR reconnaissance.
III. Results and Interpretation

Dining Hall Survey

A point of land, located south of Button Gwinnett’s plantation and Cabin “Persimmon 4”, was the subject of the initial GPR sampling (Figure 2). This site was being considered as a potential location for a proposed dining hall. After being escorted to the spot by Royce Hayes, Mr. Elliott established a small grid (20 m x 16 m) and prepared the equipment to sample a portion of the landform. Small amounts of oyster shell were visible on the ground surface but the area was mostly vegetated in grass with scattered trees. This may be part of an archaeological site originally recorded as 9Li16, identified as Persimmon Point, by Joseph Caldwell and Lewis Larson in 1952, although the location data were insufficient for accurate mapping and, consequently, the Georgia Archaeological Site File has no geographic location for the Persimmon Point site.

Figure 2. Map of GPR Block Outlined in Red (Sanger 2006).

Figures 3-5 show aerial views of the GPR Block at increasing depths below ground. These are expressed as time slices in nanoseconds. Figures 6-8 shows these same GPR aerial views superimposed on the archaeological survey map of the area.
Figure 3. Aerial View at 4-8 ns Time Depth.
Figure 4. Aerial View at 19-23 ns Time Depth.
Figure 5. Aerial View at 32-36 ns Time Depth.
Figure 6. GPR Overlay 1 on Survey Map.

Figure 7. GPR Overlay 2 on Survey Map.
Freedman Cemetery Recon

Next, Royce Hayes escorted Mr. Elliott with his GPR equipment to a suspected Freedman cemetery on the Button Gwinnett plantation. This potential site is not marked by any tombstones or other above-ground edifices. Nor were any grave depressions observed at the time of the reconnaissance. Oral tradition, however, holds this as the location of a large cemetery used by freedmen. The study area lies within visual sight of the existing Button Gwinnett plantation house. A series of exploratory GPR transects were made over this area. These were not located with reference to any geographic data but were more reconnaissance in nature. The question was, would GPR locate otherwise unknown historic graves in this vicinity? All of the radagrams in this location indicated many strong subsurface anomalies that are characteristic of human graves. One example is shown below in Figure 9. Despite the haste and lack of geographic reference in which this radagram was collected, it demonstrates excellent potential for GPR mapping of subsurface features. Numerous large point radar reflections are prominent in this radagram. These likely represent cultural features and quite possibly human burials. Many graves are probably located at this portion of the island and a systematic GPR survey of the area would be a useful method for mapping them.

Figure 8. GPR Overlay 3 on Survey Map.
Long Field Shell Ring (9Li231) Recon

Royce Hayes next escorted Mr. Elliott with his GPR equipment to an Archaic period shell ring site, then known as Long Field and now known as the St. Catherines Shell Ring (Figure 10). Surface evidence of this shell ring varies across the site. In the wooded portion it is visible as a low semi-circular ring and in the pasture/plowed portion the topography of the ring is nearly imperceptible but oyster shells are widely scattered in the ring vicinity. Two long GPR transects were made across the Long Field Shell Ring by Elliott and Hayes. No formal grid was attempted.

This shell ring was first recorded by AMNH archaeologists as 9Li231 in 1987 and the Georgia site form for 9Li231 describes the site: “just north of the Long Field boundary ditch and the ditch has probably disturbed the southern portion of the site…This is a large site mainly consisting of a large crescent shaped shell midden(s) approx. 60 m in diameter. A classic St. Simons period site. Three test pits were excavated and pottery, bones, crab clays, clay nodules, and lithics were recovered” (Peter 1987).

This Archaic shell ring later became the focus of extensive archaeological study by the AMNH. More complete GPR survey, as well as other remote sensing techniques, were conducted on the site by their study team. A large block excavation, which was strategically placed on the basis of the remote sensing results, verified many of the strong GPR reflections evidenced by their survey. Publication of their results is forthcoming from the AMNH (Sanger 2007). Sanger summarized of the AMNH work on the site:

The American Museum of Natural History (AMNH) has been lucky enough to work on St. Catherines Island, Georgia for the last 30+ years. Since 2006, the museum has focused its attention on the Late Archaic Period (3000-1000 B.C.) on the island—specifically, we have been working on the St. Catherines Island Shell Ring. Shell rings are large, some say monumental, sites that occur only in the Late Archaic Period. Because of both their size, and the apparent planned nature of the sites, the function of shell rings has been a very contested issue. Likewise, to
many archaeologists, the complexity found in shell rings brings up questions of sedentism, power, control over labor, and hierarchy to a period of time that just twenty years ago was considered populated by roving bands of egalitarian hunter-gatherers.

AMNH has carried out a variety of field methods on the shell ring including detailed topographical mapping, remote sensing surveys (including magnetometry, ground penetrating radar, and resistivity), and small-scale excavations. During May 2007, the museum decided to conduct a large block excavation within the interior of the ring. Historically, the interiors of shell rings have often been ignored, or only lightly tested, as most archaeologists focused on the areas of high shell deposit, which make up the ring itself. Based on earlier remote sensing results, along with the findings from a trench excavation, the museum decided that the interior of the ring held information that was key to understanding the function and usage of the ring. To uncover this information, the museum decided to open up a relatively large block excavation (roughly 24 square meters). The plan paid off and the field crew was excited to uncover over 20 large features in the center of the ring.

These features are all very similar in shape, color, and contents. All of them are circular, have straight walls, and flat bottoms. Their dark color appears to be caused less by burning (very little charcoal was recovered) and more by organic deposits. Not only was very little charcoal found in the features, but little cultural material of any type was found. However, several of the features did have a small amount of bone and fiber-tempered pottery, but over-all most were nearly devoid of artifacts. A single feature had a significant amount of shell in it while all the rest were empty of shell save for a single piece on occasion. The main attribute that distinguished the features was how deep they went. Some of the features were shallow—only 20-30 cm—while others went very deep; several went over a meter deep. The museum has 15 C14 dates from the features and is currently analyzing the artifacts found within them. Numerous flotation samples were gathered from each feature and they will also be analyzed as soon as possible (Sanger 2007).
Figure 11 shows the first GPR radargram executed across the shell ring. This radargram began at a temporary datum point and extended on a bearing of 288 degrees ending at a large dead tree. This radargram began on the exterior of the shell ring, crossed over the intact portion of the shell ring, traversed the interior of the ring, crossed the less-well preserved portion of the shell ring, and ended on the exterior of the ring. The interior portion of the ring, which includes the section from about 40-60 m on this radargram, contains numerous strong, large point radar reflections. These were suspected to be buried aboriginal features. The other cross-section of the shell ring produced similar results.
Mission Santa Catalina de Guale Recon

Finally, the GPR equipment was used to examine a portion of the Mission Santa Catalina de Guale site. The discovery and extensive excavations by the AMNH archaeologists at the site of Mission Santa Catalina de Guale (9Li274) are well documented by David H. Thomas and his colleagues. Mr. Hayes led the GPR device to an area that was not previously excavated. Many strong GPR reflections were displayed in this area. No formal grid was attempted and no datum was established for the GPR reconnaissance there. Despite the haste and lack of geographic reference in which this radargram was collected, it demonstrates excellent potential for GPR mapping of subsurface features. Numerous large point radar reflections are prominent in this radargram. These likely represent cultural features. These data indicate that many more archaeological secrets lie buried on this site.
Figure 12. Sample GPR Radargram at Mission Santa Catalina de Guale Site 9Li274.
IV. Summary

In the more than two decades that have passed since Ground Penetrating Radar (GPR) was first used to study the archaeological remains on St. Catherines Island, the hardware, software, and interpretation of GPR data have vastly improved. The results from the early work were less than impressive. The LAMAR Institute’s GPR demonstration on St. Catherines Island ushers in a new era for remote sensing research on St. Catherines Island. Modern GPR survey tools and methods offer a better prognosis, as suggested by the present study. The soils on St. Catherines Island appear to be very well suited for GPR survey. We recommend continued use of this technology to identify and manage archaeological resources on the island.
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