GPR Survey in Frederica Commons, St. Simons Island, Georgia

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I. Introduction

This report presents the findings of a Ground Penetrating Radar (GPR) survey by the LAMAR Institute on a previously unexplored portion of the Frederica site on St. Simons Island, Glynn County, Georgia (Figures 1-3). Frederica was constructed in 1736 as a British colonial fortified town. The site is located on a bluff fronting a bend in the Frederica River on the western (protected) side of the barrier island. The area was the scene of extensive archaeological excavations since the 1940s (most of which remains unreported or underreported). The present study was a GPR survey of a portion of Frederica’s Town Commons, which had not been the subject of any excavation project. The study area is situated between the town gate and west of the cemetery.

Figure 1. Frederica, Georgia (Google Earth 2010).
The LAMAR Institute’s GPR survey of a portion of the Frederica Commons was conducted as part of the 2010 Archaeology Festival hosted by the Fort Frederica National Monument (National Park Service) and the Fort Frederica Association, with financial assistance by a public outreach grant from the Southeastern Archaeological Conference (SEAC). The project was entitled, “Digging History” at Fort Frederica: Community Archaeology Festival. The GPR survey, public demonstrations and subsequent analysis and reporting was supported by a small stipend and donations by the author. This scientific data collection had a strong public component, in which visitors were given two formal lecture-demonstrations about GPR and its applications in archaeology. This project was an important part of the 2010 Georgia Archaeology Month program, which is an annual statewide program in May featuring archaeology activities statewide. These activities, such as the present study, are designed to educate the public. The Frederica Commons GPR study also accomplishes important scientific goals by mapping buried resources in a previously unknown part of town.

Figure 2. Recent Aerial View of Frederica, Georgia with GPR Overlay Map in Commons Area (Google Earth 2010).
GPR technology is not new to the Frederica National Monument. Previous studies were conducted on portions of the town site by Georgia Department of Transportation archaeologists Shawn Patch and Jim Pomfret. In 2006, the National Park Service hosted a remote sensing workshop at Fort Frederica, in which a suite of remote sensing technologies were applied to a 20 meter by 20 meter section of the town site (DeVore 2006). The results of that GPR effort are briefly described by Goodman (2006).
II. Research Methods

Ground Penetrating Radar, or GPR, is an important remote sensing tool used by archaeologists. The technology uses high frequency electromagnetic waves (microwaves) 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 block in this study area was composed of a series of parallel radargrams (transects or traverses). Each radargram yielded two-dimensional cross-section or profile of the radar data. 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 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, or ns), 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 cast iron 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.
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.

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. 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). 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 [Walburg Street, Savannah] (Chatham County), the Gould-Bethel Cemetery (Chatham County), Bullhead Bluff Cemetery (Camden County), Fort Saint Andrews (Camden County) and numerous other sites with satisfactory results. The same equipment has been used successfully for GPR surveys on seven of Georgia’s barrier islands, including Cumberland, Jekyll, Ossabaw, Sapelo, St. Catherines, St. Simons, and Tybee islands (Elliott (Elliott 2003a-c, 2004, 2005, 2006a-d, 2007,2008a-b, 2009a-b; Elliott and Burns 2007).

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 XV11 Monitor (Firmware, Version 3.2.36). 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. Output from the survey was first viewed using GroundVision. This provided immediate feedback about the suitability of GPR survey in the area and the effective operation of the equipment.

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 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:

**Machine Settlings**
Time Window: 85 ns
Number of Stacks: 4
Number of Samples: 632
Sampling Frequency: 7,462 MHz
Antenna: 500 MHz shielded
Antenna Separation: 0.18 m
Trigger: 0.02 m
Radargram orientation: South to North
Radargram progress: East to West
Radargram Spacing: 50 cm
Total Radargrams: 88
Dimensions: 30.5 m E-W by 20 m N-S

GPR Block A consisted of 1,185 m of radar collection, which were collected along 87 radargrams. The grid arrangement of these radargrams is shown in Figure 4. The block examined an area measuring 30.5 meters east-west by 20 meters north-south, or 610 m². The site grid coordinates for the southwestern corner, expressed in UTM Zone 17 (NAD27) was E462911, N3454238. The approximate location of the northwestern corner was at E462908, N3454254. The GPR grid was oriented perpendicular to the cement sidewalk and its southern baseline was situated approximately 1 m north of the sidewalk. Gaps in the grid were created by large trees and other unsurveyed obstacles.

Figure 4. GPR Grid, Fort Frederica Commons.

GPR data was collected in the field and returned to the Elliott’s laboratory for post-processing. The GPR data from the present study was processed with GPR-Slice (Version 7.0). Goodman’s GPR-Slice program is recognized as the world leader in GPR imaging (Goodman 2006, 2010). Mapping in 3D 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 (ns). Time-depth can be roughly equated to depth below ground. This equivalency relationship can be calculated using a mathematical formula.
III. Results and Interpretation

Results

The LAMAR Institute’s GPR survey of a portion of the Frederica Commons was conducted as part of the 2010 Archaeology Festival hosted by the Fort Frederica National Monument and the Fort Frederica Association, with financial assistance from the Southeastern Archaeological Conference. Except for a stipend provided by the sponsors, the GPR survey and subsequent analysis and reporting was donated by the author.

The sample block yielded excellent radar data for the upper 1.5 meter soil zone. Figure 5 through 8 show a series of aerial views of the GPR block with increasing depth (expressed as ns, or nanoseconds time depth). Figure 5 shows the GPR block at 5 ns time depth. Strong radar reflections are well distributed in this view. Many of these reflections may represent tree stumps or large tree root reflections.

Figure 6 shows the GPR block at 13 ns time depth. A series of linear, strong radar reflections are manifest in the north-central portion of this view. This image is one of the most telling of any generated by the survey. These may represent foot, animal or wagon paths. These paths appear to converge near the center of the GPR study sample. Informal pathways are composed of compacted soils, which often generate GPR reflections because of their differences compared to the degree of compaction in the surrounding soil matrix. Paths also may collection rainwater and other seepage in a manner distinct from the surrounding matrix and this can also generate strong GPR reflections.

Figure 7 shows the GPR block at 20 ns time depth. The cluster of linear radar anomalies seen in the previous view is no longer apparent. If these reflections signify trails or pathways, then this view lies beneath that impact. The northeastern portion of the GPR block contains several large anomalies. Other strong radar anomalies, oriented east-west, appear in the lower margin of the block. These are likely reflections created by the military road that is located in this area.

Figure 8 shows the GPR block at 27 ns time depth. Strong radar reflections are most concentrated in the northern portion of the block.

Figure 9 shows the GPR block at 35 ns time depth. Strong radar reflections are most concentrated in the northern portion of the block.

Figure 10 shows the GPR block at 42 ns time depth. Strong radar reflections are widespread in this view and are most concentrated in the northern and western portions of the block.

Figure 11 shows the GPR block at 49 ns time depth. Strong radar reflections are most concentrated in the northern portion of the block. The frequency of reflections is diminished from the previous view.
Figure 12 shows the GPR block at 57 ns time depth. Strong radar reflections are most concentrated in the northern portion of the block. The frequency of reflections is similar to the previous view.

Figure 13 shows the GPR block at 64 ns time depth. Strong radar reflections are most concentrated in the northern portion of the block. The frequency of reflections is diminished from the previous view.

Figure 14 shows the GPR block at 71 ns time depth. Strong radar reflections are most concentrated in the northeastern portion of the block. The frequency of reflections is similar to the previous view. At this depth, the GPR information is beginning to be less reliable as an archaeological indicator. Numerous “ghost-like” signals, seen as light blue, dot the map. These are not likely of cultural origin.

Figure 5. Aerial View at 5 ns.
Figure 6. Aerial View at 13 ns.

Figure 7. Aerial View at 20 ns.
Figure 8. Aerial View at 27 ns.

Figure 9. Aerial View at 35 ns.
Figure 10. Aerial View at 42 ns.

Figure 11. Aerial View at 49 ns.
Figure 12. Aerial View at 57 ns.

Figure 13. Aerial View at 64 ns.
Figure 14. Aerial View at 71 ns.
Interpretations

The LAMAR Institute’s GPR Survey at the Frederica Commons examined a 30.5 meter east-west by 20 m north-south rectangular area. The present study was a GPR survey of a portion of Frederica’s Town Commons, which had not been the subject of any excavation project. The study area is situated between the town gate and west of the cemetery. The GPR sample is located immediately north of the Visitor’s Center complex.

A strong cluster of anomalies dominate the northeastern quadrant of the sample. A secondary strong cluster of anomalies along the west-central portion of the sample was noted. The strong anomalies in the lower left (southwestern) edge of the block are likely associated with the military road that connected Frederica with Fort St. Simons (St. Simons Village). No obvious alignment of anomalies that would potentially indicate a historic cemetery is indicated by these data, although individual graves may exist within the survey block and these could easily be masked by the plethora of other non-aligned anomalies.

Overlay Analysis is a useful method for viewing and analyzing GPR time slice data. GPR-Slice software offers a convenient routine for overlay analysis. Figure 15 shows one composite (overlay) view of the GPR block at 33 ns time depth. This view combines the radar information for the zone beginning well beneath the topsoil, which is greatly affected by modern biota, and ending about 1 m below ground. The strong radar reflections (shown in shade of blue) represent a variety of natural and cultural features.

Figure 16 shows the areas of primary and secondary interest within the GPR sample block. Future researchers may wish to revisit these areas with other prospection techniques or with excavation samples. Until excavations are undertaken in the sample area, the full identification of these radar anomalies must remain speculative.

The Frederica Commons area yielded excellent radar reflections. These data were compared with GPR output from other areas of the town, which was collected by the Georgia Department of Transportation and during the National Park Service Workshop in 2006 (Patch 2005; Goodman 2010). In the 2006 workshop a 20 m by 20 m area within the domestic area of town was sampled using three different brands of GPR equipment and varying antenna types. When these data were processed with GPR-Slice software, however, the results were remarkably consistent. All three samples indicate two main areas of strong radar reflection, which likely represent buildings or massive cultural features. Numerous smaller features, which may represent wells, pits or tree stumps, also may be represented in these images. The GSSI equipment, which is the equipment used in the 2005 survey at Frederica by the Georgia Department of Transportation team, is fairly similar to the MALÅ GeoScience setup, as illustrated in Figure 17 (Patch 2005). In the present survey of the Frederica Commons, however, a 500 MHz antenna was used rather than a 250 MHz antenna. The Frederica Commons GPR results do not indicate any clear-cut building features.
Figure 15. Overlay View at 33 ns.

Figure 16. Primary and Secondary Areas of Interest Identified in Green and Red, Respectively.
Public Outreach Efforts

The GPR research just presented was conducted during a vibrant public outreach session at the Fort Frederica National Monument. The curious visitors were invited to watch and participate in the actual data collection process. Several scheduled 10 minute talks further explained the GPR process in archaeology and participants were encouraged to ask questions. GPR is an exciting new approach in archaeology and it generates great interest among the public. Figures 17 and 18 show views of the public outreach component of the project in progress.
Figure 18. Visitors Learn about GPR and Archaeology.

Figure 19. Visitors Enjoy a Practice Run on the GPR at Frederica.
V. Summary

The LAMAR Institute’s GPR Survey at the Frederica Commons collected 1.185 kilometers of radargram data within a 30.5 meter east-west by 20 m north-south rectangular area. This sample represents complete coverage of approximately 610 m² of the colonial town site. This represents a small sample of the entire site. Nevertheless, this sample yielded intriguing results. Strong radar reflections, which are likely related to cultural activities, are evident in spatial distribution maps. This particular portion of the Fort Frederica National Monument property has not experienced any prior archaeological study.

A full understanding of the meaning of these reflections within the sampled area will require additional “ground truthing” excavations. The radar equipment and software used in this study produced very useful information and additional GPR survey of this unexplored portion of Frederica is recommended. The public outreach component of the project was also successful. Many visitors to the Fort Frederica National Monument left the site with a greater understanding of the many facets of archaeological research, including Ground Penetrating Radar.
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