Ground Penetrating Radar Survey on a Portion of Fort Jackson, Chatham County, Georgia

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Introduction

In March 2007, Mr. Daniel Elliott of the LAMAR Institute performed a Ground Penetrating Radar (GPR) survey on a small portion of the Fort Jackson historic site in Chatham County, Georgia for the Coastal Heritage Society (CHS). This demonstration project was in response to an emergency outdoor plumbing repair in an area located just south of the main entrance to the fort. An open utility repair excavation, which was dug by John Robertson, CHS staff, was located immediately west of the GPR survey block. This excavation is visible on the left side of Figure 1. This excavation had been dug to repair a leaking water line. Mr. Robertson graciously assisted Mr. Elliott in the GPR field survey.

Figure 1. Fort Jackson with Approximate Location of GPR Survey Block A Shaded in Yellow.

Background

The U.S. Department of Interior, National Park Service declared Fort Jackson a National Historic Landmark in 2000. Their statement of significance reads,

Fort James Jackson was built by the United States Government between 1808 and 1812 to defend the harbor and city of Savannah, Georgia. It is nationally significant as one of only five surviving Second System Seacoast Fortifications.
Most of the Second System forts were so radically redesigned by later defensive construction that little remains of their original works. Fort Jackson has nearly all of its Second System masonry, original design, and function intact. Furthermore, Fort Jackson is the only surviving example of a masonry gun battery of that coastal defense system. Fort Jackson was manned by the Confederate Army during the Civil War, and following the fall of nearby Fort Pulaski, it successfully repelled a Union assault on October 1, 1862. The fort is preserved and interpreted through the efforts of the Coastal Heritage Society, based in Savannah (NPS, National Historic Landmark Program 2007).

In spite of its National Landmark status, very little is known of the archaeological resources at Fort Jackson. Only one published article, written by archaeologist William Kelso, has been written about archaeological explorations in the fort. Additional archaeological excavations were undertaken there in the 1960s and 1970s, but the results of those efforts are entirely unpublished (Kelso 1968; Talley Kirkland, personal communication June 15, 2006).

The Fort Jackson historic site is owned by the State of Georgia and the property is presently managed by the Coastal Heritage Society, who operate the fort as a living history park.

GPR survey was conducted in the Fort Jackson parade ground several years ago by a Charleston, South Carolina firm, but the results of their study was not examined for the present work and their results remain unpublished (Martin Liebschner, Jr. personal communication March 15, 2007).

**Methods**

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 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 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 [Waldsburg Street, Savannah] (Chatham County), and the Gould-Bethel Cemetery (Chatham County) and numerous other sites with satisfactory results (Elliott 2003b; 2004; 2006).

The area selected for GPR survey measured approximately 19 m East-West by 6 m North-South (Figures 2 and 4). It formed a rectangle that was oriented perpendicular to the exterior moat of Fort Jackson, or nearly perpendicular to the asphalt walkway that leads to the fort entrance. An open utility repair trench was located just north of Block A (Figure 3). The approximate location of this sample block was determined using a Garmin V GPS handheld unit. The approximate bearing of the long axis of this block was 75 degrees and the approximate southeast corner of the block was at UTM Zone 17S Easting 496535, Northing 3549300 (North American Datum 1927).

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 and 800 megahertz (MHz) shielded antenna were 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.

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 graphical output from the use of 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 3 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—500 MHz Antenna**
- Time Window: 79 ns
- Number of Stacks: 4
- Number of Samples: 616
- Sampling Frequency: 7751 MHz
- Antenna: 500 MHz shielded
- Antenna Separation: 0.18 m
- Trigger: 0.02 m
- Radargram orientation: West to East (75 degrees)
- Radargram progress: South to North
- Radargram Spacing: 50 cm
- Number of Radargrams: 14
- Dimensions: 19 m E-W by 6 m N-S
- Datum Reference: Southeast Corner of Grid is 0N OE, UTM Z17S E496535 N3549300 (NAD27)

**Block A—800 MHz Antenna**
- Time Window: 79 ns
- Number of Stacks: 4
- Number of Samples: 616
- Sampling Frequency: 7751 MHz
- Antenna: 800 MHz shielded
- Antenna Separation: 0.18 m
- Trigger: 0.02 m
- Radargram orientation: West to East (75 degrees)
- Radargram progress: South to North

- Radargram Spacing: 50 cm
- Number of Radargrams: 14
- Dimensions: 19 m E-W by 6 m N-S
- Datum Reference: Southeast Corner of Grid is 0N OE, UTM Z17S E496535 N3549300 (NAD27)
Figure 2. Radargram Plan for Block A, 500 MHz Survey (Grid North is to the Left).
Figure 3. Fort Jackson, Soil Profile in Emergency Repair Trench, North of GPR Block A.

Figure 4. Aerial View of Fort Jackson Main Entrance with Approximate Location of GPR Block A Shown as Multi-colored Overlay (Courtesy Google Earth 2009).
Results

The LAMAR Institute’s GPR survey at Fort Jackson covered a small plot of ground, measuring 19 meters East-West by 6 meters North-South, located outside of the main entrance to Fort Jackson. This area was selected because of a utility emergency that required some ground disturbance for repairs to a leaking water line. That problem area was located immediately north of the GPR sampled area.

The Fort Jackson site has experienced many changes since it was first established for use as a military fortification in the late 18th century. Several of the CHS staff (and former staff), John Robertson and Martin Liebschner, Jr. are particularly knowledgeable about the relatively recent land use history at Fort Jackson (at least since the 1970s). Their combined knowledge included an awareness of the location of key utilities and underground drainage systems. No comprehensive map of these underground utility systems was identified.

Figure 5 shows a plan of Block A at approximately 30 cm depth, using the 500 MHz antenna and generated with Easy 3D. The large dark-colored linear anomaly located in the central portion of this plan view is a modern utility ditch. This relatively recent soil disturbance affects the GPR information at greater depths, as visible in the ensuing plan maps (Figures 6-8, 10-11).

Figure 9 shows a Front View of Block A, Using the 500 MHz antenna. This North-South profile shows numerous strong radar reflections. The modern utility ditch creates a strong reflection from 9 to 14 m along this route and extending slightly more than one meter below ground. Several distinctive reflections created by utility pipes or cables are evident within this ditch. This view may also contain other unrelated reflections, although the modern utility masks most of the subsurface in this view.

Figure 12 shows a series of three plan views of Block A at approximately 1 m depth. These images were generated by GPR-Slice. This software package provides many useful features for imaging GPR data. In the uppermost view, the recent electrical utility trench disturbance is clearly observable. The second view, which is at approximately 1 m below ground, shows a few minor anomalies in addition to the modern utility trench. The third view, which is at approximately 2 m below ground, shows anomalies on the east and west ends of the sample block, as well as traces of the aforementioned utility ditch. Figure 13, which is an overlay of the GPR information from the surface to about 2 m below ground provides a composite view of the subsurface data.
Figure 5. Block A, 30 cm Depth, 500 MHz, Fort Jackson.
Figure 6. Plan of Block A, 60 cm Depth, 500 MHz, Fort Jackson.
Figure 7. GPR-Slice Plan of Block A at Approximately 1 meter Depth, 500 MHz.
Figure 8. GPR-Slice Plan of Block A at 2-3 meter Depth, 500 MHz.
Figure 9. Front View, Block A, 500 MHz.
Figure 10. GPR Block A, Plan at 40 cm Depth, 800 MHz.
Figure 11. Block A at 2 m Depth, 800 MHz.
Interpretive Summary

The GPR data from the present study covers a very small portion of the Fort Jackson site. Nevertheless, this small survey sample indicates the usefulness of GPR technology in mapping subsurface features at the site. The radar signals produced strong reflections in this sample and attenuation of the signal by salt water, which was feared, does not appear to be a problem in this part of Chatham County, Georgia. The strongest radar reflection is seen crossing the sample block. This signal was created by a modern utility ditch and it
observes a large portion of potential features in its vicinity. Other deeper radar reflections indicate anomalies that exist well below 1 meter. Determining the age, function, and historical significance of these anomalies will require archaeological excavation for “ground truthing”. These features also may be better understood by a more complete GPR survey coverage of this area of the fort grounds.

The conventional lore held by several long-time CHS staff is that many areas outside of the existing Fort Jackson brick compound are fill deposits that offer little archaeologically to our knowledge of Fort Jackson or its occupants. While this may be true for the most part, such a verdict seems premature, especially in light of the dearth of well-documented formal archaeological explorations outside of the fort. Excavations that were conducted by the Georgia Historical Commission in the 1960s and 1970s are poorly reported (Tally Kirkland, personal communication June 15, 2006), so the full extent of previous explorations is unknown at present. Stewards of this important historical site may wish to consider GPR in future exploration and site management activity in and around the fort.
Figure 13. Overlay View of Block A, 500 MHz.
References Cited

Conyers, Lawrence B.
2002 GPR in Archaeology.

Goodman, Dean
2006 GPR-Slice, Version 5.

Elliott, Daniel T.
2006a Sunbury Battlefield Survey.
LAMAR Institute, Box Springs, Georgia. Prepared for American Battlefield Protection Program National Park Service, Washington, D.C.

2006b Ground Penetrating Radar Survey at the Gould-Bethel Cemetery. LAMAR Institute Publication Series, Report 100. Savannah, Georgia


2004 Ground Penetrating Radar Survey at the Woodbine Mound Site. LAMAR Institute and Rocquemore Research, Box Springs, Georgia.


2003b Archaeological Investigations at Fort Morris State Historic Site, Liberty County, Georgia. Southern Research Historic Preservation Consultants, Ellerslie, Georgia. Submitted to Historic Preservation Division, Georgia Department of Natural Resources, Atlanta.

2003c Ground Penetrating Radar Survey of the Waldburg Street Site. Rocquemore Research, Box Springs, Georgia.

Joseph, Joe W., III

Kelso, William

MALÅ GeoScience USA

2006b Easy 3D. Version 1.3.3. MALÅ GeoScience USA, Charleston, South Carolina.

Rath, Frederick L., Jr.

United States Department of the Interior, National Park Service, National Historic Landmark Program [NPS]