GPR Survey at the Copeland Site (9GE18)

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Introduction

On June 11, 2008, the LAMAR Institute and University of Georgia (UGA) Field School participants collaborated in a ground penetrating radar (GPR) survey at the Copeland site (9GE18) in Greene County, Georgia. This report details the results of that research effort.

The Copeland Site was first recorded in the Georgia Archaeological Site File as Site 9GE18 in 1971 by UGA archaeologist Archie Smith. The site was revisited and another surface collection made by UGA archaeologist Chester DePratter in 1975. These two survey projects were part of the Wallace Reservoir/Lake Oconee mitigation effort. The site, however, was located outside of the reservoir flood pool. In 1987 a limited shovel testing program was conducted at the Copeland Site by Southeastern Archeological Services and the following year Phase II testing was reported by U.S.D.A. Forest Archaeologist Jack Wynn (Smith 1971, DePratter 1976, Wynn 1988). The Copeland Site is presently located on property owned by the U.S.D.A. Forest Service, who acquired the property in 1980, and it forms part of the Oconee National Forest. The Copeland Site was listed in the National Register of Historic Places in 1989.

The Copeland site has been the subject of continued study by University of Georgia archaeologist Mark Williams. Williams led field schools to the site in 1991, 2007, 2008 and 2009. His scholarship on the subject is summarized in two LAMAR Institute research publications (Williams 1992, 2010). Williams identified multiple structure remains on the site and he has interpreted the Copeland Site as a special use “busk” ceremonial complex that existed in the Late Mississippian period. In his more recent volume, Williams (2010) presents a comprehensive discussion of the site and its context, which need not be repeated here. Suffice it to say that within the area excavated by Williams and his students lie the remains of multiple buildings, dozens of pits and hundreds of post features, and thousands of artifacts from the Late Mississippian occupation. Prior to 2008 excavation season archaeological excavation was limited to a few exploratory trenches and small test units.

The GPR sampling, which was conducted on June 11 at the beginning of the 2008 field school session, covered a substantial portion of the area to be later excavated by Williams’ 2008 and 2009 field schools. The GPR coverage included some areas that remain unexplored by excavation. This GPR survey report augments Williams’ extensive delineation of the site’s archaeological resources.
Research Methods

Ground Penetrating Radar (GPR) is an important remote-sensing tool used by archaeologists (Conyers and Goodman 1997). 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 are shielded to eliminate interference from sources other than directly beneath the device. The transmitting antenna emits a series of electromagnetic microwaves, which are distorted by differences in soil conductivity, dielectric permitivity, 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 samples 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 termed 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 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 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.

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. 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.
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). An 800 megahertz (MHz) shielded antenna was used for the data gathering. MALÅ GeoScience’s Ground Vision software (Version 1.4.5) was used to acquire and record the radar data (MALÅ GeoScience USA 2006). 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 same RAMAC X3M GPR system as that used in the present study has been used successfully by the author on numerous other historic cemeteries in the southeastern United States (Elliott 2003, 2005, 2006a-f, 2008, 2009a-c; 2010).

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.

Upon arrival at the site on June 11, 2008 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:

- Time Window: 35 ns (Blocks A and B); 63 ns (Block C)
- Number of Stacks: 2
- Number of Samples: 568
- Sampling Frequency: 8955 MHz
- Antenna: 800 MHz shielded
- Antenna Separation: 0.14 m
- Trigger: 0.04 m

Three GPR grids were collected during the survey. These were designated Copeland A, B, and C. Copeland A and B comprises two contiguous grids that were slightly offset to form an irregular polygon. Copeland C was a resurvey of most of the areas of A and B, with additional coverage. Figure 1 depicts the relationship of the GPR coverage to the excavated area at the Copeland Site.
Copeland A was composed of 39 radargrams, which were spaced at 50 cm intervals. Block A measured a maximum of 17.2 m north-south by 17.5 m east-west. The survey covered a total of 592.9 meters of radargrams. Radargrams were collected from south to north and the survey progressed from east to west. Grid point 500N, 495E marks the southeastern corner of Copeland A. Figure 2 shows the radargram plan for Copeland A.

Copeland B, located south of Copeland A, was composed of 39 radargrams, which were spaced at 50 cm intervals. Block B measured a maximum of 20 m east-west by 10 m north-south. The survey covered a total of 361.9 meters of radargrams. Radargrams were collected from south to north and the survey progressed from east to west. Grid point 490N, 500E marks the southeastern corner of Copeland B. Figure 3 shows the radargram plan for Copeland B.
Copeland C was an irregularly-shaped coverage that measured a maximum of 23.6 m north-south by 19 m east-west. It was comprised of 39 radargrams, which were spaced at 50 cm intervals. The survey covered a total of 718.8 meters of radargrams. Radargrams were collected from south to north; the survey progressed from east to west. Site grid point 490N, 500E formed the southeastern corner of the Copeland C. Figure 4 shows the radargram plan for Copeland C.
Laboratory Methods
The GPR data from the present study was processed with GPR-Slice (Version 7.0). Dean Goodman’s GPR-Slice program is recognized as the world leader in GPR imaging and it has proven quite effective in mapping archaeological sites (Goodman 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 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.
Results of the Mapping Project

GPR survey at the Copeland Site yielded good, but mixed, results. Because this site is a relatively shallow plow disturbed deposit, the GPR equipment was adjusted for shallow depths. This was accomplished with the 800 MHz antenna, which is suited for that purpose. Figure 5 shows a close-up view of the excavation blocks at the Copeland Site with the GPR coverage area (A and B) superimposed. Figure 6 shows a close-up view of the excavation blocks at the Copeland Site with the GPR coverage area C superimposed. Figure 7 shows a close-up view of the excavation blocks at the Copeland Site with the GPR coverage area (A, B and C) superimposed.

Figure 5. Coverage Areas of GPR Copeland A and B, Outlined in Green.
Figure 6. Coverage Area of GPR Copeland C, Outlined in Green.
Copeland A and B both yielded good GPR information. Figure 8 shows six overlay views of Copeland A at increasing time depths. Figure 9 shows six overlay views of Copeland B at increasing time depths. Copeland C yielded a mix of good radar information and some introduced errors. Figure 10 shows two overlay views of Copeland C at increasing time depths. In the lower (right side) view a long linear (north-south) anomaly is visible near the center of the survey area. This anomaly is likely the result of operator or machine error and does not indicate any linear cultural feature at this location. No similar radar reflection appears in Copeland A or B in this vicinity.
Figure 8. Series of GPR Overlay Maps, Copeland A.

Figure 9. Series of GPR Overlay Maps, Copeland B.
Figure 10. Two GPR Overlay Maps of Copeland C.

Figure 11 shows GPR overlay maps of Copeland A and B superimposed on the site’s excavation plan. Excavation Blocks 2 and 5, which were excavated after the GPR survey was completed, overlap with the GPR coverage. A large portion on the northeastern part of the GPR coverage, however, remains unexplored by archaeological excavation. The GPR data from Copeland A and B shows a large area of strong radar reflection in that portion of Excavation Block 2 where Williams (2010) defined a series of large buildings. While the GPR coverage was not fine-grained enough to parse out individual features and posts, the GPR data from these two sample blocks does reveal broad areas of contrast between strong radar reflections and weak reflections. Several factors may contribute to the observed GPR image. Soil compaction, possibly as the result of heavy foot traffic in this area or intentional soil packing in association with the building construction episodes, may contribute to the GPR patterning. Some of the isolated radar reflection may represent large features or concentrated midden deposits. Others may indicate tree stumps or other biological disturbances. This area has a long history of agriculture and silvaculture and some of the radar reflections may be the result of these activities.

Figure 12 shows an overlay map of Copeland C superimposed on the excavation plan. The different machine settings used in the collection of this dataset produced a less smoothed plan map. Nevertheless, this dataset does contain some useful radar information. Clusters of radar anomalies are evident in Copeland C, particularly in the northeastern portion of the block.
Figure 11. GPR Overlay Map of Copeland A and B.
Figure 12. GPR Overlay Map of Copeland C, Superimposed on Excavation Plan, 9GE18.

Comparison of GPR Data with Other Survey Information

Williams (2010) describes several survey techniques that he used to define the cultural resources at the Copeland Site. These included topographic mapping, phosphate analysis, magnetometry, and close-order systematic shovel testing. The extent of each survey method varied across the site. In the following, the GPR coverage areas are shown in relation to several other survey maps.
Figure 13 shows a GPR overlay map of Copeland A and B superimposed on a phosphate density map of a portion of the Copeland Site. The GPR sample is completely within the area of the phosphate study. High levels of phosphates in the soil on archaeological sites have been shown as indicators of former organic deposits, such as middens, refuse dumps or pits (Williams and Wood 2010). The greatest deposit of phosphate within the GPR sample block is located on the southeastern portion of sample. Low phosphate levels characterize the northwestern portion of the GPR block.

Figure 13. GPR Coverage Area (Shown in Green) Superimposed on Phosphate Density Map, 9GE18.

Figure 14 shows a GPR overlay map of Copeland A and B superimposed on a magnetometry map of a portion of the Copeland Site. Only the northern portion of the GPR sample overlaps with the magnetometry coverage. Magnetic field disturbances in the soils on archaeological sites represent numerous possibilities. The prolonged use of fire, such as a prepared hearth, or catastrophic fires, such as a dwelling conflagration, may alter the soil’s magnetic properties. Disruptions of the soil fabric, such as that caused by the excavation of pits, also may alter the magnetic properties and create recognizable anomalies. In remote sensing studies where GPR and magnetometry have been used together to survey sites have demonstrated the usefulness of both methods. Certain cultural remains are better imaged by magnetometry while others are best viewed with GPR. GPR has the advantage over magnetometry in its capability for 3 Dimensional...
mapping. Unfortunately, the overlap in the coverage areas of the two remote sensing methods at the Copeland site limit any useful comparisons.

Figure 14. GPR Coverage Area (Shown in Green) Superimposed on Magnetometry Map, 9GE18.

Figure 15 shows a GPR overlay map of Copeland A and B superimposed on a sherd weight density map of the Copeland Site. The sherd weight density map was one of several maps generated from the systematic shovel test data. Large quantities of aboriginal pottery, as quantified by weight, reveals areas of artifact discard at the Copeland Site. The areas of increased sherd density generally correspond to the reflective “highs” of the GPR overlay maps of Copeland A and B.
Figure 15. GPR Coverage Area (Shown in Green) Superimposed on Sherd Weight Density Map, 9GE18.
Summary

GPR survey of a portion of the Copeland Site (9GE18) was done in June, 2008 and this report summarizes the findings of this effort. This scientific work and the equipment used in the study were donated by the author who was greatly assisted in the field by the 2008 UGA Field School students. The data was collected during one field day. The present report is a supplement to a more comprehensive study of the site by Williams (2010) and the two should be read in tandem. Subsequent block excavations examined a substantial portion of the area covered by the GPR work. Other areas covered by the GPR study remain unexplored beyond the shovel test phase. Only a small portion of the Copeland Site was covered by the GPR survey but this sample demonstrates that GPR has potential application on shallow, prehistoric sites in the Greene County uplands.
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