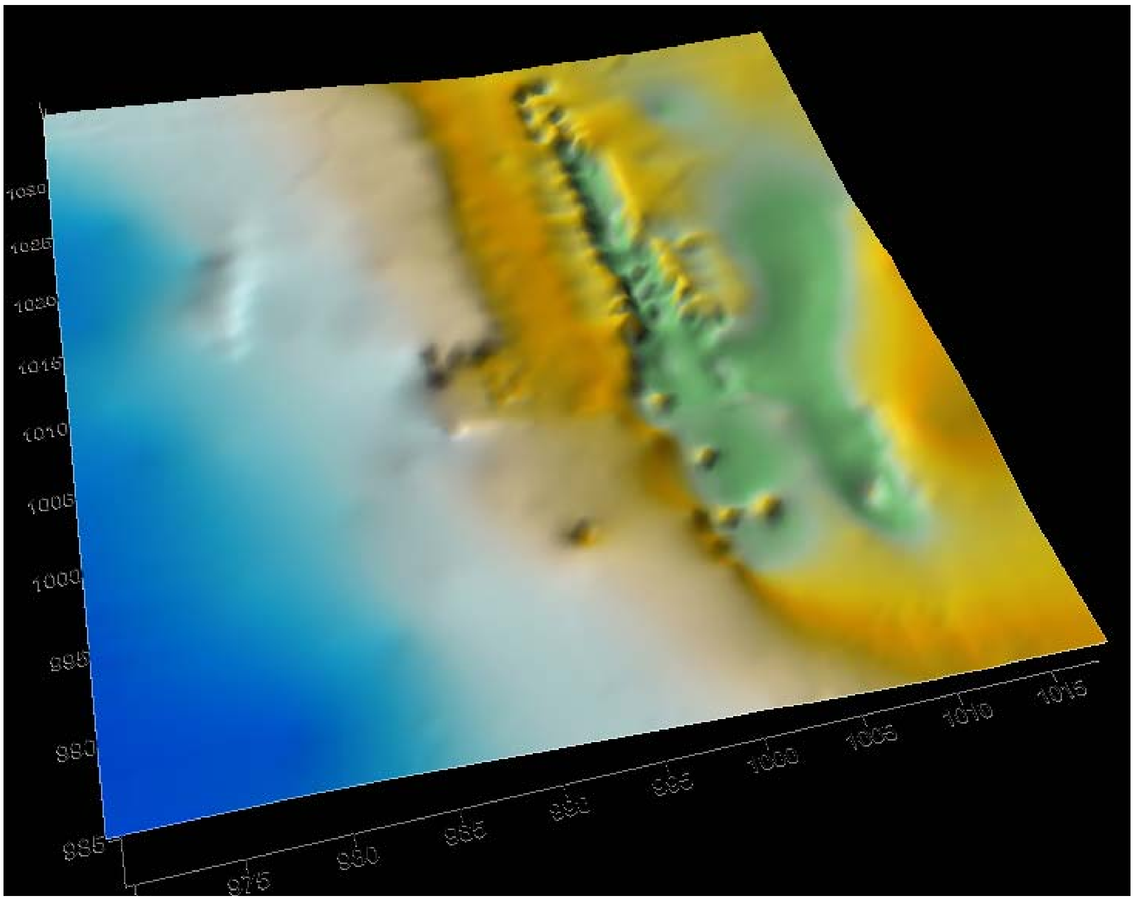
# Ground Penetrating Radar Reconnaissance at Clinton Tannery, Jones County, Georgia

## LAMAR Institute Publication Series Report Number 106




**The LAMAR Institute, Inc.
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# Ground Penetrating Radar Reconnaissance at Clinton Tannery, Jones County, Georgia

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# Introduction

Preliminary archaeological investigation at the Clinton Tannery (State Site 9Jo282) in Jones County, Georgia was provided by the LAMAR Institute, Savannah, Georgia. This research effort was performed under the direction of Daphne Owens Battle and Daniel E. Battle, Cypress Cultural Consultants, LLL (CCC). This work included Ground Penetrating Radar (GPR) sampling of the area above, and immediately adjacent to, the tanning vat complex that was previously identified during a preliminary study by CCC. The GPR fieldwork for this project was conducted in May 2006. These results are detailed in this report. The LAMAR Institute's survey team consisted of Daniel T. Elliott, Daniel E. Battle, Michael Benton, and Daphne Owens Battle.

The Clinton tannery operated from the early 1800s until the July, 1864. U.S. Cavalry raiders burned the industrial complex in that month. Apparently the fire resulted in a total loss and the tannery was never reactivated. Since July, 1864 the ruins of this factory have lain abandoned to be reclaimed by the elements.

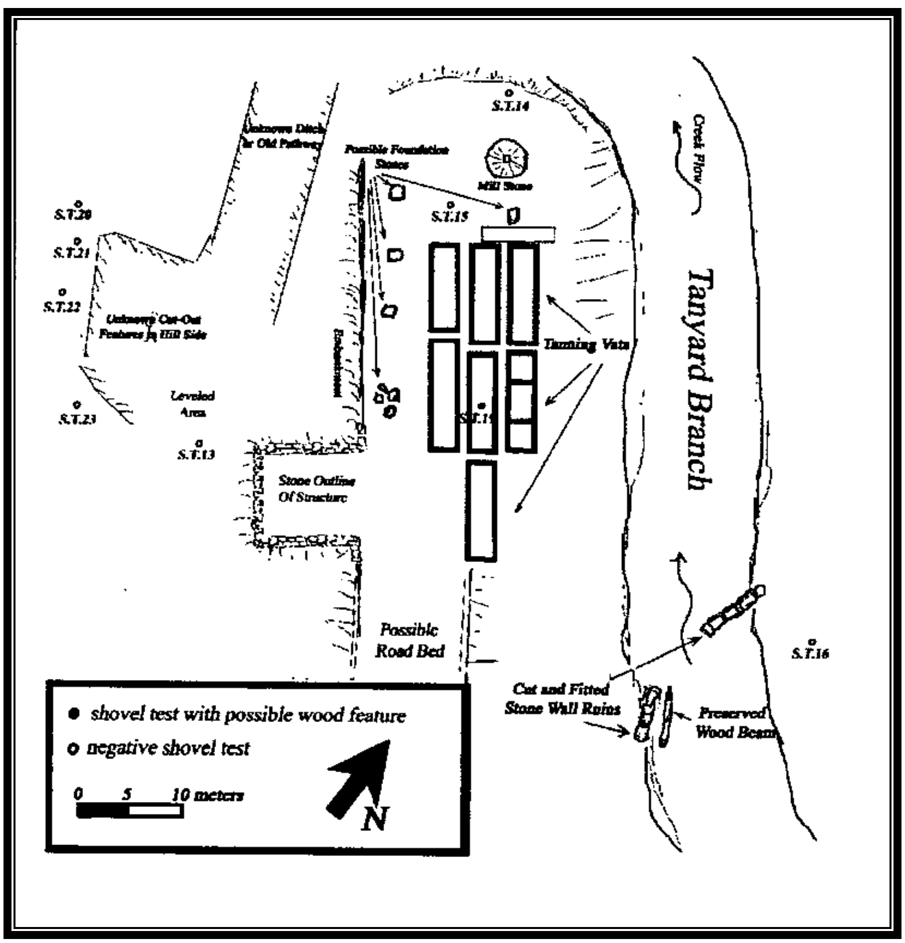


**Figure 1. Site Plan, 9Jo282.**

# Methods

## *Ground Penetrating Radar*

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 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 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.

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. 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 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.

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. The Georgia Piedmont is in an area considered to exhibit low potential for effective use of GPR. GPR has been used to a limited extent on archaeological sites in Georgia yielding mixed results. 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 (Elliott 2006a-d).

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.

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

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).

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. The underlying soils at 9Jo282 were compact clay, which was derived from ancient saprolite granite gneiss. This red clay subsoil was covered with a thin mantle of humus and sandy clay loam.

GPR Machinery settings for this survey included the following:

**GPR Block A**
Time Window: 85 ns
Number of Stacks: 4
Number of Samples: 812
Sampling Frequency: 9605 MHz
Antenna: 500 MHz shielded
Antenna Separation: 0.18 m
Trigger: 0.02 m
Initial Time Zero: 48,762
Radargram orientation: East-West
Radargram progress: South-North
Radargram Spacing: 50 cm

Number of Radargrams: 64
Dimensions: 33 m North-South by 10 m East-West
Reference: Grid coordinate of Southeast Corner is 994.71 North, 1004.36 East

Comments: GPR Block A was centered over the Clinton tanning vat ruins. Because the terrain was steeply undulating in the numerous tanning vat depressions a unique strategy was devised to create a false level land surface. This was necessary in order for the GPR equipment to function properly. This was accomplished by placing a series of planks and plywood over the vat depressions. The GPR equipment was moved slowly over these plywood sheets and by this method an unbroken radargram was obtained. This work proceeded at a snail's pace. Over the course of one morning and part of an afternoon a total of 64 radargrams were collected. A heavy thundershower preempted the complete survey coverage of the tannery ruin, although the remaining portion that could have been easily mapped was less than 2 meters wide.

The GPR grid was the same as the site grid, which was established with the aid of a Sokkia total station and TDS Recon data collector. The grid was oriented parallel to the tanning vat orientation. Grid coordinates were arbitrarily defined. Datum 1 served as the transit station and was designated 1,000 meters North, 1,000 meters East, 100 meters Arbitrary Elevation. The total station survey crew consisted of Daniel E. Battle, Daphne Owens Battle, Bucky Davis, Max Davis, Daniel Elliott, and John Simmons.

## Results and Interpretation

The total station mapping for the GPR grid was part of a larger mapping project of the overall site (9Jo282). A total of 1,281 transit points was collected by the mapping crew. Of these, 10 were discarded as junk recordings. Of the remaining 1,271 data points, 1,020 were simply topographic elevation readings. The remaining 251 data points recorded the locations of various features at the site including: test excavation units, bricks, rocks, grist mill stone, artifacts, the creek, and other miscellaneous aspects of the site. The resulting topographic map provides a greater understanding of the topography at the factory (Figure 2). Had the crew had more time and resources a more detailed map could have been generated. As it was, the topographic map has coverage gaps in some areas.

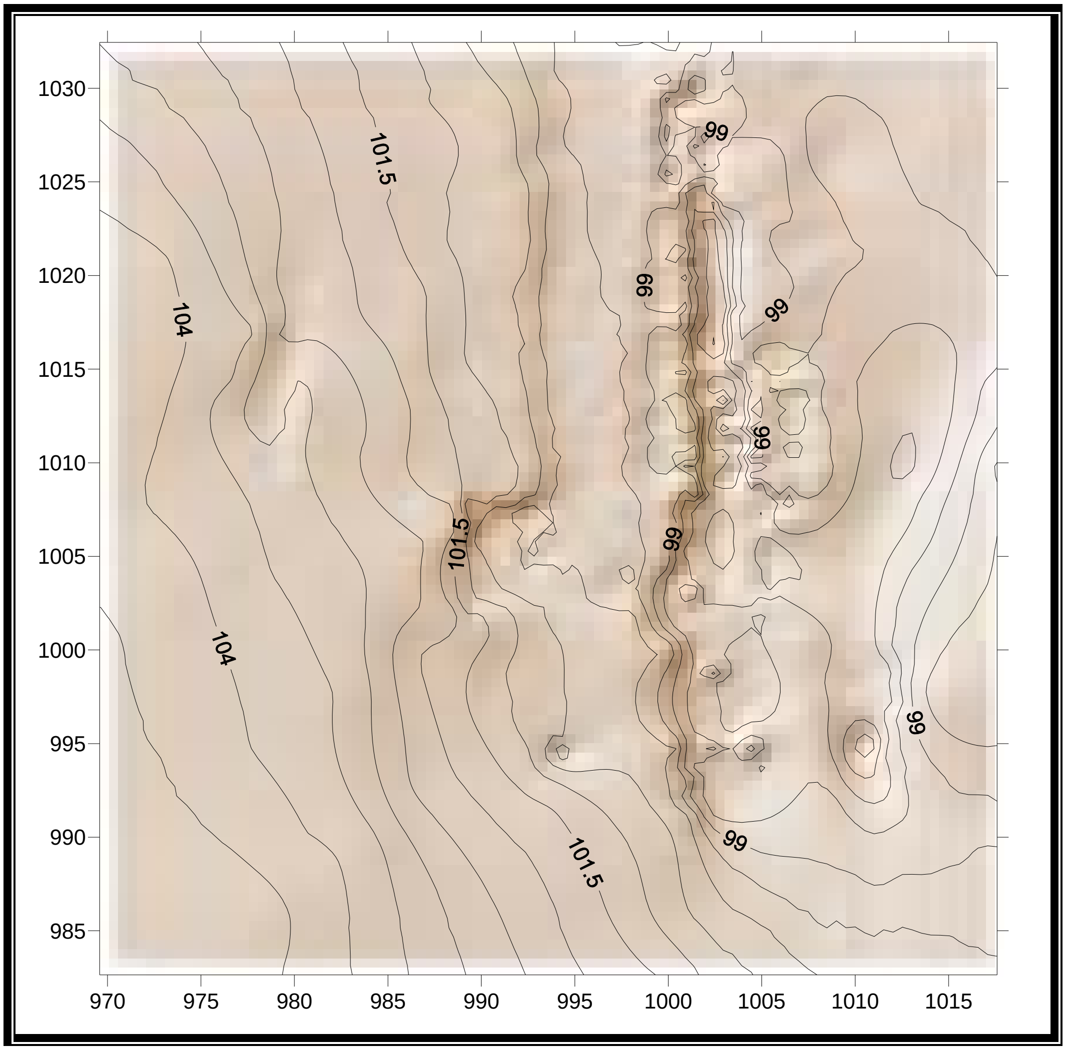


**Figure 2. Topographic Map of Clinton Tannery.**

GPR data was successfully collected from the Clinton tannery ruin. As expected, the uneven terrain of the tanning vat depression proved to be a challenge in the field data collection and in the post processing of the data. For much of the upper time slices the resulting maps depict an image of air voids. This is the air space located beneath the plywood false ground surface and the true ground surface. Consequently, the areas of the vat depressions yielded data of questionable merit.

Two time slices at different depths (or aerial views) of GPR Block A are presented in Figures 3 and 4. Figure 3 shows a plan view at 8-13 ns. Figure 4 shows a plan view at 14-20 ns.

The GPR survey did produce several interesting radar anomalies. These may relate to the activities associated with hide tanning, when the factory was in operation. These GPR maps display areas where the ground has been heavily compacted. These areas are linear and immediately adjacent to the vats on the west side. This compaction is the result of heavy foot traffic by people, wheeled vehicles, and or large draft animals.

The other area of heavy GPR anomalies is in the southwest part of the site in the vicinity of the brick floor. What the GPR map may be telling us in that area is the existence of some harder bricks and possibly compaction associated with the construction and subsequent use of the building. If these areas were used to store heavy objects, such as large hogsheads of liquids or solids, that weight may have left an imprint in the GPR record. This is all pretty speculative. The map clearly shows that the soils in this part of the site are not homogenous. There are variations surrounding the vats and these variations mean something, probably something cultural.

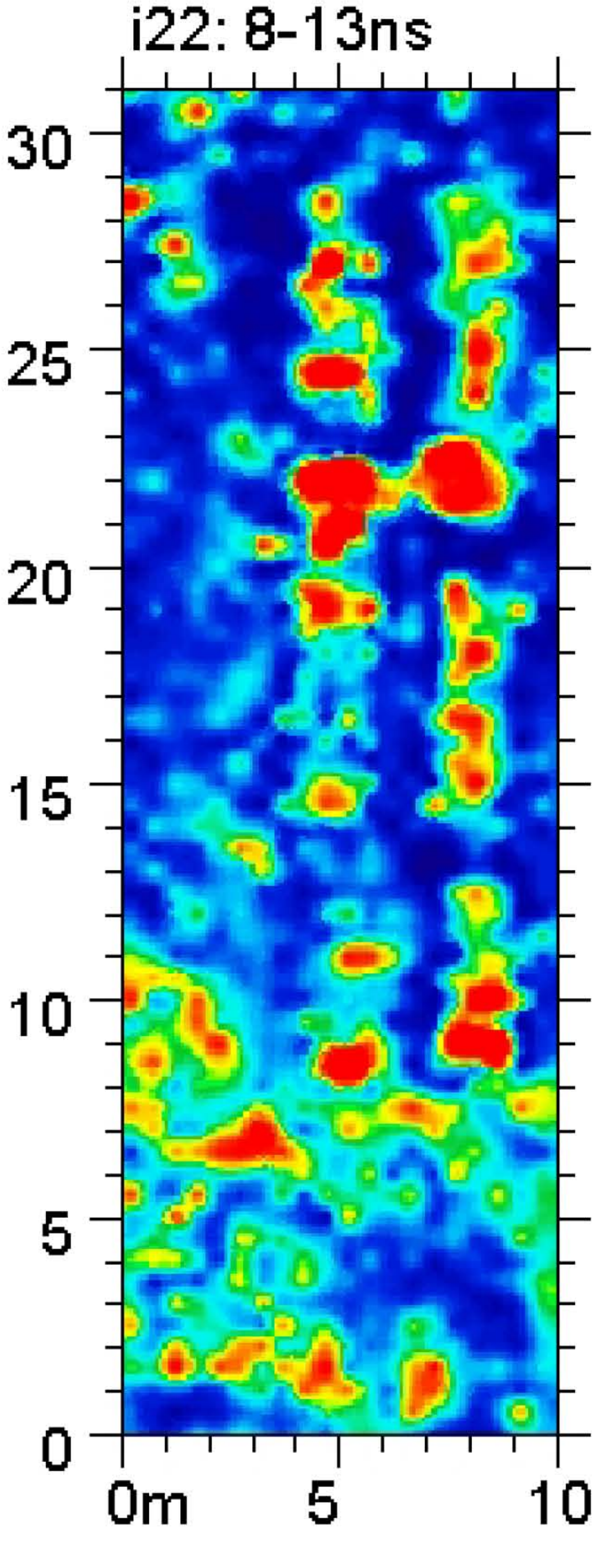


Figure 3. GPR Aerial Map of Block A at 8-13 ns Time Depth.

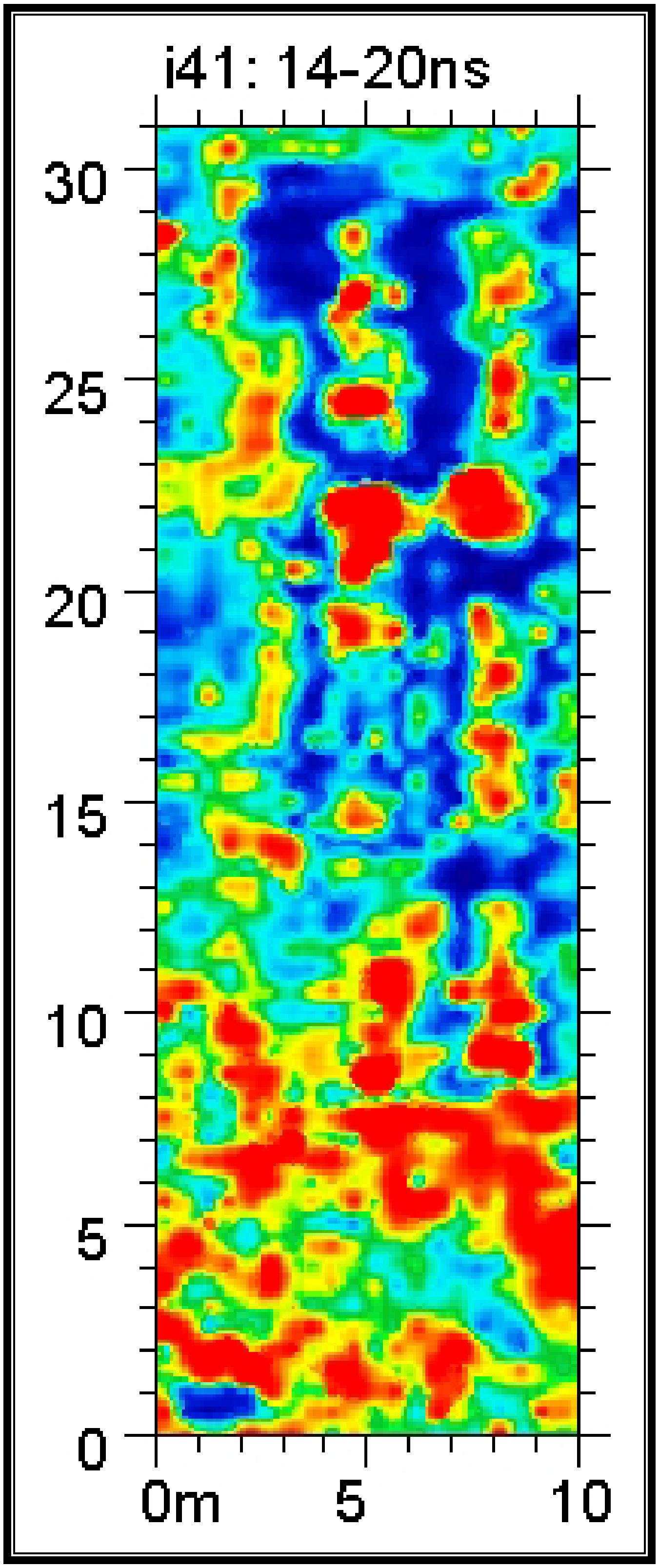

Figure 4. GPR Aerial Map of Block A at 14-20 ns Time Depth.

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