

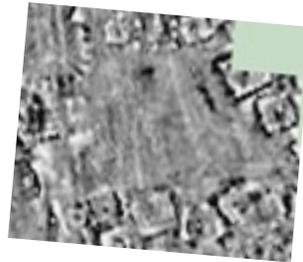
# **Geophysical Survey at the Parker Cemetery Rockwall, Texas.**

AGA Report 2010-6

Report Submitted To:

Texas Cemetery Restoration  
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Dallas, Texas 75243

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## **Executive Summary**

Based on consultation with James Brenner of Texas Cemetery Restoration, researchers from Archaeo-Geophysical Associates, LLC (AGA) performed a geophysical survey in order to identify unmarked historic graves at the Parker Cemetery in Rockwall, Texas. Geophysical data was collected with a Ground-Penetrating Radar (GPR) and this work successfully located 42 possible unmarked graves. Any excavation for new graves in or near areas with possible graves, as identified in this report, should proceed with caution.

## **Equipment Settings Used**

GSSI SIR3000 GPR with 400 Mhz Antenna  
50 cm Traverse Interval  
512 Samples Per Trace  
16 Bit Data Format  
50 Nanosecond Range  
120 Scan Rate  
30 Scans Per Meter  
Sokkia Radian IS RTK GPS

## **Introduction**

The purpose of this project was to use ground-penetrating radar (GPR) to identify potential unmarked burials and associated cultural materials in the Parker Cemetery in Rockwall, Texas. Data was collected. Data collection at the Parker Cemetery was limited to the core area of the cemetery totaling approximately 3,775 square meters (0.93 acres). The GPR survey was successful at locating numerous unmarked burials that had been placed to depths of 2 meters (6.5 feet) in the ground.

The GPR data were collected by Archaeo-Geophysical Associates, LLC, between May 11-12, 2010, using a GSSI SIR-3000 collection system with 400 MHz dipole antennas. Radar reflection data were processed to yield amplitude slice-maps and reflection profiles, both of which were then used to delineate buried features of interest. Amplitude slice-maps allow for spatial analysis in plan view, while profile analysis aids in delineating stratigraphy and the vertical structure of buried features in two-dimensional vertical slices. In addition, headstones were mapped in using RTK GPS so any burials identified in the GPR maps and profiles could be noted as being either marked or unmarked.

## **GPR Use and Background**

GPR data are acquired by transmitting pulses of radar energy into the ground from a surface antenna, reflecting the energy off buried objects, features, or bedding contacts in the soil, and then detecting the reflected waves back at the ground surface with a receiving antenna. When collecting radar reflection data, surface radar antennas are moved along the ground in transects, typically within a surveyed grid, and a large number of subsurface reflections are collected along each line. As radar energy moves through various materials, the velocity of the waves will change depending on the physical and chemical properties of the material through which they are traveling (Conyers 2004). The greater the contrast is in electrical and magnetic properties between two materials at an interface, the stronger the reflected signal, and therefore the greater the amplitude of reflected waves (Conyers 2004). When the travel times of energy pulses are measured, and their velocity through the ground is known, distance (or depth in the ground) can be accurately measured (Conyers and Lucius 1996). Each time a radar pulse traverses a material with a different composition or water saturation, the velocity will change and a portion of the radar energy will reflect back to the surface and be recorded. The remaining energy will continue to pass into the ground to be further reflected, until it finally dissipates with depth.

The depths to which radar energy can penetrate, and the amount of resolution that can be expected in subsurface deposits, are partially controlled by the frequency (and therefore the wavelength) of the radar energy that is being transmitted (Conyers 2004). Standard GPR antennas propagate radar energy that varies in frequency from about 10 megahertz (MHz) to 1000 MHz. Low frequency antennas (10-120 MHz) generate long wavelength radar energy that can penetrate up to 50 meters (164 feet) below surface in certain conditions, but are capable of resolving only

very large buried features. In contrast, the maximum depth of penetration of a 900 MHz antenna is about 1 meter or less (3.28 feet) in typical materials, but its generated reflections can resolve features with a maximum dimension of a few centimeters or inches. A trade-off, therefore, exists between the depth of penetration and subsurface resolution. In this survey, a 400 MHz antenna was used, which produced data of good resolution at depths up to about 2 meters (about 6.5 feet). Below this depth, water content and sediment mineralogy caused attenuation of the transmitted radar energy, making the resolution of any features below this depth difficult to identify.

The success of GPR surveys in archaeological and historic preservation investigations is largely dependent on soil and sediment mineralogy, clay content, ground moisture, depth of burial, and surface topography and vegetation. Electrically conductive or highly magnetic materials will quickly attenuate radar energy and prevent its transmission to a considerable depth. The best conditions for energy propagation are therefore dry sediments and soils without an abundance of clay. In this survey, we concentrated our GPR data collection in areas where the ground surface had been cleared of major vegetation and surface obstructions. Good energy propagation was achieved, allowing buried features up to just over 5 feet below the surface to be readily resolved.

The “time window” within which the GPR data were gathered was 50 nanoseconds. This is the time during which the system is “listening” for returning reflections from within the ground. The greater the time window, the deeper the system can potentially record reflections. In this survey, 50 nanoseconds is equivalent to about 3.5 meters (11.4 feet) in real depth. The lower portions of the GPR profiles do not represent usable data across the entire survey area. In general a depth of 2 m (6.4 feet) occurred across the surveyed area.

To convert time in nanoseconds to depth, it was necessary to determine the elapsed time that transpires for the radar energy to be transmitted, reflected, and recorded back at the surface by doing a velocity test. For this project, this was done using the program *FieldView*, in which hyperbolas found on reflection profiles are measured to yield a relative dielectric permittivity (RDP), which is a way to calculate velocity. The shape of hyperbolas generated in this program is a function of the speed at which energy moves in the ground, and can therefore be used to calculate velocity (Conyers 2004). In this cemetery, the Dielectric is approximately 4.22 and the velocity was 0.146 m/ns (meters per nano second). All profiles and processed maps were then converted from time in ns to depth in meters and feet using this average velocity.

### **Data Processing Procedures**

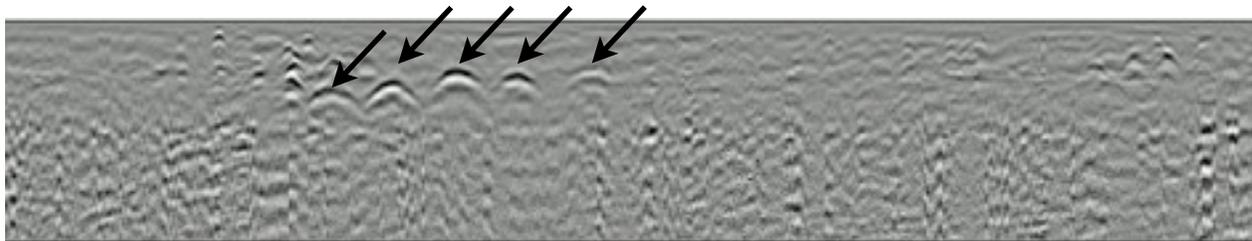
The initial data processing for the project involved the generation of amplitude slice-maps (Conyers 2004). Amplitude slice-maps are a three-dimensional tool for viewing differences in reflected amplitudes across a given surface at various depths. Reflected radar amplitudes are of interest because they measure the degree of physical and chemical differences in the buried materials. Strong, or high amplitude, reflections often indicate denser or different buried materials, such as historic features or burials. In burials, these can be generated at pockets of air, such as within caskets, at the actual caskets, or at the material overlaying the burial.

Amplitude slice-maps are generated through the comparison of reflected amplitudes between the reflections recorded in vertical profiles. In this method, amplitude variations, recorded as digital values, are analyzed at each location in a grid of many profiles where there is a reflection recorded. The amplitudes of all traces are compared to the amplitudes of all nearby traces along each profile. This database can then be “sliced” horizontally and displayed to show the variation in reflection amplitudes at a sequence of depths in the ground. The result is a map that shows amplitudes in map view, but also with depth. Often when this is done, changes in the soil related to disturbances such as burials can become visible, making many features visible to the human eye that may not be visible in individual profiles. For this project, this was done using the program *GPR Slice*.

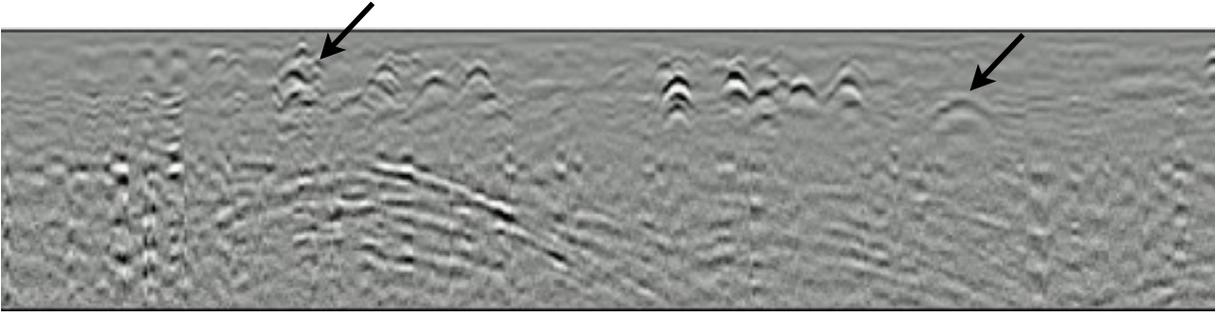
From the original .dzt files (raw reflection data), a series of image files were created for cross-referencing to the amplitude slice-maps that were produced. Two-dimensional reflection profiles were also analyzed to determine the nature of the features identified on the amplitude slice-maps. The reflection profiles showed the geometry of the reflections, which can lead to insights into whether the radar energy is reflecting from a flat layer (seen as a distinct band on a profile), or a single object or burial (seen as a hyperbola in profile). Using these profiles to confirm or refute ideas about the nature of the buried materials seen in the three-dimensional slice maps, unmarked burials were then delineated within the GPR survey areas.

### **Data Interpretation**

Numerous unmarked burials were located at the Parker Cemetery. Many burials are readily identifiable in the amplitude slice-maps as areas of high-amplitude reflections, noted in these maps by black and dark gray colors (Figure 1). In general the newer the graves tend to show up with greater contrast in GPR data. Figure 2 shows a more subtle example of a hyperbolic anomaly and is more common with older graves. In addition to identifying burials using these slice-maps, we recognized that there was the potential that older burials in wooden casket, or burials not placed in caskets, may not be distinguishable in the slice-maps, as their reflections may be too subtle to be easily mapped.



**Figure 1. GPR amplitude slice-map showing the reflections from 5 burials; these are seen here as areas of high amplitude reflections noted by black and dark gray colors. This is a good example of how recent burials show up in GPR data. Older graves can be much more subtle.**



**Figure 2.** This reflection profile shows a good example of a more subtle grave on the right side of the image. The arrow on the left of the image points to a cluster of tree roots - a common source of noise in GPR surveys.

GPR amplitude slice maps are useful for locating both marked and unmarked burials, however, it is imperative to analyze each of the reflection profiles individually for burial reflections, which are apparent as more subtle hyperbolic-shaped reflections (Figures 1 and 2), typical of individually buried objects, including burials (Conyers 2006). Using the reflection profiles is critical in not only confirming the presence of a burial noted in the amplitude slice-maps, but also in identifying subtler and older burials that may not have been apparent in the slice-maps.

The standing tomb stones at the Parker Cemetery were mapped using an RTK (survey grade) GPS (Figure 3). The locations of unmarked graves identified in the analysis of the individual GPR profiles as well as those that appear on the various GPR slice maps are shown in Figure 4. These two data sets are shown together in Figure 6. Figures 7 and 8 show the locations of the standing tomb stones overlaid on examples of GPR amplitude slice maps. In this case the 2 slice maps show data from the depths of 90-120 cm below the ground surface (Figure 6) and 120 - 160 cm below the ground surface (Figure 7). In both of these images areas of high amplitude reflections are shown in red and low amplitude reflections are shown in blue. Graves typically show up as high amplitude reflections (red), but as can be seen in both maps some standing graves do not have a corresponding positive anomaly. This is why analysis of the individual GPR profiles is necessary.

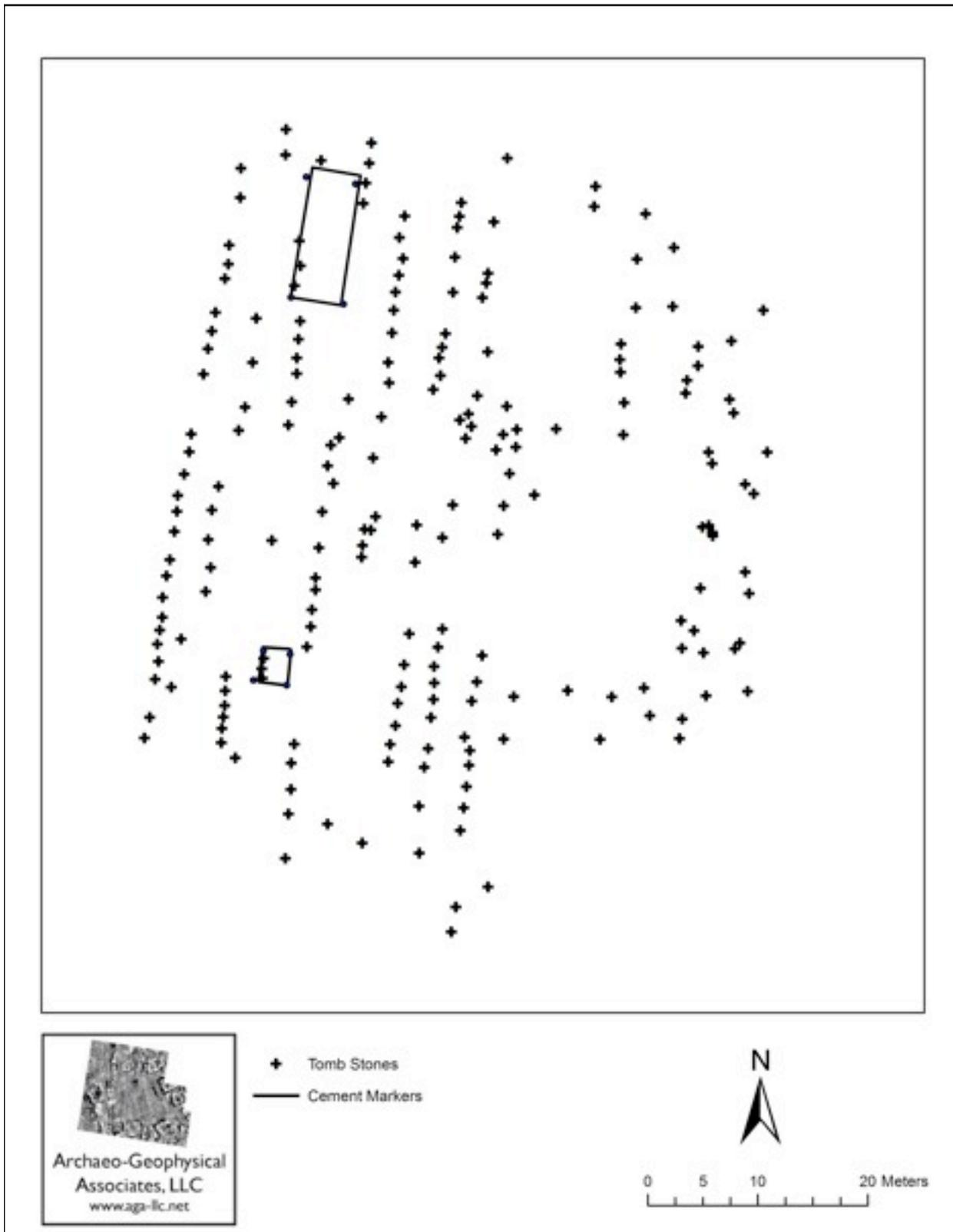
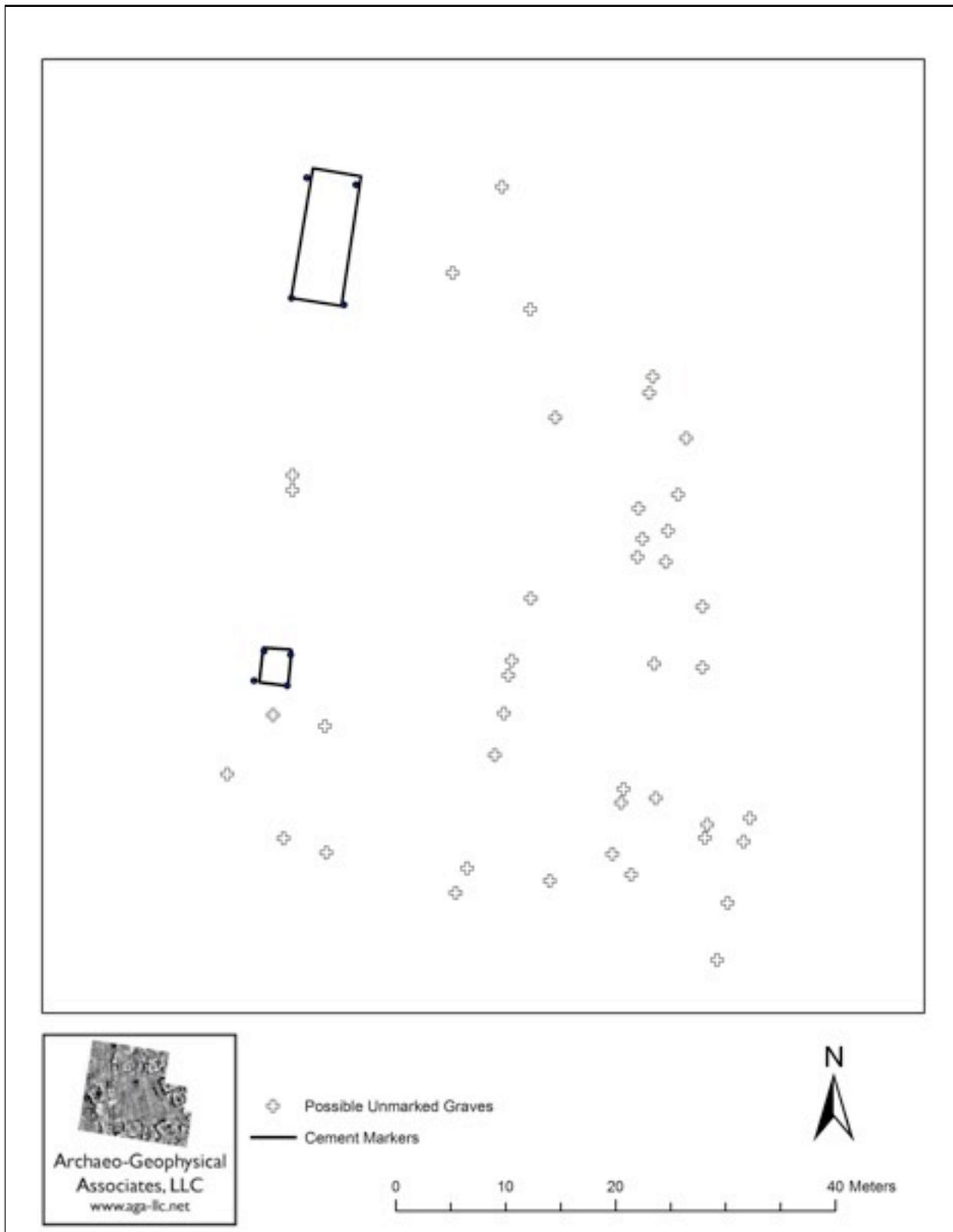


Figure 3. Map showing the locations of the current locations of the standing headstones at the Parker Cemetery.



**Figure 4. Map showing the distribution of unmarked burials. These burials were identified from hyperbolic reflections that appeared over several consecutive profiles, with geometries consistent with other known burial reflections from this area.**

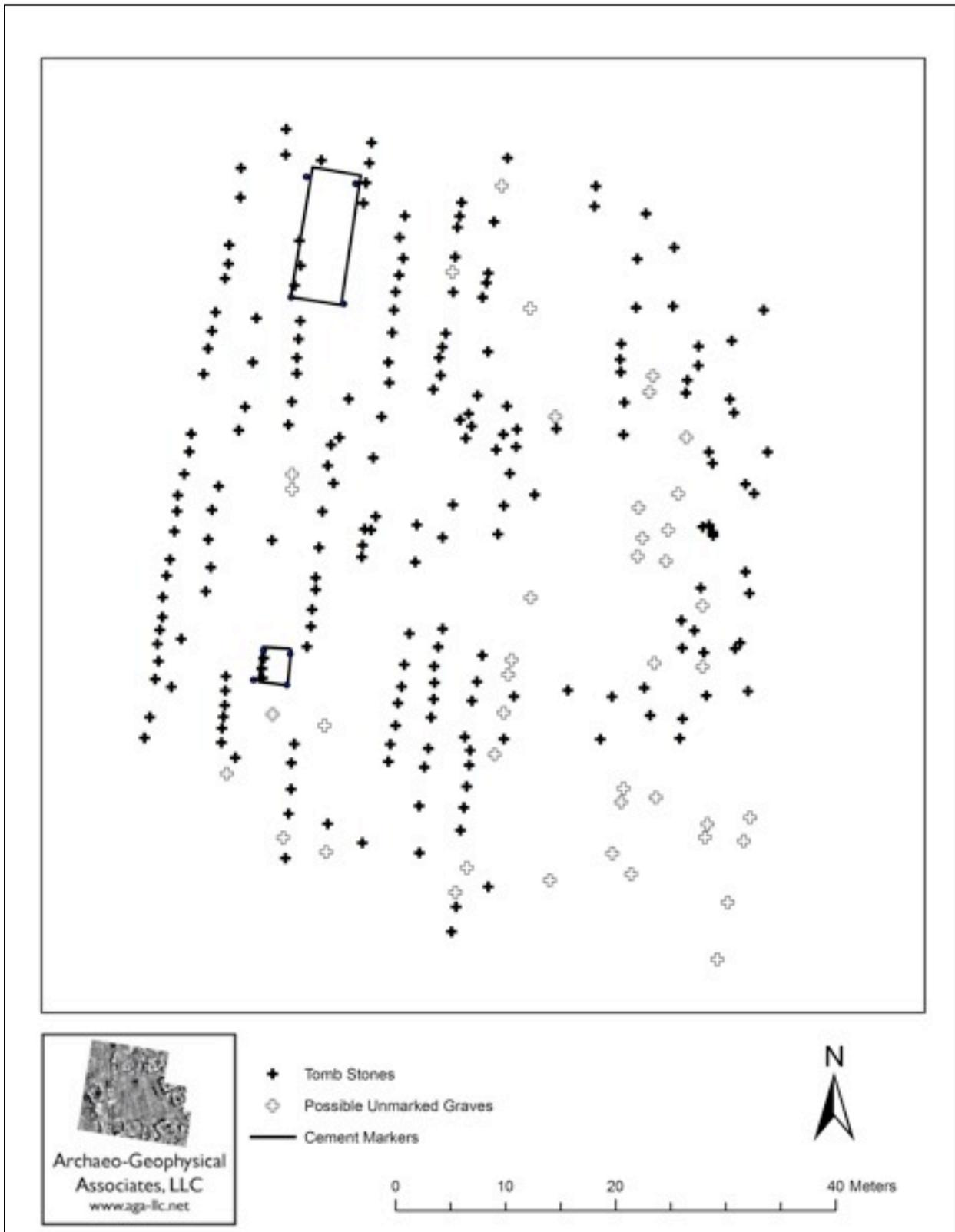


Figure 5. Map showing all burials, both marked and unmarked.

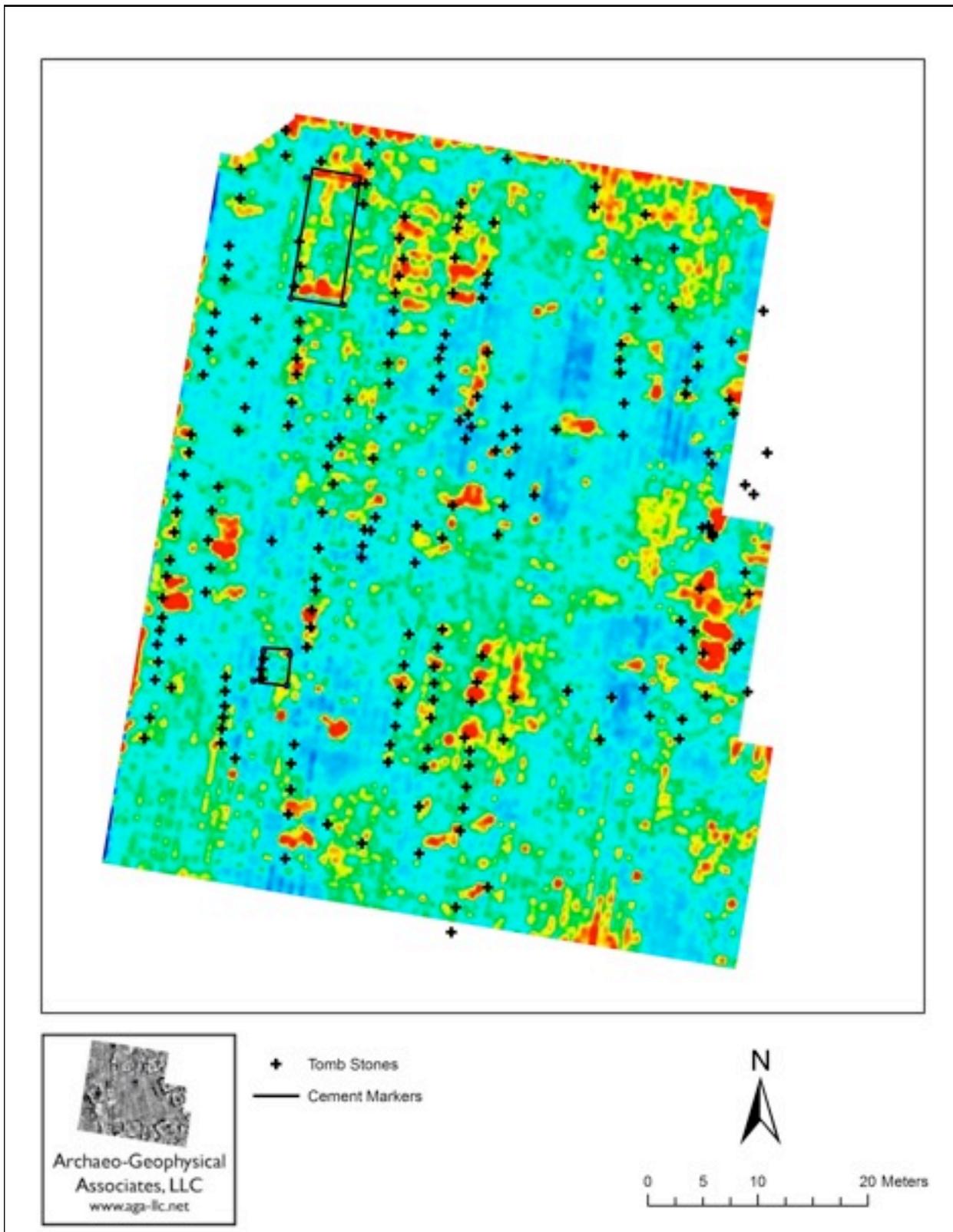


Figure 6. GPR Time Slice from 90 - 120 cm (3-4 feet) below the ground surface. Standing tomb stones are marked.

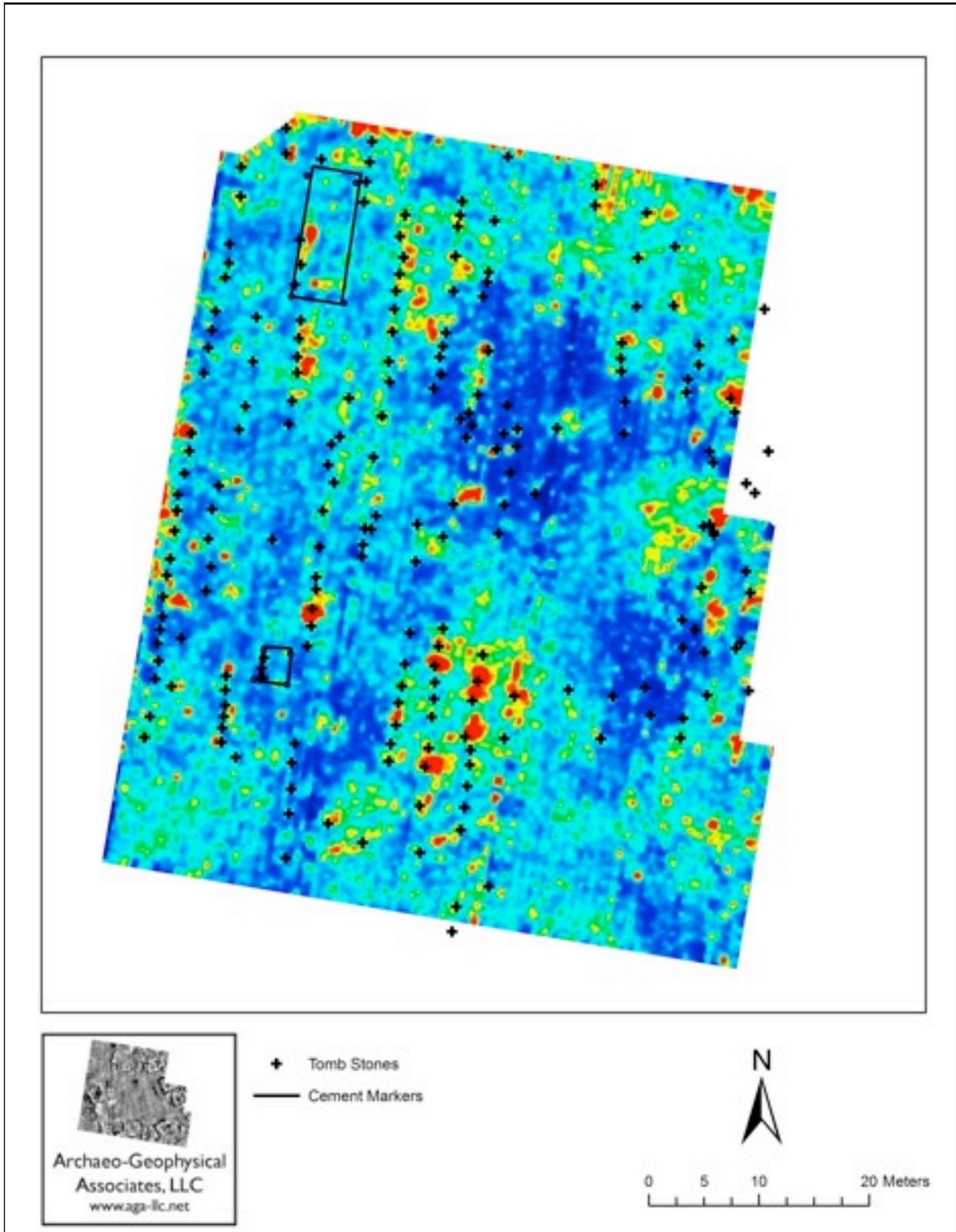


Figure 7. GPR Time Slice from 120 - 160 cm (4 - 5.25 feet) below the ground surface. Standing tomb stones are marked.

## **Conclusions**

The GPR surveys performed at the Parker Cemetery were successful in locating 42 possible unmarked burials. All interpretations of the GPR data were made using analyses of both the reflection profiles and the generated three-dimensional amplitude slice-maps, and both analyses were important for identifying potential unmarked burials. The amplitude slice-maps helped in identifying the extent and spatial layout of burials, as well as how the appearance of these burials changed with depth. Excavation of new graves in areas marked in Figures 4 and 5 should be avoided. Excavation of new graves in all other areas within the current survey area should proceed with caution.

## **References**

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