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Ground-penetrating Radar Profile Spacing and Orientation for Subsurface Resolution of Linear Features

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ABSTRACT Ground Penetrating Radar (GPR) surveys have become an increasingly used technique to aid in evaluating archaeological sites for cultural resource management purposes. As time is often an important factor in these surveys, a test was conducted that examined the benefits received from increasing data collection density. At Ceylon Plantation GPR grids were collected in both the X and Y direction at 50 cm intervals and in the Y direction at 25 cm intervals. The composite X-Y amplitude map and the 25 cm interval map both produced the highest resolution images. The X-Y composite collection method was able to resolve thin, linear features not visible in maps produced from only one transect orientation.

Key words: ground-penetrating radar; transect spacing; spatial analysis

Introduction

Ground-penetrating radar (GPR) surveys have begun to enter the archaeological mainstream in the USA because of federal laws that mandate cultural resource identification and significance assessment prior to ground-disturbing undertakings. For this reason GPR has been used in advance of construction in order to quickly and accurately identify subsurface targets for immediate archaeological excavations in what is termed 'rescue archaeology' in some countries. The typical GPR survey collects grids of transects with profiles orientated in one direction. As time is often an important consideration in compliance archaeology, maps must be produced quickly and decisions made about what features appear significant and warrant excavation. A case study was developed to test the variables of profile orientation and transect spacing in an area scheduled for excavation to test how important those factors are to subsurface resolution of targets. Two grids were surveyed over the same portion of an archaeological site, one testing the utility of surveying in both the X and Y directions at 50 cm transect intervals, and one testing the resolution differences between the 25 cm and 50 cm survey intervals collected in one direction.

The Ceylon Plantation test site

Ceylon Plantation, an early nineteenth century rice plantation located in sandy soil along the Georgia coast was tested in an area thought to contain subsurface features including possible building foundations, privies and midden deposits. Grid 1 was 10×12.5 m with profiles collected at 50 cm intervals in both the X and Y directions (Figure 1). The GSSI SIR-3000 system with a 400 MHz antenna was used for collection, and amplitude slice maps of the data were produced with the GSSI RADAN software. Reflections were migrated after

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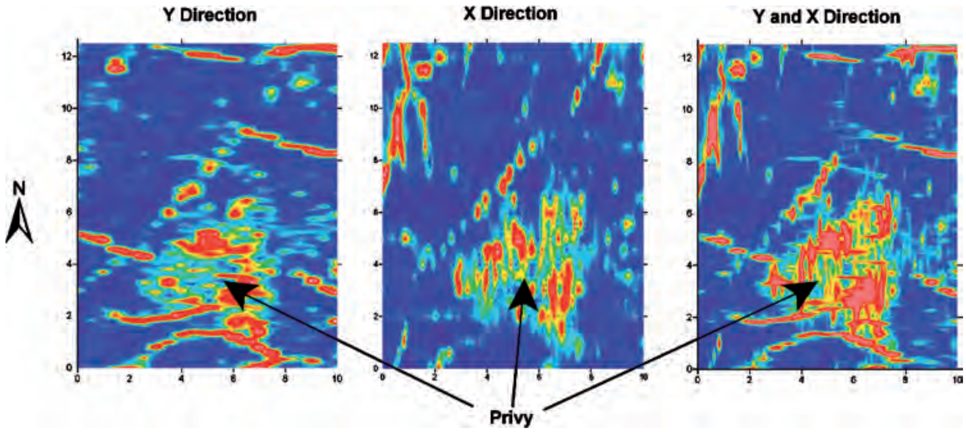

Figure 1. Three profile collection directions used to produce maps of the buried features.

velocity analysis was performed and 30 cm thick slices were analysed from various depths. A large distinctive reflection feature and a number of linear features are visible in the amplitude slice at 60 cm below the surface (Figure 1). The map of amplitudes using only the Y-orientated profiles shows many linear features orientated perpendicular to the transect direction, and the same is true with the map using only the X orientated profiles.

This type of resolution, dependent on profile and target geometry is what was expected, as the electromagnetic field orientation from the transmitting antennae will usually reflect more readily from features orientated perpendicular to the profile direction (Annan and Cosway, 1992) These linear features, when excavated, were

Figure 2. Excavation of privy feature identified in Grids 1 and 2.

found to have been produced from roots of large oak trees that lined the western edge of the survey grid. The composite amplitude map that includes both the X and Y profile orientations provides greater resolution of the subsurface features, and allows one to view all of the buried features including those that might be missed if only one direction is used. The largest reflection feature in the map was excavated and a historic privy containing thousands of nineteenth century artifacts and faunal remains was found (Figure 2). The ceramics recovered were high-quality materials, showing that the people who used this privy were privileged planters associated with the nineteenth century rice plantation, as opposed to African-American slaves who were known to live nearby. This is further supported by the faunal analysis, which revealed a prominence of bones from high-quality cuts of meat. The discovery of this feature provided a great deal of information regarding nineteenth century lifestyle and was instrumental in evaluating the site's significance.

Grid 2, which includes a portion of Grid 1 was collected using only profiles orientated in the Y direction with a 25 cm profile spacing. Reflection maps were then processed using this higher density reflection grid (Figure 3). All of the features identified in Grid 1 are evident in Grid 2 along with additional linear features in the northwest portion of the grid (Figure 3). One of these was excavated and determined to be the foundation of a nineteenth century brick and mortar wall. Although no new features were identified by using 25 cm intervals, the result of this profile density was a much better resolution map, a phenomenon that has been documented elsewhere (Conyers *et al.*, 2002; Neubauer *et al.*, 2002).

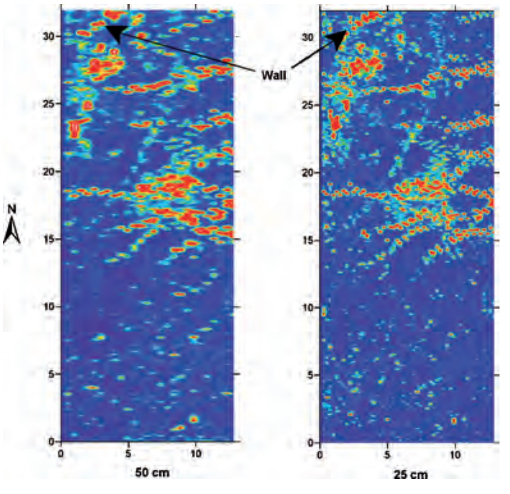

Figure 3. Grid 2 collected at 25 cm and 50 cm intervals in the Y direction, 60 cm below the ground surface.

Conclusions

The composite X–Y map from Grid 1 and the 25 cm interval map from Grid 2 demonstrate that although both methods produced higher resolution amplitude maps than the unidirectional 50 cm interval surveys, surveying in both transect orientations offered the best results for delineating small linear features. Although 25 cm profile spacing produced images of marginally better resolution, the additional time and effort to collect those profiles would not be worth the extra effort when field time is limited and test excavation must commence quickly. For maximum resolution and small linear feature detection, when time is not a critical issue, perpendicular transects would be the preferred collection method.

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