Geophysical studies of a Jamaican slave cemetery at Marshall's Pen, Mandeville

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INTRODUCTION

Located in Mandeville, Jamaica, Marshall's Pen preserves the remnants of a slave village including house foundations, refuse pits and a cemetery. It was functional in the late eighteenth/early nineteenth century and was occupied by approximately 200-300 people. The cemetery region is the focal point of our research.

Since the time of use the cemetery has endured two episodes of modification. During the first period, cut stones (headstones) from some of the graves were removed for the construction of a hotel near Mandeville. Because some graves were left without headstones it is difficult to determine the true boundaries of the cemetery. The second modification occurred during the twentieth century when a stone wall was erected to the north, south, and east sides of the area with stone marked graves to protect them from further destruction.

The objective of our project was to determine the approximate locations of subsurface graves using geophysical methods. For archaeological purposes, it is important to determine the parameters of the burial grounds (marked and unmarked) so that they may be studied and preserved.

METHODS AND MATERIALS

The instruments and methods used include: electrical resistivity, electrical conductivity, magnetometry, and magnetic susceptibility. We chose to employ these methods because they have been successful in similar studies and were well suited to our site (Fattah et al., 1993; Bevan et al., 1993). These methods were tested over known stone-marked graves and rock walls to obtain geophysical signatures. We then used the instruments to obtain geophysical changes in the ground beyond the visible cemetery boundaries. All our profile lines ran from south to north.

Electrical Resistivity. We conducted an electrical resistivity survey using the Bison Earth Resistivity Meter model 2350. We used the Wenner configuration with one meter a-spacing along six profile lines that were set three to four meters apart. Resistivity measurements were taken every meter along each profile. For a technical description of the Wenner configuration and resistivity surveys refer to Milsom (1989). Our readings were not taken on an evenly spaced grid due to non-rectilinear grave arrangement. Since we could not place probes into the stone graves, we ran our lines between rows. This also contributed to the uneven grid spacing. The resistivity data were recorded in a field book and results were compared to baseline readings.

Electromagnetic Conductivity. The conductivity survey was executed with a Geonics EM31-D Non-contacting Terrain Conductivity Meter. The instrument was set in vertical dipole mode and held approximately 1 meter above the ground. We extended the evenly spaced grid beyond the relatively modern cemetery walls, adding one grid to the north and one to the west. The profile lines were two meters apart. The readings were taken every meter along each profile and were recorded in a data logger. For a technical description of conductivity surveys refer to Morariu et al. (1988).

Magnetometry. We used two different Geometrics magnetometers during our magnetometry survey. The Geometrics G-856 (a proton precession magnetometer) was used to take base station readings every minute throughout the day to determine temporal fluctuations in the earth's magnetic field. The Geometrics G-858 (a cesium vapor optical pumping magnetometer) was carried along profile lines at approximately one meter above the ground. The area surveyed with the magnetometer was divided into two separate grids. Readings were taken every half second, marked at every two meters along each profile, and were then stored in the magnetometer. The lines themselves were separated by one meter. For a technical description of magnetometry surveys refer to Bevan (1991). It should be noted that problems with the base station magnetometer compelled us to correct for daily fluctuations in the earth's magnetic field by alternate means. For each day of our survey, we took an average of the data values and subtracted that average from each point. Since there is no significant difference between the data from one day to another we believe our correction was successful.

Magnetic Susceptibility. We used a Bartington Magnetic Susceptibility Meter (model MS2) to measure the variations in the susceptibility of the topsoil. The probe type on this instrument was an 18.5 cm-diameter search loop MS2D. We set up one grid, which included the area in which gravestones are visible above ground. The lines were set up two meters apart and readings were taken every meter along each profile and recorded in a field book.

Field Gridding. The corners of each grid were surveyed by Mary Savina and Brian McAdoo using a TopCon Total Station and a Trimble GPS unit. These grid coordinates were then plotted on a map of the entire slave village area (see Sternberg et al., 2000). In accordance with this map the (0,0) point is at the lower left corner of all of our grids and contour maps.

RESULTS

Our research area covers two major sections: One section includes the enclosure of stone-marked graves by the twentieth century wall, and the other is the extension of our grids into the surrounding areas.

Electrical Resistivity. Resistivity lines 1 to 4 run directly between the rows of marked graves. The resistivity in these lines is lower than lines 5 and 6 to the west, which were surveyed where there were no grave markers visible on the surface. For a comparison of resistivity magnitudes, see Figure 1.

Magnetic Susceptibility. Susceptibility values in the area with limestone-marked graves were between 5 and -5, which is very low. These lows are graphed on the 38-m line in Figure 2 at 7 m, 11 m and 23 m. The limestone rocks gave low susceptibility readings as well. These lows are on the 22 m line in Figure 2 at 0 m, 15 m, and 25 m. Most of the readings in the southeastern section of our susceptibility grid are low and can be matched to stone-marked graves that were noted in our field descriptions.

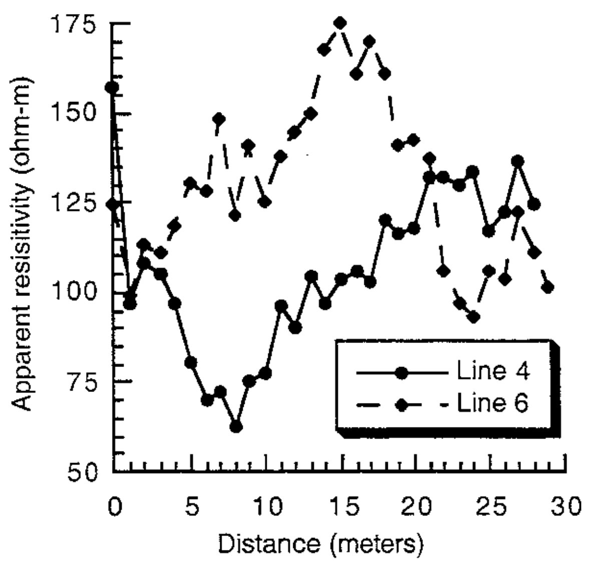

Figure 1. Representative resistivity profiles.

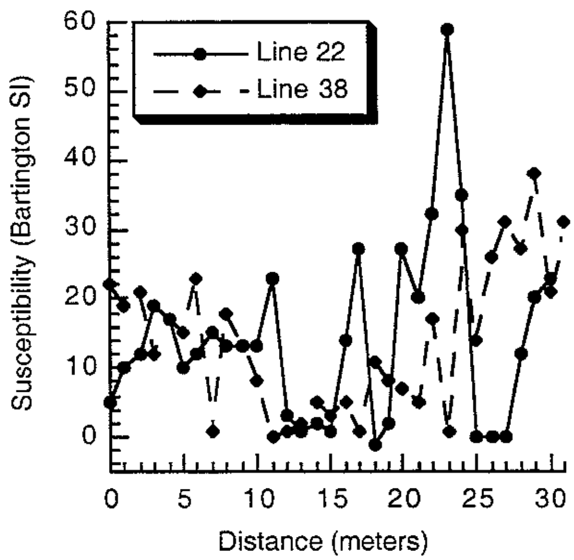

Figure 2. Representative susceptibility profiles.

Magnetometry. Our magnetometry survey produced seven major dipoles, which are labeled A-G in Figure 3. Other noticeable dipoles are marked with an x. Dipoles A-C are of the highest magnitude in the southern section. The values for each dipole range from 12 to 30 nanoteslas. These three dipoles seem to be oriented in a line running east to west. Dipoles D-F do not display as strong magnitudes as the first three and the range of values between them varies, but only slightly. They line up in a north-to-south orientation that is approximately perpendicular to the linear pattern formed by dipoles A-C. We estimated the depth of the sources of these dipoles using the half-slope and distance methods described in Milsom (1989). The depths of dipoles A-F are in the range of 0.9-1.1 m beneath the sensor. The northern section of the magnetometry grid did not show many major anomalies. It shows mostly mid-range magnetic readings. Dipole G is the only high-magnitude dipole located in the northern section of the map.

Other noteworthy results are in the area with no grave markers where our susceptibility readings show three susceptibility highs which match locations with magnetic dipoles A, B, and C. These magnetic dipole readings also correspond with the low conductivity readings. The susceptibility highs near a sinkhole at the northeast corner of our grid correspond to the magnetic highs in the same area.

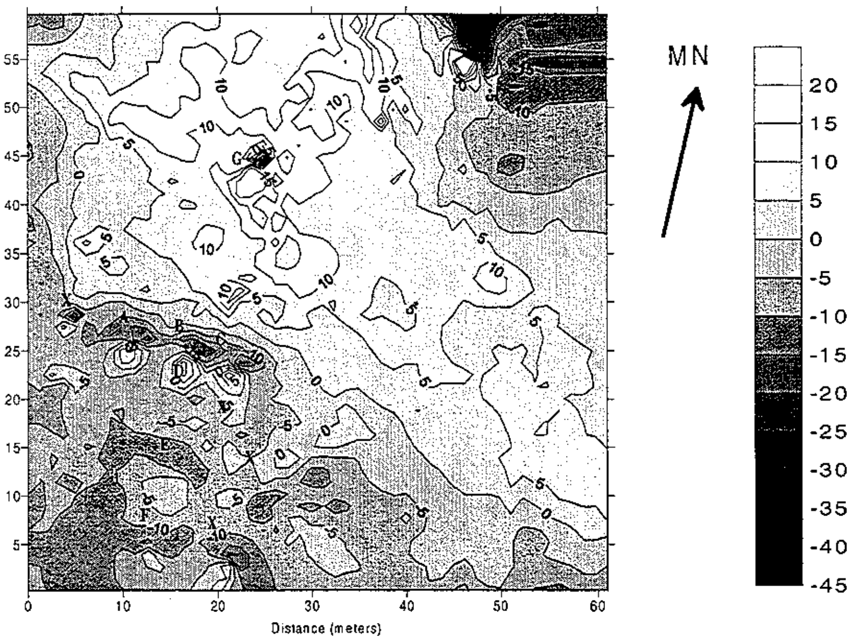

Figure 3. Magnetics contour map (nT) of cemetery area.

Electrical Conductivity. Our conductivity survey within the cemetery yielded distinct linear anomalies nearly coincident with magnetic lineations (Figure 4; lines indicate magnetic lineations of Figure 3). A comparison between our conductivity contour maps and our field descriptions revealed that some anomalies outside the cemetery grid are adjacent to trees, a phenomenon noted by Ellwood and Harrold (1993).

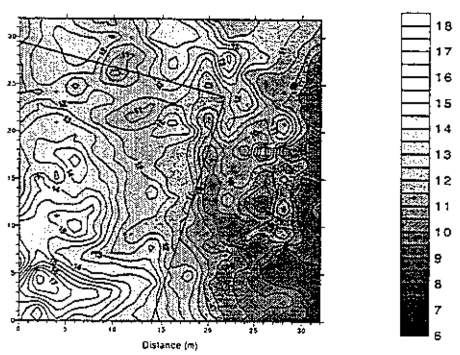

Figure 4. Conductivity contour map (mS m^{-1}) of cemetery, at same scale as Figure 3.

INTERPRETATIONS

Several graves in the cemetery are covered with cut limestone blocks, others are covered by piles of uncut rock, and there may still be others that are unmarked. We believe that the low resistivity readings in profiles 1 through 4 (which pass through the marked graves) are related to the graves themselves. The graves tend to pool water and may have caused these low resistivity values. The higher resistivity in lines 5 and 6 may be due to the the limestone rock. We decided not to use the geophysical signatures from the marked graves to locate subsurface graves in unmarked areas because of the relationship between low resistivity and the ubiquitous limestone.

We suspect that conductivity highs labeled 1, 2, and 4 on Figure 4 are caused by high water content around the trees noted in our field descriptions. We found that conductivity anomaly 3 in Figure 4 correlates with magnetic dipole F in the same area on Figure 3. It also correlates with one of the lowest susceptibility readings in our data. We are unsure of the cause for the anomalies in this area but we would recommend archaeological excavation of this spot.

We believe that the linear conductivity highs on Figure 4 may be caused by disturbances in the soil layering. Bevan (1991) and Fattah et al. (1993) found that such anomalies are often representative of burial shafts or pits. These highs correspond with magnetic dipoles A-F, dipoles marked with an x on Figure 3, an area of susceptibility highs, and a resistivity anomaly. The strongest anomalies in this area are those near magnetic dipoles A-C. Dipoles A-F are oriented east-west in rows. Bevan (1991), Fattah et al. (1993), and King et al. (1993) encountered similar grave orientations while doing geophysical research on historic-period cemeteries in various parts of New England and Iraq. The calculated depths of these anomalies are similar to the depth of burial in other studies where excavations were done (Ellwood, 1990). Because we found many correlations among resistivity, conductivity, magnetics, and susceptibility in this area we suspect that these subsurface features may be unmarked graves.

CONCLUSION

Our objective was to locate unmarked graves that could be studied for archeological/historical reasons. Magnetometry was the most helpful method in detecting possible grave locations. Conductivity and resistivity did not yield as many significant anomalies; therefore, they were not as useful for the detection of possible burial sites. The range of depth for the magnetic signatures in the area without grave markers is consistent with the range for burial sites at other locations. Moreover, the numerous correlations among conductivity, magnetics, and susceptibility in this area suggest that the subsurface features may be unmarked graves. Test excavation of some of these anomalies would allow better understanding and calibration of their meaning in this particular environment.

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