The application of field geophysics for reconnaissance of a Jamaican slave village and the surrounding area

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INTRODUCTION

As part of the 1999 Keck Geology Consortium Project at Marshell's Pen, Mandeville Jamaica, this study applied geophysics for reconnaissance around a known slave village (Sternberg et al., 2000). The property known as Marshall's Pen is located north of the city of Mandeville, Jamaica. Owned by Robert and Anne Sutton, this site now serves as a wildlife refuge and cattle ranch. During the end of the late 18th and start of the early 19th century the governor of Jamaica, the Earl of Balcarres, owned an estate known as Marshall's Penn in the parish of Manchester. Under his administration, the area was principally used as a coffee plantation, which would later define the location of the slave village. The slaves formed a community on the plantation where they lived and worked. The remains of this community is believed to be approximately 500 m east of the Great House.

On a preliminary inspection, near-surface archeological features were discovered several meters away from the known sites of the slave village and the cemetery (Sternberg et al., 2000). Subsequent geophysical surveys revealed that the village covered more area than initially proposed. The purpose of our investigation was to use geophysics to identify anomalies that could be related to cultural activity and to provide an assessment of the site's boundaries. An additional purpose was to assist in the interpretation of the geological characteristics pertaining to the area, some of which may be relevant to the location of the slave village.

GEOLOGIC BACKGROUND

Jamaica is an island country located in the northern Caribbean, about 145 km south of Cuba, and approximately 160 km west of Haiti, with an approximate area covering 10,991 km^2. The island can be divided into three distinct regions: the interior mountain ranges; interior valleys and coastal plains; and the dissected limestone hills and plateaus (Porter, 1990). Much of central and western Jamaica, including the Mandeville area, falls under the category of limestone hills and plateaus. Marshall's Pen is underlain by the Tertiary Newport formation.

Jamaican topography in the limestone regions is characterized by highly pitted karst topography producing numerous sinkholes and underground caverns (Porter, 1990). Karstification is responsible for the formation of the closely spaced, cone-shaped limestone hills present on the island, classically represented in the Cockpit Country north of Mandeville. At Marshall's Pen, a prominent sinkhole is located between several archeological areas present on the site, west of the slave village and northeast of the exposed areas of the cemetery (Sternberg et. al, 2000).

Extensive bauxite deposits on the island are found in the limestone regions. These hematite-rich soils are draped over the pinnacled weathering of the limestone.

MATERIALS AND METHODS

The geophysical equipment we used were the Bison model 2350B earth resistivity meter, Geonics EM 31-D non-contacting terrain conductivity meter with an Omnidata Polycorder, Geometrics G-858 cesium vapor magnetometer, and the Geometrics G-856 proton precession magnetometer. The first step in the survey of the archeological site was to lay out the grids over the areas to be evaluated. This was done using compasses and several 50- and 100-m-long tapes. The grids were oriented with respect to magnetic north. The lines of survey consisted of north-south oriented lines, which were spaced 5 meters as a compromise between the extensive area to be surveyed and the resolution desired. The area surveyed had an approximate dimension of 175 m x 125 m (see Sternberg et al., 2000). The objective of this broad coverage was to isolate clusters of cultural activity occurring between areas of sparse activity so that later excavations could be directed toward potentially more productive areas, an approach similar to that of Martin et al (1991) in north-central Texas. Using the global positioning system (GPS) and the total station, the grid was then located with respect to the known grids of the other groups (Hernandez et al., 2000; DeYoung et al., 2000) and relative to several base stations located on the site.

Baseline data were collected using the Geonics EM 31-D non-contacting terrain conductivity meter, the Bison model 2350 B earth resistivity meter, and the Geometrics G858 Cesium vapor optical magnetometer the same day each instrument was used in the field. Before any resistivity readings were recorded on any parts of the grid, baseline readings had to be conducted first so as to determine any day-to-day variations in our readings. This was important because moisture content in the soil, due to rainstorms, may change on a daily basis, potentially shifting our readings up or down.

The first main instrument, Geometrics G-858 cesium vapor magnetometer, automatically recorded data every 0.5 seconds and allowed the operator to mark the position every two meters. The pole with the magnetic probe was kept horizontal with respect to the ground, parallel to the line of traverse at a height of 0.9 m. The data obtained were corrected for magnetic field variations (diurnal drift) during the day, which had been measured with the Geometrics G-856 proton precession magnetometer. This magnetometer was anchored in an upright position to function as a magnetometer base station during the collection of data.

The second main instrument used to survey the grid was the Geonics EM 31-D non-contacting terrain conductivity meter. Readings were logged every meter along the traverses. The antenna boom had to be held in a horizontal position parallel with the line of traverse at a height of 0.8 m. The instrument was operated in a vertical dipole mode.

Besides surveying the gridded area with both the magnetometer and the conductivity meter, a small resistivity survey was conducted near the sinkhole. After establishing a small grid with an orientation of 10° west of north, the Bison model 2350B earth resistivity meter was laid out in a Wenner array. The outer two electrodes send the current into and out of the ground while the inner two electrodes measure the potential difference between them, which is then used to calculate apparent resistivity, measured in ohm-meters. Three resistivity survey lines were laid out through the sinkhole. One resistivity sounding measurement was conducted above the cave-like feature in the sinkhole. For line one (the northernmost line), three runs along the same profile were conducted with electrode separations (a-spacings) of 1 m, 2 m and 3 m. For the southernmost lines two and three, a-spacings of 2 m and 3 m were used. This information was important in order to give us an idea of the depth to bedrock and the electrical properties of the soil and bedrock, which would be used for interpretation of the resistivity profiles.

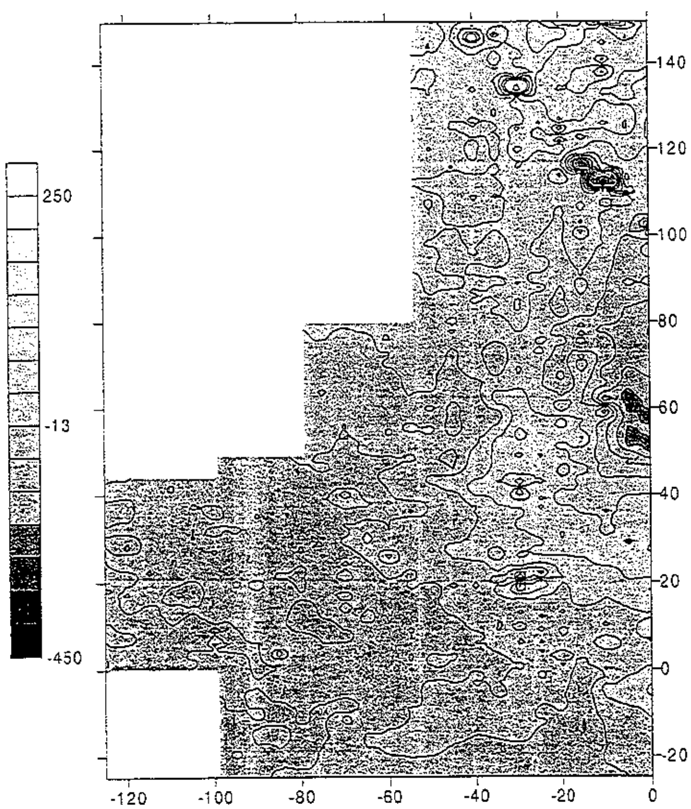

Figure 1. Magnetic contour map (nT) showing coordinate grid oriented with respect to magnetic north. Scale in meters.

RESULTS

Magnetometry proved to be the most beneficial method of collecting data. A linear series of anomalies oriented NW-SE in the

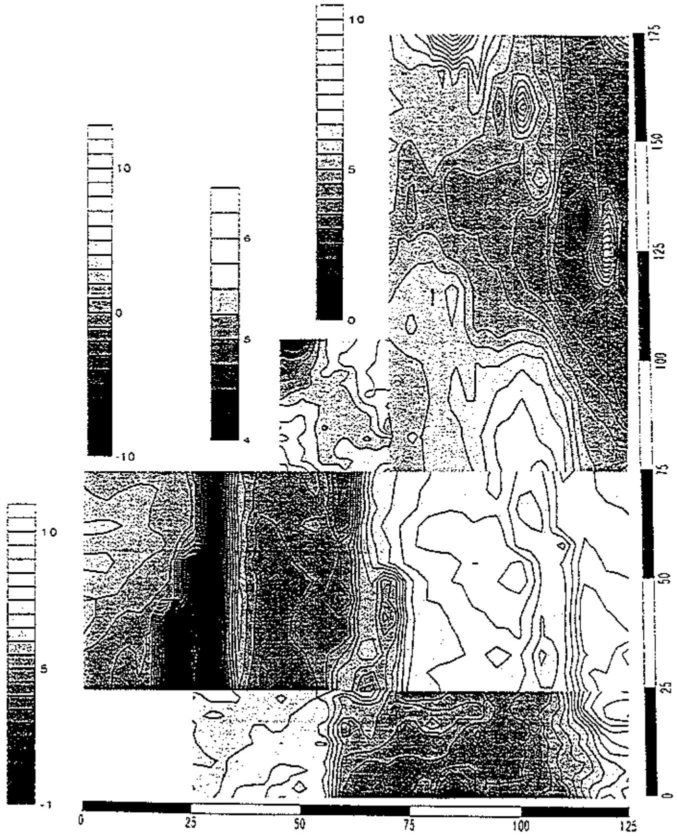

Figure 2. Conductivity contour map (mSm^{-1}) created by compiling four data files. Oriented with respect to magnetic north. Scale in meters.

northern portion of the grid (Figure 1) was due to the presence of a modern barbed-wire fence. Several other large, discrete dipolar anomalies were detected across the grid, suggesting smaller, possibly artifact-related sources. The anomalies located in the area of the cemetery were confirmed by more detailed surveys (Hernandez et al., 2000). There is a broader, generally NE-SW grain in the data, which nay be geologic in origin.

Conductivity measurements complemented the results obtained by the magnetic measurements. However, the resolution obtained by conductivity measurements did not reveal as many small anomalies, possibly artifact-or feature-related, as did the magnetometry method. The barbed-wire fence was clearly detected through conductivity measurements (Figure 2). There is a discrete anomaly at the southern edge of the map, and broader, generally N-S trending anomalies on the east and west sides of the cemetery. The large, linear conductivity anomaly in the southwestern part of the grid was not seen with magnetometry; however, there was evidence for EM-31 malfunction for that block of data.

The resistivity sounding done above the cave produced information about three possible layers of material below the surface. The first of the three layers was calculated to have a thickness of 0.5 meter, while the second layer had a thickness of two meters. The upper and lower layers had resistivities of 300 ohm-m and 450 ohm-m, respectively. These two values varied significantly from the middle layer value of 750 ohm-m. In addition to the sounding data, profile results through the sinkhole showed a wide range of resistivity. However, profile data collected just outside of the sinkhole indicated rather uniform resistivity in the underlying surface. The middle layer represents the cavity of the sinkhole; layers above and below are soil horizons.

DISCUSSION

Both the magnetic and conductivity surveys were aimed at detecting irregularities and anomalies with archaeological significance. Smaller-wavelengt anomalies detected by either magnetometry or conductivity may represent a wide variety of archaeological features or artifacts, such as burn areas, housing platforms, hearths and metal tools. Correspondence of anomalies within the village with such features was investigated by an archaeological team heading by James A. Delle after we left the site. However, even without knowing exactly what each anomaly represented, the surveys were successful in determining the localities of clustered anomalies. By doing so, suggestions can be made regarding human activity areas around the village.

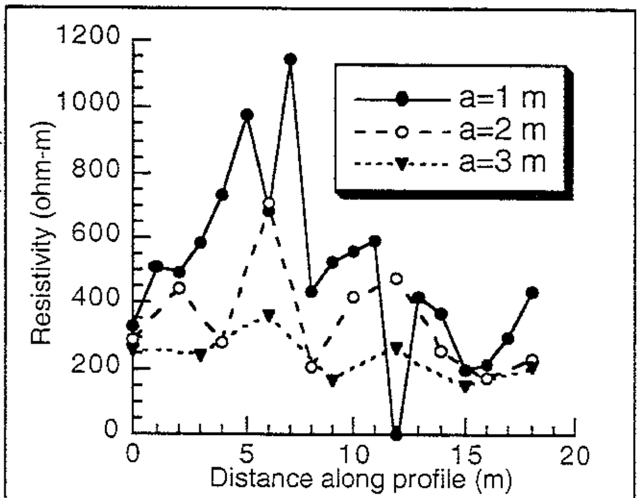

Figure 3. Varying resistivities along line 1 through the sinkhole.

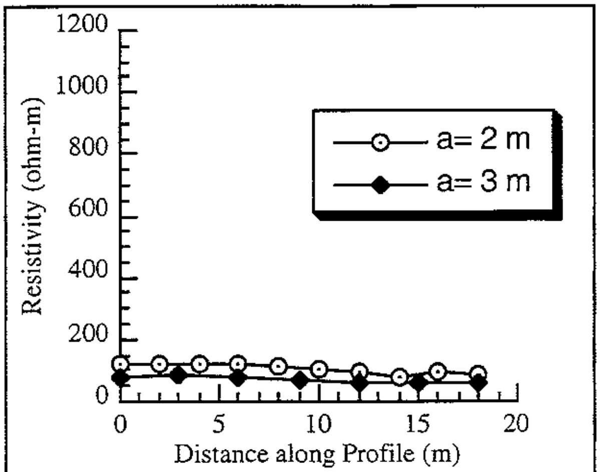

Figure 4. Uniform resistivities along line 3 outside of the sinkhole.

The resistivity results, along with broader trends in the magnetic and conductivity data, may reveal aspects of bedrock relief, soil thickness, and topographic effects that will help to understand the geologic setting of the site and natural factors that affected habitation of the area. The resistivity profiles were conducted in an effort to determine whether or not a fault or fracture zone was the primary cause of the sinkhole. The profile data within the sinkhole was very scattered and did not reveal a significant pattern (see Figure 3). However, the profile of line 3 outside the sinkhole was much more stable and uniform. This indicates that there is no prominent fracture present, and is therefore not the cause of the sinkhole (see Figure 4). Also, it was discovered after data collection that landowners filled the sinkhole with debris during the past few decades. This might partially explain the varying resistivities along the profile through the sinkhole.

CONCLUSIONS

Geophysical surveys are fast and economical. The conductivity and magnetometry methods allow coverage of large areas in a relatively short period of time. A disadvantage of the conductivity method is its decreased ability to record small features at shallow depths. Magnetometry serves well to identify smaller features generally related to cultural activity. According to Martin et al. (1991), the ability of a magnetometer to detect cultural anomalies depends on the geological and pedological properties of the site as well as the kinds of cultural features present. As buried features become more sharply defined in two and three dimensions, it is possible to make a morphological identification of the features indicated by the geophysical survey; this often allows for a clear distinction between natural and cultural features (Bevan, 1984). The combination of magnetics and conductivity integrated with resistivity methods served well in providing information that could facilitate future archaeological investigations of the Marshall's Pen site.

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