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Magnetic and GPR Survey to Identify Archaeological Features on Cacoal Site, Anajás River, Marajó Island, Pará, Brazil

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ABSTRACT

Two geophysical survey techniques, magnetometry and ground-penetrating radar (GPR) were used at the Cacoal archaeological site, in Marajó Island. Analysis of geophysical data shows that magnetometry produced good results, while GPR was less satisfactory, producing efficient results only in conjunction with magnetic data. These data were very helpful for choosing optimal areas for excavation, leading to the identification of subsurface remains (sherd concentrations and buried vessels) in areas of geophysical anomalies.

INTRODUCTION

Marajó Island, situated between the mouth of the Amazon River and the Atlantic Ocean is famous for its numerous and rich archaeological sites. The first known human settlement of Marajó - dating to ca. 3,250 years before present - dispersed over a large portion of the island. By ca.1,000 years ago, local culture development in Marajó reached a high level of social complexity, the so-called Marajoara Culture, characterized by monumental earthworks and a sophisticated ritual pottery. This culture can be compared in complexity and relevance with many New World complex societies on the eve of European contact (e.g., Circum-Caribbean areas).

Since the primary cultural remains are ceramics, the magnetic geophysical techniques are very appropriate to investigate them, due to the remanent magnetization exhibited by the burnt clay. Magnetic minerals present in ceramics produce small distortions (around 10 to 50 nT) on the earth's magnetic field, which permit the detection of these material buried at low depths (less than 2 m) in subsurface by magnetic measurements.

The application of geophysics as a tool to locate archaeological ceramics in Marajó Island (probably the first use of geophysical techniques for archaeological purposes in Brazil) began in 1977, when MSc student José Jerônimo Alves, supervised by Professor José Seixas Lourenço, carried out a research on Teso dos Bichos archaeological site, in Marajó (Alves 1979, Alves and Lourenço 1981, Roosevelt 1991). In this early work, both resistivity and magnetometry surveys were used. Later, archaeological field work in 1983-1985 at Teso dos Bichos, conducted by researcher Anna Roosevelt, also involved extensive geophysical research, including resistivity, magnetometry, electromagnetics, and GPR (Roosevelt 1991).

In our work (11/27 to 12/12/1998) we did magnetic and GPR measurements on Cacoal archaeological site located in Anajás county, in center of Marajó Island (Figure 1). Measures were first analyzed in the field and anomalies were checked by excavation revealing significant archaeological features.

GEOPHYSICAL METHODOLOGY

A proton free-precession magnetometer (model GSM-19) was used to measure the magnitude of earth's magnetic field at points established on a 4 m grid. The magnetometer sensor was maintained at a constant height of 0.5 m above the ground. To correct temporal variations in the earth's field, measurements at a single reference station were repeated each 30 minutes. Magnetic measures are displayed on the map showed in Figure 2.

Ground Penetrating Radar measurements were done with a RAMAC device with 400 MHz antennas. The transmitter and reception antennas were maintained at a constant distance of 0.60 m from each other, with sampling every 0.02 m. The profiles partially covered the magnetic profiles and their placements were determined by the previous analyses of magnetic data and archaeological surface observation.

DATA ANALYSIS

The magnetic map shows four primary anomalies named A to D in Figure 2. The anomaly A is bounded by L130 and L142 and is 48 m in length, extending from N140 along a South/North axis; the anomaly B is rounded (about 4 m in radius) and centered over the N152 L158 point; the anomaly C is also rounded (about 4 m in radius) and its center is at N188 L174; the anomaly D is elongated and is located between L186 and L198, extending from N140 to N192.

The GPR profiles showed anomaly features that can be related to magnetic anomaly sources, as can be observed on the GPR profiles taken on magnetic anomaly B and on part of magnetic anomaly D (Figures 3 and 4).

In general, the radar wave reflections became more attenuated after 40 ns two-way time, indicating buried clay material at depths related to this time (the archaeological excavation in the site revealed the increase of clayed compound in the soil after about 0.40 m).

GPR profiles, when taken alone, do not produce reliable and precise information about archaeological remains distribution in Cacoal site. On the other hand, when correlated to magnetic data, GPR can be useful to provide details like depth and width of the magnetic anomaly source.

ARCHAELOGICAL EXCAVATION

Five small areas of the site were chosen for archaeological excavation, three of them to investigate anomalies indicated by the geophysical survey (anomalies B and D described above).
In the center of anomaly B charcoal and sherds were found in large quantities from a depth of 0.10 to 0.25 m with a concentration between 0.20 and 0.25 m.
The area defined by anomaly D was excavated at N146, L186 to L190 and at N154, L188. In the first location excavation revealed scattered sherds in all levels and two buried bowls with charcoal; the bowls were placed in a hole hollowed out of clay-rich soil at a 0.40 m depth. In the second location nothing was found.
Samples of charcoal and pottery are being dated by radiocarbon and termoluminescence methods. Ceramics and soil samples are being studied at Museu Paraense Emílio Goeldi and Universidade Federal do Pará..

CONCLUSIONS

The magnetic anomalies were very useful to define specific areas of cultural activity in the archaeological site.
The GPR measurements, as a unique method, are less effective to define exact positions of cultural features. However, GPR helped to refine magnetometric evidence, providing further definition regarding geometry and depth of anomaly sources.

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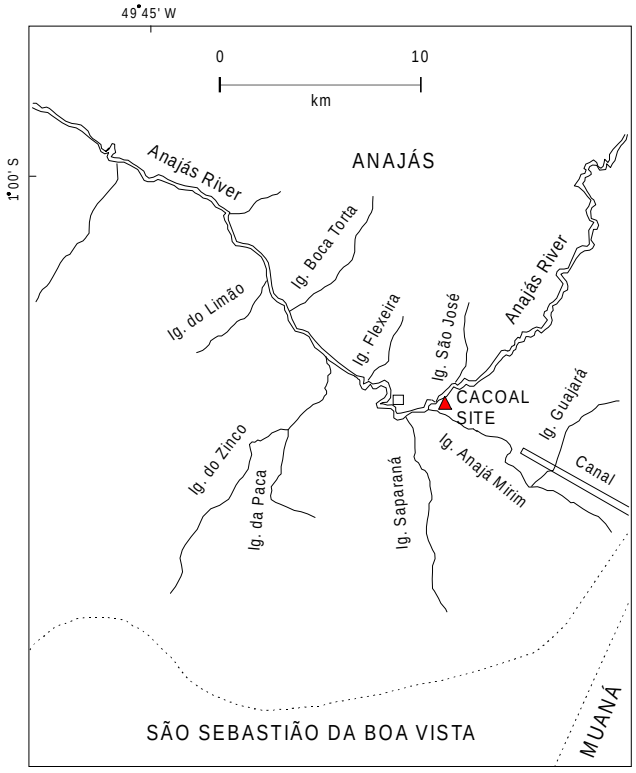

Figure 1 - Location map for Cacoal site. The red triangle marks the site position.

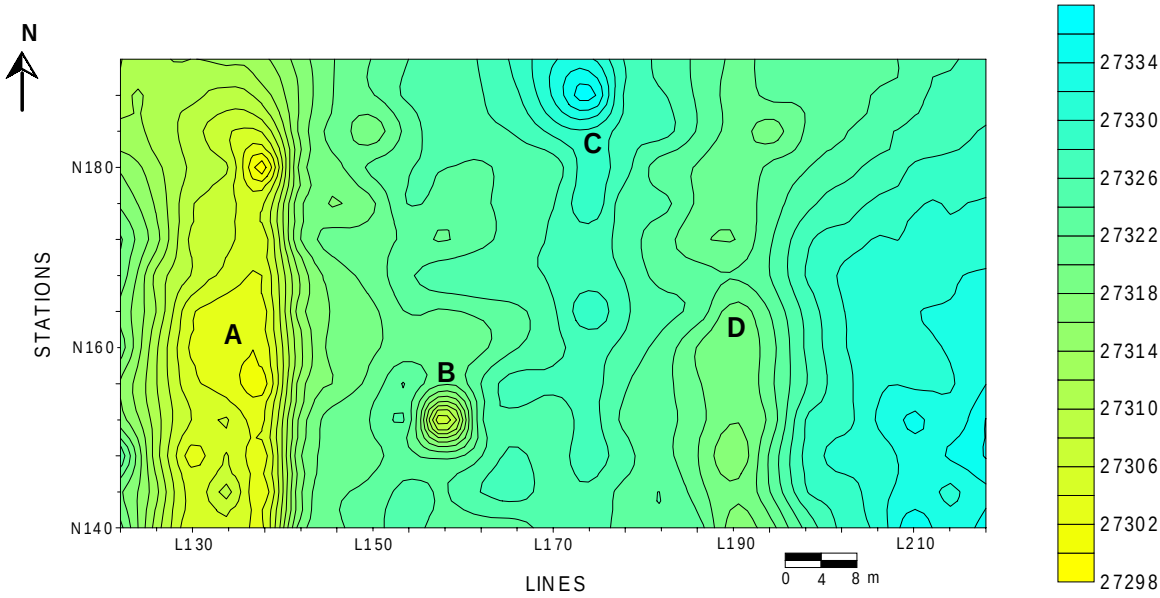

Figure 2 - Magnetic Map of part of Cacoal site.

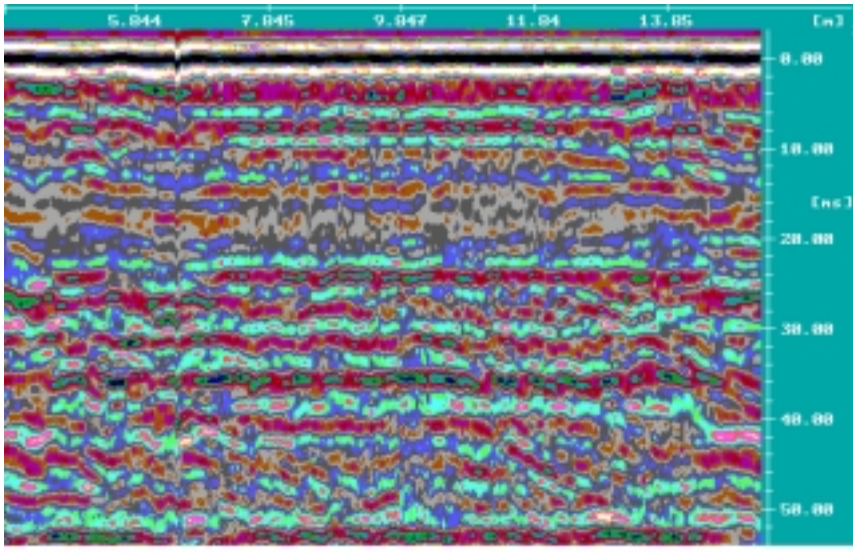

Figure 3 - GPR profile on part of line L158. The region bounded by positions 7-12 m and 12-20 ns shows anomalous features probably related to magnetic anomaly B. Zero position is at station N140.

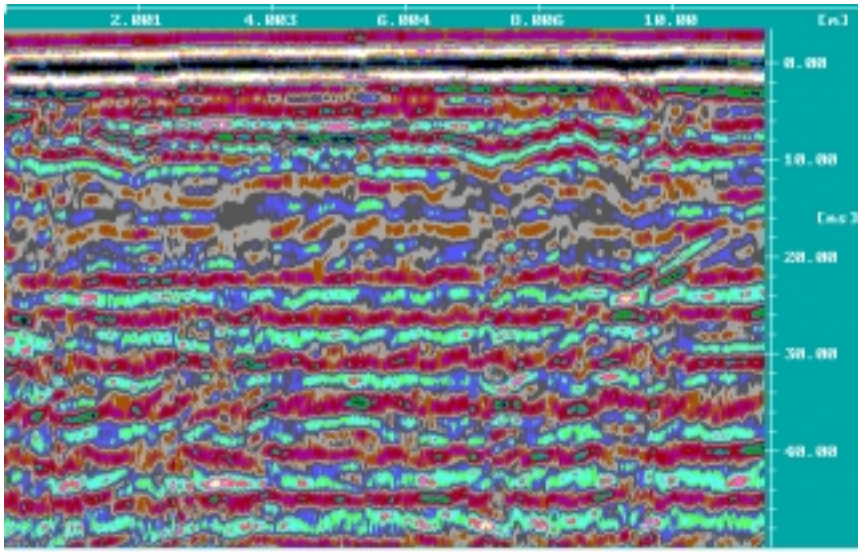

Figure 4 - GPR profile on part of line L190. The region bounded by positions 3-10 m and 10-20 ns shows anomalous features probably related to magnetic anomaly D. Zero position is at station N140.