The use of GPR on Pseudo-Archaeological Site in UFMG

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Abstract

Ground-Penetrating Radar – GPR (Davis and Annan, 1989) is a technique to image the subsurface soil in high resolution, which allows one to identify some subsurface structures and facies. The wave propagation of radar is controlled by the survey frequency and the electric environment subsurface properties. GPR was used on Pseudo Archaeological Site in the Universidade Federal de Minas Gerais (UFMG) to study what could be the appropriate antennas and settings to survey an archaeological site. Ground-Penetrating Radar emits radios waves ranging from 10 to 3,500 MHz. For our research were used antennae of 200, 500 and 800 MHz, thus, been possible a range of results to compare and notice what could be the appropriate frequency to be used in archaeological researches. The data processing sequence was: dewow, set time zero and remove background. After, analyzing the hyperboles presents on the radargram we could find the velocity and make a depth conversion locating properly the response from the objects buried. Results of GPR agree with the topographic coordinates previously made, and have helped to identify the features observed in the radargram and its corresponding object.

Introduction

The electromagnetic method can be applied at geotechnical and archaeological survey to localize buried objects (Kearey et al., 2009). Archeological studies on Ilha do Marajó (PA) Roosevelt (1988) applied the GPR prospection in indigenous tomb; however the radargram does not present a good distinctness and resolution because of absorption EM-wave by the organic superficial ground of investigated sites. The depth penetrating of an electromagnetic field (Spies, 1989) rely on the frequency and electric conductivity of the environment which the wave propagates. Controlled sites already were studied by Borges (2007) in Brazil, using a gravels to simulated a contour of a remains of ancient fire, and Hildebrand et al (2002) treating about pottery vessels buried and a wooden crypt buried with a pig inside, respectively, both of them to simulated a pseudo archaeological site.

Our Goal to create and developed this project were to understand better how the GPR method can be integrate with the archeological studies in a way that the results of GPR may be a guidance for further archaeological researches, focus on the interpretation the features observed in the radargrams and the corresponding buried pieces.

The Pseudo Archaeological Site in Ecological Station of UFMG is located in Belo Horizonte, Minas Gerais, Brazil.

(Fig.1): Study area localization in UFMG, Belo Horizonte, Minas Gerais (Aranha et. Al. 2011).

The Ecological Station is an urban conservation area with one hundred and fourteen hectares of vegetation that consists of typical semi-deciduous forests and savanna. It also presents a variety of native plant species. This scenario is ideal to test the behavior of the remains buried in front of the biome that is found (EC-UFMG).

Besides the soil of the region is made of sandy and clay sediments, the most common class of soil in the area belongs to the group of Cambisoils. The site was made in a controlled way to further in the research we know where the objects could be. The hole dimensions are approximately (3 ± 0.2) meters X (3.2 ± 0.2) meters and profundity is about (1.2 ± 0.2) meters. After the hole opened the objects was been placed carefully in different places and profundity layers (Fig 2). While the objects were put on the ground the topographic coordinates were

acquired. These objects are break potteries, bones and empty pottery vessels or filled which cow bones and clay to simulate a real indigenous

There were two roots of trees at the edge of the hole that goes into the hole but which were not removed because could be interesting to know the outcome of this situation too (Fig 3). When all of objects had been buried and the hole was completely cover grass was planted over the study area (Fig.4).

(Fig.3): The roots on the left side of the picture and a lying down pottery buried.

(Fig.4): The Grassy area. grid is represented by dotted

Further in our study we will need references to GPR lines to compare with topographic coordinates and see the outcome for every object, thus references in grid was made on study area. Eleven parallel lines spacing 0.5 meters perpendiculars with another eleven parallel lines also spacing 0.5 meters build the references grid (Fig.4).

Method

The GPR by Mala Geosciences - RAMAC was used to acquire data. For a satisfactory range of results, which allow comparison between them, were used 800 and 500 MHz shielded antenna and a 200 MHz unshielded antenna. Although the site were in a conservation area, it is inside of a big city where there are many types of interference that can produce EM-noise, thus, had both types of antennas (shielded and not shielded) is good to observe how much the shielding preserves the data.

The acquisition method used was the common off-set where the distance between the transmitter and receptor's antenna was constant, while the acquisition system was transported along the lines thereby obtaining a profile of reflections versus position. Transmitter antenna position was parallel to each other and to the ground. The spacing between each trace acquired in the profiles was 0.05 meters to improve the lateral resolution. it was used the technique of multiple acquisition at each point, i.e. 32 waves emitted to the ground in a short period of time at each point of acquisition to increase the signal to noise ratio, which, in theory, improve the quality of the signal (Annan, 1992).

The first antenna frequency used was 800 MHz; the time window used was 45 ns. We then use an antenna frequency of 500 MHz with a time window 64 ns. Both antennas were shielded. After the antenna of 200 MHz unshielded was used and its time window was 80ns. The profiles had a satisfactory quality and there was a low interference of external factors. The set time zero processing was used thereafter Dewow filter to take out of data the low frequency, remove background which remove the coherent noise and through hyperbole's velocity we made to apply the depth conversion. Thus we could analyze the GPR results about distance and depth for which frequency.

We took two profiles of which frequency, one in x coordinate and another in y coordinate. All profiles in x for frequencies of 800, 500 and 200MHz are about the same survey line and the same argument was assumed to survey lines in y coordinates.

We choose the third line in X direction and the seventh line in Y direction. The spacing between lines in both directions is 0.5 meter (Fig.5b and c). By a previous topography study on site we know where the objects are buried, so we can verify if the GPR can show the location of which object.

A map indicating what kinds of objects was buried, a picture with coordinates X and Y, and draw represent the relation between the buried objects and the GPR line is showed in the Figure 5a.

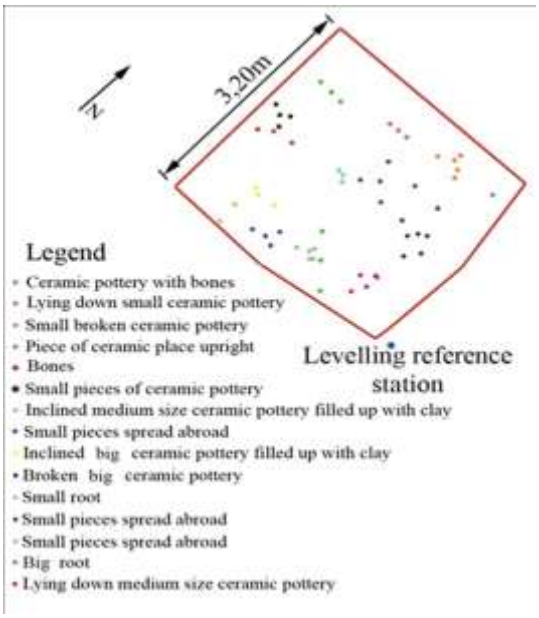

Figure 5a – Map of pseudo- archaeological site (Aranha et. Al. 2011).

Figure 5b. Photo showing The X and Y coordinate of Pseudo Archaeological Site

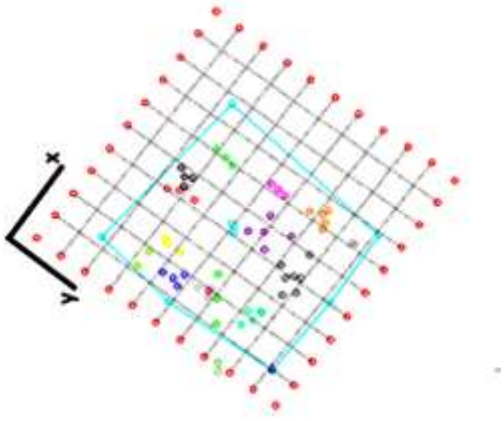

Figure 5c. The X and Y coordinate of Pseudo Archaeological Site

Results

We show the results from 800, 500 and 200 MHz in "X" direction in figures 6(a, b, c) of the line 3. It's possible to observe the difference among the three profiles. The profiles obtained with higher frequencies 800, 500 MHz had a better vertical resolution. Also its possible see the difference about the length of time coordinate because of different time window used. The third line in "X" direction lies over the buried pieces: the bones, some ceramic fragments that were spread shallower than the bones, and a big pottery vessel. The bones are about 2 meters in "x" coordinate, the pieces of ceramic away from 2 meters to 2,4m and the big pottery vessel is about 3,0 meters also in "x" coordinate. Nearly to 0.8 meters in depth and 3 meters in "x" coordinates all of X-profiles show a hyperbole that can be correlated to the big pottery vessel. In the radargram of 800 MHz antenna we can observe just below the direct wave, about 2 meters distance and from 0.1 to 0.4 meters of depth, some discontinuities can be correlated to fragments ceramic. The feature interpreted as bones appears about 0.8 m of depth and in the distance of 1.5 to 2 on the radargram obtained with the 500 MHz.

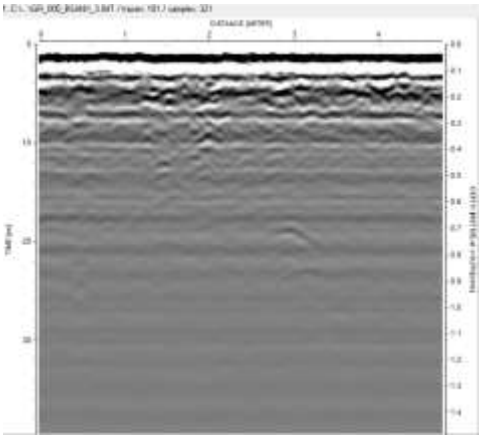

Figure 6a. Radargram obtained with 800MHz antenna in X-direction

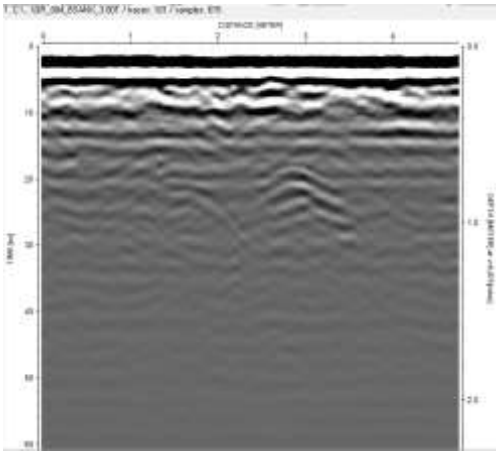

Figure 6b. Radargram obtained with 500MHz antenna in X-direction

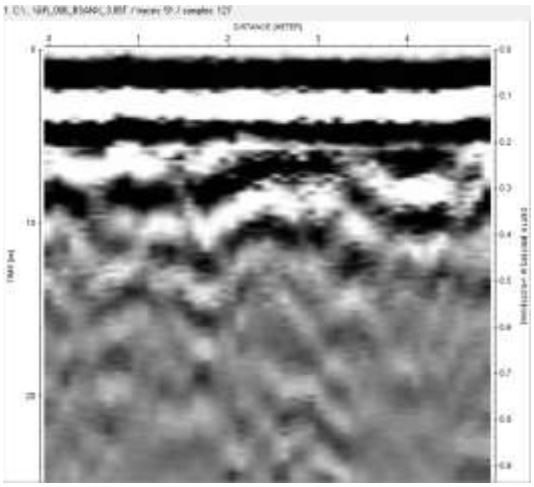

Figure 6c. Radargram obtained with 200MHz antenna in X-direction

The radargrams obtained from 800, 500 and 200 MHz antennas in Y-direction is showed in figures 7(a, b, c). For these GPR lines, which is the seventh in Y-direction, the survey cross over a big pottery vessel in the distance range from 1.5 meters to 2 meters; and from 2.5 to 3m it crosses over a small lying down pottery vessel; and from 3.5 to 4.0m a small ceramic fragments and finally at 4.5m a piece of ceramic fragment upright. In these profiles ones can notice two strong amplitude reflections. The first occurs on the distance of 1.4 m and 0.6 m depth. This hyperbole represents the reflection on the big pottery vessel. For the second event the hyperbole appears about 3.4 meters of distance and 0.6m depth. This event can be correlated to the small broken ceramic pottery. It can be observed on the radargram obtained with 800MHz antennas, many short reflectors in a range of 0.1 m to 0.4 m of depth and from 1 to 3.5m of distance, and it also can be observed on the radargram obtained with 500 MHz antenna. Meanwhile on radargram obtained with 200 MHz data the resolution is lower and it became hard to distinguish these small reflectors.

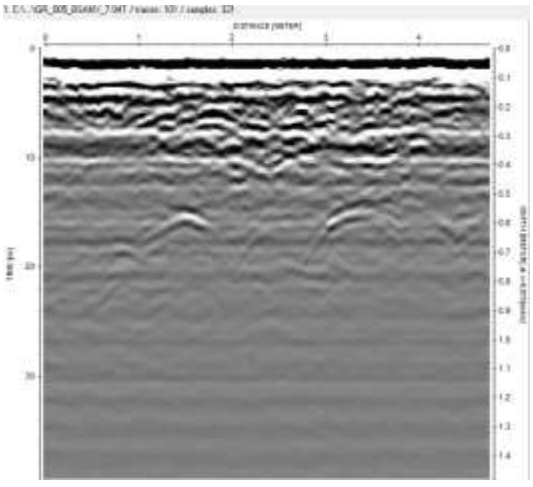

Figure 7a. Radargram obtained with the 800MHz antenna in Y-direction.

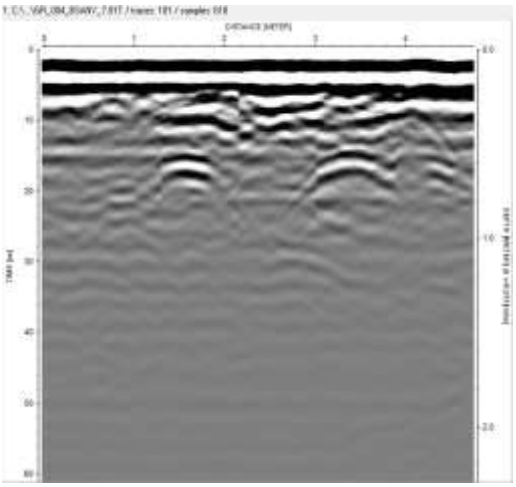

Figure 7b. Radargram obtained with 500MHz antenna in Y-direction

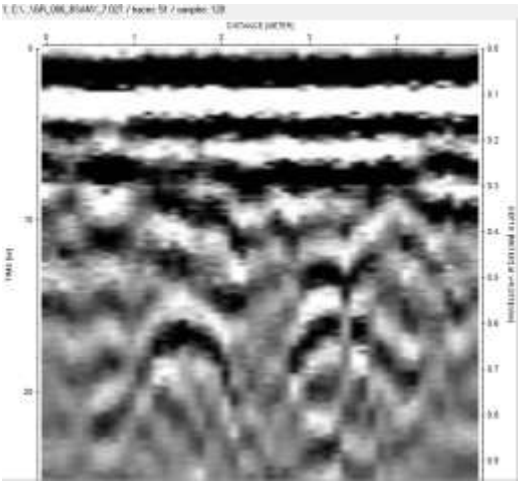

Figure 7c. Antenna 200MHz in Y-direction

Conclusions

The pseudo-archaeological site allows one to distinguish the reflection pattern of different pottery vessel buried. And also, allows one to check the interpretation with profile obtained in one direction with other obtained in a perpendicular direction, with different reflection pattern. So, it allows the interpreter be aware of the different types of pattern reflection related to the orientation profile concerned with the buried object. Other possibility that can be observed is that with a change of antennas set it is possible to combine the results obtained at different depths to increase the accuracy of interpretation GPR data from an archaeological site.

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