Location of forensic target with ground penetration radar (GPR) at the federal police controlled Site (SITCRIM)

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Abstract

The Controlled Site of Criminalistics (SITCRIM), built in the National Institute of Criminalistics, Federal Police of Brazil (INC / DITEC / PF), has the purpose to create a pattern for buried crime evidences, although the focus of the work is in the presence of a colony of ants that emerged after the creation of the test site. This study shows the best results of GPR in a small area of SITCRIM, where an anthill, found in an area of 5x4m, is studied. We acquired the data with an IDS GPR, and processed then in ReflexW software. We consider the results satisfactory, since the anomalies were in the presence of bioturbation at the site. Thus, the tag used confirms the efficiency in mapping the target mentioned above, which makes the method a tool for locating buried targets.

Introduction

The present paper shows the application of an electromagnetic method, GPR (Ground Penetrating Radar), to locate subsurface structures of an anthill. The GPR method is widely used because of its non-destructive, non-invasive character, low operating cost and rapid field surveys, making it suitable for mapping structures and objects presents in the subsurface. Oliveira (2008, p.8, after Reynolds, 1997).

At the studied target, there are several items dispersed and buried at red latosol in an area of 25x25 m^2, and after 8 years of construction, with the soil already settled, some anthills appeared, being the selected one seen superficially only a little. The procedures of acquisition were similar to those used in forensic investigations. The **Figure 1** shows the area of the SITCRIM, where the target is located.

Figure 1 - Location of the Controlled Site of Criminalistics (SITCRIM) highlighting the area where the target was located (adapted from Blum & Russo, 2012).

Method

By the development of Forensic Science occurs the integration of knowledge and techniques of various scientific specialties, such as Geophysics. It`s responsible for direct studies (probes), and indirect (geophysical methods), which can be active (measurement of the subsurface response to electric, electromagnetic and seismic energy) or passive (measuring the magnetic, gravitational and electric field) in the subsurface. The method used in this paper will be an indirect active, which uses electromagnetic waves with certain frequency range. Its use began in the late 1920s, and in Brazil, its application began around 1985 for geological purposes (Porsani, 1999).

As a physical principle, it is generated through a small high-frequency pulse, which energy is repeatedly radiated into the ground by a transmitting antenna. The propagation of the signal and the depth of reach of the electromagnetic waves depends on the signal frequency and the electrical properties of the materials, such as electrical conductivity, dielectric permissiveness and magnetic permeability. A part of the reflected signal is a variation of these properties (Rodrigues, 2006).

As previously stated, the object of study is an anthill. The creation of structures such as tunnels and chambers that composes an anthill is collectively coordinated by simple behavioral acts of excavation of the ants, that based in the simple removal of soil with the jaws (Camargo et al., 2013, p.1, apud Cassil et al., 2002). The way that the nests are built allows the air to pass through the tunnels and not to enter rainwater. The anthills can have many entrances, which lead to the tunnels under the earth. They interconnect different chambers or even lead to nowhere, to confuse possible invaders (Tim, 2015).

In this hand, it is possible to know the electrical properties of the subsurface studied. According to (Porsani, 1999) the electrical conductivity of the air is 0 mS / m, second (Schön, 2011), the dielectric permittivity corresponds to 1 C^2 / N.m^2 and the speed of the electromagnetic waves is equal to 30 cm / ns.

After the 8 years of creation of SITCRIM, there have been several anthills formed over the years. In order to verify any superficial evidence that indicated an abnormality, the team identified the place and delimitated the area to use the equipment. **Figure 2** illustrates the equipment used in capturing the data. **Figure 3** shows the data being acquired in SITCRIM.

Figure 2 – Picture of the equipment Opera Duo (IDS Georadar) used in data capture.

Figure 3- Photo of the data being acquired in SITCRIM by one of the authors.

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After the acquisition, the data were processed in specific software for GPR data (ReflexW software, version 7.5).The processing steps were applied according to the characteristics of the data and depends essentially on the interpreter. In addition to the two-dimensional processing, the GPR data set performed with the same antenna allowed the generation of a three-dimensional data set.

Results

As a result, 102 GPR lines were acquired in an area of 5x4 m² in SITCRIM. The equipment used was a GPR system, model Opera Duo (IDS Georadar) with dual frequency antenna, with 250 and 700MHz. It is known that as the higher the frequency, the lower is the depth range and higher the quality of the data acquired. Thus, the frequency of 250MHz was disregarded. On the day before the acquisition the precipitation was 0 mm, however on the day of acquisition it rained a little, therefore the soil was saturated, thus the speed used in the apparatus was 0.10 m/ns. The spacing between the lines was of 0.05 m. In the data analysis, the ReflexW program (developed by Sandmeier, K.J., 2018 - Sandmeier software, Germany) was used. In the process, static corrections, dewow removal, spurious noise removal, decay energy gain, FK filter, FK-type inversion (stolt) were performed, and electromagnetic velocity was obtained in the medium through of the size measurement of one of the hyperbols of one line (value 0.0885 m / ns). After the 2D analysis, the data were interpreted in 3D.

In the bi-dimensional analysis, three significant figures were identified in the study. In **Figure 4**, it's possible to see the results obtained on the acquisition through ReflexW. After analyzing the anomalous behavior, we've observed a reflectoranomaly line of approximately 0.10m, which perpetuates in practically all acquired lines. Item L22 represents line 22 of the survey, which is about 1.1m from the walk. Item L64 represents line 64 of the survey, which is about 3.2m from the walk. Item L101represents line 101 of the survey, which is about 5m from the walk. The three items have three parameters in their section being, from left to right, time (ns), distance on the walk (m) and depth (m).

The item L22 has two hyperboles that are more pronounced. The first one being closer to the surface at 0.15m depth that extends from 0.55m to 1.15m of the walk. Immediately below, is the trace of approximately 0.10m thick and in the right corner, the second hyperbola, with 0.96m of depth that extends from 1.96 to 5.00m of the walk. This hyperbole surges in line 13 and disappears at line 32. The item L64 has a more pronounced hyperbole at 0.74m depth that extends from 2.5m to 5m in the course, this hyperbole surges at line 57 and disappear at line 84. On the left side of these hyperboles, three more subtle hyperboles are below the perpetuating line, and during these 27 lines, they vary considerably in intensity. The item L101, has two more hyperboles, both are below the most demarcated line. The first hyperbola is 0.82m deep that extends from 2.5m to 5m from the walk. In the middle part of the section, from line 80, a hyperbole begins to appear and until the last line it has been expanding.

It has 1.75m of depth and extends from 0.5 to 2.95m of the walk. The three-dimensional analysis was performed from the two-dimensional analysis, in which it was possible to visualize with more prominence the anomalies already highlighted in 2D, however it was not possible to place it in the study, due to its unusual format for image, in this specific case.

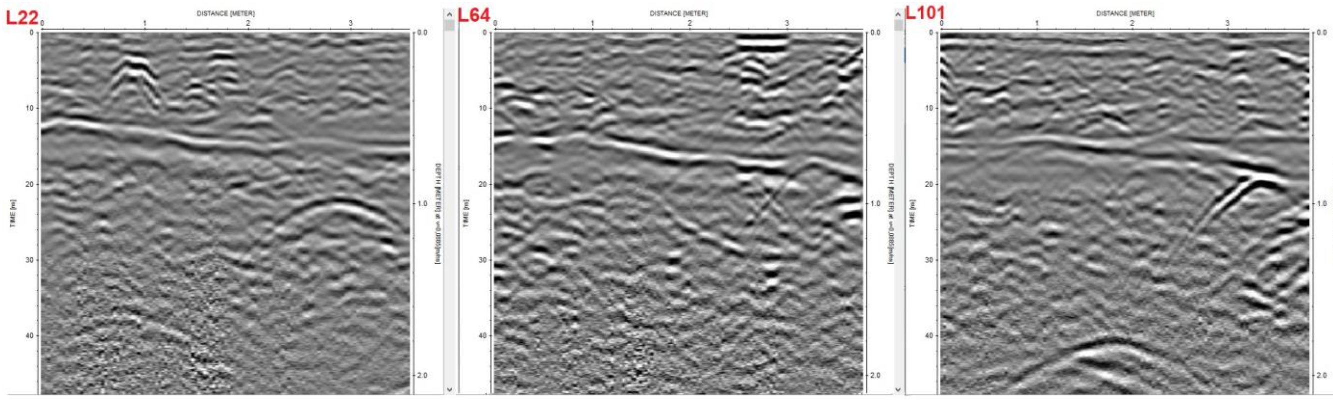

Figure 4 – Radargrams obtained through ReflexW software.

Conclusions

As mentioned in the "Results" section, item L22 has two hyperboles that are more pronounced. The first one closest to the surface to 0.15m depth that extends from 0.55m to 1.15m of the path, where it may probably contain a chamber of the anthill. The second hyperbola, with 0.96m of depth that extends from 1.96 to 5m of the path, where probably may contain another chamber. The item L64, has a more pronounced hyperbole at 0.74m depth that extends from 2.5m to 5m in the walk, which is an anomaly in depth and walking similar to line 22, which may be the same camera. It was observed on the left side of the hyperbola, three more subtle hyperboles are below the perpetuating line, and due to the variation of intensity of them can indicate that this line is a tunnel that connects the camera. The first hyperbole of item L101 may also represent the same camera as item L22 and L64. And the second may indicate a larger chamber than the first one, because of its increasing depth. This constant line may also suggest a hint of ruffled soil.

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