Use of seismic refraction and resistivity in bauxite deposit in the region of Barro Alto – Goiás, Brazil.

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Abstract

In this work we used the geophysical methods of seismic refraction and resistivity in a mineral deposit of bauxite in the region of Barro Alto, Goiás. The goal was to define the contact between the layer of bauxite and the crystalline basement composed mainly of anorthosite. The main problems in this study were the complex geometry of residual concentration deposits and the gradational interface that occurs between the anorthositic rock and the layer of bauxite. This gradational interface can decrease the contrast between the layers making it very difficult to ascertain it.

Introduction

Lateritic bauxite deposits account for approximately 90% of the world production of aluminum. These deposits are formed due to the weathering of rocks rich in aluminum, mainly in tropical grounds. The concentration of aluminum occurs by the leaching of mobile elements and enrichment of residual aluminum. Bauxite is the name given to rocks that have more than 45.5% of aluminum weight in its composition, and no more than 20% of weight in iron. Bauxite is composed of a mixture of grains of fine to very fine particle size that commonly include minerals such as gibbsite, boehmite and diaspore. Lateritic profiles of bauxite in tropical regions generally occur in the form of layers. (Retallack, 2010).

The study area is a deposit of bauxite in the region of Barro Alto (Figure 1), which is located in the Tocantins Province, between the São Francisco and Amazon Cratons (Almeida 1977).

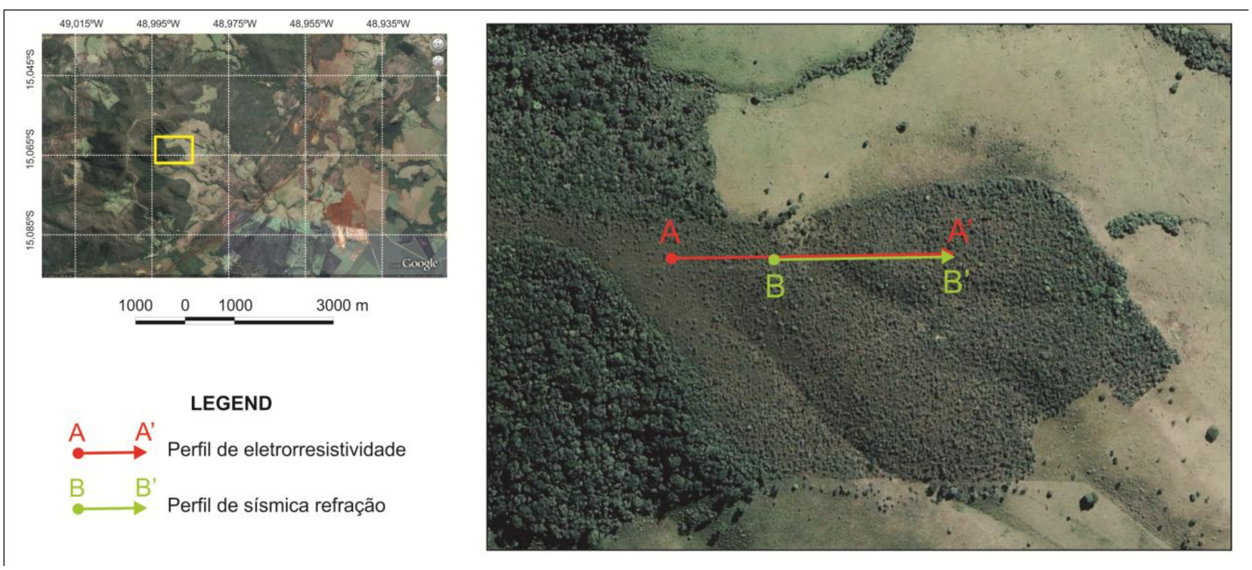

Figure 1 – Location of the study area, on the region of Barro Alto – GO.

The deposit is situated in the Barro Alto Mafic-Ultramafic Complex, characterized mostly by pyroxene, anorthosite and gabbro (Fuck 1994). The anorthositic rocks are the main responsible for the high concentrations of aluminum in the layers of bauxite. The deposit studied is in evaluation stage, therefore it is necessary to model the ore body. Until now this has been made with boreholes to estimate a volume for the body. With the use of indirect methods (geophysics) is expected to map the ore body with a reduction of costs during the mapping of the deposit. The contrast between the layers is essential for the geophysical methods used in this work. The residual concentration type deposits, such as bauxite, has a highly irregular and complex morphology and can cause problems in data acquisition. In this context, the methods of seismic refraction and resistivity were applied in order to define the interface between the bedrock and the mineralized portion in the study area.

Metodology

Seismic

The seismic refraction follows the principle of wave propagation in elastic medium. Artificial sources generate seismic waves that travels through the underground layers, which are detected by sensors (geophones) fixed on the ground. From the measurement of the travel time of these waves it's possible to ascertain the velocity of the medium, and also to calculate the layer thickness. To use this method it is necessary that the seismic wave velocity of the layers increases with depth, and it is a prerequisite for the occurrence of critical refraction, which allows the return of energy to the surface. A possible problem during the use of this method is that the source may not produce seismic waves with enough energy to reach the farthest geophones, due to attenuation of the medium. In order to overcome this issue, normally is used a more powerful source, like explosives. In this work were used two different types of source, sledgehammer and explosives.

In this work were made two seismic lines 115 meters each, generating a total profile of 230 meters in a previously studied region of the bauxite deposit, where a grid of boreholes were previously made. The seismograph used was a Geode (Geometrics Instruments) with 24 channels. We used geophones with dominant frequency of 14 Hz and equally spaced five meters.

In the first seismic line (0 to 115 meters) the seismic source used was an explosive like ANFO (Ammonium Nitrate Fuel Oil), with a load of one kilogram at each shot point. For the same profile, data were also acquired using an eight kilogram sledgehammer as a seismic source in order to compare them. In each shot point, were hammered 30 times, which the signal was stacked in order to improve the signal. In the seismograms using the explosive, we observed a significant decrease in the level of data noise, however, the pulse generated by the explosion was very broad, turning difficult to define the first break (Figure 2a). We believe that this pulse stretching is related to the detonation velocity of the explosive, suggesting that this is not an ideal source for seismic surveys, which require impulsive sources. In the seismograms using a sledgehammer (Figure 2b) one can observe that the pulses are shorter (as expected), however, the noise level is higher, requiring more hits to increase the signal amplitude, thus increasing the signal/noise ratio.

For the second seismic line, only a sledgehammer was used as source, performing 40 strikes at each point. The seismic data were processed using the program SEISIMAGER 2D (Oyo Corporation).

Resistivity

The method of resistivity is based on the fact that the medium shows a resistance to the passage of electrical current. In this method are normally used four electrodes (two for the current and two for the potential) to measure the current flow and the electrical potential generated by it. Knowing the position of the electrode in the surface and obtaining the readings of current and potential is possible to calculate the electrical resistivity of the medium.

For this work we used a multi-electrode resitivimeter SYSCAL PRO 72 (Iris Instruments). The electrode spacing was five meters, and the geometry acquisition used was dipole-dipole. The line length had 360 meters. The data were processed with the program RES2DINV.

Results

In the seismic profile (Figure 3) were identified two layers. The shallowest layer is the bauxite and the deepest is the crystalline (anorthosite). The first layer has a velocity of 600 m/s and the second layer has a velocity of 3300 m/s. The bottom layer presents a lower velocity than those of a common anorthosite, which can be explained by the strong weathering process at which these rocks were applied.

Comparing our results with the boreholes data (private data) it was possible to see a reasonable correlation between the depths of the interface of the transition of the bauxite to the anorthosite layer, showing the efficience of the method.

The results of the resistivity profile are shown in the Figure 4. Low resistivity anomalies (low aluminum) are observed in the central and eastern part of the profile. High resistivity anomalies are concentrated in the western part of the profile. The resistive areas in the beginning and end of the profile can be associated with bauxite. The top of bedrock is well defined along the profile except for the portion located near the position 60 meters, due to the possible underestimating of the investigation depth, or by the existence of a fault zone.

Comparing the geophysical methods with direct probing results, we can observe a good correlation in the depth of the interface of bauxite and anorthosite, which indicates the success of these geophysical methods in layered type of deposits.

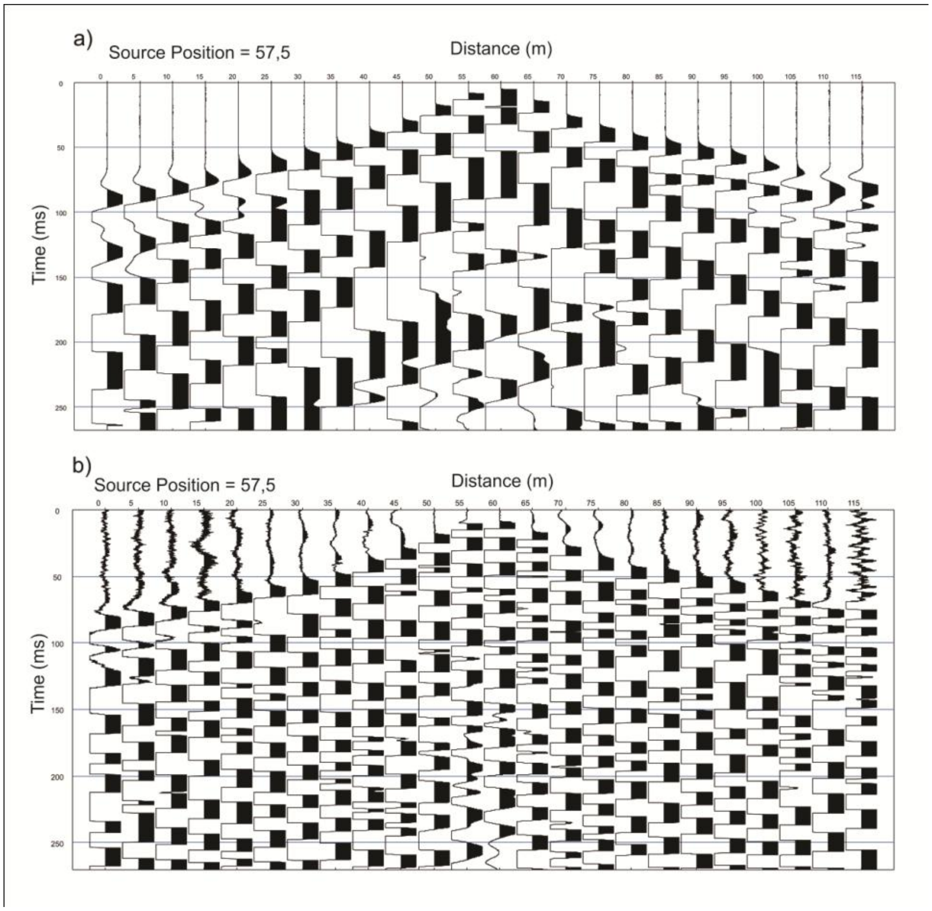

Figure 2 – Velocity model obtained with the method of seismic refraction. The distance axes are in meters.

Conclusions

The type of explosive used is not ideal for use in seismic methods because the source signature does not have high frequency. The use of a sledgehammer as source is perfectly feasible, since it generates enough energy to generate clear first arrivals.

The interface between the layer of bauxite and anorthosite was well defined mainly with seismic refraction, where the bauxite layer had an average thickness of 22 meters.

With the resistivity was possible to mark the interface between the anorthosite and bauxite, but the geological structures of percolating water, such as fractures, could cause anomalies that mask the definition of this interface.

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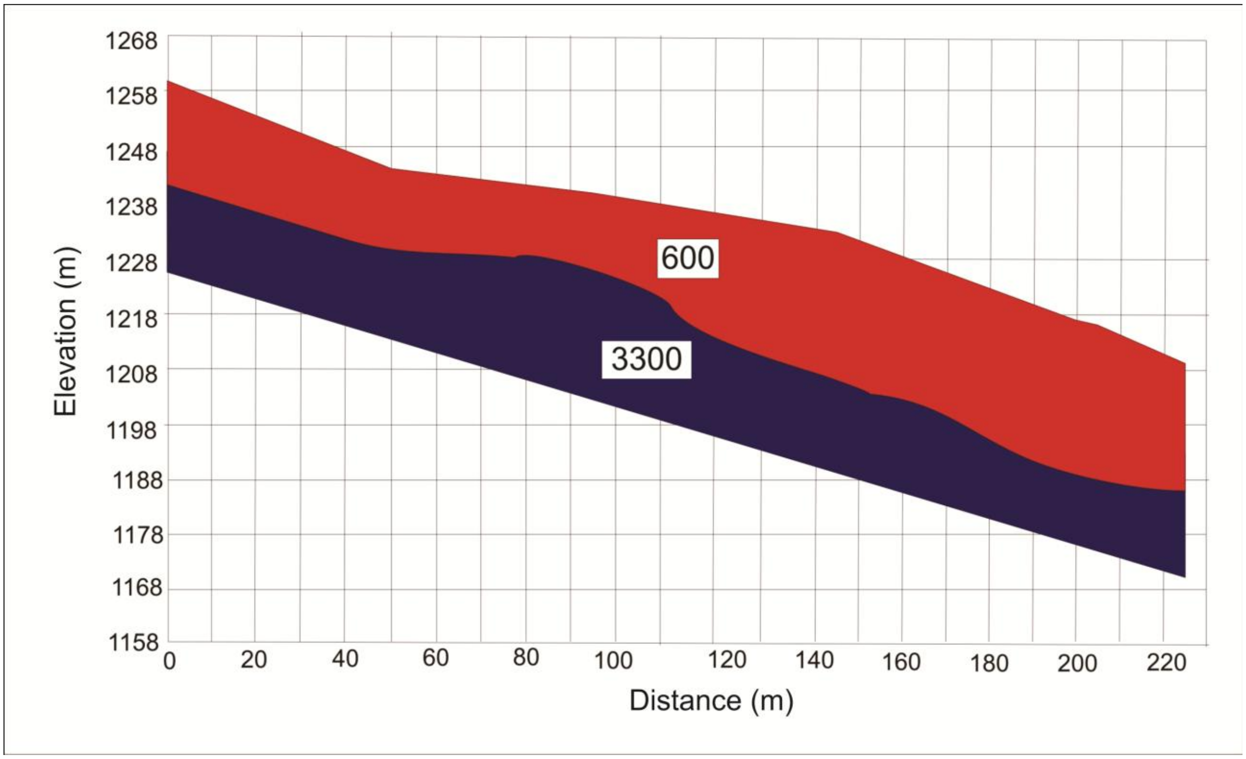

Figure 3 – Velocity model obtained with the method of seismic refraction.

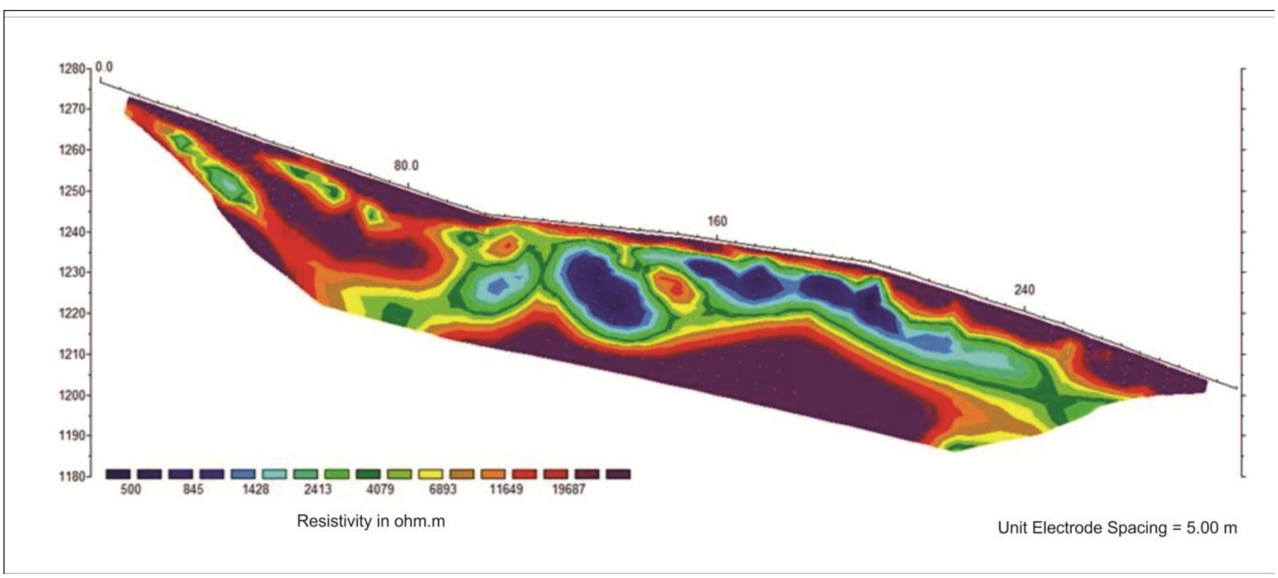

Figure 4 – Resistivity model obtained in the study area.