Geophysical characterization of geological interfaces on the University of Brasilia

Paulo Araujo de Azevedo[1] (paulopaico@hotmail.com); Marcelo Peres Rocha[2] (marcelorocha@unb.br); Welitom Rodrigues Borges[2] (welitom@unb.br); Luciano Soares da Cunha[2] (lucianosc@unb.br); Eduardo Xavier Seimetz[1] (eduseimetz@unb.br); Marcio Maciel Cavalcanti[1] (marciom.cavalcanti@hotmail.com); Pedro Vencovsky Nogueira[3] (pvencovsky@gmail.com);

[1] Graduate student of the Program of Applied Geosciences, IG/UnB
[2] Professor of the Institute of Geosciences, UnB
[3] Undergraduate student in Geology of the Institute of Geosciences, UnB

Abstract

This work shows results of resistivity and seismic refraction in an area within the University of Brasília (UnB), Campus Darcy Ribeiro. The main objective is to show the geological structure of the underground, using only geophysical data. The results led to observe three geophysical interfaces related to the geological structure. These results could be used to support engineering works, by providing physical features of the medium. These results will serve as the initial model for the practical classes for undergraduate courses in geology and geophysics at the University of Brasília.

Introduction

Currently geophysical methods are indispensable for geotechnical works applied in urban environments. With its use, you can get information of the subsurface in areas with difficult access and in places where informations of underground distribution networks (water distribution pipes, drainage and surface water drainage, and power grids) aren't available.

The seismic refraction method was used in this work in order to obtain a velocity model in the subsurface for a investigated depth of approximately 30 meters.

We use of resistivity method to detect the deviations from the expected potential differences in soil, which provide information about the shape and electrical properties of subsurface heterogeneities.

The study was conducted behind the Central Institute of Sciences (ICC in portuguese) on Campus Darcy Ribeiro at the University of Brasilia (Figure 01). Our study area is located in Paranoá Group. The soil of the region in general has characteristics related to the porous clay, slate, and their saprolite metarhythmite sandy, silty clay, silty clay containing lateritic concretions, clayey silt and silty sand (Alves et al., 2009). Details of the geology of Brasilia can be found in the work of Blanco (1995) and Martins (2000).

Methodology

The first method used was resistivity, which electrical currents are injected into the soil, and the resulting potential differences are measured in surface (Kearey, et al., 2009).

During the data acquisition, we used the multi-electrode resistivimeter SYSCAL PRO 72 (Iris Instruments) with 60 electrodes. The data acquisition technique was used with two-dimensional tomography electric dipole-dipole and Wenner-Schlumberger. The spacing between the electrodes was 5 meters, and a total of 2818 points investigated in a section of 360 meters. A total of 51 levels were investigated, with an investigation depth of 40 meters. Field data were filtered (removal of outliers) and later modeled in the program RES2DINV (Geotomo, 2010).

In the method of seismic refraction, the seismic rays are refracted under a critical angle of incidence, which propagate on the interface that separates the two layers with different velocity. For data acquisition we used a seismograph Geode (Geometrics Instruments) with 24 channels, where we used geophones of 14 Hz equally spaced 5 meters on a line of 115 meters. The source was a sledgehammer of eight kilograms with an impact trigger coupled, which was impacted against a metal plate to the generation of waves. The first geophone was being considered as the reference (position zero). The shots points were arranged in relation to the reference geophone in positions: -50, -2.5, 57.5, 117.5 and 160 meters.

For the processing of the seismograms, marking the first arrivals and for the generation of final velocity model, we used the program SEISIMAGER2D of OYO Corporation. An example of seismogram with first break marks can be observed in the Figure 02.

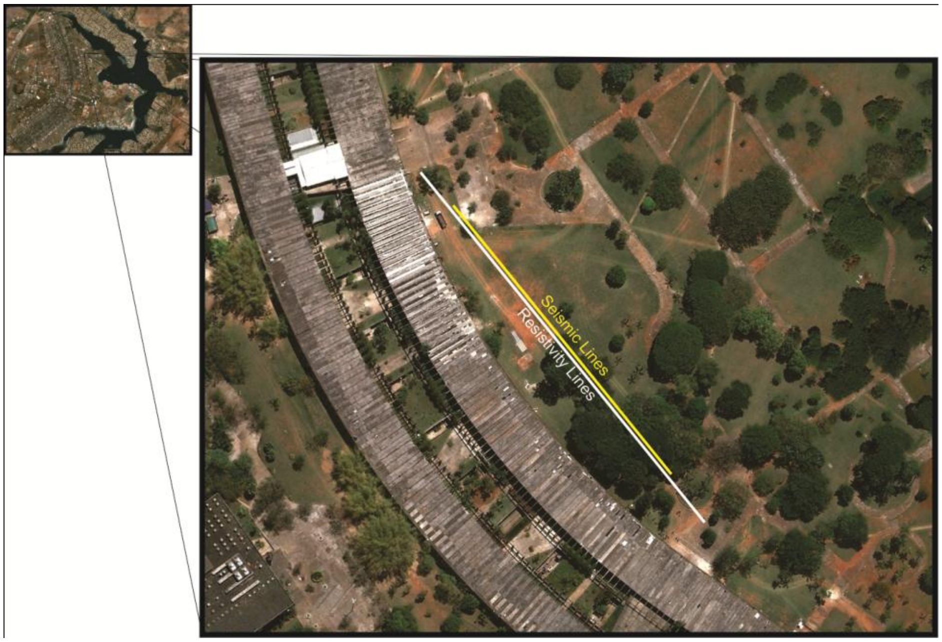

Figure 01 - Study area. Highlights of the seismic refraction lines (yellow) and resistivity (white). Above, satellite view of the Pilot Plan, Brasilia, (Source: Google Earth, 2010).

Results

Results of seismic refraction are shown in Figure 03. This figure shows the time of first arrivals for each shot point (top) and also the final velocity model obtained (bottom).

The shallowest layer has a velocity of 376 m/s, with a depth of approximately 8.5 meters and we interpreted as soil. This layer is not characterized by a single type of soil, being mainly a result of the time of the construction of the ICC. In the second layer, the depth observed is around 20 meters and a thickness of about 12 meters. The velocity found for this layer is 1805 m/s, which we interpreted as a fine grain saprolite.

The velocity of the third layer is 3071 m/s. We believe that this layer is related to a coarse saprolite or a typical slate from the Paranoá Group.

The interpreted resistivity model (Figure 04) shows considerable local heterogeneity. The heterogeneities are probably due to underground structures or due to rainwater infiltration. Between positions 60 and 80 meters and between 260 and 290 meters, electrodes were attached to concrete. Between positions 95 and 130 meters, there is a region of high resistivity, around 3500 Ω·m where quartzite may be present.

Discussion and Conclusions

The results obtained using the methods of seismic refraction and resistivity were of great importance, since it allowed to characterize the geological structure.

The results obtained from seismic refraction helped to determine three geologic layers, which have characteristics similar to those of bedrock, but with variations due to weathering, and the construction of the ICC.

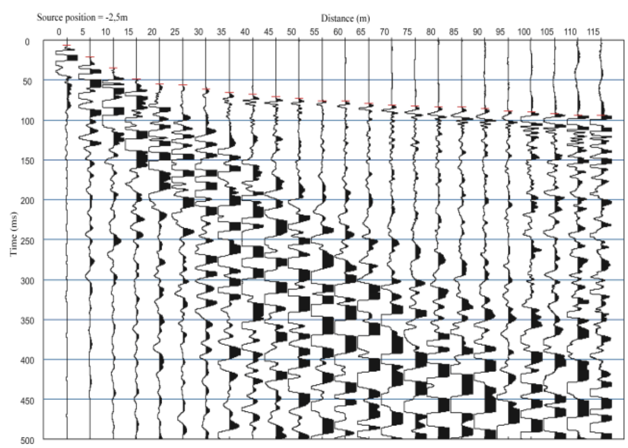

Figure 02 – Example of seismogram.

The resistivity results show the efficiency of the method, since it allows observing anomalies not observed by seismic refraction. The lateral heterogeneity observed in the results of resistivity is directly related to the movement of material during construction of the ICC, which did not permit a characterization of geological rock types with this method. The resistivity surveys were done during the dry season, therefore we didn't interpret the results of this method regarding the water content in the ground.

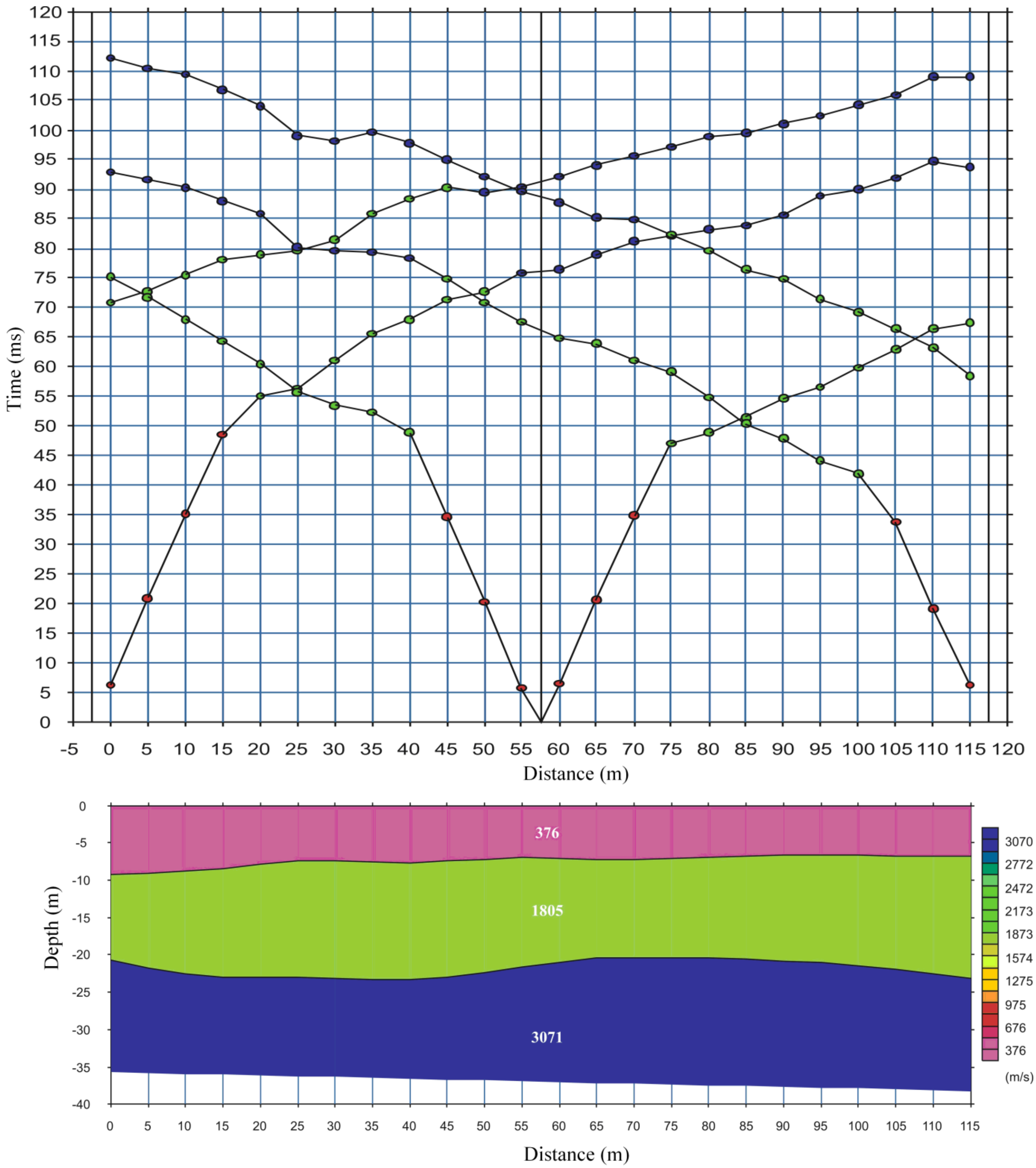

Figure 03 - (Top) Arrival time by the distance graph to each shot point. (Bottom) Velocity model

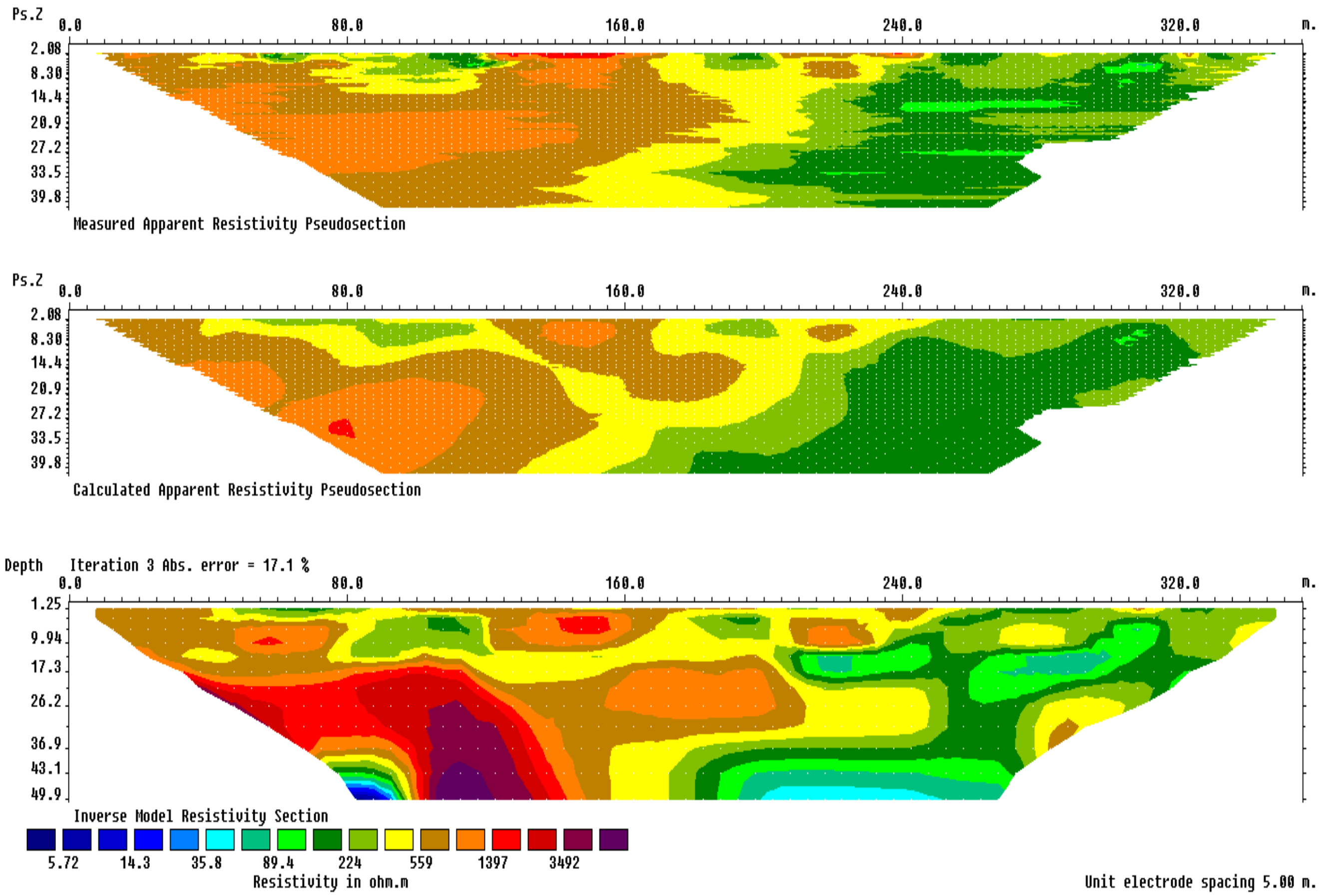

Figure 04 - Resistivity profiles. a) Data pseudo-section. b) Calculated pseudo-section. c) Resistivity model.

Acknowledgments

The authors thank the Laboratory of Applied Geophysics of the Geosciences Institute of the University of Brasilia, for the loan of field equipment. We would like to thank Pericles de Brito Macedo for his help during the data acquisition. We thank Professor José Eloi for valuable discussions related to the geology of Brasília and interpretation of results.

References

Alves, P. C., (2009). Cartografia Geotécnica para Obras Subterrâneas: Condições de Construções de Garagens Subterrâneas e Metrô no Plano Piloto de Brasília. Dissertação de Mestrado, Publicação G.DM 178/09, Departamento de Engenharia Civil e Ambiental, Universidade de Brasília, Brasília, DF, 168 p.

Blanco, S. B., (1995). Aspectos de Geologia de Engenharia da Escavação do Metrô de Brasília: Trecho Asa Sul. Dissertação de Mestrado, publicação nº G.DM 019/95. Departamento de Engenharia Civil e Ambiental, Universidade de Brasília, Brasília, DF,95p.

Geotomo, 2010. SOFTWARE RES2DINV: Rapid 2-D resistivity & IP inversion using the least-squars method. Malaysia, Ver. 3.59.

Google Earth, 2010. http://earth.google.com/.

Martins, E. S. (2000). Petrografia, Mineralogia e Geomorfologia de Rególitos Lateríticos do Distrito Federal. Tese de Doutorado, Instituto de Geociências, Universidade de Brasília, Brasília, DF, 196 p.

Kearey, P.; Brooks, M. & Ian, H. Geofísica de exploração. São Paulo: Oficina de textos, 2009.