GPR Survey in rocks of Cuiaba Group on Cangas District, MT – Applicability Test

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Abstract

In the late decades, the GPR was established as a high resolution method used in shallow investigations of the sub-surface, in many different applications. In the area, the Cuiabá Group is composed by a sequence of folded layers of phyllites and metasandstones, whose structures and arrangement could be well defined in the GPR profiles, including some quartz veins. In these lithotypes, the best reflectors correspond to the interfaces of the sandy layers, due the high electrical resistivity of the quartz in comparison to clay minerals.

Introduction

The ground penetrating radar (GPR) is a very high frequency electromagnetic (EM) technique used to produce high-resolution images from the subsurface. GPR is used for both target detection and for characterizing the subsurface stratigraphy, water-table, or geology in hydrogeologic, environmental, and geotechnical site characterizations.

The success of the GPR methodology depends on the amount of EM signal attenuation experienced at any given site. GPR signal attenuation is caused by four loss mechanisms: conductive losses, which is the greatest factor of signal attenuation, molecular relaxation losses, "clay" (or interfacial polarization) losses, and scattering losses. However, in this case, a considerable part of the losses refers to clay, due the lithology of the studied area, enriched in clay minerals. Many experiments have shown that even a small percentage of clay will attenuate the GPR signal, especially when wet, resulting in reduced signal penetration and resolution.

Method

The GPR data, exposed as reflection profiles, were acquired through a step by step acquisition, with a sampling density of 40 scans/meter. A portable SIR-3000 GPR system was used in the reflection survey mode to obtain the GPR profiles, using antenna frequencies of 200 MHz. The system is composed by 2 modules: one with the pair transmitter/receiver and a central control electronic unit that keep the data.

After the survey, the GPR data were submitted to a series of processing, to obtain a better relation signal/noise. These procedures were executed in the software RADAN 6.5, and allowed to emphasize the reflectors of interest. The used sequence of processing: Gain (Linear and Exponential), Low and High Pass Filter, Infinite Impulse Filter (IIF) and Finite Impulse Filter (FIR). After that, the dielectric permissivity was defined in 18 and the conversion time/depth was executed, correlating with depth measures taken in the field.

Geology

The Cuiabá Group outcrops in the base of the Paraguay Fold Belt, a neoproterozoic cover situated in the oriental margin of the Amazonic Craton, deformed by Brazilian Tectogeny (700-450 Ma). The studied area is located around of the Cangas region (Poconé Gold District) far 100 km from Cuiabá City, capital of the Mato Grosso State, Brazil. The investigated rocks constitute a sequence of sedimentary rocks metamorphosed on the Greenschist Facies. The lithologies comprise a sequence of phyllites, metarhythmites, metadiamictites and metasandstones, incorporated in Acorizal Formation and represent the Sub-units 3 and 5 of the Cuiabá Group.

Results

The figure 01 shows the GPR profile obtained over a line parallel to a mining trench. This profile presents a very good correlation with the structures of the rocks in sub-surface, showed in the photograph composition. Generally, in the upper portions (until 1.5m depth), characterized by an argillaceous red soil, occurs an attenuation of the radar signal, due probably the high electrical conductivity of the soil. It is possible to observe some small and weak reflections until 1.2m depth, related to the presence of gravels, associated with iron oxides. Under this portion it is possible to observe, between the stations 20m and 78m, a continuous and strong reflector, sub-horizontal, related to a horizontal quartz vein system situated at 1.50m depth. Many local changes in the vein's position are well defined in the GPR profile.

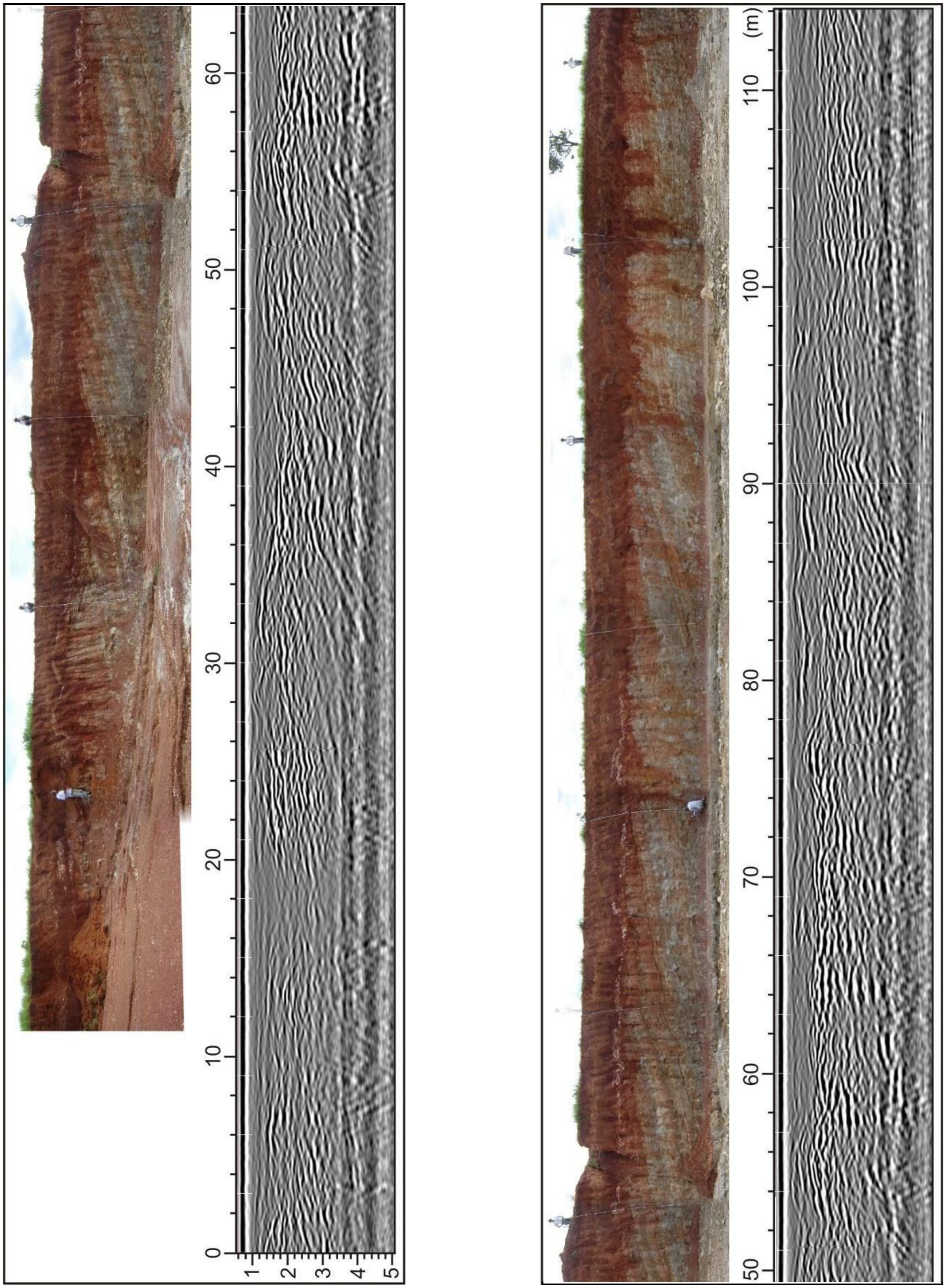

Figure 01 – Profile 01. Above there is a photograph composition of the side of trench. Below there is the processed GPR Profile.

After the station 78m, the vein is not present anymore, as showed in the photograph composition.

Below 1.5 meters depth occurs the saprolite, as sequence of dipping layers, composed by altered phyllites and metasandstones of the Cuiabá Group. The layers and their orientation clearly appear in the GPR profile as a sequence of inclined reflectors, that follow the stratification of the lithotypes. The strongest reflectors are related to the sandy layers interfaces.

The figure 02 shows the GPR profile obtained over a line orthogonal to the mining trench and two thin vertical quartz veins mineralized with gold. The objective of this profile was verifying the applicability of the GPR method in the prospection of thin quartz veins in the area.

Generally, there is a good correlation between the reflectors on the GPR profile and the sub-surface structures showed in the photograph. The upper portions are characterized by an argillaceous red soil, where occurs a radar signal attenuation. Below this portion occurs the saprolite, composed by a sequence of altered phyllites and metasandstones, that appear in the GPR profile as a sequence of horizontal reflectors. However, the two thin quartz veins do not appear as good reflectors (hyperbolic reflectors) in the GPR profile.

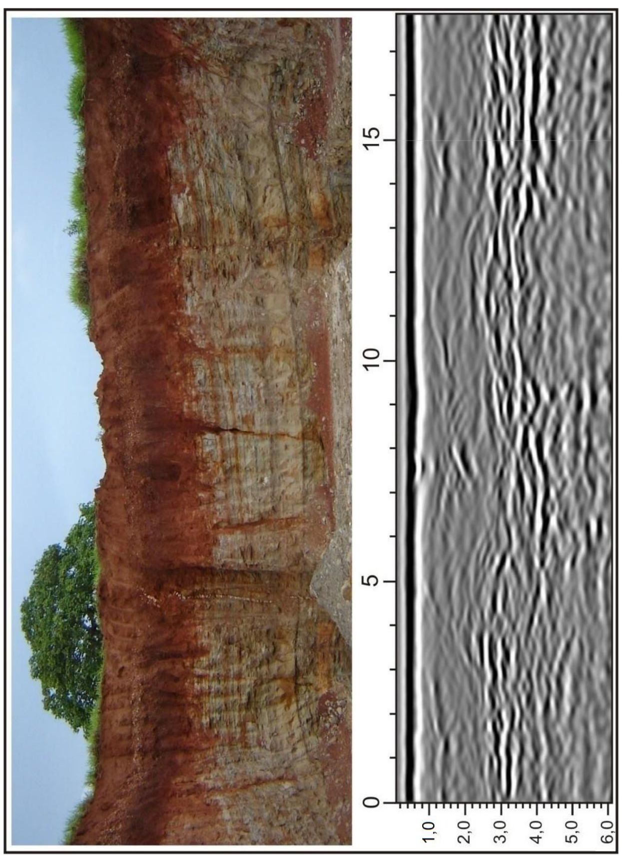

Figure 02 – Profile 02. Above there is a photograph of the front of exploration trench. Below there is the processed GPR Profile.

Conclusions

The Ground Penetration Radar (GPR) showed good results in the survey over the rocks of the Cuiabá Group. The shallow structures in the sub-surface were well defined and recognized in the GPR profiles, together with some of the quartz veins that cut these rocks. The best reflectors obtained with the survey were related to the interfaces of the sandy layers due the high electrical resistivity of the quartz in comparison to clay minerals. The depth of investigation, using 200 MHz antennas, was limited to approximately 6.0 meters in the area, due the clayish characteristics of the soils/rocks. However, the GPR method, established by its high resolution, was not efficient in the detection of the vertical thin quartz veins mineralized to gold in the area, which thickness is often less than 5 centimeters.

Acknowledgments

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References

GSSI. 2003. RADAN for Windows – User's Manual. Version 5.0. New Hampshire. Geophysical Survey Systems, Inc.

LUIZ, J. G.; COSTA e SILVA, L. M. 1995. *Geofísica de Prospecção*. Belém, PA. Ed. Cejup. V. 1. 311 p.

PEREIRA, M. J. 2005. *Geofísica Aplicada para a Caracterização da Cobertura Pedológica de uma Vertente na Região de Dom Aquino - MT.* 92 p. Dissertation – Instituto de Ciências Exatas e da Terra, Universidade Federal de Mato Grosso. Cuiabá, MT.

PORSANI, J. L. 2003. *Métodos GPR: Aplicações em Geologia, Geotécnica, Meio Ambiente e Planejamento Urbano*. V Summer School, Universidade de São Paulo (IAG/USP), São Paulo-SP. 31 p.

PORSANI, J. L. 1999. *Ground Penetrating Radar (GPR): Proposta Metodológica de Emprego em Estudos Geológicos – Geotécnicos nas Regiões de Rio Claro e Descalvado – SP.* Thesis – Instituto de Geociências e Ciências Exatas, Universidade Estadual Paulista. Rio Claro, SP.

REYNOLDS, J. M. 1997. *An Introduction to Applied and Environmental Geophysics.* Ed. Wiley. 796 p.

TELFORD, W. M.; GELDART, L. P.; SHERIFF, R. E. 1990. *Applied Geophysics.* 2 ed. Cambridge. Cambridge University Press. 770 p.