Modeling of aero data (magnetic and electromagnetic) of Cristalino Cu-Au Deposit, Carajás, Pará, Brazil

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Abstract

The Cristalino Cu-Au deposit is located in Carajás Mineral Province. The area of the deposit was covered by a aereo survey (time domain electromagnetic and magnetic) in order to identify the most conductive areas. Six resistivity depth images were built for these data, ImagEM software and the magnetic data was processed obtaining Analytical Signal Amplitude. The ImagEM software is under development by the Electromagnetic Interpretation Research Group of Universidade de Brasilia. ImagEM showed very good results for the Cristalino area, where the low resistivity core is very clear in central area and coincident with maps of electromagnetic channels.

Introduction

The Carajás Mineral Province (CMP) is a highly mineralized metallogenic province in the southern of the Amazon Craton in Brazil, located in the Carajás Neoarchean Domain between the Araguaia Belt at east and overlying Proterozoic sequences at west (Figure 1; Docego, 1988; Araújo and Maia, 1991; Tassinari and Macaimbra, 1999). To the north, it is concealed by Proterozoic and Cenozoic sedimentary rocks of the Amazon Basin (Pinheiro and Holdsworth, 1997) and the south, it is contact with the Rio Maria granitoid-greenstone terrain (Docego, 1988; Hunh et al., 1988a,b; Villas and Santos, 2001) It lies at eastern margin of one of the most extensive A-type granitoid provinces globally (Grainger et al., 2007).

The CMP comprises two Archean tectonics blocks, the older southern Rio Maria granitoid-greenstone terrain (Hunh et al., 1988a,b), and the northern Itacaiúnas Shear Belt, one of the best preserverd Archean volcano-sedimentary sucession of the world (Grainger et al., 2007; Araújo et al., 1988). The later contains world-class Fe-oxide Cu – Au deposits and the most significant examples are: Salobo, Cristalino, Sossego and Igarapé Bahia-Alemão. The focus of this work is on the Cristalino deposit.

Discovery of the Cristalino deposit was in 1998 through integration of geological and soil geochemistry data. The anomaly is associated with intense potassic alteration related to a magmatic brecciated/stockwork system. The magnetic, electromagnetic and induced polarization anomalies are the response of these hydrothermal zones (Huhn, 1999) and these data were very important to show the potential and define the anomalous area.

The Cu - Au Cristalino deposit is located on southwest Itacaúnas Shear Belt part in the Serra do Rabo Ridge and its mineralization is hosted by mafic to felsic volcanic rocks hydrothermally altered and interlayered with iron formation of the Grão Pará Group and was classified as a Fe-Cu-Au-U-REE deposit type (Figure 2; Docego, 1988; Huhn, 1999).

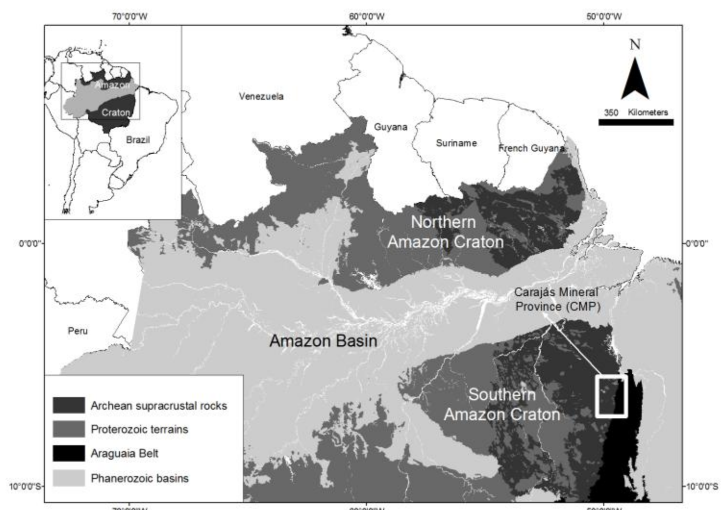

Figure 1 – Simplified sketch map of Amazonian Craton showing the located of Carajás Mineral Province.

The mineralization occurs in breccias and as stockworks, disseminations and fracture fillings in both the intrusive and metamorphic host rocks. The main ore minerals are chalcopyrite, pyrite, magnetite, bravoite, cobalite, millerite, vaesite and gold (Ribeiro, 2009). The resource is estimated at greater than 500 Mt grading 1.0 % Cu and 0.3 g/t Au (Huhn et al., 1999).

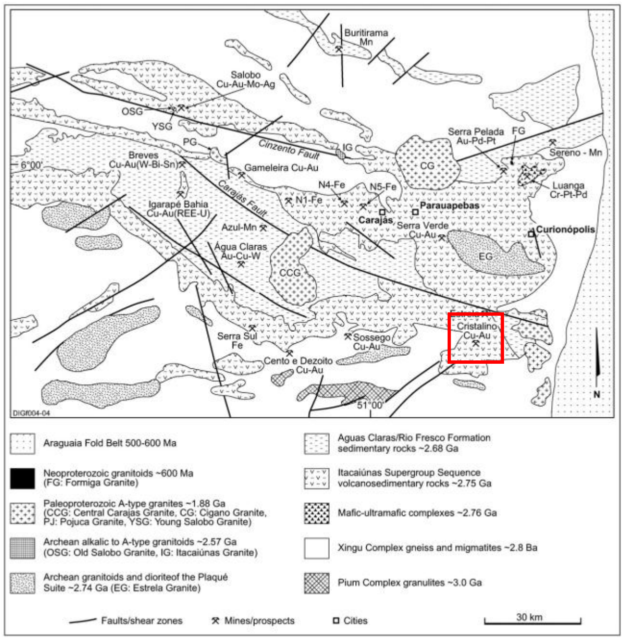

Figure 2 - Simplified geological map of the Neoarchean Carajás Domain, showing the study area (Docegeo, 1988).

Method

The eletromagnetic time-domain (TDEM) and magnetic methods are very important for exploration of massive to semi-massive sulfide related deposits. An airbone GEOTEM and magnetic survey was flown by Geoterrex-Dighem on behalf of Companhia Vale do Rio Doce over the Cu-Au Cristalino deposit aiming to identify the conductive and posite magnetic anomalys zones. Eletromagnetic data were acquired using the GEOTEM eletromagnetic multicoil system, in time domain, base frequency of 90 HZ, current of 700 A. receiver multicoil system (x, y and z) recording 20 channels for each component, these five were off time. Magnetic data were acquired using the Scintrex Cs-2 single cesium vapor with towed-bird installation, with a sensitivity of 0.01 nT, sample rate equal 0.1 sec., and ambient range 20,000 to 100,000 nT. The flight direction was N-S, fligth lines spacing of 250 m (Figure 3) and flight control lines spacing of 6000 m.

An image of Analytical Signal Amplitude (ASA; Figure 4A) was built for these data using the Geosoft ™ 7.2 software. In Aeroelectromegnetic (AEM) data only channels 7, 10 and 14 will be shown in map (Figure 4B, C and D). The channels 5 to 20 were used in Resistivity Depth Image (RDI) processing. The software used was ImagEM, which is under development by the Electromagnetic Interpretation Research Group of Universidade de Brasilia.

Initially, the ImagEM was based on the RAMPRES software (Sandberg, 1988; Von Huelsen, 2007; Von Huelsen et al. 2008). New software calculates the apparent resistivity, using the potential difference in the receiver coil that is concentric to the transmitter coil. It does a simplified inversion, applying the secant method (Von Huelsen et al., 2011).

The RDI of six survey lines (Figure 4 C) was gridded in a 2D grid, generating a image of 20 m cell size, using the software Geosoft ™ 7.2 (Figure 5).

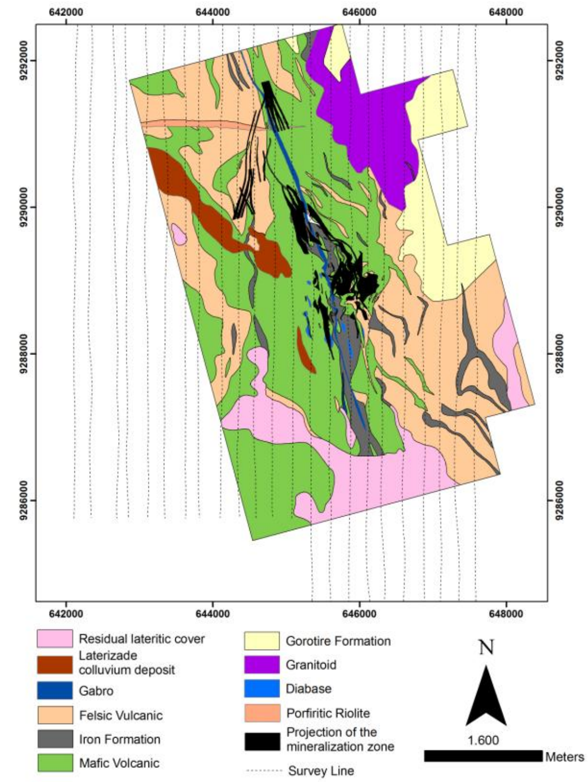

Figure 3 - Geological map of the Cristalino Deposit, showing the survey lines (modified after Huhn, 1999).

Results

The image of EM channel 10 delineates the general framework of the deposit and it shows the conductivity boby and the NW/SE direction of deposit (Figure 3 and 4).

It is important to consider that the mineralization style is not massive but instead a mixture of breccia, stockwork veins, veinlets and disseminated sulfide (chalcopyrite). Therefore, the electromagnetic response will vary depending on the sulfide concentration and type, but also on how much the disseminated sulfide, veins and veinlets are linked to each other in the ore zone. The lines with the best secondary field values are in central area and east area (Figure 4 C and D).

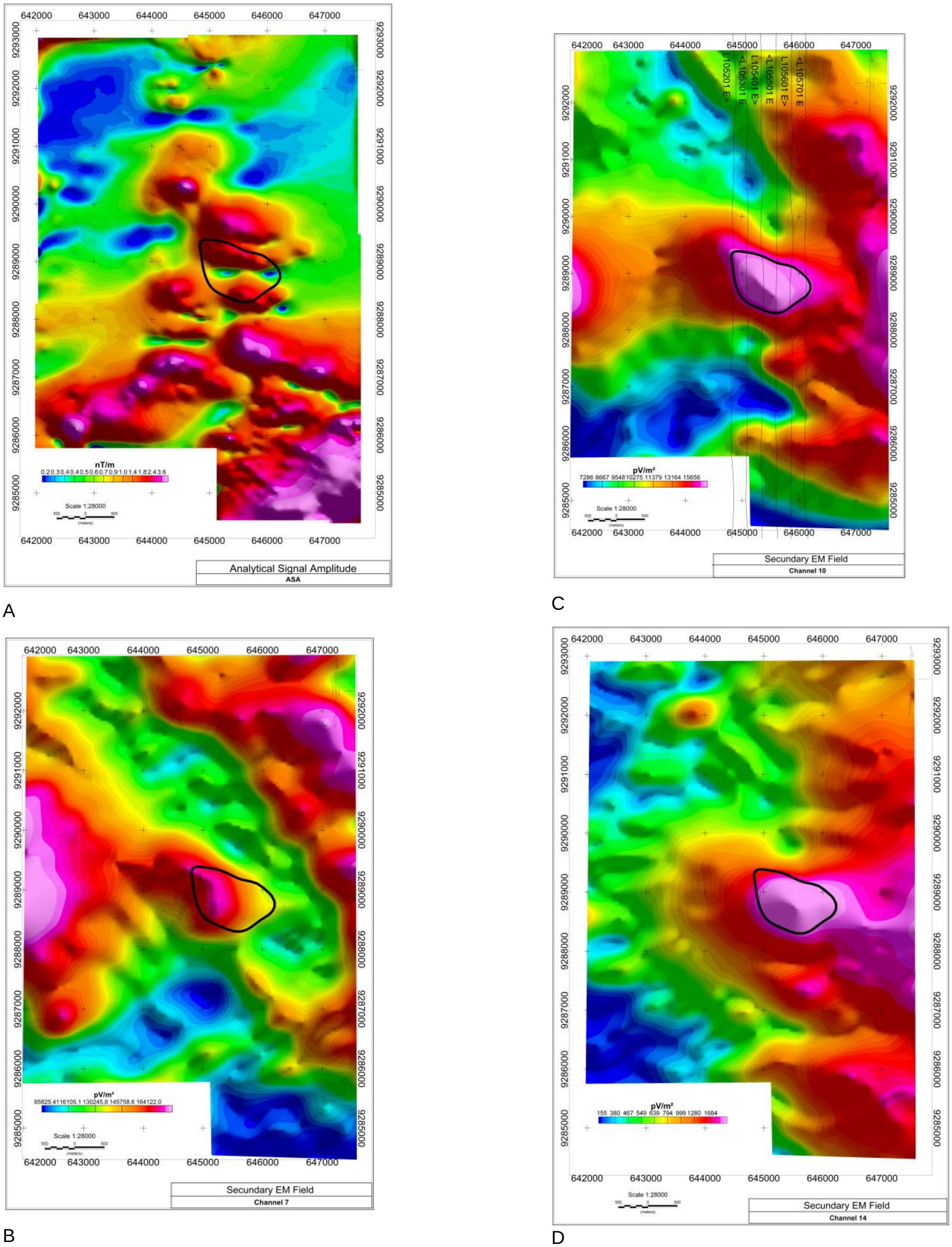

Figure 4 – A: Image of Analytical Signal Amplitude; B: Secondary EM Field (channel 7); C: Secondary EM Field (channel 10) and the blach line are survey lines that there RDI images; D: Secondary EM Field (channel 14); the black trace in all images is the contour line with amplitude EM of the 15.000pV/m² , where is the conductor body.

The high magnetic signal in the ASA image delimited lateritic covers and mafic intrusions. In southeast area, the image ASA shows high magnetic fields at edge of the conductive body. This area is more favorable for mineral occurrences of associations between magnetite and sulfides.

The ImagEM result shows a low resistivity, smooth W-dipping, body in the central part of the survey area (between 4000 and 5200m of distance; Figure 5). In south area there is a smaller conductor (RDI 105301; thereabout 7200m of distance).

Figure 5 shows the lowest resistivity core, indicating that there are two main bodies.

Conclusions

The high magnetic signal in the ASA image delimited lateritic covers and mafic intrusions, and high magnetic fields at edge of the conductive body. This area is more favorable for mineral occurrences of associations between magnetite and sulfides.

The EM images of channels show a conductive body in central area and other to south (less conductive and smaller).

ImagEM software does not demand any geological prior information and has a very fast result, independent of the user experience.

ImagEM showed very good results for the Cristalino area, where the low resistivity core is coincident with the most conductivity map channels and the mineralized zone (figures 3, 4 and 5).

Considering that in greenfield areas without outcrops the body geometry is not known, then a fast modeling can be a good guide for other processing.

Acknowledgments

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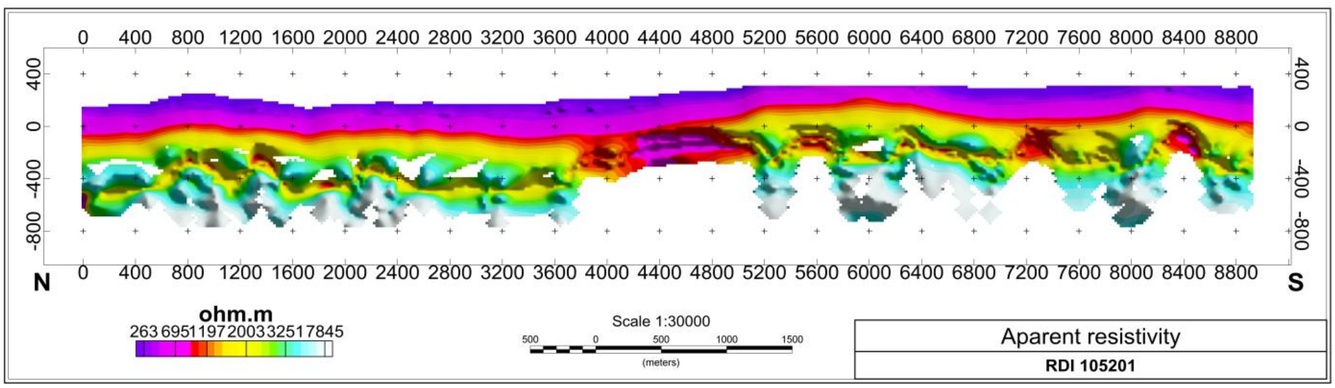

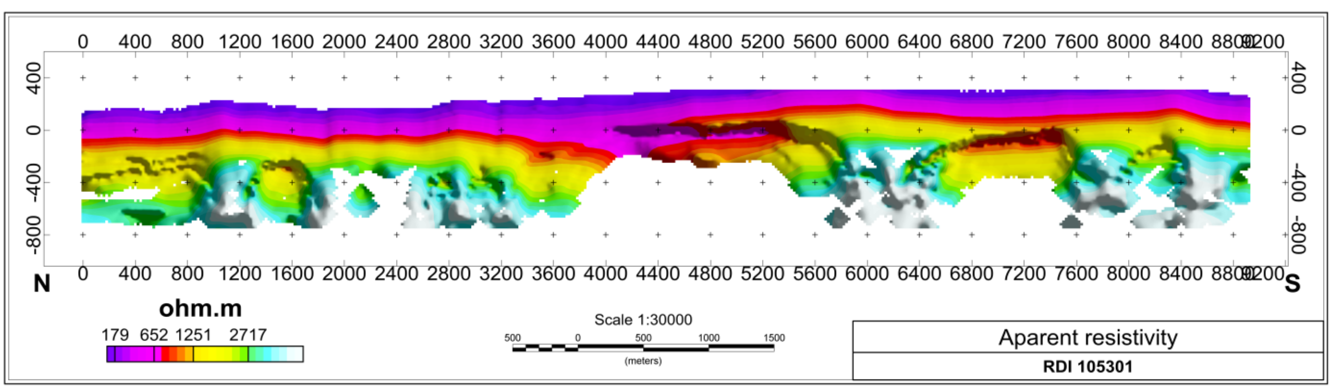

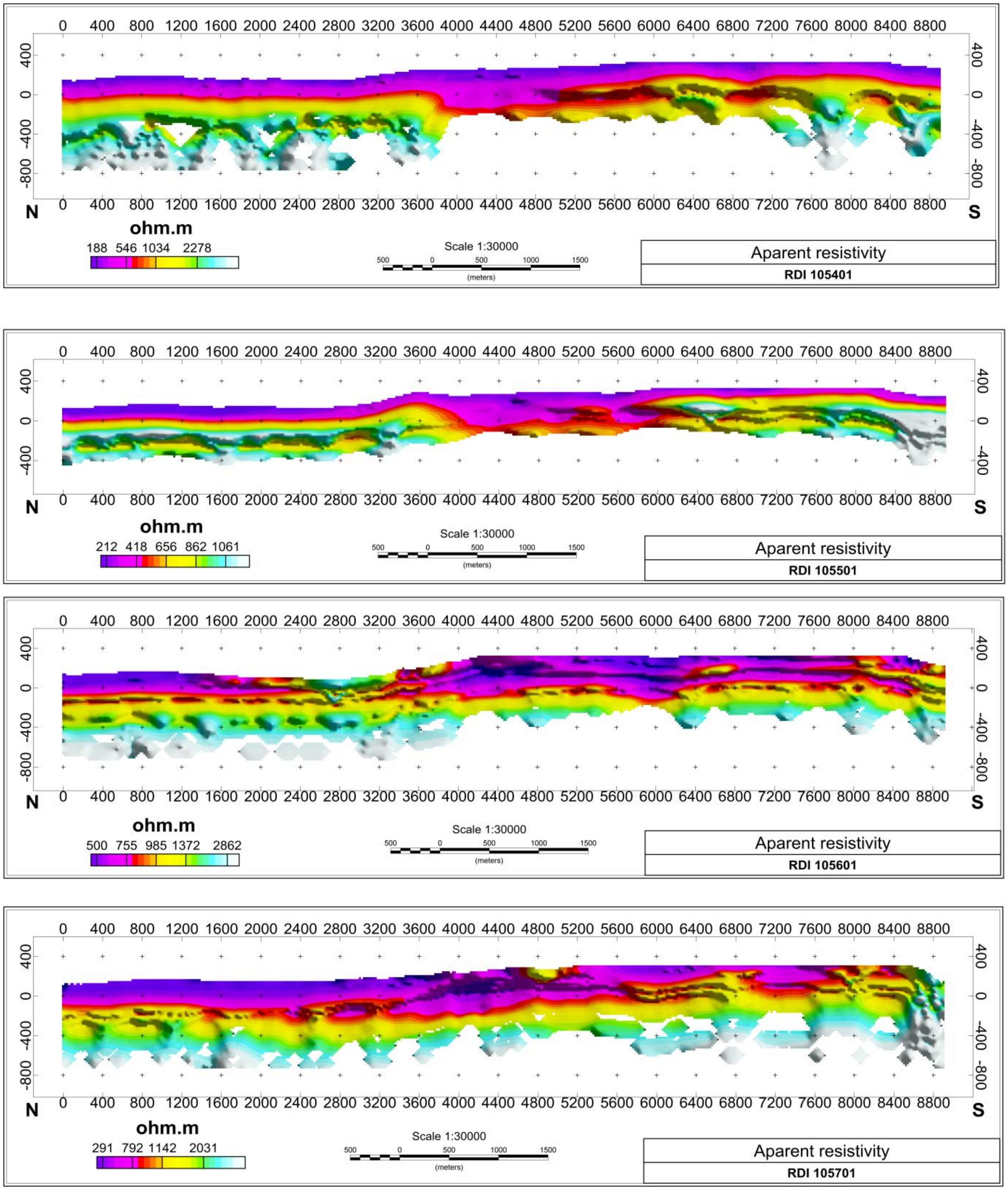

Figure 5 – RDIs of 105201, 105301, 105401, 105501, 105601 and 105701 lines, y -axis is the depth and x-axis is the distance of line (N-S direction)

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