Phase Roll Out of Quadrant effect in MT Data from a Gold Prospect

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This paper was prepared for presentation during the 13th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, August 26-29, 2013.

Abstract

Magnetotelluric (MT) data collected over a gold prospect area exhibit in some stations a 3D effect that is present on the phase data for the transverse electric (TE) mode, i.e., the electric field parallel to the local strike. This effect occurs when a conductive body is embedded in a very resistive host and the TE phase presents values larger than 90 degrees due to strong current channeling along the conductive body. Two-dimensional (2D) inversion was performed reliably for the TM mode, since it was not affected by PROQ and yielded a smooth model of the background. Information from the 2D TM inversion and from drill holes helped guide the 3D modeling, which explained the effect and shows a coincidence of strong PROQ effects with the target in the area.

Keywords: mineral exploration, 3D effects

Introduction

Mining applications of the magnetotelluric (MT) method usually targets structural and lithological interpretation that supports the occurrence of ore bodies. However, there are some effects in the MT data that may provide more than that. When the target is a conductive body inserted in a resistive host, for example, the TE mode data can exhibit an effect that will guide the location of the target. *Lezaeta and Haak (2003)* discuss this effect and show a method of tensor decomposition that can recover the local strike of the 3D body, which may be different than the regional strike. Also, this effect was presented earlier by *Livelybrooks et al. (1996) and Chouteau and Tournerie (2000).*

The MT data acquired at a gold prospect presents such phase effect and can help guide the location of the interesting targets.

Method

The effect of TE mode phase values higher than 90 degrees, or **Phase Roll Out of Quadrant (PROQ)** effect, that occurs in our data is due to strong current channeling in a preferred direction due to the presence of an elongated conductor embedded in a resistive host. Figure 1 shows one station that presents PROQ in the TE node circled in red.

The TM mode was not affected in any of the stations. The fact that the TM mode was more reliable for interpretation of a 3D conductive body inserted in a resistive host was already showed in *de Lugão and Kriegshäuser (1997).* Therefore, we performed 2D modeling for the TM mode and used it, together with other geological and drill hole information, to build a 3D conceptual model.

Since the TE mode data exhibited the PROQ effect we performed 3D modeling studies to understand the behavior of the TE mode data.

We used a 3D integral equation code based on *Xiong (1992)*. The program was designed for EM modeling of 3D structures in a multi-layer anisotropic earth.

Our analysis was qualitative, that is, we explained the behavior of these complex data with a simple model that still had a geological meaning. It is important to note that, unlike the 2D inversion that could only consider the TM mode, both TE and TM modes can be explained by the 3D modeling.

Examples

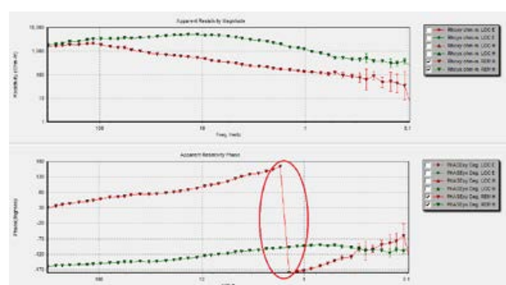

Figure 1: MT station displaying phase values over 90 degrees in the TE mode.

Results

The conceptual model consisted of a conductive body in a layered medium as shown in Figure 2. Host resistivity varied along the survey ranging from 500 ohm-m to 2,000 ohm-m and 5,000 ohm-m. We included in the 3D model a deep conductive layer of 2 ohm-m that was present in all 2D TM mode inversions at 6,000 m depth. The resistivity of the 3D body was considered to be 0.1 ohm-m. The 3D body extended along the survey area strike.

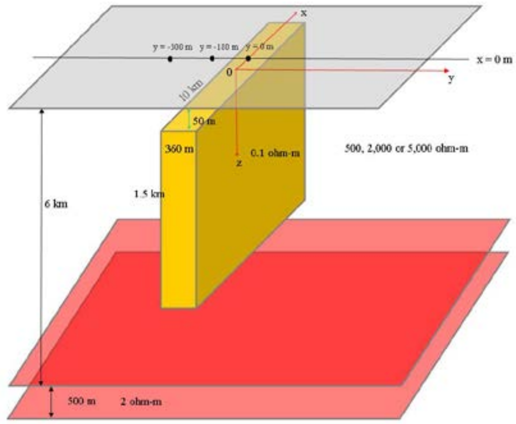

Figure 2: 3D model used to simulate MT responses for the PROQ effect in the data.

The data fit, for both TE and TM modes, for two stations that exhibited PROQ are shown in Figure 3.

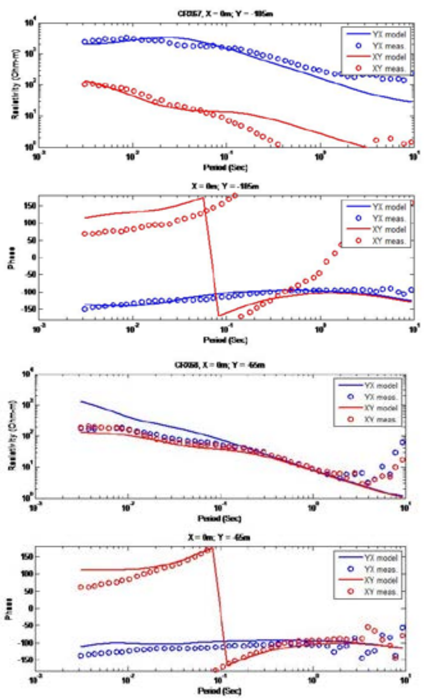

Figure 3: Fit of 3D modeling on real data for station outside body (upper two pannels) and station inside the body (bottom two pannels).

The upper two panels show a fit between a station in the model that is located outside the conductive body, while the bottom two panels show the fit between a station located on top of the body. Both TE and TM modes can fit quite well.

Conclusions

Qualitative 3D modeling was performed to explain the TE mode phase behavior presenting values higher than 90 degrees on data acquired at a gold prospect area. Unlike the 2D inversion, we could explain both the TE and TM modes with the 3D model. The model also showed a correlation between the geology and the occurrence of PROQ.

Acknowledgements

We would like to thank everybody in this project and our clients for permission to publish the work.

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