3D inversion of MT data in Misiones and Corrientes, NE Argentina

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Abstract

In this work we present a 3D inversion model for a magnetotelluric survey carried out in the provinces of Misiones and Corrientes, Argentina. The most prominent electrical feature in our inverted model is the occurrence of a lower crustal conductive lineament (<10 Ω m) that runs parallel to our profile between stations 18 and 06, almost coincident to the Paraná river in the Paraguay-Argentina border, turning southwards between stations 06 and 05. Previous electromagnetic studies have shown that this conductive lineament continues in Brazil, close to the Paraná basin depocenter. These works suggested that close to the Brazil-Argentina border, it deflects to the east towards the Torres Syncline. We now see that in fact the conductive lineament continues inside Argentina. Moreover, in Brazilian territory it is spatially coincident to areas where the magmatic Serra Geral formation is thicker, suggesting a genetic relationship with the Paraná Magmatic Province.

Introduction

The South American continent was formed through several episodes of rupture and amalgamation between different tectonic units throughout its evolution (ALMEIDA et al., 2000). Most of these units are now concealed underneath thick sedimentary basins, hampering our understanding of their present limits and nature. In this respect geophysical methods have been determinant to help us understand these units and their tectonic evolution.

The magnetotelluric method has been successfully used to determine the limits of stable and cold tectonic units, as the Rio de la Plata craton in Argentina (cf. PERI et al., 2013 and references therein) and Uruguay (BOLOGNA et al., 2018), as well as the remnants of old suture zones, as the PACA lineament between the northern Paraná block and the Amazon craton (BOLOGNA et al., 2014).

Seeking to better control the tectonic units underneath the Paraná and Chaco-Paraná basin, this survey was planned in order to cross the gravity-defined WPS (Western Paraná Suture/Shear zone) DRAGONE et al., 2017), which marks the transition between the Tebicuary craton and the Paraná basin lithosphere.

Method

The magnetotelluric is a passive method that consists in measuring natural electric (E) and magnetic (H) fields in orthogonal directions. The electric and magnetic fields are related through impedance tensors, from which apparent resistivity and phase curves are derived. Vertical resolution is one of the method's core and is attained through a relationship between frequency and depth of exploration due to signal attenuation, called skin depth. The method's final product is the electrical conductivity distribution in subspace, and variations in this property can be related either to composition, temperature or fluids presence.

For this work, data was gathered at 18 sites with an average spacing of 25 km, resulting in a 450 km transect (Figure 01). We used a broadband MT system, which covers the period range from 0.0001 to 3600 s. Time-series were processed using the robust method of Egbert (1997).

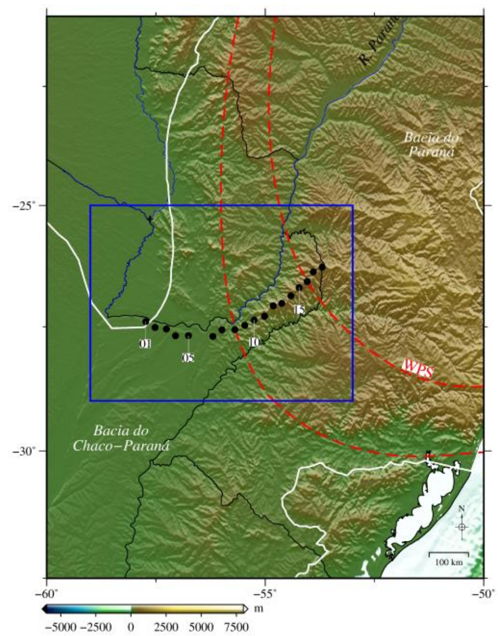

Figure 01 – Study area. Black circles are the MT stations. White contour is the Paraná and Chaco-Paraná basin limits. Dashed red is the WPS.

Results

Groom-Bailey (GROOM and BAILEY, 1989) decomposition shown that all stations fit into a 2D parametrization. In spite of that, stations 7 to 18 have an average strike of N30E, confirmed by the induction arrows strongly and systematically pointing outside our profile (Figure 02). This suggests the occurrence of an electrically conductive structure parallel to our profile, bringing our problem to the 3D realm.

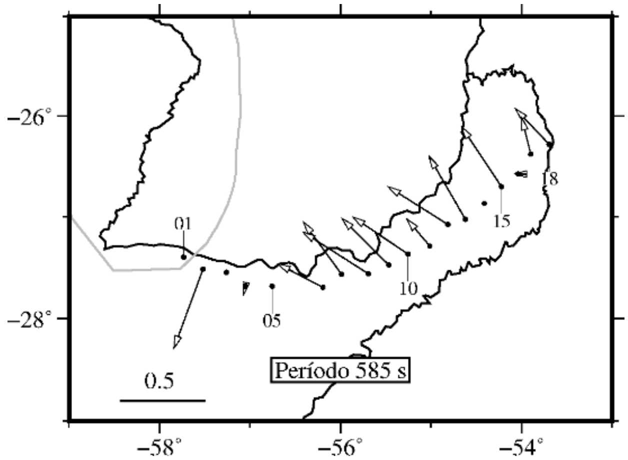

Figure 02 – Induction arrows for the 585 s period.

Data was inverted using the ModEM 3D inversion code developed by Kelbert el al. (2014). Our model was discretized into a 52 x 102 x 52 (X,Y,Z) grid with 6x6 km width inside our data area, expanding with a 1,5 factor out of it to avoid contour problems. A 100 ohm-m half-space was attributed to the initial model. Both horizontal and vertical impedances were taken into account. We present in Figure 03 a horizontal slice at 25 km depth of our preferred inversion to the moment. It reached a global nRMS value of 1,52 after 69 iterations.

Stations 1 to 4 are in a region characterized by a resistive crust and upper mantle (> 1000 Ω m), probably related to the Rio Tebicuary craton (DRAGONE et al., 2017; CORDANI et al., 2001). The same happens to stations 11 to 18, which are in the Paraná basin lithosphere. Between stations 5 and 6 a crustal conductor (< 10 Ω m) separates these two resistive units. This conductor however is not limited to the MT profile, parallelly following it from stations 18 to 06.

Although structures outside of the data area should be interpreted with caution, this conductor is robust, since it appeared in every inversion we run, using different initial models and parameters, and was also suggested by the induction arrows behavior in this part of the profile, where they point northwestwards. In Brazil, other MT and GDS studies conducted by PADILHA et al. (2015) and MAURYA et al. (2018) have shown a similar conductive lineament continuing to the northeast, from the Argentina-Brazilian border on. In Brazil it is close to the basin depocenter, coincident to areas where the basalt layer is thicker. Maurya et al. (2018) have proposed a deflection of this conductive lineament to the east at latitude ~28S, towards the Torre Syncline. Our inverted model suggests another possibility, that it continues directly into Argentina.

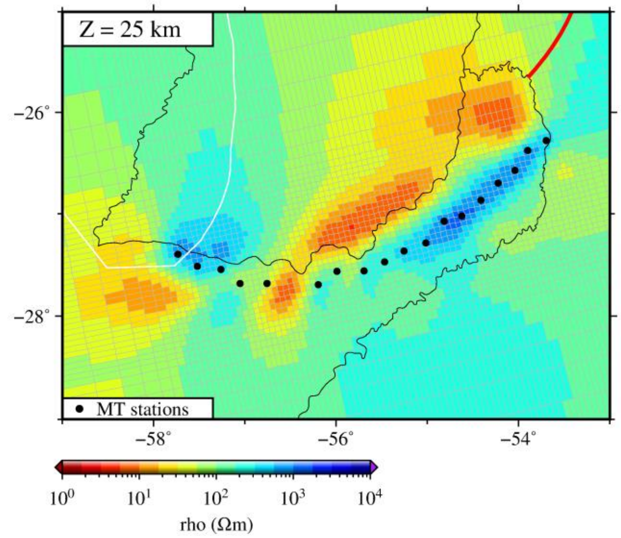

Figure 03 –Horizontal slice at 25 km depth of the 3D inversion result. Red line is the continuation of the conductive lineament in Brazil (see text for details).

Conclusions

The MT study conducted in Argentina herein presented has shown that a conductive lineament previously observed in Brazil continues into Argentina. Future work to be done include refining the inversion and updating the basalt layer thickness in Argentina using geologic data if available and/or MT 1D inversion. Also, further discussions should be made regarding the nature and geophysical aspects of the conductive lineament, integrating these results with other geophysical and geological data available.

Acknowledgments

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