MAGNETOTELLURIC STUDY IN THE WESTERN BORDER OF THE RÍO DE LA PLATA CRATON (CHACOPAMPEANA PLAIN AND EASTERN SIERRAS PAMPEANAS)

Invited

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Abstract

The electric resistivity provides a valuable constraint to define mantle structure, this information is independent of the one obtained by seismology or other geophysical techniques. The bulk resistivity is controlled by temperature and composition, but it can be enhanced by the presence of fluids (water or melt), sulfites or graphite. Magnetotelluric (MT) studies performed in different continental zones showed that the lithosphere is very resistive (> 1000 ohm-m) and it was observed a decrease on the resistivity values (5-25 ohm-m) between 50 and 250 km deep, defining the top of the electrical asthenophere. So, the MT method becomes an useful tool to identify vertical and horizontal boundaries of crustal blocks in cratonic areas.

This paper presents two dimensional (2D) inversion of MT data acquired along four transects in the Chacopampeana plain that provided resistivity models crossing the western border of Rio de la Plata Craton (2.1-2.3 Gy). The profiles are placed in Formosa (~ 24 ° LS), Santiago del Estero - Chaco (~ 27 ° LS), Córdoba (~ 31.5 ° LS) and San Luis (~ 34 ° LS) provinces.

A regional characterizing was obtained from models, finding a very high resistive sector, at the eastern part, with typical resistivity values (>5.000 Ohm-m) for the ancient structures corresponding to the Río de la Plata Craton. The thickness of the resistive zone is variable, reaching a maximum depth of around 140 km. Below this depth the resistivity decreases showing the presence of the listosphere-astenophere boundary.

Introduction

The Rio de la Plata Craton (RPC) is the southernmost craton of the American continent. It is placed at the core of SW Gondwana in most of the paleogeographic reconstructions and is bounded by the Sierras Pampeanas on the proto-Pacific margin and by the Cuchilla Dionisio terrane on the proto-Atlantic margin. In the Chacopampeana plain, many authors inferred that the western border of the RPC is the southern continuation of the Trans-Braziliano (TB) Araguaia lineament in Brazil. The TB is a continental scale suture, bounds Amazonia from the São Francisco craton and Amazonia from the Paraná block (Kröner & Cordani, 2003; Feng *et al.*, 2004; between others).

The RPC border (Fig. 1) is defined by different geologic evidences and include the so-called terranes, blocks and belts. Its outcrops are mostly on the Atlantic margin. These are dominated by juvenile Palaeoproterozoic rocks (2,3-2,1 Gy) with restricted Archaean sectors (3,4-3,1 Gy) and Neoproterozoic belts (~600-550 My) (Bossi & Gaucher, 2004; Basei *et al.*, 2000; Cingolani & Bonhomme, 1982; Dalla Salda *et al.*, 1988, Cordani *et al.*, 2001, Kröner & Cordani, 2003; Saalman *et al.*, 2006). At the NW part, this border probably follows the NE–SW main fault bounding the Las Breñas depocenter (Early

Paleozoic; Rapela *et al.*, 2007; Ramos *et al.*, 2010), while at the W it is not exposed. The Eastern Sierras Pampeanas represent a Neoproterozoic–Early Cambrian orogen developed at the SW paleo-Pacific margin of Gondwana. Its tectonic evolution has been continuously debated. The main proposed models share that the subduction of oceanic lithosphere was dipping to the E beneath the RPC followed by a collision in long (900-540 My) or short (20 My) orogenic periods (Kraemer *et al.*, 1995; Ramos, 1988; Rapela *et al.*, 1998; Simpson *et al.*, 2003; Schwartz & Gromet, 2004).

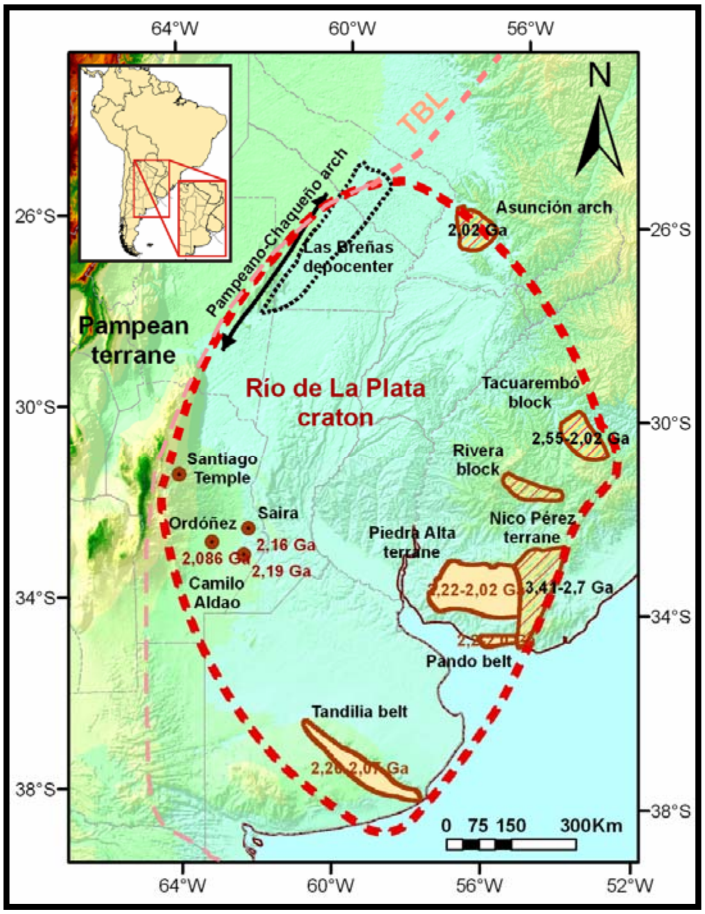

Figure 1. Proposed boundaries of the RPC by Rapela (2007; red) and Ramos (2010; pink) that were inferred from different geological and geophysical evidences.

The inferred western border (Fig.1) of the RPC is based on: a) belts of ophiolites found in Sierras de Córdoba that suggested an approximated location of the Early Cambrian suture (Kraemer *et al.*,1995; Rapela *et al.*,1998; Escayola *et al.*, 2004); b) strong gravimetric anomaly in central Sierras de Córdoba has been related to a Neoproterozoic suture RPC-SP (Miranda & Introcaso, 1996; Ramos, 1988); c) N-NE deformation belts found at the easternmost sector of the Pampeano belt, inferred Early Cambrian age (von Gosen & Prozzi, 2005; Martino, 2003); d) seismic reflexion cross-sections in a faulted margin of Gral. Levalle basin, that evidences the Early Palaeozoic boundary RPC-SP (Webster *et al.*, 2004); e) borehole samples in Córdoba province (Rapela *et al.*, 2007) showed Palaeoproterozoic ages encompass the range of ages of RPC and f) MT studies showed the contact between RPC and PT (Favetto *et al.*, 2008).

Methodology
Data collection and analysis

The data were acquired with long period GPS-controlled MT systems (NIMS) for all the sites. All the MT profiles deployed between 2000 and 2010 are shown in Figure 2. The time series data-processing was performed using a robust, multi-site statistical method (Egbert, 1997). The dimensionality and best geolectrical strike estimation were obtained using phase tensor analysis (Bibby *et al.*, 2005) and multisite, multrifrequency tensor decomposition (McNeice and Jones, 2001). This dimensional analysis demonstrated that regional-scale electrical structures are mainly two-dimensional with a strike direction oriented parallel to the surface geological strike.

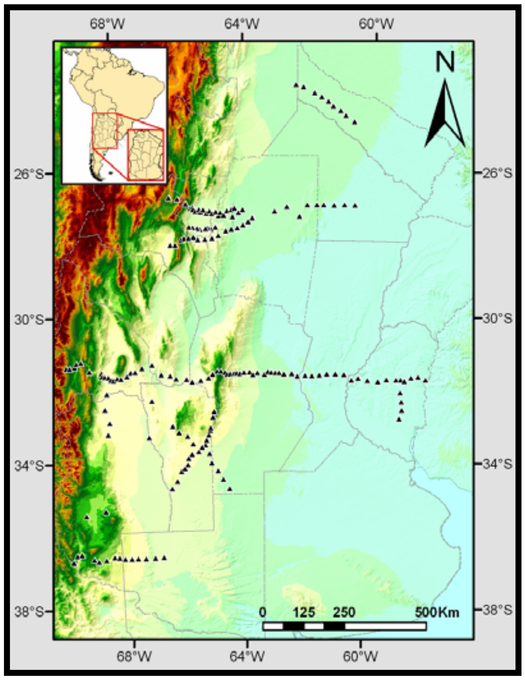

Figure 2. MT sites obtained (2000-2010) with the long period GPS-controlled MT systems (NIMS).

2D Inversion

The impedance tensor for 2D structures, allows rotating to principal axes. In that condition there are two modes (TE and TM), with the apparent resistivity (ρ) and the impedance phase (φ) for each mode. Also the complex transfer function between vertical and horizontal magnetic field (Tzy) in principal axes were used to obtain models with the NLCG algorithm of Rodi and Mackie (2001) included in the WinGLink interpretation software package. Model roughness was minimized through an iterative algorithm up to a pre-established misfit. A number of inversions were performed to reach the most reliable model by testing both modes independently.

Results and Analysis

Models generated from long period responses from all the profiles show significant lateral variations in the lithosphere (Figure 3).

The model corresponding to profile A shows a very resistive block (>3000ohm-m) at the eastern end of the profile up to a depth of 140 km, which is interpreted as the (RPC). In the western end a highly resistive sector (> 5.000 ohm-m) is detected at depths between 5 and 25 km, which can be interpreted as another crustal block. In the central part of the profile a zone (100 km long) shows a lower resistivity around 100 ohm-m.

In profile B resistive zones (>1000 ohm-m) are observed at both ends of the profile. They are separated by a more conductive (50-100 Ohm-m) zone extended along 100 km. The sharp lateral discontinuity observed in the model represents the boundary between the (RPC) and the (PT) or another precambriam cratonic fragment.

The model corresponding to profile C shows a lateral discontinuity that was interpreted as the suture between RCP and PT by Favetto *et al.*, 2007. The resistivity model presents a sub-vertical limit approximately along the eastern border of the Sierra Chica de Córdoba.

In model D, a sharp sub-vertical lateral discontinuity in the eastern part was detected. It represents the boundary of RPC. The resistive layer (> 3000 ohm-m) has a thickness around 100 km. The conductive zone in the central part of the profile (20 ohm-m) reaches a depth of 60 km and represents the lower crust. The resistive body at the western end with variable thickness is interpreted as PT.

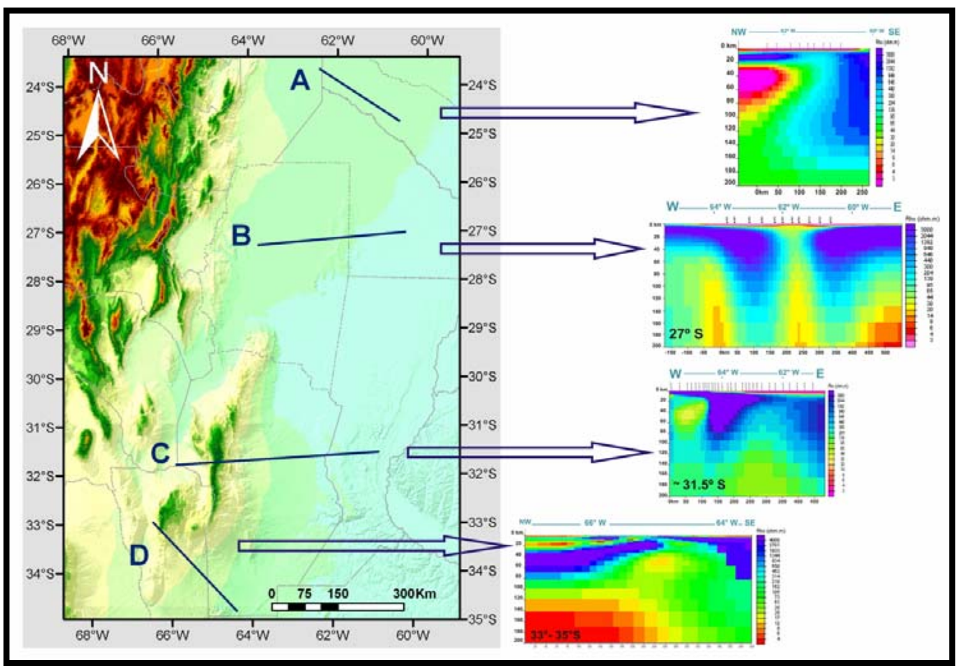

Figure 3. MT profiles and the 2D models obtained.

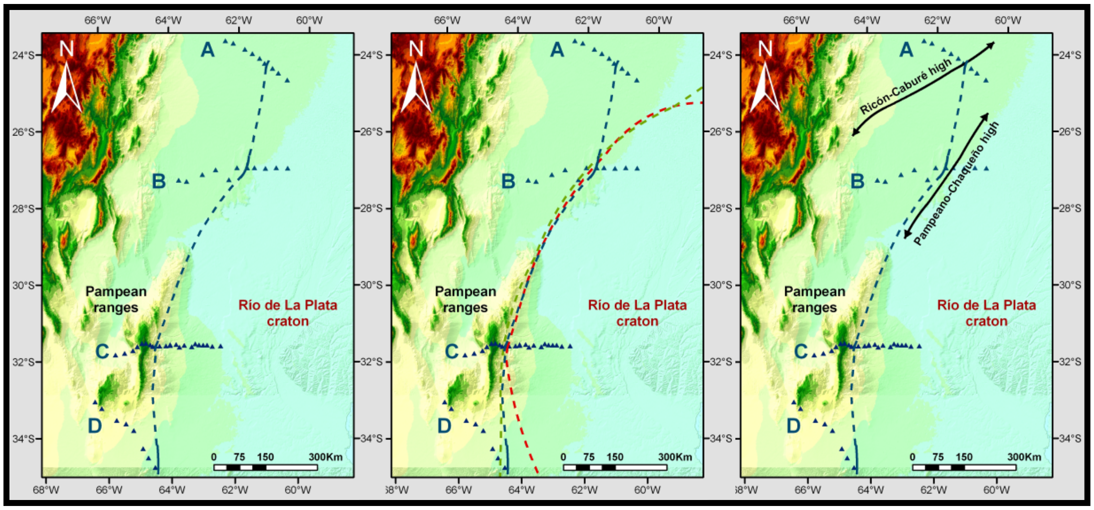

Figure 4. In blue the inferred border of RPC in this paper, in red by Rapela *et al.* (2007), in green by Ramos *et al.* (2010). The right figure shows the coincidence of some highs of basement with the deeper anomalies.

Conclusions

All lateral discontinuities observed in the resistivity models show the boundary between the RPC and the PT or another crustal block, representing an Early Cambrian suture, based on geotectonic. A tentative limit between approximately 23.5 SL and 34 SL for the western border of the RPC was provided from the joint interpretation of the models (Fig. 4). These studies show new data about the deep structure across the RCP border where there are no outcrops and deep geophysical studies. These anomalous areas are coincident with basement highs, which led us; consider that the old crustal structures were reactivated by modern tectonic events.

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