Geophysical characteristics of the Neoproterozoic Amazon Plate-Tocantins Province suture in central Brazil

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Abstract

An array of six broadband seismographic stations was installed in central Brazil, covering the transition between the Tocantins Province and the Amazon paleoplate along two NW-SE profiles, with the aim to imaging the structure of the crust in the region. Using teleseismic event recordings, we were able to determine the Vp/Vs ratio and the crustal thickness under the stations, applying the receiver function method. The results allow to conclude that: i) the crust is anomalously thick (~50 km) in the transition region, which grossly coincides with the gravimetric gradient anomaly of central Brazil. It marks the collision front between the two provinces; ii) the crust thins away from the suture, tending to be thicker under the Amazon paleoplate than below the Tocantins Province, and iii) the crust thickens northwards.

Introduction

The Tocantins Province, in central Brazil, is the result of convergence of the São Francisco, Amazon and Paranapanema paleoplates during the Neoproterozoic Brasiliano orogeny. The northern part of the province, formed between the São Francisco and Amazon paleoplates, displays a NE-SW geological trend, which is roughly coincident with the direction of a regional gravimetric high (200 km wide, 700 km long) that stands out in central Brazil. Integrated interpretation of deep seismic refraction and gravimetric data has shown that the gravimetric high reflects a corridor of shallow Neoproterozoic lid mantle which is denser, hotter and probably less depleted than the neighboring Paleoproterozoic and Archean mantle tracts related to the São Francisco and Amazon plates, respectively. In contrast with the São Francisco Plate border, the behavior of the crust in the transition Amazon Plate-Tocantins Province is poorly known. In order to determine the crustal behavior in this limit the Lithosphere Research Lab./IG/UnB installed six broadband stations across the western limit of the gravimetric high (herein called west gravimetric gradient). Stations were deployed along two NW-SE profiles: i) one close to 13°S, where two seismographic stations (RET8 e RET9) complement the previous deep refraction profile (one station is placed on the gravimetric gradient and the other to the northwest of it); ii) the second profile, close to 12°S, comprises three seismographic stations (RET2, RET3 e RET4) installed on the gravimetric gradient, and to the west and east of it (Figure 1).

Northwards, in the Porto Nacional Complex, an additional seismographic station (RET1) was recently installed, placed in the domain of the gravimetric high, for which preliminary results are shown.

Methodology

Receiver function is a technique applied on teleseismic data records to infer the crustal structure under the seismographic stations.

It is a method that allows to obtain the mean Vp/Vs ratio and the thickness of the crust under seismographic stations, through the arrival time of Ps (P converted in S in the Moho) and PpPms (S multiple) phases, setting the average crustal Vp, according to the relations below (Zandt and Ammon, 1995; Zandt *et al*., 1995):

$$\frac{V_P}{V_S} = \left\{ \left(1 - p^2 V_P^2\right) \left[2 \left(\frac{t_{P_s} - t_P}{t_{PpPms} - t_{P_s}} \right) + 1 \right]^2 + p^2 V_P^2 \right\}^{1/2},$$

$$H = \frac{V_P (t_{P_s} - t_P)}{\left(\sqrt{\frac{V_P^2}{V_S^2} - p^2 V_P^2} - \sqrt{1 - p^2 V_P^2} \right)},$$

where p is the ray parameter, H the crustal thickness and t the arrival time of the phases.

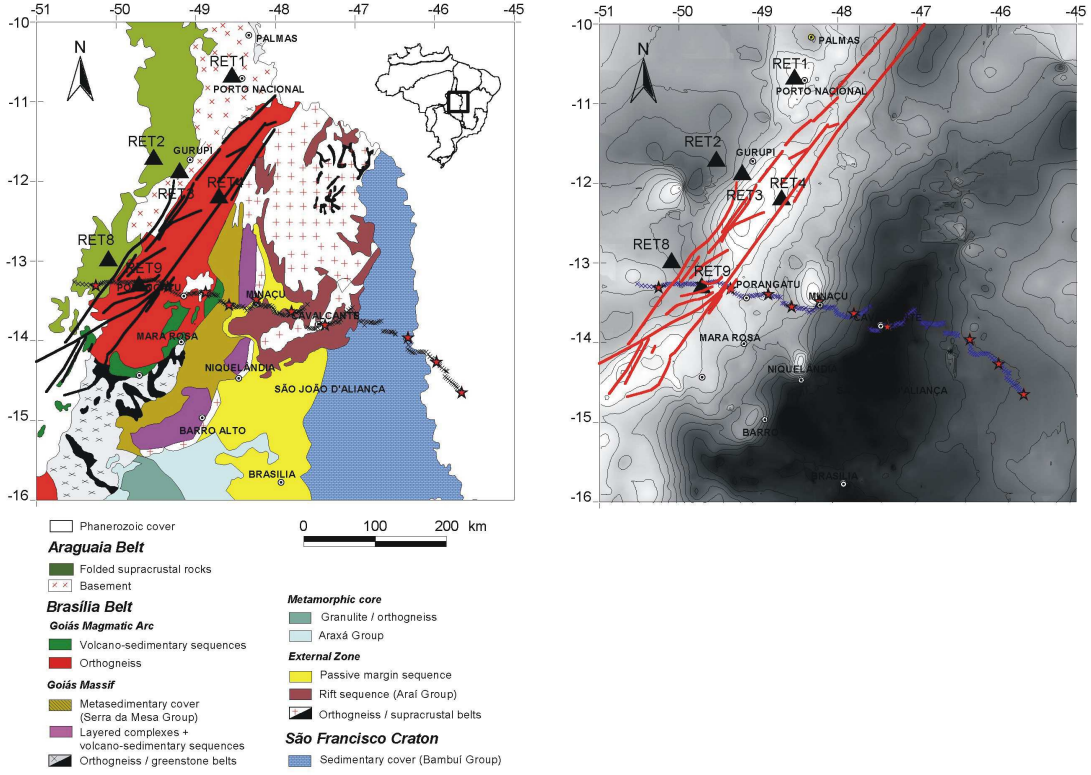


Figure 1 - Geological and Bouguer gravimetric maps of central Brazil showing: i) previous deep seismic refraction line, represented by blue x (receivers) and red stars (shots); ii) broadband seismographic stations represented by black triangles, and iii) Transbrasiliano Lineament, represented by NE lines. The regional high Bouguer gravimetric anomaly represents variations in the composition of lithosphere mantle of central Brazil.

The Ps and PpPms phases are obtained deconvolving the vertical component of teleseismic records from the radial and transversal ones. The receiver function traces with similar ray parameters (p) were stacked (Figure 2) and the Vp/Vs ratio and crustal thickness (H) were obtained with the H-K stacking program (Zhu e Kanamori, 2000) (Figure 3).

As Vp is unknown, in this work the crustal Vp/Vs and H were calculated to Vp of 6.3 km/s and 6.7 km/s, which means minimum and maximum crustal thickness, respectively. Changing Vp, the Vp/Vs changes slightly. The exception is the RET9 station where refraction studies suggest Vp of 7.0 km/s for the crust (Ventura, 2010).

Results

The Vp/Vs and crustal thickness results are summarized in Table 1.

Discussion

These results indicate that:

i) the crust is thicker along the gravimetric gradient than in the Amazon paleoplate and Tocantins Province;

ii) along the seismic profile Moho presents a step of 14 km at the transition zone (gravimetric gradient), suggesting lower crust duplication, probably related to Amazon paleoplate subduction under the Tocantins Province;

iii) inside each domain the crust is not homogeneous, tending to be thicker northwards;

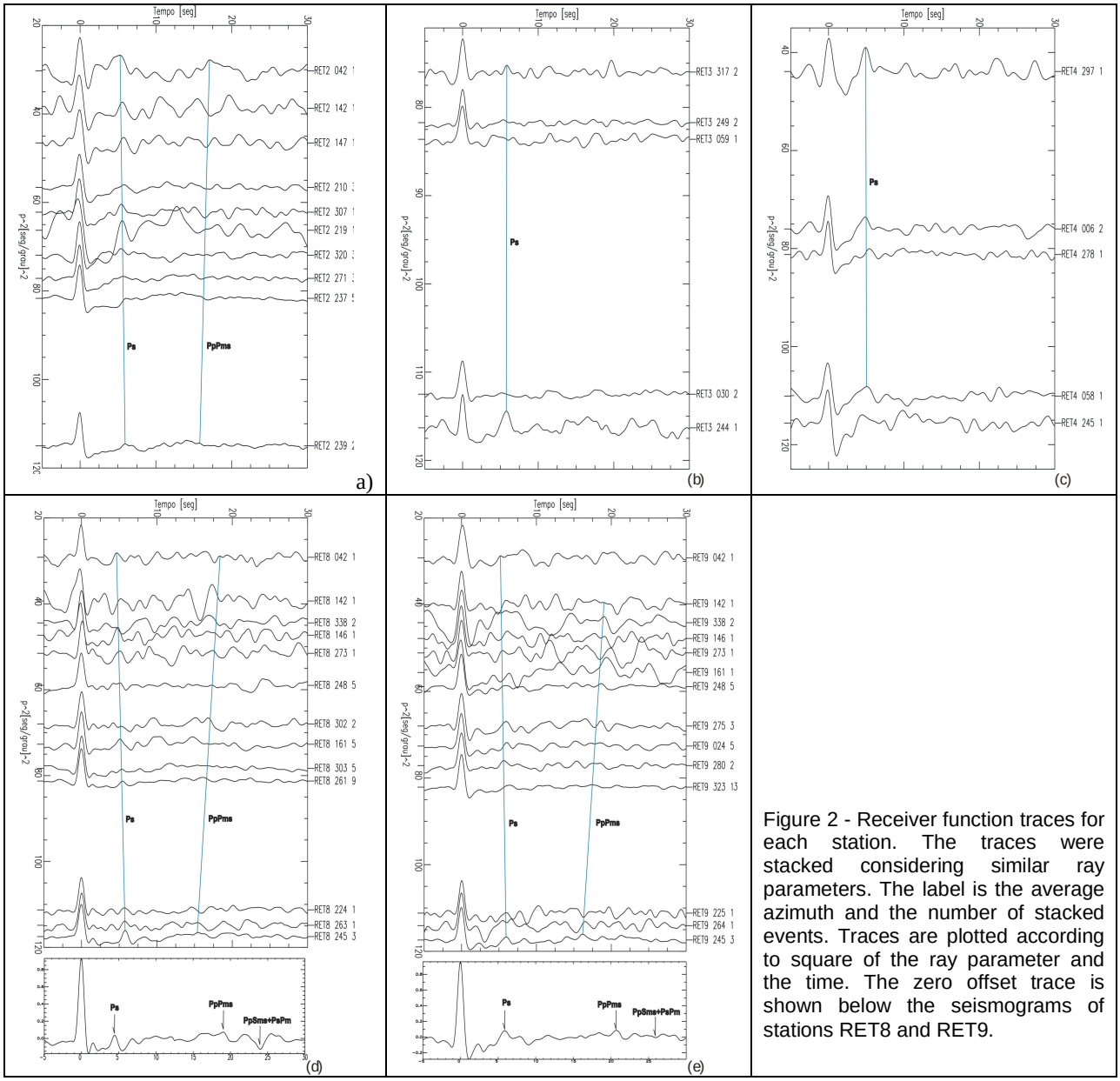


Figure 2 - Receiver function traces for each station. The traces were stacked considering similar ray parameters. The label is the average azimuth and the number of stacked events. Traces are plotted according to square of the ray parameter and the time. The zero offset trace is shown below the seismograms of stations RET8 and RET9.

iv) the central Brazil gravimetric high reflects density variation within lithospheric mantle, and in view of Vp of 8.05 km/s (Soares *et al.*, 2006) and density of 3.3 g/cm^3 (Ventura, 2010), it probably represents undepleted Neoproterozoic mantle;

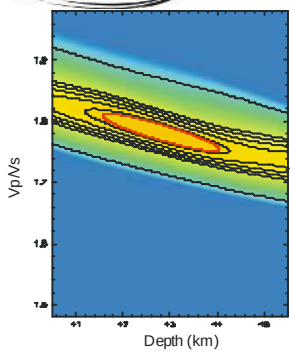
v) the crust of the Amazon paleoplate (Vp/Vs of 1.78) is different from the crust of Tocantins Province (Vp/Vs of 1.72);

vi) the lower crust of the Amazon paleoplate is of mafic composition;

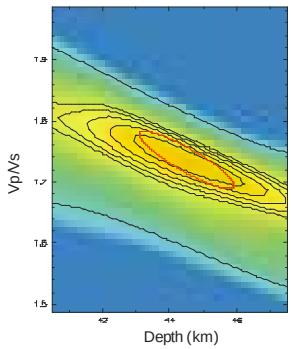
vii) along the refraction profile (13ºS), the Transbrasiliano Lineament coincides with the collisional front. Northwards it goes to NE while the suture bends to NW.

Conclusion

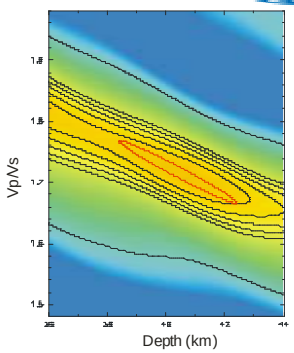
The western limit of the Bouguer gravimetric high in central Brazil is the collision front between the Amazon paleoplate and the Tocantins Province. It separates crust and lithosphere of different composition and thickness.



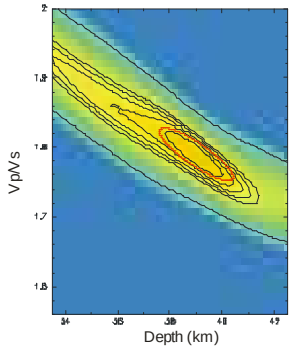
Vp = 6.3 Km/s; h = 42.8 +- 2.5 km;
Vp/Vs = 1.78 +- 0.06
correlation = -90.6%



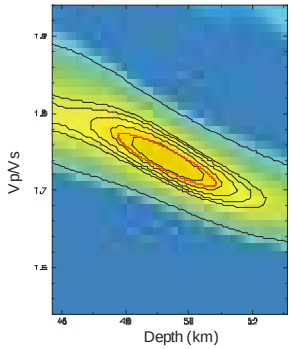
Vp = 6.3 km/s; h = 44.5 +- 2.8 km;
Vp/Vs = 1.74 +- 0.09
correlation = -88.9%



Vp = 6.3 km/s; h = 40.4 +- 4 km;
Vp/Vs = 1.72 +- 0.1
correlation = -98.3%



Vp = 6.3 km/s; h = 39 +- 2.8 km;
Vp/Vs = 1.79 +- 0.08
correlation = -86.6%



Vp = 6.7 km/s; h = 49.3 +- 3.1 km;
Vp/Vs = 1.74 +- 0.07
correlation = -89.8%

Figure 3 - HK-stack, from left to right and up to down, of RET2, RET3, RET4, RET8 and RET9 stations for Vp=6.3 km/s.

Table 1 – Receiver function results for the central Brazil seismographic array

Station	Coordinates Lat.(^{0})/Long.(^{0})	Vp/Vs	Vp (km/s)	H(km)	Geological Setting
RET1	-10.67/-48.55	1.72	6.3	42.5*	Porto Nacional complex Gravimetric high
RET2	-11.70/-49.53	1.79/1.76	6.3/6.7	42.8/46.3	Araguaia Belt Gravimetric low
RET3	-11.87/-49.21	1.74/1.71	6.3/6.7	44.5/48.4	Araguaia Belt Gravimetric gradient
RET4	-12.19/-48.71	1.72/1.70	6.3/6.7	40.4/43.5	Goiás Magmatic Arc Gravimetric high
RET8	-12.97/-50.10	1.79/1.77	6.3/6.7	39.0/42.6	Araguaia Belt Gravimetric low
RET9	-13.29/-49.72	1.74	7.0	52.4	Araguaia Belt Gravimetric gradient

* Preliminary result.

Acknowledgments

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