Interpretation and inversion of magnetic-gravimetric data of Parnaíba Basin near LTB

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Abstract

This work intend to contribute to a better comprehension of the structural basement of Parnaíba Basin, as well as the possible influences in the tectono-sedimentary environments surroundings and overlapping the basement. For such, aerogravimetric and aeromagnetic data were used in an integrated way to generate a structural geological model for the chosen area of interest, near LTB (Cordani et al., 1984) shear zone, southeast of the basin. Since, most rifts and grabens structures in northeast region of Brazil were formed or controlled by the reactivations of the shear zones stablished in Brasiliano (Darros de Matos, 1992), as for example, the strain and thermal changes that occurred over the shear zone of the Transbrasiliano (de Castro et al., 2016).

Introduction

Using potential geophysical methods, the work pursue identify regional geological structures already established in literature to review and interpreted them in association of surface geological data. Generating a model through an integrated magnetic and gravimetric data in a cross-section modeled and inverted with 140km of extension and a NW-SE orientation.

The data used at this work was prevenient of an aerial survey realized by ANP in 2005/2006 (Andrade & Konzen, 2006) that covered all the Parnaíba Basin. Thus, processing, treatments and interpolations technics were used to generate magnetic and gravimetric maps that served as base to the following interpretations of this work. As well as, would continue to serve at the development of the graduate thesis associated, in its more complex deepening.

Method

The acquisition of the potential geophysical data used here are well detailed at Andrade & Konzen (2006) and the first processing of the data was done by the IAG/USP according to Santos et al. (2011), with the removal of the principal errors and noises. At this work, the magnetic and gravimetric data were gridded and interpolated by bi-directional methods at Oasis Montaj - Geosoft® software with a 1,5km x 1,5km mesh, equivalent of ¼ of flight lines spacing. In which, several anomaly maps were created, such as Bouguer, Free-air, Magnetic Regional, Analytical Signal, First Vertical Derivative and Digital Model of Elevation (DME). Being that, at magnetic data was done a low-pass filtering to remove or attenuate the higher frequencies associated with local acquisition noise.

Following that, the GM-SYS 2D extension was used to model and invert in cross-section A-A' of 140 km, perpendicular to the LTB, using the input data of the Regional Magnetic Anomaly grid, Bouguer Gravimetric Anomaly grid and DME grid. As well as, the input of the Moho surface and the top of basement surface to accomplish a direct modeling and geophysical inversion to refine the parameters in use.

Results

The cross-section (Figure 1) are produced in a compatible scale of Parnaíba Basin depth, showing locally a variation of 3,3 to 1,7 km of basement depth, since, the DME has 300 to 150 meters of elevation. In addition, the Moho surface added to the model are present at approximately 30 km depth and cannot be seen at the visual scale, at basin, chosen for this work. The minor signal error adjusted at the modeling are 2.749 (nT) to magnetics and 1.733 (mGal) to gravity, comparing the difference between the observed acquisition data and the inversion calculated data.

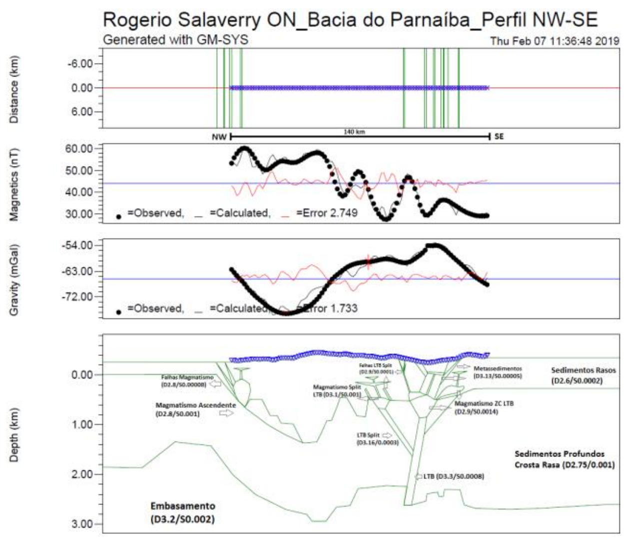

***Figure 1 –** Cross-section A-A' generated at GM-SYS 2D, with NW-SE orientation and 140 km of extension, illustrating the gravimetric and magnetic signal joint inversion (Note: values of density and magnetics susceptibility model at cgs units).*

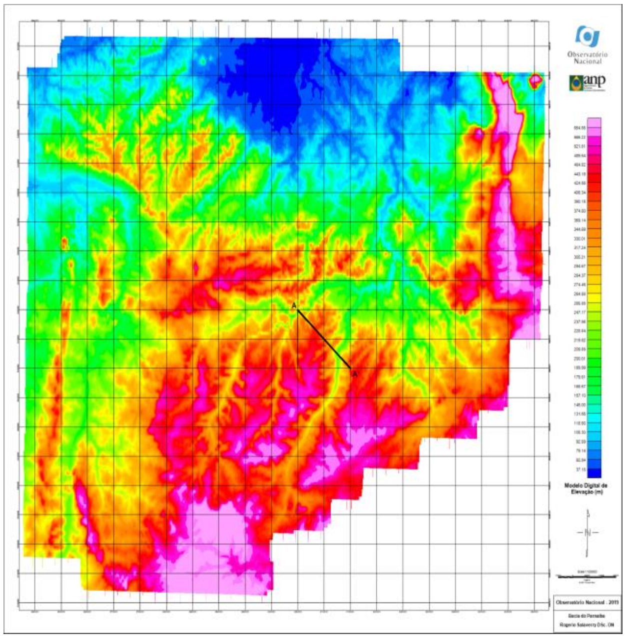

***Figure 2 –** Digital Model of Elevation (DME in meters) of Parnaíba Basin area, interpolated at bidirectional method at Oasis Montaj software. Data used as reference to the model of surface terrain in the area of studied profile A-A', showing a high, valley and high elevation again at southeast associated with a LTB geological structures fitting.*

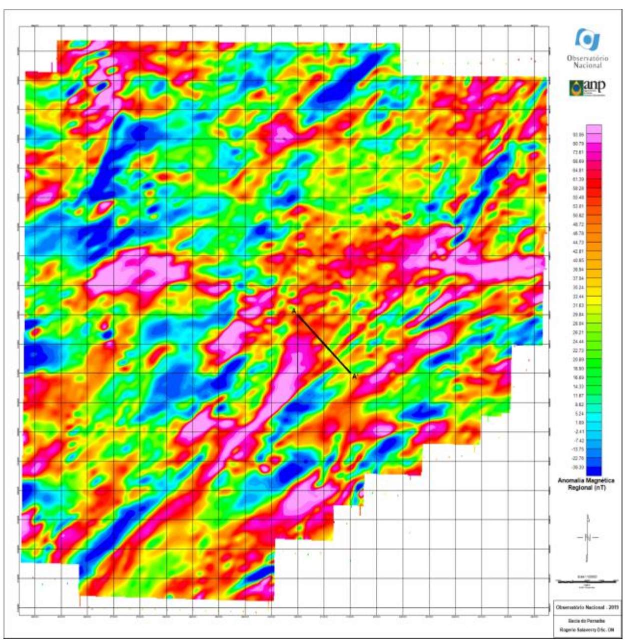

***Figure 3 –** Regional Magnetic Anomaly Map (nT) interpolated at bidirectional method and noise filtering remove at Oasis Montaj, illustrating the studied area. The profile A-A' (NW-SE) cross the big anomalies (NE-SW) associated with LTB and consequent fault splits and magmatism. Data used as reference to the modeling and inversion methods.*

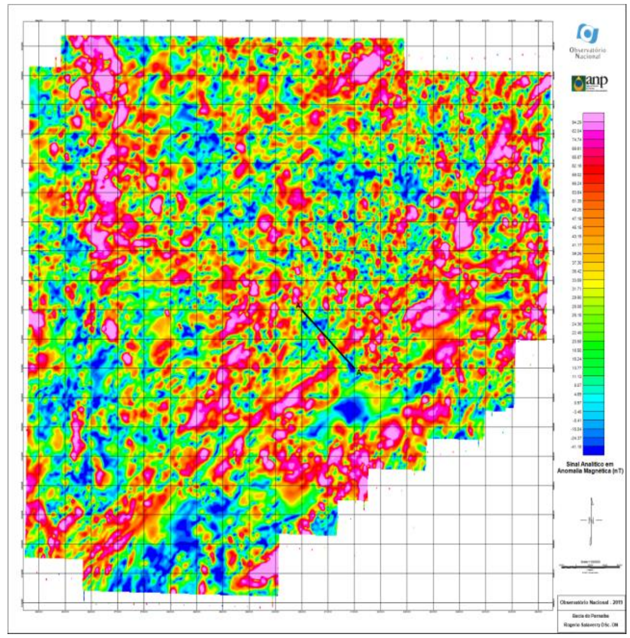

***Figure 4 –** Analytical Signal of Magnetic Anomaly Map (nT) interpolated at bidirectional method with a low-pass filtering, removing the high frequency noises. It is indicated the cross-section A-A' and the perpendicular Lineament Transbrasilian (LTB) with a regional inflection to east that could be correlated to a transcurrent split of faults.*

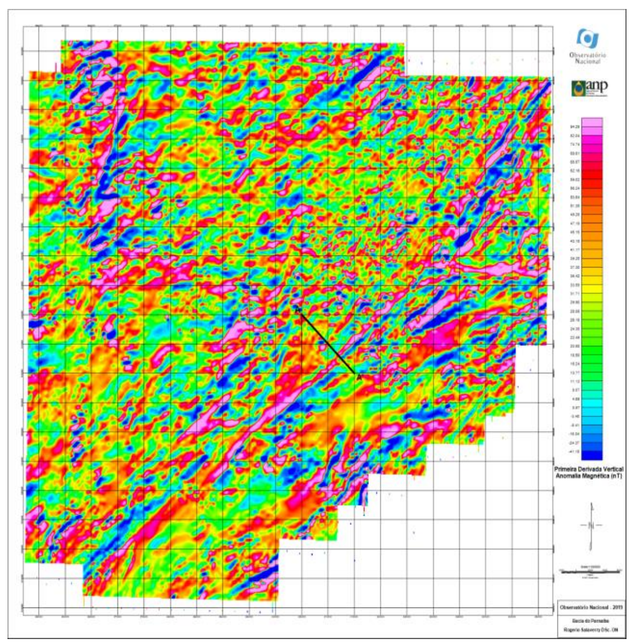

***Figure 5 –** First Vertical Derivative at Magnetic Anomaly Map (nT) interpolated at bidirectional method with a low-pass filtering. It is indicated the cross-section A-A' and the perpendicular Lineament Transbrasilian (LTB) with a local bifurcation in two structures (NE-SW) correlated to a transcurrent split of faults.*

The magnetics analytical signal and first derivative gridding maps were showed excellent to identify the major geological lineament structures of the basin, associated with another gridding maps and well-known literature (Cordani et al., 1984; Nunes, 1993; Milani & Zalán 1999; Vaz et al., 2007; De Castro el al., 2014).

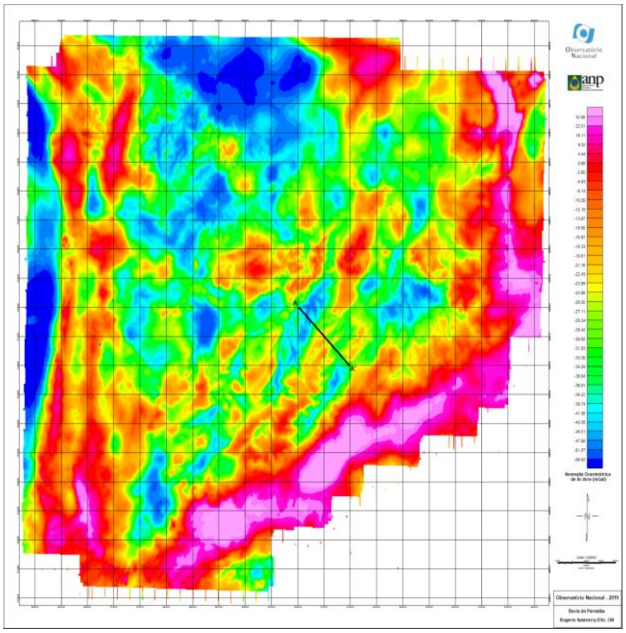

Figure 6 – *Free-air Gravimetric Anomaly Map (mGal) interpolated at bidirectional method at Oasis Montaj software, indicating the profile A-A' crossing an anomaly split at NE-SW strike.*

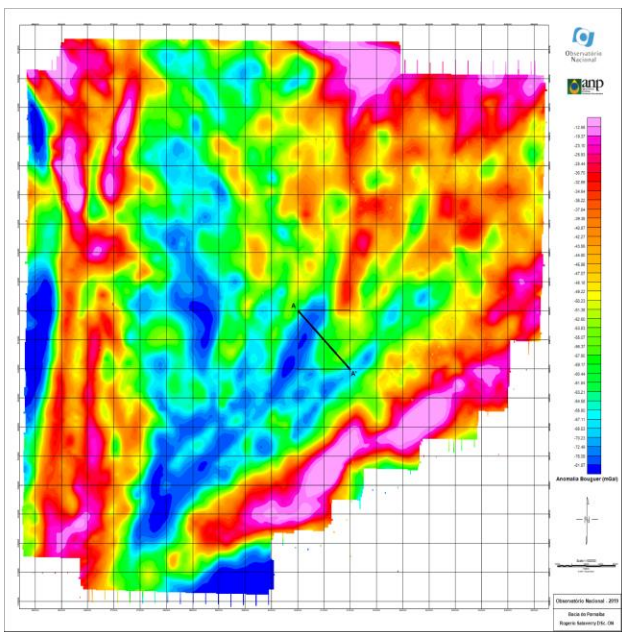

Figure 7 – *Bouguer Gravimetric Anomaly Map (mGal) interpolated at bidirectional method at Oasis Montaj software, indicating the profile A-A' crossing an anomaly bifurcation with NE-SW strike, possibly correlated to a transcurrent split of faults associated with LTB. Data used as reference to the modeling and inversion methods.*

Table 1 - Gravimetric and magnetic final values, corresponding to each type of rock / structure, used while modeling and inversion at cross-section A-A', southeast of Parnaíba Basin.

Rock/Structure	Density (cm/s²)	Mag. Suscept. (emu/cm³)
Basement	3.20	0.00200
Deep Sediments	2.75	0.00100
Shallow Sediments	2.60	0.00020
LTB (major shear zone)	3.30	0.00080
LTB Split	3.16	0.00030
Magmatism Split	3.10	0.00100
Magmatism LTB	2.90	0.00140
Metasediments	3.13	0.00005
LTB Split Faults	2.90	0.00010
Ascending Magmatism	2.80	0.00100
Asc. Magmatism Faults	2.80	0.00008

Conclusions

The magnetic and gravimetric observed data shows strong linear anomalies with NE-SW strike, correlated to LTB structures formed at Neoproterozoic accretionary belts during the Brasiliano orogeny and possibly before at Proterozoic rifting process (De Castro el al., 2014). As well as, E-W and NW-SE observed trends could be correlated to a transferring faults and accommodation zones structures (Darros de Matos, 1992) and the major volcanic exposures belts in the central and southeast part of the basin (De Castro el al., 2014), near this work studied area. This volcanic exposure could be linked with the strain and thermal changes over the shear zone of the Transbrasiliano (de Castro et al., 2016) and Cambrian–Ordovician grabens and faults reactivations over the eastern and southern parts of Parnaíba Basin (Oliveira and Mohriak, 2003).

At this work, we raised some hypotheses starting with a dextral and posterior sinistral movement of LTB (Silva et al., 2011 and Morais Neto et al., 2013) correlated to a complex generation of faults, metamorphism and magmatism at basin scale. In this model (figure 1), the LTB structures does an inflection to east, that would generate a local distensive-compressive region with rifting and magmatic uplift followed by crustal uplift and metamorphism (Ribeiro, 2001), at the west part of the curved LTB fault, possibly correlated to a transcurrent split of faults, in a bifurcation of two major structures with NE-SW trend.

At this way, we observed at the potential data maps a significant positive anomalies at this local profile area (A-A'), which based on literature we try to be faithful to the complex structural geological settings while we did the modeling and inversion processes, leading to a constant reduction of the gravimetric and magnetic signal error. At this manner, we highlight that this present work is an opening to a more vast association of geophysical and inversions methods related to the first author's thesis.

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