Aeromagnetometric Expression of the Transbrasiliano Lineament in the Northern Part of the Tocantins Province - A Possible Suture Zone

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Abstract

High resolution aeromagnetometric survey is used to determine the tectonic framework along the Transbrasiliano Lineament, a large lithospheric discontinuity that occurs in the north of the Tocantins Province.

Introduction

Aiming to understand a important lithophesric struture, a compilation of the interpretation of aeromagnetometric data from the Tocantins Project, publications and field data at the domain Transbrasiliano Lineament in the northern part of the Tocantins Province was performed, in the southern Tocantins state, Brazil.

Convergent and collisional accretionary events caused the amalgamation of the Amazônico and São Francisco-Congo cratons in the late Brasiliano Orogeny (Almeida, 1968, 1977, Almeida *et al*., 1981, Cordani *et al*., 1984). This tectonic regime lead to crustal shortening of geological units, placing distinct lithospheric blocks side by side, as a response to oblique convergent movements, resulting in the Transbrasiliano Lineament in the Tocantins Province.

Presently, one major seismogenic zone, named Goiás-Tocantins Seismic Belt, is apparently related to the Transbrasiliano Lineament and interpreted as an effect of stress relief along weakness zones in the displacement of the South American Plate. The seismogenic zone is associated with the Mesozoic reactivation of South Atlantic (Mioto & Hasui, 1988). These zones of weakness represent the reactivation of a deep crustal discontinuity, supported by gravity and magnetic data and interpreted as an ancient collisional suture zone (Haralyi and Hasui, 1981, 1985; Blum, 1999; Chiarini, 2007).

A direct application of aeromagnetometric surveys, on a regional scale, is the tectonic discrimination of lithospheric blocks and characterization of collisional sutures, whose interpretation reflects the contrasting signature of anomalies at different sides of a major geophysical discontinuity (Holm *et al*. 2007; Chernicoff & Zappettini, 2004). The suture has been identified by the presence of granulite terrains, associated with strong contrasts in magnetic signatures between two crustal blocks, whose boundaries are represented by shear zones (Rao *et al*., 2006). The contrast of the geophysical signatures is attributed to the large amount of mafic lower crust rocks, which have high magnetic susceptibility and form band pairs of high and low magnitudes and bipolar anomalies parallel to the structural trend along the suture zone (Mishra and Kumar, 2006).

Large magnetic lineaments are formed parallel to regional foliation along strike-slip shear zones for more than 400 km, such as the suture zone of the Kalahari (Brett *et al*., 2000). Generally, deep lineaments are recognized by the contrasts of magnetic domains. Usually these lineaments define shallow and deep discontinuities patterns, whose trend corresponds to the boundaries between the different lithospheric blocks (Chernicoff *et al*., 2002). Deep structures geometries in models of global tectonics provide information on the relative movement of crustal blocks and support models of supercontinents reconstruction.

The interpretation of seismic refraction data crossing the Transbrasiliano Lineament in northern Goiás suggest that major discontinuities represent crustal blocks boundaries with different densities and displaying abrupt changes in the depth of the seismic Moho, individualizing these lithospheric segments (Soares *et al*., 2006; Melo, 2007).

Interpretation of high resolution aeromagnetometric data of northern Goiás, including the shear zones that constitute the Transbrasiliano Lineament, using Euler Deconvolution for structural planar index showed a high-density of solutions, depicting a vertical plane direction striking N30°E. That plane has been assigned to the main suture zone in the area (Chiarini, 2007).

The previous contributions reveal the magnitude of the Transbrasiliano Lineament, which is responsible for setting boundaries of lithospheric segments and collisional suture zones of N30°E direction within the Tocantins Province.

Method

This paper is based on data from the Tocantins Aerogeophysical Project, which was the result of the MME-ANP-CPRM Cooperation Agreement 017/CPRM/05 included in the Geology Program of Brazil (PGB). The data were acquired in 2005 and 2006, but due to the establishment of calibration, were only released by CPRM/SGB in 2010. So this is the first time that these data come to the public.

Figure 1 illustrates the location of the project, which consists of 164,003 kilometers of linear profiles, covering an acquisition area of approximately 75,872 km^2. Table 1 shows the main survey parameters.

To execute the data processing a cell size of 125 m was used, according to the literature which shows that dimensions between 1/4 and 1/8 of flight lines spacing avoids losing information and appearance of the aliasing effect or the incorporation of the high frequencies without solution for low frequencies (Vasconcelos *et al.*, 1990). For magnetometry interpolation the Bigrid algorithm was applied.

The signal was converted to the frequency domain, using Fast Fourier Transform and thereafter the following products were generated: three orthogonal directions derivative, Analytical Signal Amplitude (ASA) and Inclination of Analytical Signal (ISA). This processing aims to produce images that highlight the abrupt variations of the different magnetic susceptibility. For the horizontal directions of the derivatives azimuths of 45° and 135° were applied in order to minimize noises, since the acquisition had NS direction.

Table 1: General Parameters of the Tocantins Aerogeophysical Project.

MAIN PARAMETERS	
Flight heights	100 m
Flight line direction	N-S
Flight line spacing	500 m
Tie line direction	E-W
Tie line spacing	10.000 m

Figure 1: Schematic Location of the Aerogeophysical Tocantins Project.

Figures 2 to 5 show the result of data processing.

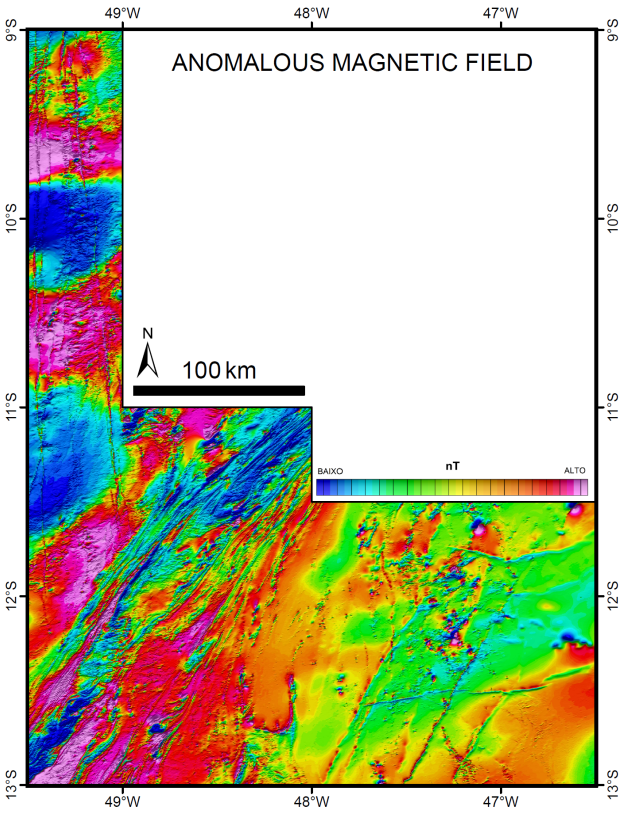

Figure 2: Image of the Magnetic Anomalous Field.

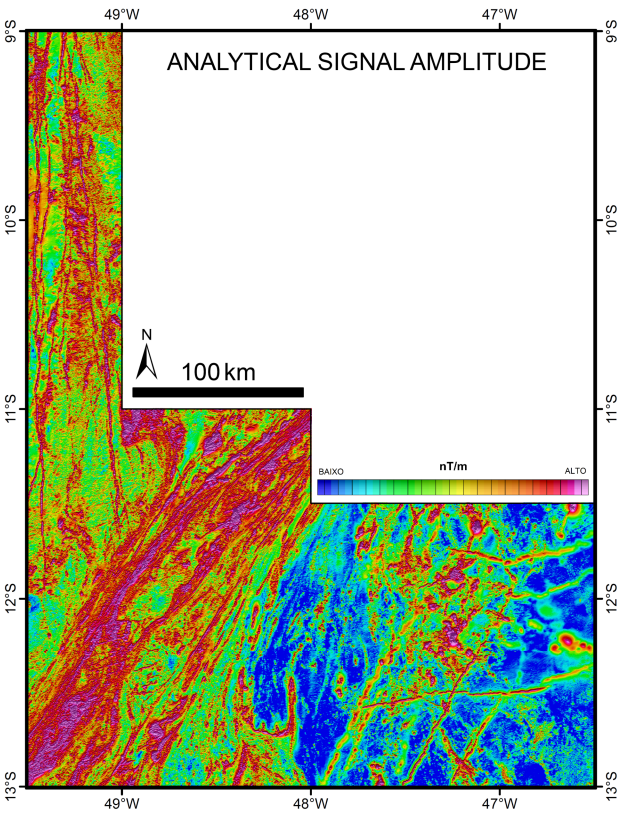

Figure 4: Image of the Analytical Signal Amplitude.

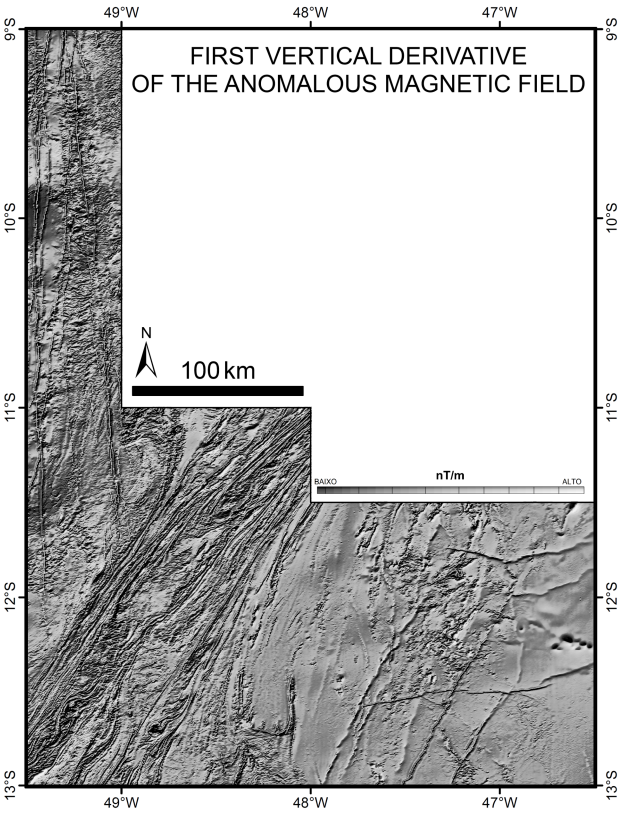

Figure 3: Image of First Vertical Derivative of Magnetic Anomalous Field.

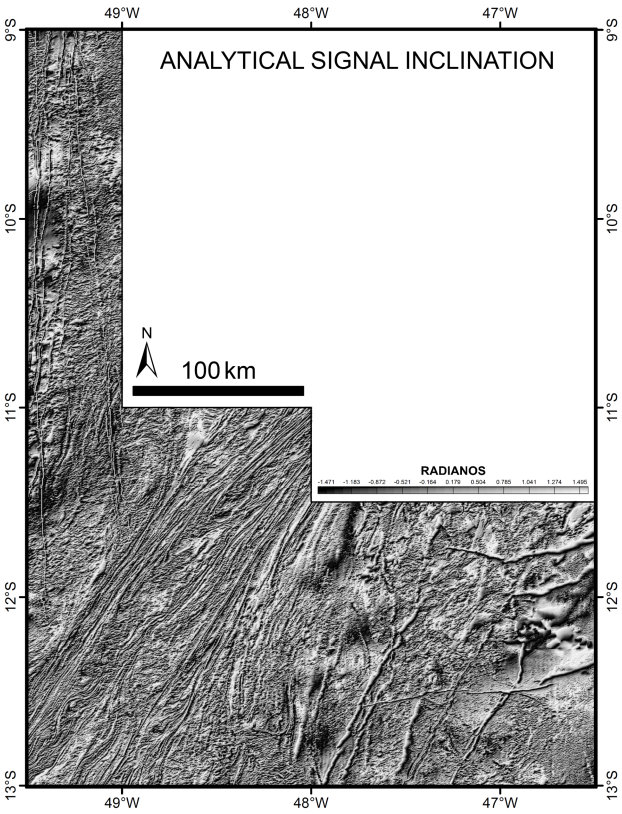

Figure 5: Image of the Analytical Signal Inclination.

Results

Based on the magnetometric images (Figures 2 to 5), domains and lineaments were interpreted (Figures 6 and 7).

The frequency, the size and the directions of the magnetometric lineaments associated with distinct and well marked Analytical Signal amplitudes, discriminate magnetometric domains with rectilinear and parallel boundaries, as shown in Figure 6. This pattern and the very strong magnetic susceptibility contrast in geophysical signature is typical of suture zones, well recognized elsewhere in the world. The depicted feature is larger than 250 km length and 90 km wide (size underestimated due to the limit of this survey), displaying a regional character, as identified in aeromagnetic products presented in this paper. The adjoining areas display distinct magnetometric signatures, suggesting distinct tectonic compartments.

Strong and rectilinear contrasts in the magnetometric signature are associated with granulite terrains set in a NE trend near the Goiás-Tocantins border (Gorayeb, 1997; Hasui *et al.*, 1994) These high-grade terrains have also been identified in recent geological mapping carried out by the Geological Survey of Brazil. Despite discontinuous exposure, granulites extend from Porangatu to Porto Nacional cities and are limited by ductile shear zones, marked by mylonites. Thus, geological and geophysical evidence (high magnitude shear zones, milonites and granulite belts, and magnetometric signature with strong rectilinear contrast) suggests that this part of the Transbrasiliano Lineament represents a possible lithospheric suture zone.

The geometry of the set of magnetometric lineaments may elucidate questions about the relative kinematics between tectonic blocks. In all processed images it is possible to notice groups of tectonic features composing drag features, both to the east and west of the major N30°E strike-slip fault zone, corresponding to the Transbrasiliano Lineament ilustrated in Figures 5 and 6. These features suggest a dextral kinematic behavior for the main strike-slip system.

The curvilinear geometry of magnetometric domains with undisturbed texture inside the major NE trending zone influenced by the Transbrasiliano Lineament provides timing information regarding these rock bodies. The contrast of shape anomalies with the pattern of their surroundings, which is strongly rectilinear in the N30°E direction, allows to inferring that such features are caused by syn- to late tectonic intrusions. This interpretation is supported by preliminary field and analytical data provided by CPRM/SGB for the 1:250.000 scale Gurupi Sheet, which show that these magnetometric domains correspond generally to granites with U-Pb ages between 530 Ma and 508 Ma. This age interval can be taken as compatible with the closing of the shear system.

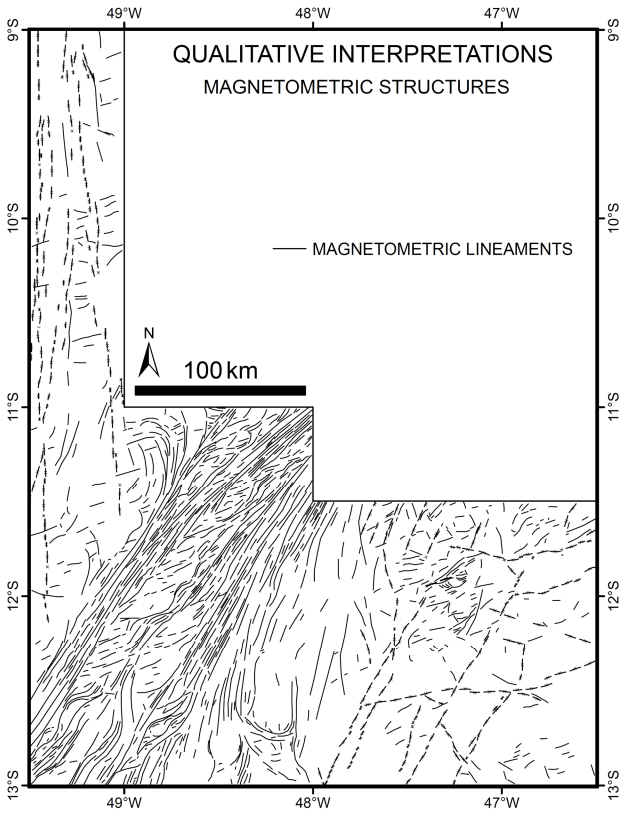

Figure 6: Map of Qualitative Interpretation of Magnetometric Structures.

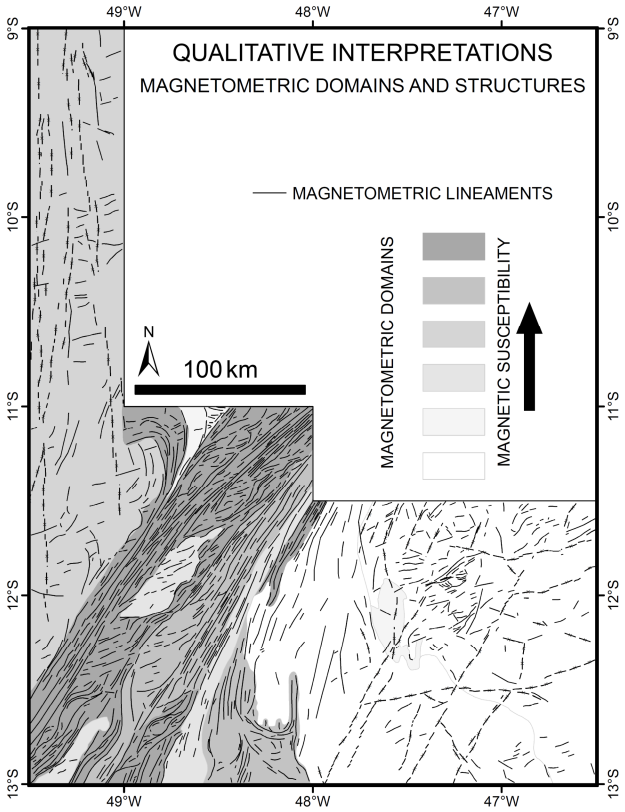

Figure 7: Map of Qualitative Interpretation of Domains and Magnetometric Structures.

Magnetometric lineaments displaying typical signature of magnetic bodies with dyke geometry are identified throughout the studied area. These features are noted in the Araguaia Belt which stand out by the preferred NS direction westwards of the Transbrasiliano Lineament, and are confirmed in the field by outcrops of extensive diabase dikes primary dated around 495 Ma and 225 Ma (Almaraz,1967 *in* Cunha *et al*. 1981). Eastwards, in Brasília Belt basement, the diabase dikes occur more often in the NE-SW and EW directions. This difference in diabase dikes trends can be associated with different types of rock rheology, supporting the idea that the Transbrasiliano Lineament limits distinct geological entities.

The kinematics recorded in the regional geophysical anomalies can be interpreted as the result of oblique collision of continental blocks, where the strike-slip shear zones developed as a manner to dissipate energy that was previously consumed in subduction.

Conclusions

The interpretation of high-density geophysical data of the Tocantins Aerogeophysical Project allowed the characterization of the magneto-structural framework of the study area in southern Tocantins, Brazil, and the identification of the main tectonic boundaries between different geological domains, discriminated by their magnetometric properties.

The recognition of a magnetic signature possibly related to a collisional suture zone, associated with the occurrence of granulites, by continental amalgamation processes is the major contribution of this paper. Lithospheric blocks were placed side by side in an oblique convergent tectonic regime. Boundaries of these blocks were identified based on contrasting geophysical anomalies. The main magnetometric domains match crustal discontinuities, which mark the boundaries between the Araguaia and Brasília belts in the Tocantins Province.

The structural character of the Transbrasiliano Lineament in the study area is remarkable, dominating and controlling the geometry of the more than 90 km wide, N30°E deformation zone. It is also responsible for generating drag and "horse-tail" structures tens of kilometers long in the bordering terrains.

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