Airborne geophysical data as an aid to geological mapping and target selection in the Tapajós Gold Province, Brazil

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Abstract

Airborne geophysical data acquired over the Tapajós Gold Province (TGP) in west Central Amazon Province display different patterns previously not identified in geological field mapping. Integrated analysis of airborne magnetic and gamma-ray spectrometric data plus available geological data was conducted to map and analyze these patterns, and to obtain insight in their regional significance.

Enhancement of the airborne magnetic and gamma-ray spectrometric data have resulted in better definition of both geological structure and lithological boundaries than indicated on previous maps. Comparison of multiple geophysical signatures and known mining occurrences were particularly valuable for defining old targets and direct new ways for gold prospecting in the area. Areas with high to moderate favorableness encompass well-known gold deposits, as well as new signatures that may have economic importance.

Geophysical data were successfully used to highlight relationships between main crustal domains, as well as their internal structures and boundaries. The northeast domain bears the signature of older crustal material covered by rocks of the Uatumã Supergroup generated through partial crustal melting. The western limit of this domain is close to the supposed limit that divides the Central Amazon and Ventuari-Tapajós provinces. A large structure marked by high amplitude in the western part may record oceanic crust subduction and formation of the Cuiú-Cuiú arc.

Introduction

The Amazon region yields a large part of the Brazilian mineral production. However, this area is covered by dense equatorial forest and a thick lateritic profile developed over Precambrian substratum. These physiographic characteristics have hindered geological research in the area

The present capability to acquire, process and display very large geophysical data sets of high quality has increased the capacity to extract geological information. Interpretation of magnetic and radiometric data have been used in some area in Brazil and the results have decreased the costs of geological mapping programs.

In this paper, an integrated interpretation of airborne geophysical and geological data is used to analyze geological structure and lithological boundaries, as well as the signature of well-known gold deposits and new ones that may bear economic value.

Geological setting

The TGP is located in southern Amazon Craton (Figure 1). The province is formed of Paleoproterozoic rocks. The basement comprises metasedimentary rocks (Jacareacanga Group) associated with migmatite and orthogneiss (Cuiú-Cuiú Complex) formed in island arc environment and metamorphosed under amphibolite facies conditions (Almeida et al. 1998). Younger rocks were formed during post-collisional (Creporizão Intrusive Suite) and post-orogenic events (Parauari and Maloquinha suites) in extensional regime (Vasquez et al, 2002). Most of these units display primary gold mineralization.

Geophysical data

The geophysical survey included coverage with two different datasets. The oldest survey has flight and control lines spaced 2000 m and 20000 m, respectively, oriented N-S for the production lines and E-W for the control lines. The high resolution surveys (blocks 1 and 2) are spaced 1000 meters and the control lines were every 13000 m. The flight line orientations are NS for both blocks and EW for the control lines. Nominal flight altitude was fixed at 100 m for high resolution surveys and 150 m for the oldest survey.

Method and Results

Software Oasis Montaj, 5.07 version of GEOSOFT™ was used in all four processing steps: pre-processing, interpolation, microleveling, and transformed maps elaboration. Pre-processing includes remotion of anomalous peaks in magnetic data with fourth difference technique and remotion of negative values of gamma-ray data, adding standard deviation in each channel. For interpolation, geophysical data were separated in two blocks. The first, with 1 km flight line spacing, was interpolated with 250 meters of cell size. The second block, with 2 km flight line spacing, was interpolated with 500 meters of cell size. Algorithm Microlevel.gs, developed by Blum (1999), based on Minty´s (1991) method, was used for microleveling.

For interpretation of regional structures, the datasets of different resolutions were joined with 500 meters of cell size. Algorithm Grid Knitting (GRIDSTCH GX) available in software was used for this union.

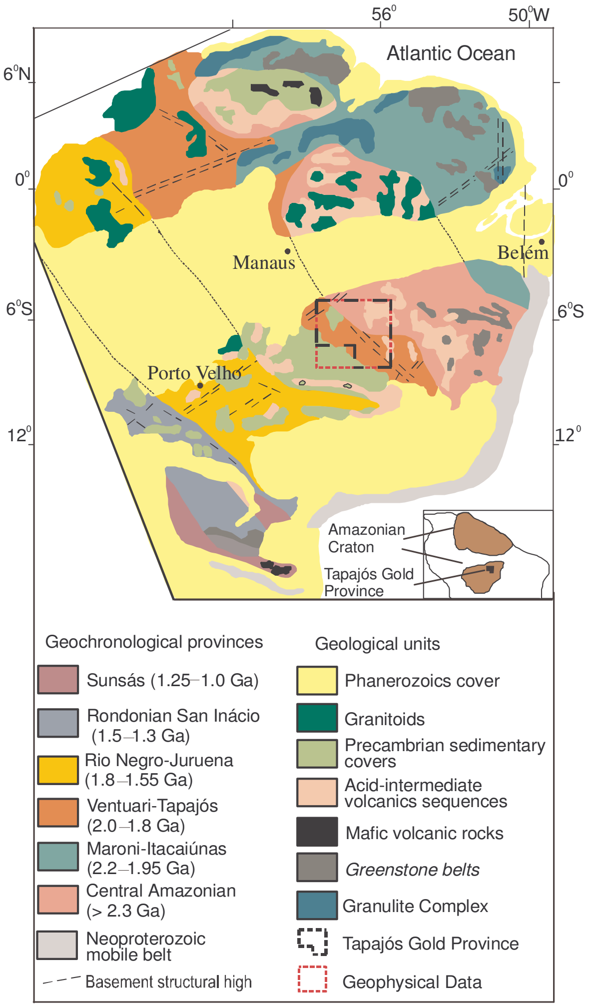

Figure 1. Map of Amazon Craton showing geochronological provinces and position of TGP (modified from Tassinari and Macambira, 1999).

The main transformed maps used in interpretation is amplitude of analytical signal, first vertical derivative and Euler deconvolution for depth estimation from magnetic data, and K, U and Th maps and ternary maps in RGB and CMY colors from gamma-ray spectrometry.

A large database has built in ArcView™ 3.2 of ESRI, including all transformed maps and geological data from 1:250.000 maps with location of most gold deposits of the province. Interpretation in GIS environment allowed identification of structures and qualitative classification of magnetic and gamma-ray domains. Gamma-ray domains were classified in low, medium or high concentration of each element, and magnetic domains were classified in low, medium or high amplitude of analytical signal, and according to magnetic relief shown in first vertical derivative that is smooth or rough.

Regional geology results

Figure 2 shows the interpreted magnetic domains. Domain A, at the northeast of the province, is marked by low to medium amplitude of analytical signal, with rough magnetic relief (classes 3 and 5, east of dotted blue line). This is interpreted as the association of older crustal material with rocks of the Uatumã Supergroup, that has formed by partial crustal melting. The western limit of this domain (dotted blue line) is close to the supposed limit that divides the Central Amazonian and Ventuari-Tapajós provinces (Tassinari, 1996). This can be useful to confirm the limit between both provinces.

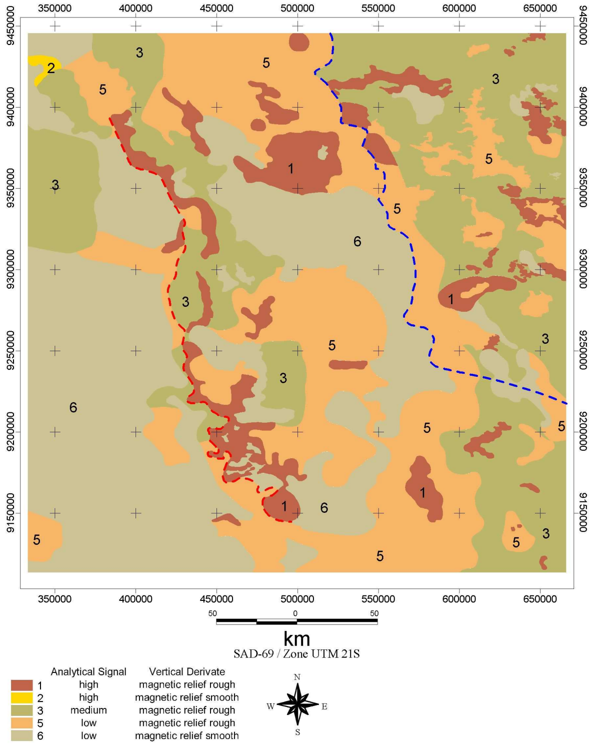

Figure 2. Map of interpreted magnetic domains showing supposed limit (dotted blue line) between Central Amazonia (domain A) and Ventuari-Tapajós provinces and possible record of oceanic crust subduction and formation of the Cuiú-Cuiú arc (dotted red line).

The large structure (Figure 2) limited by high amplitude of analytical signal (dotted red line) in the western province is interpreted as a possible record of oceanic crust subduction and formation of the Cuiú-Cuiú arc. This model is coherent with Vasquez et al (2002) model, that suggests the formation of an island arc (Cuiú-Cuiú Intrusive Suite) colliding with the Central Amazonia cratonic area, and generating the Creporizão Intrusive Suite in a post-collisional event, followed by formation of the Parauari and Maloquinha suites in post-orogenic events, in extensional regime.

Gold mineralization

The Pacu district (Figure 3A, 3B) is a gold production region in TGP. Figure 3A (gamma-ray domains) shows that many gold deposits are associated with a body (red arrow) classified as class 20 (high K, high Th, and medium U). One of these deposits, the Ouro Roxo, is hosted by tonalite-granodiorite, and its mineralization is associated with mafic xenoliths (Santos et al. 2001).

High concentrations of K shown in tonalite-granodiorite host-rock is due to original concentration of K in granodiorite and to hydrothermal alteration, which is a common process in Ouro Roxo-type gold deposits. Classified by as orogenic-related, these deposits are hosted by the Cuiú-Cuiú magmatic arc (Santos et al. 2001). Hence, bodies with high K concentrations (blue arrows) in this context are potential targets.

Although there are not many recognized gold deposits in the southeastern region of TGP, some interesting geophysical features have been identified as potential targets. In this area, one batholith (Figures 3C, 3D), mapped as Parauari Intrusive Suite (interpreted as class 10, inside black square) is cut by straight and shallow magnetic lineaments (as shown by Euler Deconvolution), with spots having high K concentration (red arrows in Figure 3C) and high amplitude in the analytical signal amplitude (blue arrows in Figure 3D). Around the batholith, there are intrusions of the Maloquinha Intrusive Suite, interpreted as class 22.

Geophysical characteristics suggest the possibility of mineralization in quartz veins related to intrusion, as suggested by Santos et al. (2001). Magnetism can be related to mafic dikes and, in this case, mineralization could be disseminated in pyrite rich alteration zones. Alternatively, magnetism could be due to sphalerite-gold-bearing quartz veins. Both situations have been observed already in field (Santos et al. 2001).

K enrichment by hydrothermal processes (sericitization) is common in this kind of mineralization. Granites of Maloquinha Intrusive Suite could have supplied the needed heat to drive hydrothermal fluids circulation, as suggested by Santos et al. (2001).

Conclusions

The lack of rock exposures and connections of rock formations at surface poses problems for regional geologic mapping and interpretation, which are difficult to be surpassed. In this paper, an attempt was made to map the TGP, using aerogeophysical magnetometric and gammaspectrometric data, with a twofold aim: to evaluating the usefulness of the method to unravel regional rock domains and to highlighting structure and mineralization.

Geophysical data were successfully used to highlighting relationships between the main crustal domains, as well as their internal structures and boundaries.

The eastern limit identified in the map of magnetic domains is in agreement with the suggested limit between Central Amazonia and Ventuari-Tapajós provinces (Tassinari, 1996). Interpretation of the western limit as a possible record of subduction has to be tested. Both limits have to be confirmed in field work and through other geophysical methods, like gravimetry, for example. The suggested geophysical interpretation is in agreement with the model proposed by Vasquez et al. (2002).

Areas with high to moderate favorableness encompass well-known gold deposits, and new targets highlighted by geophysical signature may be useful as guidelines for gold exploration in the TGP.

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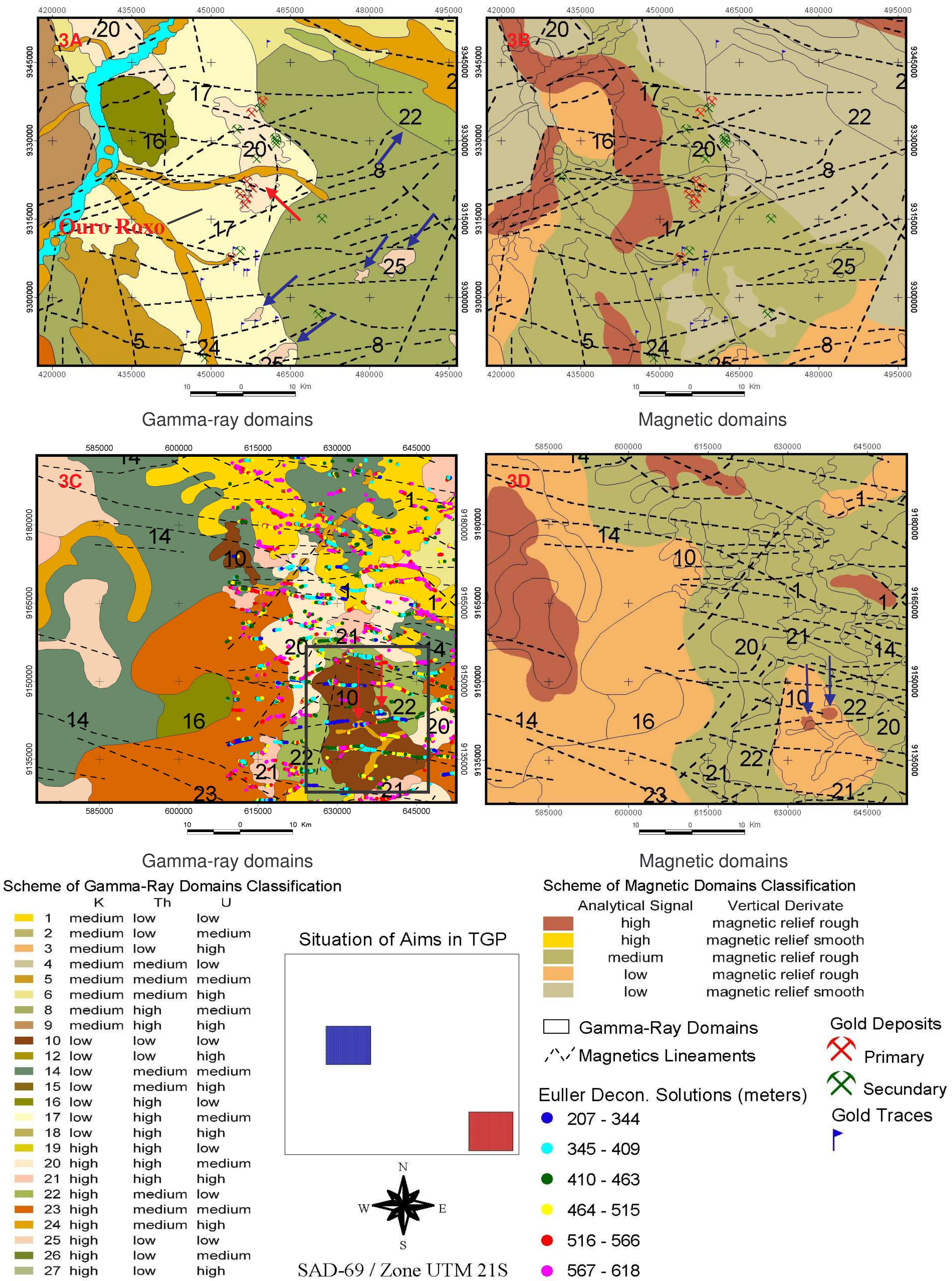

Figure 3. 3A/3C and 3B/3D show gamma-ray and magnetic domains, respectively. Blue and red boxes show position of 3A/3B and 3C/3D in TGP, respectively. Numbers refer to gamma-ray domains and colored points (figure 3C) refer to depth of magnetic source (Euler Deconvolution with structural index equal to one).