HIGH RESOLUTION AEROMAGNETICS AS AN AID TO GEOLOGIC MAPPING OF RIO DAS VELHAS GREENSTONE BELT, QUADRILÁTERO FERRÍFERO, MINAS GERAIS, BRAZIL

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ABSTRACT

A high resolution geophysical survey was acquired in 1992 as a part of Rio das Velhas Project and was used to investigate the regional structural setting of the area and better define lithological boundaries. High resolution geophysical surveying is fundamental to modern geoscientific mapping, providing cost-effective definition of structure and lithology in a diverse range of geological terrains. The airborne magnetic data are particularly valuable for defining north-south Archean structures and the continuity inside the study area. This paper illustrates the usefulness of the aeromagnetic data in the support of geological mapping in the Rio das Velhas Greenstone Belt.

INTRODUCTION

The Quadrilátero Ferrífero (QF) covers an area of approximately 7190 km^2. Approximately 25% of this area is mapped as the Rio das Velhas Greenstone Belt (RVGB). This region is one of the most important gold provinces in the world and has contributed significantly to the economic development of Brazil. The RVGB contains one of the largest publicly available airborne geophysical surveys carried out in Brazil in terms of data acquisition and resolution. The survey has 250 meter flight line spacing and was designed in different blocks with multiple flight and tie line directions that run perpendicularly to the geologic structures of RVGB.

This paper describes preliminary results from studies of airborne magnetic data from the RVGB, which were undertaken with the goal to better define the structures and lithological boundaries. In particular, this paper concentrates on the new lithostructural information provided by interpretation of derivative products from magnetic data, and it examines the implication of this new information with regard to gold deposits of Rio das Velhas Greenstone Belt.

REGIONAL GEOLOGIC SETTING

The QF is situated in the southern portion of the São Francisco Craton and is composed of Archean granite-gneissic terrains (GGTs); Archean Greenstone Belt (Rio das Velhas Supergroup); Paleoproterozoic (Minas Supergroup and Itacolomi Group) and Paleoproterozoic-Mesoproterozoic (Espinhaço Supergroup) supracrustal units.

The supracrustal units, namely Minas and Rio das Velhas Supergroups, surround and are surrounded by granite-gneiss domes including Bação, Caeté, Bonfim, Belo Horizonte and Santa Rita. These domes consist of poly-deformed gneiss, metatonalites to metagranites, amphibolites, meta-ultramafic rocks, as well as pegmatites formed in amphibolites facies conditions during the Archean and in the Tranzamazonic Eras (Cordani *et al*. 1980, Machado *et al*. 1989a, Chemale *et al*. 1994). The contact with adjacent supracrustal units is tectonic.

The Rio das Velhas Supergroup (RVSG – 3.0-2.7 Ga, Machado *et al*. 1989a) is divided into two groups. The first, Nova Lima Group (NLG) comprises a lower ultramafic unit, an intermediate felsic-mafic unit and a clastic-mafic-felsic unit (Ladeira, 1980; Schorscher, 1978). These rocks are overlain by quartzites of Maquiné Group that is divided in two formations: Palmital and Casa Forte (Dorr, 1969).

DATA PROCESSING

Flight line data were converted to grids that allowed for immediate application of enhancement techniques. Initial processing involved flight line editing, the application of a gridding algorithm (Webring, 1981), the removal of Earth's background magnetic field, and, the leveling of all data to a common base. Data processing details are given in Silva (*in preparation*).

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AIRBORNE MAGNETIC INTERPRETATION

Analytical techniques applied to the magnetic data provide new interpretative information by enhancing particular trends or wavelengths. Magnetic expressions of structures and lithologic variations within the Rio das Velhas greenstone belt are enhanced. A reduction- to-pole (RTP) filter for low geomagnetic latitudes (Phillips, 1997) was applied to the magnetic anomaly data. This program utilizes an azimuthal filter to minimize the directional noise caused by the low geomagnetic latitude in the frequency domain. It is known that significant concentrations of mineral deposits are correlated with greater magnetic responses. Because of that, high-pass, horizontal gradient and terracing filters were applied in order to enhance high frequencies and/or define body edges.

The reduced- to- pole magnetic anomaly map (Figure 1) shows that the magnetic field in the area is characterized by low and high frequency, small, positives and negatives anomalies. The short wavelength positive anomalies map magnetite-rich banded iron formation (BIF) and volcanic rocks. The banded iron formations are by far the most important hosts of the gold mineralization. In accord with Ribeiro Rodrigues (1998), they can be divided into three types: oxide type (magnetic), carbonate-sulphide type and ankerite/ferroan dolomite, quartz and plagioclase type (Lapa Seca). The banded iron formations have contributed 99% of the total gold production and the magnetic BIF is the principal host in terms of number of deposits (Ribeiro Rodrigues, 1998). The elongate high frequency anomalies in the northeast of the area are also associated with the strips of Archean banded iron formation that made contact with chemical metassediments of the RVGB. In the southeast, the circular anomaly is correlated to Ouro Fino Syncline (Minas Supergroup) that occurs inside of the Rio das Velhas area. The positive magnetic values are due to the Lake Superior BIF in the syncline, typical of this unit.

The edges of magnetic anomaly sources become sharper or better defined if derivative operators are applied to the data. Maximum magnitudes of horizontal gradients generally occur above lithologic contacts that have contrasting magnetizations. In the analysis of the horizontal gradient, it is possible to map the important known and the not well known structures that are one of the main controls of the Archean-greenstone hosted mineralization. Such structures were also found in the high pass map, however the north-south structures are more clear in this product than in the horizontal gradient map.

North-south structures are well mapped in the southern portion of the area, in the same region that Endo (1997) has defined this type of structure as Archean age and related to the Rio das Velhas Tectonic-thermal event. The Rio das Velhas Supergroup (RVSG) is older than 2740Ma and was strongly deformed by a dextral transcurrent tectonic. This is considered the main deformation mechanism for the RVSG units and for the GGTs associates. However, almost all of the RVSG units were tectonized and metamorphosed by the Transamazonic and Brasiliano Events, which makes the tectonic characterization of the RVSG more difficult. According to Endo (1997) and Endo and Machado (1998), the coincidence of the north-south structural directions, in the metamorphic complexes and in the supracrustals of the RVSG, shows that these segments were targets for successive tectonic reactivations of crustal weakness zones, of ductil to ruptil nature, generated during the Mesoarchean. They proposed that the generation of the structural matrix of the QF and its successive reactivations, during the Neoarchean, occurred during a tectonic regime of transpressional nature.

There are two large Paleoproterozoic structures that can be mapped with the aeromagnetic data: Bem-te-vi and São Vicente faults. The Bem-te-vi fault separates different magnetic domains in the Greenstone Belt. The São Vicente system is one of the most important gold structural controls. It also marks the contact between the Nova Lima and Maquiné Groups.

Another important group is represented by the northeast Paleoproterozoic NE structures. They are predominant and cut the other structures mentioned. In the field, they represent a broad system of fractures and lineaments. The borders of the survey make contact with the Minas Supergroup and the high-frequency associated with these tectonic contacts are due to BIF, Lake Superior type, that occur in these zones.

The terracing technique was applied to aeromagnetic data after it was reduced to the pole. By comparing the color images with the Rio das Velhas geologic map, it is possible to see geologic features and variations that can be correlated to the greenstone. However, the short wavelengths do not show the important features. It is often useful to filter the potential field data prior to terracing to enhance features of particular interest. Because of that, this technique was applied to the high-pass map. The results show the form and amplitude of magnetic responses of the magnetic banded iron formation in the Greenstone Belt Rio das Velhas that concentrates important gold sites.

The analytical signal filter was applied to the residual magnetic field. The analytical signal is independent of the direction of the magnetization of the source. The amplitude of the analytical signal is related to amplitude of magnetization. The most significant concentrations of mineral deposits in this area are correlated with high amplitude anomalies.

DISCUSSION AND CONCLUSIONS

Analysis of geophysical features provides new insights into structural history and can help geologists target new areas for mineral exploration. Recognizable patterns of geophysical anomalies correspond to geological targets for mineral potential, such Archean banded iron formations and associated volcanic rocks. The integrated interpretation of high-resolution magnetics has provided both an overview of the regional structure as well as further insight into structural controls of the Archean-greenstone-hosted-gold mineralization. Interpretation of the aeromagnetic map shows one detailed assessment of the known and north-south structures in the area. The recognition of the extension of north-south structures has important implications for the understanding of Rio das Velhas Tectono-thermal event.

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