Gravimetric and Magnetic interpretation of Catalão II anomaly (GO-Brazil).

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Abstract

Catalão II anomaly is located approximately 14 Km from the ultramafic-alcaline-carbonatite complex Catalão I which is a very important site explored by mineral companies in the extraction of phosphate, niobium, rare earth, titanium and vermiculite.

The geophysical modeling of Catalão II anomaly can help to understand if there is a relationship between Catalão I and Catalão II intrusions and also evaluate the shape of the body itself.

The Geophysical Inversion Facility of the University of British Columbia (UBC-GIF, mag3d and grav3d programs) were used to invert the magnetic and gravimetric data. The resultant susceptibility and density models from both methods were compared in the same mesh and confronted with the geological knowledge of the anomaly. The outcome models agree with the expected contrasts and the overall result can be used for a preliminary estimation of the anomaly and motivate a more detailed investigation over all the complex area.

Introduction

The goal of the present study is to give an insight of the geophysical characteristics of the carbonatite complex of Catalão II based on magnetic and gravimetric methods as well as contribute to the studies over the Paranaiba alkaline province.

The magnetic and particularly the airborne magnetic data is one of the most commonly used geophysical approaches to identify features in the range from geological structures to small mineralized bodies caused by susceptibility contrast in the rocks.

Gravimetric methods are also widely used in geological research and mineral exploration when significant density contrasts exist. When applied jointly with the magnetic interpretation, the gravity method can reduce the amount of ambiguity which is inherent to the potential field methods.

To produce the magnetic modeled inversion, the gridded data were filtered and the regional influence was removed. In addition, another inversion from the magnetic data reduced to the pole was obtained and compared to evaluate the stability of the modeled results. The analytic signal amplitude of the magnetic anomaly was used to constrain the contours of the body.

However, when the target area shows a significant complexity in the magnetic parameters, which cannot be neglected, then the susceptibility distribution obtained from the inversions can be inconsistent with geologically acceptable scenarios.

In order to assay the inversion results, both models were compared with a gravimetric inversion in the same area. The modeled bodies obtained are compatible with published works related to these anomalies as well as the geological observations in the area (Requejo, 2012; Palmieri, 2011; Machado Junior, 1992a) and suggests a connection between Catalão I and Catalão II intrusions.

Geological context and methodology

The study area is the Catalão I and Catalão II alkaline complex, located near to Catalão city in the south east of Goiás state (Fig 1). The complex is part of the Alto Paranaíba province and the regional geology consists of schists and quartzites of Araxá group (Requejo, 2012).

***Fig. 1 -** Map location of the anomalies in the south east of Brazil*

Palmieri (2011) and Machado Junior (1992a), described the geological model and metallogenetic aspects of Catalão II and Morro do Padre Reservoir. Machado Junior

(1992a) discriminated the lithotypes of Catalão II as five major groups: a) pyroxenites composed by augite, biotite, apatite, magnetite, zircon with amphibole, K-feldspar, titanite and calcite as accessories; b) quartz syenite and alkali feldspar syenite; c) carbonatites, including calcite carbonatites, silicon-carbonatites and dolomite carbonatites; d) lamprophyres in thin dikes, with phenocrysts of olivine embedded in phlogopite carbonate matrix and e) phlogopitites produced by metasomatism of ultramafics rocks.

Palmieri (2011) also reports that Catalão II can be considered either as one or multiple magmatic chambers with complex combinations of fractional crystallization, liquid immiscibility, magmatic segregation and metasomatism, resulting in a wide diversity of rock types and mineralization, with intricate relations.

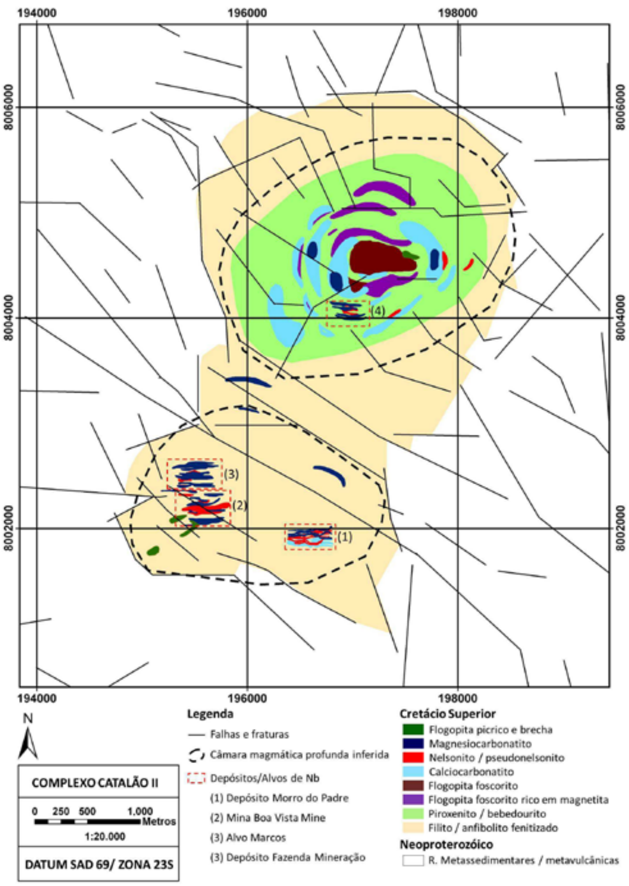

Fig. 2 *- Geological map of Catalão II modified from Palmieri (2011).*

The magnetic data used in the present study was provided by the Brazilian Geological Survey in partnership with the Goiás state government. These data have been acquired in 2005 as part of the Faixa Brasília Sul airborne geophysical project. The ground gravimetric data were acquired by IAG/USP. A total of 353 stations over Catalão I (295 stations) and II (58 stations) area were collected and processed as part of the Paranaíba alkaline province project developed by Geolit research group.

The anomalies are spatially close to each other and indicate the existence of significant remanent magnetization. They also suggest a possible connection between then the Catalão I and Catalão II intrusions.

All grid calculations were performed using the geosoft Oasis Montaj in the frequency domain. We start attempting to model Catalão I and II together to check if there is connection between the intrusions. For magnetic and gravimetric data, we have used the same steps: a) removal of the regional component of data by subtracting the upward continuation at 15000m followed by the removal of a second degree trend polynomial. The observed TMI and Bouguer anomaly data for the Catalão I and II anomaly is shown in figures 3 and 4.

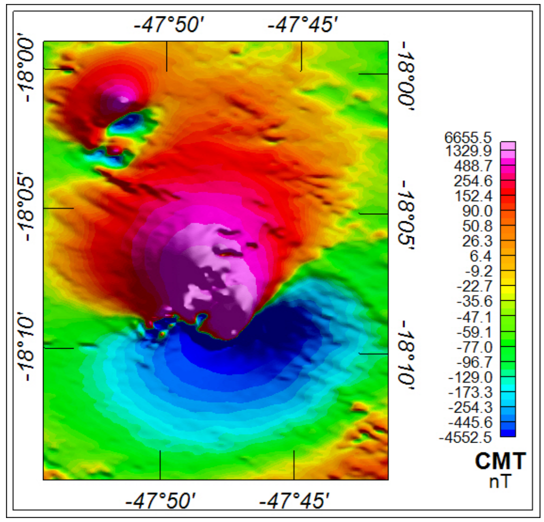

Fig. 3 *- Residual magnetic intensity map for Catalão I and Catalão II alkaline complex*

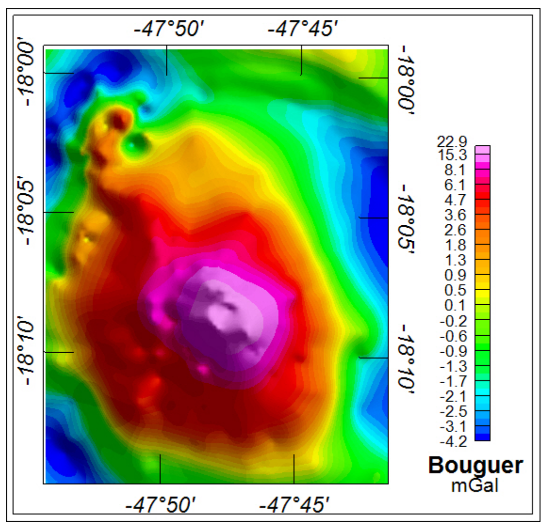

Fig. 4 *- Residual Bouguer anomaly intensity map for Catalão I and Catalão II alkaline complexes*

As a second phase, we modeled just Catalão II to get a more detailed picture of that complex. The same steps were followed in the grid process, although, the upward continuation height was 5000m. Also it was produced the analytic signal amplitude from the magnetic residual grid and the ternary image of Potassium, Thorium and Uranium from the gamma-ray airborne survey over

Catalão II and Morro do Padre area isolated from Catalão I anomaly.

Using the same map area, we obtained the digital elevation model (DEM) grid from the Shuttle Radar Topography Mission (SRTM) data in the geosoft dap (global data explorer) server and it is presented in the figure 5.

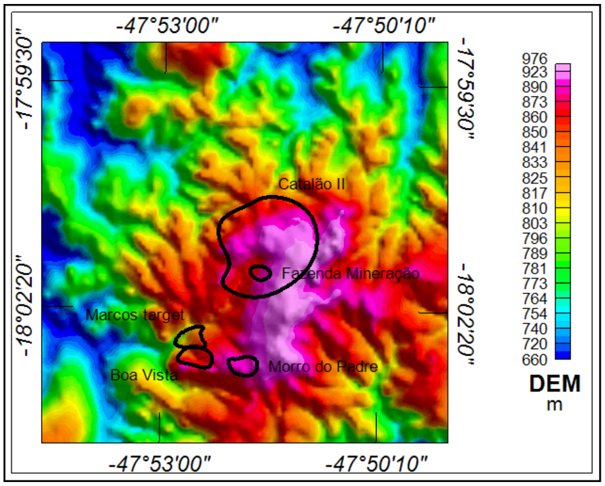

Fig. 5 *- Digital elevation model (DEM) for the Catalão II and Morro do Padre Areas with the inferred anomalies marked.*

Figures 6, 7, 8, 9 and 10 show the residual magnetic intensity map, the Bouguer anomaly map, gravimetric/magnetic/terrain in North/South profile at longitude -47.51.30, the analytic signal amplitude from magnetic data and the ternary image.

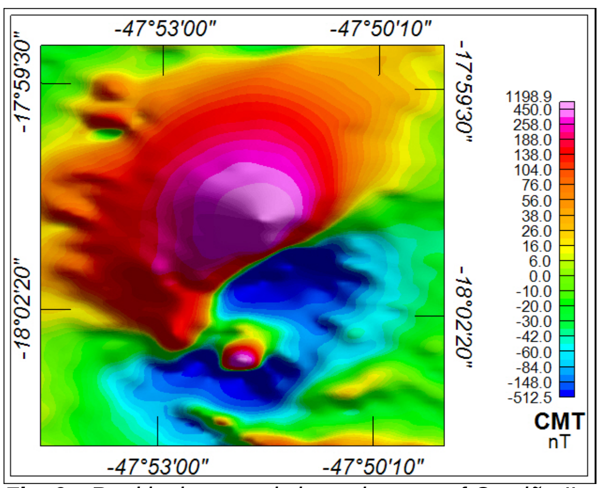

Fig. 6 *- Residual magnetic intensity map of Catalão II and Morro do Padre Area.*

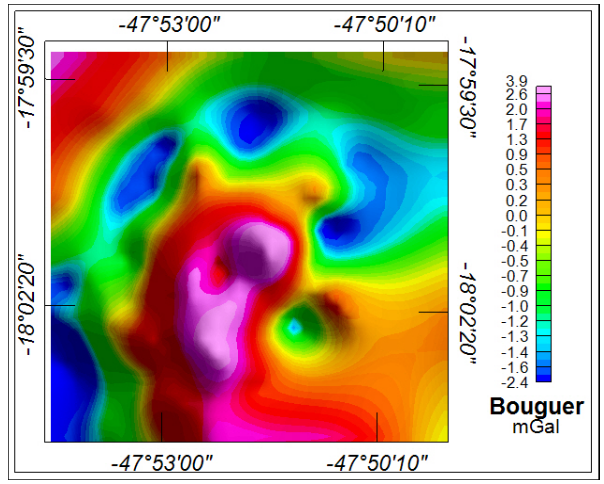

Fig. 7 *- Bouguer anomaly map of Catalão II and Morro do Padre Area*

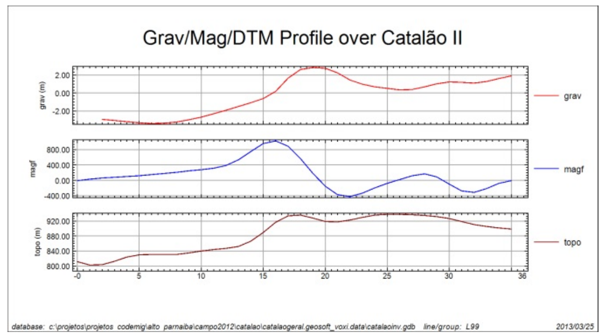

Fig. 8 *- Bouguer anomaly (red), residual magnetic intensity (blue), and digital terrain model (wine) profiles of Catalão II and Morro do Padre*

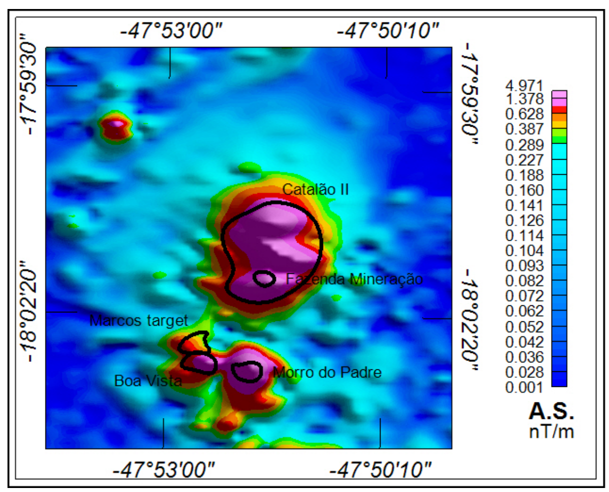

Fig. 9 *- Analytic Signal Amplitude from residual magnetic intensity map for Catalão II and Morro do Padre Area.*

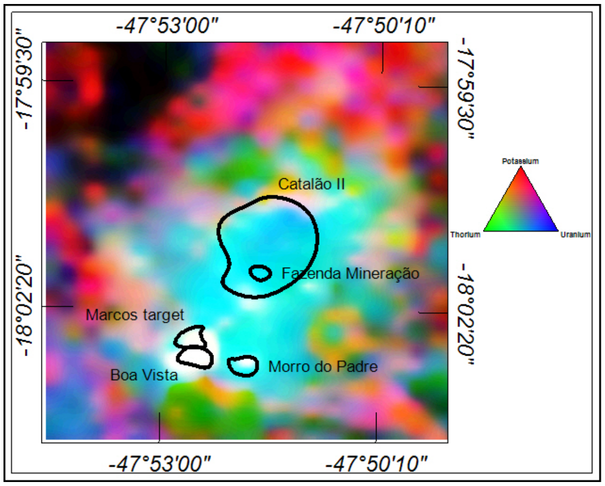

***Fig. 10** - Ternary image map of Catalão II and Morro do Padre Area*

For the magnetic modeling in both cases, the gridded data (residual) were exported as xyz and inverted using the mag3d program from UBC-GIF package. All anomalies were considered having purely induced magnetization. Also, we tested the reduction to the pole procedure as suggested by Fedi et al. (1994). The inner mesh cell size used in the total area inversions was 650m. As we wish a more detailed model at Catalão II alone inversion, we changed the inner mesh cell size to 125m.

For the gravimetric modeling, the xyz data were derived directly from the acquisition points in the field, which were scattered over the anomaly area. The inversions were obtained using the grav3d program from UBC-GIF package. In the total (Catalão I and II) area we have used a 650m inner mesh cell size, and to detail Catalão II we chose 75m for the mesh cell size.

Results and Discussion

The magnetic and gravimetric data (figs 3 and 4) suggest that all the anomalies could be interconnected in depth, with Catalão II and Morro do Padre being a different root or pulse in the same intrusion that generated Catalão I. The Bouguer anomaly grid also shows an elongated high area in the northwest direction pointing in the same direction of Catalão II. However, the model of density contrasts obtained by the inversion of the total area using the Bouguer anomaly doesn't show any interconnection as can be seen in the figure 11.

The model shows the isosurface of 0.07 g/cm^3 in density contrast. The modeled bodies are similar to vertical intrusions with a large magma chamber at approximately 6000m depth.

The magnetic inversion for the whole area didn't show a good result, probably affected by the remanent magnetization observed for Catalão I anomaly. Therefore, the obtained model is not shown here.

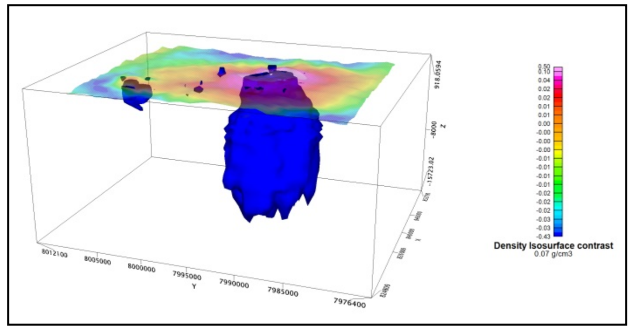

***Fig. 11** - Inversion model from Bouguer anomaly showing the isosurface of 0.07 g/cm^3 density contrast*

After this first approach, we evaluated the available data for Catalão II area alone.

The ternary image of gamma-ray (fig 10) shows a different signature from Marcos target, Boa Vista mine and Morro do Padre reservoir (white) to the Catalão II area (blue to cyan), what could indicate the inferred fractional crystallization, liquid immiscibility and magmatic segregation described by Palmieri (2011). Also, we could see that the diatreme of the intrusions spread the gamma-ray signature following the drainage pattern as seen in the same figure.

Considering the magnetic data, we can infer the borders of Catalão II, Morro do Padre and Fazenda Mineração reservoirs and Boa Vista mine from the analytic signal as shown in fig. 9. However, it is difficult to discriminate from Marcos target area from Boa Vista Mine. This borders marked agreed with the geological interpretation from Palmieri (2011) and with the gamma-ray signature.

Following to the inversions, we first analyzed the model body obtained from the residual magnetic field directly. The model is consistent with the geological information for an alkaline complex (Biondi, 2003, Brod et al, 2004) and shows different ramifications with a single root pointing in the direction of Catalão I as shown in figure 12.

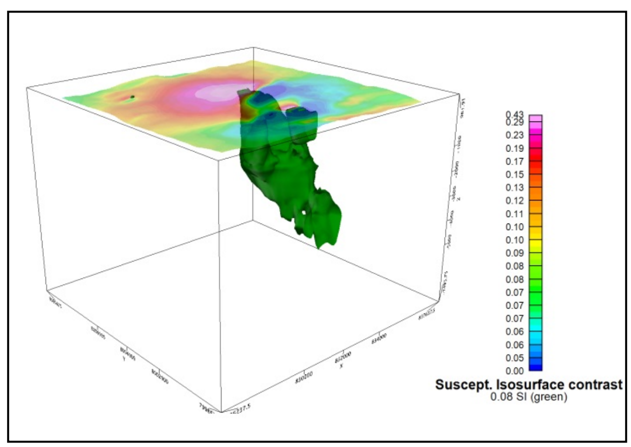

***Fig. 12** - Inversion model from residual magnetic intensity anomaly showing the isosurface of 0.08 SI susceptibility contrast*

When looking the modeled body cut showed in the figure 13, we could notice that the susceptibility variation inside the model points down a deep root towards Catalão I direction.

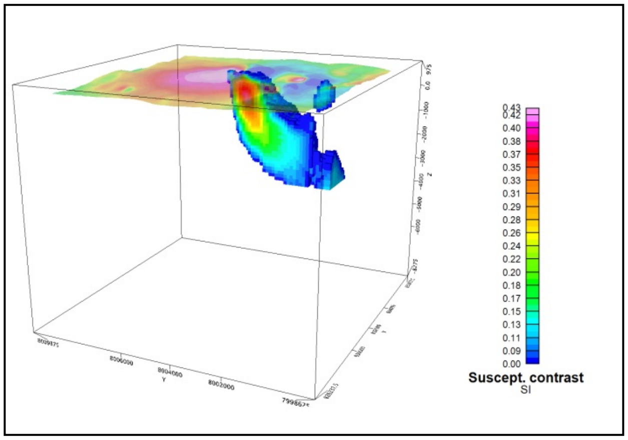

Fig. 13 - *Inversion model cut from residual magnetic intensity anomaly*

The second inversion from magnetic data used the RTP procedure from Fedi et al. (1994) and the modeled body is very similar to the original magnetic anomaly as shown in figure 14.

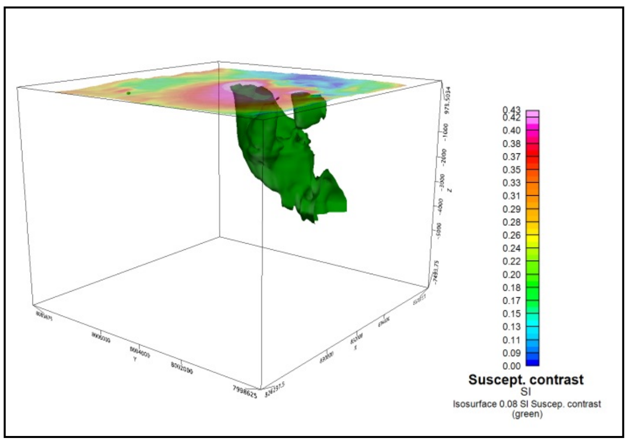

Fig. 14 - *Inversion model from RTP magnetic intensity anomaly*

Moving to the gravimetric data, we obtained the model of density contrasts from the inversion of the residual Bouguer anomaly directly. The result is consistent with the previous models and also shows a deep root in Catalão I direction as shown in figure 15.

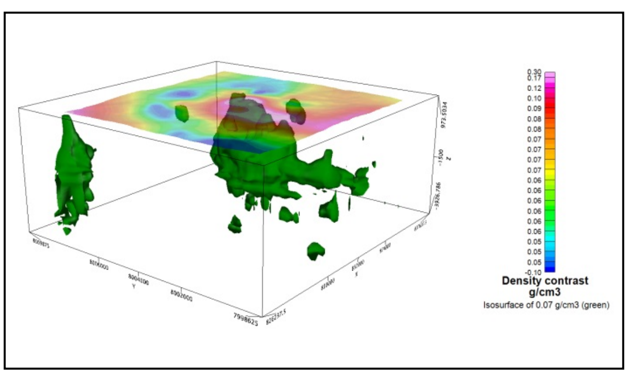

Fig. 15 - *Inversion model from residual Bouguer anomaly*

Looking now the gravimetric modeled body cut, the inflexion observed in the magnetic inversions it not so clear, although the denser part has a little inclination to the south as we can observe in figure 16.

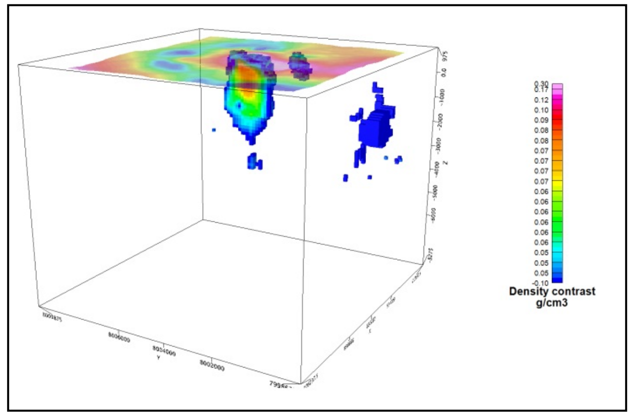

Fig. 16 - *Inversion model cut from Bouguer anomaly*

The final step is to compare the models obtained from the magnetic and gravimetric data. The result was not excellent as expected, although all known structures could be detected. At Catalão II, the top of the model has the density and susceptibility contrasts in accordance of geological information and position, but the modeled bodies seems to derive from different directions with increasing depth (fig. 17).

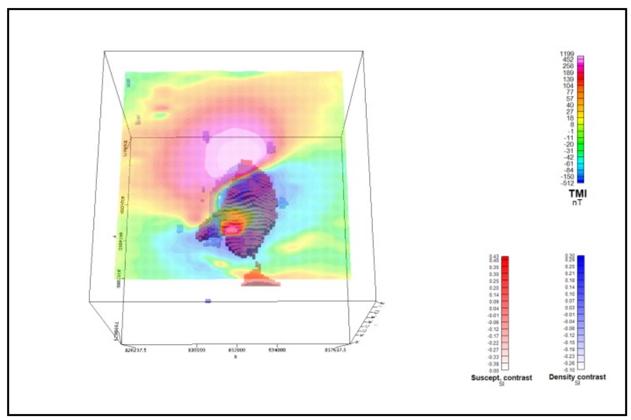

Fig. 17. - *Inversion models of magnetic and gravimetric data covered by the residual magnetic map.*

Nevertheless, as shown in figures 18 and 19, the models fitted the geology interpretation map proposed by Palmieri (2011). The location for Catalão II, Morro do Padre, Boa Vista mine, Marcos target and Fazenda Mineração could be identified.

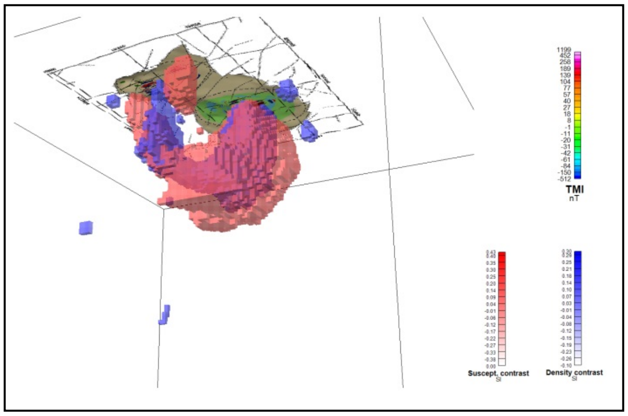

***Fig. 18** - Inversion models of magnetic and gravimetric data and the geology interpretation map from Palmieri (2011)*

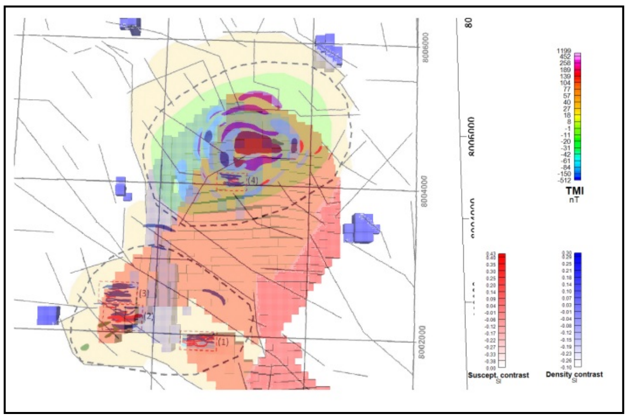

***Fig. 19** - Inversion models of magnetic and gravimetric data and the geology interpretation map from Palmieri (2011)*

Conclusions

The inversion of magnetic and gravimetric data is a powerful tool to help in geological interpretation. The relationship between Catalão I and II is not totally defined, and requires more detailed data to refine the modeling of the anomalies boundaries. The 58 stations of gravimetric data produced a good model for Catalão II that is in accordance with the known publications. We suggest the acquisition of detailed gravimetric data between Catalão II and Boa Vista mine and also between Catalão I and II to better understand the interrelationship.

For the next steps in the interpretation we will use additional boundary constrains from the available geological information in the inversion programs to refine the modeled bodies.

Acknowledgments

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