An easy procedure to estimate the preliminary shape of a complex magnetic anomaly through inversion software

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This paper was prepared for presentation during the 12th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, August 15-18, 2011.

Abstract

The inversion of magnetic data is a difficult task when remanent magnetization is present. The available softwares do not take into account the remanence component in order to simplify the involved mathematics and reduce the time consuming processing.

Here, we examine and compare two different approaches to invert a magnetic complex anomaly set with induced and remanent magnetization, using transformations of the total magnetic field.

The first method uses the analytic signal of the vertical integral of the TMI data. The second method uses the amplitude of the magnetic anomaly field. Both methods simulates the anomaly responses as they were just induced under a vertical magnetic field.

The University of British Columbia's Geophysical Inversion Facility (UBC-GIF, mag3d and grav3d programs) were used to invert the data. The susceptibility models resultant from both methods were compared with gravity inversion over the same anomaly. The outcome models show a certain difference in the result parameters, however, the overall result can be used for a preliminary estimation of the anomaly and instigate the further pass of research.

Introduction

The Magnetic methods and principally the airborne magnetic data is one of the most commonly used geophysical approaches to identify from major geological structures to small mineralized bodies. Nowadays, in a short time, large areas can be covered with very high resolution in terrain.

In the low magnetic latitudes, the use of analytic signal of the TMI is a wide spread artifice to simplify the response of magnetic bodies and facilitate the interpretation of data, transforming the vector sum of induced and remanent magnetizations, if present, in one quantity that is less dependent on their directions.

When the target area shows a significant complexity in magnetic parameters that cannot be neglected, the susceptibility distribution resulted from the inversions could be inconsistent with the reality or geologically acceptable.

The inversion of analytic signal of vertical integral of TMI (ASVI) data was proposed by Paine et al. (2001) as a mode to overcome the problem of remanence and obtain a reasonable preliminary model for the anomalies.

In the same way, Shearer (2005) developed a different algorithm to invert the amplitude of the anomalous magnetic field (Ba) that has a small dependency of the magnetization direction. Li et al. (2010) suggests estimating the total magnetization direction and incorporate the resultant direction into the inversion. Ribeiro (2011) proposed to use the mag3d to invert directly the Ba data in the inversion program.

We have tested the ASVI and Ba approaches using the mag3d from UBC-GIF (Li and Oldenburg, 1996) to invert the TMI data over a complex magnetic and gravimetric anomaly in Brazil and check out the inversion results to discuss the viability of these procedures.

In order to evaluate the inversion results, both models were compared with a gravimetric inversion using grav3d program over the same area. The gravity data set over the anomaly has a lower resolution compared to the magnetic, however, the modeled bodies obtained are compatible with the previous works published to the anomalies and with the geological observations in the area.

Method

The area of study is the Serra Negra and Salitre 1 and 2 alkaline complex that is located near to Patrocinio city in the Minas Gerais state, south east of Brazil (Fig 1). The complex is part of the Alto Parnaiba province and the regional geology is composed by metasediments of Bambuí group (Rugenski, 2002).

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

The observed TMI data for the Serra Negra/Salitre area is shown in figure 2. The anomalies are very close to each other becoming not possible to distinguish the magnetic response of them separately. It can be seen that the anomalies are very complex which suggests the presence of remanent magnetization in the bodies.

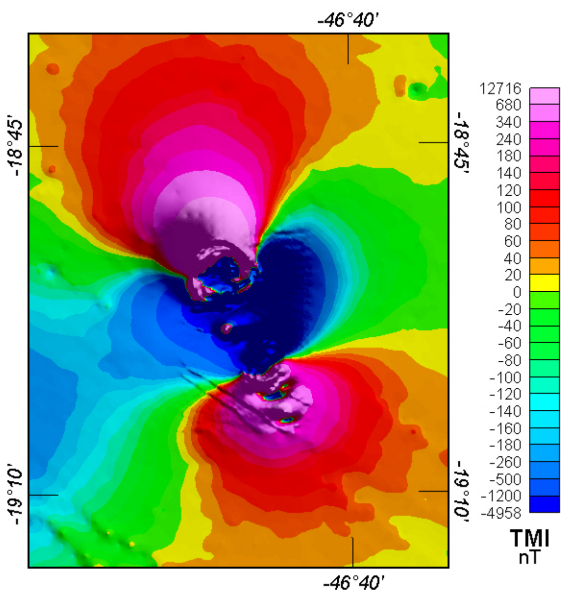

Fig. 2. *Total magnetic intensity map for Serra Negra, Salitre 1 and Salitre 2 alkaline complex anomalies*

All grid calculations were performed using the geosoft Oasis Montaj in the frequency domain. We start using the first approach calculating the ASVI transform for the dataset. The result grid is shown in figure 3 and is qualitatively similar to a pure induced magnetization under a vertical field, but has smaller amplitude.

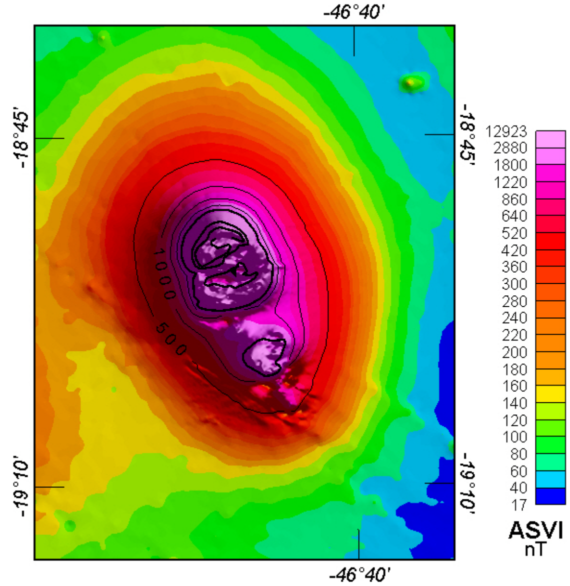

Fig. 3. *ASVI transform of magnetic intensity map for Serra Negra, Salitre 1 and Salitre 2 alkaline complex anomalies*

To perform the second approach, we have calculated the conversion between field components and afterwards the amplitude of the anomalous field in the wave-domain transformation. The result grid shown in figure 4 and is very similar to the ASVI response; however the amplitude is close to TMI original.

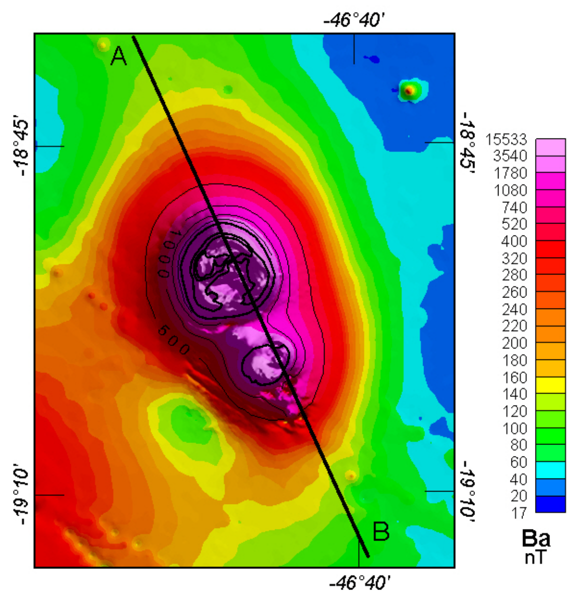

Fig. 4. *Amplitude of anomalous field (Ba) transform of magnetic intensity map for Serra Negra, Salitre 1 and Salitre 2 alkaline complex anomalies*

In the figure 5 we compare the magnetic profiles over the AB distance.

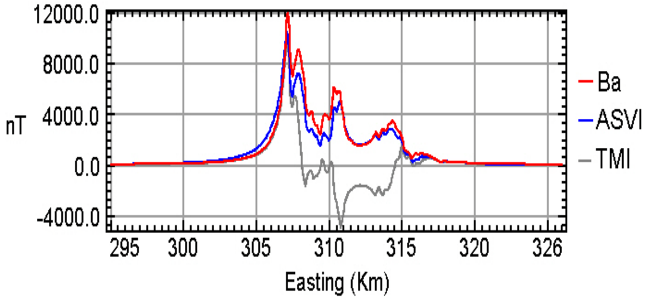

Fig. 5. *Magnetic profiles over the AB distance*

The figure 6 shows the bouguer gravity anomaly over the target. The dataset was collected as described by Rugenski (2006).

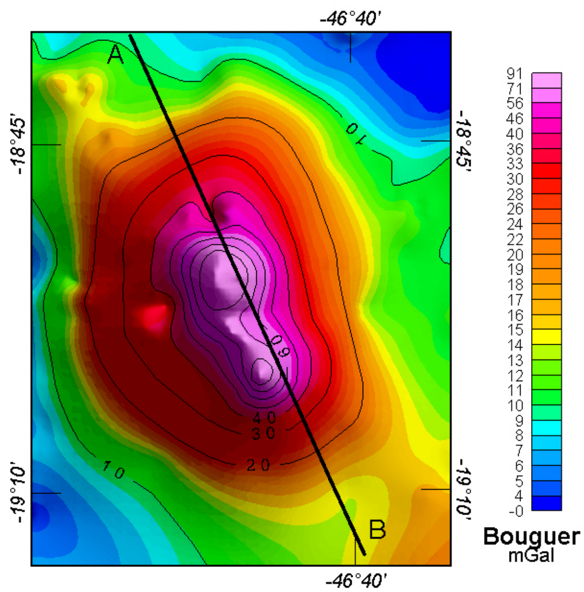

Fig. 6. *Bouguer Anomaly gravity map for Serra Negra, Salitre 1 and Salitre 2 alkaline complex*

The figure 7 shows the Bouguer profile anomaly over the same profile AB.

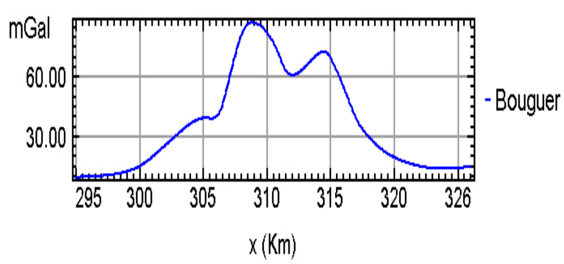

Fig. 7. *Bouguer profile over the AB distance*

The area of the anomaly has about 350 Km^2. In order to evaluate the inversion over the anomaly with a good resolution the data were divided in two different spacing intervals. The regional was setup with 1500m data space and the central part has 300m between data points.

The figure 8 shows the data point spacing over the anomaly area.

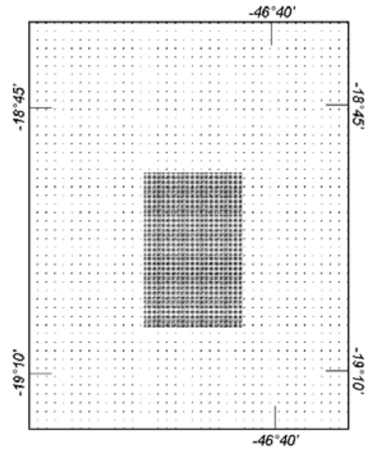

Fig. 8. *Density data used in the inversion programs*

The SRTM data was used for topographic information over the anomaly. The gravity data was upward continuated to be at the same level of the magnetic data extracted from the airborne survey flown by the Brazilian government in 2006.

Results and Considerations

All the resultant models are acceptable and compatible with geological knowledge from previous works at the anomaly site.

The ASVI model in figures 9 and 10 shows two different chambers interconnected at approximately 10Km depth. The body has 0.25 SI susceptibility minimum contrasts.

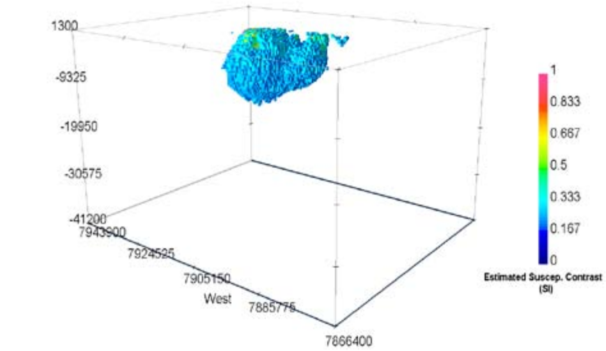

Fig. 9. *Obtained model from ASVI data. The susceptibility cutoff is 0.25 SI. The max depth of the body is 12.5 Km*

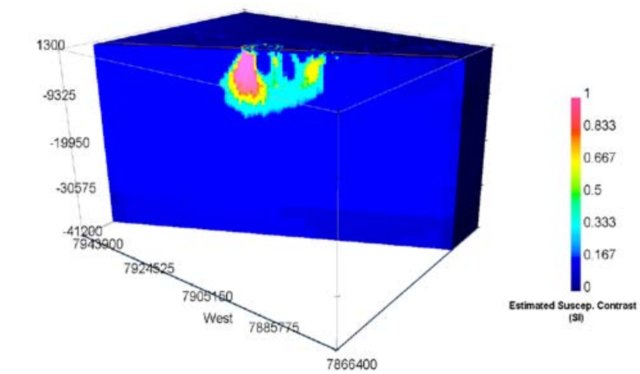

Fig. 10. *Diagonal slice of the resultant model from ASVI data showing the internal distribution of susceptibility*

The Ba model shown in figures 11 and 12 is similar in shape to ASVI but with different susceptibility contrasts.

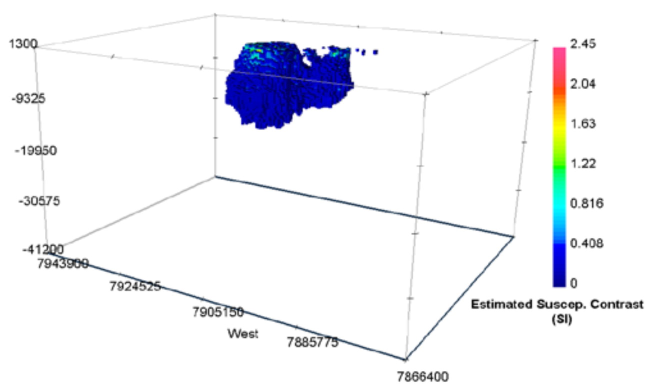

Fig. 11. *Obtained model from Ba data. The susceptibility cutoff is 0.25 SI. The max depth of the body is 12.5 Km*

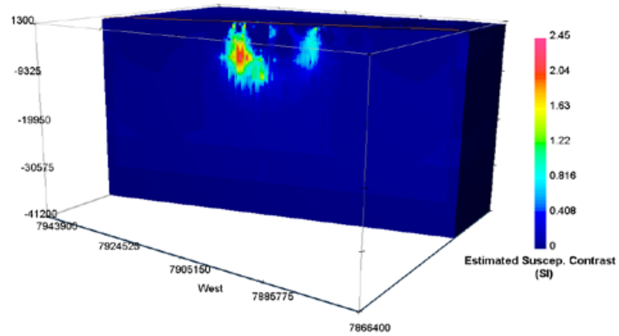

Fig. 12. *Diagonal slice of the resultant model from Ba data showing the internal distribution of susceptibility*

The gravity model shown in figures 13 and 14 has a good similarity of size and shape with the magnetic models, but the depth extent is considerably different, however as all models have almost 15km of depth, the discrepancy is acceptable.

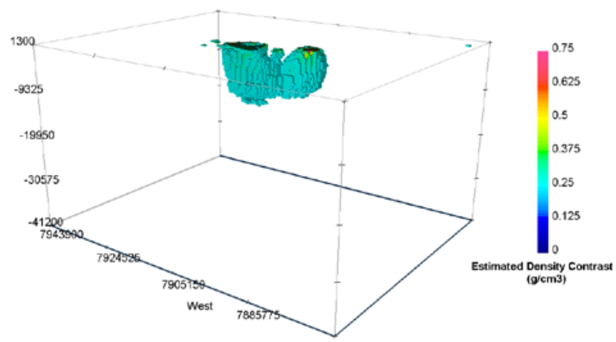

Fig. 13. *Obtained model from gravity data. The density cutoff is 0.25 g/cm^3. The max depth of the body is 13 Km*

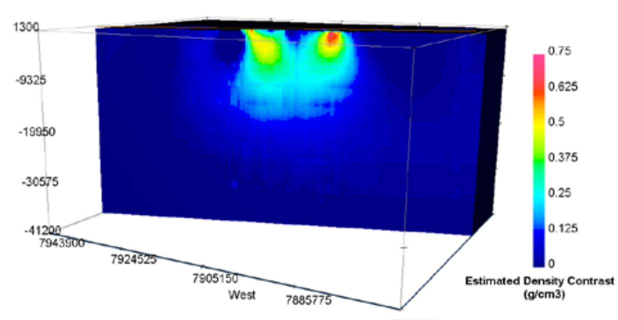

Fig. 14. *Diagonal slice of the resultant model from gravity data showing the density internal distribution*

In the figures 15, 16 and 17 we can compare all three models in the same mesh. The ASVI (blue), the Ba (red) and the grav (green). The purple model formed is the common intersection of separate models. We have a good correlation between the models showing that the magnetic field transformations are a good first approximation for the body geometry. The discrepancy in the models could be related to the difference in the data resolution. The gravity data doesn't have the same space density of magnetic.

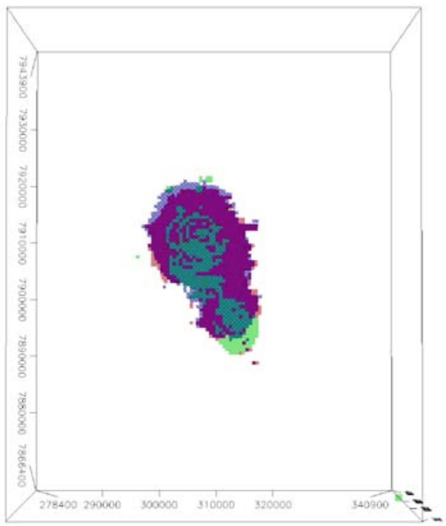

Fig. 15. *Top view for the composition of the three models*

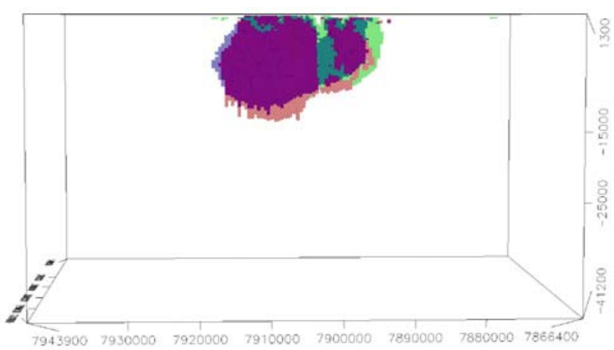

Fig. 16. *Side view for the composition of the three models*

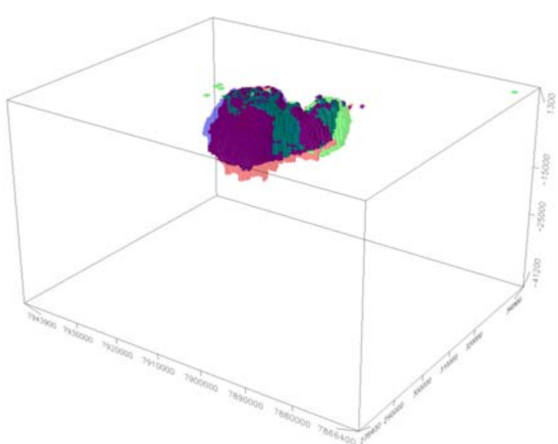

Fig. 17. *Diagonal view for the composition of the three models*

Conclusions

The use of magnetic field transformations in the wave domain can simplify the use of inversion programs in order to obtain an easy preliminary estimative for magnetic anomalies with remanent magnetization or a set of magnetic anomalies with different magnetization parameters. The resultant models can be used to guide the next steps of studies in the area and reduce the drilling costs.

Acknowledgments

We thank to Codemig/CPRM for providing the data used in the study. Grateful to the UBC-GIF group for providing the academic use of mag3d version 4.0 and grav3d version 3.0 program Library for Forward Modelling and Inversion of Magnetic Data over 3D Structures Developed under the consortium research project Joint/Cooperative Inversion of Geophysical and Geological Data, UBC-Geophysical Inversion Facility, Department of Earth and Ocean Sciences, University of British Columbia. Financial support was provided by FAPESP and CNPq.

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