# Magnifying kimberlitic magnetic anomalies in Vazante area, MG, Brazil

Marcos de Barros Munis (CPRM, Brazil Geological Survey)*, João Batista Freitas de Andrade (CPRM, Brazil Geological Survey).



This paper was prepared for presentation during the 15th International Congress of the Brazilian Geophysical Society held in Rio de Janeiro, Brazil, 31 July to 3 August, 2017.




## Abstract

The application of special filters in magnetic anomalies has been a constant in geophysical prospecting in order to reduce costs and obtain results in the shortest time possible. These techniques, although widely publicized in the geophysical community, have also been underutilized by the mineral industry, and this is due, in part, to the small dissemination in these media, of advances in the processing and even reprocessing of geophysical data. This work shows the 3D result of the application of analytical signal filter in magnetic anomalies in the SW region of Vazante, MG.


## Introduction

In 2001 CODEMIG (Minas Gerais Development Company) along with CPRM (The Geological Survey of Brazil) made several high-resolution aero magnetic and gama spectrometric surveys throughout the State. The Paracatu-Vazante area, within this cooperation project, was named Area 1. The flight height was 100m above the surface, due to gamma spectrometry specification. The flight lines direction in the studied area were NE-SW with 250m interval and the control lines direction were perpendicular to these, with 2500m interval. A cesium vapor magnetometer (Geometrics - G822) with a resolution better than 0.01 nT was used and sampling was 10 readings / second (Moraes, 2014).

This work uses only the magnetic data of the southern part of Area 1, reaching only 4500 km$^2$. Some diamond occurrences are known, in this region and the aeromagnetic survey showed punctual concentrations of anomalies. Figure 1 is the location map. Reprocessing of aeromagnetic data, Euler deconvolution and analytical signal filters were used to reinforcement of kimberlites anomalies.

## Geology

Figure 2 is the geological map of all Area 1 according to the Geological Map of Brazil to the Millionth (Sheet SE.23 - Belo Horizonte), published by CPRM, 2004 edition.


***Figure 1*** *– Location Map*

Neo and Meso Proterozoic sequences of Bambuí, Rio Verde, Vazante and Paranoá Groups occur as components of the Brasilia Fold Belt (BFB). These supracrustal sequences rest on the Craton of San Francisco (CSF), which in this area occurs only in subsurface. Tertiary and Quaternary covering complete the sequence. The weathering is quite intense reaching a few tens of meters and the formation of lateritic crusts is frequent.

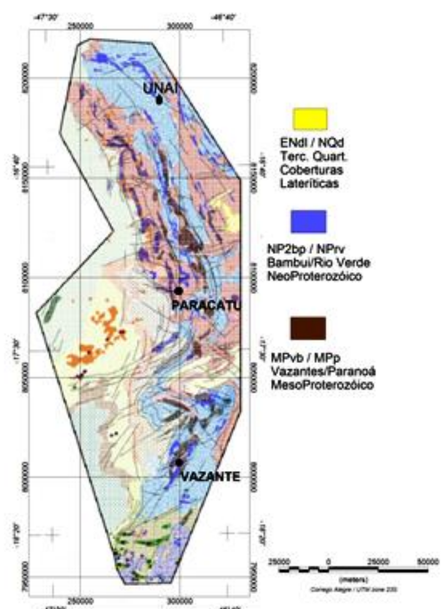


***Figure 2*** *– Geological Map of Area 1*

At the SW end of the studied area several kimberlites were mapped in regions of diamond mining highlighting the municipality of Coromandel that has already produced some of the largest diamonds in the world. The metasedimentary sequences that make up the BSB present small differences of magnetic susceptibility, and the weathering adds more limitations to the magnetic method. On the other hand, kimberlites show a good contrast in susceptibility with both BFB and CSF, except when weathered.

**Geophysics**

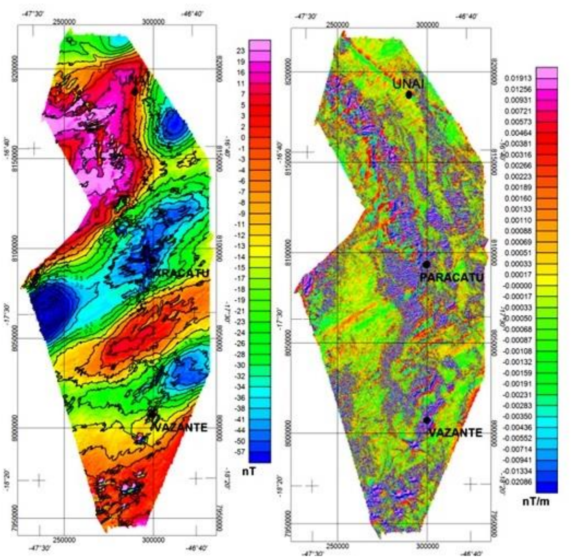


***Figure 3*** *– Total magnetic field IGRF reduced (left) and first vertical derivative of magnetic field (right).*

Comparing the geological map of Figure 2 with the map of the total magnetic field of Figure 3 (left) it is observed that the geological and geophysical lines do not correspond. This is due to the small magnetic contrast of BSB rocks added to the deep weathering cover cited above. Thus, the total field responds with greater intensity to the rocks of the SFC, in subsurface, with greater magnetic contrast and less degree of weathering. Even with this limitation, the signal coming from BFB is present and a better way to visualize it is to make use of the derivative maps. The map on the right part of Figure 3 represents the first vertical derivative of the function, and in it, we can already observe a good correlation with the geological map. Silva & Zalan, (2005), show two seismic profiles, one from Cristalina (GO) to Serra da Água Fria (MG), passing through N of Unaí, MG (see Figure 2) and the second from Paracatu (MG) to the same Serra da Água Fria, with 340 km, where this BSB behavior over the SFC is recorded. Thus, it can be shown that a fast, simple and inexpensive geophysical method as aeromagnetometry is, can be of great help in mineral prospecting.

**Analytical signal and Euler deconvolution.**

Since our target is in the kimberlites that occur at the southern end of Area 1, a new map of the total magnetic field intensity has been developed, using a continued upwards by 400m, for smoothing. Figure 4 represents this map.

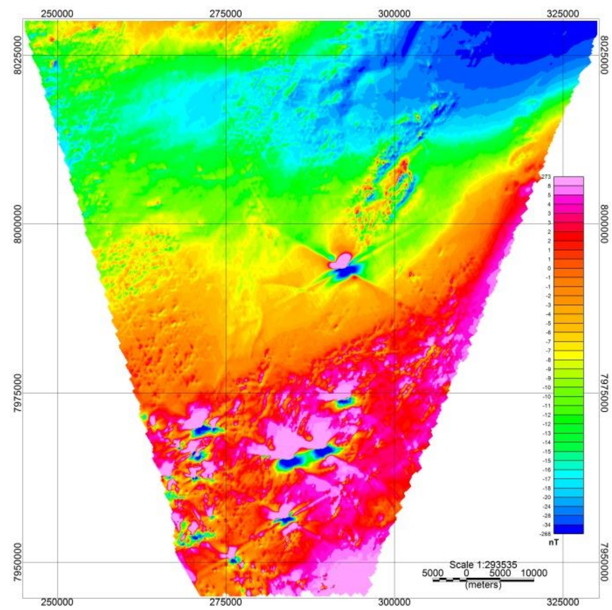


***Figure 4*** *– Total magnetic field upward and reduced from IGRF Southern part of Area 1.*

Here you can clearly see some punctual anomalies. One at point 293000/7968000, and several others in the southernmost part of the map forming a cluster. All these anomalies have the negative pole in the southern part (blue color) and the positive one in the northern part (pink color) characteristic of pipe-shaped bodies magnetized by induction in regions of low geomagnetic latitudes. And kimberlites occur exactly in the form of pipes. Nabighian (1972), showed the importance of using the analytical signal in magnetic and gravimetric data emphasizing the contacts between rocks with different densities or magnetic susceptibilities. This filter is given by:

$$SA = \sqrt{\left(\frac{\partial f}{\partial x}\right)^2 + \left(\frac{\partial f}{\partial y}\right)^2 + \left(\frac{\partial f}{\partial z}\right)^2}$$

which shows that it is the module of the total component of the first derivative of the function. In this case, the magnetic field. Figure 5 represents the application of the analytical signal and clearly shows the positioning of the kimberlite bodies forming a large cluster.

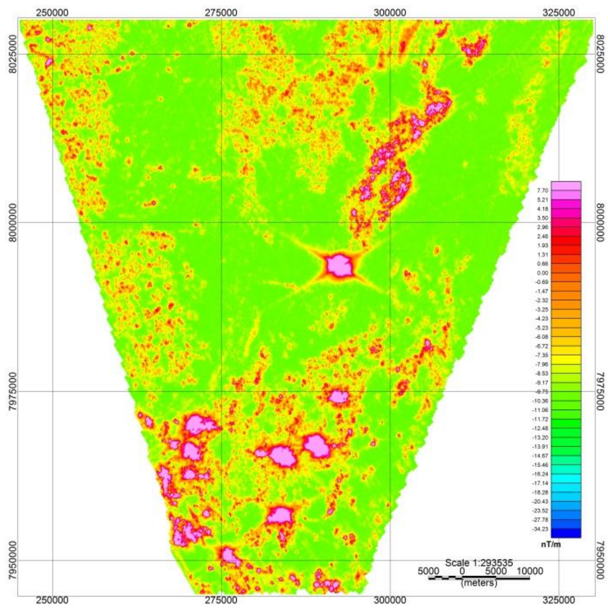


***Figura 5** – Analytical Signal of function. Southern part of Area 1.*

Thompson (1982) demonstrated that the Euler equation for homogeneous functions (such as those describing the magnetic or gravimetric field) could be used to detect and locate the causative sources. Thus, the following equation must be satisfied:

$$(x - x_o)\frac{\partial f}{\partial x} + (y - y_o)\frac{\partial f}{\partial y} + (z - z_o)\frac{\partial f}{\partial z} = nf$$

Where "f" is the function, (x, y, z) are the coordinates of the measurement point, ($x_o$, $y_o$, $z_o$) the coordinates of the point of origin of the anomaly and "n" the structural index, which depends on the type of source. Xo, yo and zo are the unknown we are looking for and "n" can be unknown or pre fixed. In this case it was used n=2, for vertical cylinder, or pipes. Obtaining the coordinates of the sources that cause the anomalies in each window of observation involves the solution of a system of as many equations as the points of the window, for three unknowns. The window used was (20 x 20) points, corresponding to (2.5 x 2.5) km. Thus the solution of the system involves a statistical processing and a series of constraints must be applied by the interpreter so that the presented solutions have a geological meaning. In addition to this essentially mathematical problem, the geological problem also occurs because, when the window is too large it involves the presence of several sources (noise and signal), and if it is very small, it may not completely identify the vertical cylinder, a geophysical model corresponding to the kimberlitic pipe. Figure 6 shows the result of the Euler Deconvolution by applying the parameters described above. The depths of the sources (not weathered rock) are between 70 and 230m considering an average flight height of 100m.

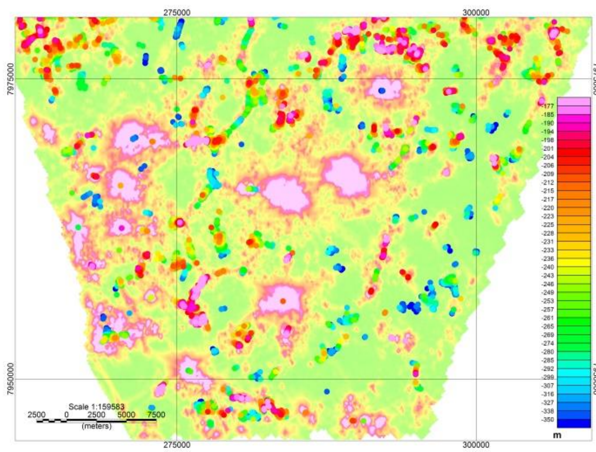


***Figure 6** – Euler depths over the shaded analytical signal Kimberlitic southern part of Area 1.*

Figure 7 shows the same result of Figure 5, but as block diagram, highlighting the anomalies due to kimberlitic bodies, which in the SW end of the studied area present as a large cluster.

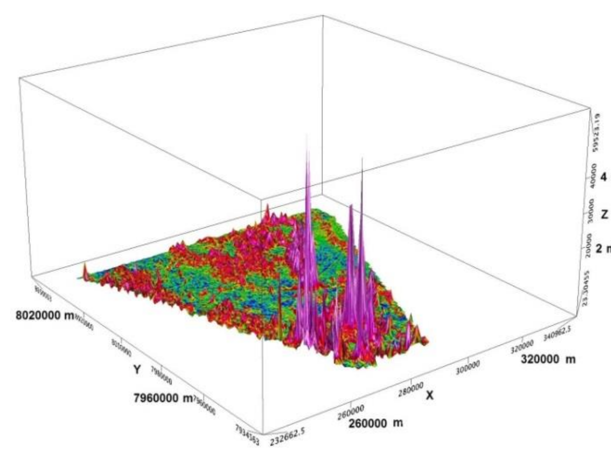


***Figure 7 –** Block diagram of the analytical signal of the total component of the magnetic field.*

**Conclusions**

Diamond prospecting in Brazil is mainly done by prospectors, in alluviums. The mother rock that bring the diamonds are of ultrabasic composition, easily alterable by weathering. The magnetic method, with its sub-surface detection capability of these ultrabasics, coupled with the use of suitable filters that amplify the contrast perception of the magnetic susceptibilities, is highly recommended in diamond prospecting as shown in the case studied.

**Acknowledgments**

We thank CPRM for the use of the data and facilities offered.

**References**

Moraes, R. A. V., 2014, “Processamento avançado de dados aerogeofísicos para a detecção de estruturas controladoras de mineralizações”, 2º Seminário de Províncias Metalogenéticas Brasileiras, InterGeo, Belo Horizonte. Apresentação CPRM / CODEMIG.

Nabighian, M. N., 1972, “The analytical signal of two dimensional magnetic bodies with polygonal cross-section: It’s proprieties and use for automated anomaly interpretation”, Geophysics, 37, p.507-517.

Silva, R. and Zalan, P. V., 2005, “Contribuição da sísmica de reflexão na determinação do limite oeste do Cráton do São Francisco”, Anais do III Simpósio sobre o Cratón do São Francisco, Soc. Bras. de Geologia.

Thompson, D. T., 1982, “Euldepth – A new technique for making computer assisted depth estimates from magnetic data”, Geophysics, 47, p31-37.