Gravimetric characterization of Ponte Nova mafic-ultramafic massif (SP-MG)

Débora S. Cotis[1], Yára R. Marangoni[1], Herbert Ferreira[1], [1]Instituto de Astronomia, Geofísica e Ciências Atmosféricas da Universidade de São Paulo

Abstract

The Ponte Nova massif is located in Serra do Mar Alkaline Province in the southeast part of Brazil. The massif is mainly composed of alkaline gabbro association, with 2 outcrops of 5km² and 1 km² areas. A detail gravimetric survey was made, resulting 98 stations, to model the subsurface mass distribution and to understand the geodynamic context of the massif. The data processing shows high gravimetric anomaly (33.3 mGal) in accordance with the Ponte Nova outcrop after removal of a first order polynomial trend line. The gravity high suggests one body with an area not much larger than the intrusion. Based on these results, a 2D preliminary mass distribution model was made. It resulted a body that extends to 5 km in depth.

Introduction

Paraná Basin, at the SE of Brazil, is surrounded by some alkaline provinces with outcrops and covered intrusions, with mafic ultramafic lithologies, some with carbonatite rocks. One of these provinces is Serra do Mar Alkaline Province (SMAP), located at the eastern border, with age between 750-450 Ma. Some of regions around Paraná Basin have been geophysically studied (Marangoni and Mantovani, 2013) to understand geological and geodynamic context about their preferential location bordering the basin and the viability of mineral prospecting.

The SMAP presents alkaline occurrences in the coastal region of the states of São Paulo and Rio de Janeiro and it extends into the country up to Serra da Mantiqueira. These alkaline are embedded in igneous and metamorphic rocks mainly granitic composition from Ribeira Belt.

The gravity method has been used as a tool to model alkaline intrusions in subsurface. It has been applied, for instance, at the study of Morro do Engenho Alkaline Complex by Dutra and Marangoni (2009), which shows 3D models of subsurface mass distribution. Marangoni and Mantovani (2013) present a compilation of geophysical studies of three alkaline provinces in the Paraná Basin's edge.

Due to the good results obtained with the provinces around the Paraná Basin, it was made a detail gravimetric acquisition to characterize the Ponte Nova Massif (PNM). This massif is one of the intrusions of SAMP, located 100 km from the coast. The Bouguer anomaly map of the area shows the presence of a gravimetric high in accordance with the Ponte Nova outcrop. Figure 1 presents the location of Bouguer anomaly map. In this study we intend to discuss the results and preliminary model.

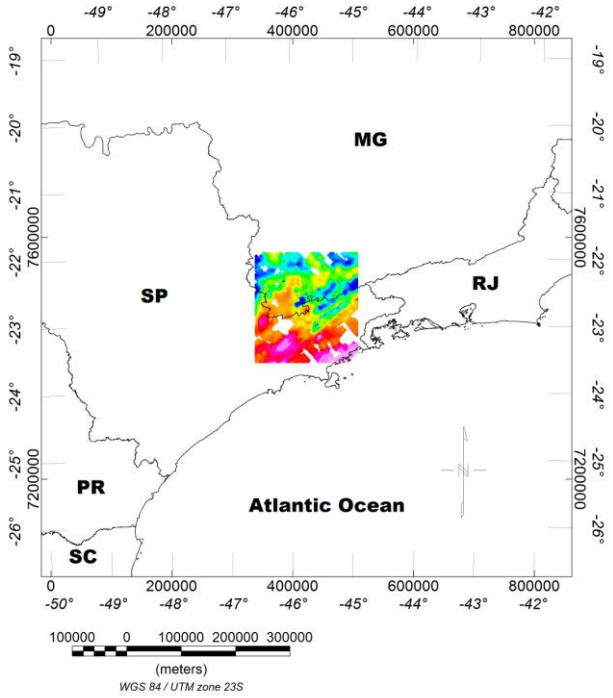

Figure 1 – Bouguer map of area**. SC –** Santa Catarina State**. PR –** Paraná State. **SP –** São Paulo State. **MG –** Minas Gerais State. **RJ –** Rio de Janeiro State.

Geological Aspects

The PNM present mafic lithologies (Azzone et al., 2009) and shows two outcrops 0.9 km apart. The largest one has an elliptical format with an area of circa 5.5 km^2, with a large variety of lithotypes. The major axis, at the NS direction, has an extension of 4 km, while the short axis is 3 km long. The exposed rocks have high density and the main lithotipes are cumulate rocks with alkaline affinity. The two exposures are separated by granitic rocks from Precambrian age. The geological map of the intrusion is found at figure 2.

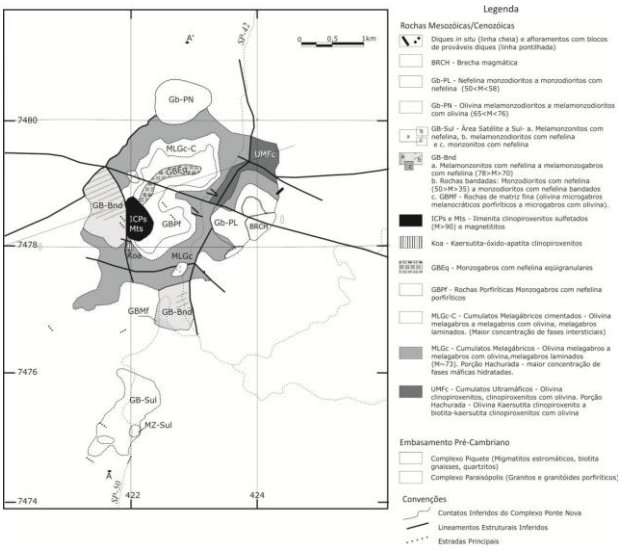

Figure 2 – Ponte Nova mafic-ultramafic massif geological map (Azzone et al., 2009).

According to Azzone et al. (2009) the more abundant rocks are melagabbros and ultramafic cumulates (e.g., olivine clinopyroxenites and olivine-bearing melagabbros) found in the lower parts of the massif, together with porphyritic, equigranular and banded gabbros and monzogabbros in the upper portions. It is mainly composed of an alkaline gabbro association.

Azzone et al. (2009) interprets the PNM as the result from successive alkaline magmatic pulses that intruded the granitic-gneissic basement circa 87.6 Ma ago.

Method

The gravimetric field survey took place in April and June 2014. In the period were acquired 98 gravimetric stations, most of them located on the PNM. Both field surveys used the Lacoste & Romberg, G type gravity meter, and Ashtech Z-12 GPS. Gravimetric circuits were closed circuit with opening and closing in a base station from a second order gravimetric network. The base station is in located in the survey area, at a bench mark at Sapucaí Mirim, Minas Gerais, (g=978554.75 mGal).

After the acquisition, the conventional reductions were applied using the 1967 Earth Normal model and 2.67 g/cm³ density for the Bouguer correction.

The gravimetric data processing resulted in the usual maps of gravimetric anomalies. The Bouguer anomaly map is used in the processing to determine the mass distribution model in subsurface. The software used for the processing was Geosoft Inc. Oasis Montaj ^{TM} 8.2.

The preliminary model was obtained by the software GravMag 1.0 fc 10 (Jones, 2003-6).

Results

The PNM lies in rugged terrain, at the northern part of SMAP and its two outcrops are covered by dense vegetation that poses some problems in acquiring GPS data. Figure 3 shows the topography obtained with the gravimetric field survey.

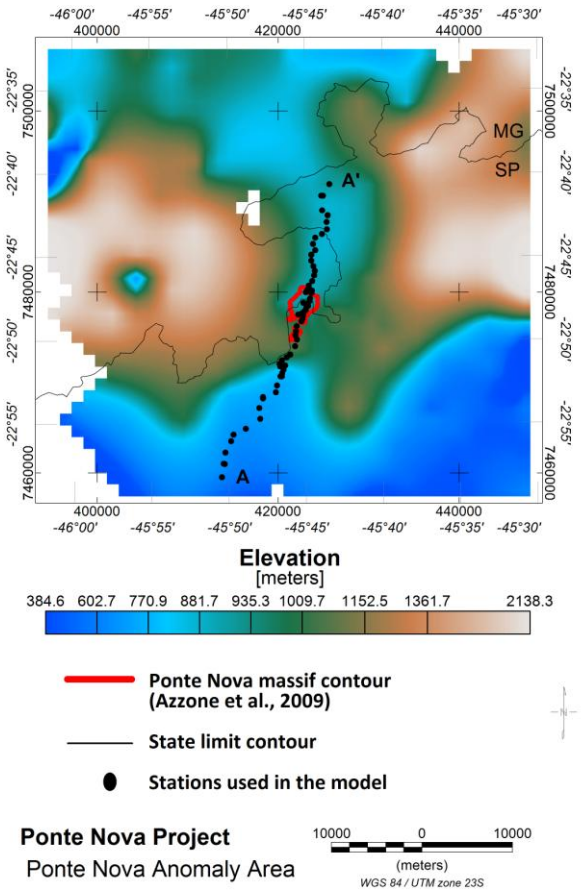

Figure 3 – Topography map of Ponte Nova massif area. **MG –** Minas Gerais State. **SP –** São Paulo State.

The Bouguer anomaly in Ponte Nova region, showed in figure 4, exhibits a gravity high with maximum amplitude of 33.3 mGal in the center of the area, inserted into a low gravimetric field, of average of -4.0 mGal. To the northwest of anomaly, it is observed a marked low of -69.0 mGal. The residual Bouguer anomaly map (figure 4) was obtained by removing a first order polynomial trend line from Bouguer data, not showed here.

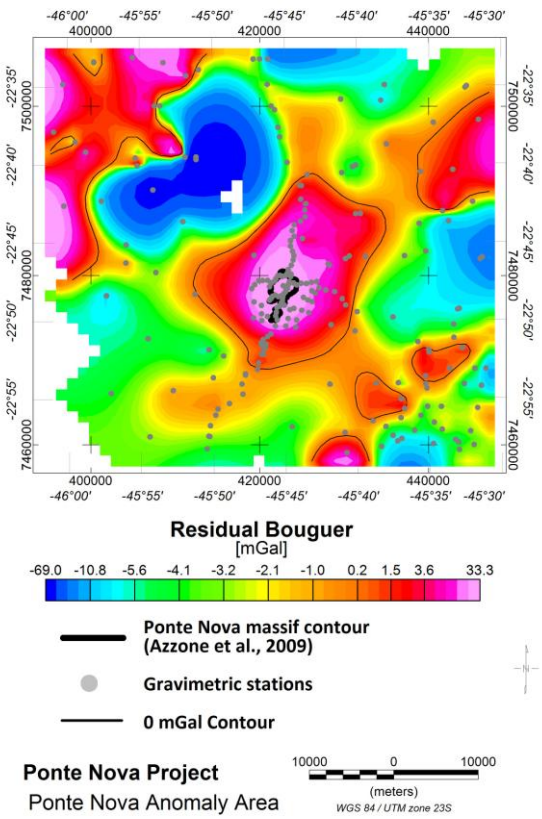

Figure 4 – Residual Bouguer anomaly map with gravimetric stations, 0 mGal contour line and Ponte Nova outcrops.

To define the edges of the body, it was applied the total horizontal derivative. It is noticed, in figure 5, the high amplitude around the center of the anomaly. This result, as the residual anomaly, shows only one gravimetric source, therefore, there is no gravimetric separation of the two outcrops.

The vertical derivative filters of order 1 and 2 (figures. 6 and 7) show one anomaly that encompass both outcrops. The second order vertical derivative filter highlighted the NS direction as the main one for the intrusion setting. PNM is cut by NS and EW faults (figure 2) and maybe the NS faults controlled the intrusion set at depth.

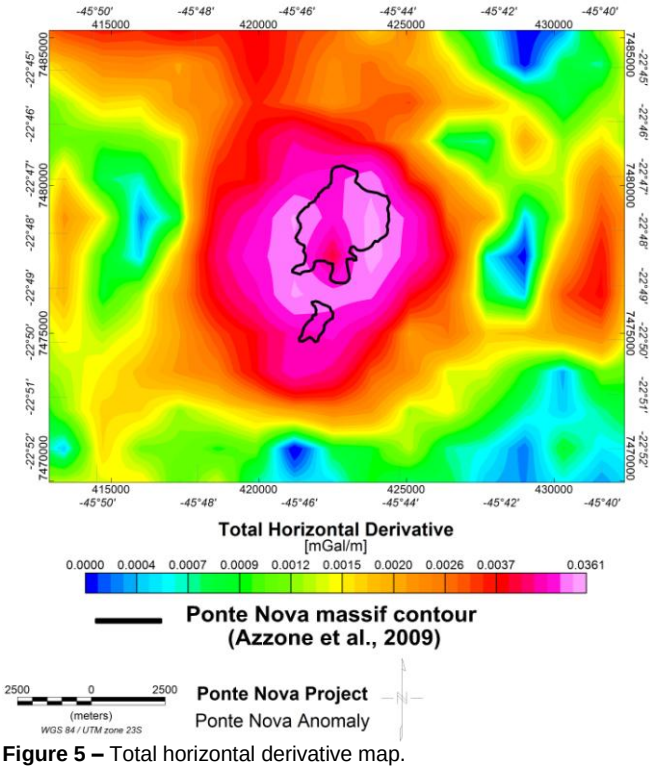

Figure 5 – Total horizontal derivative map.

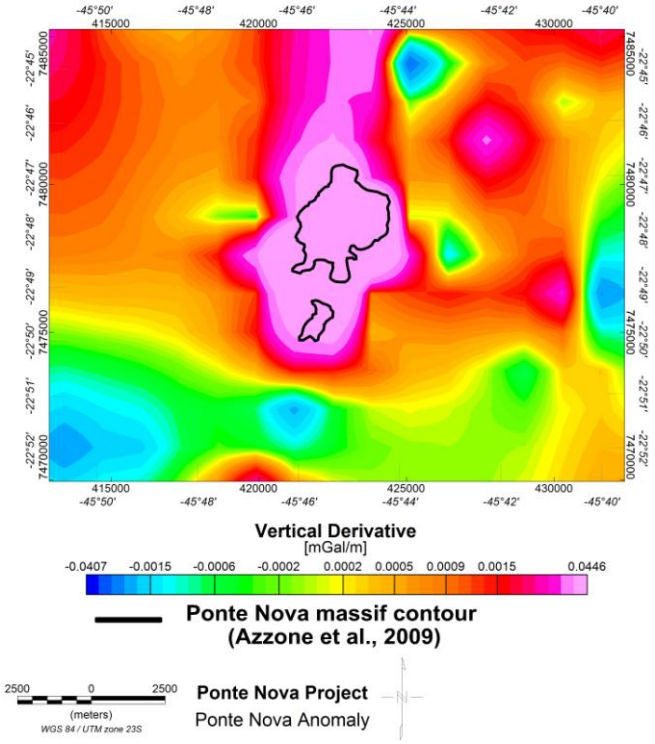

Figure 6 – First vertical derivative map.

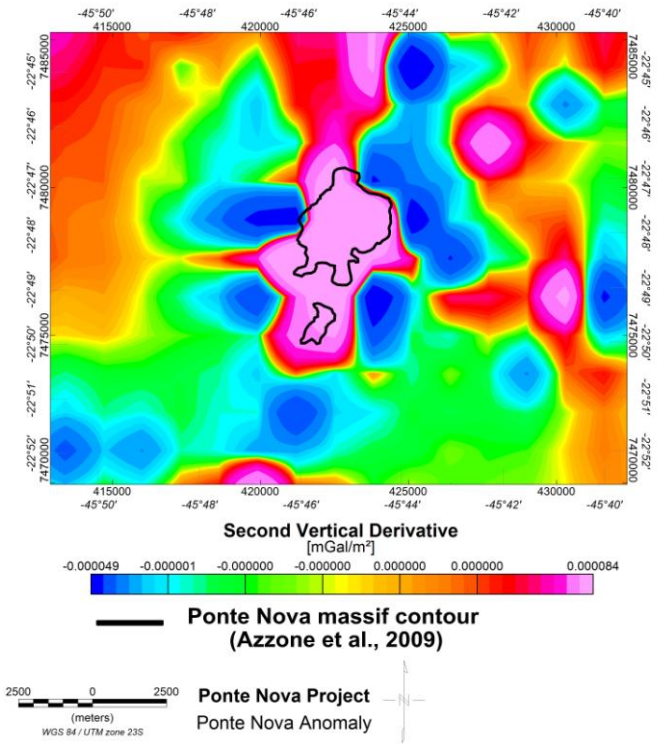

Figure 7 – Second vertical derivative map.

In the Bouguer anomaly map (figure 4) one of the main restrictions from gravimetric data is present: the ambiguity of potential fields. Gravity field alone cannot rule out two possible hypotheses that can fit the geological problem. The possibility of two disconnected, but very close, mass source in subsurface or just one source connected in depth. The applied filters does not helped at choosing one or another possibility, but clearly not separated south and north outcrops. So we decided to model just one source at depth.

For the preliminary forward model, figure 8, we use the data profile showed at figure 3. We set a density of 3200 kg/m³ for the massif and supposed just one source at depth. Density value was based on lithology described by Azzone et. (2009). The intrusion extends to almost 5 km in depth, with a mass distribution that diminish at depth. Although we choose just one source, it is thinner in the south, close to the smaller outcrop.

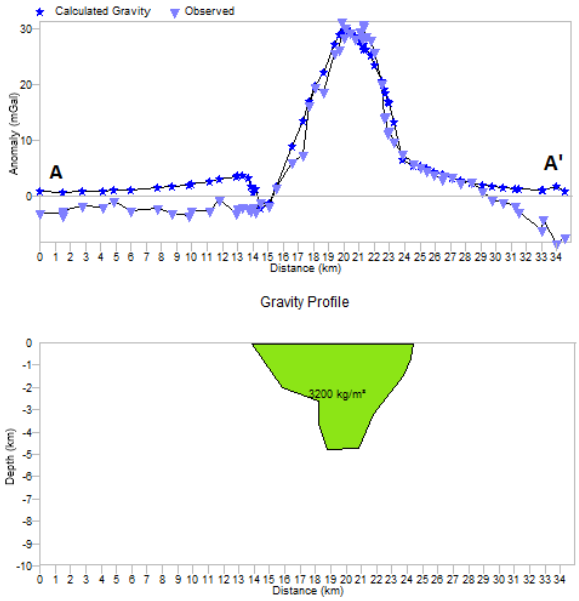

Figure 8 – Ponte Nova massif preliminary mass distribution model.

Conclusions

The gravimetric survey at PNM found a high gravity anomaly over the outcrops, like in others alkaline intrusions around the Paraná Basin. The gravity high, in the order of 33.3 mGal, is not extended much further away from the outcrops, suggestion that the anomaly source may be deep but not much larger in area than the intrusion observed at surface.

Gravimetric data alone is not enough to answer the question about one or two mass source in depth. A very detailed gravity data or another type of geophysical data would be helpful. The results from derivative filter application are more favorable to an individual source at depth: an elongated NS narrow source.

Based on figures 6 and 7 results, the forward gravimetric model was based on the hypotheses of one source. The 2D model resulted in a mass distribution that extends to 5 km depth, narrows in depth and is shallower at the south part.

We now will try a 3D inversion in order to verify the forward model and the possibility of two separate intrusions.

Acknowledgments

We are thankful to CNPq agency (PIBIC), FAPESP Project 2012/06082-6 and Rogério Azzone from IGc-USP.

References

Azzone, R.G., Ruberti, E. Rojas, G.E.E. and Gomes, C.B., 2009. Geologia e Geocronologia do Maciço Alcalino Máfico-Ultramáfico Ponte Nova (SP-MG) Revista do Instituto de Geociências – USP, Geol. USP, Sér. cient., 9(2): 23-46.

Dutra, A. C. and Marangoni, Y. R., 2009. Gravity and magnetic 3D inversion of Morro do Engenho Complex,

Central Brazil. Journal of South American Earth Sciences, v. 28, n. 2, p. 193-203, AUG-SEP.

Jones C.H., 2003-6. GravMag 1.0 fc 10. Based upon the original 1992 GravModel and MagModel software by Douglas Burger and H. Robert Burger.

Marangoni, Y.R. & Mantovani, M.S.M., 2013. Geophysical signatures of the alkaline intrusions bordering the Paraná. J. South Am. Earth Sciences, 41:83-98.