Two-dimensional gravity modeling of Casa de Pedra graben (Volta Redonda Basin) integrated with high-resolution seismic data - preliminary results

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Abstract

A preliminary two-dimensional gravity model is presented in order to better understand the structural framework of the distinct Cenozoic Casa de Pedra graben (GCP), Volta Redonda Basin, Rio de Janeiro. Several gravity data was acquired at the study area and to enhance the gravity anomaly produced by shallow sources, an upward continuation was performed to represent the regional data, which was removed from the total gravity anomaly, resulting in the residual gravity anomaly. We also acquired high-resolution seismic data, intended to diminish some ambiguities of the gravity modeling. Results show the depth of the basement shallower than the original estimates of the theoretical geological model, but the shape appears to be consistent, endorsed by the seismic section next to the modeled profile.

Introduction

The Volta Redonda Basin is a Cenozoic basin on the southwest of Rio de Janeiro state, their basement consists of Proterozoic metasedimentary rocks and granitoids, all of them NE-SW oriented. The stratigraphy of the basin consists, generically, in successions of sandstones and mudstones, deposited on interlaced rivers ambiences. The presence of ultrabasic volcanic and alkaline rocks is a distinct factor of this basin, found only in the southwest of GCP (Figure 1), principal depocenter of this basin and target on this study (RICOMINI, 1989, SANSON *et al.*, 2006, NEGRÃO *et al.*, 2015).

Geophysical methods are efficient tools for studying geological structures, tectonic evolution, basement relief and sedimentary thickness (SHARMA, 1986, OLIVEIRA et al., 2007). Potential-field methods are important for determination of physical properties that are quite useful for regional studies. Gravity measures are relevant in determining density variations in subsurface (TELFORD *et al.*, 1990).

Gravity forward modelling is useful to estimate density/ depth parameters that can vary in order to fit observations and test geological hypothesis (BUTLER & SINHA, 2011). Gravity models are not unique (i.e. several earth models can produce the same gravity response). Furthermore, many solutions may not be geologically realistic. To overcome this drawback, another geophysical data set must be considered. After integration of different geophysical methods and data sets, the interpreter is ready to evaluate the geologic reasonableness of any model (GMSYS, 2004).

In this work we present a preliminary gravity model from the set of gravity data acquired on GCP. Gravity reductions are considered for the processing of the acquired data and an upward continuation is also computed for regional-residual separation (BLAKELY, 1996). We also acquired a seismic line at the same region to provide a better analysis of the basement morphology.

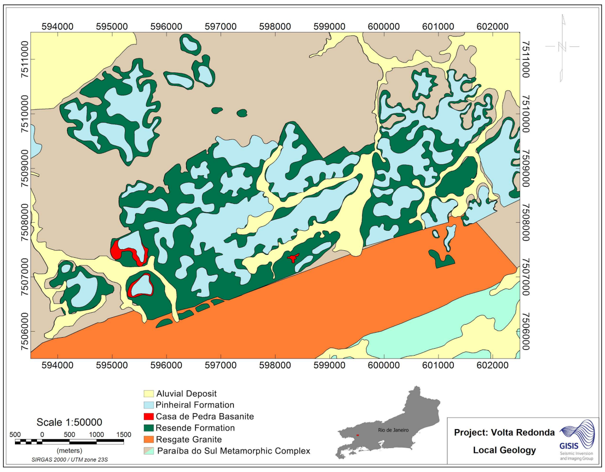

Figure 1 – Geological map of GCP. Localization of the area on the detail. (modified from NEGRÃO *et al.*, 2015).

Method

It was acquired 113 gravity stations, using a CG-5 Gravimeter from Scintrex and around 2 kilometers of seismic data using Geodes by Geometrics (see Figure 3), both with support of Differential Global Positioning System (DGPS), which can give a decametric resolution for coordinates.

Gravity processing were performed in Oasis montaj by Geosoft and followed a traditional workflow, as presented in KEAREY et al., 2002. Drift, tide, latitude, free-air, Bouguer and terrain reductions were obtained for a Bouguer plate with density (ρ) of 2,67 g/cm³. For free-air and latitude reductions, the reference adopted was the WGS-1984 (LI & GÖTZE, 2001, HOFMANN-WELLENHOF & MORITZ, 2005).

After applying all reductions, we obtain a total Bouguer anomaly map of the study region, as presented in Figure

2A. For dealing with short wavelengths, we need an extra processing step. Among several techniques, we decided to work with the upward continuation filter of 1000 meters (BLAKELY, 1996, FERNANDES & CHANG, 2001, NOZAKI, 2006, RIBEIRO & MANTOVANI, 2011). Afterwards, the continued Bouguer anomaly (Figure 2B) was subtracted from the total Bouguer anomaly, resulting in a residual Bouguer anomaly map, as presented in Figure 2C.

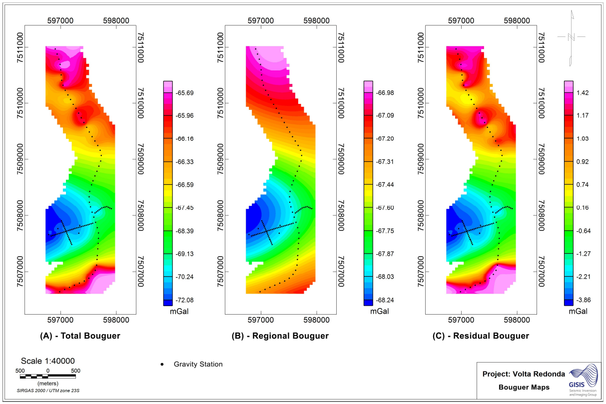

Figure 2 – (A) Total Bouguer anomaly (-72.1 to -65.7 mGal). (B) Regional Bouguer anomaly (-68.2 to -66.9 mGal). (C) Residual Bouguer anomaly (-3.8 to 1.4 mGal).

The forward 2D modelling (Figure 4A and 4B) was performed in GMSYS by Geosoft, which the method used to calculate the gravity model response is based on TALWANI *et al.*, 1959, TALWANI & HEIRTZLER, 1964, and WON & BEVIS, 1987.

Results

The map of residual Bouguer anomaly (Figure 3) got a range from 1.4 to -3.8 mGals, the gravity stations are located on direction S-N and near the center of the graben. A profile of 3200 meters, for modelling, was traced on this map, also with direction S-N.

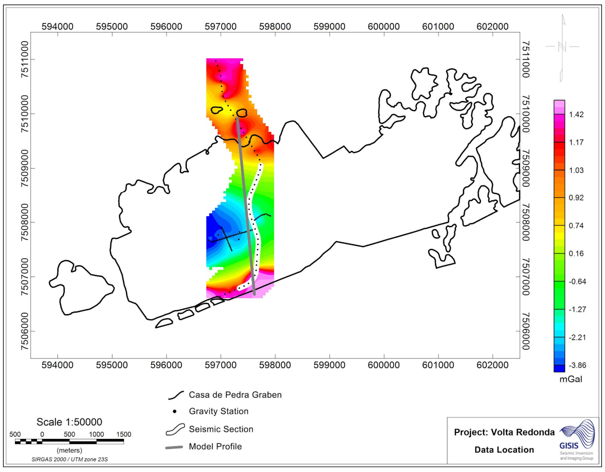

Figure 3 – Residual Bouguer anomaly of GCP, location of the gravity stations, model profile and seismic data.

The gravity modelling profile in Figure 4A presents a mathematical error of 4% between observed and calculated data. Figure 4B shows the topography of the model profile and estimated depth of basement, which has a maximum of 137 meters. The density used for the basement was 2,67 g/cm³ and 1,90 g/cm³ for the sediments, based on grain density measurements of GCP by researches of Universidade Federal do Rio de Janeiro (UFRJ), which are working simultaneously at the same area.

To minimize the non-uniqueness inherent to the gravity modelling, a stacked seismic section (Figure 4C) and a theoretical geological section (Figure 4D) from the area with a maximum depth around 200 meters and the volcanic rock between the two sedimentary formations.

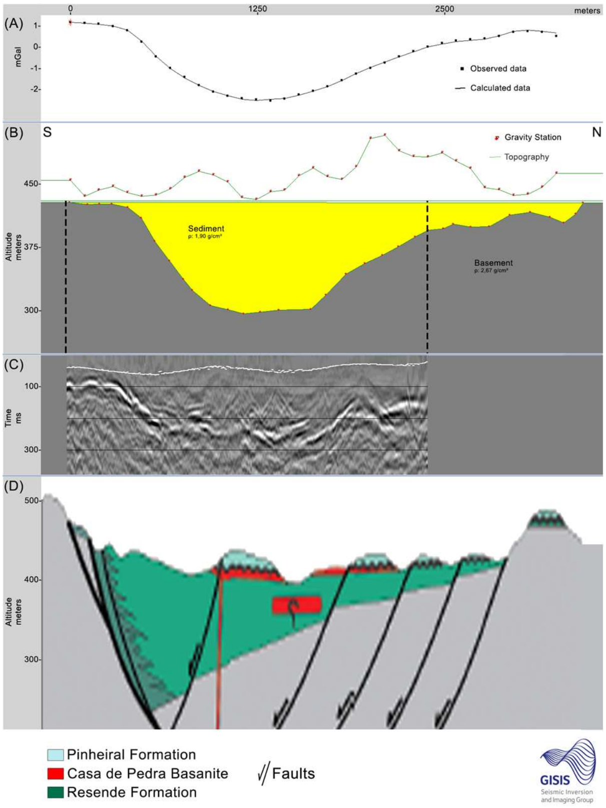

Figure 4 – (A) Observed and calculated data from the model profile. (B) Model of GCP. (C) Seismic section. (D) Geological concept of GCP (modified from NEGRÃO *et al.*, 2015).

Conclusions

The result is a initial model, which presents a good fit between the observed data and the calculated data, it also presents a coherent structural tendency with the seismic session and the conceptual model. In this case the maximum depth from the model was around 140 meters. The initial model could not represent the volcanic rock on this region of the graben.

New gravity and seismic data is already acquired and is in processing stages. New models will be made for a better understanding of the basement geometry inside the GCP.

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