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Integration of Gravimetric and Magnetometric Data for Identification of the Shape of the Taubaté Basin and Possible Basement Structures

André Bittencourt, Leonardo Miquelutti (Universidade Federal Fluminense - UFF), Brenno Alves Nobre (GISIS/UFF), Marco Cetale (GISIS/UFF), André Negrão (USP), Claudio Limeira Mello (UFRJ), Klauss Sampaio Silva (GISIS/UFF), Renato Ramos (UFRJ), Andrea Uchoa

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Abstract Summary.

This work aims to analyze the morphology and structures of the basement of the Taubaté Basin (SP) using public gravimetric and magnetometric data from CPRM. The data were processed and modeled using the Oasis Montaj software, with the application of filters and regional-residual separation. The forward modeling used information from seismic sections to define the top of the basement and sought to simultaneously fit the gravimetric (Bouguer) and magnetometric (TMI) data. The presence of a magnetic-only anomaly (i.e., not evident in gravimetric data) indicated a possible intrusive body in the basement, suggested as an alkaline plug or dike. The integration between the methods increased the reliability of the proposed model and contributed to the structural understanding of the basin.

Introduction

The study involves the collection of gravimetric and magnetometric data in the region of the Taubaté Basin, with the objective of studying its morphology and the structures present in the basement. The Taubaté Basin, together with the Volta Redonda, São Paulo, Resende, Curitiba basins and the Guanabara Depression, make up the Southeastern Brazilian Continental Rift (RCSB), being a rift-type basin with predominantly continental sedimentation (Fernandes & Chang, 2001).

The analysis of the geophysical data revealed a region that drew our attention. The magnetometric data show an anomaly with a dipolar pattern (with inverted dipole) in the central part of the basin (Figure 1a, red rectangle), indicative of a possible cylindrical intrusion in the basement, initially not evident in the gravimetric data (Figure 1b). However, the basin model and the basement topography, built from seismic data, show a mismatch between the simulated and observed gravimetric data, which suggests the presence of some body intruded only into the basement (with different density from it), responsible for this mismatch. The identification and study of these features are essential for advancing the understanding of the deep structures of the region and the various intrusions of alkaline bodies associated with the RCSB.

Method and/or Theory

Public gravimetric and magnetometric data provided by CPRM were used, originating from ground surveys and airborne surveys, respectively. The data processing, treatment, and modeling were carried out using the Oasis Montaj software, where grids of Bouguer gravity anomaly and TMI (Total Magnetic Intensity) magnetic anomaly were constructed.

From these grids, several potential field filters were applied with the objective of enhancing relevant structural features. Among the filters used, reduction to the pole and tilt stand out, as they preserved the observed anomalies well. However, the technique that proved most effective for enhancing the target structures was the regional-residual separation, providing greater contrast and definition of the anomalies of interest (Denttith & Mudge, 2014).

Considering the hypothesis that the basement structures are located at greater depths, it was decided to use the Complete Bouguer Anomaly and TMI grids in the forward modeling stage. To improve the model's accuracy, the following were also incorporated: the topography grid, the airborne magnetic survey grid (BARO), and the gravimetric station grid. Since gravimetric measurements are made at the surface, the topography grid was essential to ensure better control of the model's geometry.

In the construction of the initial geometry, seismic data available in the literature on the Taubaté Basin were used, which provided the horizon corresponding to the top of the basement. From this structural boundary, two-dimensional models were created, to which specific physical properties were assigned for the applied potential field methods: density in the gravimetric model and magnetic susceptibility in the magnetometric model.

The objective of the forward modeling was to adjust the geological bodies so that the calculated responses (solid black and red lines) satisfactorily reproduce the observed data (dashed lines), minimizing the error between the curves. The modeling began with the adjustment of the basin shape (top of the basement). Next, bodies were inserted into the basement aiming to simultaneously fit the gravimetric and magnetometric responses. This integrated approach provides greater robustness and credibility to the proposed structural interpretations.

Results

Four grids were generated (Figure 1): TMI, high-pass TMI, complete Bouguer, and high-pass Bouguer anomaly. The magnetic anomalies (TMI and high-pass) preserve an inverted dipole in the central region of the basin, typical of alkaline intrusions, consistent with the modeled body (Figure 3). The gravimetric data, on the other hand, do not directly reveal this feature, but the high-pass Bouguer anomaly map shows a significant low near the magnetic anomaly. The initial modeling, based on the basin geometry obtained from seismic data, did not fit the observed gravimetric data, suggesting the presence of a body less dense than the basement. The inclusion of this body in the model improved the joint fit of the data, reinforcing the hypothesis of an intrusion in the basement.

Our initial modeling excludes the intrusion (Figure 2) which presents a two-dimensional model containing the top of the basement, inserted based on seismic data acquired in the basin by CPRM (Andrade et al., 2022). However, a significant misfit is observed between the observed and calculated data, both in magnetometry and gravimetry The calculated responses (solid line) are distant from the observed data (dashed line), indicating a high modeling error. This result highlights the limitation of the initial model in adequately representing the geometry and physical properties of the subsurface bodies, reinforcing the need for adjustments to achieve a better joint fit.

Our final product (Figure 3) shows the two-dimensional model that resulted in the best joint fit between the observed and calculated data. Although the model is 2D, a width was assigned to the modeled body within the software, simulating a three-dimensional extension that better represents the geological reality. This approach aimed to make the simulated response compatible with the dipolar characteristic of the magnetic anomaly, which suggests the presence of a body with an approximately cylindrical geometry, such as an intrusive plug, rather than a narrow and planar dike.

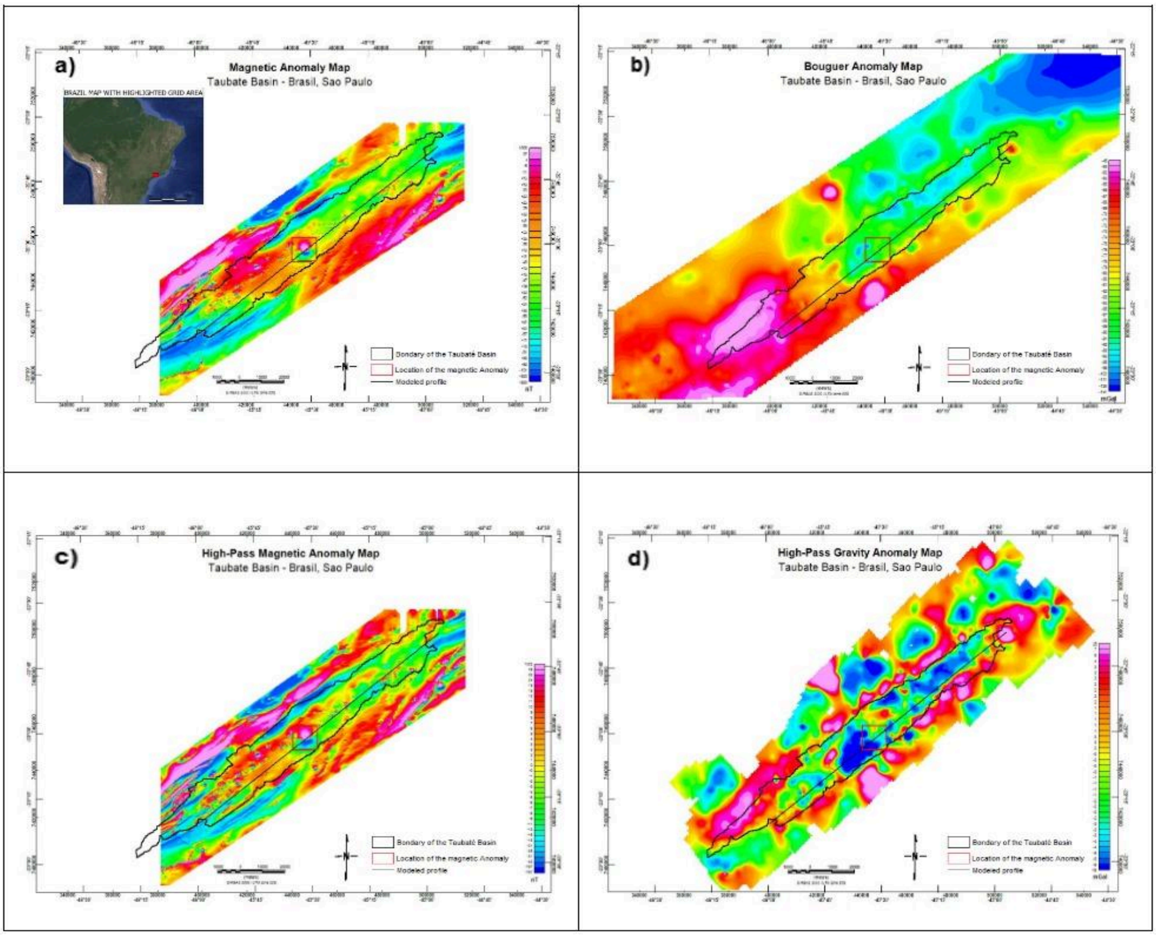

Figure 1: Four maps with gravimetric and magnetometric grids: a) Total Magnetic Intensity (TMI) anomaly map of the Taubaté Basin; b) complete Bouguer gravity anomaly map; c) high-pass magnetic anomaly map; and d) high-pass Bouguer gravity anomaly map. The red rectangle highlights the region of the anomaly interpreted as a possible intrusion in the basement.

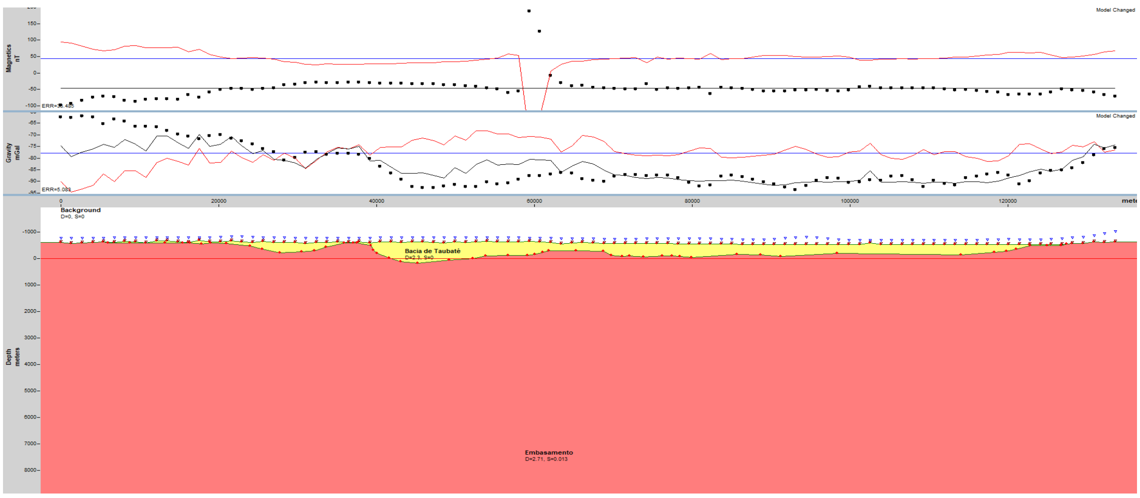

Figure 2: Modelled profile without the inclusion of the intrusion, showing the calculated responses (solid line) of the geophysical data compared to the observed data (dashed lines).

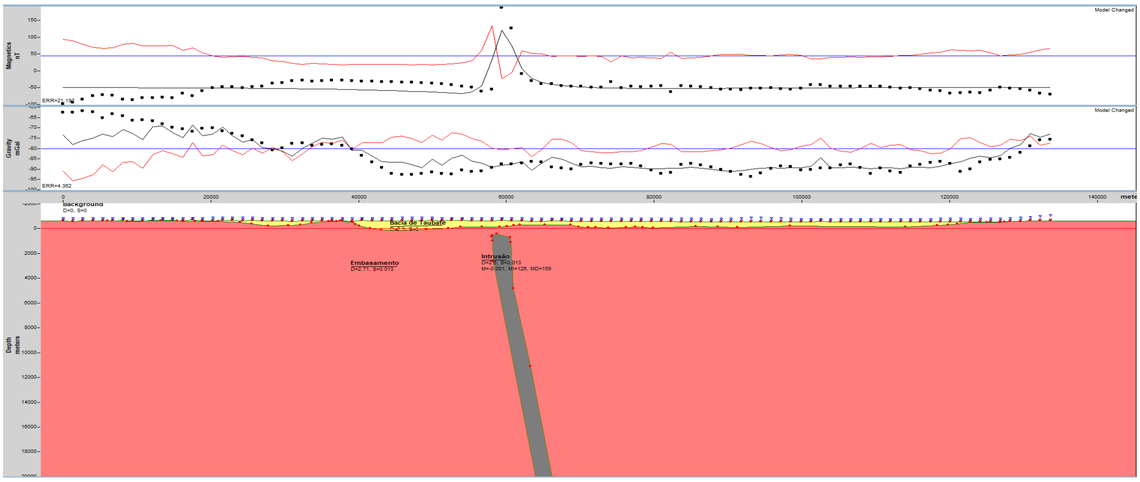

Figure 3: 2D geological model with the best fit between observed data (dashed lines) and calculated data (solid black lines). The intrusive body was represented with a cylindrical geometry, as suggested by the dipolar magnetic anomaly.

Conclusions

The main objective of this study was to identify the top and structures of the basement of the Taubaté Basin through the integration of gravimetric and magnetometric data in forward modeling, as well as to determine the cause of the evident magnetic anomaly. The models generated so far present reasonable geophysical responses with the inclusion of a possible alkaline intrusion. We observed that the basement model recovered by seismic data did not fit the gravimetric data either without the inclusion of a body less dense than the basement in the region of this anomaly. However, different geometries and dimensions for this structure are still being tested, aiming to consolidate a more geologically plausible model. The simultaneous correspondence between gravimetric and magnetometric data has been fundamental to ensuring greater reliability in the interpretations. Based on the consolidation of these results and integration with geological information, the next steps of the project involve the development of a detailed 3D model, which will be essential to improve the understanding of the basement and the tectonic evolution of the basin.

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References

ANDRADE, J. J. C. de; SEVERINO, R. R.; CAMPOS, F. F.; GUERRA, G. I. T.; LIMA, R. A. P. de. Modelo geofísico-geológico da Bacia de Taubaté - SP. *Informe de Geofísica Aplicada*, nº 07, CPRM – Serviço Geológico do Brasil, 1 recurso eletrônico (PDF). (2022). ISBN 978-65-5664-213-0.

DENTITH, M.; MUDGE, S. T. Geophysics for the mineral exploration geoscientist. Cambridge University Press. (2014). ISBN 978-0-521-80951-1.

FERNANDES, F. L. CHANG, H. K. Gravity modeling of Taubaté Basin: Paraíba do Sul river valley, east of São Paulo State. *Brazilian Journal of Geophysics* **19**(2), p. 131–144. (2001). DOI: 10.1590/S0102-261X2001000200002