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Two-Dimensional Gravity Modeling of the Resende Basin Using Terrestrial Data

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Abstract Summary

The Resende Basin, a Lower Cretaceous rift between Rio de Janeiro and Minas Gerais, formed during the breakup of Gondwana. This study uses 2D forward gravity modeling with terrestrial data from GISIS/UFF to investigate its basement geometry and sedimentary thickness. Modeling was performed in GMSYS (Oasis Montaj) along two profiles, including one from the Itatiaia Alkaline Massif (IAM). Density values were based on lithological references. Results indicate an asymmetric rift structure, sediment thicknesses of 300–500 m, and a dense IAM root reaching ~3 km depth. The model fits validate gravity methods as effective tools for basin structure analysis in southeastern Brazil.

Introduction

The Resende Basin (Figure 1), located between the states of Rio de Janeiro and Minas Gerais, is a Lower Cretaceous rift basin associated with the breakup of Gondwana and the opening of the South Atlantic Ocean (Riccomini et al., 2004). In addition to its scientific interest, it is notable for its aquifer and mineral potential (Zalan & Oliveira, 2005). Understanding its internal structure, especially the basement geometry and the thickness of the sedimentary package, is fundamental for tectonic and natural resource studies. Gravity methods are an effective tool for this purpose, as they detect density contrasts between geological units.

This study aims to perform a 2D forward gravity modeling based on ground data acquired by the Seismic Imaging and Inversion Group of the Fluminense Federal University – GISIS/UFF, using the GMSYS software by Seequent. Two profiles were defined: Profile01 (SE-NW), which crosses the basin passing through a structural high, and Profile02 (NE-SW), which originates from the Itatiaia Alkaline Massif (IAM).

Densities were assigned based on the literature: the IAM presents values between 2.4 and 2.55 g/cm³ (Gomes & Comin-Chiaramonti, 2011), with 2.5 g/cm³ adopted for the modeling. For the basin sediments, values between 2.1 and 2.2 g/cm³ were used, which are typical of poorly consolidated rocks (Silva et al., 2016).

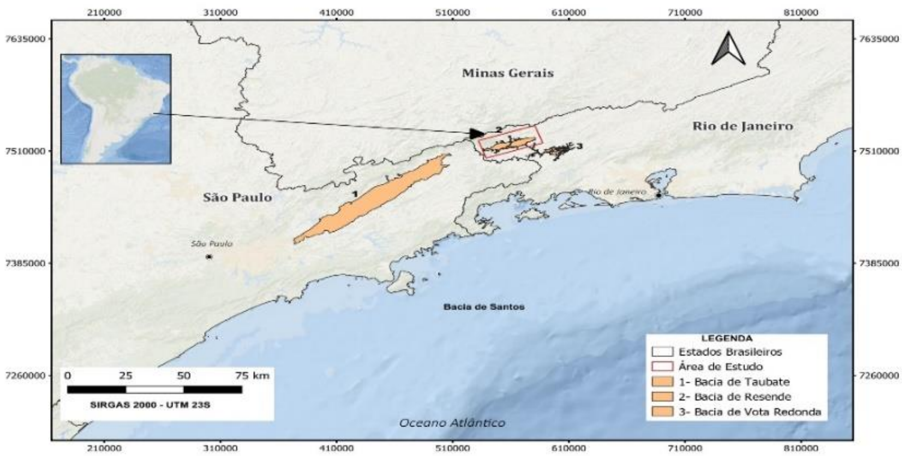

Figure 1: Location of the Resende Basin within the context of the sedimentary basins in the Continental Rift Southeast Brazil (CRSB).

Methodology

The gravity modeling was performed based on two geophysical profiles named Profile01 (SE-NW), which fully crosses the basin along the strike direction, passing through a central structural high, and Profile02 (NE-SW), as shown in Figure 2, which originates from the IAM and partially crosses the basin. The data was acquired in the field using gravity stations spaced at regular 1 km intervals.

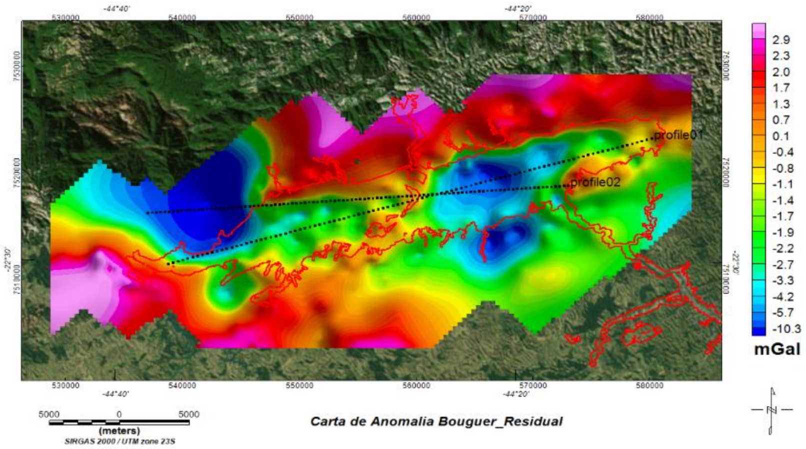

Figure 2: Residual Bouguer Anomaly Map highlighting the two profiles used in the modeling.

For the modeling, the GMSYS software integrated into Seequent's Oasis Montaj platform was used. The 2D forward modeling was based on density values obtained from the literature. For the IAM, considering its heterogeneous lithological composition — including nepheline syenite, trachyte, and phonolite — an average density of 2.5 g/cm³ was adopted, based on a range of 2.4 to 2.55 g/cm³ (e.g., Gomes et al., 2011). For the sedimentary package of the Resende Basin, densities ranging from 2.1 to 2.2 g/cm³ were considered (Silva et al., 2016), consistent with poorly consolidated sedimentary rocks.

Results

The gravity modeling along the two profiles showed good agreement between observed and calculated data, as indicated by low standard deviations in the fits. Profile01, whose modeling is shown in Figure 3, revealed a geometry typical of rift basins, with an asymmetric basement and deepening toward the northwestern sector. Two distinct zones of sedimentary thickening were identified: the first between 300- and 350-meters depth, and the second, deeper one, between 450 and 500 meters.

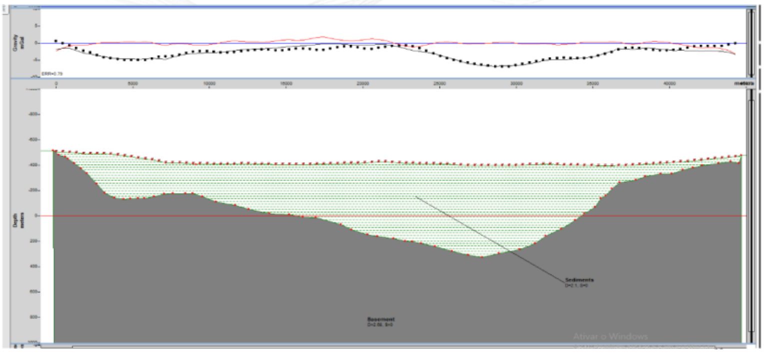

Figure 3: Modeling of Profile01 using Seequent's GMSYS, highlighting the thickness of the sedimentary package.

The modeling of Profile02, illustrated in Figures 4A and 4B, which starts at the Itatiaia Alkaline Massif, revealed the presence of the crystalline basement at an average depth of approximately 3 km. This finding is consistent with the topographic elevation of the IAM, which reaches an altitude of about 2,791.55 m (IBGE, 2023).

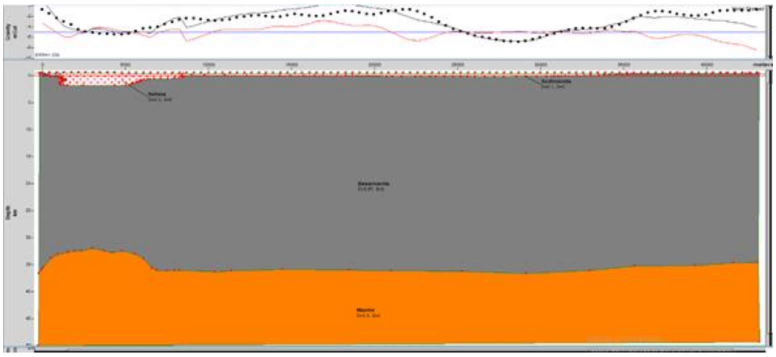

Figure 4A: Modeling of Profile02 using Seequent's GMSYS, showing the depth of the IAM and the thickness of the sedimentary package, with a visualization including the mantle.

The densities assigned to the IAM adequately represented its gravity signature, producing a high-magnitude positive anomaly at the end of Profile02. Conversely, the sediments of the Resende Basin resulted in low-amplitude negative anomalies, consistent with less dense materials.

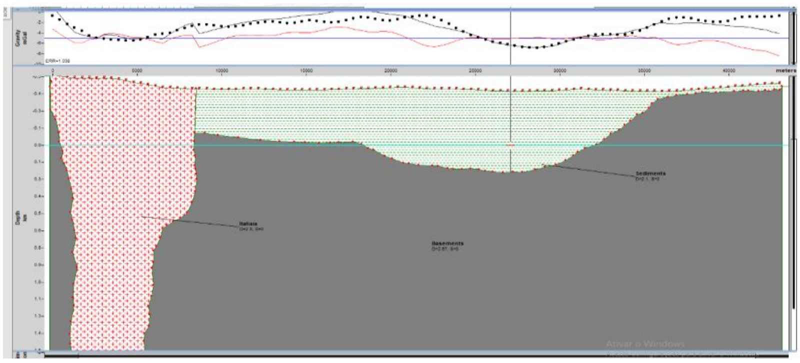

Figure 4B: Modeling of Profile02 using Seequent's GMSYS, providing detailed representation of the depth of the IAM and the thickness of the sedimentary package.

Conclusions

The 2D gravity modeling enabled the identification of key structural features of the Resende Basin. The results confirm the presence of a deep crystalline basement beneath the basin, with sedimentary thicknesses ranging between 300 and 500 meters. The modeling of the IAM showed consistency with topographic and lithological data from the literature, requiring the inclusion of a localized “bulge” on the hill, adjusted according to the extent of the IAM root, to calibrate the gravity data. This study highlights the effectiveness of gravity methods in defining the geometry of sedimentary basins and contributes to an improved geological understanding of the region.

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