Submission code: ZDAWLRXAD4

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Integrated Gravity and Seismic Interpretation for Subsurface Characterization and Stratigraphic Well Placement in the Resende Basin, Brazil

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Abstract Summary

This study presents an integrated geophysical investigation of the Resende Basin, in the central segment of the Continental Rift of Southeastern Brazil (CRSB). New gravity data and seismic lines were acquired and interpreted to improve subsurface imaging in a structurally complex, data-scarce region. Gravity anomalies were used to guide seismic acquisition, which in turn supported the placement of a stratigraphic well. The initial well location was re-evaluated during interpretation, leading to a successful relocation that reached the crystalline basement at 387 meters, closely matching the 383 meters estimate from seismic data. These results demonstrate the value of a dynamic, adaptive workflow and highlight the importance of real-time geophysical integration in exploration. The consistency among gravity, seismic, and well data confirms the robustness of the methodology.

Introduction

The Resende Basin is a Cenozoic extensional structure located in the southwestern portion of Rio de Janeiro state, within the central segment of the Continental Rift of Southeastern Brazil (CRSB) (Figure 1). Despite previous geological studies focused on surface geology and regional tectonics, the Resende Basin lacked key subsurface data (Asmus and Ferrari, 1978; Riccomini, 1989; Riccomini et al., 2004). To address this gap, the present study was developed as part of a larger research initiative led by the Seismic Imaging and Inversion Group (GISIS) from the Universidade Federal Fluminense (UFF), in partnership with Petrobras, Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (ANP), Universidade Federal do Rio de Janeiro (UFRJ) and Universidade de São Paulo (USP). This broader project investigates the evolution of the CRSB and its connection to the southeastern brazilian offshore margin.

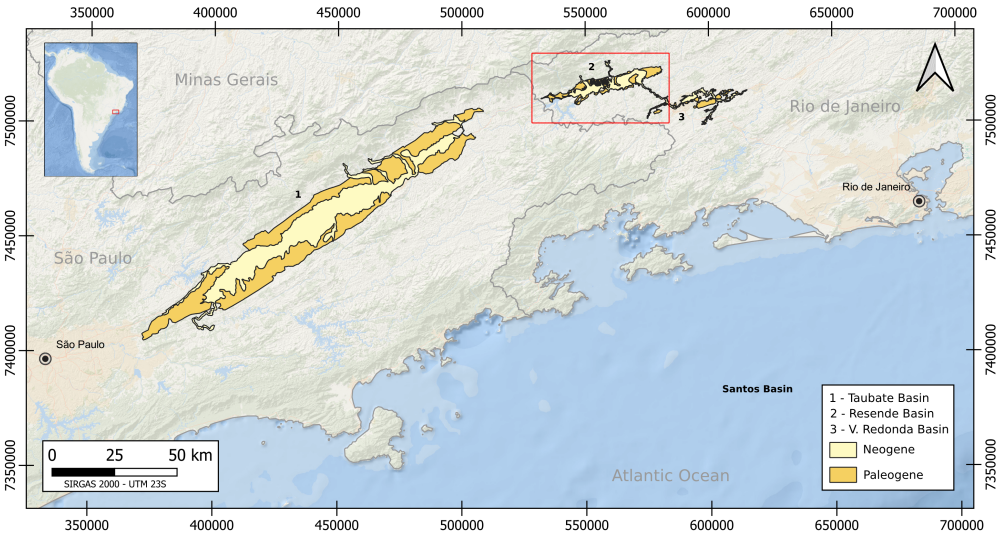

Figure 1: Location of the basins that form the central segment of the CRSB: (1) Taubate, (2) Resende and (3) Volta Redonda.

In this work, we present the acquisition, processing, and interpretation of new gravity and unprecedented seismic data in the Resende Basin. These datasets were integrated to support the sub-

surface characterization of the basin and to guide the precise placement of a pioneer stratigraphic well designed to penetrate the entire sedimentary sequence. The workflow enabled dynamic, data-driven decision-making that proved essential to the success of the well operation.

Methodology

A total of 608 gravity stations were acquired using a Scintrex CG-5 gravimeter and processed with Oasis Montaj software (Seequent). Standard gravity corrections were applied, and regional-residual separation was performed via upward continuation to 1 km (Kearey et al., 2002). The resulting residual Bouguer anomaly delineated key subsurface features, including the Porto Real depocenter, and served as a first-order guide for positioning the seismic lines.

Following land access negotiations and environmental permitting, five 2D seismic lines were acquired using a 72-channel Geode system with a PEG-40 impulsive source. The seismic data were processed using Echos software (AspenTech) with a workflow that included static corrections, noise attenuation, velocity analysis, stacking, and migration (Yilmaz, 1987).

Interpretation of the initial seismic lines revealed that the planned well location would not reach the basement within the available drilling budget. In response, the gravity data trends were re-evaluated, and two additional 2D seismic lines were acquired in a structurally favorable area, where a shallower basement was inferred. Interpretation of this new dataset allowed for the relocation of the stratigraphic well, which was successfully drilled to its target and intercepted the crystalline basement. The final well location was selected based on the integrated interpretation of gravity and seismic data, in alignment with both geological targets and logistical feasibility.

Results

The residual Bouguer anomaly (Figure 2) obtained in this study is consistent with previous works in the region (Bettini, 2004), confirming the presence and geometry of the main depocenter on the eastern side of the Resende Basin. This gravity-defined structural low guided the positioning of the seismic profiles. However, the presence of nearby alkaline intrusions generates localized negative anomalies that partially obscure the gravimetric signal associated with the basin fill.

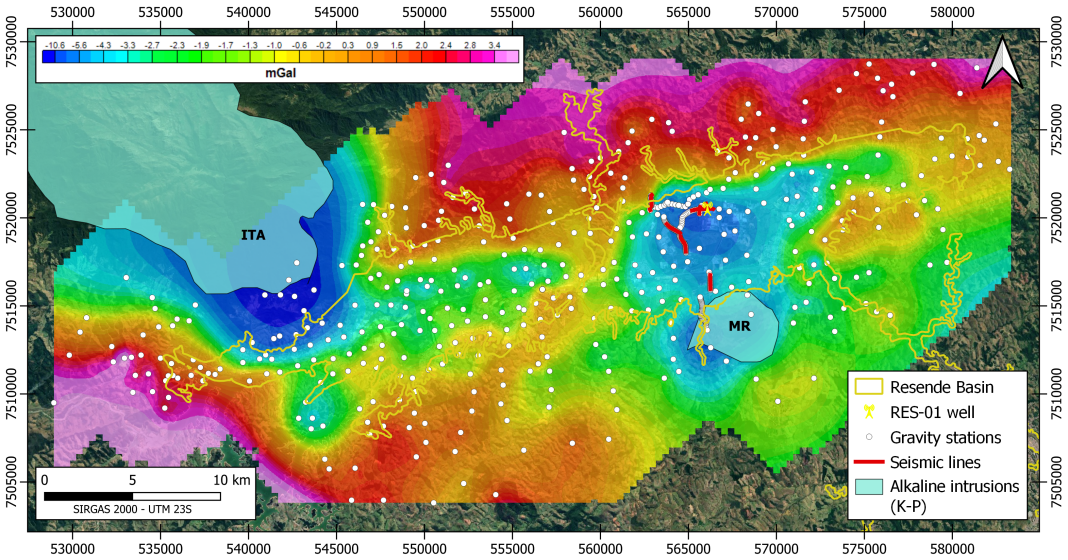

Figure 2: Residual Bouguer anomaly map of the Resende Basin. White dots indicate gravity stations, and red lines show the seismic acquired in the basin. Strong negative anomalies outside the basin boundary are associated with the Itatiaia (ITA) and Morro Redondo (MR) alkaline rock bodies.

Seismic line L7 (to the west), located near the depocenter, revealed a thick sedimentary succession, exceeding the feasible drilling depth for the planned stratigraphic well. Line L8 (to the east), positioned in a structurally favorable area based on residual gravity trends, displayed a comparatively thinner sedimentary package and a shallower basement surface. Despite high levels of ambient and cultural noise typical of near-surface land acquisition, reflector alignments observed at the intersection of L7 and L8 were coherent, contributing to a more reliable interpretation of the basin's basement structure (Figure 3).

The stratigraphic well intercepted the crystalline basement at a depth of 387 meters, closely matching the 383 meters estimate derived from seismic interpretation. Additionally, the density log acquired in the well showed strong agreement with the seismic facies identified along Line L8, even though no seismic-well tie was performed (Figure 3). This correlation further supports the reliability of the seismic interpretation and highlights the consistency between the geophysical datasets.

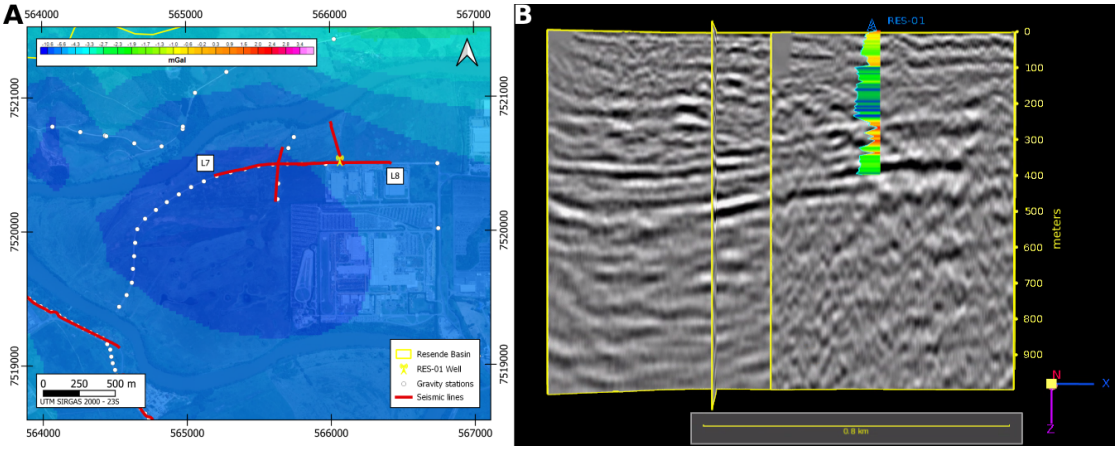

Figure 3: (A) Porto Real depocenter with the gravity stations in white dots, the seismic lines in red and the stratigraphic well location. (B) L7 and L8 seismic section with density log projected on.

Conclusions

This study demonstrates the value of an integrated and adaptive geophysical workflow for subsurface characterization in the Resende Basin, within the central segment of the CRSB. Residual gravity data provided a reliable structural framework, while seismic imaging refined the interpretation and supported the placement of a stratigraphic well. The well successfully reached the crystalline basement at 387 meters, closely matching the 383 meters estimate from seismic interpretation. Additionally, the correspondence between seismic facies and density log data, even without a formal seismic-well tie, reinforces the internal consistency of the geophysical dataset. The ability to reinterpret data during the project and adjust the acquisition strategy, particularly by relocating seismic profiles based on gravity trends, was essential to achieve these results. This dynamic and iterative workflow contributes to a more accurate understanding of the Resende Basin's internal structure and provides a methodological reference for similar studies within the CRSB.

Acknowledgments

The authors acknowledge the support of Petrobras through the R&D project "Tectônica Cenozoica da Margem Continental do Sudeste do Brasil: padrões de deformação e controle na sedimentação" (ANP No. 22969-0). The strategic importance of the R&D funding regulation by ANP is also recognized. We express our gratitude to AspenTech and Seequent for providing academic software licenses, and to the Grupo Porto Real for allowing geophysical operations on their properties. We thank Rodrigo S. Stern for his crucial IT support.

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