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Stratigraphic Adjustment of the Seismic Data from the Taubaté Basin Based on Outcrops

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Abstract Summary

The Taubaté Basin, located in southeastern Brazil in the state of São Paulo, is a rift-type basin formed during the Oligocene. It 's composed of four main stratigraphic units belonging to the Taubaté Group: the Pindamonhangaba, Tremembé, São Paulo, and Resende Formations. Despite the available dataset, there is still a significant gap in studies focused on the detailed seismic interpretation of these formations. This work presents an approach aimed at adjusting the horizons observed in seismic data based on outcrops of the mentioned units, except for the São Paulo Formation.

Introduction

Located on the Atlantic Plateau, between the Serra do Mar and Serra da Mantiqueira mountain ranges, the Taubaté Basin is part of a series of NE–SW oriented intracontinental grabens related to extensional tectonics that shaped the South Atlantic continental margin. It is approximately 170 km long (Riccomini et al., 2004) and reaches a maximum sedimentary thickness of about 850 meters (Molinari and Borghi, 2005). The tectono-sedimentary evolution of the Taubaté Basin is characterized by fluvial, lacustrine, alluvial, and colluvial deposits that span from the Paleogene to the Quaternary (Riccomini, 1989; Riccomini et al., 2004). The identification and interpretation of depositional systems, especially sandstones associated with alluvial fans, are important to understand the structural and stratigraphic evolution of the basin (Campanha, 1994; Vidal et al., 2004). In rift basins, the recognition of sandstones linked to alluvial fan systems has significant potential as a tectonic marker during basin evolution (Gawthorpe and Leeder, 2000; Vidal et al., 2004). Seismic data acquired by Petrobras in 1988 reveal the presence of strike-slip and normal faults that control the geometry of structural blocks and directly influence the distribution of sedimentary packages (Marques, 1990). In this context, the purpose of the present study is to analyze and interpret the Pindamonhangaba, Tremembé, and Resende formations in the subsurface and their correlation with surface geological data, using a seismic line that shows truncation of these stratigraphic units. This approach allows for the refinement of the basin's stratigraphic model and provides new perspectives on its geological evolution. These studies may also support research in marginal basins such as Santos and Campos, which exhibit sedimentary correlation with the Cenozoic fill of the Taubaté Basin.

Geological Setting

The Taubaté Basin, located in southeastern Brazil, developed over terrains of the Ribeira Belt in response to extensional processes related to the South Atlantic rifting during the Cenozoic. Included in the Southeastern Brazilian Rift System (RCSB), its sedimentary evolution reflects successive episodes of tectonic accommodation and paleoenvironmental changes. According to (Riccomini, 1989), the main evolutionary phase of the RCSB occurred during the Eocene–Oligocene, with the development of half-grabens in the central segment of the rift. The syntectonic sedimentary infill of this stage is associated with the Taubaté Group (Resende, Tremembé, and São Paulo formations)**(Figure 1)**. Sedimentation in the basin begins with alluvial deposits related to border faults and braided river plains in the central region, along with fluvial systems, which characterize the Resende Formation

(Vidal et al., 2004). In gradation, the Tremembé Formation consists of organic-rich lacustrine sediments understood as records of an extensive lacustrine system during the Oligocene. Subsequently, with tectonic reactivation and basin infill, the meandering fluvial deposits of the Pindamonhangaba Formation are established (Riccomini, 1989), marking the top of the succession.

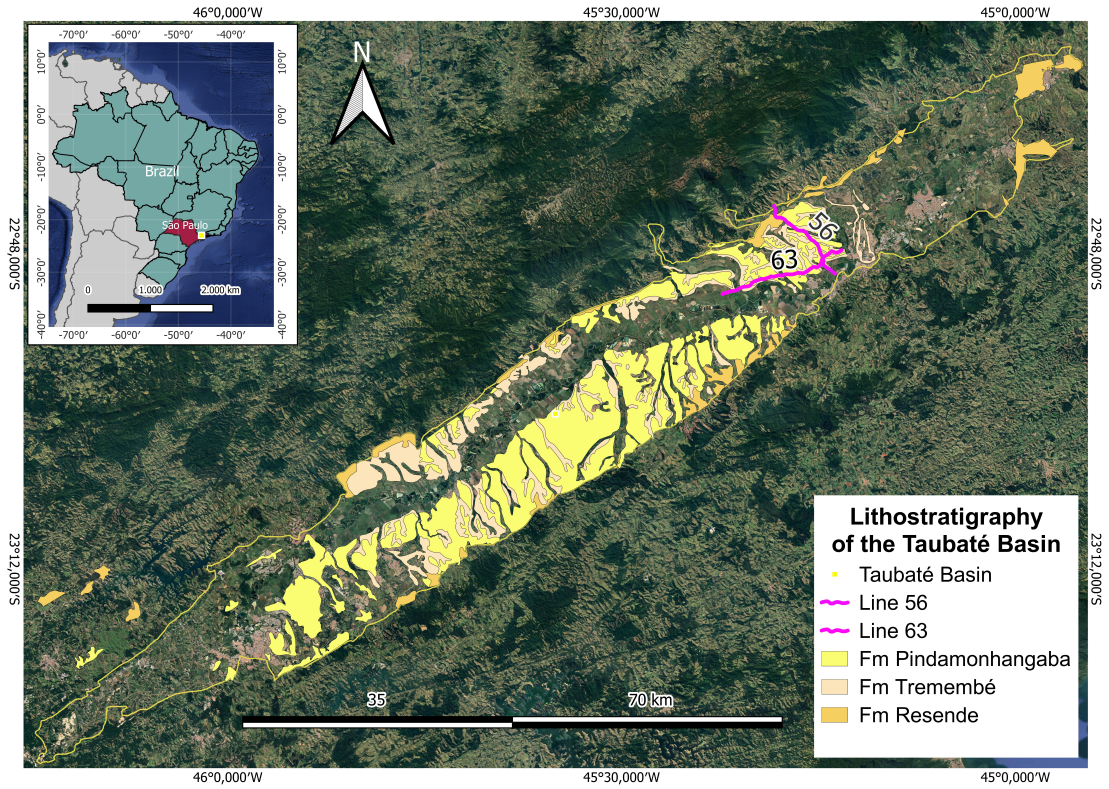

Figure 1: Outline map of the Taubaté Basin with the Pindamonhangaba, Tremembé, and Resende formations, and seismic lines 56 and 63.

Methodology

The methodology adopted in this study consisted of converting seismic line 56, oriented NW–SE, to depth and interpreting it using the Paradigm™22 software (Aspentech). Seismic reflectors were analyzed with the aim of identifying structural discontinuities and stratigraphic surfaces representative of the Resende, Tremembé, and Pindamonhangaba formations. For spatial support and geological correlation, satellite images and vector layers were used in QGIS, where the CMPs (*Common Midpoints*) of the seismic line were georeferenced and overlaid on the geological map of the basin. This integration allowed the verification of coincident points between the seismic data and the mapped geological units at the NW end, enabling the adjustment of seismic horizons to the mapped formation boundaries to establish a stratigraphic framework in the seismic section.

Results

At the NW end of line 56, the outcrops of the contacts between the studied stratigraphic units allow an interpretation of the events observed in the seismic data **(Figure 2)**. The Resende Formation

begins to outcrop at CMP 243, followed by the Pindamonhangaba Formation at CMP 309. Then the Tremembé Formation outcrops at CMP 403, with intermittent outcrops for approximately 3.7 km, being covered again by the Pindamonhangaba Formation at CMP 436. At CMP 619, the Pindamonhangaba Formation occurs again, and then, once again, the Tremembé Formation outcrops from CMP 625 to CMP 715 **(Figure 2)**. From this interval up to CMP 996, there is an intercalation of outcrops between the Tremembé and Pindamonhangaba Formations. The Pindamonhangaba Formation has been partially eroded in parts of the basin, and in the valleys between the outcrops there are depositions of Quaternary sediments. The intercalation of outcrops indicates that the top of the Tremembé Formation, beneath the Pindamonhangaba Formation, must be relatively shallow, as indicated in the interpretation proposed in **(Figure 2)**.

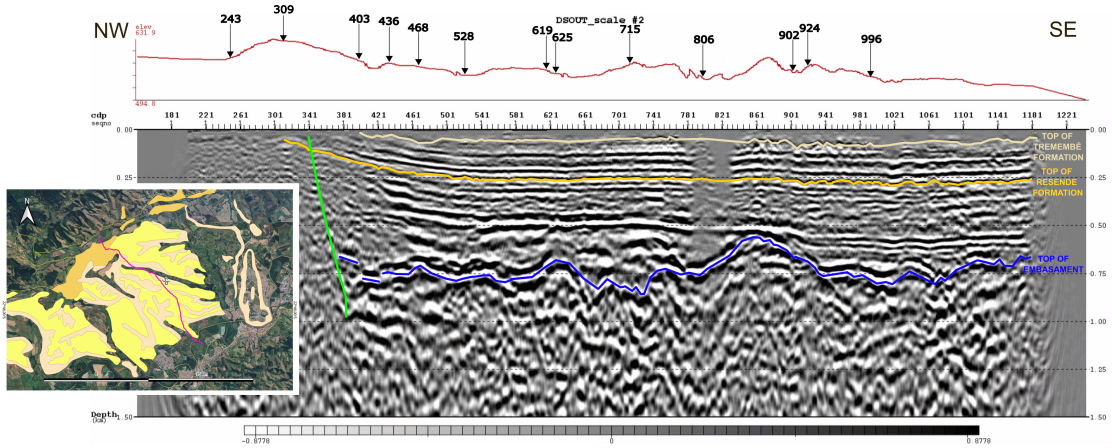

Figure 2: Interpreted seismic reflectors of the Tremembé (beige) and Resende (orange) formations, and of the basement (blue), with *common mid points* (CMP) points from the outcrops. On the left, the geological map of the outcropping formations with the interpreted seismic line in pink (see map legend in **Figure 1**).

Conclusions

The proposed methodology shows good potential for aligning geological and seismic data. As a complement to the analysis, seismic line 63 **(Figure 1)**,perpendicularly oriented, is being processed and interpreted with the objective of improving the correlation between the identified horizons. Additionally, a technical field visit to the region will be conducted to enhance the geological understanding of the area. The integration of these seismic lines and the collection of local samples aim to contribute to the advancement of the stratigraphic modeling of the Taubaté Basin and provide support for future studies with academic and exploratory applications.

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