Analyzing depositional patterns through seismic facies of Barremian-Aptian carbonate reservoirs in the Raia Manta and Raia Pintada Fields, Campos Basin

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Introduction

The exploration and production of hydrocarbons remain strategic to Brazil's economy, with the Campos Basin standing out as one of the country's most productive offshore basins, located along the eastern Brazilian margin. Due to the complexity and high cost associated with exploration in the pre-salt interval, there is an increasing need to enhance interpretation techniques and integrate geological data more effectively. These advancements are essential for achieving more accurate characterization of subsurface features and for constructing reliable geological models and analogs. These models enhance the understanding of subsurface conditions in exploration contexts, and they are essential for analyzing processes of hydrocarbon generation, migration, and accumulation. They also help identify false-positive zones, reducing exploration risks and optimizing resource allocation. This research focuses on the recently declared Raia Manta and Raia Pintada fields, officially recognized in 2023 by ANP following an exploration campaign in the BMC 33. During this campaign, ten wells were drilled over the main structural highs: Seat, Gávea, and Pão de Açúcar. The main objective of this study is to understand the evolution of carbonate and volcanic reservoirs, particularly the Barremian-Aptian units, through the correlation of well data and 3D seismic interpretation, contributing to a better geological understanding of this newly drilled area.

Method and/or Theory

The study was conducted using a 3D seismic dataset and the 10 wells data provided by ANP/BDEP. The main methodological steps included: (i) loading and quality control of the received seismic and well data; (ii) structural interpretation combining automatic fault extraction methods with manual refinement and interpretation; (iii) well-to-seismic correlation to identify and individualize key reflectors; (iv) detailed-scale seismic stratigraphic and geomorphological interpretation; (v) full-volume seismic interpretation, in which a relative geological time model was applied to enhance and improve the global interpretation of the pre-salt formations; (vi) application of a set of seismic attributes to highlight structural features and stratigraphic sequences; and (vii) construction of a tectono-stratigraphic model. All these steps were integrated to achieve a comprehensive understanding and characterization of the sedimentary environment. The resulting interpretation was compared with interpretations available in the literature for the Macabu Formation in the Campos Basin, and studies of the Barra Velha Formation, which has been extensively investigated in the Santos Basin

Results and Conclusions

The results demonstrate strong structural control of the basement over the pre-salt units, composed of graben and horst systems, evidence of their formation under an extensional tectonic regime. This structural framework directly influenced the deposition of adjacent formations, as well as the distribution and thickness of the Macabu interval. A comprehensive analysis made it possible to subdivide the mapped stratigraphic units based on fault control and variations in seismic facies within the Aptian interval. Seismic interpretation revealed distinct facies such as debris flows, carbonate build-ups, and deep to shallow lacustrine deposits, each associated with different tectonic and geomorphological stages. The 3D structural model enabled the visualization of reservoir geometries, highlighting contrasts between structural highs and the compartmentalization patterns, which directly impact hydrocarbon migration and accumulation across the three main structural highs. This study provides valuable insights into the evolution and sedimentary context of the Barremian-Aptian formations. It may serve as a useful analog for carbonate reservoirs with strong volcanic and structural influences.