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Unveiling the potential of carbonate mounded features as reservoirs in the Santos Basin, SE Brazil

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Introduction

The Barra Velha Fm. is the main oil-bearing reservoir of the Santos Basin, comprising lacustrine lithofacies such as calcirrudite, calcarenite, spherulestones, and shrubstones. Seismically resolvable mounded features with thicknesses of up to 600 m are commom in the Santos Basin with several implications for the compartmentalization and trapping of hydrocarbons in pre-salt reservoirs. This case study thoroughly investigates the geometry and the reservoir potential of a NE-SW elongated mounded structure located at about 200 km offshore Rio de Janeiro at water depths of > 2000 m.

Method and/or Theory

For this study, a high-quality seismic database comprising Ocean Bottom Nodes (OBN) full-stack and angle-stack volumes was available, in addition to 3 (three) wells drilled at the reservoir interval. Seismic data quality check and conditioning to mitigate seismic artifacts, such as random noise, seismic multiples, and amplitude or phase distortions was the first step of this workflow, followed by the generation of seismic attributes to aid in the interpretation of 5 (five) key seismic reflections and a number of faults of regional expression in the pre-salt interval. A model-based constrained sparse spike inversion was performed for an area of approximately 200 km2, resulting in P- and S-impedance seismic volumes. In parallel, four petroelastic facies, namely shaly, high porosity, medium porosity, and closed/tight carbonates, were estimated considering the P-impedance, S-impedance, Vp/Vs, and effective porosity well log curves. The outputs of seismic inversion were integrated with the petroelastic facies through Bayesian facies classification to assess the lateral and vertical distribution of these rock facies.

Results and Conclusions

The most probable facies volume indicates the predominance of tight/closed carbonates at the top of the mounded features in the study area, followed by medium porosity carbonates at the base of mounds. High porosity carbonates predominate at the lower portion of this interval, defined by the top of Barra Velha Fm. and the Intra-Alagoas Unconformity. More porous carbonates are located in the southern portion of the study area and at the hanging wall of the main NE-SW-trending faults that delimit the mounds. Interestingly, the occurrence of shaly carbonates is restricted to the northwest of the study area, indicating the absence of relevant stratigraphic barriers to the flow of hydrocarbons. Below the Intra-Alagoas Unconformity horizon, there seems to be a predominance of tight/closed carbonates. The findings of this research suggest that the carbonate mounds, are thick porous accumulations in the reservoir interval, but quite heterogeneous spatially in the study area. While the results from seismic inversion and the probabilistic classification of facies are robust for an initial assessment of the reservoir, it is paramount to also take into account other factors that may impact the quality of this pre-salt reservoir. Understanding the depositional and structural controls that gave rise to these mounds is an essential follow-up for a thorough and assertive characterization of highly heterogeneous carbonate reservoirs.