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Structural Characterization and Geological Modeling of the Pitu Field Using a Gridless Approach

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Introduction

The discovery of Pitu Field, in the Potiguar Basin, marks the first confirmed hydrocarbon occurrence in the region's deep waters, with reservoirs hosted in the Upper to Middle Aptian section of the Alagamar Formation (Upanema Member). These reservoirs are composed of fine to very fine sandstones interbedded with shales and siltstones, deposited within a transitional rift-drift tectonic setting. The gradual shift from continental to marine environments, driven by thermal subsidence and tectonic stability, controlled the deposition of the Upanema Member in a fluvio-deltaic setting. The Pitu Field comprises a mixed petroleum system, making it a strategic target for hydrocarbon exploration and research in the Potiguar Basin.

Method

This study aims to conduct the geological and structural characterization of a selected area within the Pitu Field through the construction of a facies model using the gridless approach. To achieve this, 3D seismic data, attribute maps, interpreted horizons, and well data from three boreholes — including lithological descriptions and composite logs — were integrated. Structural interpretation focused on seismic attributes to enhance fault detection, enabling a semi-automatic extraction of faults and improving understanding of reservoir compartmentalization and potential hydrocarbon migration pathways. The structural framework was built by incorporating 46 mapped fault surfaces and 4 interpreted horizons, which defined three stratigraphic compartments outlining the extent of the reservoir within the area of interest. Geological modeling was carried out using the gridless approach, which removes the need for a predefined grid and enables modeling at the original data resolution. Facies property propagation was performed using two different approaches: one model calibrated with a conventional pre-stack depth migration (PSDM) seismic volume, and another based on a volume derived from seismic inversion. The objective is to evaluate potential improvements in stratigraphic fidelity and spatial representation of facies between the two models.

Results and Conclusions

The structural framework revealed a dominant WNW–ESE fault system, associated with subordinate NW–SE and NNW–SSE faults arranged in a rhombohedral pattern. Gridless modeling improved the detection of thin layers with reservoir potential by preserving heterogeneity and reducing scenario generation time. The model calibrated with the PSDM seismic volume identified three main intervals: (i) A heterogeneous reservoir in a cyclic depositional setting (e.g., delta front, distal turbidite, stratified lake) with frequent laminite layers lead to vertical compartmentalization; (ii) A more transitional and heterogeneous interval, marked by reduced fine sandstone content and increased sealing/transitional facies, likely reflecting a distal turbiditic or lacustrine setting influenced by suspension-dominated, cyclic deposition; (iii) An interval characterized by intermediate facies in a low-energy, distal setting with episodic higher-energy events. Rhythmic layering and the balanced occurrence of laminite and muddy sandstone indicate strong vertical heterogeneity, likely related to distal turbidites, deltaic transitions, or reworked shallow marine deposits. As a future step, a comparative analysis of the two generated models will be conducted to quantify the impact of seismic inversion calibration on the accuracy of the geological model, with the potential to enhance facies characterization and vertical resolution. Additionally, this work aims to emphasize the importance of structural modeling and gridless techniques in representing heterogeneities, particularly in complex depositional systems such as the fluvio-deltaic environment of the Upanema Member in the Potiguar Basin.