Growth and displacement analysis of faults in the pre-salt interval of the Tupi Field, Santos Basin

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Abstract

The study of fault growth and displacement is essential for understanding the techno-stratigraphic evolution of sedimentary basins and the structural geometry of petroleum reservoirs. This study specifically focused on calculating displacement for a fault within the pre-salt interval in the southwestern region of the Tupi Field in the Santos Basin. The identification of seismic reflector continuities and terminations along the study volume's inlines and crosslines was utilized to interpret the horizons. Discontinuities characterized by structural attributes such as Gradient Magnitude, Directional Blending, 3D Edge Enhancement, and Structural Smoothing were manually recognized to determine the faults. Displacement analysis was conducted using Displacement-Length (D-x) and Throw-Depth (T-z) diagrams. The study resulted in the identification of five horizons corresponding to the geological formations: Camboriú, Itapema, and production intervals within the Barra Velha Formation (BVE-300, BVE-200, and BVE-100). Additionally, 18 high-angle faults with an NW-SE direction were interpreted. Among these interpreted faults, the one with the largest vertical and horizontal dimensions was qualitatively selected for displacement analysis. Thus, the fault located in the central portion of the study area, measuring 1250 meters vertically and 1300 meters horizontally, was chosen. Using the D-x analysis, five diagrams were generated by intersecting the fault with each interpreted horizon. The maximum displacement (Dmax) of 868.05 meters was observed in the Camboriú Formation horizon, while the smallest Dmax of 3.42 meters was found in the BVE-100. The throw distribution was assessed using a T-z diagram, revealing a maximum throw of 730.00 meters associated with the Camboriú Formation horizon. Segments in the curves of the D-x and T-z diagrams indicated fault reactivation. Notably, the Camboriú Formation horizon did not display any segmentation, whereas the other horizons exhibited segmentations in their D-x curves, indicating a polycyclic growth history of the fault. The highest throw value in the T-z diagram corresponded to fault nucleation, suggesting that the analyzed fault originated during the Lower Cretaceous period. Furthermore, the T-z plot showed a decrease in throw with depth within the fault, indicating a sharp reduction in fault propagation after the rifting phase of the basin's evolution. Additionally, the fault played a significant role in influencing the geometry and thickness of the petroleum system by dividing two blocks and causing thicker geological layers in the area adjacent to the fault.

Keywords: fault displacement, pre-salt interval, growth analysis, sedimentary basins, petroleum reservoirs.