3D SEISMIC GEOMETRIC CHARACTERIZATION OF IGNEOUS SILLS IN SOUTHERN CAMPOS BASIN, SE BRAZIL

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ABSTRACT: The study of igneous intrusions, widespread in sedimentary basins, is important to evaluate their impact on petroleum systems, preventing negative exploration outcomes. In particular, sills are associated with the thermal maturation, migration, accumulation, and therefore the entrapment of hydrocarbons, due to their complex geometries. In this study, we provide a characterization of geometries and morphometric parameters of sills. Based on a 183-km^2 3D seismic survey and well log data from 8 wells, in the southern part of Campos Basin, offshore Brazil, we identified sills by interpreting and mapping: (1) high-amplitude events, (2) local sheet transgressions, (3) saucer-shapes, and (4) blunt terminations. We distinguished sills in different types using quantitative morphometric analysis of: (1) area, (2) long and short axis length, (3) long axis azimuth, (4) height, (5) depth, (6) flat sections dip, (7) inclined segments dip, (8) mean dip orientation, and (9) eccentricity. A set of seismic attributes helped to characterize the seismic expression of sills: (1) root-mean-square amplitude, (2) variance, (3) dip and azimuth, and (4) spectral decomposition and RGB color blending. We also used the vertical amplitude gradient difference, derived by the QR factorization gradient technique. High-amplitude anomalies, with a tuning frequency of *c.* 20 Hz, characterize the interpreted sills. The distribution of major faults was obtained co-rendering (1) background dip-steering cube, (2) maximum curvature, and (3) differential resolution similarity. In well log analysis for lithofacies and sills classification, we used Self-Organizing Maps (SOM), followed by K-means clustering method (SOM/K-means). A positive correlation was found between the density and sonic well logs for igneous lithofacies, characterizing high acoustic impedance layers. In addition, decreases in gamma ray go along with density increases and sonic decreases. Based on SOM/K-means we classified three igneous and two carbonate facies. We identified fifteen sills grouped into five types: (1) saucer-shaped, (2) slightly saucer-shaped, (3) climbing saucer-shaped, (4) transgressive, and (5) layer-parallel rough. The sills, within an area of 67.35 km^2, comprise a wide range of areal extents (0.43-14.35 km^2), which increases with depth (up to 3.18 km depth), vertically extending from 0.06 to 0.23 km and varying from low (1.82-3.31°) to high dips (6.05-15.74°). High area-to-depth ratios reflect favorable conditions to form transgressive and layer-parallel sills. The high eccentricity values (0.71-0.97) of saucer-shaped sills cannot corroborate the approximately circular plan-view morphology suggested by the 1.46 long-to-short axis ratio. Conversely, the slightly saucer-shaped sill long-to-short axis ratio (1.86) suggests a moderately circular shape and elliptical plan-view morphology (0.84 of eccentricity). The sills striking trends (NW, NE, NNW, and N) may be associated with the trend of main fault lineaments, as 89% of the faults are aligned NE-SW and 11% are aligned NNE-SSW, suggesting a structural control on the sills distribution due to apparent spatial correlation. Finally, the used systematic approach may reduce interpretation biases, which, in turn, allows reliable geometric characterizations. Despite the study area recording few and small-sized sills, the recognition of analogous geometries from other basins suggests that the used approach is appropriate for similar geologic contexts.

KEYWORDS: SILLS, GEOMETRY, CAMPOS BASIN.