Unsupervised Machine Learning Techniques and Multi-Attribute Analysis for Hierarchical Modeling of Deepwater Deposits: A Case Study in North Carnarvon Basin, Australia, and Comparison with Deposits in the Southwestern Deepwater GOM

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ABSTRACT

Seismic characterization of a high-resolution 3D seismic volume from offshore North Carnarvon Basin, Australia revealed a detailed stratigraphic configuration of deepwater deposits from the Cenozoic Trealla Formation. Four main groups of architectural elements are identified and measured within eight stratigraphic sequences interpreted in the studied area: (1) erosive channel-fills, (2) channel-levee complexes, (3) mass transport deposits, and (4) sand fan lobes or sheets. Each depositional element exhibits a characteristic morphology and seismic response.

Similar unconfined stratigraphic configuration is found in the southwestern deepwater GOM, offshore Mexico in deepwater strata. Falling stage systems tracts are characterized by development of small erosive channels in the upper slope, channel-levee complexes in the middle and lower slope, and sand fan lobes on the lower slope.

To characterize and map the variety of these elements within a sequence stratigraphic framework we present a workflow to map these deposits using a hierarchical modeling approach. First, we use a multi-attribute analysis to create two-dimensional maps and probability volumes to constrain the distribution of the geometry of architectural elements. Using sequential indicator simulation, the probability volumes and maps are included to obtain a reliable aerial distribution of the geometries of the architectural elements. Second, we use unsupervised machine learning techniques (Self-organized maps, K–means, and principal component analysis) to map the facies present within the architectural element geomorphologies. The resulting volumes are used to model the distribution of facies (lithologies) within the geometries previously populated in the reservoir model.

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The resulting models show a better representation of the heterogeneity and internal distribution of the facies regarding the architectural element geometry, improving the prediction of the distribution of facies and reducing the uncertainty of volumetric analysis for exploration prospects within the 3D reservoir model.