Improving the Understanding of Non-Matrix Components in a Brazilian Pre-Salt Carbonate Reservoir Using a Machine Learning Approach

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Abstract

The triple porosity/ permeability system in carbonate reservoirs, plays an essential role in controlling fluid storage and flow dynamics. Matrix porosity is typically small and homogeneously distributed, while non-matrix porosity is related to post-depositional process and often results in excess permeability that significantly impacts reservoir performance. In the pre-salt carbonate reservoirs of the Barra Velha Formation (BVE) in the Santos Basin, non-matrix porosity is a key driver of enhanced production. Consequently, numerous studies have been conducted to understand the occurrence and relationships of these features within the reservoirs, revealing a correlation between non-matrix porosity, silicified intervals, and fractured zones.

To improve the knowledge on the distribution and magnitude of the vuggy areas away from the boreholes, this work applies a machine learning approach into 3D seismic interpretation using multi-attribute analysis, by establishing a mathematical relationship between the seismic data and vuggy porosity through the application of a Multiattribute Analysis in a dataset composed of a PSDM seismic volume and wells with conventional and special logs, including vuggy porosity, and Dry Weight Silicon (DWSI) logs. Once a transform is found and validated, through the quantification of the final prediction error, we produce a seismic volume whose Z value is the predicted property at the target interval, which is then correlated with production rates and silica content.

Illumination differences, seismic resolution, and presence of coherent noise in the pre-salt section of the seismic volume are the main factors that challenge the application of this quantitative interpretation workflow. To address this, we have established low, middle, and high confidence zones in the seismic data and incorporated them into result evaluation. Finally, this study provides a more accurate understanding of the spatial distribution and magnitude of non-matrix porosity, enhancing reservoir characterization and offering valuable insights into production optimization and geological modeling in the BVE.