Impact of Silicification on the Pore System of Pre-Salt Lacustrine Carbonates

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Abstract

Carbonate reservoirs are characterized by highly heterogeneous pore systems that span multiple scales, from microscopic pores to field-scale features. Post-depositional alterations associated with fluid interactions, such as hydrothermal alterations, metasomatism, and dissolution, play a significant role in controlling porosity in carbonate reservoirs, which are known for their dual porosity, associated with both matrix and non-matrix porosity.

In the pre-salt carbonate reservoirs of the Barra Velha Formation, silicified intervals significantly impact reservoir properties. Recent studies suggest that silica is closely associated with non-matrix porosity features, such as vugs, gigapores, and fractures, which can contribute to zones of high permeability. Silica may occur as a replacement phase or as pore-filling cement, drastically altering the reservoir's flow properties. These intervals, however, challenge traditional petrophysical evaluations, as routine core analyses (RCA) and nuclear magnetic resonance (NMR) often fail to adequately capture the connectivity and flow characteristics of these non-matrix features.

This study investigates the relationship between pore types and the occurrence of silica in lacustrine carbonates of the pre-salt Barra Velha Formation, located in the Santos Basin. Using Digital Rock Analysis (DRA) techniques, including computed tomography (CT), integrated with petrography and descriptive core analysis, we evaluate pore types and their relationship with silicified intervals.

The multiscale classification of pore types included thin sections, micro-CT, and CT scans at the core scale, enabling the identification of the diversity and distribution of pore systems across different scales. This is an ongoing study aimed at better understanding how silica affects the petrophysical properties of the reservoir, focusing on fundamental characteristics such as porosity and pore connectivity, and comparing these features with borehole image data.

Multiscale integration is essential for accurately characterizing carbonate reservoirs and their flow units. By exploring the relationship between pore types, silicification, and dissolution features, this study provides valuable insights into the geological and petrophysical heterogeneities that govern reservoir behavior. The expected results aim to enhance the understanding of diagenetic processes and their implications for reservoir modeling and simulation, contributing to the advancement of exploration and production strategies in pre-salt carbonate systems.