AAPG

6th Edition
AAPG Siliciclastic Reservoirs of the Middle East GTW
1-3 December 2025 | Kuwait City, Kuwait

Unraveling Clastic Reservoir Heterogeneities: Characterizing Depositional Environments and Reservoir Quality Through Advanced Sedimentological and Petrographic Techniques

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Abstract

This study aims to investigate clastic reservoirs behavior via lithofacies analysis and develop depositional models incorporating various data types and scales. In order to gain a better understanding of reservoir rock qualities on both vertical and lateral scales, this study utilizes AI applications to characterize subsurface core and petrographic data, and innovatively integrate results with modern analogues in order to build a conceptual model that explains the depositional setting and reservoir unit distribution.

The dataset comprised subsurface conventional core data meticulously collected from multiple wells across the targeted zone. Detailed analyses focused on lithology, sedimentary textures, and structural features. Sedimentological analysis identified five facies associations: dune, sand sheet, interdune, playa lake, and paleosol. This was followed by a petrographic study for representative petrographic thin section samples that account for facies variations. Additionally, Scanning Electron Microscope (SEM) images were utilized to identify the cementation and clay minerals present in the various recognized lithofacies.

The sedimentological analysis concluded that the upper part of the studied succession was deposited in an arid to semi-arid environment, likely a wind-dominated aeolian environment, with strong evidence of a water table-controlled system. The results of petrography and SEM analysis using the latest technology contribute to the understanding of reservoir heterogeneity and reservoir quality. It showed that illite, kaolinite, and quartz overgrowth were the main pore fillings that reduced the reservoir quality in the area of investigation, which is another indication for a water table-controlled system. It is self-evident that a better understanding of sedimentological depositional settings and analogs leads to better inputs for geological models and a more accurate assessment of prospects in hydrocarbon exploration.

The employed methodology consists of a series of systematic tasks, including the comprehensive collection and examination of sedimentological and stratigraphic data, from core and depositional system interpretation to digital petrographical analysis of rock. The integration of data provides an improved understanding of reservoir heterogeneity, complementing and validating reservoir divisions. The novel application of modern analogues in this study facilitates a more thorough understanding of the evolution of precise depositional models that account for all data scales.