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Decoding Reservoir Complexity: Facies Architecture and Sedimentological Insights into Reservoir Quality in Mixed Aeolian–Fluvial Systems

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Abstract

This study presents an integrated sedimentological and reservoir quality assessment of a siliciclastic system shaped by the complex interplay between aeolian and fluvial depositional environments. Detailed core descriptions from several cored wells and image logs interpretation were used to define lithofacies, which were subsequently grouped into seven facies associations. This classification was based not only on sedimentological features but also on porosity and permeability relationships, ensuring that facies grouping is reflecting reservoir performance accurately.

A refined conceptual depositional model was developed to capture the spatial and temporal transitions between aeolian dune, interdune, and fluvial channel fill and overbank deposits. These depositional changes were identified as primary controls on reservoir heterogeneity and quality. Diagenetic influences were systematically evaluated through petrographic, SEM, and XRD analyses of over 50 thin sections, 30 SEM samples, and 60 clay-fraction XRD samples. The key porosity-reducing processes identified included: mechanical compaction, silica cementation via quartz overgrowth, and pore-filling clay cements. In contrast, the presence of early-formed clay coatings was found to inhibit quartz overgrowth, thereby preserving primary porosity.

A paragenetic sequence was constructed to illustrate the relative timing and impact of diagenetic events on reservoir evolution. The integration of palynological data enabled the establishment of a chronostratigraphic framework, which improved the stratigraphic correlation across the field. Furthermore, advanced XRD techniques allowed the discrimination between depositional and diagenetic origins of clay minerals, providing additional resolution to the diagenetic model.

This multidisciplinary approach offers a robust workflow for linking depositional facies and diagenetic processes to reservoir quality prediction in mixed aeolian–fluvial systems, with significant implications for optimizing development strategies in similar siliciclastic reservoirs.