Facies Analysis and Reservoir Quality of the Early Ordovician Braided Deposits of Saudi Arabia, Outcrop Approach

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Abstract

Reservoir quality within braided fluvial deposits is subject to considerable variability, influenced by diverse geological factors and sedimentological characteristics. Braided fluvial systems possess the capacity to transport and deposit substantial sediment loads, resulting in the formation of porous and permeable deposits with potential reservoir characteristics. In Saudi Arabia, the Ordovician Risha Member of the Saq Formation stands as a noteworthy reservoir characterized by pronounced heterogeneity across various scales, exerting a profound influence on critical reservoir properties and overall quality. A thorough evaluation of the reservoir quality of braided fluvial deposits demands a comprehensive and multi-disciplinary approach, integrating geological, petrophysical, and chemical data. This study focuses on a central Saudi Arabian outcrop analog of the Risha Member, where detailed descriptions and samples were systematically collected at 50 cm intervals from two vertical and one horizontal sections. Methodologies encompassed porosity and permeability measurements derived from plugs, petrographic assessments from thin sections, and quantitative mineralogical and elemental analyses through QEMSCAN. The examined outcrop, comprising 38 m of amalgamated sand bodies occasionally interspersed with thin mudstone layers, revealed six lithofacies types interpreted as deposits from a mature braided fluvial system. The Risha Member is distinguished by the presence of stacked cross-bedded sand bodies exhibiting lateral amalgamation, interspersed with minor occurrences of mudstones. This lithological composition is indicative of high-energy braided stream environments. Paleocurrent measurements indicated a depositional trend dipping toward the ENE direction. The primary channel exhibited a total width of approximately 1000 m, featuring a complex amalgamation of sub-channels with varying widths between 5 and 10 m. Porosity values ranged from 8% to 32%, with an average of 21%, while permeability exhibited significant variability, ranging from 0.1 to 5400 mD, with an average of 996 mD. This extensive permeability range is attributed to geological factors influencing pore space connectivity and size within the rock, thereby influencing fluid flow characteristics within the reservoir. The outcomes of this study furnish critical geological data, both quantitative and qualitative, substantially advancing the comprehension of subsurface Saq reservoirs. Consequently, this heightened understanding contributes to more precise geological modeling and facilitates fluid flow simulations for these reservoirs.