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Tight Reservoir Potential of the Early Eocene Bou Dabbous Formation in Northwestern Tunisia

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Early Eocene limestones in Tunisia exhibit notable variations in facies and thickness, indicative of a depositional environment primarily within a platform setting. Most planktonic-rich microfacies are deposited in slope-basin areas conducive to preserving organic matter. This study focuses on the Bou Dabbous Formation, a known source-rock explored in various wells across Tunisia. It aims to evaluate its potential as a tight reservoir through a comprehensive analysis of core samples from two outcrop analogs: Oued Kasseb (OK) and Ragoubet Tassera (TS) sections in northwestern Tunisia.

Rock-Eval pyrolysis of 42 samples revealed variable organic richness, with higher Total Organic Carbon (TOC) in the OK section (max TOC = 2.75 wt.%) compared to the TS section (max TOC = 1.11 wt.%). Tmax values ranged from 433°C to 454°C, indicating a predominantly mature to marginally mature stage of hydrocarbon generation. Hydrogen Index (HI) values classified the organic matter primarily as Type II, with some Type II/III, suggesting a planktonic marine origin under anoxic to suboxic conditions.

Inorganic analysis, including XRF and XRD analyses, showed significant lithological variations between massive limestone and marly limestone layers. Major oxides such as MgO and SiO₂ varied notably, with silica-rich layers prominent in the TS section and magnesian limestones in the OK section. Trace elements like Sr and S highlighted diagenetic processes and variations in paleoclimate, suggesting semi-humid conditions during deposition. The presence of pyrite, influenced by anoxic conditions and diagenesis, further supports these findings. The complex diagenetic processes affecting the Bou Dabbous limestones impact their petrophysical properties, including fractures, silicification, and cementation.

The region's significant tectonic activity has resulted in a complex fracture network, as observed in field studies and thin-section analyses. These fractures, partially filled with calcite and asphaltene, are attributed to compaction and tectonic stresses. Stylolites, formed by chemical compaction and bitumen-filled fractures, indicate the circulation of acidic solutions related to petroleum generation processes. These processes altered the primary pore system by either enhancing reservoir properties (such as fracturing and oxidation) or reducing and destroying porosity through cementation, mechanical and chemical compaction, and the precipitation of asphaltene, phosphate, and pyrite. This emphasizes the complexity of diagenetic controls on the porosity

evolution. The brittleness index (BI) for the Bou Dabbous Formation, determined based on carbonate fractions, detrital content, and TOC percentages, was high, ranging from 0.84 to 0.98. This suggests a high fracturing sensitivity among the studied area's rocks.

Overall, the findings indicate that the Bou Dabbous limestones have potential as a tight reservoir with favorable conditions for unconventional hydrocarbon exploration, influenced by its significant organic content, mature hydrocarbon generation, and brittleness characteristics. These results underscore the formation's importance in regional petroleum exploration and development. Further investigations should be conducted on borehole cuttings, along with rigorous fracturing simulations, to realistically evaluate the potential of the Bou Dabbous Formation in Tunisia as an unconventional hydrocarbon reservoir within the explored petroleum system.