Microfacies Analysis, Diagenesis and Chemostratigraphy of the Early Cretaceous Habshan Carbonate Formation in Jabal Akhdar, Northern Oman: Insights into Reservoir Characterization

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Abstract

This study presents a detailed analysis of the Lower Cretaceous carbonate Habshan Formation in Wadi Muaiden, in Jabal Akhdar, Northern Oman. The analysis encompasses a detailed examination of microfacies, depositional environment, diagenetic alterations, reservoir quality, and chemostratigraphy. The exposed Habshan Formation was meticulously measured and logged based on depositional dip, lithology, bed thickness, fossil content, bed continuity, and nature of bed contact. Eighty-three whole rock samples were systematically collected at intervals of fifty centimetres from different lithofacies and subjected to portable X-ray diffraction analysis. In addition, a total of 49 thin sections underwent preparation and examination. Compositional models were established through the enumeration of 300 points in each thin section. This method served to elucidate the texture, fossil assemblages, and fabric of primary constituents, as well as to identify any diagenetic alterations. Furthermore, eight whole rock slides were directly subjected to scanning electron microscopy (SEM) techniques to discern high-resolution pore geometry. Eight selected thin sections underwent Energy Dispersive X-ray Spectroscopy (EDS) analysis for further geochemical examination to determine the chemical composition of specific parts within the thin section and to establish cement mineralogy. The findings of integrated sedimentology, petrography, and geochemical investigation indicated a variety of microfacies and diagenetic processes that had significant effects on reservoir quality. A total of seventeen microfacies types were clearly identified and classified into five facies associations, ranging from the inner to the outer ramp. lagoon, backshoal, shoal, foreshoal, and offshoal. The Habshan Formation is represented as a prograding succession of shallowing upward facies, primarily comprised of oolitic packstones to grainstones with some bioclasts deposited in a shallow marine environment. The diagenetic alterations that were observed in the exposed formation include micritization, calcite cementation, fracturing, compaction, and minor pyritization and silicification. Diagenetic modifications such as cementation of calcite micritization, and chemical and physical compaction are the main factors leading to reduced porosity, while processes such as dissolution, open fractures, vugs, and interparticle contribute to improved porosity. Additionally, elemental chemostratigraphy integrated with microfacies analysis was employed to establish a sequence stratigraphic interpretation of the Habshan Formation, particularly emphasizing the establishment of the sea level curve. Aluminium, silicon, potassium, and uranium were utilized as elemental proxies to delineate the transgressive system tract (TST), highstand system tract (HST), and maximum flooding surfaces (MFS). This study offers a comprehensive understanding of the Habshan Formation in Wadi Muaiden in Northern Oman, providing valuable insights into its microfacies, depositional environments, diagenetic alterations, and elemental chemostratigraphy framework. The findings could offer valuable insights into the oolitic shoal systems in the Oman and might contribute to the global knowledge of oolitic shoal shallow marine carbonates.