

# **Diagenetic Overprints and Diagenetic Facies of a Middle Eastern Carbonate Reservoir**

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## **Abstract**

The Permo-Triassic carbonate reservoir of the study area consists of shallow marine carbonates and evaporites. The reservoir is known for its heterogeneity and complex pore system. This study aims to integrate petrography, geochemistry, and core characterization to contribute to the overall understanding of this unit by defining diagenetic overprints and diagenetic facies architecture to better characterize interwell heterogeneity. This study utilizes two methods: (1) petrographic characterization of stained thin sections, taken from cored wells across the study area, to identify diagenetic overprints; (2) geochemical analysis of 93 carbon-oxygen isotopes to assess origin and timing of the diagenetic overprints. Results of the two methods were integrated with wireline logs and legacy core descriptions to identify and map diagenetic facies. Petrographic characterization revealed a total of 16 porosity-modifying diagenetic processes that vary in intensity and impact on reservoir quality of all depositional facies. The main processes are replacive dolomitization, calcite cementation, dissolution, anhydrite cementation, dolomite cementation and compaction. The late-stage diagenetic processes (i.e., anhydrite, calcite, and dolomite cements) diminish reservoir quality, whereas the late patchy anhydrite cement may positively impact the reservoir flow. Geochemical analysis shows enriched values for tight overdolomitized rocks, which indicate evaporitic settings. The limy tight mudstone and grainstone show depleted carbon-oxygen isotopic ratios, which mean less restricted settings. The carbon-oxygen isotopes suggest a contemporaneous marine origin of the studied carbonates. The common pore types include interparticle, intercrystalline, moldic, microporosity, and fracture, while vuggy and within particle pore types are rare. Most diagenetic pore types resulted from dissolution, replacive dolomitization, and fracturing. Petrographic characterization provided the basis to identify seven diagenetic facies based on three main criteria: porosity, texture, and lithology. The seven diagenetic facies include: (1) tight dolomitized mud-supported (TDM); (2) porous dolomitized mud-supported (PDM); (3) tight limy mud-supported (TLM); (4) tight dolomitized grain-supported (TDG); (5) porous dolomitized grain-supported (PDG); (6) tight limy grain-supported (TLG); (7) porous limy grain-supported (PLG). A diagenetic facies can be a subdivision of a single depositional facies or an amalgamation of different depositional facies; diagenetic facies are easier to map. This study represents the first attempt to identify and time diagenetic overprints with a novel method to identify and classify diagenetic facies of the reservoir. The methodology of this study can be applied to different carbonate reservoirs to improve static and simulation models.