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The complexity of carbonate porosity distribution in the Upper Marrat Formation, Central Saudi Arabia

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In terms of reservoir properties distribution carbonate rocks are very heterogeneous. Moreover, the types of porosity in carbonate rocks is very diverse. In our study of the Upper Marrat Formation near Khasm-adh-Dhibi (central Saudi Arabia) we have documented the pore system complexity and are deconvolving the impact of various post-depositional processes on porosity and permeability evolution of the formation. The Upper Marrat Formation is exposed in the central part of the Arabian plate in a north-south elongated mountain belt. It forms the lower part of the thick Jurassic petroleum-rich succession. The sediments forming the Upper Marrat Formation were deposited during the Early Jurassic time, the Toarcian. The Upper Marrat Formation shows fossiliferous biomicrite to sparse biomicrite carbonates with an evaporite deposit at the top. It is bounded by clayey units at both the top and the base. In general, because of the muddy matrix of the Upper Marrat, sediments are very tight and show low permeability. During the last 175 My, the Upper Marrat has been subjected to a series of diagenetic and tectonic processes. The initial micro- and intergranular porosity was reduced due to early compaction and cementation, however, during later diagenesis and tectonism, porosity and permeability were enhanced. The dominant diagenetic porosity in the Upper Marrat sediments is vuggy porosity, followed by fabric selective intragranular porosity. Many of the horizons in the Upper Marrat are heavily burrowed and mostly filled with sand-sized grains showing a higher porosity than the matrix. Dolomite is limited to evaporite strata and contain extensive inter-crystalline porosity produced during dolomite formation. Tectonism has enhanced porosity through the development of micro- and macro-fractures. The different sized and orientated micro-fractures are important while they enhance permeability by connecting different pore types. Then extensive macro-fracture network has a major impact on the reservoir qualities, both porosity and permeability. The heavily fractured formation shows numerous fractures sets with NNE to SSW and ENE to WNW orientations. Fractures are mostly vertical to near-vertical; they are nearly all open, and often crosscut beds, or end at bedding planes. These fractures are the most abundant porosity type and their connectivity results in a very high permeability. In conclusion, initial porosity and permeability, and subsequent diagenetic and tectonic processes reduced and enhanced the porosity and permeability development of the sediments of the Early Jurassic Upper Marrat Formation.