Unveiling Diagenetic Evolution and Reservoir Characterization of Kingriali Formation, Paniala Section, Khisor Range Pakistan

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The dolomite from 105m-thick Kingriali Formation in the Paniala section, Khisor Range was sampled, and 48 representative samples were randomly collected. Current petrographic observations and geochemical analysis indicate that the most prevalent dolomitization process in the formation involves the replacement of limestone with dolomite. This implication is supported by matrix-selective dolomitization, overgrowth of crystal leading to overdolomitization, cementation of dolomite, mold and vug development, the existence of calcium sulfate cement, two distinct dolomite populations, and the formation of saddle dolomite. Three primary stages of the dolomitization process are depicted in the study leading to the formation of a densely packed low porosity replacive dolomite. Finally, neomorphism modifies this phase into RD-II replacement dolomite during progressive dolomitization. The petrographic observations are zipped into eight distinct microfacies. Stable isotope analysis ($\delta^{13}C$ and $\delta^{18}O$) of selective samples from each microfacies was carried out to support petrographic and geochemical data for decoding the origin of dolomite and the nature of dolomitizing fluids. The isotopic analysis of $\delta^{13}C$ and $\delta^{18}O$ in samples MKD-2, MKD-5, and MKD-6 shows a decrease in $\delta^{13}C$ and an increase in $\delta^{18}O$ values, indicating dolomitization influenced by slightly warmer basinal brines and meteoric water. Conversely, MKD-1, MKD-4, and MKD-8 show consistent marine signatures in their isotopic ranges. It suggests that during the late Permian to middle Triassic interval,

seawater-derived brines with high levels of Fe, Mg, and radiogenic strontium were heated as they followed through clastic sediments. This process likely played a role in replacing the precursor limestone in the Kingriali Formation. Also, meteoric water is key in modifying dolomitization phases and inducing dissolution processes. Petrophysical analysis reveals significantly high porosity and permeability values, which are believed to result from various modifications of shallow marine limestone into current dolostone. The formation of molds and vugs can be attributed to several processes, including the breakdown of calcite at shallow depths, the replacement of unstable carbonate minerals on a mole-for- mole basis, and fractures resulting from active tectonics and burial compaction. Investigating the reservoir properties, we find that the 3D porosity spans a range of 8.62% to 16.73%, while the 2D porosity varies from 2.16% to 30.37%. The values of air permeability range from 0.064 to 30mD, and the liquid permeability exhibits values within the range of 0.037 to 27.2mD. These distinctive characteristics closely resemble those of a promising hydrocarbon reservoir.