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Massive dolomite on the Upper Jurassic to Lower Cretaceous Carbonate Shelf, Northeastern Saudi Arabia: Insights from Reactive Transport Modeling

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ABSTRACT

Recent regional mapping has shown that massive, stratigraphically discordant dolomite occurs within the Upper Jurassic to Lower Cretaceous intervals in the Jaladi area, northeastern Saudi Arabia. Petrographic and geochemical analyses indicate the dolomitization is complicated with a wide range of associated diagenetic processes including precipitation of calcite, fluorite, and kaolinite, silicification, dedolomitization, and emplacement of pyrobitumen-hydrocarbon. Previous studies proposed two dolomite formation mechanisms: (1) during burial, lateral migration of compaction-induced magnesium-rich brines from the Gotnia basin in the North, and/or; (2) migration of hot fluids upward along fractures/faults sourced from sub-Jurassic stratigraphic systems. In this study, an additional hypothesis of regional-scale seepage reflux dolomitization has been proposed. Reactive Transport Modeling (RTM) has been conducted to test the feasibility of these three hypotheses and reconstruct the diagenetic history. The modeling results indicate that (1) in order for hot fluids to cause massive dolomitization, intensive fractures/faults conduits might have to be available to allow hot fluids repetitively to inject into the system; (2) compaction is a likely mechanism for the large scale dolomitization; (3) massive, stratigraphically discordant dolomite bodies could be formed from brine reflux, shortly after sedimentation. However, none of the three mechanisms can entirely explain the complicated diagenetic history alone. A combination of two/three processes may be required, i.e., reflux and/or compaction-driven dolomitization accounts for early dolomite and late stage hydrothermal dolomitization overprints the existing dolomite in the vicinity of fracture systems. RTM also predicted some of associated diagenetic processes. Results of this study will enhance the understanding of the dolomitization mechanism and associated diagenetic processes and may provide new insights on exploration strategies for extensively dolomitized carbonate platforms.