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Paleofluid flow and hydrothermal dolomitization: petrographic and geochemical evidence from foreland vs. intracratonic sedimentary basins

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Diagenetic fluids in sedimentary basins form under diverse tectonic (e.g., foreland versus intracratonic) and sedimentologic settings. These fluids impose a major control on reservoir-quality evolution of carbonate successions whereby diagenetic modifications, such as dolomitization occur in several geochemical zones. Specific diagenetic mineral assemblages with largely well-defined isotopic and trace elemental compositions characterize each of these zones.

In the Western Canada Sedimentary Basin, petrographic and isotopic evidence from both the Devonian and Mississippian matrix and fracture-filling dolomites indicate the presence of a hydrothermal fluid source. This evidence suggests two different hydrothermal episodes related to early (Antler) and late (Laramide) tectonic events with possible compartmentalization of hydrothermal systems and their associated brines in the basin. In the Devonian system, the fracture-fill saddle dolomite is characterized by highly negative $\delta^{18}O$ isotopic values combined with enriched $^{87}Sr/^{86}Sr$ isotopic ratios and higher homogenization temperatures and salinity values, show significant differences from the Mississippian saddle dolomite, which is characterized by less negative $\delta^{18}O$ isotopic values, less radiogenic $^{87}Sr/^{86}Sr$ isotopic ratios, and lower homogenization temperatures (T_h) and salinity values of fluid inclusions.

In comparison, data from intracratonic Michigan Basin show that Cambrian to Devonian carbonates have experienced multiple fluid events with compartmentalization of diagenetic fluid systems characterized by an earlier fluid system for Cambrian dolomite that shows a pronounced negative shift in oxygen and carbon isotopic composition, more radiogenic Sr ratios, warm and saline signatures, higher average ∑REE compared to warm water marine brachiopods, negative La anomaly, and positive Ce anomaly; and a later Ordovician system, characterized by less negative shifts in oxygen and carbon isotopes, comparable T_h, hypersaline, a less radiogenic, less negative La anomaly, and primarily positive Ce anomaly but also higher average ∑REE compared to warm water marine brachiopods. In contrast, the isotopic and geochemical data of the overlying Silurian and Devonian carbonates show evidence of dolomite recrystallization of earlier formed matrix dolomite by hydrothermal fluids that also resulted in the formation of saddle dolomite with high T_h and salinity, which suggest the involvement of localized fluxes of hydrothermal fluids during its formation during Paleozoic orogenesis. Geochemical proxies also suggest that the diagenetic fluids were originally of coeval seawater composition, subsequently modified via water-rock interaction possibly related to brines, which were modified by the dissolution of Silurian evaporites from the Salina series.