Isotopic geochemistry of Ordovician Yeomen Dolomite Reservoirs: Implication for Process of Dolomitization and Diagenetic Modification of Dolomites

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ABSTRACT

The discovery of prolific Ordovician Red River reservoirs in 1995 in southeastern Saskatchewan was the catalyst for extensive exploration activity which resulted in the discovery of more than 15 new Red River pools. The best yields of Ordovician Red River production to date have been from dolomite reservoirs indicating that dolomitization has played a major role in forming reservoir quality porosity. Understanding the processes of dolomitization, including sources of dolomitizing fluids and timing of dolomitization is, therefore, crucial for the prediction of the connectivity, spatial distribution and heterogeneity of dolomite reservoirs.

Dolomitization patterns in Red River carbonates are complex. In the Yeoman Formation, there are dolomitized *Thalassinoides* burrows with the host matrix preserved as limestones, dolomitized *Thalassinoides* burrows as well as host matrix resulting in complete dolostones, minor saddle dolomite precipitated as cement in vugs and fractures, and limestone sections where both (*Thalassinoides*) burrows and host matrix escaped dolomitization.

$\delta^{18}O$ and $\delta^{13}C$ and $^{87}Sr/^{86}Sr$ were measured from samples collected from well 3-8-1-11W2 in the subsurface of southeast Saskatchewan. This well was selected for the investigation because its Red River cores contain a complete suite of diagenetic products, including saddle dolomite cements, one of the primary targets for this study.

The $\delta^{18}O$ values of dolomited *Thalassinoides* burrow infills (–5.9 to –7.8 ‰, PDB) are lower than the estimated $\delta^{18}O$ values of dolomites precipitated from normal late Ordovician seawater (-3.5 to -1.5 ‰, PDB); and the $^{87}Sr/^{86}Sr$ ratios (0.7084 to 0.7088; avg. 0.7086) are much higher compared to the expected values of late Ordovician seawater dolomites (0.7078 to 0.7080). If these borrow infills are the

products of early dolomitization by Late Ordovician seawater, their original isotopic signatures must have been modified or reset by later diagenetic fluids during burial.

The $\delta^{18}O$ values of matrix dolomite (-6.6 to –8.1; avg. -7.4 ‰ PDB) are lower than the estimated values for late Ordovician marine dolomite; and the $^{87}Sr/^{86}Sr$ ratios (0.7082 to 0.7087; avg. 0.7085) are higher than the expected $^{87}Sr/^{86}Sr$ ratios of late Ordovician marine dolomites. If the matrix dolomite occurred during burial, the low $\delta^{18}O$ values could due to formation of dolomite at higher temperatures during burial. The high $^{87}Sr/^{86}Sr$ ratios suggest that dolomitizing fluid were late Silurian seawater; or formation waters expelled from Winnipeg or Deadwood sediments; or hydrothermal fluids associated with “thermal convection”.

The trace amounts of saddle dolomite cement in the Red River carbonates in the Williston Basin are probably due to much tranquil tectonic events in this intra-cratonic basin. The low $\delta^{18}O$ value of saddle dolomites (-10.2 to -11.1 ‰ PDB) and the variable $^{87}Sr/^{86}Sr$ ratios (from 0.7082 up to 0.7097) suggest the possible influence of hydrothermal fluids in the region, or “cannibalism” of earlier replacement dolomite due to chemical compaction.