Burial Dedolomitization of the Zechstein-2-Carbonate Reservoir, North West Germany

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ABSTRACT

Dedolomitization converts a dolomite back into a calcite, and conventionally is interpreted to occur in an eogenetic or telogenetic diagenetic environment, where meteoric water dissolves evaporites to supply excess calcium. Hydrologic connectivity between a dolostone and the surface water may then lead to a dedolomitized interval, often times being a diagnostic indicator for an erosional unconformity, subaerial exposure, and/or karst. In contrast to these classic models we present a case study for pervasive burial dedolomitization, unrelated to meteoric fluids. Dedolomitization of the Zechstein-2 Carbonate (Ca2) gas reservoir in NW Germany is strongly altering reservoir quality on a regional scale. The Ca2 shows a textbook correlation between reservoir quality and mineralogy. Petrographic analyses show that around 80% of all observed calcite exhibit a dedolomite microtexture, with a reduction of average matrix porosity by 5% to 10% as a result of dedolomitization. Shallow water platform facies shows dedolomite in the form of massive to irregular- and bulbous-shaped nodules. An exceptional large amount of calcium-rich fluids must have been mobilized to account for approximately 40% of the whole Ca2 carbonate being dedolomitized. However, core fabrics related to meteoric diagenesis, such as karst fabrics or typical fresh water stable isotope signatures have neither been observed in the Ca2 nor in the over- and underlying anhydrite beds. Excess calcium needed to dedolomitize the Ca2 reservoir therefore likely comes from the anhydrites during gypsum-to-anhydrite conversion and pressure solution under shallow burial conditions. Anhydrite-after-gypsum pseudomorphs (“swallow tails”) and frequent stylolites observed in many cores strongly support these mechanisms. An influx of strontium-rich waters derived from the anhydrite beds is indicated by up to 5-times higher strontium contents measured in dedolomite nodules compared to their dolomite host rock. An early burial timing for dedolomitization is supported by compaction-related curvature of laminaes in the dolomitic host rock around dedolomite nodules and a minor shift of ~ 3 ‰ d18O and ~ 1 ‰ d13C towards lighter values in the dedolomites compared to dolomite. Early mesogenetic burial dedolomitization of the Zechstein-2 Carbonate is likely not constrained to the study area and responsible for strong porosity reduction over large parts of the Ca2 fairway across the Southern Permian Basin.