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Reservoir Quality Prediction in the Zechstein-2-Carbonate Reservoir, NW 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 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. Petrography shows that around 80% of all observed calcite exhibit a dedolomite microtexture, with a reduction of average matrix porosity by 5% to 10%. 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 sandwiching anhydrites themselves, supported by high strontium contents of the dedolomite. 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 ‰ $\delta^{18}O$ and ~ 1 ‰ $\delta^{13}C$ in the dedolomites.
Homogenization temperatures between 51 and 56 °C measured in some early fluid inclusions in dedolomite textures further exclude a pristine meteoric water input and suggest fluid entrapment in a burial depth range of 900 to 1400 m. Comparing these results with literature data furthermore indicates that mesogenetic dedolomite is either volumetrically underestimated in other carbonate-evaporite settings or that it formed under very unique diagenetic conditions across the Southern Permian Basin.
Reservoir quality-reducing dedolomite increases from platform to basin, which is explained by downdip-migrating Ca^{2+}-rich fluids and dolomite dissolution in organic-rich slope/basinal sediments. The vertical and lateral distribution patterns evaluated by this study can be used to de-risk exploration-scale projects.