Anhydrite-dissolution porosity: implications for geo-energy and gas storage in the Swiss Molasse Basin

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In the Swiss Molasse Basin (SMB), Middle Triassic dolomite rocks within the Upper Muschelkalk Aquifer are currently being investigated for geothermal energy and geological storage of gas. These dolomites locally show high matrix porosities and permeabilities ($\leq$ 25 vol.% and $\leq 10^{-13}$ m^2, respectively), which are in part due to the selective dissolution of eogenetic anhydrite nodules. However, the spatial distribution of anhydrite-dissolution pores is not well known as the basin is underexplored. The present study reconstructs the genesis and evolution of these pores, thus providing conceptual understanding to support ongoing exploration. The reconstruction is based on fluid inclusion and isotope analyses (i.e. δ^2H, $\delta^{18}O$, $\delta^{13}C$, and $^{87}Sr/^{86}Sr$) of secondary pore-filling calcite, quartz, and kaolinite.

Fluid inclusions show that the early diagenetic porewater of the dolomite was highly saline and in equilibrium with anhydrite. Subsequent influx of low-salinity water with a meteoric component diluted the original porewater and dissolved the anhydrite nodules. This mixing scenario is evidenced by trends in salinity, $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ ratios of the parent waters of secondary minerals. These trends suggest that the low-salinity water had partially equilibrated with the underlying Buntsandstein and/or the Variscan gneiss basement prior to infiltrating the Muschelkalk. Two scenarios are conceivable for the path of infiltration. The low-salinity water could have infiltrated the Muschelkalk via ascending cross-formational faults. Alternatively, as the Buntsandstein and the Variscan gneisses are exposed in the Black Forest Highlands (BFH) to the north of the SMB, surface water that had interacted with these exposures could have recharged the Muschelkalk laterally.

These two scenarios have totally different implications for exploration strategies: infiltration along deep faults implies that the high matrix porosity and permeability are restricted to the vicinity of such structures. In contrast, lateral recharge of meteoric runoff from the BFH implies that the spatial distribution of anhydrite dissolution is determined by regional hydraulic gradients. Our ongoing investigations aim to discriminate between the two scenarios and to define appropriate exploration strategies.