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Is the clogging process in Maqarin natural analogue controlled by accessory clay minerals? A reactive transport study with new data.

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The safety of nuclear waste repositories is based on the functionality of multiple natural and engineered barriers for very long time. The barrier system typically combines geochemically different materials that might interact with each other. One example is the long term alteration of sedimentary host rocks by the interaction with high pH pore water from cement materials used for tunnel support, seals and as backfill material.

Within this context the Maqarin site in Jordan was investigated since more than 20 years as a natural analogue for rock alterations and pore clogging due to ingress of high pH solutions. In this work we examine the geochemical evolution of Maqarin marl rock in contact with a fracture through which a hyper-alkaline groundwater is circulating. The new reactive transport calculations were performed with the code OpenGeoSys-GEMS and utilize a state-of-the-art geochemical model for cement-clay interactions.

The simulations reveal that the precipitation of ettringite, and to a smaller extent the precipitation of calcium-silicate-hydrate (CSH), is responsible for pore clogging in the rock matrix. Clogging of the pore space effectively seals the rock matrix on a centimeter scale after some hundreds of years and suppresses mass transfer of solutes from the fracture into the adjacent rock.

In our Maqarin marl rock model typical clay minerals like kaolinite and illite are present in accessory mineral quantities only. A sensitivity analysis reveals that in this setup clay minerals are the main source for Al, necessary for the formation of ettringite-type solid solutions. It is thus the clay mineral content and the dissolution reactions that to a large degree control the spatial and temporal precipitation of ettringites and the associated pore clogging.

Recently collected mineralogy and porosity data will be used to re-calibrate the model and to verify our improved findings that overall Maqarin system is controlled by accessory clay minerals.