

## Reactive transport modeling of cement/concrete – rock interaction: The Tournemire and Maqarin cases

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In the framework of the GTS-LCS project (JAEA-Japan, NAGRA-Switzerland, NDA-UK, POSIVA-Finland, SKB-Sweden), reactive transport modeling of 2 analogues of cement-rock interaction in a repository is being performed: The DM borehole at Tournemire (France) and the Eastern Springs hyperalkaline system at Maqarin (Jordan). In Tournemire solute transport is dominated by diffusion between concrete and rock (mudstone); in Maqarin there is flow along a fracture zone from a cement-like metamorphic rock body with diffusion between fracture and wall rock (clay-containing limestone). The two cases are examples of diffusion (Tournemire) and fracture-flow (Maqarin) dominated systems. In the modeling presented here, calculations have been performed with the CrunchFlow reactive transport code. Results are compared with observations.

Results for the Tournemire case (concrete-mudstone interaction during 15 years) show sealing of porosity at the rock side of the interface (mm scale) due to the precipitation of C-A-S-H, calcite and ettringite, together with clay dissolution. The location of sealing is influenced by cation exchange. Without exchange, sealing is at the concrete side of the interface.

The hyperalkaline system at Maqarin may have been active for tens or several hundreds of thousands of years. The high-pH solution flows along the full length of the fracture (ca. 80 m), with intense mineral alteration in the wall rock (cm scale). Major secondary minerals include ettringite-thaumasite, C-S-H/C-A-S-H and calcite. C-S-H/C-A-S-H precipitation is controlled by the dissolution of primary silicates. Ettringite precipitation is controlled by diffusion of sulfate and aluminum from the wall rock to the fracture, with aluminum provided by the dissolution of albite. Calcite precipitation is controlled by diffusion of carbonate from the wall rock. Extents of porosity sealing along the fracture and in the fracture-wall rock interface depend on assumptions regarding flow velocity and composition of the high-pH solution. The multiple episodes of fracture sealing and reactivation evidenced in the fracture infills were not included in the simulations.

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## Spatial heterogeneity of benthic methane dynamics in the subaquatic canyons of the Rhone River Delta (Lake Geneva)

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Heterogeneous benthic methane (CH<sub>4</sub>) dynamics from river deltas, resulting from variable organic matter accumulation, have been recently reported in various aquatic and marine environments. The spatial heterogeneity of CH<sub>4</sub> sediment release from the Rhone delta of Lake Geneva (Switzerland/France) was thus investigated. Methane benthic dynamics were compared (1) between three underwater canyons of different sedimentation regimes, (2) along a longitudinal transect of the canyon most influenced by the Rhone River, and (3) laterally across a canyon. Results indicate higher CH<sub>4</sub> diffusion rates in the canyon, which continuously receives loads from the Rhone River compared to the other canyons, as well as in intermediate sites instead of proximal and distal reaches of the canyon. The lateral canyon survey results were inconclusive due to the shorter length of the cores. The more allochthonous material is found in higher sedimentation rate environments and partially explained the greater CH<sub>4</sub> diffusion rates. The lower river velocity in the intermediate region characterized by a smaller fraction of coarser sediment allowed more organic matter to settle down and be preserved. This induced higher CH<sub>4</sub> diffusion rates than in the proximal region, where the upper layer of sediments were potentially more disturbed by a stronger river inflow. Total CH<sub>4</sub> sediment release was found to range from 0.9 to 1.2 x 10<sup>4</sup> t CH<sub>4</sub> yr<sup>-1</sup> for the entire delta, although it is most likely oxidized before CH<sub>4</sub> reaches the atmosphere due to the oxic water column. Finally, turbidites were shown to act as sealing layers beneath which CH<sub>4</sub> could accumulate in high amounts and potentially act as source layers for ebullition.