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Tracer transport and reactive transport modeling of clay-concrete interaction: The CI/CI-D experiments at Mont Terri.

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The CI-D Experiment is a field test performed at the Mont Terri rock laboratory (Switzerland). It concerns the diffusion of HTO and $^{36}Cl^-$ through concrete and Opalinus Clay (OPA) from a small point-source-like circulation interval in a concrete-filled borehole. The concrete-filled borehole was made in 2007, as part of the CI experiment. The circulation of synthetic high-pH solution started in July 2018, and the tracers were included in the circulation system in May 2019. Porosity, transport and retention properties may have been affected by alteration at the clay-concrete interface.

Concerning CI-D, a 3D tracer transport model has been calibrated to the observed evolution of tracer concentrations in the borehole circulation system. Transport parameters in OPA (including potential clogging at the concrete-clay interface) do not have a significant impact on the calculated results, due to the limited amounts of tracers diffusing into the rock. The same can be said about anisotropic diffusion in the clay. To tackle these issues, the use of tracer distribution profiles measured in the rock after the end of the experiment will be required.

Reactive transport calculations of the evolution of the concrete-clay interface before the tracer test have also been performed (CI experiment). Fast reaction kinetics (local equilibrium) have been assumed for the cement phases and for all the secondary phases. For primary minerals in OPA (and the calcite and quartz aggregate in the concrete), reaction rate laws from the literature have been implemented, together with calculated geometric surface areas. The results are in fair qualitative agreement with experimental observations (samples collected at t = 4.9 a), especially concerning the small changes in porosity up to t = 5 a, and the presence of a Mg maximum in the clay at a distance from the interface. The high Mg content is controlled by the model mineralogy of the secondary Mg phases (hydrotalcite and serpentine-type M-S-H) at the dolomite reaction front. Fine-tuning of the results may require careful consideration of (1) EDL effects and anion exclusion in the clay, and (2) possible oxidation of pyrite during early stages of the experiment.