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Tracking high-pH reaction fronts in MX-80 bentonite using infiltration techniques and 4D CT

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Geological storage of radioactive waste foresees bentonite as backfill material enclosing spent fuel drums. Concrete is proposed as building material for tunnel reinforcement or as backfill. The emplacement of high-pH cementitious material next to clay generates a chemical gradient in pore water chemistry that drives diffusive transport. Laboratory studies and reactive transport modeling predict significant mineral alteration near interfaces [1].

We aim to characterize and quantify the cement/bentonite skin effects spatially and temporally, focusing on the advective-diffusive transport domain resolved at intermediate spatial scales. Equipment made of carbon fiber and plastics holds a cylindrical sample under confining pressure and imposes a constant hydraulic gradient to drive a small advective flux. Compacted and saturated MX-80 bentonite and sand/bentonite mixtures are used. Infiltration of high-pH pore-fluids into the bentonite plug alters the mineral assemblage over time. The related change in phase densities, porosity and local bulk density is tracked by CT scans during ongoing infiltration. The resulting micrographs describe the electron density distribution in 3D and as a function of time. Electron densities are transformed into material densities using reference materials and are calculated on the basis of the data of the NIST [2]. After 1-2 years the experiment is stopped and the samples subjected to post-mortem analysis.

In a first experiment running for >6 months, MX-80 bentonite (ϱ_{wet}=1.875 g/cm^3) is used as starting material, and a synthetic cement pore fluid of pH 13.7. The reaction front is tracked in the CT and appears as precipitations in the thin filter separating bentonite and infiltration fluid, and as an evolving zone of higher density in the bentonite next to it. Simultaneously, hydraulic conductivity is decreasing by 58% over 6 months.

References

[1] Fernández R, Mäder U K, Rodríguez, M, Vigil de la Villa R and Cuevas J (2009) *European Journal of Mineralogy* **21**, 725-735. [2] Phillips, D. H. and J. J. Lannutti (1997) *NDT & E International* **30(6)**, 339-350.