Portland cement – rock interaction. Diffusion and advection scenarios.

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Several experimental and modeling studies of Portland cement – rock interaction have been performed in the framework of the HPF and LCS international projects at the Grimsel Test Site (Switzerland). Within HPF, laboratory and in situ injection of high-pH solutions into fractured granite were performed. In LCS, pre-hardened cement was placed in a borehole intersecting a fracture. Grimsel groundwater was circulated and injected into this borehole. In addition, modeling studies of a natural analogue (Eastern Springs at Maqarin, Jordan) and an industrial analogue (DM borehole at Tournemire, France) were performed. The different rock structures (impermeable clay rock, fractured porous limestone, fractured tight granite) imposed very different transport regimes translating into very different spatial extents of alteration.

In the case of Tournemire (concrete-mudstone interaction during 15 years), transport control by diffusion resulted in a very small spatial extent of alteration. Porosity was clogged at the cement – rock interface (mm scale) due to the precipitation of C-A-S-H, calcite and ettringite, together with clay dissolution (source of Al and Si). Porosity of the cement (concrete) increased due to portlandite dissolution. At Maqarin, long term circulation of portlandite-saturated solutions along a fracture (ca. 80 m) resulted in intense mineral alteration along the fracture and in the wall rock (cm scale), due to the porous nature of the rock (matrix diffusion). Primary aluminosilicate dissolution also provided Al and Si for C-S-H/C-A-S-H and ettringite precipitation. The relative magnitudes of flow velocity in the fracture vs. diffusion in the rock matrix control the extent of fracture-rock interface clogging vs. fracture clogging.

In the Grimsel granite experiments (year scale), there is very limited mass transfer from the fracture to the rock matrix due to the very small granite porosity. pH buffering by reaction is limited and primary aluminosilicate dissolution (fault gouge) controls also C-S-H/C-A-S-H and ettringite precipitation in the rock fracture. Mineralogical changes are only minor. Fracture heterogeneity is an important control in the spatial distribution of alteration within the fracture.

This study was possible thanks to the financial support from NAGRA and POSIVA and the collaboration with the HPF and LCS teams.