Using reactive transport modelling to analyse cement-groundwater-rock interaction. The LCS experiment at Grimsel

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To understand the geochemical processes due to rock-cement interaction, an experiment was conducted at the Grimsel underground rock laboratory (Switzerland). Pre-hardened Ordinary Portland Cement was emplaced in a borehole intersecting a water conducting fracture. Grimsel groundwater was circulated and injected into this borehole. Two other boreholes placed at 0.56 and 1.12 m from the emplacement borehole were used to monitor the evolution of the water composition for 5 years. We analysed this experiment by means of a reactive transport model, using the Retraso-CodeBright code. The calculations included a 1D radial model for the emplacement borehole and a small volume of the surrounding rock (fault gouge filling the fracture), and 2D models for the rest of the domain. A simple homogeneous fracture was taken into account, together with the reactions resulting from the interaction between the cement, Grimsel groundwater and the fault gouge. Both models (1D and 2D) showed dissolution of the fault gouge minerals. Results from the 1D model showed an increase in porosity in the cement due to portlandite dissolution. C-A-S-H and calcite precipitated at the interface between cement and rock. The 2D model predicted a reduction in porosity in the fracture due to mineral precipitation. The minerals were found to precipitate according to the location with respect to a hyperalkaline plume. Ettringite precipitated near the emplacement borehole. C-A-S-H and hydrotalcite precipitated at the centre of the hyperalkaline plume. Calcite, hydrotalcite and illite precipitated at the edge of the plume. Calcite precipitation was especially important at the extraction borehole, due to the mixing between Grimsel groundwater and the cement-derived high-pH water. This calcite precipitation caused a strong reduction in porosity.