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High-pH plume from fracture grouting. Application to low-pH-cement grouting at ONKALO (Finland).

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Grouting of water-conducting fractures with low-alkali cement is foreseen by Posiva (Finnish nuclear waste management agency) for the potential future repository for high-level nuclear waste in Finland (ONKALO). A possible consequence of the interaction between groundwater and grout is the formation of high-pH solutions which will be able to react with the host rock and engineering-barrier materials, altering their mineralogy and porosity.

Calculations were already performed (Soler et al., 2011) simulating the interaction between flowing water and grout and the alteration of the host rock (gneiss) as this water flowed beyond the grouted section of the fracture. The calculations included the hydration and simultaneous leaching of the grout through diffusive exchange between the porewater in the grout and the flowing water in the fracture. The formation of an alkaline plume was extremely limited when the low-pH grout was used. And even when using a grout with a lower silica fume content the extent and magnitude of the alkaline plume were rather minor.

New calculations have now addressed the effect of different groundwater compositions. The results show that after grouting with low-pH cement, the duration of the initial high-pH peak is short (< 0.5 a), which compares well with observations at a test borehole. Mg in the groundwater induces the precipitation of brucite at the grout-fracture interface, which consumes OH-. In the longer term, the results show a gradually decaying pH tail (pH < 9) controlled by the precipitation of calcite at the grout-fracture interface. The duration of this tail correlates inversely with the carbonate content of the inflowing groundwater.

A major outcome of this study is that mineral precipitation controls the formation of a potential high-pH plume by consuming alkalinity and limiting diffusive solute exchange between the grout and the circulating groundwater. Assumption of long-term interaction between rocks or engineering-barrier materials with flowing high-pH (> 12) solutions is most probably very unrealistic.

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Reference

Soler, J.M., Vuorio M., Hautojärvi, A., 2011. Reactive transport modeling of the interaction between water and a cementitious grout in a fractured rock. Application to ONKALO (Finland). Applied Geochemistry 26, 1115-1129.