



Water uptake and cation exchange – fast processes observed in geotechnical barrier systems in field experiments

Reiner Dohrmann and Stephan Kaufhold

Federal Institute for Geosciences and Natural Resources (BGR), Technical Mineralogy and Clay Mineralogy, Germany
(reiner.dohrmann@bgr.de)

Bentonites are candidate materials for the encapsulation of radioactive waste in barrier systems in crystalline and clay host rocks. Their long-term behaviour of up to 1 million years is important to understand. Alteration of bentonites can be studied in laboratory or large scale experiments at numerous conditions or in natural analogues (illitization, alkaline plume). Few natural analogues exist and laboratory experiments were usually performed at unrealistic conditions such as high solution/solid ratios and dynamic (batch) experiments. Important knowledge about bentonite performance is gained from large-scale experiments in under-ground rock laboratories with different type of groundwater.

Compacted bentonites used in large-scale experiments take up water from the rock after installation. Along with the water, cations enter the bentonite blocks causing cation exchange on the exchangeable cation pool of the clay minerals, mainly smectites. Cation exchange is important because it determines physical and chemical properties of bentonites (Sellin and Leupin, 2014).

Similarities and differences were observed in crystalline rock with high and low ionic strength waters. In the Prototype Repository (PR) experiment (Äspö, Sweden) bentonites reacted with a Na-Ca-Cl dominated groundwater of relatively high ionic strength. PR was heated to 65-85 °C (section 2) for 8 years. In the “full-scale engineered buffer experiment” (FEBEX) experiment (Grimsel, Switzerland) salinity of the groundwater was low and of Na-Ca-HCO₃-F type. The FEBEX experiment was heated up to 100 °C for 18 years of operation.

Both experiments have been (partly) terminated recently and water saturation was not reached yet, however, cation exchange was observed (Dohrmann and Kaufhold, 2014; Fernández et al., 2018) which is relevant to assess bentonite erosion in low salinity waters in a post glacial phase.

Intermediate scale experiments with high temperatures (up to 140 °C and far above the KBS-3 concept) were performed to estimate loss of swelling capacities by illitization of smectites (Sellin and Leupin, 2014). Here damages were observed that could be explained by local boiling in the bentonite barrier (Dohrmann and Kaufhold, 2017).

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