Mineralogical alteration of highly compacted bentonite in permeability tests using $Ca(OH)_2$

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Bentonite is used as an engineered barrier in radioactive waste disposal facilities owing to its suitable physicochemical properties for preventing nuclide migration, such as low permeability. Alteration of cementitious materials will make highly alkaline pore fluid, then the physicochemical properties of the bentonite would change with the mineralogical alteration under alkaline condtion. Understanding the influence of alteration on the physicochemical properties of the bentonite is important to assess a long-term behavior of the engineered barrier. In this study, the permeability tests and a reactive transport modeling were carried out to evaluate the mineralogical alteration of the compacted bentonite under alkaline condition.

In three permeability tests, the compacted bentonite with an initial dry density of 1.6 Mg/m^3 was prepared using Na-type bentonite, Kunigel V1, and the influent solution was 5 mM-$Ca(OH)_2$ solution. The periods of two permeability tests were about 3.2 and 6.9 years and another test is still continuing over 11 years. The concentration of elements in effluent solutions and mineralogical changes of the solid phase were analysed. Furthermore, 1D reactive transport modeling using the CrunchFlow code[1] was carried out to reproduce the experimental results.

No change in the hydraulic conductivities of the samples was observed for 11 years. Si concentration of effluent solutions was kept in high value until about 1000 days then gradually decreased. The concentrations of Na, Ca, K and SO_4 ion showed high value in initial of permeability tests then decreased. From the results of XRD, no change in the mineral compositions of the samples was observed during the experiment, approximately 6.9 years.

The results of 1D reactive transport modeling showed high reproducibility to the experimental results, the ion concentrations of the effluent solutions. Although no change of the mineral compositions was observed by XRD, the numerical simulation showed a slight change of the composition. Calcite precipitated in the compacted bentonite at inflow side of the alkaline solutions, consequently the porosity decreased. The decrease in porosity will contribute to reduction of the hydraulic conductivity of the bentonite.

[1] C.I. Steefel (2009) User's Manual, Berkeley, USA.