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Effect of bacteria on the water storage and retention capacity of swelling clays

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The influence of the metal reducing bacterium Shewanella putrefaciens on the water storage and retention capacity of two clays (NAu-1 nontronite and montmorillonite-containing MX80 bentonite) was studied using a flow through reaction chamber, adapted for in-situ X-ray monitoring. Experiments were conducted to quantify water uptake into the interlayers (responsible for sealing) and non-interlayer sites (open pores and absorption on free surfaces, Warr & Berger, 2006) and to monitor bacterial influence within a confined volume system. Transmission electron microscopy (TEM) and conventional X-ray diffraction texture samples was applied to characterize the samples during and at the end of a 6 week period of water inflow. Nontronite samples incubated with bacteria (initial density 1.2E07 colony forming units (cfu) /ml) showed increased total water uptake (by 9%) compared to bacteria free samples. Quantification of water storage sites furthermore revealed 15% enhanced storage as non-interlayer water compared to the bacteria free sample and decreased interlayer expansion. TEM observations revealed that bacteria incorporated Si, Ca and Fe and led to partial dissolution of the clay. In case of MX80 the total water uptake was as well enhanced (18%) when bacteria were present (initial density 4.0E05 cfu/ml) but as opposed to nontronite, the MX80 showed no decreased interlayer expansion and no mineral dissolution was detected by TEM. The depletion of the clay with respect to major elements (Na, Al, Si and Ca) due to consumption by bacteria was only detectable directly adjacent to them. The different response of the clay on the bacteria's activity can be attributed to differences in i) the function of consumed cations (Ca is the major interlayer cation in nontronite and its hydration leads to swelling), ii) surface area, which is 3 times higher for Nontronite (Nontronite: 84m2/g; MX80: 30 m2/g) and facilitates access for bacteria. This experiments show how the effects of bacteria

on the water storage and retention potential of clays are dependent on the type of material and provide additional constraints for modeling elemental transport and sorption processes in porous media. In case of nontronite the bacterial activity has highly detrimental effects on the properties as reduced interlayer swelling decreases the sealing capacity and the enhanced water storage in pores facilitates transport in the system, whereas in MX80 the sealing effect is maintained and enhanced transport is not likely.

Warr, L.N. & Berger, J. (2006). Hydration of bentonite in natural waters: Application of "confined volume" wet-cell X-ray diffractometry. Physics and Chemistry of the Earth, in press.