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Monitoring the interaction of swelling clays and metal-reducing bacteria

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The interaction of two different clays (NAu-1 nontronite and montmorillonite-rich MX80 bentonite) and the metal-reducing bacteria Shewanella putrefaciens was studied using a flow-through-reaction chamber. This experimental setup allows in-situ X-ray diffraction (XRD) monitoring of mineral reactions in percolating solution and hence the study of reaction kinetics. Flow-through experiments were conducted to evaluate the influence of a high clay/solution ratio on the bacteria and at the same time monitor the changes in hydration behavior of smectite due to the bacterial activity. Additionally, batch experiments with a low clay/solution ratio served as an analogue to study clay bacteria interactions in aqueous environments of varying solution chemistry. Quantifying the inter-crystalline swelling of the nontronite (Fe(III)-rich smectite) by in-situ XRD shows that the bacteria reduce the amount of inter-crystalline swelling despite the fact that bacteria cell counts show a progressive decrease in population (initial density of 1E06 cells/ml). In the case of montmorillonite (MX80), the bacteria appear not to inhibit swelling, although viable cell counts showed a less rapid decrease in population density compared to the nontronite experiments. The differences between the studied clays concerning the decrease in population are attributed to differences in i) the osmotic gradient induced by the clay ii) the competition for water during clay expansion and iii) the build up of swelling pressure in the reaction chamber. Transmission electron microscopy observations support the rapid decrease of bacteria within the swelling clays. In turn, the reduced swelling of the nontronite clay incubated with bacteria might reflect octahedral iron reduction and related changes in layer charge.