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Microbial reduction of structural Fe^{3+} in nontronite by a thermophilic bacterium and its role in promoting the smectite to illite reaction

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ABSTRACT

The illitization process of Fe-rich smectite (nontronite NAu-2) promoted by microbial reduction of structural Fe^{3+} was investigated by using a thermophilic metal-reducing bacterium, *Thermoanaerobacter ethanolicus*, isolated from the deep subsurface. *T. ethanolicus* was incubated with lactate as the sole electron donor and structural Fe^{3+} in nontronite as the sole electron acceptor, and anthraquinone-2, 6-disulfonate (AQDS) as an electron shuttle in a growth medium (pH 6.2 and 9.2, 65 °C) with or without an external supply of Al and K sources. With an external supply of Al and K, the extent of reduction of Fe^{3+} in NAu-2 was 43.7 and 40.4% at pH 6.2 and 9.2, respectively. X-ray diffraction and scanning and transmission electron microscopy revealed formation of discrete illite at pH 9.2 with external Al and K sources, while mixed layers of illite/smectite or highly charged smectite were detected under other conditions. The morphology of biogenic illite evolved from lath and flake to pseudo-hexagonal shape. An external supply of Al and K under alkaline conditions enhances the smectite-illite reaction during microbial Fe^{3+} reduction of smectite. Biogenic SiO_2 was observed as a result of bioreduction under all conditions. The microbially promoted smectite-illite reaction proceeds via dissolution of smectite and precipitation of illite. Thermophilic iron reducing bacteria have a significant role in promoting the smectite to illite reaction under conditions common in sedimentary basins.

Keywords: Dissolution, illite, microbial Fe^{3+} reduction, nontronite, precipitation, sedimentary basin, smectite, *Thermoanaerobacter ethanolicus*