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Review Paper

Microbe-clay mineral interactions

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Abstract

Clays and clay minerals are common components in soils, sediments, and sedimentary rocks, and they play an important role in many environmental processes. Iron is ubiquitous in clays and clay minerals and its oxidation state, in part, controls the physical and chemical properties of these fine-grained minerals. The structural ferric iron in clay minerals can be reduced either chemically or biologically. Biological reductants include mesophilic and thermophilic microorganisms from diverse environments such as soils, sediments, sedimentary rocks, and hydrothermal hot springs. Multiple clay minerals have been used for microbial reduction studies, including dioctahedral smectite-illite series, palygorskite, chlorite, and their various mixtures in natural soils and sediments. All of these clay minerals are reducible by microorganisms under various conditions with smectite (nontronite) being the most reducible and illite the least. The rate and extent of bioreduction depends on many experimental factors, such as the type of microorganisms and clay minerals, solution chemistry, and temperature. Despite significant efforts, current understanding of the mechanisms of microbial reduction of ferric iron in clay minerals is still limited. Whereas some studies have presented evidence for a solid-state reduction mechanism, others argue that the clay mineral structure partially dissolves when the extent of reduction is high. This inconsistency may be related to several experimental conditions, and their specific effects are discussed in this paper. Whereas past experiments have been largely conducted in well-controlled laboratory systems, recent efforts have attempted to transfer knowledge to the field to improve our understanding of more complex soil systems for better agricultural practices. Biologically reduced clay minerals are also important agents in remediating inorganic and organic contaminants in soil and groundwater systems. This paper reviews the most recent developments and suggests some directions for future research.

Keywords: Bacteria, illite, mechanism, microbial Fe(III) reduction, nontronite, smectite