Overviews of Microbe-Mineral Interaction

Jinwook Kim

Department of Earth System Sciences, Yonsei University, Seoul
email address: jinwook@yonsei.ac.kr

Smectite-illite clays are ubiquitous in nature. The smectite to illite transformation (S-I) is linked to the maturation, migration and trapping of hydrocarbons, the development of pore pressures, rock cementation, and pore water chemistry. Despite the importance, considerable ambiguity exists as to how geological variables control the transformation. Past research has focused on temperature, pressure and time factors. In this study, we have demonstrated for the first time that subsurface microbes can significantly promote the S-I transformation, and this represents a previously unknown mechanism with implications for clay science, mineral-microbe interactions, sedimentary basin analysis, and petroleum industry. This study will affect clay mineral reactions, current kinetic model of the smectite-to-illite reaction, and clay mineral geothemometry which will have major implications for a number of geological processes, including organic matter maturation and oil migration, development of pore pressure, rock cementation and porosity reduction, and thermal evolution of sedimentary basin. Furthermore, biotransformation of clay minerals will modify the clay surface potential that affects the environmental factors such as flocculation properties of clay particles which has implications of removing contaminants in the solution, and the interaction of clay particles and organic matter which will evaluate the pathway of carbon. Clay may trap/release the carbon in/from the structure depending on microbe-clay mineral interaction which will affect the carbon cycling.

For the study of microbial Fe(III) reduction in magnetite was also investigated. Electron energy loss spectroscopy (EELS), energy filtered transmission electron microscopy (EFTEM), and high resolution transmission electron microscopy (HRTEM) were employed to investigate mineral transformation associated with microbial Fe(III) reduction in magnetite. *Shewanella putrefaciens* strain CN32, a dissimilatory metal-reducing bacterium was incubated with magnetit as a sole electron acceptor and with lactate as an electron donor for 14 days under anaerobic conditions in a bicarbonate buffer. The elemental map of Fe, O, and C and RGB composite map were created by EFTEM technique. The interface between magnetite and siderite were also investigated using EELS technique to understand the Fe oxidation state in each mineral. The Fe oxidation state was determined based on the integral ratio of L_3 to L_2. The integral ratios of L_3 to L_2 of magnetite (6.29) and siderite (2.71) corresponded to 71% of Fe(III) in magnetite, and 24% of Fe(III) in siderite based on the technique of van Aken et al. (1988). A chemical shift (about 1.9 eV) in the Fe-L_3 edge of magnetite and siderite indicated a difference in the oxidation state of Fe between the two minerals. Furthermore, EELS spectrum images of magnetite and siderite were extracted from the electron energy loss ranging from 675 to 755 eV, displaying the contrast of magnetite-siderite interface. Our results demonstrate that EELS is a powerful technique to study Fe oxidation state change as a result of microbial interaction with iron-containing minerals.