Biological weathering and clayey biomineralization. -A role of microbes during the formation of layered silicate minerals-

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The extracellular polymeric substances (EPS) exuding from microbial cells were noted as a template for clayey biomineralization. Transformation of K-feldspar into halloysite was observed within EPS layer, composed of acidic polysaccharides, exuding from cyanobacteria in a glaze. On the other hand, nontronite was formed within EPS material, mainly composed of acidic polysaccharides, exuding from microbes in deep sea sediments. The EPS exuding from microbial cells are important for mobilization and/or immobilization of the elements on and in the Earth's crust. Particularly, polysaccharide polymers may contribute to clayey biomineralization.

Microbial transference of elements on global environment is a key to understand diagenesis and elemental cycles. Clays are one of major component on terrestrial surface and are easily removable, so that, can contribute to elemental cycles. To reveal the interaction between microbes and silicate minerals and their micromorphorogy is a key role for elemental transportation induced in biosphere.

In this study, the extracellular polymeric substances (EPS) exuding from microbial cells. were noted as a template for clayey biomineralization. The clayey biomineralization process and mechanism are micromorphologically, microstructurally investigated in case of weathering under room temperature and mineralization of deep sea sediment under hydrothermal conditions.

Biological weathering process of K-feldspar was investigated on the Kutani Glaze suspension as the model of microbial transportation from silicate minerals of major components on the terrestrial surface. Green, brown and black microbial mats were formed on the surface of the precipitates. Transformation of K-feldspar into halloysite was observed in the green microbial mats. The primitive clay precursors, intermediate states between K-feldspar and halloysite, formed in EPS layer of cyanobacteria. The biological weathering of K-feldspar and the sequential halloysite mineralization were proceeded within the microbial EPS. At the primitive stage, minute particles of the K-feldspar were trapped on or into the EPS layer. The minute particles were digested and were eventually transformed to halloysite within the EPS layer. The EPS, composed of acidic polysaccharides and other organic acids, plays a key role for K and Si release from the K-feldspar and the subsequent halloysite transformation.

Deep sea sediments are also rich in silicate minerals. Formation process of nontronite was observed on the surface of Deep sea sediments of Iheya Basin, Okinawa Trough, Japan. Ferrisiliceous sediments including nontronite and microbes were observed in this study. The observations imply that nontronite was formed within the EPS material, mainly composed of acidic polysaccharides, exuding from the microbial cells. The primitive nontronite lattice images were oriented along the direction of the polymer exudation, which suggest nontronite grew in the same direction as the ribbon (two-dimensional chained) structure of polysaccharide polymer. The nontronite formation was induced by accumulation of Si and Fe ions in deep sea.

To understand a role of polysaccharides in formation of Fe-rich layered silicates, synthetic experiment was complementarily performed using dextrin and pectin added with ferrosiliceous groundwater solution. The solutions were stirred with sealing for 2 days. The results suggest that the importance of polysaccharide polymer orientation on nontronite formation. The precipitates including Fe-rich layered silicates were observed within the dextrin and the pectin aggregates, whereas rod-shaped or spherical Si-bearing Fe-hydroxides were observed in the ambient area of the dextrin and the pectin aggregates. The observations imply that the polysaccharide polymers are necessary for the formation of Fe-rich layered silicates. The process of nontronite formation was assumed that SiO_4 tetrahedra were oriented on the ribbon structure of polysaccharide polymers, and then the residual OH groups of the tetrahedra oxidize ferrous ions in the solution. It can be applicable to the nontronite formation process in deep sea sediments.

The results obtained in this study indicate that microbial activity gives great impacts for elemental transportation on terrestrial surface, particularly, the EPS exuding from microbial cells are important for mobilization and/or immobilization of the elements on and in the Earth's crust. Moreover, it is necessary to evaluate the influence of chemical compounds exuding from microbes on the stability of the Earth's crust.