Diversity of cementation faces in bentonite ores

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In the geological disposal of high-level radioactive waste, bentonite will be used as a buffer material due to its high swelling property and low permeability. However, it is concerned that bentonite could be altered in the long-term period, resulting in the reduction of the barrier functions. One of the possible alterations is the cementation of bentonite, in which secondary minerals precipitate in the pores and adhere to coexisting minerals. This may cause adverse effects such as the reduction of swelling pressure, but the geochemical processes and changes in microstructure of bentonite are poorly understood. Since it is difficult to evaluate such a long-term alteration only in the laboratory, a natural analogue study is useful to analyze samples that have experienced similar alteration in the natural environment and to evaluate the mechanisms of alteration.

In this study, bentonite ores from Tsukinuno Mine in Yamagata Prefecture, Japan, was collected for microstructural observation and geochemical analysis. This bentonite deposit has been formed by the diagenesis of volcanic ash deposited ~15 Ma, and is expected to be an analogue for cementation in a relatively low temperature, as assumed in disposal sites. Thin sections of bentonite were prepared by dry polishing technique to observe the flat surface of bentonite ores. Scanning electron microscope (SEM) demonstrated the widespread distribution of authigenic micro silica in the matrix of montmorillonite. Transmission electron microscope (TEM) revealed that the micro silica minerals (commonly quartz and less commonly amorphous silica) were bonded to the montmorillonite edge. The relative abundance of montmorillonite and micro silica minerals varied among the different bentonite beds. This relative abundance did not correlate with the stratigraphy and the chemical composition of the original volcanic ash estimated from the immobile element composition (Nb/Y vs. Zr/TiO_2). In addition, a case where silica and calcite cementations occurred together was observed within the same bentonite unit.

This study demonstrated the diversity in cementation states, such as the type of cementitious materials, their relative amounts, and distribution. This might be strongly influenced by the mass balance during diagenesis, for example, the supply of magnesium from seawater for montmorillonite formation and the presence of carbon sources for calcite formation. To predict cementation in actual disposal environments, it is important to understand the relationship between the cementation states and geochemical conditions.

