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Pressure dependance of swelling state of Na-montmorillonite

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It is known that montmorillonite clay minerals have the property of swelling with water molecules hydrated to interlayer cations. Clay minerals present on and under the Earth's surface, forming a card-house structure consisting of montmorillonite stacks, and they hold interlayer water and external pore water. The relative abundance of interlayer water and external pore water contributes the macro-scale material properties such as permeability and viscosity. Sample preparation is following. Bentonite sample used in this study is mined from Tsukinuno Mine, Yamagata Prefecture, and it is purified to obtain montmorillonite (Kunipia-F, Kunimine Industry Co., Ltd.). Na-montmorillonite, of which interlayer cation was replaced by sodium ion, is used in this study. Dry Na-montmorillonite and pure water with appropriate ratio were sealed in a sample tube. Water contents were measured after experiments. Water content is between 30 ˜ 50 wt%, and they have properties between highly viscous fluid and solid. Relation between dry density, water content and swelling state is observed. At small water content (˜30wt%), swelling state is a 2-layer hydration state, and a 3-layer hydration state at the large water content(˜50%). At intermediate water contents, 2-layer and 3-layer hydration state coexist. Experimental procedure is following. Basal spacings of Na-montmorillonite is examined using in-situ X-ray diffraction methods. To obtain the temperature and pressure conditions near the earth's surface (a depth of up to 1 km) in the laboratory, the environment-control system was used for in-situ X-ray diffraction methods. The experiments were carried out to varying sample temperature from 30 to 80 degree at 10 MPa, and sample pressure from 10 MPa to 50 MPa at 30 degree. The exchange of water between interlayer and external pore was determined from swelling state change due to pressure and temperature. As a result, the swelling states, which is determined strongly by the water content or dry density, changes slightly due to pressure and temperature. By increasing temperature, there is a tendency that swelling state changes from 3-layer to 2-layer. Temperature dependance of swelling state is mainly on entropy. So, by increasing temperature, water moves from interlayer to external pore, which has higher entropy, and swelling state changes from 3-layer to 2-layer. Pressure dependance is mainly on molar volume, but there is almost no difference between the volume of interlayer water and external pore water. So, it is difficult to observe the pressure dependance. We are going to observe pressure dependance at higher than 50 MPa of swelling state.

Keywords: Montmorillonite, Smectite, Fault gouge, Radioactive waste