In situ observation of swelling of bentonite in contact with saline solutions

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The swelling of smectite aggregate plays an important role in the microstructural evolution of bentonite. In the present study, the swelling of aggregated particle of smectite (ped) in contact with NaCl solution was investigated quantitatively and in-situ using a laser scanning microscope. Na-type smectite aggregates in size of several hundreds µm were placed on glass plates with a thin coverglass. A NaCl solution (0.00 to 1.00 mol/dm3) was introduced into the planar space between the glass plate and the coverglass by capillary action. When aggregates came into contact with the NaCl solution, they initially swelled quickly and then the rate of swelling became more gradual. The ER value reached a steady-state 900 s after the beginning of the experiment. The steady-state ER value (ERst) was independent of the initial size of the aggregate at each NaCl concentration. The ERst decreased with increasing NaCl concentration drastically as NaCl concentration increased up to 0.1 mol/dm3 and then gradually as NaCl concentration increased above 0.3 mol/dm3. This mesoscopic swelling behavior was controlled by the microscopic swelling mechanisms: double-layer and crystalline swelling mechanisms. An XRD study suggested that the latter mechanism is dominant for ≥ 0.3 mol/dm3, because a diffraction peak indicating a crystalline swelling regime was observed, while no diffraction peak appeared below 0.3 mol/dm3. The obtained results of the mesoscopic swelling indicated an increase in a fraction of macropore among smectite aggregates, which is the possible pathway for the fluid flow, with increasing NaCl concentration. This change in the pore fraction likely accounts for an increase in the hydraulic conductivity at high salinity conditions.