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Dissolution behavior of compacted smectite clay

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Smectite, a clay mineral forming natural bentonite widely exists in altered meteorite to sedimentary rock as micro to nano-crystal. Since smectite can appear in the various forms from as-grown {001} stacking to random-aggregate, its dissolution behavior is poorly understood. For example, dissolution of colloidal suspension of smectite can be driven by solution pH, undersaturation ΔG and temperature (Sato et al., 2005), while compacted smectite is stabilized (Nakayama et al., 2004).

Among many approaches for dissolution of smectite, AFM (atomic force microscopy) can directly measure dissolving nano-dispersed particles, but high-densiry random aggregates. In order to improve AFM, we developed in-situ VSI (vertical scanning interferometry) and auto-compaction cell. By this means, we conducted in-situ measurements of compacted smectite (Na-montmorillonite) immersed in 0.3M NaOH at 70 ℃. This method can realize real-time measurements of decreasing material volume of smectite under various densities. After measurements, recovered particles were measured by AFM to refine the step-edge surface area.

As the result of AFM-assisted VSI measurements, dissolution rates of compacted smectite vary from 2.9E-11 mol/m^2/s (density 0.001, Sato et al., 2005) to 2.6E-13 mol/m^2/s (density 1.64, compacted, Satoh et al., 2013). Most possible reason explaining this behavior is self-masking effect which nano-particulates mask step-edges each other (reduced dissolution). However, compaction on random aggregates induces edge-dislocation that newly produces dissolution centers. This was well-recognized especially in the early compaction stage (promoted dissolution).

Thus, high density clay as nano-stacked or aggregated particles always accompanies with dissolution, but it is not continued by self-masking effect as a kind of negative-feedback mechanism. To investigate and understand such a complex behavior of clay, computer simulation by Monte-Carlo calculation is needed.

Keywords: smectite, dissolution, compaction, AFM, VSI