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In-situ AFM study of smectite dissolution under alkaline conditions at room temperature

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ABSTRACT

An experimental study on smectite dissolution was carried out using in-situ TMAFM and CMAFM (tapping mode and contact mode atomic force microscopy, respectively) analyses at 25 °C under alkaline conditions. Smectite particles dissolved via the retreat of the edge surfaces without scratching by the AFM tip, except in a series of the dissolution experiment in CMAFM. The retreat of each straightened edge surface appeared to occur with a constant rate. In contrast, the basal surface was unreactive within the experimental duration. The dissolution rates normalized to the edge surface area (ESA) of smectite at a certain pH and temperature condition, therefore, had a constant value independent of the particle size, whereas the dissolution rates normalized to the total surface area (TSA) varied with the particle size. These dissolution rates were consistent with those derived from wet-chemical data in previous studies. The anisotropic dissolution behavior was also observed along the ESA, that is, the retreat of dissolution fronts along the {110} faces was much faster than that along {010} faces. This difference can be explained by smectite dissolution under alkaline conditions being controlled by OH^- attack, which is catalyzed by protonated Al-OH groups, on the bridging O atoms of both Al-O-Si sites, which locate only on the {110} surfaces, and Al_2-O-Si sites on the {010} and {110} surfaces. The bridging O atoms of Al_2-O-Si sites on the {010} surfaces are buried more deeply in the structure than those of Al-O-Si sites on the {110} surfaces, which would be more difficult to attack on the {010} surfaces.

Keywords: AFM, in-situ TMAFM in liquid, smectite dissolution, kinetics, surface studies, smectite