Direct High-Resolution Transmission Electron Microscopic Measurement of Expandability of Mixed-Layer Illite/Smectite in Bentonite Rock

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Abstract: Samples of mixed-layer illite/smectite were investigated from a single bentonite bed zoned with respect to expandability from 90 to 30%. Chips of natural rocks were embedded in a resin, using procedure designed to preserve the original fabric, cut with an ultramicrotome, and observed by high-resolution transmission electron microscopy (HRTEM). These observations confirmed the X-ray powder diffraction (XRD) model of mixed-layer days, i.e., that illite/smectite grains in natural rocks are built mixed-layer crystals, from 1 to as many as 15 silicate layers thick (4 – 6 interlayers per crystal on average). These crystals are present either as individual particles (loose crystals) or, typically, they form nearly parallel face-to-face groupings called here quasi-crystals. Free fundamental smectite and illite particles defined by Nadeau and coworkers were essentially absent.

Illite and smectite interlayer spacings were 10 and 13.5 Å, respectively. Crystal thickness and number of interlayers were measured for 35 – 100 mixed-layer crystals per sample. Illite/smectite expandabilities were calculated from these data in two ways: either neglecting the crystal edges or accounting for them. The former determinations agree well with XRD estimates of expandability and the latter, with expandabilities calculated from the distributions of fundamental panicle thickness measured by a shadowing technique in the TEM. This result explains the systematic discrepancy between XRD and TEM measurements of illite/smectite expandability.

Key Words: Expandability • Fundamental particle • High-resolution transmission electron microscopy • Illite/smectite • Interstratification

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