

Interstratified kaolinite-smectite: Nature of the layers and mechanism of smectite kaolinization

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ABSTRACT

This study aims to contribute to a better understanding of the nature and evolution mechanism of interstratified clay minerals. We examined the $<2 \mu\text{m}$ or $<0.2 \mu\text{m}$ size fraction of interstratified kaolinite-smectite (K-S) formed by hydrothermal and hydrogenic alteration of volcanogenic material from a Tortonian clay deposit (Almería, Spain), a weathered Eocene volcanic ash (Yucatan, Mexico), and a weathered Jurassic bentonite (Northamptonshire, England). The methods used were X-ray diffraction analysis (XRD) of random and oriented preparations, thermogravimetry, chemical analysis, and ^{29}Si MAS nuclear magnetic resonance. The proportions of kaolinite and smectite in K-S (%K) were determined by fitting the XRD patterns of ethylene-glycol-saturated samples with patterns calculated with the NEWMOD computer program. The obtained range of compositions is 0–85%K. A comparison of the results from the various techniques showed non-linear relationships, indicating that the layers in K-S are complex and hybrid in nature. The smectite-to-kaolinite reaction is a solid-state transformation proceeding through formation of kaolinite-like patches within the smectite layers. The process consists of several non-simultaneous stages: (1) removal of parts of the tetrahedral sheet, resulting in formation of kaolinite-like patches; (2) layer collapse to $\sim 7 \text{ \AA}$ where the kaolinite-like patches are sufficiently large; (3) Al for Mg substitution in the octahedral sheet, simultaneous or slightly delayed with respect to layer collapse, causing a layer-charge decrease and loss of interlayer cations; (4) Si for Al replacement in the tetrahedral sheet and further loss of interlayer cations. Iron remains in the kaolinite or is lost at the latest stages of the process.

Keywords: Crystal structure, kaolinite-smectite, solid-state transformation, TGA, XRD