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Phase relations among smectite, R1 illite-smectite, and illite

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ABSTRACT

A variety of smectitic and illitic clays were studied by TEM and AEM, following expansion by L.R. White resin, to define phase relations for clay minerals undergoing digenesis and low-grade metamorphism. Samples included a prograde shale sequence from the Gulf Coast, a hydrothermal bentonite from Zempleni, Hungary, and shales from the Nankai Trough, Japan, Michigan, and the Welsh sedimentary basin. All samples were dominated by various proportions of only three kinds of clay minerals: smectite having no 10 Å layers, R1 illite-smectite (I/S) (50% illite), and illite with only small proportions of smectite-like interlayers; mixed-layer phases with intermediate ratios of I/S were observed only as minor components of other layer sequences. Lattice fringe images show that the common layer spacing of R1 I/S is 21 Å and that it has 0.7–0.8 K pfu; its properties are not an average of those of smectite and illite, which is consistent with the uniqueness of the R1 I/S structure.

A prograde sequence of clay mineral transitions in the studied samples can be characterized by five stages with different combinations of the three major phases (i.e., smectite, R1 I/S, and illite) corresponding to different grades. The sequence from low to high grade is (1) pure smectite, (2) smectite with small proportions of discrete R1 I/S and illite, (3) R1 I/S with small proportions of smectite and illite, (4) illite with some R1 I/S and smectite, and (5) illite. Common exceptions to this scheme are inferred to be caused by the inherent metastability of all phases, in occurrences that are rate or path dependent.