Role of Water in the Smectite-to-Illite Reaction

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Abstract: A series of hydrothermal experiments was performed to determine the effect of fluid abundance on the reaction of smectite to illite. Experiments were conducted on K-saturated montmorillonite (<0.1-μm fraction) in a closed system at 250° to 400° C using run times of 1, 7, 14, 30, and 60 days at 100 MPa (1 kbar) pressure. In fluid-deficient systems (pore spaces not saturated), the rate and extent of illitization was significantly inhibited. A rock:water ratio of 20:1 (mass:mass) produced an R0 illite/smectite (I/S) having 82% smectite layers after 60 days at 250° C, whereas a rock:water ratio of 1:1 produced an I/S having 57% smectite layers under the same conditions. The effect became less pronounced at higher temperatures, with the 20:1 and the 1:1 experimental products differing by only 11% expandability at 400° C after 60 days. In addition, the low-fluid experiments produced fewer crystalline byproducts (quartz, cristobalite, chlorite) than did the fluid-rich runs, and the I/S was more difficult to disperse and orient in the fluid-deficient samples, suggesting enhanced cementation at grain contacts or the production of particle morphologies that did not lend themselves to orientation. The difference in reactivity of the smectite and I/S as a function of water content appears to be attributable to the reduced capacity for low volumes of water to mediate the dissolution, solute transport, and precipitation reactions that make up the series of reactions collectively termed illitization. Of these variables, solute transport is likely to be affected most by reduction of fluid.

Key Words: Hydrothermal • Illite • Interstratification • Smectite • Water

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