
Hydrothermal Treatment of Smectite, Illite, and Basalt to 460° C: Comparison of Natural with Hydrothermally Formed Clay Minerals

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Abstract: Wyoming bentonite, Fithian illite, and basalt from the Umtanum Formation, Washington, were treated hydrothermally at 200° to 460° C and 260 to 500 bars for 71 to 584 days. No change was detected for the bentonite and basalt, except for the loss of calcite and exchange of Ca for K in the smectite and the growth of a small amount of smectite (presumably from a glass phase) in the basalt. Calcite in the initial bentonite may have stabilized the smectite by Ca/K exchange; thus, if the latter is used as a packing material in a nuclear waste repository, limestone should be added. No change was detected in the illite samples treated <300° C; however, at 360° C, euhedral crystals of berthierine and illite grew at the expense of original illite/smectite, apparently by a solution-crystallization process. Significant changes involving the dissolution of starting phases and the formation of illite and chlorite were also detected in mixtures of basalt and bentonite at 400° C; at temperatures <400° C, no changes were observed.

The newly formed mineral phases (berthierine, illite, and chlorite) observed by transmission electron microscopy showed euhedral to subhedral shapes. These shapes are the same as those observed in hydrothermally altered sediments from the Salton Sea field and different from those from burial metamorphic environments, such as Gulf Coast sediments. The reaction mechanism is apparently the dissolution of reactants followed by the crystallization of products from solution, without conservation of structural elements of the reactants. Reactions apparently required temperatures greater than those for analogous changes in nature, suggesting that the degree of reaction was controlled by kinetics. The lack of dissolution in experimental runs at low temperatures, however, does not necessarily imply long-term stabilities of these clay minerals.

Key Words: Basalt • Berthierine • Hydrothermal • Illite • Smectite • Stability

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