

Formation of secondary minerals and its effect on anorthite dissolution

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ABSTRACT

To examine the relationship between product secondary minerals and dissolution of anorthite ($An_{95}Ab_5$ from Fugoppe, Hokkaido, Japan), anorthite batch dissolution experiments were carried out. The dissolution experiments were done at 90, 150, and 210 °C for 3 to 355 days at pH 4.56 measured at 25 °C, which corresponds to 4.69, 4.97, and 5.40 at the respective experimental temperatures. A sequence of secondary minerals including boehmite, “modified boehmite,” and kaolinite formed with increasing time. Modified boehmite, probably a metastable phase, is basically similar to boehmite in structure, but their stacking orders of the Al octahedral layers as well as morphologies and chemistries are different. Modified boehmite shows laminations normal to the b^* axis and contains 3 to 30 mol% Si. Silicon may be present between the Al octahedral layers of modified boehmite. The anorthite dissolution is incongruent under the above conditions and approximated by a two-stage process. The first is characterized by the formation of boehmite, and the second by formation of modified boehmite. The dissolution rate in the second stage is slower than the first by approximately one order of magnitude because of the saturation state with respect to anorthite. To estimate the effect of the formation of secondary minerals on the anorthite dissolution, Gibbs free energies of anorthite dissolution (ΔG) were calculated, assuming conditions without the formation of secondary minerals. The calculations reveal that the formation of secondary minerals decreases the ΔG values significantly, and thus we can predict that the dissolution rates of anorthite increase due to the influence of the secondary minerals on ΔG . Modified boehmite functions as a sink for Si, and thus accelerates the dissolution rate of anorthite. The results indicate that the overall dissolution rate near equilibrium is affected by both the saturation with respect to a primary mineral and the formation of secondary minerals, but in the opposite sense.