American Mineralogist, Volume 93, pages 1028–1033, 2008

In situ observations of muscovite dissolution under alkaline conditions at 25–50 °C by AFM with an air/fluid heater system

Yoshihiro Kuwahara*

Department of Evolution of Earth Environments, Graduate School of Social and Cultural Studies, Kyushu University, Ropponmatsu, Fukuoka 810-8560, Japan

Abstract

Dissolution behavior of muscovite under alkaline conditions at 25–50 °C was investigated using in situ atomic force microscopy (AFM) with an air/fluid heater system to derive reliable dissolution rates and determine the dissolution mechanism and the effect of temperature on the dissolution rates. The muscovite dissolution took place only at the edge surfaces that are less than a few percent of the total surface area (TSA), while the basal surfaces were completely unreactive. During the initial stage of the experiments, some rough edge surfaces of muscovite dissolved much faster at the reactive site and appeared to straighten. The straightened edge surfaces seemed to retreat with a lower constant rate, which may correspond to the actual dissolution rate of muscovite, in the late stage. The edge surface area (ESA)-normalized dissolution rate at a certain pH and temperature condition, therefore, has a constant value independent of the size of etch pit or island (particle). The ESA-normalized dissolution rates derived from this AFM study were consistent with the dissolution rates renormalized to the estimated ESA of the earlier studies. In contrast, the TSA-normalized dissolution rates varied with the size of etch pit or island.

The activation energy for muscovite dissolution under alkaline conditions was very close to that for montmorillonite and illite dissolution. A model dissolution rate equation, which simultaneously includes the effect of pH and temperature, was deduced from the effect of pH on the activation energy, the rate equation of muscovite dissolution at 25 °C, and the Arrhenius equation. The dissolution rates estimated from the model were in good agreement with the experimental rates from 25 to 70 °C. The dissolution reaction order with respect to hydroxyl activity (or pH) increases with temperature.

Keywords: Muscovite, AFM, dissolution kinetics, dissolution mechanism, surface studies, hot-stage AFM