

## **Characterization of neoformed illite from hydrothermal experiments at 250 °C and $P_{v, \text{soln}}$ : An HRTEM/ATEM study**

**DOUGLAS M. YATES\* and PHILIP E. ROSENBERG**

Department of Geology, Washington State University, Pullman, Washington 99164, U.S.A.

### **ABSTRACT**

Solid products from hydrothermal experiments conducted at 250 °C and  $P_{v, \text{soln}}$  were characterized by powder X-ray diffraction (XRD) and ATEM/HRTEM. Experiments were conducted with muscovite, kaolinite, and quartz or amorphous silica in 2M KCl solutions for 43 to 176 d. Post-experiment solution compositions lie either within the illite(0.88 K) stability field or on the illite(0.88 K)-kaolinite or illite(0.88 K)-diaspore univariant boundaries in  $\log(a_{\text{K}^+}/a_{\text{H}^+})$  vs.  $\log a_{\text{H}_4\text{SiO}_4}$  activity space. Transmission electron microscopy (TEM) observations of muscovite grain edges reveal the neoformation of illite crystals with a range of compositions (ATEM) from 0.31 to 0.89 K/O<sub>10</sub>(OH)<sub>2</sub>. The range of K-contents appears to narrow toward 0.88 K/O<sub>10</sub>(OH)<sub>2</sub> with increased experiment duration. HRTEM suggests the presence of 2 to 11 layer fundamental particles composed of illitic layers with 10 Å periodicity. Fundamental particle thicknesses increase toward an average of 8 layers/particle with increased experiment duration. In the longer duration experiments, fundamental particle thicknesses were normally distributed about thicknesses of 4 and 8 layers, whereas fundamental particles with thicknesses <4 layers were common in a shorter duration experiment.

The compositions and structure of the illites are consistent with the multiphase model, which states that the smectite-to-illite transition occurs through the step-wise formation of solubility-controlling phases consisting of fundamental particles with thicknesses of 1, 2, 4, and  $\geq 8$  layers. The increase in K-content and fundamental particle thickness with the extent of reaction suggests that the illite crystals underwent a prograde reaction culminating in the formation of end-member illite [0.88 K/O<sub>10</sub>(OH)<sub>2</sub>]. This reaction, in conjunction with the previously observed, retrograde reaction from muscovite to end-member illite, demonstrates the stability of end-member illite in the system K<sub>2</sub>O-Al<sub>2</sub>O<sub>3</sub>-SiO<sub>2</sub>-H<sub>2</sub>O at 250 °C.