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Alteration of Muscovite to a Mg-Clay

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Transformation of detrital micas to Mg-rich phyllosilicates (e.g. kerolite or saponite) is known to occur in alkaline lakes; however, the rates of such transformations are unknown. Simulation of the alteration of a primary to secondary phyllosilicate phase was conducted at 80 degrees C in a pH 9.2 0.00041 m $MgCl_2$/0.0005 $Na_2B_4O_7$ solution at atmospheric CO_2 partial pressure. A single sheet of 2 M_1 muscovite approximately 12 mm square and 1 mm thick was reacted with this solution in a stirred-flow reactor for a period of 7 weeks at a flow rate of 0.8 mL/min. Such conditions could represent constant washing of a detrital mica flake in a large volume of alkaline lake water. Extent of alteration on the reacted basal (001) surface was characterized quantitatively using SIMS depth-profiling of Si, Al, and Mg concentrations and isotope ratios. *Ex-situ* synchrotron X-ray specular reflectivity measurements of the reacted and unreacted surfaces were made at the Advanced Photon Source to characterize surface structural changes. The morphology of the altered surface was determined using TappingMode atomic force microscopy (TMAFM). SIMS analyses indicate that Al was leached from the muscovite surface and replaced by Mg, suggesting that the phyllosilicate transformed from a dioctahedral to trioctahedral structure. TMAFM images revealed the presence of aligned elongated hexagonal islands 10-20 nm high and 0.1 to 0.4 μm in lateral dimension. The heights of these hexagonal lamellar features are consistent with the depth of exchange of Mg for Al based on measurements of the sputtered holes in the SIMS analyses. X-ray reflectivity data show significant differences in surface structure between the unreacted and reacted muscovite, which are interpreted in terms of compositional and structural changes between the primary and secondary phases as well as surface roughening and changes in mosaic structure. Using activation energies typical for surface-controlled dissolution, the alteration of a 1 μm thick particle of detrital muscovite to Mg-rich clay would take place within ~8,000 years at 25 degrees C. Possible mechanisms of alteration of a primary dioctahedral mica to a secondary trioctahedral clay are discussed.