

TITLE: Clay Synthesis: Modeling the Uptake of K^+ during Low-Temperature Illitization of Smectite

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Introduction: Authigenic lacustrine clay sediments have long been recognized as important chemical precipitates in sedimentary environments in East African Neogene lakes. Understanding how these minerals form is important to understanding the paleohydrologic, paleoclimate, and diagenetic histories of lake basins. We designed a suite of clay synthesis experiments to test the role of varying K concentrations during the process of illitization, after layer charge has been increased through Fe reduction. Specifically we are testing the hypothesis that elevated aqueous K concentration leads to enhanced illitization, and that this effect is greater with clays in which Fe has been reduced.

Method: To test this hypothesis, the Clay Minerals Society Fe-rich nontronite clay standard (NAu-1) was artificially reduced by mixing with a sodium dithionite ($Na_2S_2O_4$) solution buffered to neutral pH with sodium citrate – sodium bicarbonate buffer following the methods of Stucki et al., 1993. Clay aliquots were then exposed to solutions of increasing K concentrations in a flask under a nitrogen rich atmosphere. Solution concentrations were based on Lake Dabusun, China, a K-rich saline lake (Spencer et al., 1990). Fluid chemistry was monitored through AA spectroscopy for both reduced and non-reduced samples, before and after experiments. XRD analysis was used for identifying mineralogy (before and after experiments) and XRF analysis was used to identify major element composition (before and after experiments).

Results: Element ratios K_2O/Al_2O_3 and K_2O/TiO_2 in the clay fractions provide evidence of effective uptake of K by the clay minerals. K_2O/Al_2O_3 ratios using raw NAu-1 clay fraction separates were 0.05, 0.19, and 0.93, representing increasing dissolved K concentrations. With reduced nontronite, K_2O/Al_2O_3 was 0.17, 0.45, and 1.47. Therefore, exposure to greater K concentrations leads to greater K uptake, and the effect is stronger in the reduced clay. Further experimentation may focus on microbial reduction of Fe-rich nontronite as opposed to artificial reduction.

Conclusion: The results of the experiments may be used to interpret the geochemistry of paleoclays as well as, in the field of petroleum geology to show the association between the smectite to illite transition and the thermal maturation of organic compounds in the production of petroleum and natural gas.