

Soft X-ray STXM study of clay-salt interactions

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The exchange and re-distribution of cations between clays and the adjacent aqueous environment has been studied using scanning transmission X-ray microscopy (STXM) at ALS beamlines 5.3.2 and 11.0.2 with the goal of identifying mechanisms responsible for structural degradation of salt-affected soils and sediments. Images and spectra of thin films (<5 μm) of nontronite, sodium bicarbonate and their mixtures were measured at the C 1s, Ca 2p, O1s, Fe 2p and Na 1s edges. Both dry, and fully hydrated samples in wet cells, were examined. The anion components of the bicarbonate–nontronite system could be identified from O 1s NEXAFS spectra (Fig.1). Chemical component maps (fig. 2) created from differences of images on/off resonance lines specific to each chemical species, of a dried sample after mixing Ca-saturated clay with 1 M NaHCO_3 indicate that cations and salt species are considerably redistributed. Bicarbonate and Ca^{2+} are associated strongly with the edges of clay platelets, but Na^+ is uniformly distributed throughout the clay particle (probably also on its surface) indicating essentially complete exchange of Ca^{2+} by Na^+ at the charge complex of the clay. Upon re-wetting of the sample, Ca^{2+} was found to be uniformly dispersed throughout the particle and to have lost its prior association with clay platelet edges, indicative of dissolution of a Ca precipitate.

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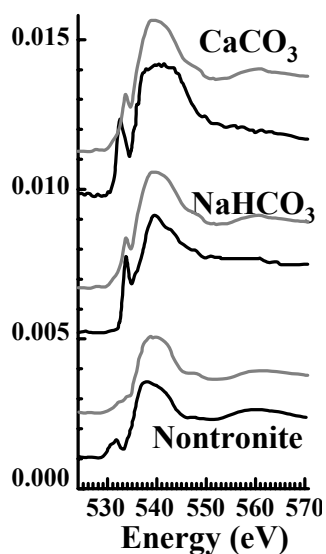


Fig. 1 O 1s spectra of reference minerals (black) compared to spectra from saline clay sample (grey).

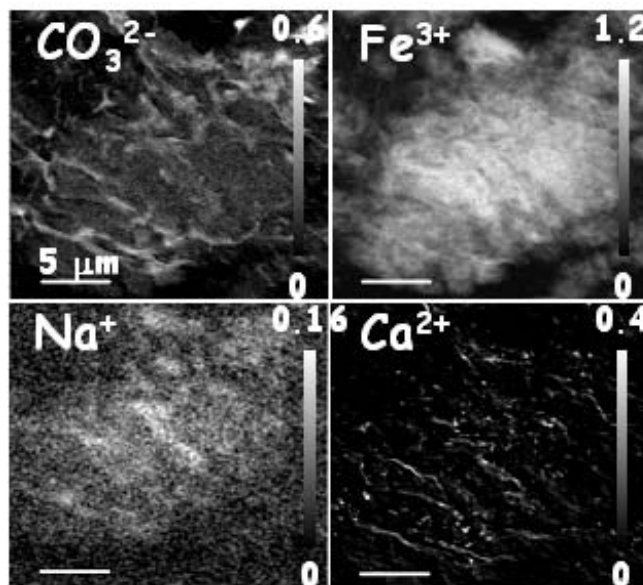


Fig. 2 Maps of carbonate, clay and cations in dry salt-clay mixture from image differences (on/off resonance) at C 1s, Fe 2p, Na 1s and Ca 2p edges. Gray scale limits are difference optical density.