

# Shedding light on carbon-mineral complexation in the soil environment: impacts on C sequestration and cycling

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## *Abstract*

Organic matter (OM)-mineral complexation plays a critical role in soil carbon (C) stabilization. However, direct investigations of organo-mineral associations have been hampered by a lack of methods that can simultaneously characterize soil organic matter and soil minerals. We have applied scanning transmission X-ray microscopy (STXM), combined with near edge X-ray absorption fine structure (NEXAFS) spectroscopy at the C1s, Ca 2p, Fe 2p, Al 1s and Si 1s edges to investigate C distribution and speciation and its associations with Ca, Fe, Al and Si species in soils within the Christina River Basin Critical Zone Observatory (CRB-CZO). Results showed a strong role of Ca in C-mineral association. Fe oxide coatings were more important than aluminosilicates in promoting C-mineral associations. The major C forms associated with soil minerals were aromatic C, carboxylic-C and polysaccharides. Ferrihydrite contributed significantly to organic matter complexation. OM-ferrihydrite complexes can be formed by either adsorption or coprecipitation. We examined these interactions by preparing OM-ferrihydrite complexes at varying C:Fe ratios (0.05-5.36) using dissolved organic matter extracts from a forest litter layer. We monitored C retention capacity, chemical fractionation of OM by UV-Vis spectroscopy, changes in specific surface area (SSA), micro- and mesopore volumes of the OM-ferrihydrite complexes by N<sub>2</sub> adsorption and desorption, and desorbability of the adsorbed and coprecipitated OM associated with adsorption and coprecipitation processes. These studies were combined with NEXAFS and Fourier transform infrared (FTIR) spectroscopy to compare the mechanisms of OM-ferrihydrite complex formation. The STXM-NEXAFS technique was employed to study the spatial distribution, macromolecular structure, and chemical composition of the adsorbed and coprecipitated OM at the nanometer-scale. Our study demonstrated that coprecipitation could result in higher C retention and increased C stability than adsorption in the natural environment.

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