From imaging to understanding: frontiers in chemical imaging of soil carbon dynamics

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Soil carbon cycling occurs in a three-dimensional network of pores, driven by interactions between organic matter, minerals and microbes. Traditionally, these interactions have been examined with bulk isolation techniques that disrupt the physical architecture of soils. However, the advent of minimally invasive imaging techniques capable of obtaining physical and chemical information at the submicron scale has made it possible to study structurally intact soil microenvironments.

This presentation will highlight how high-resolution imaging approaches have provided mechanistic insights into the roles of organic matter composition, mineral-organic assemblages, and redox active metals in controlling the microbial cycling of carbon in soils. Specifically, we will focus on the use of synchrotron-based spectromicroscopy (STXM/NEXAFS, μ-FTIR, and μ-XRF/XAS) and mass-spectrometry imaging (NanoSIMS and VUV-LDPI) to illuminate carbon mineral-microbe-organic interactions in a diverse set of soil microhabitats: soil aggregates, root-soil interfaces, and litter layers. In addition, this presentation will discuss future directions in sample preparation and imaging approaches that could further our understanding of carbon cycling in soil microenvironments.