Revealing Biomineralization and SOM-Mineral Associations with Chemical Imaging Methods

A. Dohnalkova[1]*, L. Kovarik[1], T. Varga[1], Anil K. Battu[1], Y. Jiao[2], D. Park[2], M. A. Marcus[3], O. Krivanek[4], T. Lovejoy[4] and R. Kukkadapu[1]

[1]Pacific Northwest National Laboratory, Richland, WA 99354, USA (*Alice.dohnalkova@pnnl.gov)

[2]Lawrence Livermore National Laboratory, Livermore, CA 94550, USA

[3]Advanced Light Source, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA

[4]Nion, Kirkland, WA 98034, USA

Although macro-scale in nature, most biogeochemical proceses are driven by interactions at the micro- and nano-scale. Therefore, precise characterization of both organic and inorganic system componets requires multi-scale, multi-capability approaches. Here, we present the state-of-the-art characterization of microbial biomineralization and organic matter-mineral associations by high-resolution correlated chemical imaging through a couple examples.

First, a biosorption experiment aimed at recovering rare earth elements (REE) from industrial leachates are discussed. Nd and Gd were effectively extracted using hydrogel beads containing microbial cells in a fixed-bed column. High-resolution elemental mapping by energy-dispersive x-ray spectroscopy (EDS) coupled with scanning transmission electron microscope (STEM) further revealed cell-specific associations of newly formed REE biominerals.

Second, we probe organo-mineral associations between soil organic matter (SOM) and minerals in a marginal soil from Prosser, WA using a suite of chemical imaging methods including STEM, EDS, scanning transmission X-ray microscopy (STXM/XANES) and Energy electron loss Spectroscopy (Aloof EELS). While SOM behavior is notoriously difficult to image and analyze by electron-beam methods, correlated chemical imaging reveals distinct spatial and chemical correlation with Ca^{2+} mineral surfaces, substantiating the theory of 'Ca-OM bridges' crosslinking mechanism. This characterization of the Ca mineral-SOM reactive surface composition in turn strengthens our understanding of processes at mineral-OM interfaces, relevant to the stability of SOM under environmental shifts.

Ultimately, correlated chemical imaging can provide unprecedented insight into the interactions between OM and minerals in a variety of environments.