

## Poster #223

### Metabolic Constraints on Carbon Oxidation Impacting Metal Cycling and Greenhouse Gas Production

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Microbial metabolism of organic carbon has central controls on carbon dioxide and methane efflux from soils and sediments; it also has a primary influence on metal cycling and water quality. Four processes are widely believed to control the stability of carbon in soils and sediments, and thus its potential recycling to the atmosphere. These include 1) physical protection that spatially removes SOM from microbial enzymes, 2) chemical protection via stable bonds between soil minerals and SOM, 3) carbon composition, which determines whether SOM is suitable substrate for decomposition enzymes such as oxidases or hydrolases, and finally 4) climate, specifically cold climates, which can limit chemical and microbial activity due to frozen conditions. These largely physical processes allude to but don't directly capture the biochemical aspect of organic matter decomposition. Soil/sediment organic matter is utilized by microorganisms as an energy source, often as an electron donor. Reduced compounds require greater energy to break down and should not support microbial growth when coupled to low energy electron acceptors. This energetic limitation is seen in enzyme specialization, where enzymes either specialize on less complex hydrolysable compounds or else require oxygen in the case of very complex, often reduced or aromatic, compounds. Thus, whether a given compound is consumed should depend on how much energy it can provide the local microorganisms. Our work seeks to test whether microbial energetics play an important role in soil carbon cycling, and to examine the subsequent influence on metal cycling and greenhouse gas production.

Within the framework of microbial energetics, the presence or absence of oxygen is a key predictor of organic carbon decay pathways. As the most favorable electron acceptor (i.e. highest reduction potential), oxygen maximizes organisms' growth. In the absence of oxygen, alternative electron acceptors such as nitrate, sulfate, etc. are used, often in conjunction with organic matter as an electron donor. Contrary to traditional modeling assumptions, ours and other groups have recently found extensive respiration to be possible under anoxic conditions using alternative electron acceptors such as Fe(III) or nitrate. However, the extent of carbon mineralization under anaerobic conditions depends heavily on the chemistry of the carbon being respired. Furthermore, the importance of specific microbial taxa and communities for promoting SOM breakdown under low-energy (anoxic) conditions is largely unknown.

To test the role of microbial energetics and community structure in regulating carbon mineralization, we constructed flow-through reactors using soils that allow oxygen saturated water to diffuse downward through the soil column. Pore-water and solids were examined at depths corresponding to redox potential, as measured by microelectrodes. Inorganic chemical profiles confirm the establishment of a redox gradient and decreased respiration rates with depth. Carbon analysis via high-resolution mass spectrometry shows buildup of reduced carbon compounds. Near-edge X-ray absorption spectroscopy similarly indicates a loss of oxidized functional groups within the anaerobic domain. These chemical findings suggest that different redox zones lead to unique carbon mineralization pathways predicted using thermodynamic-kinetic models. Microbial DNA and RNA extracted from the different soil depths is being profiled, via metagenomics and transcriptomics, to elucidate communities responsible for carbon transformation within redox zones.