Poster #203

Metabolic Constraints of Organic Matter Mineralization and Metal Cycling During Flood Plain Evolution

Scott Fendorf[1], Marco Keiluweit[2], Hannah Naughton[1], Christian Dewey[1], Peter Nico[3], and Markus Kleber[1]

[1] Stanford University
[2] University of Massachusetts-Amherst
[3] Lawrence Berkeley National Laboratory
[4] Oregon State University

Contact: Scott Fendorf [fendorf@stanford.edu]

Floodplains are poorly understood and dynamic components of the global carbon cycle that not are well represented in Earth system models. Further, they have a dominant influence on the cycling of important metals, such as uranium, within critical transport conduits between surface waters and groundwater. The physical characteristics of floodplains make the hydrology and associated coupled biology and geochemistry particularly responsive to ongoing and impending changes in climate, river management, and land development.

An important control on carbon cycling within soils and sediments is constraints on microbial metabolisms induced by the respiratory pathway, and specifically the electron acceptor in respiration, which further serves to control metal fate and transport. Within floodplain soils and sediments, variations in hydrologic state (water saturation) coupled with structured porous media lead to extensive heterogeneity in redox environments and thus metabolic trajectories controlling organic carbon oxidation.

Combining micro-scale laboratory experiments with field-scale observations, we find that oxygen diffusion limitations lead to heterogeneous redox profiles, shifting microbial metabolism to less efficient anaerobic SOC oxidation pathways. In both saturated and unsaturated systems, microsensor measurements in combination with gas flux measurements showed that particle size exerts a strong control on the extent of the anaerobic volume, thereby causing an overall decrease in OM oxidation rates. In model soils and sediments, we determined the distribution of operative microbial metabolisms and their cumulative impact on SOM transformations and overall oxidation rates within anaerobic microsites. Metabolic profiling showed that texture-induced anaerobic microsites reduced carbon oxidation rates by an order of magnitude relative to aerobic rates, with Fe reduction contributing more than 75% of the overall metabolism. Density separations in combination with C 1s NEXAFS spectroscopy and high-resolution FT-ICR-MS showed that texture-induced anaerobic microsites resulted in the preferentially preservation of reduced (electron-rich) organic carbon compounds (both dissolved and particulate), a result corroborated by field measurements across multiple sites. Near-edge X-ray absorption spectroscopy similarly indicates a loss of oxidized functional groups within the anaerobic domain.

Collectively, our results suggest that anaerobic zones have prominent controls on organic carbon oxidation in both saturate and unsaturated soil/sediment, thermodynamically stranding reduced carbon compounds. Removing anaerobic metabolic constraints upon a shift in oxygenation will stimulate microbial oxidation of thermodynamically protected carbon.