Poster #21-34

Organic Carbon Stability During Fe Redox Reactions: Coupling Geochemistry, Microbiology and Field Monitoring

Yu Yang[1], Eric E. Roden[2], Daniel Obrist[3,4], Annie B. Kersting[5], and Baohua Gu[6]

[1]University of Nevada, Reno, Reno, NV
[2]University of Wisconsin, Madison, Madison, WI
[3]Desert Research Institute, Las Vegas, NV
[4]University of Massachusetts, Lowell, Lowell, MA
[5]Lawrence Livermore National Laboratory, Livermore, CA
[6]Oak Ridge National Laboratory, Oak Ridge, TN

Contact: yuy@unr.edu

BER Program: SBR
Project: University Award

In the past two years, we have coupled geochemistry, microbiology and field monitoring to study the stability and reactions of soil organic carbon during the redox reactions of iron (Fe) minerals.

Our geochemical analysis showed that organic carbon associated with pure phase iron (Fe) oxide minerals (hematite, ferrihydrite) and natural Fe oxides in soils was released to the solution phase in conjunction with the reduction of Fe(III). When natural soils were exposed to an anaerobic- aerobic transition, organic carbon respiration was negatively linked to the amount of poorly crystalline Fe-oxide-bound organic carbon, but positively with the crystalline Fe-oxide-bound organic carbon. These results suggest that generation of poorly crystalline Fe oxides during the re- oxidation processes potentially can sequestrate organic carbon. Other experiments showed that under aerobic conditions, binding with ferrihydrite inhibits the bioavailability of labile substrates such as glucose and formic acid.

We also showed the extracted organic carbon can serve as both electron donor and shuttle for the reduction of hematite and ferrihydrite. In the presence of extracted organic carbon, metagenomes from hematite-reducing cultures had an overrepresentation of genes involved in the degradation of polysaccharides and to a lesser extent aromatic compounds, suggesting complex OC metabolism. Genomic searches for the Porin-Cytochrome Complex resulted in matches to Ignavibacterium/Melioribacter, DIRB capable of polymeric OC metabolism. These results indicate that such taxa may have played a role in both Fe reduction and decomposition of complex OC in anoxic soils and sediments. Metagenomes from ferrihydrite-reducing cultures also showed enrichment of genes that may have contributed to the degradation of complex OC (i.e., lignocellulose) into simpler organic compounds that can serve as electron donors for Fe reduction.

For the tundra soil organic carbon dynamic monitoring, in situ observations of CH_4 and CO_2 concentrations were undertaken within and above the soils at the Toolik Field Station over a 2- year period. Field observations showed both net oxidation of CH_4 and production of CO_2 in tundra soils, and suggest that fluxes of both species from the soil are subject to different temperature sensitivities and hysteresis effects upon freezing and thawing. The dynamics of greenhouse gas emissions can potentially be linked to the redox fluctuations.

Collectively our project has provided unique integrative understanding about the biogeochemistry of organic carbon during the redox reactions of Fe.