Metabolic Constraints on Organic Matter Decomposition and Metal Cycling in Sediment Deposits

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Abstract: Depositional environments such as 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 metal cycling within critical transport conduits to surface and groundwater. Importantly, the fate of carbon and redox active metals such as iron and uranium (and other metal contaminants) are intimately linked. In addition to the global importance of processes controlling carbon cycling, the fate of uranium and other metal contaminants within floodplains are an important consideration for the U.S. DOE. Legacy contamination throughout the Colorado River Basin has led to a host of floodplains with persistent uranium plumes Thus, there is an urgent need to understand the fundamental biogeochemical processes that contribute to or protect against the persistence of redox-active metal and radionuclide contaminants in groundwater.

Herein we propose to examine metabolic constraints on OM decomposition within floodplain sediments, and their impact on metal contaminant fate and transport, using cutting-edge -omics techniques (metagenomics, metatranscriptomics, proteomics and metabolomics) coupled with advanced stable isotope probing and imaging approaches (NanoSIMS). We will examine spatial organization of metabolic pathways within undisturbed sediment cores (representing a range of sediment characteristics) and model systems. Our molecular multi-omics data -- coupling gene expression, protein secretion, and metabolite dynamics -- will be linked to biogeochemical pathways, and results utilized within the integrative, scalable BioCrunch model. Using our multifaceted approach, we will deduce spatial variations in metabolic function and potential within floodplain sediments, and the resulting governance over greenhouse gas emissions and fate and transport of metals.