The Role of Surface-related Microbial Ecology in Organo-Mineral Stabilization of Carbon in Soil

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Project Goals

This project will improve our understanding of fundamental ecological determinants of soil C-cycling and provide insights into the metabolism of diverse non-cultivated soil microorganisms. The specific goals include: mapping the microbial carbon food web using cultivation-independent stable isotope probing (SIP) and identifying metabolism that impacts the stabilization of carbon in soil. These efforts are aimed at placing the ecology of soil communities in the greater context of terrestrial carbon cycling to inform and improve modeling and management practices.

Abstract

Microbial transformations of soil organic matter influence its accumulation and stabilization on soil minerals. Microbial metabolism alters the sorptive and adhesive properties of organic matter (OM) both directly (via enzymatic reactions) and indirectly (by conversion into living and dead biomass). The fate of carbon within organo-mineral complexes depends on a balance of environmental and ecological factors promoting accumulation or mineralization. In previous stable isotope probing (SIP) experiments[1,2] with ^{13}C, we observed that microorganisms that degrade soluble versus insoluble forms of OM exhibit different competitive strategies. The majority of insoluble OM degraders were commonly abundant in soil, yet belonged to groups with few cultured representatives, such as *Verrucomicrobia*, *Chloroflexi*, and *Planctomycetes*. The capacity of these groups to colonize and degrade insoluble OM, and their recalcitrance to culturing, support the hypothesis that their ecology is, in part, linked to surface-mediated interactions, which are difficult to reproduce *in vitro*. We designed SIP experiments to determine whether differences in microbial metabolism of soluble and insoluble substrates in soil cause differences in C-fate. In the first experiment, we used metabolomics and metagenomics to assess the fate of ^{13}C from ^{13}C-glucose and ^{13}C-cellulose (i.e. the insoluble form of glucose) added to soil, and we assessed the fate of ^{13}C from ^{13}C-vanillin added either in soluble or mineral-sorbed form. We hypothesize that metabolite pools from surface-colonizing populations will be more heterogeneous and their genomes will exhibit signatures of metabolic dependency, reflecting greater microbe-microbe interaction in resource exploitation. We expect surface-associated processes to produce more stable OM than processes that take place in soil solution, which we will test using a suite of biological and physical tests for carbon stability. In a second experiment, we will load soil with biomass from ^{13}C-labeled *P. putida* or *B. subtilis* mutants, including both biofilm overexpression and biofilm deficient phenotypes, and use this soil in a SIP experiment to measure differences in metabolism and stability of carbon from their biomass. This on-going research aims to demonstrate how ecological tradeoffs associated with living on surfaces or in soil solution, effect soil carbon cycling and sequestration.

References

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