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Root Influences on Mobilization and Export of Mineral-bound Soil Organic Matter

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Biogeochemical cycles within mountainous watersheds are key regulators of ecosystem carbon storage and downstream nutrient loadings, and they have shown to be particularly vulnerable to climate change impacts. Increasing temperature and persistent droughts have already dramatically changed vegetation cover across the mountainous western US, with unknown consequences for carbon and nutrient cycles in soils belowground. What remains elusive is to what extent associated changes in root-soil interactions may mobilize the vast pool of organic matter (OM) that has been stabilized by associations with minerals for centuries or millennia. Although plant root-driven OM mobilization from minerals may be a central control on carbon loss and nutrient export, such mechanisms are currently missing from conceptual and numerical models.

The overall goal of this project is to identify the (bio)geochemical mechanisms by which roots destabilize mineral-OM associations and the cumulative impact of OM mobilization on the fate of carbon and nitrogen. To accomplish this goal, we initiated model system experiments to assess the vulnerability of isotopically labeled OM bound to different soil minerals to various root-driven mobilization strategies. Our results show that OM bound to mineral phases with the greatest sorptive capacity are also the most susceptible to root-driven mobilization. We further highlight ongoing greenhouse experiments, as well as field-based experiments aiming to quantify the impact of root- driven OM mobilization across a hillslope transect in the subalpine East River watershed.

In addition, we have developed a well-controlled “rhizobox” approach to identify the (bio)geochemical mechanisms roots emploiy to mobilize OM from minerals. Using a combination of spatially-resolved micro(bio)sensors and high-resolution mass spectrometry, our results show how growing roots of *Festuca thurberi*, an abundant grass species across the East River watershed, alter the composition and availability of OM on extremely short time scale. Our data show that OM mobilization in the rhizosphere is linked to root growth, which promotes diurnal changes in redox and pH that control metal precipitation/dissolution. By parameterizing a rhizosphere (hydro)biogeochemistry reactive transport model, we are able to show that such OM dynamics in therhizosphere are directly related to rhizodeposition and water fluxes. In sum, our initial results validate the strong control plant roots exert on the stability of mineral-OM associations in the rhizosphere and, thus, on the potential for C and N export from watersheds.