

Organo-mineral Interactions of Manganese and Iron Oxides in Arctic Tundra

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Climate change is rapidly warming Arctic tundra. Permafrost thaw associated with warming changes soil saturation and associated redox conditions by creating flow paths in the seasonally thawed active layer that either drain soils or form depressions that pool water. In oxic soils, redox-sensitive elements like iron (Fe) and manganese (Mn) can form organic complexes or insoluble oxides; in reducing conditions, Fe/Mn oxides undergo reductive dissolution. Previous studies have found that Mn and Fe oxides sequester organic matter while Mn oxides can sequester or degrade organic matter. Our purpose is to understand interactions of dissolved organic matter with Fe and Mn oxides in permafrost-underlain tundra soils. Quartz sand was coated with synthetic hydrous Mn oxides (HMO) or ferrihydrite (Fh) or left uncoated, encased in 5 μm mesh bags, and buried for up to 28 days in the shallow active layer of dry hilltop and wet valley soils along a hillslope transect near Toolik Lake, Alaska. Mineral-coated sands were analyzed for total C and dithionite-extractable Fe and Mn. Surface Fe and Mn oxidation states and C functional groups were examined using X-ray photoelectron spectroscopy. Additionally, concentrations of dissolved ($<0.02 \mu\text{m}$) and colloidal ($0.02 - 0.45 \mu\text{m}$) Fe, Mn, and organic C were measured in wet soils. Manganese concentrations in HMO-coated sand decreased while Fe concentrations in Fh-coated sands stayed constant over time. Surface Fe and Mn oxidation states decreased, suggesting reactivity with organic C. Total C increased over time in all treatments. Fh-coated sands had the highest C concentrations, but Mn oxides accumulated the most C when normalized to surface area. Organic C became more oxidized over time for all minerals. In porewaters, colloidal organic C was strongly correlated with Fe but not Mn, indicating colloidal Fe oxides may sequester organic C. In addition, the correlation between Fe and DOC suggests colloidal Fe oxides affect organic C movement within the active layer. These results suggest that ferrihydrite accumulates more C than Mn oxides or quartz and may contribute to C retention in soils where ferrihydrite forms. In comparison, reductive dissolution of Mn oxides may limit its ability to sequester organic C.