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Landscape Change and Metal Transport in Arctic Watersheds

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To understand landscape-scale watershed dynamics in arctic regimes, it is critical to investigate abiotic and biotic interactions in the transition zone, where the active layer meets the permafrost. Permafrost, which is a considerable component of arctic soils, contains a unique interface at the transition zone characterized by a sharp redox gradient and a phase change from liquid water to ice. The biogeochemical composition and environmental conditions at this interface influence reactivity—i.e., as permafrost thaws, a higher proportion of interfacial water may be present, disrupting the localized microenvironment. Associated changes in the amount of unfrozen water present will likely affect redox environment, microbial activity and diversity, speciation, water density, conductivity, and soil wettability.

Imnavait Creek is a tundra stream on the North Slope of Alaska where we collected soil and water samples across seasonal thaw and coupled ground penetrating radar (GPR) and electrical resistivity tomography (ERT) to characterize watershed active layer thickness and identify permafrost extent across the stream, respectively. Our work shows the permafrost-active layer interface is a reducing zone highly susceptible to mass flushing of redox active elements (e.g. iron; Fe) if thawed and this mass flush will likely occur in late fall/early winter. Additionally, we observed high concentrations of Fe in the nearby surface water in late fall/early winter corresponding to when the soil surface is frozen, but the active layer is at its deepest annual depth. As permafrost degradation accelerates, there will be rapid changes to the first 1-2 meters of the soil with potentially significant chemical and biological changes occurring near the permafrost-active layer interface.