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Mercury Dynamics in Permafrost-Affected Watersheds from MIS 3 through the Holocene: Insights from Alaskan Lake Sediment Record



Permafrost soils are among the largest terrestrial reservoirs of mercury (Hg). With accelerated permafrost thaw driven by anthropogenic greenhouse warming, substantial amounts of Hg are projected to be released into northern watersheds. Mercury in aquatic environments is of particular concern because its methylated form, methylmercury, is highly toxic, bioaccumulative, and poses risks to ecosystems and human health.

This research examines how past climate changes influenced Hg mobilization from permafrost-affected watersheds using well-dated, millennial-scale sediment records from four Alaskan lakes.

During the cool, dry conditions of the Last Glacial Maximum and the more moderate Marine Isotope Stage 3, the records show relatively low Hg concentrations, with mobilization primarily associated with mineral sediments. As the climate became progressively warmer and wetter during the Holocene, two distinct mechanisms of Hg transport emerged. In watersheds that remained under continuous permafrost, Hg mobilization was dominated by dissolved-phase transport through saturated, organic matter-rich active layers, resulting in low but stable Hg fluxes and elevated concentrations. In contrast, catchments that transitioned to discontinuous permafrost during the early Holocene experienced enhanced fine-sediment delivery, leading to higher Hg concentrations and pronounced flux variability. These findings place current and projected Hg release from permafrost-affected watersheds into a long-term context, as the variability recorded during past climate warming provides a reference point against which the impacts of modern, greenhouse gas-driven warming can be evaluated.

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