

From Rust to Risk: The Mobilization of Trace Elements in Kobuk Valley, Alaska

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Kobuk Valley National Park, one of the most remote and pristine wilderness areas in the United States, is experiencing significant environmental changes due to climate-induced permafrost thaw. As Arctic temperatures rise, previously frozen ground is melting, exposing once-buried minerals to the atmosphere. This thaw has led to observable shifts in water chemistry, most notably in the Salmon River, with the water gaining an orange-hue and rainbow-like sheen. Unlike anthropogenic contamination which may result from mining or infrastructure development, these changes stem from the oxidation of pyrite and other sulphide minerals that were once locked in frozen ground. The oxidation of these minerals releases iron and sulphuric acid into the water, leading to acidification and the formation of iron-rich precipitates. This process not only alters the river's appearance but also mobilizes trace elements such as arsenic, cadmium, lead, and copper. These metals pose significant ecological and human health risks. Elevated concentrations of these contaminants can be toxic to aquatic organisms, disrupt food webs, and compromise water quality for downstream communities. Similar processes have been observed in other Arctic and sub-Arctic regions, underscoring the broader implications of permafrost thaw in driving natural acid rock drainage.

To better understand these transformations, weathered rocks, iron-rich precipitates, and sediments were collected from affected streams for analysis. These samples were examined using a range of techniques, including thin section analysis, inductively coupled plasma mass spectrometry (ICP-MS), secondary electron microscopy (SEM), and Fe-isotope analysis to determine the speciation and distribution of trace elements and assess their potential for environmental release. Given the rapid pace of climate change, continued investigation into these geochemical shifts is essential for predicting and managing their environmental impact.