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Natural attenuation of mine drainage-borne zinc in permafrost of Northern Canada

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In this study the natural attenuation of zinc in mine drainage was investigated at the northern limit of the discontinuous permafrost zone in central Yukon Territory of northern Canada. The mine drainage contained ∼150mg/l Zn; where these same waters enter the receiving environment, the Zn concentrations have been reduced to ∼2mg/l. Site investigation of the water balance indicates a minor degree of dilution. Water samples collected at sites along the longitudinal mine drainage path showed no temporal trends, but clearly outlined a dramatic decrease in Zn concentrations with distance from the adit. Soil samples of upper organic and lower mineral horizons showed that Zn concentrations are elevated in samples in contact with mine drainage; upper organic horizon samples in particular were found to contain highly anomalous Zn levels. Laboratory investigation of the collected samples for batch adsorption tests showed that organic soils have the highest Zn attenuation capacity; in particular, organic soils from the midpoint of the site were found to have the highest adsorptivity. Similar results were obtained in column leaching and desorption tests, with organic samples from the midpoint of the site having both the highest Zn attenuation capacity and the greatest degree of Zn retention under increasingly aggressive desorption conditions. Selective extractions of the collected soils showed that the oxide fraction was the repository for much of the soil zinc. In the organic soils in particular, the oxide fraction dominates the geochemical fractionation of Zn. Manganese in high concentration was removed from the mine drainage simultaneously with Zn. Co-precipitation of Mn-Zn oxides appears to be the dominant process for natural attenuation of Zn.