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Geochemical evolution of legacy tailings and associated waters at the former Hanson Lake Mine, Saskatchewan, Canada

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The former Hanson Lake Mine is located ~65 km west of Creighton, Saskatchewan, Canada. This underground mine produced Cu-Zn and Pb-Zn concentrates from a Paleoproterozoic volcanogenic massive sulfide ore deposit located beneath Hanson Lake. Sulfide mineralization occurred in two zones, with sphalerite, chalcopyrite, and galena accompanied by variable amounts of pyrite, pyrrhotite, and arsenopyrite. The mine discharged ~113,000 m^3 of sulfide-rich tailings into a ~38,000 m^2 tailings pond from May 1966 to July 1969. Sulfide mineral oxidation within the tailings beach has generated acid and metalliferous drainage (AMD) characterized by low pH and high dissolved metal concentrations. We have observed extensive accumulation of secondary Fe (jarosite), As (scorodite, bukovskýite, zýkaite) and Pb (beaverite, anglesite) phases in the vadose zone, while pyrite, arsenopyrite, sphalerite, galena, and chalcopyrite persist below the water table. Corresponding tailings pore waters exhibit pH values ranging from approximately 2 to 6, with maximum dissolved concentrations of Fe, Al, and Zn exceeding 1,000 mg L^{-1}. Extremely high As concentrations, which can exceed 10,000 mg L^{-1}, complicate potential for critical mineral recovery from these legacy tailings. We found evidence of AMD migration in adjacent wetlands, where acidic surface and groundwaters persist downgradient of the tailings beach. However, substantial pH buffering and metal attenuation occurs within these wetlands, and we found limited evidence of sulfide-mineral oxidation in water-saturated tailings collected from the beach and pond. Although sulfide-mineral oxidation has led to substantial acid generation and metal release, we also found significant potential for AMD mitigation within the tailings pond and downgradient wetlands at this legacy mine site.