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Tailings Characterization at the Former Lake George Antimony Mine, New Brunswick, Canada: Implications for Remediation and Critical Mineral Recovery

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Mine tailings represent both long-term environmental liabilities and potential secondary resources for critical minerals. The abandoned Lake George Antimony Mine, once the largest primary antimony (Sb) producer in North America, contains approximately 1,250,000 tonnes of tailings generated during flotation processing to produce Sb-rich concentrates between 1971 and 1996. Today, the tailings are stored in an unlined impoundment and exposed to ongoing weathering. The tailings are enriched in Sb, arsenic (As), and gold (Au) and are the focus of ongoing assessments to evaluate both environmental risks and potential opportunities for resource recovery. This study integrates bulk geochemistry, quantitative mineralogy (Rietveld XRD and mineral liberation analysis (MLA)), acid-base accounting (ABA), and analyses of surface waters and tailings pore waters to evaluate metal(loid) mobility and reprocessing potential. The tailings are comprised mainly of silicates (92–98%), including quartz, mica-group minerals, and mixed-layer clays, with minor carbonates and sulfides, such as pyrite, arsenopyrite, stibnite, and berthierite. MLA-based sulfur deportment analysis demonstrates that sulfur is predominantly hosted in pyrite, followed by arsenopyrite, stibnite, and berthierite, confirming that the oxidation of sulphide and sulfosalt minerals is the primary driver of acid generation and associated metal(loid) release. The occurrence of secondary phases, such as jarosite and Sb–Fe oxides in oxidized tailings, further confirms active sulfide weathering and localized acid formation. The tailings contain median concentrations of 2750 ppm Sb (400–7140 ppm), 4330 ppm arsenic (240–13,200 ppm), and 370 ppb gold (1–1500 ppb), reflecting incomplete historical recovery. Acid-base accounting indicates that most tailings are potentially acid-generating; however, circumneutral surface and pore waters on-site suggest that residual carbonate minerals currently provide temporary buffering capacity. The identification of sulfur-hosting phases provides evidence supporting the feasibility of sequential reprocessing and remediation strategies. Selective flotation could be applied to recover Sb-bearing minerals, such as stibnite and berthierite, followed by targeted desulfurization to reduce the residual sulfides, particularly pyrite and arsenopyrite, thereby decreasing acid generation potential and improving the long-term environmental stability. The results of this study will be combined with recent environmental assessment data to support the development of long-term mine waste management and reprocessing strategies at the Lake George site.