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Speciation and recovery of arsenic and antimony from mine tailings

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Antimony (Sb) and arsenic (As) are identified critical elements in many countries, including Australia, the USA and European Union. The growing demand for critical minerals, including Sb and As, necessitates the identification of new, cost-effective sources. Assessing the mineral content and speciation in mine tailings is urgently needed to evaluate their potential as a sustainable secondary supply. However, recovering critical minerals from mine tailings is unlike initial bodies due to lower concentrations and modified mineralogy. This is especially important information when considering historic tailings with a higher degree of weathering.

The aim of this study is to investigate 1) speciation of As and Sb in mine tailings, and 2) recovery pathways for effective extraction of As and Sb from tailings. Tailings were sampled and characterized for elemental composition and mineralogy using x-ray diffraction, x-ray photoelectron spectroscopy (XPS), and electron microscopy. The site examined is an operating gold-antimony mine in Victoria Australia, with an approximate tailings volume of 1 x 10^6 Mg of tailings.

To examine the potential recovering critical minerals from tailings, we employed a low-temperature acid-iron chloride extraction over 90 minutes of reaction. This included 0.5 M solutions of ferric chloride, ferrous chloride, and a mixed Fe(III):Fe(II) chloride solution (0.5M Fe) in HCl solutions. The average arsenic concentration was 379 mg/kg (165-726 mg/kg) and average antimony concentration was 2313 mg/kg (873-4990 mg/kg). Mineralogical characterisation via XPS of arsenic in the tailings samples suggested a high proportion (80%) of the samples to be arsenate with trace amounts (20%) of arsenite and an atomic percentage of 7%, and Sb existing largely as stibnite. Kinetic trials demonstrated that ferric chloride was the most effective extractant, with 760 g Sb/Mg extracted over 90 minutes reactions, in agreement with Sb recovery approaches for stibnite ores. This study demonstrated the value in weathered mine as a source of arsenic and antimony, with effective extraction methods identified.