

Revalorising Historical Tin Mine Wastes: A Sustainable Source of In, Sn, Sb, W and Bi

Rosie Blannin¹, **Steve Chingwaru**¹, Nathan Fox¹, Olivia Mejías¹, Anita Parbhakar-Fox¹

¹University Of Queensland, Brisbane, Australia

Demand for critical elements such as In, Sn, Sb, W, and Bi is increasing due to their importance in advanced technologies, renewable energy systems, and strategic industries. However, global supply remains uncertain because many of these metals are produced as by-products, are geographically concentrated, and have declining discovery rates. Reprocessing historical mine waste offers a sustainable alternative by recovering valuable metals without new mining, while simultaneously reducing environmental liabilities associated with legacy tailings.

This study evaluates mine waste from eight legacy sites in the Herberton Sn–W–Sb–Bi mineral field, Australia, as a secondary resource for In, Sn, Sb, W, and Bi. A multi-scale characterisation workflow integrating bulk geochemistry, automated mineralogy, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), and gravity recovery modelling was applied to determine element concentrations, mineral hosts, and recovery potential.

Results reveal significant enrichment of critical elements, with maximum concentrations of In (1,155 ppm), Bi (3,640 ppm), Sb (53,600 ppm), Sn (81,600 ppm), and W (11,650 ppm). Element deportment varies systematically between samples. Lower-grade materials host critical elements primarily within secondary Fe–Sn–Pb–Sb phases, whereas higher-grade materials contain these elements within primary sulphides (chalcopyrite, pyrite, tetrahedrite, sphalerite, and bismuthinite) and Sn–W oxides.

Gravity separation modelling indicates potential recoveries of 22–85% In, 53–99% Sn, 26–91% Sb, 13–91% W, and 26–51% Bi. Reduced recoveries are associated with silicate locking, fine grain size, and secondary mineral hosts.

These results highlight the substantial untapped potential of historical mine waste in the Herberton mineral field as a secondary source of critical elements. The integration of mineralogical characterisation with geometallurgical modelling demonstrates that legacy mine wastes can represent viable resources for critical mineral supply while supporting more sustainable and circular mineral development.