

From Penalty to Opportunity: Geometallurgical Characterisation of Gold Concentrates and Tailings for Critical Metal Recovery Using Novel Solvents

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Bismuth, tellurium and tungsten are widely classed as critical metals due to their strategic importance and limited supply. It is crucial to diversify the sources of these metals, whilst minimising environmental impact. By-product recovery at operational gold mines could be a promising part of the solution, as gold deposits are often enriched with other rare metals. Recovery of by-products from existing mines would increase supply and reduce the need for new mines, avoiding additional environmental impact and long lead times. Unrecovered by-products may report to tailings, metallurgical wastes or facility emissions, incurring penalty fees and adding to the environmental burden of mines.

This work is a case study with Björkdal Gold Mine in Sweden. It investigates geometallurgical properties of Bi, Te, and W minerals, tracing these through mineral processing, and tests a recovery process involving environmentally-benign Deep Eutectic Solvents (DESs).

Samples from the mineral processing input and outputs underwent detailed mineralogical characterisation and bulk geochemical analysis. Automated SEM-EDS revealed near-total deportment of both bismuth and tellurium into tsumoite (BiTe), and 100% deportment of tungsten into scheelite. The characteristics of both tsumoite and scheelite differed greatly between the different concentrates and the tailings, with particle size, grain liberation, and susceptibility to froth flotation the key parameters for recovery. Two concentrates had promising tsumoite characteristics for a tailored DES-based recovery with an oxidising agent. Dissolution rates were examined through optical profilometry, which, together with the mineralogical data, informed a model for bulk leach behaviour to compare with experiments. Efficient, selective leaching of Bi and Te is possible even at 30°C. Although scheelite does not leach, a multi-step process can produce a tungsten-rich residue.

Selective leaching of bismuth and tellurium from gold concentrates is promising for on-site by-product recovery, and highlights the importance of geometallurgy for understanding by-product behaviour in mineral processing.