

Mineralogical Distribution of Critical Minerals in Value and Waste Streams: An Example From a Porphyry Cu Mine

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The mineralogical hosts of critical minerals (CM) control their partitioning into value or waste streams during ore processing, which can lead to CM-enriched mine waste. Therefore, mineralogical characterization is a key component in evaluating mine waste as a potential source of CMs. We examine the chemical and mineralogical deportment of mineral commodities into mill and smelter output streams at the Bingham Canyon porphyry Cu-Mo mine, Utah, using whole-rock chemistry and microanalytical approaches including electron microscopy, laser ablation inductively coupled plasma mass spectrometry and automated mineralogy.

At the Bingham Canyon mine, after flotation of the crushed ore to separate the primary commodities, the tailings contain CMs as sparse discrete minerals (e.g., Te in tellurides or sulfosalts, Ge in catamarcaite, REEs in monazite). Additionally, a significant proportion of some CMs, such as Co, Ni, and Te, are hosted in gangue pyrite in tailings either within the pyrite structure in solid solution or as nanometer- and micrometer-sized inclusions. The association of these CMs with pyrite in tailings suggests generating a pyrite separate may concentrate them. During smelting of Cu concentrates, a slag waste is generated. The critical minerals Bi, Pb, and Sb associate with immiscible blebs of chalcocite and Cu-arsenide, whereas Mo and Zn partition into silicate and oxide phases in the smelter slag. During the crushing and flotation of this slag to recover residual Cu, elements associated with the silicate and oxide phases mostly end up in the slag tailings, while those associated with the Cu-rich blebs are recycled into the furnace. Heterogeneity of waste streams from over 100 years of processing at this site is likely high, but documenting the mineralogical distribution of these elements in monthly composites and grab samples is an important first step in determining approaches to concentrate them for recovery.