

Overcoming Challenges with Characterizing Mine Waste for Resource Recovery: Insights Using Automated Mineralogy

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Detailed mineralogical characterization of critical minerals (CM) and other valuable commodities in mine wastes is essential for assessing resource potential. Automated mineralogy analysis (AMA) has become a workhorse in mineral processing industries for determining elemental partitioning, mineral abundance, and liberation (ore-bearing particle separation) in ores, which inform geometallurgical approaches for target commodity recovery. Challenges to using AMA to analyze mine wastes include the absence of AMA standard reference materials and the limited characterization of heterogeneous mine waste materials. To overcome these challenges, we developed a grain mount standard by combining known quantities of five common minerals to validate AMA instrument and analyst performance for modal abundances. We also developed a unique energy dispersive spectrometer (EDS) mineral library, informed and validated by powder X-ray diffraction and electron probe microanalysis for each mine waste sample set.

Varying acquisition parameters along with development of sample-specific mineral classification schemes were necessary for each sample set. A common classification challenge was mixed spectra due to features that are similar in size to the electron beam interaction volume ($\sim 2 \mu\text{m}^3$). For example, a slag sample containing magnetite (Fe_3O_4) needles intergrown in Si-rich glass matched the EDS spectra of fayalite (Fe_2SiO_4). Correct assignment required energy level filtering of trace elements (Al for glass, Mg for fayalite) combined with back-scattered electron thresholding. Another recurring challenge was the low EDS detector sensitivity for low atomic number elements. In a weathered tailings sample, fine-grained weathering rims of hemimorphite ($\text{Zn}_4\text{Si}_2\text{O}_7(\text{OH})_2 \cdot \text{H}_2\text{O}$) and smithsonite (ZnCO_3) on quartz were classified by using the count ratios of EDS energy ranges associated with C, O, and Si.

Recognizing, understanding, and overcoming analytical challenges resulting from the mineralogical properties of mine waste are key to utilizing AMA properly, a necessary first step in applying AMA to evaluate the recovery potential of CM in mine wastes.