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Evaluating sulfide minerals in mine tailings from volcanogenic massive sulfide and sedimentary exhalative zinc-lead deposits as a potential source of critical mineral resources

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Waste products from ore processing that contain high concentrations of gangue sulfide minerals, such as pyrite and pyrrhotite, may represent a source of critical minerals (CMs). CMs are frequently associated with sulfide minerals either as discrete minerals or as trace elements in base-metal sulfide minerals. Further, sulfide-rich tailings can represent a significant environmental burden and financial liability for mining companies, governmental agencies, and local communities. Reprocessing tailings can serve the dual purpose of mitigating environmental risks and providing a source of CMs. However, the viability of reprocessing for CM extraction is affected by both the concentration and mineralogical host of CMs within tailings.

A suite of mill tailings from VMS and SEDEX deposits from the United States, Canada, and Finland was examined using SEM-EDS and EMPA analyses in order to evaluate sulfide-hosted CM abundance. Based on prior analyses of bulk chemistry and mineralogy [1,2], 11 samples containing >2% sulfide minerals were selected for analysis. Semi-quantitative elemental concentrations collected by energy-dispersive spectroscopy (EDS) and quantitative elemental concentrations collected by wavelength-dispersive spectroscopy (WDS) reveal that CM concentrations vary both between deposit types and between individual mineral grains within a tailings sample.

Based on preliminary EDS analyses, ~1% of pyrrhotite grains from ultramafic VMS deposits contain trace to minor Co (~0.7 wt%), with rare grains containing trace Ni. In comparison, ~2% of pyrrhotite grains and ~8% of pyrite grains from SEDEX deposits contain trace to minor Co (~0.5 wt%) but neither contained EDS-detectible Ni despite bulk chemistry analyses finding similar concentrations of Ni in the SEDEX and ultramafic VMS samples. These differences in CM content and mineral distribution in tailings from different deposit subtypes are consistent with geologic differences in the parent ore material. Additional analyses are ongoing to understand the distribution and concentration of CMs in sulfides within samples from other VMS and SEDEX deposits. Understanding the relationship between base-metal sulfide mineralogy and CM concentration is key to evaluating the resource potential of mine waste materials.

[1] Green, C. J., Seal II, R. R. & Piatak, N. (2020) doi:10.5066/P9IWPGM7.

[2] Green, C. J., Seal, R. R. & Piatak, N. (2022) doi:10.5066/P9GZKFUO.