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Geochemical Characterization of W, Cu and F Skarn Tailings at Yxsjöberg, Sweden

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Abstract

Little attention has been paid to tailings from skarn ore deposits and their environmental impact, even though they can contain elevated concentrations of elements of potential concern together with sulfides and fluorite. Historical skarn tailings at Yxsjöberg, Sweden, containing e.g. Be, Bi, Cu, F, Sn, S, W, and Zn were geochemically characterized as a first step to evaluate the environmental impact and the potential to re-mine the tailings. The tailings were deposited between 1897 and 1963 in the Smaltjärnen Repository without dams or a complete cover, and have been in contact with the atmosphere for more than 30 years. Four vertical cores throughout the tailings were taken and divided into 134 subsamples, which were analyzed for total concentrations and paste pH. Selected samples from different depths were mineralogically characterized using optical microscopy, scanning electron microscopy (SEM) with energy dispersive X-ray spectroscopy (EDS), Raman vibrational spectroscopy, and X-ray diffraction (XRD). Minerals, hand-picked from drilled rock cores, were analyzed for the element content, and a modified Element to Mineral Conversion (EMC) that pinpoints the quantitative distribution of elements between the minerals in the tailings was carried out. The average concentrations of Be, Bi, Cu, Sn, Zn, W, F and S in the tailings were 284, 495, 946, 559, 301, and 960 ppm, and 1.9 and 1.2 wt.%, respectively. The tailings has reached a late stage development due to pyrrhotite oxidation resulting in low pH (<4) in the uppermost tailings, and formations of secondary minerals such as gypsum, hydrous ferric oxides (HFO) and orthogonal calcite. Secondary pyrite and magnetite, formed from monoclinic pyrrhotite was detected, and different weathering rates of secondary pyrite, hexagonal and monoclinic pyrrhotite was indicated, with secondary pyrite as the most stable and monoclinic pyrrhotite as the least. The rare and easily-weathered mineral danalite ($Fe_4Be_3(SiO_4)_3S$) was found in the drilled rock cores and by XRD in the tailings. However, the mineral could not be found by optical microscopy or SEM-EDS. This suggests that the mineral has been weathered to a great extent, which poses a high risk of releasing elements of potential concern to the groundwater since danalite contains approximately 40% of the total Be and Zn