Forensic tracing of historical environmental conditions and danalite weathering in mineralogically-complex mine wastes: A $\delta^{34}S$, $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ isotopes approach

M. SALIFU[1*], T. AIGLSPERGER[1] AND L. ALAKANGAS[1]

[1]Luleå University of Technology, 97187, Luleå, Sweden

([*]correspondence: musah.salifu@ltu.se)

Knowledge of mineral weathering processes and historical environmental conditions in mine wastes with complex mineralogy is central to developing acid mine drainage (AMD) attenuation methods. In this study, elemental contents, $\delta^{34}S$, $\delta^{18}O$ and $^{87}Sr/^{86}Sr$ isotopes of ore minerals, solids and water-soluble fractions (WS) of a Cu-W-F skarn tailings in Yxsjöberg, Sweden, were used as tracers of past environmental conditions in the tailings and weathering of danalite [$(Fe, Mn, Zn)_4Be_3(SiO_4)_3S$], a rare sulphur-bearing silicate containing high concentrations of Be and Zn. Eighteen subsamples from a drill core of the tailings were subjected to batch leaching tests to obtain water-soluble fractions. The tailings were divided into 3 geochemical zones: oxidized (OZ), transition (TZ) and unoxidized zones (UZ), based on existing pH and chemistry. $\delta^{34}S_{SO4}$ values of the WS in the OZ, TZ and upper UZ (UUZ) suggest pyrrhotite and danalite weathering in the upper OZ (UOZ) of the tailings and mobilized downwards. Low $\delta^{34}S$ fractionation (+0.9 ‰) between pyrrhotite and SO_4^{2-} coupled with low $\delta^{18}O_{SO4}$ values (-3.5 to -5.2 ‰) in the lower OZ, TZ and UUZ suggest the complete oxidation of pyrrhotite by Fe^{3+} when pH<3 in the tailings. Thus, AMD conditions had previously existed in the tailings and may have led to the mobilization of metals into groundwater and downstream surface water bodies. The fact that Fe^{3+} is a rapid oxidant of S at pH<3 is also indicative of a faster oxidation rate in the UOZ during the early stages of the tailings oxidation. $\delta^{34}S_{SO4}$, and $^{87}Sr/^{86}Sr$ ratios in the UUZ suggest the dissolution of gypsum which precipitated from a leachate with the isotopic composition of danalite.