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Mineralogical evidence of Tungsten (W) mobilization from Scheelite in alkaline reduced legacy mine tailings: Implications on mine waste management strategies

LINA P.B HÄLLSTRÖM AND DAWN MAY PATILAN
Luleå University of Technology

Tungsten (W) is classified as an emerging contaminant of concern due its unexpected high mobility in the terrestrial environment and its adverse impact on human health. It is also classified as the most economically important EU-critical raw material, with extraction expected to double fold within five years[1]. Knowledge regarding W geochemistry is limited, yet crucial for develop efficient mine waste management strategies to avoid mobilization to the surrounding environment. Tungsten is primarily hosted by oxides, but waste management has traditionally focus on sulfidic waste, to generate an anoxic environment, thereby preventing acid mine drainage (AMD). Little is known regarding the stability of W-oxides under anoxic conditions. Legacy mine tailings from Scandinavia's largest W deposit were studied for 10 years to elucidate geochemical conditions mobilizing W[2]. Two different Tailings Storage Facilities (TSF) containing waste from the same ore, were compared: (i) *Smaltjärnen* (1912-1963), which was dry stacked for more than 100 y, and (ii) *Morkulltjärnen* (1969-1989), which was water saturated and covered with 2 m of peat. Tailings from different depths in both TSFs were analyzed with geochemistry and mineralogy, and groundwater was sampled monthly using dialysis (<1 kDa). This is one of the first field studies to mineralogically confirm that W has mobilized from scheelite in the alkaline anoxic conditions of TSF Morkulltjärnen, resulting in very high concentrations of truly dissolved W in the groundwater (max: 37 mg/L). The genesis of Scheelite weathering was revealed by subhedral and anhedral morphologies and decreased W in the crystal lattice. Mine drainage with dissolved W had reached surface water, groundwater and a nearby drinking water aquifer (>0.8µg/L). These findings demonstrate that the traditionally used mine waste management strategy - maintaining an anoxic environment - is unsuitable for W-bearing waste, but it has efficiently reduced the release of other metals in the tailings, such as Be, Al, F, Fe and SO_4. Therefore, oxides, fluorite and silicates should be separated from sulfides and carbonates at the processing stage, and stored separately to minimize environmental impact.

[1] Bolan et al. (2023). Environment International, 108276.

[2] Hällström et al. (2020). Environmental Science and Pollution Research, 27, 6180-6192.