Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.35417

Dissolved organic matter composition controls on critical mineral extraction in coal mine drainage

ELIZABETH J TOMASZEWSKI[1], BONNIE MCDEVITT[1], MATTHEW VARONKA[1], JACQUELINE GREEN[2], AMELIA SKINNER[3], MARTIN KUREK[3], JACOB VANDERROEST[3], THOMAS BORCH[3] AND AARON M JUBB[1]

[1]U.S. Geological Survey
[2]US Geological Survey
[3]Colorado State University

Coal mine drainage (CMD) can be elevated in critical minerals (CMs) such as cobalt (Co), manganese (Mn), nickel (Ni), zinc (Zn), and rare earth elements (REEs), with orders of magnitude higher concentrations (100s-10,000s of mg/L) than surface waters, which typically have <50 mg/L of these elements. Coal rank (i.e., bituminous vs. anthracite) can influence critical mineral content in CMD and can shape dissolved organic matter (DOM) composition. DOM plays a vital role in the speciation, solubility, and mobility of metals; however, DOM-metal interactions in CMD have not been extensively investigated. Here, we analyzed DOM and dissolved CM relationships in untreated CMD at eight anthracite and six bituminous sites in Pennsylvania, USA to better understand the potential for critical mineral extraction and processing.

Across sites, untreated bituminous CMD had higher maximum concentrations of dissolved CMs such as SREEs (200 mg/L vs 75 mg/L), Mn (20,000 ug/L vs 4,000 mg/L), and Zn (2,700 mg/L vs 600 mg/L) compared to untreated anthracite CMD. Excitation-emission matrices showed fluorescent peaks representative of biologically derived aliphatic (peak T) and terrestrial (peak A) carbon in CMD from both coal ranks. Inverse linear correlations between SREEs and peak T intensities were present in anthracite CMD and varied throughout three seasons of sample collection (R^2=0.51-0.84), whereas this correlation was not observed in untreated bituminous CMD in the single season sampled. In summer months, peak A intensities were correlated with multiple elements including Co, Ni, REEs, and Zn (R^2=0.4-0.87) in both anthracite and bituminous CMD. The results suggest molecular differences in DOM at anthracite and bituminous CMD sites, which could be attributed to coal rank as well as environmental factors such as adsorption processes with mine waste precipitates, seasonality, and/or microbial community dynamics. DOM structure and the influence on CM dynamics in CMD will be further probed using high-resolution mass spectrometry. Elucidating organic and inorganic geochemical interactions in these systems is vital to optimizing downstream processing of CM, which may involve separation based on size and/or molecular properties such as hydrophobicity, both of which may be altered as a result of organometallic complex formation.