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Bioavailability and environmental behavior of critical and trace elements in mineral deposits and mine wastes using synchrotron-based X-ray techniques

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There has always been a link between mining and energy production/storage, from the earliest coal mines to U/Th mining for nuclear power, and now for the critical elements required for green energy (lower CO_2 emissions per generated kilowatt hour relative to traditional sources). Many of the critical elements occur at trace levels (0.01–0.1 weight % bulk) in the ore of other (primary) commodities, at levels comparable to or even lower than those of potentially toxic trace elements (PTTE; e.g., As, Cd, Cr, Hg, Pb, Se) whose effects on human and environmental health are better studied. Most critical elements are also PTTE, but current knowledge of their toxicity is primarily limited to human health and derived from studies of occupational exposure. The types and scales of environmental impact resulting from large-scale increase in production and processing of critical PTTE are not adequately understood. In this talk, I will summarize several studies of PTTE and critical elements in unmined mineral deposits and mine wastes to illustrate how synchrotron-based spectroscopic methods (including but not limited to X-ray absorption and X-ray fluorescence) have been used over the past 2 or more decades to provide unique *in situ* information on the valence and coordination environment of trace elements to support a wide variety of mineral resource, environmental, and human health studies. Specific systems to be discussed include (A) coal fly ash residuals, (B) waste rock analogs of low-sulfide Ni-Cu-PGE deposits; (C), Ni-Co laterite deposits, (D) Au and Au/Ag mine wastes, and (E) seafloor Fe/Mn crust deposits. Topics investigated in these systems include As speciation and environmental behavior and human gastrointestinal tract bioaccessibility/bioavailability (A, D) [1]; Ni and Cr environmental geochemistry (B, C) [2,3]; Ni, Co, and Mn resource extraction feasibility (B, C, E) [2,3]; As speciation in tortoise scutes and microbial mats (D) [1], and Pt, Te, and W extraction feasibility (E) [3].

[1] Foster and Kim, 2014 *Rev Mineral Geochem* v 79 pp 257-369; [2] Diedrich et al., 2017 *IMWA Proceedings* v II, pp 712-719; [3] Kochinsky et al., 2019 *Chem Geology* v 539, #119426.