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Examining California's Empire Mine Arsenic Bioaccessibility through Empirical and Quantitative Micro-XRF Analysis

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California's Empire Gold Mine, now a state park, has a legacy of mine wastes that impact visiting and surrounding communities due to the transport and distribution of metal(loid)-bearing wastes. Arsenic represents a long-term concern from these mine tailings because it is naturally elevated and could represent potential exposure through the incidental ingestion and inhalation of fine-grained dust. Arsenic bioaccessibility is known to vary widely across mine sites due to characteristics of particle size, reactive surface area, and how arsenic is distributed within the particles. The challenge in assessing bioaccessibility is both time- and sample-intensive, so there is significance in identifying factors that predict when and where bioaccessibility is likely to be high.

This study combines two approaches to assess Empire Mine waste: (1) empirical *in vitro* simulated gastric fluid (SGF) extractions to measure the bioaccessible arsenic, and (2) micro-X-ray fluorescence (μXRF) mapping collected at the Stanford Synchrotron Radiation Lightsource (SSRL) to quantify arsenic's spatial distribution in the same samples before and after SGF exposure.

The samples sieved ranged in 11 different particle-size fractions, with reactive surface area being quantified through the Brunauer–Emmett–Teller (BET) method. The SGF extractions were used to experimentally simulate the ingestion pathway, and dissolved arsenic was measured by ICP-OES to calculate percent As bioaccessibility. To simulate effects of physical weathering, samples were ground in a ring mill and re-analyzed to compare the bioaccessibility pre- and post-grinding. In comparison, μXRF maps distinguish how arsenic is distributed (e.g. surface bound, homogeneously distributed, or as clusters associated with individual particles) and how these patterns change with SGF exposure.

The analysis of Empire Mine waste includes the experimental measures of bioaccessibility through SGF, ICP, BET and the impact of grinding particles, while the μXRF provides a quantitative way to track where arsenic is located within sample particles and the relationship spatial pattern has with bioaccessibility. This comparison assesses whether μXRF spatial distribution patterns can explain and potentially predict changes in arsenic bioaccessibility with particle size and weathering. This combined analysis enables long-term risk interpretation of exposed mine tailings containing arsenic to help prioritize where remediation is most needed.