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Legacy of Historical Mining and Metallurgy in Taxco, Mexico: Geochemical Controls on Metal Lability and Bioaccessibility

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Geological and geochemical processes strongly influence the environmental behavior and human exposure potential of potentially toxic elements (PTEs) in historical mining districts. In the Taxco mining district (Guerrero, Mexico), centuries of polymetallic mining and ore processing have generated large volumes of mine wastes, including tailings, slags, and other metallurgical residues. These materials constitute long-term sources of PTE contamination that can be redistributed through erosion, surface runoff, and atmospheric transport, leading to their accumulation in soils and sediments across the region. In addition, sulfide-rich wastes drive acid-generating reactions that enhance the mobility of metals and metalloids.

Previous investigations have documented contamination in the Cacalotenango and Taxco river basins, largely attributing it to modern industrial tailings facilities rather than to historical metallurgical haciendas. Elevated arsenic (As) and lead (Pb) concentrations in environmental media and biomonitoring studies indicate ongoing exposure risks. Remediation efforts have focused exclusively on industrial tailings dams, while the spatial distribution of contamination and the relative contribution of different sources remain insufficiently constrained.

In an area where high blood lead levels have been detected in the population, an abandoned historical metallurgical hacienda was identified. This study examines the geological and geochemical controls on PTE distribution and mobility in this area, where a school is located, using an integrated approach that combines geological context, detailed geochemical characterization of soils and mine wastes, sequential extraction to evaluate geochemical lability, and pathway-specific in vitro bioaccessibility assays.

Results indicate that, in addition to known tailings deposits, previously unrecognized sources associated with historical metallurgical haciendas contribute significantly to the regional PTE load. Variations in mineralogical composition and weathering conditions controlled by pH–pe conditions exert strong control on the mobility and bioaccessible fractions of arsenic and lead. Health risk calculations based on established EPA methodologies identify areas of potential concern, particularly for child exposure scenarios.

These findings suggest that historical metallurgical haciendas represent an important and underrecognized source of PTE contamination in the Taxco district. More broadly, the results underscore the importance of integrating geochemical processes and exposure pathways when reassessing legacy mining environments and highlight the need to improve human health risk assessment models.