

Geochemistry of historical smelting slags from S. Domingos (Iberian Pyrite Belt) and implications for metal recovery

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Resumo

The historical mining area of S. Domingos, located in the Iberian Pyrite Belt (IPB), southwestern Portugal, hosts significant accumulations of mining wastes including, smelting slags, iron oxides, milled blocks of pyrite and other residues resulting from centuries of processing Cu-rich massive sulfide ores. Polymetallic sulfide exploitation in this region dates to pre-Roman times and continued until 1966. These slags represent an important record of historical metallurgical practices and a potential secondary resource for critical and strategic raw materials (CRM/SRM) and other valuable metals. This study investigates the geochemical composition and mineralogical characteristics of historical smelting slags, to access not only their potential to metal recovery, but also their associated environmental risks. The slags are heterogeneous and chemically unstable waste products, typically Fe-rich, and dominated by fayalite, $\text{Fe}_2+2\text{SiO}_4$ (the iron-rich member of the olivine mineral group) together with glassy matrices. Fayalite is the result of the reaction of iron oxide with silica at high temperatures and host a range of metals including As, Ba, Co, Cu, Sn, Pb, Sr and Zn. Weathering processes promote metal mobilization of these elements, contributing to local contamination and to the development of acid mine drainage (AMD) products in the surrounding areas. Geochemical assessment indicates that significant quantities of valuable metals remain trapped within these historical slags due to inefficient recovery during earlier smelting technologies. Studies across the IPB suggest that mining wastes may contain significant valuable reserves of metals such as Fe, Zn, Cu and Pb, as well as CRM and other important trace metals. Consequently, these residues represent potentially promising targets for reprocessing using advanced metallurgical or hydrometallurgical technologies. Detailed geochemical characterization provides insights supporting the development of sustainable recovery strategies within a circular economy framework for historic mining districts of the Iberian Pyrite Belt. The results underscore the dual importance of recovering the S. Domingos slags as potential secondary mineral resources, while also mitigating the environmental impact associated with AMD.

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