

# **Characterization of Smelting Slags from the Riotinto Mining District (Huelva, Spain): Mineral Phases, Metal Mobility, and Recovery Potential**

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Many economically valuable elements remain trapped in metallurgical wastes due to inefficiencies in mineral processing technologies. This study examines abandoned smelting slags from the Riotinto mining district (Huelva, Spain), focusing on their geochemical and mineralogical composition and the mobility of hazardous and economically valuable elements.

Two representative slag samples were analyzed using multi-acid digestion (HCl, HNO<sub>3</sub>, HClO<sub>4</sub>, and HF) followed by ICP-OES and ICP-MS. Quality control with reference material (OREAS 904) yielded recoveries between 94% and 106%. Element mobility was assessed using a four-step sequential extraction procedure (BCR).

The slags are composed mainly of Fe (40%), with notable concentrations of Cu (4,648 ppm), Pb (2,258 ppm), Zn (>10,000 ppm), and trace amounts of Cr (247 ppm), Co (228 ppm), As (115 ppm), and rare earth elements plus yttrium (32 ppm). SEM-EDS images reveal heterogeneous particles with mineral phases such as fayalite and magnetite, consistent with high iron content and typically found in copper slags [1]. Additionally, jarosite and anglesite were identified, correlating with minor element composition.

Sequential extraction indicates high mobility for Cu (62%), Zn (45%), Co (48%), and Cd (28%) in the most available fraction, raising environmental concerns. The presence of sulfur in the oxidizable fraction suggests potential for acid mine drainage formation. Meanwhile, Al, Fe, Si, Cr, and Mn show limited mobility, likely due to their incorporation in the crystalline mineral matrix.

From a resource perspective, the slags contain significant amounts of copper, zinc, and lead, making them potential candidates for metal recovery. Since these metals are concentrated in the most available fraction, they could be extracted more efficiently. However, the stability of certain mineral phases may hinder element mobility, highlighting the need for further research to optimize valorization strategies.

This study underscores the dual nature of these slags—as both an environmental risk and a potential resource—emphasizing the importance of proper waste management and recovery

approaches.

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## REFERENCES

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