High-tech critical metals from primary deposits and tailings of the Massif Central: evaluation of the potential of les Malines Pb-Zn deposits

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Résumé

The rise of renewable energy and digital technologies in Europe has increased the need for High-Tech Critical Metals (HTCM), particularly indium (In), gallium (Ga), and germanium (Ge). These metals are vital for technologies such as photovoltaic panels and advanced electronics. In, Ga, and Ge have geochemical affinities with polymetallic ores. Despite their strategic importance, the grade and mineral distribution of HTCM remain poorly understood in particular in Pb-Zn deposits. Recent research suggests that their concentration and mineralogy are influenced by primary geological processes such as deposit types, metal sources, fluid temperature and salinity or eventually sudden changes in pressure/temperature conditions. And by secondary geological features like metamorphic conditions or supergene alterations.

This study focuses on the mineralogical and geochemical characterization of HTCM in primary deposits from Les Malines historic mine, which operated from 1880 to 1991 and was among the first producers of lead and zinc in France and Europe in the 1980s, with over 800 000 t of Zn and Pb extracted. The modern tailings dam covers 13 hectares, holding 4.2 million cubic meters of material. The tailings come from four main stages of mineralization, chronologically: Cambrian zero ore, karstic ore, barite co-genetic ore and supergene alteration minerals.

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Those preliminary results aim to develop robust analytical tools and protocols for resource assessment, as well as a predictive model to explore future Ge deposits. This multidisciplinary approach integrates traditional mineral exploration techniques (field campaigns, geological mapping, sampling, structural analysis, UAV) with in situ analysis (SEM-EDS, Laser-Induced Breakdown Spectroscopy (LIBS), EPMA, μXRF and LA-ICP-MS). First LIBS analyses reveal at least two generations of sphalerite, with the later generation showing Ge enrichment. EPMA high resolution mapping confirmed two generations of colloform sphalerite nonetheless with an intermediate euhedral prismatic generation which is the one enriched in Ge and Fe. Quantitative analyses using EPMA highlight Ge concentrations up to 800 ppm and a mean value from core to edge in these colloform sphalerite around 150 ppm.
Complementary analysis on other mineralization stages is currently underway to identify if only this barite stage is enriched in Ge and to understand the HTCM concentration processes.

Mots-Clés: high, tech, critical, metals, geochemistry, germanium, gallium, indium, metallogeny, Les Malines, Massif, central