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Germanium distribution in Mississippi Valley-Type systems from sulfide deposition to oxidative weathering: A perspective from Fule Pb-Zn(-Ge) deposit, South China

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Abstract

Germanium (Ge) is a critical raw material for emerging high-tech and green industries, resulting in considerable recent interest in understanding its distribution and geochemical behavior in ore deposits. In this contribution, the distribution of Ge and related trace elements in the Fule Pb-Zn(-Ge) deposit, South China, is investigated to reveal the distribution of Ge in the hydrothermal ores and during sulfide weathering, using multiple microanalytical techniques, including scanning electron microscopy, electron probe microanalysis and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). In the Fule MVT deposit, sphalerite (ZnS) is the most significant Ge-carrier relative to other sulfides, though the five recognized textural types of sphalerite display progressive depletion in Ge from the first sphalerite generation to the late one. In the early stage, sphalerite with fine-grained chalcopyrite inclusions has the highest Ge concentrations, probably accounting for a significant proportion of the total Ge. We interpret that high Ge concentrations in the early sphalerite may be attributable to high Cu activity in the mineralizing fluids. During oxidative weathering, Ge was redistributed from its original host, sphalerite, to the weathering product willemite (Zn_2SiO_4) rather than smithsonite ($ZnCO_3$), with high levels of Ge (up to 448 μg/g) present in the willemite. The formation of abundant willemite largely prevents the dispersion of Ge during weathering. In principle, willemite-hosted Ge should be fully recoverable, and the Zn-silicate ores may, therefore, be a potential target to meet future demand. This study provides new information on how Ge behaves from sulfide- to weathering-stage in MVT systems, which directly impacts Ge mobility and deportment changes and the development of metallurgical strategies for Ge recovery.

Keywords: Germanium, sulfides, LA-ICP-MS, mineral weathering, element mobility; Critical Minerals for a Sustainable Future