Microstructural characterization of zinc sulfides from modern seafloor hydrothermal systems: insights into Au-Ag enrichment mechanisms

ZHONGWEI WU[1], XIAOMING SUN[1,2,*], HUIFANG XU[3], HIROMI KONISHI[3], YANG LU[1], AND KAIJUN CAO[2]

[1]School of Marine Sciences, Sun Yat-sen University, Guangzhou 510006, China (*correspondence: eessxm@mail.sysu.edu.cn)

[2]School of Earth Sciences and Engineering, Sun Yat-sen University, Guangzhou 510275, China

[3]NASA Astrobiology Institute, Department of Geoscience, University of Wisconsin-Madison, WI 53706, USA

Recently, a close Zn-Ag-(Au) association has been noted in several polymetallic sulfide ore deposits from the Indian Ocean. Sphalerite, which commonly encountered as a host mineral for submicroscopic gold or electrum, can be regarded as a significant Ag-carrier in hydrothermal precipitates from the Edmond vent field, Central Indian Ridge. However, the role of nanotextural controls on "invisible" silver distribution within ZnS is still not well understood. In this study, these typical ZnS samples are roughly classified into two different groups based on their chemical compositions and mineral textures. Among them, sulfosalt-bearing, Fe-poor Zn sulfides in sulfate-dominated outer chimney-wall fragments usually contain higher contents of Ag, Cu and Pb (up to wt.% levels) than Fe-rich, massive to euhedral sphalerite in Zn-(Fe)-rich chimney debris. Such Ag-rich ZnS group is represented by colloform and botryoidal aggregates of optically anisotropic sphalerite with a strongly disordered structure or hexagonal habit (admixed polytypic intergrowths), which are formed by coalescence-agglomeration of colloidal nanoparticles.

Using HRTEM, we have investigated the ultrastructure and crystal-chemistry of the {111} twin boundaries and wurtzite-type stacking faults that occur in colloform or porous dendritic sphalerite. Actually, the morphological features and aggregation state of these highly-defective sphalerite crystals exhibit signs of fast precipitation caused by extensive mixing and cooling at Edmond. The inhomogeneous distribution of precious metals is generally concordant with the extent of recrystallization, intragranular porosity as well as bulk defect density. Therefore, lattice defects and nanoscale interfaces may play an important role in promoting the introduction of exotic impurities into ZnS domains during rapid growth. Physicochemical conditions and submarine disequilibrium processes indicated by ore-forming mechanism might also facilitate the incorporation and enrichment of Ag, Au or other chalcophile elements in hydrothermal sphalerite.