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One-size-does-not-fit-all: Diversity of critical elements distribution in sphalerite at the nanoscale

DENIS FOUGEROUSE[1], ALEXANDRE CUGERONE[2], KAI LUO[3], JOACHIM KRAUSE[4], STEVEN M. REDDY[1], DAVID W. SAXEY[1] AND WILLIAM D. A. RICKARD[5]

[1]Geoscience Atom Probe, ARCF, John de Laeter Centre, Curtin University

[2]University of Geneva

[3]Yunnan University

[4]Helmholtz-Zentrum Dresden-Rossendorf, Helmholtz Institute Freiberg for Resource Technology

[5]John de Laeter Centre, Curtin University

Presenting Author: Denis.Fougerouse@curtin.edu.au

Germanium (Ge) and indium (In) are classified as critical elements due to their utility for in demand high-tech and defence applications. Ge is mainly used in fibre optics and infrared night vision applications, whereas In is used for display technologies such as touch-screens and flat panel TVs. A large proportion of Ge and In is associated with sphalerite in Pb-Zn ore deposits, and is thought to be hosted in the crystal lattice of sphalerite with substitution mechanism only inferred from microscale analyses. However, systematic nanoscale investigation of Ge and In distribution in sphalerite is lacking. Furthermore, sphalerite appears frequently metamorphosed in Pb-Zn deposits, but the impact of metamorphism on the redistribution of critical elements is poorly constrained.

In this study, we use a multiscale approach to study the distribution of critical elements in sphalerite, including electron backscattered diffraction (EBSD), laser-induced breakdown spectroscopy (LIBS), time-of-flight secondary ion mass spectrometry (ToF-SIMS), and atom probe tomography (APT). A range of samples from France, Germany, China and Australia originating from various geological settings were investigated. Our results show that Ge and In exist in a range of nanoscale distribution in sphalerite, including solid-solution, nanoparticles of briartite ($Cu_2(Zn,Fe)GeS_4$), Na-K-O-Pb-Ge nanoscale inclusions, clusters enriched in In-Cu-Sn and plate-like In-Cu-rich phases. The diversity of distribution of critical elements in sphalerite indicates different incorporation mechanisms characteristic of fluid physicochemical conditions and remobilization processes during metamorphism.