Nanoscale compositional segregation in complex In-bearing sulfides

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Indium-bearing sphalerites from the Hämmerlein skarn deposit, located in the western Erzgebirge (Germany), show complex distribution patterns of major and minor elements on a micrometer to sub-micrometer scale. However, with the spatial resolution of traditional analytical methods, such as SEM-based image analysis and field emission electron probe microanalysis (FE-EPMA), many features in these samples cannot be resolved. It remains unclear whether Cu, In and Fe are in solid solution in the sphalerite or form discrete phases.

Atom probe tomography combined with transmission Kikuchi diffraction has been used to resolve the compositional heterogeneity and the nanostructure of these complex In-Cu-Fe-sphalerites. The obtained data indicate a complex structure with micro- to nanometer sized, plate-shaped inclusions of chalcopyrite in the sphalerite. In addition, a nanometer scale In-Cu-sulfide phase forms plate-like segregations in the sphalerite. All types of segregations have similar crystal structure and record the same crystal orientation indicating that they likely formed by exsolution.

The results indicate that complex sulfides containing cations of more than one element as minor or major constituents may represent discrete, exsolved phases, rather than solid solutions. This heterogeneous nature will affect the nanoscale properties of the sphalerite, which may have implications for the economic extraction of precious elements such as In. Furthermore these nanoscale properties will open up new perspectives on formation processes of In-Cu-Fe-sphalerites, which might be relevant for other chemically complex minerals as well.