Nanoscale study of clausthalite-bearing symplectites in Cu-Au-(U) ores from South Australian deposits: Implications for ore genesis

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Nanoscale investigation of symplectites comprising clausthalite (PbSe) and host Cu-(Fe)-sulfides (chalcocite, bornite and chalcopyrite) are instructive for understanding the genesis of South Australian Mesoproterozoic Cu-Au-(U) ores. High-resolution Focussed Ion Beam (FIB)–SEM imaging and Transmission Electron Microscopy study of FIB-prepared foils reveal that clausthalite 'inclusions' vary in size from a few μm to down to nm-scale (<5 nm), and are present as rods, blebs or needles in any of the aforementioned sulfides. The Cu-(Fe)-sulfides outside inclusion areas still contain measurable Se; these are highest in chalcopyrite. Pb is, however, absent from these areas, suggesting formation from solid solution in the system Cu-Fe-S-Se with Pb supplied from an external source. Although the orientation of swarms of smaller clausthalite inclusions is broadly congruent with the host, there is an orientation offset with host sulfide that increases with bleb coarsening, nm-scale inclusions of other phases, and with boundary corrosion/displacements. These are particularly apparent in 2*a* bornite and high-T chalcocite. Such decrease in the degree of crystallographic congruency with the host sulfide indicates that the symplectites record superimposed thermal event(s). Moreover, trace element re-mobilisation within the ores is concordant with sulfide recrystallization within nanoscale domains during fluid percolation as observed by presence of pores, nucleation of multi-component inclusions along boundaries between low-T chalcocite and bornite, etc. Although clausthalite may have initially exsolved from Cu-(Fe)-sulfides, cyclic solid-state diffusion processes, also facilitating incorporation of mobilized radiogenic Pb released from U-(Th)-bearing minerals, have progressively modified primary structures. Such observations are concordant with preliminary LA-ICP-MS Pb-isotope data for Pb-chalcogenides, which reveal Pb-Pb ages younger than the initial ~1590 Ma mineralisation event.