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Nanoscale mineralogical evidence confirms Cu transport as chloride complexes in brines in the Central European Kupferschiefer district

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High-grade sediment-hosted stratiform copper (SSC) deposits will be critical for securing future supplies of Cu. However, current genetic models for SSC deposits have few constraints on the physicochemical properties of ore fluids and timing of ore-stage mineralization. In the Central European Kupferschiefer district, SSC deposits are assumed to have formed following basin-scale circulation of metal-bearing chloride-rich brines, but direct evidence of Cu transport in these brines is lacking. Here, we present results from a transmission electron microscopy (TEM) investigation of the pore-scale mineralogy of Cu mineralized mudstones from the Saale subbasin (eastern Germany). The TEM results indicate that $Cu_xCl_y(OH)_z$ mineral phases, including $Cu_2Cl(OH)_3$ (atacamite) and, to a lesser extent, CuCl (nantokite) nanoparticles (NPs, ∼ 5-20 nm), are broadly intergrown with illite in pore spaces surrounding disseminated Cu (Fe) sulfides. The $Cu_xCl_y(OH)_z$ likely formed within, and between, the illite layers due to the adsorption of soluble Cu(I) chloride complexes on illite edges. The preservation of the $Cu_xCl_y(OH)_z$-illite assemblage in pore spaces adjacent to ore-stage bornite provides important boundary conditions for mineral systems models; specifically, that Cu was transported as chloride complexes in low-temperature brines that reacted with host units undergoing burial diagenesis. Thus, mineral systems models for the Kupferschiefer need to consider how brines, likely derived from deposition of the overlying evaporitic sequence, circulated deep into the basin where they leached metals before moving up towards the site of metal deposition.