

Complex Metal(loid) Department in Porphyry Ore Sulphides - Insights from LA-ICP-MS Mapping

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With the global transition to low-carbon technologies, porphyry Cu deposits are gaining in importance, not only as a Cu supplier, but also as a source of other critical raw materials. Enhanced Cu production will promote the recovery of by-product commodities, such as Ag, Au, Te, Co, Ga, Ge, In and PGEs, some of which are key constituents in modern energy technologies. It is critical to understand the mineral-metal(loid) associations of the ore to ensure recovery of these by-product commodities. In porphyry Cu ores, chalcopyrite, bornite, digenite, chalcocite, pyrite and where present, sulfosalts, electrum and tellurides are generally identified as hosts of critical metal(loid)s. However, mineral replacement and exsolution processes can lead to more complex metal(loid) department in Cu-sulfides with challenges for mineral processing.

We present LA-ICP-MS maps that reveal metal(loid) redistribution through exsolution in hypogene and through partial replacement in supergene Cu ores. Hypogene examples show digenite lamellae that are enclosed in bornite, which is widely interpreted as an exsolution product from a Cu-rich bornite solid solution [1]. Element distribution maps show that the exsolution processes can result in a distinct trace element fractionation between digenite and bornite. Silver, Au and Te are markedly enriched in digenite over bornite, while In, Sn and Bi are mainly retained in bornite. We further present examples of complex metal(loid) department in Cu sulfides from a supergene zone, developed over hypogene ore. The ore samples show supergene chalcocite that is partially replacing hypogene chalcopyrite along its outer grain margins. The replacing chalcocite is distinctly enriched in Ag and Au, but depleted in In, Sn, Se and Bi relative to chalcopyrite. Supergene fluids most likely introduced elevated precious metal contents, but also remobilized In, Sn, Bi and Se as chalcopyrite was altered to chalcocite. Our element mapping results highlight the complex mineral-scale distribution of metal(loid)s in Cu ores. This spatial information can be integrated into metallurgical models to improve recoveries of critical raw materials.

[1] Phase relations in the Cu-Fe-S, Cu-Ni-S and Fe-Ni-S systems. Kullerud, G., Yund, R.A., and Moh, G.H. (1969), *Economic Geology Monograph* 4. p. 323-343