Variations in Chalcocite Trace Element Compositions: Comparison of Hypogene and Supergene Sulfide Environments

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A preliminary study of chalcocites representing hypogene and supergene geochemical environments was undertaken to determine variations in trace elements that characterize weathering-derived (supergene) vs. hypogene chalcocite. The objective is to determine those elements which might be useful in distinguishing these geochemical environments and therefore assist in assessing the nature of copper sulfides in exploration for copper ore deposits.

For this initial study, polished ore samples were prepared representing andesite-hosted Cu-Ag, copper vein, porphyry Cu-Mo systems, and carbonate replacement deposits. The polished samples were described, emphasizing copper mineralogy, textural relationships, and mineral paragenesis. Samples were then analyzed using standard electron microprobe methods, with quantitative analyses for Cu, Fe, S, Ag, As, and Bi. This suite of elements was selected because they permit discrimination of chalcocite formed from hypogene processes vs. that developed from the weathering of hypogene copper occurrences.

In similar studies of copper sulfides (e.g., see Cook et al. 2011 for a study of minor elements in bornites), researchers note that partitioning of Ag and Bi into some copper sulfides may be significant, suggesting that silver contents may be substantial contributors to the net value of a copper ore. In this study, we examine copper ores to determine whether certain trace elements are diagnostic in defining the geochemical origin of chalcocite, with subordinate interest also in covellite. For each sample we analyzed, the assessment of whether the chalcocite represented hypogene or supergene environments was initially based on spatial location within a given ore deposit, mineral textures, and ore mineral associations.

Our study shows that silver and iron are enriched in chalcocites of hypogene derivation but are generally very scant in supergene chalcocites. Supergene chalcocites are uniformly low in As and Bi, probably reflecting the limited mobility of these elements in the supergene environment in the presence of oxidized iron. Because Ag and Fe substitute for copper in most copper sulfides at hypogene temperatures (e.g., Yund and Kullerud, 1966; see also Chávez, 1985; Craig and Vaughan, 1994), the supergene chalcocites are found to be uniformly low in with respect to Ag and Fe contents. Our initial results suggest that discrimination of supergene and hypogene chalcocites, and very likely, associated covellites, is possible using the trace elements Ag and Fe; analyses of other trace elements, notably Co and Zn, would likely improve our ability to distinguish between hypogene and supergene copper sulfides. Application of such determinations would enhance interpretation of copper and silver geochemical exploration survey data when engaged in ore search for, and economic evaluation of, copper deposits modified by weathering-related processes.

2019 New Mexico Geological Society Annual Spring Meeting
April 12, 2019, Macey Center, New Mexico Tech campus, Socorro, NM