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Fluid Evolution and Ore Genesis of the Permian Hongshanliang Manto-type Copper Deposit in the Eastern Tianshan

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The Hongshanliang copper deposit, a typical copper deposit in the Aqishan-Yamansu belt, Eastern Tianshan, is hosted in the tuff of the Lower Carboniferous Yamansu Formation. Five alteration/mineralization stages have been established: chlorite–sulfide stage (Stage I), quartz–pyrite stage (Stage II), quartz–polymetallic sulfide stage (Stage III), late veins (Stage IV), and supergene process (Stage V), based on detailed crosscutting relationships of veins, textural relationships, and mineral assemblages. Stage I has chlorite–pyrite ± chalcopyrite ± quartz ± sericite assemblage and is commonly characterized by euhedral pyrite with silicates and/or chalcopyrite as its pressure shadow, indicating an early mineralization event with apparent deformation. The late main mineralization stage (Stage III) has typical mineral assemblages of quartz–chalcopyrite ± chlorite ± calcite ± sericite, quartz–chalcopyrite–sphalerite–galena ± pyrite, and quartz–sphalerite–galena ± chlorite, with veins, veinlets, disseminations, and local massive ore types, which is similar to Manto-type copper deposits regarding mineralization and ore structures.

Detailed fluid inclusion study shows an evolved hydrothermal ore-forming system, with temperatures decreased from Stage II (310–480 °C) through Stage III (160–180 °C) to Stage IV (130–170 °C), and corresponding salinities of 2.7–26.2 wt% NaCl equiv., 2.1–12.3 wt% NaCl equiv., and 0.5–7.7 wt% NaCl equiv., respectively. Such fluid evolution is consistent with corresponding stages of H–O isotopes. Moreover, sulfur isotopes suggest that the two mineralizing fluids are predominantly magmatic–hydrothermal, with other influx contribution into the ore-forming system, i.e., minor Early Carboniferous seawater in Stage I and minor organic materials in Stage III.

In combination of alteration, paragenesis, nature and source of ore-forming fluids, sericite ⁴⁰Ar/³⁹Ar geochronology, and comparison with other typical deposits, we proposed that the Hongshanliang copper deposit underwent two mineralization events with the Permian main mineralization similar to Manto-type copper deposits.