Temporal Evolution of Copper Isotope in Dexing Porphyry Cu-Mo-Au Deposit, China, and Its Implications for Explorations and Cu Isotope Fractionation in Ore-forming Processes

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Cu isotope analyses have provided direct constraints of supergene enrichment and ore-forming processes in porphyry copper deposits. While the heavy Cu-isotope signature of the enrichment zone is successfully illustrated by preferential partition of ^{65}Cu (the heavy copper isotope) into oxidized fluids in the leaching process, the understanding of Cu-isotope patterns in the hypogene zone is hindered by relatively poorly constrained Cu isotope fractionation behaviours in the ore-forming processes at high temperatures. We analyzed Cu isotope ratios of chalcopyrite from all four-stage veins in the Dexing giant porphyry Cu-Mo-Au deposit, China, and found a different Cu-isotope variation trend from the reported patterns. The Dexing-pattern features an increase of δ^{65}Cu (in permil) values from the innermost A vein samples (–0.26 ± 0.03‰, n = 3, 2SD) outward toward B and C vein samples (–0.12 ± 0.14‰, n = 19, 2SD), and a sudden drop to the outmost D vein samples (–0.42 ± 0.17‰, n = 9, 2SD). Combining the Cu-isotope measurements with previously published fluid inclusion data, we dipicted the detailed ore-forming processes of precipitation and multiple fluid boiling events by the Cu-isotope pattern. The enrichment of the heavy Cu isotope in B and C vein (the main stage of mineralization at Dexing) is similar to Northparkes porphyry Cu-Au deposit, Australia, where δ^{65}Cu values of sulfides drop from the high-grade core to the margin of orebodies. Deposit-scale Cu isotope studies suggest that the heavy copper isotope enrichment coincides with the high-grade ores in hypogene zones, which can be a vectoring tool for explorations. In addition, the overall low Cu-isotope signature (median = –0.17‰, n=31), relative to the average Cu isotope composition of bulk silicate Earth (0.06 ± 0.20‰, 2SD), may be caused by the tendency for ^{63}Cu (the light copper isotope) to partition into the exsolved fluid from silicate magmas.