

Link Mo isotope fractionation with molybdenite precipitation processes in porphyry systems: Insights from the Yulong Cu-Mo deposit, Tibet

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Large Mo isotope variations (up to ~2 ‰ $\delta^{98}\text{Mo}$) of molybdenite from individual porphyry-type deposits have been widely reported. However, the mechanisms of Mo isotope fractionation and its implications for mineralization processes remain poorly understood due to the lack of tight geological constraints. Here we link contrasting variations of Mo isotopes with different processes of molybdenite precipitation by integrating a new set of Mo isotope data from two successive mineralizing stages of the Yulong porphyry Cu-Mo deposit in Tibet with existing fluid inclusion data and high-precision Re-Os dates. The relatively uniform Mo isotopic composition ($\delta^{98}\text{Mo} = 0.03\text{-}0.18\text{ ‰}$) of the earlier stage is consistent with the precipitation of molybdenite from the relatively stagnant, high-density brines. In contrast, the large spread of Mo isotopes ($\delta^{98}\text{Mo} = -0.16\text{-}0.60\text{ ‰}$) of the later stage requires a process similar to Rayleigh fractionation, and suggests molybdenite precipitation during rapid ascent of the single-phase, intermediate-density fluids. This study highlights that the degree of Mo isotope fractionation in molybdenite is arguably determined by the interplay of metal precipitation efficiency and fluid migration rate, and that the large variations of Mo isotopes in molybdenite of many porphyry deposits can be simply explained by molybdenite precipitation from dynamic fluids passing through propagating fracture systems. The newly obtained Mo isotopic evidence, additionally, contributes to a better understanding of the deposit-scale Cu-Mo separation at Yulong.