

Mo isotopic variations in molybdenite: Vapor transport and Rayleigh fractionation of Mo

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Analyses of Mo isotopes in twenty molybdenite samples precisely dated by the Re-Os method and representing a range of mineralized geologic settings, show fractionation spanning 0.63 per mil per atomic mass unit (‰/amu). Analysis by multi-collector inductively coupled plasma mass spectrometry (MC-ICP-MS), following introduction of a ⁹⁴Mo-¹⁰⁰Mo double spike and purification by ion exchange, assures high-precision results with full correction for chemically or instrumentally induced mass fractionation.

Interpretation of previous Mo isotope data for molybdenite, which revealed variations in fractionation of less than 0.5 ‰/amu, is hampered by the limited number of samples in each study, the lack of a common standard needed for interlaboratory comparison, and limited variability in or knowledge of the geologic setting. Here we show that the Mo isotopic compositions of molybdenites are not correlated with crystallization temperature, age, or geologic conditions. Rather, kinetic fractionation may explain variations of up to 0.34‰/amu within a single molybdenite occurrence or deposit, exceeding the suggested variability in typical continental crust [1].

We propose that Mo is transported in the vapor phase in hydrothermal systems as molybdate species [2]. Expansion of vapor into propagating fracture systems (e.g., stockwork veins in a Climax-type porphyry Mo deposit) is a highly energetic and chaotic event, almost certainly resulting in chemical disequilibrium and kinetic isotope fractionation upon reduction of Mo and precipitation of molybdenite. Simple modelling shows that Rayleigh distillation can account for Mo isotope variations of a few tenths of a permil even with 75% or more of the Mo remaining in the fluid.

References

- [1] Siebert, C., Nögler, T.F., von Blanckenburg, F., and Kramers, J.D. (2003) *EPSL* **211**, 159-171.
- [2] Rempel, K.U., Migdisov, A.A., and Williams-Jones, A.E. (2006) *GCA* **70**, 687-696.