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Tracing the evolution of fluids during batholith and deposit formation: In-situ and bulk rock Mo isotopes from the Questa Porphyry Mo Deposit

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The Oligocene Questa porphyry Mo deposit, located in New Mexico, USA, formed over 400 kyr, punctuating the 8 Myr formation of the Questa-Latir batholith. The deposit was assembled during the emplacement of a series of small volume dikes and sills, establishing a detailed age relationship for causative magmas relative to mineralization. Through detailed sampling of the intrusions and minerals associated with hydrothermal mineralization, as well as bookending barren intrusions, examining the Mo isotope record of the formation of both the deposit and its host batholith can yield insights into the long-term evolution of fluids associated with mineralization and upper crustal magmatism.

We present new Mo isotope data of bulk rocks from pre-, syn- and post-mineralization magmatism of the Questa Mo deposit, measured with conventional double spike technique at the University of Bern, and Mo isotopic compositions of molybdenites (MoS_2) measured in-situ with a femtosecond-laser ablation system coupled to a Neptune Plus MC-ICP-MS at the University of Hannover. For in-situ measurements, the instrumental mass bias was calculated and corrected by simultaneously measuring a Zr solution. Further, the unknowns were bracketed by measurements of a MoS_2 crystal with a known isotopic composition. The precision of these in-situ δ^{98}Mo data is approximately ±0.1‰ (2SD), capable of resolving previously published variations found in MoS_2.

The Mo isotopic compositions of barren intrusions show a trend towards lighter δ^{98}Mo with progressing age. However, intrusions associated with Mo deposit formation yield heavier δ^{98}Mo relative to barren magmatism, by up to 2.0‰. This indicates that they were affected by an isotopically heavy and Mo-rich fluid. The in-situ data from molybdenite covers the range observed in the bulk rocks. However, individual samples consistently yield Mo isotopic variations of 0.4‰ to 0.5‰. The consistency of the δ^{98}Mo variation in in-situ analyzes of MoS_2 within hand samples and individual mineral grains is likely the result of MoS_2 crystallization in a closed system and reflects an almost complete precipitation of Mo.