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The molybdenum isotope composition of Bulk Silicate Earth (BSE)

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Mass-independent Mo and Ru isotopic variations of nucleosynthetic origin among meteorites and Earth offer unique insights into the source of Earth's late-stage accretionary materials. Moderately siderophile Mo and highly siderophile Ru bear great potential to investigate the origin of the Earth's building blocks added during the latest 10 to 20% and the final 0.5% of accretion, respectively [1,2]. However, both Mo and Ru isotope data revealed conflicting constraints on the composition of the late-stage building blocks which may have consisted of carbonaceous chondrite (CC), non-carbonaceous chondrite (NC), or a mixture of CC- and NC-type materials [1-4]. For Mo, some additional complexity is involved owing to different estimates for the Mo isotope composition of the BSE [3-5].

To address this and to firmly establish the Mo isotope composition of the BSE, we present high-precision isotope data for 10 molybdenite samples collected from various locations in China, with ages of 145 to 1889 Ma. Owing to the high percentages of MoS_2 (76-88%) and extremely low concentrations of potentially interfering elements like Fe, Zr and Ru, the Mo isotope data were obtained for unprocessed molybdenite sample solutions to avoid potential fractionation effects imparted during column chemistry. The data are reported as ε-unit deviations relative to the NIST 3134 Mo solution standard, which we consider to represent the modern silicate Earth's isotope composition. The molybdenite results allow us to constrain the Mo isotope composition of the BSE as follows: ε^{92}Mo =+0.10±0.05, ε^{94}Mo =+0.01±0.03, ε^{95}Mo=+0.02±0.02, ε^{97}Mo=-0.03±0.02, ε^{100}Mo =+0.03±0.04 (n=49, 95% confidence interval). In comparison to [4] we do not observe resolvable ε^{94}Mo and ε^{95}Mo anomalies. Instead, our new data align with [3], suggesting a BSE composition consistent with NC-type materials.

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[2] Fischer-Gödde et al. (2020), *Nature*, **579**, 240-244. [3] Bermingham et al. (2025), *GCA*, **392**, 38-51.

[4] Budde et al. (2019), *Nature Astronomy*, **3**, 736-741.

[5] Budde et al. (2023), *Geochemistry*, **83**, 126007.