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Zinc and Copper stable isotope fractionation in lunar mare basalts: constraints on interior composition and volatile depletion processes.

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Compared to Earth and chondrites, most lunar rocks show a stronger depletion in volatile elements, which has evolved to a key aspect to understand the formation of the Earth-Moon system. The strong volatile element depletion of the lunar interior estimated from mare basalts [1] may result from volatile loss in the aftermath of a giant impact of a Mars-sized impactor onto the proto-Earth. The heavy isotopic compositions of moderately volatile elements (*e.g.,* K, Zn) support this scenario [2-3]. In contrast, enhanced volatile element contents in some lunar lithologies were interpreted in favour of a much less volatile-depleted lunar interior [4]. If this is correct, the volatile element depletion of many lunar samples and their stable isotopic compositions would require much greater volatile loss during their formation (e.g., by effusive degassing). Here we present new mass-dependent Zn and Cu isotope data on mare basalts to evaluate the role of effusive evaporation, fractional crystallization, and source compositions in the lunar mantle.

Elemental and isotopic compositions of Zinc and copper of mare basalts were obtained from the same aliquot via double spike and standard-sample bracketing, respectively, using a Neoma MC-ICP-MS. Similar ranges of isotopic compositions as in previous studies were obtained, including large negative and positive values, likely reflecting shallow magmatic volatile redistribution processes. However, the majority of the basalts (most evidently high-Ti basalts) now define a negative correlation between Zn, Cu content and their respective isotopic composition, interpreted to reflect fractional crystallization processes. $d^{66/64}Zn$ values of Mg-rich high-Ti mare basalts overlap with evolved low-Ti mare basalts, suggesting that mare basalt mantle sources may have similar $d^{66/64}Zn$. The inferred mass-dependent Zn isotope homogeneity of mare basalt mantle sources may indicate that the volatile loss and the associated isotope fractionation occurred prior to the formation of lunar mantle sources and magma ocean crystallization.

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