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Fractionation of Zn Isotopes by Post Accretion Volatile Loss from the Moon

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Zinc isotope systematics in lunar rocks have been used as a key piece of evidence to understand the mechanism of volatile loss from the Moon and constrain models of the Giant Impact event. On average, lunar rocks have heavier Zn isotope ratios than chondritic meteorites and terrestrial rocks, which could represent lunar volatile depletion occurring prior to or during accretion [1]. However, significant Zn isotopic heterogeneities exist between and within the major lunar lithologies, which can only be generated by fractionating processes that operated after the Moon had formed. These secondary fractionation processes complicate the link between the current isotopic composition of lunar rocks and the initial composition of their source reservoirs, which in turn affects our ability to use Zn systematics to assess the timing of volatile loss from the Moon.

Here, we present new Zn isotope data from a suite of mare basalts, KREEP-rich basalts/breccias and crustal rocks to better understand the processes that constrain bulk rock Zn systematics. The results show that KREEP-rich samples, including rocks from the intrusive Magnesian Suite (MGS), are systematically enriched in the heavy isotopes of Zn compared to most mare basalts. Correlation between the isotopic composition of Zn (δ^{66}Zn) and the La/Sm ratio is caused by variable mixing of KREEP into the parent magmas, with KREEP containing a distinctive REE pattern and a highly fractionated δ^{66}Zn value (δ^{66}Zn >3.8‰). Similarities in the behavior of Zn and Cl isotopes in KREEP rich rocks indicate that isotopic fractionation of urKREEP was caused by magmatic degassing, potentially due to a crust breaching impactor [2]. Given the propensity of Zn to undergo kinetic fractionation during evaporative processes, and the >20‰ range of Zn isotope ratios in lunar rocks, it's unclear whether mare basalts record the initial Zn isotopic composition of the Moon. As such, the purported ~1‰ isotopic difference between the δ^{66}Zn value of the Earth and Moon may not be a primary signature of the Giant Impact event.

References: [1] Paniello, R., et al., 2012, *Nature*, 490(7420), 376. [2] Barnes, J., et al., 2016. *EPSL*, 447, 84-94.

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