Investigating Zn and Ga Isotope Systematics on the Moon

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Moderately volatile element (MVE) isotope systems undergo kinetic fractionation during evaporation and are relatively insensitive to magmatic processing, making them ideal systems to trace evaporative loss from volatile depleted bodies such as the Moon. While we would expect to observe broad scale isotopic homogeneity in primary melt products of the lunar mantle, analyses of mare basalts show that this is not the case. In fact, for MVE isotope systems such as Ga and Zn the isotopic compositions of mare basalts are an order of magnitude more heterogeneous than in basalts on Earth. This suggests that either volatile loss and redistribution occurred post accretion or that our assumption that magmatic processes do not fractionate Ga and Zn isotopes is incorrect. To address these questions we present new δ^{71}Ga-δ^{66}Zn data from a suite of high and low-Ti mare basalts. We aim to confirm the scale of isotopic heterogeneity in these rocks and use the relationship between δ^{71}Ga and δ^{66}Zn to discern the processes that control isotopic fractionation in mare basalts. This will enable us to make a more representative estimate of the bulk composition of the Moon.

Based on isotopic analyses of laser levitation experiments we know that during evaporation from a simple silicate system there is a clear positive correlation between δ^{71}Ga and δ^{66}Zn values in volatile depleted samples. While we can confirm that mare basalts have relatively heterogeneous δ^{71}Ga and δ^{66}Zn values the δ^{71}Ga-δ^{66}Zn systematics do not positively correlate. In fact, the δ^{71}Ga and δ^{66}Zn data lie on a rough negative slope, which is difficult to reconcile with kinetic fractionation during evaporation. To explain these data either requires i) a highly complicated evaporative history with changes in speciation and/or fractionation factor during evaporation, or ii) that Ga or Zn are fractionated during processes such as cumulate formation or partial melting. Correlations between isotopic compositions and trace element ratios suggest the latter may be more likely. Ultimately, we show strong evidence that the isotopic composition of mare basalts is controlled, at least in part, by fractionation processes that occurred post-accretion. It follows that current estimates for the bulk isotopic compositions of the Moon may not be accurate.

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