# Reassessing Gallium Isotopic Evidence for Volatile Loss from the Moon

JOSH WIMPENNY[1*], LARS BORG[1], CORLISS SIO[1]

[1]Lawrence Livermore National Labortaory, Livermore California, 94550. *Email: wimpenny1@llnl.gov

The stable isotope ratios of moderately volatile elements including Ga, Zn, K and Rb have been used to estimate the extent of volatile loss from the Moon. These systems are assumed to be insensitive to isotopic fractionation during igneous processes, such as fractional crystallization [1]. This means any isotopic differences between the Moon and Earth can be interpreted purely as an indicator of evaporative loss, as is hypothesized to result from the Giant Impact event. However, it is often overlooked that isotope ratios in mare basalts are an order of magnitude more heterogeneous than corresponding isotope ratios in terrestrial basalts. Here we present new Ga isotope data from a suite of low and high-Ti mare basalts in order to reassess a) the degree of isotopic heterogeneity and b) whether Ga isotopes covary with indices of magmatic evolution of the lunar magma ocean (LMO). Previously published data obtained an average $\delta^{71}$Ga value of +0.18 ± 0.44‰ for mare basalts (relative to a BSE value of 0), and observed no systematic difference between the composition of low and high Ti basalts [2]. From our analyses we obtain an average $\delta^{71}$Ga value of +0.32 ± 0.20‰ for mare basalts, consistent with isotopic fractionation during evaporative loss. However, low and high-Ti basalts have average $\delta^{71}$Ga values of +0.22 ± 0.13‰ (n = 5) and +0.38 ± 0.12‰ (n = 9) respectively, which are resolvably different. Furthermore, $\delta^{71}$Ga values correlate with Ti content and REE ratios, including the calculated $^{147}$Sm-$^{144}$Nd ratio of the basaltic source regions. These data imply that Ga isotopes were also fractionated during crystallization of the LMO. Thus, the assumption that Ga isotopes are insensitive to igneous processes is incorrect. Gallium isotope ratios must be carefully evaluated, alongside petrogenetic constraints and trace element data, in order to calculate the bulk composition of the Moon and estimate the extent of volatile loss.

References: [1] Paniello et al., 2012, Nature, 490(7420), 376. [2] Kato et al., 2017, Science Advances, 3(7), e1700571

Prepared by LLNL under Contract DE-AC52-07NA27344.
LLNL-ABS-770761