Earth's Role in Isotopic Fractionation of Moderately Volatile Elements on the Moon

H. TANG[1], H.E. SCHLICHTING[1,2], E. D. YOUNG[1]

[1] Department of Earth and Space Sciences, UCLA (*correspondance: haolantang@ucla.edu),
[2] Department of Earth, Atmospheric and Planetary Sciences, MIT

Isotopic compositions of moderately volatile elements (MVE) are keys for understanding the behaviour of these elements during the process of planet formation. Previous studies of the isotopic systematics of MVE, including K, Zn, and Rb, show that the Moon is enriched in MVE heavy isotopes compared to the Earth (e.g., [1-3]). Various volatile-loss mechanisms, including Rayleigh evaporation, have been proposed to explain the heavy isotope enrichments.

Here we investigate isotopic fractionation in different stages of formation and evolution of the Moon right after the Giant Impact. We find that partial condensation during Moon's accretion (e.g., [4]) yields chemical depletion of MVE, and neither partial condensation nor Rayleigh evaporation can explain MVE isotopic composition in lunar basalts. Instead, the presence of a fractionated steady-state rock vapor atmosphere provides an efficient mechanism for modifying the isotope ratios of the LMO and thus the Moon. The isotopic composition of the atmosphere mainly relies on the gas loss mechanism, which is determined by surface melt temperature and Earth-Moon distance. We will discuss three gas loss mechanisms, including hydrodynamic escape, Jeans' escape, and loss to Earth by diffusion across Moon's Hill sphere in both static and well-mixed atmospheres. We demonstrate that vapor-melt isotopic exchange is the most viable mechanism to fractionate MVE isotopes in comprising the Moon.

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