Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.18017

Origin of moderately volatile element depletion on differentiated bodies: Insights from the evaporation of indium from silicate melts

DEZE LIU[1], FRÉDÉRIC MOYNIER[2], JULIEN SIEBERT[3], PAOLO A. SOSSI[4], YAN HU[1] AND EDITH KUBIK[5]

[1]Université Paris Cité, Institut de Physique du Globe de Paris
[2]Université Paris Cité, Institut de Physique du Globe de Paris, CNRS UMR 7154
[3]Institut de physique du globe de Paris, Université Paris Cité, CNRS, UMR 7154
[4]ETH Zürich
[5]Universität Bayreuth

Presenting Author: liudeze@ipgp.fr

Compared to the Sun and CI chondrites, terrestrial planets and other small, rocky differentiated bodies are depleted in moderately volatile elements (MVEs) . The bulk silicate Earth (BSE) shows a near log-linear decrease in MVE abundances with their 50% nebular condensation temperature (T_c^{50}), which has been traditionally used to infer elemental volatility during planetary formation and accretion.

However, indium (In) deviates from this correlation, despite being a siderophile element that could have been depleted by core formation. In is overabundant for its calculated T_c^{50} in the BSE, as well as in the silicate portions of other small bodies. This overabundance of In suggests that T_c^{50}, calculated under nebular conditions, may not be applicable to planetary evaporation that occurs at much higher oxygen fugacity (fO_2) and pressure than nominal nebular conditions.

To address this issue, we conducted a series of evaporation experiments for basaltic melts to quantify the volatility of In under conditions relevant to planetary evaporation. We used a novel temperature scale, the evaporation temperature (T_e^1), which refers to the temperature at which 1% of element i has evaporated from liquid to gas phase under equilibrium. Our results show that the abundances of volatile elements, including In, of the Moon and Vesta display a progressive depletion with increasing volatility (decreasing T_e^1). This smooth depletion pattern contrasts with the overabundance of In shown on the T_c^{50} scale, suggesting that volatile depletion on small bodies occurred under non-nebular environment instead of nominal nebular condensation.

On the other hand, the volatile element composition of the BSE (including In) could be explained by integrating (i) early accreted precursor materials of the proto-Earth that underwent volatile loss under conditions more oxidizing than those of the solar nebula with (ii) late added volatile-rich materials which arrived to the Earth before core-formation ceased.

In summary, the T_c^{50} scale does not accurately represent the volatile behavior of elements during planetary formation, and the T_e^1 provide a more accurate representation. Additionally, the abundance observed in the Moon, Vesta, and the BSE indicate that volatile depletion occurred under non-nebular environments and that volatile-rich materials arrived on Earth before core-formation ceased.