Tracking the origin of Earth’s volatile elements depletion with indium

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The abundances of volatile elements provide insight into fundamental processes of planetary accretion and differentiation. In chondrites, the abundances of volatile elements vary primarily as a function of the temperature at which 50% of their mass has calculated to condense during cooling of the solar nebula (Tₜ₅₀). In contrast, core formation also plays an important role in controlling the volatile element depletion in the bulk silicate Earth (BSE). Indium is a siderophile and volatile element. Its terrestrial abundance paradoxically lies above the abundance vs. Tₜ₅₀ trend defined by lithophile volatile elements in the BSE [1]. Notably, the use of Tₜ₅₀ presumes depletion took place under nebular conditions [2], and hence may not be an appropriate description of the volatility of indium under more oxidizing- and higher pressure conditions during chondrule formation and post-nebular processes.

To constrain the volatility of In from silicate melts under conditions close to chondrule and planetary formation, we performed evaporation experiments on an In-doped basaltic melt under variable oxygen fugacities (fO₂) and temperatures (T). Elemental volatility is quantified by deriving the enthalpy and entropy during evaporation at the given conditions (T, fO₂ and duration)[3].

Our results show that the volatility of indium strongly increases with decreasing fO₂, as observed for other moderately volatile elements [3,4] and is relatively less volatile than Zn for fO₂ typical of planetary mantles. In spite of this new volatility scale, In is no more depleted than Zn in the BSE notwithstanding its more siderophile nature. Therefore, the chondritic Zn/In ratio in the BSE is either i) a coincidence or ii) consistent with a ‘hockey stick’ volatile depletion pattern [5]. The lower volatility of In relative to Zn supports the idea that its over-abundance in the BSE may be inherited from its source materials, which have a CI-like ratio for volatile elements whose Tₜ₅₀ < 750K [6].