Pebbles or bam bam?: Insights into Earth's source material, accretion and differentiation from Zn metal-silicate partitioning

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Zinc is a moderetaly volatile and slightly siderophile element and as such it can provide information on the timing, conditions and eventual fate of volatile elements on Earth. Importantly, Zn can be used to investigate the behavior of S as they share similar volatilities, with 50% condensation temperatures of ~730 K and ~660 K, respectively. When a known S/Zn ratio is assigned (e.g. CI chondritic), Zn can then be used to estimate the S content of the Earth’s core through modelling. This is of particular interest as S is a candidate element for explaining the density deficit of the core, and because debate persists as to whether or not the Earth is chondritic.

In the current study we have conducted Zn metal-silicate partitioning experiments at high pressure (up to 81 GPa) and temperature (up to 4100 K) in laser-heated diamond anvil cells, between iron and two distinct silicate compositions (one pyrolytic, one basaltic), while varying S contents to characterize Zn metal-silicate partitioning as a function of these variable. Results from these experiments and literature data have been used to parameterize the thermodynamics of Zn metal-silicate partitioning, and specifically to hone constraints on the effect of pressure on Zn partitioning at conditions relevant to Earth’s accretion and differentiation (approx. 40-60 GPa). We have input this parameterization into continuous core formation models in which various controls have been tuned (fO_2 path, source material, timing and equilibration of volatile payload) to determine plausible set(s) of conditions that can harmonize Zn and S abundances in the present-day mantle with S abundance estimates for the Earth’s core. Our results indicate that in order to maintain a chondritic S/Zn ratio for Earth and to arrive at presumed present-day mantle and core S contents, either a late-stage, partially-equilibrated impactor delivered S and Zn (and other volatiles) to Earth, or the Earth accreted from a volatile depleted source material chemically akin to the type I chondrule-rich CH chondrites.