

Chalcogen isotopic constraints on the accretion history of Earth's volatile elements

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Earth's volatile elements, particularly those essential for life, play an important role in Earth's evolution and its habitability formation. Compared with primitive chondrites, the bulk silicate Earth (BSE) has a similar refractory lithophile element abundance pattern but is strongly depleted in volatile elements [1]. Various theories have been proposed to explain this depletion pattern of Earth's volatile elements. One group of hypotheses suggests that proto-Earth accreted mainly from nearly volatile-poor materials from the inner Solar system, and that volatile elements in the BSE were established by a late addition of volatile-rich materials after core-mantle differentiation [2], known as a "late veneer". This model was originally proposed to explain the abundances of highly siderophile elements (HSEs) in the BSE [3], because nearly all HSEs were thought to be segregated into the metal phase during Earth's core formation. However, recent experiments reported low metal-silicate partition coefficients for some HSEs [4], which goes against the fundamental assumption of the "late veneer" model. Alternatively, previous melting and vaporization experiments suggested that the volatile element depletion pattern in the BSE is consistent with partial melting and vaporization rather than with late accretion of volatile-rich chondrite-like material [5]. It is still highly debated as to how and when Earth acquired its volatile elements.

Chalcogen isotopes can be used to constrain the origin and evolution of Earth's volatile elements, but this requires knowledge of the isotope fractionation caused by protoplanetary differentiation. Here we investigate the chalcogen isotope fractionation during planetesimal evaporation and core formation using theoretical calculations. By combining our data with chalcogen isotopic signatures in the BSE, we can constrain the accretion history of Earth's volatile elements.

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[4] T.-A. Suer et al., *Nat. Commun.* 12, 2913 (2021).

[5] C. A. Norris, B. J. Wood, *Nature.* 549, 507–510 (2017).