

Late accretion of volatiles to a dry proto-earth: really?

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Terrestrial volatiles may have been acquired by a late veneer of carbonaceous chondrite-like material impacting the proto-Earth after core formation was completed. However, volatile exchange between the surface and the deep Earth has likely clouded some of the late-veneer signatures. In this talk, we will present recent advances in our understanding of the isotope geochemistry of key volatile elements. A particular focus on sulfur, selenium, and nitrogen. allows us to assess whether the late veneer delivered substantial amounts of volatiles to Earth.

Mantle plume sources show variable sulfur isotope signatures. ³⁴S/³²S ratios appear correlated with proxies of recycling. The trends show that basalts with no clear evidence of recycled materials have a sub-chondritic ³⁴S/³²S ratio. Sulfur partitioning experiments suggest metal/silicate equilibria may be at play: the sub-chondritic S isotope composition observed in the modern mantle is likely a relic of planetary differentiation. This observation does not require a volatile-rich late veneer.

Selenium is often compared to sulfur, since S and Se likely behave similarly in high-temperature processes. High-precision ⁸²Se/⁷⁶Se data show basalts are more depleted in ⁸²Se than most carbonaceous chondrites. This is evidence against the delivery of volatiles by late accretion of carbonaceous chondrites.

Nitrogen is an atmophile, largely partitioned into the Earth's atmosphere. The Earth's mantle has a peculiar ¹⁵N/¹⁴N ratio from a meteoritical perspective, with values halfway between enstatite and carbonaceous chondrites. Estimates of modern N fluxes appear consistent with mantle N being attributable to subduction. If so, any primordial ¹⁵N/¹⁴N would have been erased over time. Recent measurements of the doubly-substituted isotopologue ¹⁵N¹⁵N in volcanic gases have shown, however, that the nitrogen fluxes to the mantle may have been overestimated. The ¹⁵N/¹⁴N ratio of the Earth's mantle may in fact be vestiges of planetary formation rather than inheritance from the surface. The planetary N isotope composition is also not consistent with a carbonaceous late veneer.

Overall, new isotopic observations appear to challenge the notion that volatiles were delivered by a volatile-rich late veneer to a dry proto-Earth.