Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.22957

Mantle sulfur isotopic composition: constraints on early Earth evolution

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The differentiation of the core and mantle and the heterogeneity of the mantle are key to understanding the formation and evolution of the early Earth. Sulfur isotopes are useful for tracing important processes in early evolution, such as core-mantle differentiation and the addition of late veneer. Siderophile elements (including sulfur) preferentially enter the core during core-mantle differentiation, however, the observed concentrations of these elements within the mantle significantly surpass those anticipated by theoretical calculation. Based on this, the late veneer hypothesis posits that after the cessation of core-mantle differentiation, about 0.5-1% of the Earth's mass in the form of chondritic meteoritic material was added to the mantle, becoming the main source of siderophile elements. Therefore, it can be predicted that the sulfur isotope composition of the mantle should be consistent with that of chondrites, which aligns with previous analyses of $\delta^{34}S$ values in MORB and OIB (~0 ‰). Labidi et al. (2013, 2012) improved the method for extracting sulfur and re-measured the $\delta^{34}S$ values of MORB glass, finding that the upper mantle source region has a deficit in $\delta^{34}S$ values, representing the preservation of early core-mantle differentiation effects. However, first-principles calculations have shown that under high temperature and high pressure, strongly reducing conditions during core-mantle differentiation, sulfur isotopes almost do not fractionate between the metal phase and silicate melt phase[3]. Moreover, the differences in $\delta^{34}S$ values between the modern depleted upper mantle, lower mantle, and lithospheric mantle reflect the potential heterogeneity and distinct evolutionary patterns within mantle sulfur isotopes, a domain where constraints on early deep mantle sulfur isotopic compositions remain elusive. Limited by the geological record, research on the early deep mantle mainly relies on komatiites. We conducted in situ SIMS analyses on 3.48-3.26 Ga Barberton komatiites in South Africa. We found that they have positive $\delta^{34}S$ values, providing new constraints on the sulfur isotope composition of the primordial mantle.

[1] Labidi et al.,(2013), Nature 501, 208-211.
[2] Labidi et al.,(2012), Chemical Geology 334, 189-198.
[3] Wang et al., (2021), Nature Geoscience 14, 806-811.