Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.37441

Isotopic constraints on Earth's deep sulfur cycle

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Geochemical analysis of basaltic lavas at ocean islands and mid-ocean ridges indicate that the Earth's interior is geochemically heterogeneous due to processes of melt removal and crustal recycling. However, the detailed constituents and relative age of the recycled materials relative to the ambient mantle remain enigmatic. We have produced bulk and in-situ S isotope data on a variety of materials (e.g., olivine, pyroxene, and matrix hosted sulfides) from ocean island basalts (OIB). There are several observations to be made from the data. First, we observe large mass-independently fractionated (MIF) S-isotope signals associated with OIB from Samoa (EM II), Tubuai (HIMU), Raivavae (HIMU), Sao Miguel Island, and Kosrae (EM), a suite of hotspots that broadly sample the Pacific Large Low Shear-Wave Velocity Province (LLSVP). The measured MIF-S component at Samoa contradicts previous assertions that recycled S materials erupted at Samoa are linked to Proterozoic continental crust[1-3]. The data from Mangaia, Tubuai, and Raivavae confirm the presence of a distinct, and possibly abundant, recycled Archean S component erupted among Cook-Austral hotspot lavas. Second, among the Pacific LLSVP hotspots we observe the strongest positive anomalies concentrated in the northwest quadrant, and the strongest negative anomalies concentrated in the southeast quadrant. Third, observations of MIF-S are not apparent among OIB erupted above the African LLSVP or OIB not linked to a mantle plume. Recycled components erupted at the Bermuda hotspot are thought to derive from the mantle transition zone[4], as opposed to a deeper source tapped by many South Pacific plume conduits. Bermuda bulk S-isotope values are remarkably similar to the Mangaia bulk S-isotope values[5], but the Bermuda in-situ S-isotope data exhibit no evidence of recycled MIF-S. Together the data suggest (1) a prevalence of recycled Archean S components erupted among South Pacific hotspots, (2) the Pacific and African LLSVPs may be composed of genetically distinct recycled sulfur components, and (3) distinct recycled S components may be stratified throughout the mantle.

[1] Labidi et al. (2015), EPSL; [2] Dottin et al. (2020), EPSL; [3] Dottin et al. (2021), GCubed; [4] Mazza et al. (2019), Nature; [5] Dottin et al. (2020b), Gcubed.