Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.31433

Sulfur isotopes at subduction zones: sediment heterogeneity and arc homogeneity

ALLY PECCIA[1], **TERRY PLANK**[2], SHUO DING[3], PROF. ALESSANDRO AIUPPA[4], SALVATRICE VIZZINI[5], ZOLTÁN TARACSÁK[6], BRIAN DAVID MONTELEONE[7], DAVID PYLE[8] AND TAMSIN A. MATHER[8]

[1]Lamont-Doherty Earth Observatory
[2]Lamont-Doherty Earth Observatory, Columbia University
[3]University of Florida
[4]University of Palermo, Dipartimento di Scienze della Terra e del Mare
[5]University of Palermo
[6]University of Cambridge
[7]Woods Hole Oceanographic Institution
[8]University of Oxford

Due to its presence as both sulfide and sulfate in the marine realm, sulfur has considerable leverage in its effect on the redox budget and $\delta^{34}S$ of subducted materials. Of the lithologies entering subducting zones, sediments have the largest range in $\delta^{34}S$ and thus are expected to drive considerable differences in the bulk $\delta^{34}S$ input from arc to arc. Motivated by this prediction, we have carried out the most comprehensive work to date quantifying sulfur fluxes and $\delta^{34}S$ of subducting sediments. Our focus has been on four subduction zones that encompass a variety of sedimentary lithologies: Central America (biogenic), Aleutians (turbidite-dominated), Marianas (pelagic-volcaniclastic) and Tonga (red clay and chert). In a parallel effort, we have also measured $\delta^{34}S$ in melt inclusions via SIMS in volcanic suites from these same subduction zones in order to assess S recycling from sediment to arc. The surprising result is the small range in arc $\delta^{34}S$ despite the extreme heterogeneity in sediment input. Using a combined approach of XRF core scanning, ICP-MS and EA-IRMS, we measure S concentrations and $\delta^{34}S$ along 100s of meters of drill cores. The subducting sedimentary sections at Central America and Alaska have pyrite-dominated bulk $\delta^{34}S$ (-14 and -4‰, respectively) while the Marianas and Tonga sections have sulfate-dominated bulk $\delta^{34}S$ (+16.5 and +19.5‰, respectively). Despite this extreme variation in input, undegassed arc magma $\delta^{34}S$ estimates (based on our melt inclusion data) span from +1 to +5‰, with most between +2 and +3‰, but all notably higher than MORB (≤ 0‰). Thus, the sulfur recycled to arcs is pervasively shifted to a narrow range of enriched $\delta^{34}S$ compositions relative to the sediment input. We propose two processes to explain this observation: 1) a substantial contribution of MORB sulfur from the subducted oceanic crust that modulates sediment sulfur, and 2) widespread oxidation of slab pyrite to fluid-mobile sulfate, which preferentially transports ^{34}S (and high oxidative power) to the sub-arc mantle source. The complement of this process is the subduction of reduced, low $\delta^{34}S$ residual slabs to the deeper mantle.