Revealing the subduction zone sulfur recycling: The slab perspective

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Sulfur belongs among H_2O, CO_2, and Cl as one of the key volatiles in Earth's chemical cycles. High oxygen fugacity (fO_2), sulfur concentration, and $\delta^{34}S$ values in volcanic arc rocks have been attributed to significant sulfate addition by slab fluids[1,2]. However, the arc high fO_2 has alteratively been interpreted to magma evolution[3] or differentiation[4], and arc $\delta^{34}S$ signature to degassing or crustal assimilation[5]. This debate is largely driven by the unknown fate of sulfur during subduction zone processes, in particular, the sulfur speciation, mass flux, and isotopic composition during transport by slab fluids. Here we use whole-rock and in-situ $\delta^{34}S$ compositions of exhumed subduction zone rocks and enclosed veins linked to calculated sulfur concentrations in fluids to decipher slab sulfur flux and $\delta^{34}S$ signatures transported into the mantle wedge. Textural and thermodynamic evidence indicates the predominance of reduced sulfur species in slab fluids. Vein sulfide reveals that fluids derived from metasediments, altered oceanic crust, and serpentinite have $\delta^{34}S$ values of approximately –8‰, –1‰, and +8‰, respectively. Mass-balance calculations demonstrate that 6.3% (up to 20% maximum) of total subducted sulfur is released between 30–230 km depth, and the predominant sulfur loss takes place at 70–100 km with a net $\delta^{34}S$ composition of –2.5±3 ‰. We conclude that modest slab-to-wedge sulfur transport occurs, but that slab-derived fluids provide negligible sulfate to oxidize the sub-arc mantle and cannot deliver ^{34}S-enriched sulfur to produce the positive $\delta^{34}S$ signature in arc settings. Most sulfur has negative $\delta^{34}S$ and is subducted into the deep mantle, which could cause a long-term increase in the $\delta^{34}S$ of Earth surface reservoirs.

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[2] Bénard *et al.* (2018) *Nat. Comm.* **9**, 3500.
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