Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36416

Sulfur isotope variations in arc melt inclusions record magmatic degassing and oxidation

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

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

The sulfur cycle at subduction zones is intimately linked to redox budgets and reactions in the slab, mantle and in magmas. Here we focus on new $d^{34}S$ measurements of MIs measured by SIMS from 10 arc volcanic suites[1] that reveal strikingly different degassing trends. In some suites (Makushin, Cerro Negro and Volcano A), $d^{34}S$ increases by 3-4 ‰ as S decreases from 1000's to 100's of ppm. In others (Seguam and Volcano 19) $d^{34}S$ decreases by several ‰ during S degassing. Such behavior is consistent with different initial sulfur speciation, a function of oxygen fugacity (fO_2). In oxidized magmas, the dominant degassing reaction involves equilibrium between sulfate in the melt and SO_2 in vapor. During progressive degassing, the lighter isotope (^{32}S) is taken up by the gas phase (where S^{4+} is the dominant species), and $d^{34}S$ increases in the melt (where S^{6+} is the dominant species). The opposite happens in reduced magmas, where the dominant melt species (sulfide) is now of lower oxidation state than the vapor (SO_2). This behavior is consistent with independent estimates of magmatic fO_2, based on uXANES measurements of Fe speciation and olivine/melt V partitioning data from the same samples. A modified version of the Sulfur_X model[2] that incorporates the S isotope fractionation factor can adequately reproduce the observed direction and magnitude of the MI degassing trends. Thus, the variations in $d^{34}S$ in MIs during degassing is a sensitive recorder of magmatic fO_2. Such variations may be large (> 4 ‰), and need to be accounted for when interpreting volcanic gas data and when inferring primary $d^{34}S$. In the arc volcanic suites included in this study, the variation in measured $d^{34}S$ from ~0 to +11 ‰ reduces to a remarkably narrow range (+2.7 ± 1.2 ‰ 1sd) after correcting for degassing. Reproducing the narrow range in $d^{34}S$ of parental arc magmas is a requirement of any S recycling model[3], and implicates a common slab source for S and oxidation: the oceanic crust.

[1] Taracsak et al. (in revision, Science Advances). [2] Ding et al. (2023, G3). [3] Peccia et al. (2025, Chemical Geology)