Tracking Slab-Derived Sulfur and its Effect on Magma Oxidation State in the Southern Cascades

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In subduction zones, the transport of sulfur from the subducting slab into the sub-arc mantle has the potential to strongly affect magma redox state, long-term cycling of ore-forming metals, and the global output of sulfur by volcanic degassing. Despite this, the flux of slab-derived sulfur and its redox effects in arcs remain uncertain. Here, we use the Lassen Volcanic Region in the Southern Cascades to investigate sulfur cycling in subduction zones and its relationship to magma redox state. We integrate measurements of major and trace elements (including chalcophile elements), $\delta^{34}S$ values, $Fe^{3+}/\Sigma Fe$, $S^{6+}/\Sigma S$, and volatiles (H_2O, S, and Cl) in olivine-hosted melt inclusions (MIs) from five cinder cones. This integrated dataset for MIs in high-Mg (Fo 83-90) olivine allows us to minimize signals from crustal processes and investigate the behavior of sulfur during mantle melting.

Lassen melt inclusion compositions vary systematically between each studied cinder cone. Within cone averages of the MI data range from 750 to 2,240 ppm S, 66 to 155 ppm Cu, 0.25 to 0.87 $S^{6+}/\Sigma S$, 1.7 to 5.1‰ $\delta^{34}S$, and relative fO_2 (calculated from measured $Fe^{3+}/\Sigma Fe$) of QFM+0.2 to QFM+1.5. The MI data show clear correlations between trace element indicators of slab-derived material (e.g. Sr/Nd), S contents, $\delta^{34}S$ values, and fO_2 values. These correlations indicate the presence of oxidizing, sulfur-rich material in the Lassen sub-arc mantle. Previous work and our new data show that this slab-derived material is also H_2O and Cl rich and likely to be a hydrous partial melt of the subducted oceanic crust [1].

We use our results together with pMELTS modeling, trace element partitioning calculations, and models of sulfide behavior [2,3] to create a forward model of subduction-modified-mantle melting beneath the Lassen region. This model shows that while Lassen magmas have both elevated fO_2 and elevated S contents relative to MORB, metal contents and dissolved melt S are controlled by the presence of residual mantle sulfide, consistent with the relatively restricted range of Cu measured in the MIs.

[1] Walowski *et al*. (2016) *EPSL* **446,** 100-112. [2] Fortin *et al*. (2015) *GCA* **160,** 100-116. [3] Jugo *et al*. (2010) *GCA* **74,** 5926-5938.