

Variable Sulfur Release Predicted for Hot and Cold Subducting Slabs

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Here we present the first thermodynamic models that predict the full range of possible S-liberating reactions during the subduction of mafic oceanic crust. Models for MORB and AOC were created in Perple_X utilizing the combined thermodynamic databases of [1] and [2]. Transitions from pyrrhotite to pyrite and pyrite to anhydrite are observed with increasing *P-T*. The pressure of the pyrite-anhydrite transition depends on initial $\text{Fe}^{3+}/\Sigma\text{Fe}$: 3.2 GPa for MORB ($\text{Fe}^{3+}/\Sigma\text{Fe} = 0.16$) and 2.3 GPa for AOC ($\text{Fe}^{3+}/\Sigma\text{Fe} = 0.28$) at 650 °C. Reactions were monitored along slab-top geotherms for Honshu and Cascadia (D80, [3]). Above the pyrite-anhydrite transition HSO_4^- , SO_4^{2-} , and HSO_3^- are the dominant fluid species (<0.9 mol/kg), whereas HS^- is dominant in the sulfide fields (<0.1 mol/kg). Along the Honshu path, oxidized S-species increase from 0.05 to 0.4 mol/kg over 550 to 625 °C (82-84 km depth), concurrent with an increase of 70 % in the total fluid volume due to reactions such as lawsonite-out. Sulfur oxidation is balanced by the reduction of Fe^{3+} , with a 48 % decrease in $\text{Fe}^{3+}/\Sigma\text{Fe}$. In contrast, oxidized S-species increase from 0.0 to 0.4 mol/kg, over 600 to 675 °C (68-77 km depth) along the Cascadia path, concurrent with a 15 % increase in total fluid volume. Nearly 85 % of the total fluid released along the Cascadia path occurs where HS^- dominates and S concentrations in fluid are low.

Our data suggest that slab-derived S-bearing fluids are a viable mechanism for oxidation of arc magmas. Coeval sulfur and water loss along cold *P-T* paths are expected to result in high fluxes of oxidized sulfur to volcanic arcs, whereas significant dehydration prior to sulfur oxidation will result in low sulfur fluxes along hot *P-T* paths. This discrepancy is expected to be accentuated by the less oxidized nature of younger oceanic crust at hot subduction zones.

[1] Holland & Powell (2011) JMG

[2] Servjensky et al. (2014) GCA

[3] Syracuse et al. (2010) PEPI