Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.4948

A thermodynamic model for sulfur content at sulfide saturation (SCSS) in hydrous silicate melts: with implications for arc magma genesis and S recycling

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Modeling the effect of H_2O on the "sulfur content at sulfide saturation" (SCSS) in silicate melt is essential for the estimation of SCSS in both arc magmas and slab melts. Here we present a SCSS model for hydrous silicate melt, in which SCSS has been modeled as a combination of S dissolving as S^{2-} and HS^-/H_2S, based on the sulfide capacity ($C_S{}^{2-}$) and the hydro-sulfide capacity (C_{HS}), respectively. By adopting the thermodynamic framework of O'Neill and Mavrogenes [1], S dissolution as HS^-/H_2S can be modeled in an analogous fashion to that for modeling S^{2-} in anhydrous melt. With the contribution of S dissolving as S^{2-} in basaltic and andesitic melts calculated based on the updated SCSS model for anhydrous basic melt from O'Neill [2], and S^{2-}considered negligible in rhyolitic and dacitic melts, we obtain an expression for C_{HS} based on a compilation of published experimental data on SCSS in hydrous silicate melts covering a *PT* range of 0.15-3 GPa and 785-1600°C, and melt H_2O contents of ~1-13 wt%.

Our model produces SCSS values for the primitive arc magmas compiled by Ruscitto et al. [3], that are in most cases higher than the measured S contents, implying sulfide under-saturated conditions during mantle wedge melting. The contribution of H_2S dissolution to the calculated SCSS values varies in a range of 82-1410 ppm, which increases with the increase of H_2O content (0.3-6.2 wt%). H_2S dissolution therefore contributes to the higher S content in arc basalt compared to MORB. Applying our current model to experimentally produced sediment melts spanning a *PT* range of 690-1050°C and 2.5-4.5 GPa, demonstrates that sediment melts, especially those of intermediate supercritical character with >25 wt% H_2O and peralkaline in composition, can have high SCSS values as a result of H_2S dissolution, and act as the transfer medium for S recycling between the slab and mantle wedge under reduced conditions.

[1]O'Neill & Mavrogenes (2002) *J. Petrol.* 43, 1049–1087. [2]O'Neill (2020) in: *Earth and Space Science Open Archive.*https://doi.org/10.1002/essoar.10503096.2 [3]Ruscitto et al. (2012) *Geochemistry, Geophys. Geosystems* 13, Q03025.