Tracking sulfur behavior and fO_2 evolution in the 1257 CE Samalas magma reservoir (Indonesia)

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The 1257 CE Samalas eruption in Indonesia produced the largest stratospheric SO_2 release in the Common Era[1]. Most (~80%) of these SO_2 emissions were likely derived from a pre-eruptive vapor phase[1]. In this study, we present XANES measurements of S and Fe redox states in plagioclase-hosted melt inclusions and matrix glasses from the 1257 eruption to track the interplay between S behavior and fO_2 evolution at an unprecedented level of detail for an evolved magmatic system. The examined melt inclusions show decreasing S with decreasing Cl at relatively constant H_2O contents, consistent with extensive pre-eruptive degassing. The $S^{6+}/\sum S$ ratio in melt inclusions is negatively correlated with S content, with the low-S matrix glasses only containing S^{6+}. In contrast, $Fe^{3+}/\sum Fe$ ratios in melt inclusions decrease with decreasing S, and matrix glasses show the lowest $Fe^{3+}/\sum Fe$ ratios. These findings differ significantly from observations in basaltic systems, where $S^{6+}/\sum S$ and $Fe^{3+}/\sum Fe$ ratios are both positively correlated with S contents[2]. While degassing of S^{2-} as SO_2 could have increased $S^{6+}/\sum S$ ratio and reduced the Fe^{3+} to Fe^{2+} in the melt, decreasing FeO and TiO_2 concentrations along with the decreasing $Fe^{3+}/\sum Fe$ suggest that crystallization also contributed to Fe reduction in the melt. The observed decoupling of Fe and S redox states at Samalas suggests that fO_2 might not be the only factor controlling S speciation in intermediate-to-silicic melts[4].

[1]Vidal et al., 2016, *Sci. Reports*; [2]Brounce et al., 2017, *PNAS*; [3]Jugo et al., 2011, *GCA*; [4]Nash et al., 2019, *EPSL*.