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Sulphur behaviour and oxygen fugacity variation in Mt. Etna system revealed by melt inclusions

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It has long been recognized that melt inclusions (MIs) have the potential for providing insight into how magmas and their volatiles evolve during cooling and crystallization.

We analysed H_2O, CO_2, S and Cl contents of olivine-hosted MIs in several eruptive products of Mt. Etna (Italy), together with their major element composition, and iron speciation ($Fe^{3+}/\Sigma Fe$). Using these data, we investigated fractional crystallization, degassing and redox conditions variations occurring during magmatic ascent.

MIs have composition extending from volatile-rich picro-basaltic toward volatile-poor evolved trachybasalt. The picro-basaltic MIs are extremely enriched in H_2O and CO_2 (up to 5.9 and 0.58 wt.% respectively). S content in Etnean MIs ranging from some ppm up to more than 4000 ppm, whereas the oxygen fugacity (fO_2, estimated using XANES $Fe^{3+}/\Sigma Fe$ ratios and oxybarometers models) ranges from NNO-0.9±0.1 to NNO+1.6±0.2, with NNO being the Nickel-Nickel Oxide buffer [1].

Based on (i) S concentration and (ii) oxygen fugacity estimates in MIs, and using an empirical model predicting the variation of S partitioning between fluid and melt phases ($DS^{fluid/melt}$) upon variations in P, T and fO_2, our research suggests that during magmatic ascent in the Etnean system a fO_2 decrease occurs, affecting the S behaviour.

The empirical $DS^{fluid/melt}$ model coupled to MELTS code [2, 3] provides evidence of fO_2 decrease during volatile exsolution and crystal fractionation of olivine, clinopyroxene, spinel and plagioclase, upon T and P decrease. The fO_2 diminution is responsible for the increase in $DS^{fluid/melt}$, and thus the decrease of S solubility in the melt and, consequently, for the increasing exsolution of S (which further enhances the reduction of fO_2) from the magma before eruption.

References

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