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Determination of the oxidation state of arc primary melts using two fO_2 proxies

MARION GABORIEAU[1], **MURIEL LAUBIER**[1], NATHALIE BOLFAN-CASANOVA[1] AND MASSIMO POMPILIO[2]

[1]Laboratoire Magmas et Volcans
[2]INGV-Sezione di Pisa

Presenting Author: muriel.laubier@uca.fr

Although many studies have demonstrated that arc magmas are more oxidized than mid-ocean ridge (MORB) and oceanic island basalts (OIB) [1-5], the oxidation state of their mantle source is still debated. This ongoing debate is mainly due to contradictory fO_2 values obtained from different proxies (e.g., $Fe^{3+}/\Sigma Fe$ of olivine-hosted melt inclusions and glasses, Zn/ΣFe, V/Sc, V/Ga of lavas).

Here, we estimate the oxygen fugacity of high-Mg olivine-hosted melt inclusions from mid-ocean ridges and various arcs (Aoba, Mount Meager, Vulcano, Stromboli), from one hot spot (Reunion Island) and Mount Etna using two fO_2 proxies: the $Fe^{3+}/\Sigma Fe$ of melts and the partition coefficient of V between olivine and melt ($D_v^{Ol/Melt}$ [6]). Our results indicate that secondary processes such as H_2O and fO_2 re-equilibration, volatile degassing and fractional crystallization are unlikely to be responsible for the large variation in magmatic fO_2. After reconstructing primary melt compositions, we show that (1) fO_2 values derived from $Fe^{3+}/\Sigma Fe$ and $D_v^{Ol/Melt}$ are comparable and (2) arc and Mount Etna primary melts are more oxidized than primary melts from mid-ocean ridges and Reunion Island. We then demonstrate, using trace element ratios, that the observed variability in primary melt fO_2 is not due to the chemical variability of the mantle source prior to its metasomatism (using Zr/Nb) but is rather a consequence of the addition of slab-derived material (using Ba/Th and Sr/Th) during subduction processes.

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