Fe-redox in olivine-hosted melt inclusions and embayments across the Andean Southern Volcanic Zone

STEPHEN J TURNER[1] MADELEINE HUMPHREYS[2] ANDREW MATZEN[3] DANILO DI GENOVA[4] ALEXANDER IVESON[2] DUANE SMYTHE[3] TAMSIN MATHER[3] DAVID PYLE[3]

[1]Washington University in St. Louis Dept. of Earth and Planetary Sciences, sjturner@wustl.edu
[2]Durham University Dept. of Earth Sciences
[3]University of Oxford Dept. of Earth Sciences
[4]University of Bristol School of Earth Sciences

Fe K-edge XANES analyses were conducted on olivine-hosted melt inclusions and embayments from six mafic tephras from the Southern Volcanic Zone (SVZ). The samples include three tephras from the arc front, and three rear-arc scoria cones. Trace-element and boron isotopic analyses indicate that the mantle sources of the arc-front tephras were heavily impacted by a slab-derived component, while the rear-arc samples received little to no slab input. Despite this, rear-arc melt inclusions contain high volatile contents (up to ~2500 ppm CO_2, 3 wt% H2O, 2000 ppm S) due to their generation by very low extents of mantle melting.

The most primitive arc-front inclusions from Villarrica and Hornipiren have Fe^{3+}/Fe_{Total} from .20 to .30. Primitive inclusions from Apagado, however, are as high as Fe^{3+}/Fe_{Total}=0.42. Surprisingly, the primitive inclusions from the rear-arc cones span almost the same range as the arc-front cones, with Fe^{3+}/Fe_{Total} up to 0.38, apparently indicating fO_2 values 1.8 log units above the fayalite-magnetite-quartz buffer [1]. Fe^{3+}/Fe_{Total} tends to decrease with decreasing MgO and S concentrations in both the rear arc and arc front, though with some notable exceptions.

High Fe^{3+}/Fe_{Total} values in the arc front may be due to the addition of slab material to the mantle, but some other process must account for high Fe^{3+}/Fe_{Total} in the rear arc. Low-degree melting of the mantle will elevate Fe^{3+} contents in mantle melts, but is unable to account for the full range of observed compositions [2]. It is possible instead that given the very high rear-arc S concentrations, electron exchange between Fe and S during quenching of the inclusions substantially elevates Fe^{3+}/Fe_{Total} values [3]. If true, then this process must also be significant in the arc-front Apagado sample, which has up to 2600 ppm S. After accounting for melting, quenching, and differentiation, the fO_2 of the mantle in both arc-front and rear-arc settings can be estimated.

[1] Kress and Carmicheal (1991) Contrib. Mineral. Pertol. 108, 82-92. [2] Gaetani (2016) Geoch. et Cosmo. Acta, 185, 64-77. [3] Nash et al. (submitted), Earth and Plan. Sci. Let.