The oxidation state of Fe in glasses from the Austral Islands: limits on effects of the HIMU mantle end-member on oxygen fugacity

M. E. PETERSON*[1], M. BROUNCE[2], E. STOLPER[1], J. EILER[1], T. HANYU[3], A. NICHOLS[4], M. JACKSON[5]

[1]California Institute of Technology, Pasadena CA, USA (*petemary@caltech.edu)
[2]U. of California Riverside, Riverside CA, USA
[3]Japan Agency for Marine-Earth Science and Technology, Yokosuka 237-0061, Japan
[4]U. of Canterbury, Christchurch, New Zealand
[5]U. of California Santa Barbara, Santa Barbara CA, USA

Ocean island basalts (OIB) display geochemical variability attributed to ancient recycled lithospheric material in their mantle sources. Such recycled material from near-surface environments can contribute to heterogeneity in mantle fO_2. The high-μ isotopic end member (HIMU) has radiogenic Pb isotope ratios attributed to recycled oceanic crust (potentially Archean in age). This might lead to quantifiable differences in the $Fe^{3+}/\Sigma Fe$ ratios (and hence the fO_2) of HIMU sources relative to average upper mantle.

We present μ-XANES measurements of the oxidation state of Fe in submarine matrix glasses from the Austral Islands (AI), an OIB chain with HIMU isotopic ratios. $Fe^{3+}/\Sigma Fe$ ratios of AI glasses are 0.17–0.30. MgO contents range from 3.9-6.8 wt%. The more primitive glasses (MgO > 4 wt%) have $Fe^{3+}/\Sigma Fe < 0.20$, corresponding to a magmatic fO_2 range relative to the QFM buffer (ΔQFM, calculated at 1 atm and 1200°C) of 0.17–0.64. MORB glasses with comparable MgO have an average ΔQFM 0.175: i.e., fO_2s of primitive AI glasses overlap the range of MORB glasses but extend to ~0.5 log units more oxidizing than the average MORB. The $Fe^{3+}/\Sigma Fe$ ratios of the AI glasses do not correlate with their isotopic ratios.

Evolved AI glasses (MgO < 4 wt%) have $Fe^{3+}/\Sigma Fe$ ratios of 0.28–0.30, suggesting that crystal fractionation is accompanied by significant oxidation. Cl/K is < 0.1, and H_2O/Ce is < 200 in the most oxidized glasses, suggesting that interactions with oxidized near-surface materials are unlikely to have generated the high $Fe^{3+}/\Sigma Fe$ ratios. Likewise, S/Dy ratios are similar between glasses at either end of the range of $Fe^{3+}/\Sigma Fe$, implying that S-degassing is not responsible for variations in $Fe^{3+}/\Sigma Fe$. The overall similarity of the $Fe^{3+}/\Sigma Fe$ ratios of AI glasses to MORB glasses suggests that the amount of HIMU component in Austral Islands mantle sources is either too small to significantly affect the fO_2 or not significantly different from average upper mantle.