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Experimental measurements of Fe_2O_3 partitioning during partial melting of peridotite with implications for Fe_2O_3 concentration in the MORB-source mantle

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The $Fe^{3+}/\Sigma Fe$ ratio of Earth's upper mantle influences the chemistry and abundances of mantle minerals and, consequently, the chemistry of mantle-derived basalts. At ridges, peridotites and MORB glasses record information about fO_2 in the convecting upper mantle, but to connect this information to the $Fe^{3+}/\Sigma Fe$ ratio and fO_2 of the unmelted mantle requires constraints on how FeO and Fe_2O_3 partition between minerals and silicate melts during MORB petrogenesis.

We present experimentally determined partition coefficients for Fe_2O_3 between mantle minerals and basalts from high-temperature experiments at pressures of 1 bar [1] (and see Ajayi et al., this meeting) and 1.5 GPa [2] (and see Little et al., this meeting) and over a range of f_{O2} (about QFM-2 to QFM+2). The high-pressure experiments use PtFe alloy capsules to control oxygen fugacity by varying the proportion of Fe in the alloy. We measured $Fe^{3+}/\Sigma Fe$ ratios in glasses by XANES. We measured $Fe^{3+}/\Sigma Fe$ ratios in spinels by EPMA using Mössbauer-characterized standards, and we calculated $Fe^{3+}/\Sigma Fe$ ratios in cpx and opx using Fe-Mg exchange relationships with coexisiting olivines [2].

Spinel/melt DFe_2O_3 decreases with temperature and increases with spinel Fe_2O_3 concentration. Cpx/melt DFe_2O_3 is greater in our experiments than measured by [3] but conforms to trends of increasing cpx/melt DFe_2O_3 with increasing cpx Al_2O_3 concentration. Given that pyroxenes at high pressure in equilibrium with spinels will have high Al_2O_3 concentrations, our measurements of cpx/melt DFe_2O_3 should be appropriate for modeling partial melting in the MORB source region. Modeling based on our experimental results suggests that the mantle source of MORB may contain considerably more Fe_2O_3 than has been estimated previously from the xenolith record [4]. Redox-dependent reactions in Earth’s mantle, such as those that enable melting to initiate, may extend to greater depths than previously suggested [2].

[1] Davis and Cottrell, Am Min, (2018); [2] Davis and Cottrell, CMP, (2021); [3] Rudra and Hirschmann, GCA, 2022; [4] Canil et al., EPSL, (1994)