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Partitioning of Fe^{3+} during peridotite partial melting at 1 bar and 1.5 GPa

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Melt extraction trends in peridotite xenoliths show Fe^{3+} behaves incompatibly during partial melting in the mantle [1]. Similarly, Fe^{3+} concentrates as an incompatible element in the melt during olivine fractionation in MORB [2], but Fe^{3+} does not positively correlate with other incompatible elements, such as Na, in fractionation-corrected MORB, but rather may correlate negatively [2,3]. Cottrell & Kelley [2] hypothesized this trend could result from a decrease in the bulk Fe^{3+} partition coefficient (D_{Fe3+}) of peridotite with increasing T, but there were insufficient experimental Ds to test this model.

We present the results of multiple-saturation experiments performed on melt + peridotite systems at 1 bar [4] and 1.5 GPa over a range of f_{O2} conditions from about QFM-2 to QFM+2 that allow for the measurement of D_{Fe3+} between spinel, a key host of Fe^{3+} in peridotite, and melt. We controlled f_{O2} in 1.5 GPa expriments using Pt-Fe alloy capsules of varying composition, which act as sliding redox buffers [5]. We analyzed $Fe^{3+}/\Sigma Fe$ ratios of glasses by XANES and $Fe^{3+}/\Sigma Fe$ ratios of spinels by electron probe using Mössbauer-analyzed correction standards [6].

Spinel-melt D_{Fe3+} is about a factor of 2 greater in 1 bar experiments performed at 1225 °C with spinel Cr# 0.61-0.68 than in 1.5 GPa experiments performed at 1380-1400 °C with spinel Cr# 0.15-0.33. Although effects of P, T, and X cannot yet be completely deconvolved, the absence of correlation between spl/melt D_{Fe3+} and spinel Cr# within each set of experiments suggests this effect is related to increasing T and/or P. If so, the spinel contribution to the bulk D_{Fe3+} can account for a factor of 1.2 change in bulk D_{Fe3+} between potential temperatures of 1320 and 1450 °C, a significant contribution to the factor of ~2 change need to explain the Na(8)-Fe^{3+}(8) trend of MORB [2]. Experimental measurements of pyroxene-melt D_{Fe3+} are needed to further test this hypothesis. If increasing mantle T leads Fe^{3+} to behave more incompatibly, then high Fe^{3+} concentrations in primitive MORB will tend to track with high Fe^{2+} concentrations, which are already known to increase with potential temperature. Consequently, $Fe^{3+}/\Sigma Fe$ ratios of primitive MORB should vary little as has been observed [2].

[1] Canil et al. 1994, EPSL [2] Cottrell & Kelley 2011, EPSL [3] Bézos & Humler 2005, GCA [4] Davis & Cottrell 2018, Am. Mineral. [5] Kessel et al. 2001, Am. Mineral. [6] Davis et al. 2017, Am. Mineral.