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High-pressure experiments investigating of Fe_2O_3 partitioning between minerals and silicate melts in refractory peridotite

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Upper mantle fO_2 determines the depths of redox reactions, such as diamond/graphite reacting to carbonated melt. The fO_2 of the mantle prior to melting may be different from measurements of fO_2 recorded by MORB or residual peridotites because fO_2 of melts and mantle residues may evolve during partial melting. To project back to $Fe^{3+}/\Sigma Fe$ ratio of the unmelted mantle we require partition coefficients of Fe_2O_3 between mantle minerals and melts. Recent experimental studies of Fe_2O_3 partitioning give varying estimates of the mantle $Fe^{3+}/\Sigma Fe$ ratio [1,2]. These studies showed that mineral compositions affect the partitioning of Fe_2O_3 [1,2]. As Fe_2O_3 in spinel increases, so does spinel/melt DFe_2O_3 [1], and cpx/melt DFe_2O_3 increases with increasing cpx Al_2O_3 concentration [2]. This study extends the experimental approach of [1] to test for compositional effects on Fe_2O_3 partitioning in refractory peridotites with higher Cr# spinel.

We conducted piston cylinder experiments using preequilibrated FePt alloy capsules at 1.5 GPa and 1380°C over a range of fO_2 from QFM -0.28 to QFM +3.04 (determined by measuring glass $Fe^{3+}/\Sigma Fe$ ratios by XANES), to generate melts in equilibrium with clinopyroxene, orthopyroxene, olivine and chrome-rich spinel (Cr# 0.21 to 0.52). We measured oxide concentrations in all phases by EPMA and spinel $Fe^{3+}/\Sigma Fe$ ratios using Mössbauer-characterized standards. We calculated $Fe^{3+}/\Sigma Fe$ ratios in orthopyroxene and clinopyroxene coexisting with olivine using Fe-Mg exchange [1].

Pyroxenes in these experiments have lower Al_2O_3 than previous experiments with more Al-rich spinels [1], but the cpx have higher Al_2O_3 than experiments undersaturated in spinel [2]. Comparing cpx/melt DFe_2O_3 from our experiments to literature data shows a continuation of the positive correlation with cpx Al_2O_3 defined by [2] and affirms that Al_2O_3 concentration has a controlling effect on cpx/melt DFe_2O_3. As partially molten mantle ascends beneath a ridge and residues become increasingly refractory, changes in mineral compositions may affect Fe_2O_3 partitioning (also see Ajayi et al. this meeting). Preliminary results imply that Al_2O_3 concentrations in cpx will remain relatively high in refractory residues and decreases in cpx/melt DFe_2O_3 will be modest (cpx/melt $DFe_2O_3 > 0.6$) .

[1] Davis and Cottrell, CMP, 2021. [2] Rudra and Hirschmann, Chem Geol., 2022.