Goldschmidt 2025 Abstract
https://doi.org/10.7185/gold2025.27012

Experiments constraining ferric iron partitioning between silicate melts and garnet peridotite

RAYANN REHWINKEL[1,2], FRED A DAVIS[1,2] AND ELIZABETH COTTRELL[2]

[1]University of Minnesota Duluth
[2]National Museum of Natural History, Smithsonian Institution

Mid-ocean ridge basalts (MORB) and oceanic island basalts (OIB) are partial melts of the upper mantle, and the oxygen fugacities (f_{O2}) they record can be related to the ferric iron (Fe^{3+}) contents of their mantle sources through experimentally derived Fe^{3+} partition coefficients. Such estimates of upper mantle Fe^{3+} contents anchor models of subsolidus f_{O2} deeper in the upper mantle. MORB record f_{O2} approximately equal to the quartz-fayalite-magnetite (QFM) buffer [1] and are dominated by partial melts of spinel peridotite. OIB record a wider range of f_{O2}, from near QFM to several orders of magnitude higher [2], and record greater contributions from garnet-bearing sources.

Thermodynamic models in which bulk $Fe^{3+}/\Sigma Fe$ and bulk composition are held constant indicate that garnet peridotite equilibrates at higher f_{O2} than spinel peridotite because of the difference in Fe^{3+} distribution among minerals [3]. This observation led [3] to suggest that OIB may be oxidized relative to MORB because OIB tap melts from the garnet stability field and erupt without equilibrating in the spinel field. Experiments are required to test this hypothesis.

Several experimental studies have investigated Fe^{3+} partitioning between melt and spinel peridotites, but studies of Fe^{3+} partitioning between silicate melt and garnet peridotites are lacking. We conducted piston cylinder experiments at 2.8 GPa, 1480 to 1520°C, and from QFM-0.5 to QFM+2.5 using techniques from [4] to determine Fe^{3+} partitioning between melt and a garnet peridotite phase assemblage of olivine + orthopyroxene + clinopyroxene + garnet. We determined $Fe^{3+}/\Sigma Fe$ in glasses and garnets using XANES [5] and $Fe^{3+}/\Sigma Fe$ in pyroxenes using an olivine-pyroxene Fe-Mg K_D regression [4]. We calculate garnet peridotite Fe^{3+} partition coefficients, model the expected f_{O2} of the accumulated partial melts, and compare these to modeled melts of spinel peridotite with the same bulk $Fe^{3+}/\Sigma Fe$ and bulk composition.

[1] Cottrell et al., Magma redox geochemistry, 2021. [2] Brounce et al., CMP, 2022. [3] Birner et al., Nature, 2024. [4] Davis and Cottrell, CMP, 2021. [5] Holycross and Cottrell, Science, 2023.