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Bromine partitioning between olivine, orthopyroxene and silicate melt at MORB and OIB source conditions

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Heavy halogens, particularly bromine (Br) and iodine (I), are highly incompatible in mantle minerals, making them valuable tracers for volatile transport processes in the Earth's mantle. However, their budget and distribution remain poorly constrained due to their extremely low concentrations in major upper mantle minerals and the absence of well-defined partition coefficients describing their behavior during partial melting in mid-ocean ridge basalt (MORB) and ocean island basalt (OIB) source regions.

To address this, we conducted high-pressure high-temperature experiments at 1.0 and 2.3 GPa and 1573–1873 K to partially melt an Fe-free peridotite analogue doped with Cl, Br, and I. The resulting run products contained olivine and/or orthopyroxene embedded in quenched silicate melt. Given that Br concentrations in these minerals are expected to be below 1 ppm, conventional analytical methods are insufficient for direct quantification. We coupled neutron-irradiation noble gas mass spectrometry (NI-NGMS) with UV-laser ablation, enabling for the first-time precise measurement of trace Br in individual nominally anhydrous minerals.

Initial results confirm Br's strong incompatibility, with partition coefficients between olivine/orthopyroxene and silicate melt well below 10^{-3} at MORB and OIB source conditions. For example, $D_{Br}^{fo/melt} = 4.5 \pm 1.6 \times 10^{-4}$ at 1773 K and 1 GPa, and $D_{Br}^{opx/melt} = 1.3 \pm 1.0 \times 10^{-5}$ at 1873 K and 2.3 GPa.

These findings suggest, with additional consideration of modal abundances, that olivine is the dominant Br carrier in the Earth's upper mantle, whereas orthopyroxene plays only a minor role. By combining our newly determined partition coefficients with existing Br bulk rock concentrations in MORBs and OIBs [1], we are able to estimate Br concentrations in their respective mantle source regions. Our results suggest that Br is significantly depleted in HIMU and high-$^3He/^4He$ OIB sources relative to primitive mantle estimates, implying that Earth's mantle experienced early and efficient heavy halogen depletion into surface reservoirs.

[1] Kendrick M.A. et al. (2017) *Nature Geoscience* 10, 222–228.