

Experimental insight into komatiite-harzburgite reactions at 3 GPa

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Cratonic peridotites exhibit more variable olivine/orthopyroxene (ol/opx) than simple residues of closed-system melting of fertile mantle at 2-5 GPa, exemplified by opx-rich harzburgites from the Kaapvaal craton. Their origin is debated, with many models invoking SiO₂-rich liquids. Alternatively, thermodynamic modelling^[1] and microstructures^[2] suggest that reactive melt flow of komatiite through proto-cratonic harzburgite caused opx enrichment, preserving ordinary mantle O-isotopes^[3].

To test this hypothesis, we performed sandwich (50% komatiite + 50% harzburgite) piston-cylinder experiments at 3 GPa and 1400-1650°C. The selected model harzburgite-only experiment resulted in a bi-mineralic 3 GPa solidus assemblage with opx/ol 0.30. The selected komatiite (MgO 32wt% and SiO₂ 48wt%) composition was modelled to represent a 7 GPa experimental liquid that had previously reacted with harzburgite at 5 GPa. All sandwich reaction experiments crystallised strongly layered charges (Fig.1). The bulk solid opx/ol ratio at the solidus is 0.92, but within the former komatiitic layer, opx mode is 80%. This opx has too low Mg# (0.91) and excessive Ti and Na compared to natural high Si/Mg harzburgites. Bulk opx/ol ratio decreases with melt fraction until opx-out at 1600°C with ~60% melt. At 22% melt, opx has Mg# of 0.93, similar to high Si/Mg harzburgites. This reaction still preserved a thick reaction layer of opx/ol >1 at the harzburgite-komatiite interface.

Our closed system reaction experiments show that very high opx modal abundance can locally be achieved when deep komatiite reacts with shallower 3 GPa residue harzburgite. This is partly due to the high Si/Mg of komatiite in equilibrium with >6 GPa garnet dunite. Although the experiments strictly approximate melt impregnation, open system implications can be inferred by mathematically subtracting the melt. This could explain removal of incompatible elements and suggest that high opx/ol harzburgite experienced the escape of modified komatiite. Depending on melt/solid ratio, the escaping melt evolves from high-Mg komatiite to picrite with substantial change in Si/Mg, as observed in erupted komatiite. Diffusive equilibration of Fe-Mg, as seen in the experiments, obliterates original reaction mineral chemistries but cannot erase the compositional layering in the generally coarse-grained harzburgites.

[1] Tomlinson&Kamber(2021), NatComms. 12(1):1802.

[2] Dazcko et al.(2024), Contrib.Mineral.Petrol. 180,5.

[3] Regier et al.(2018), Geochem.Persp.Lett. 9,6-10.

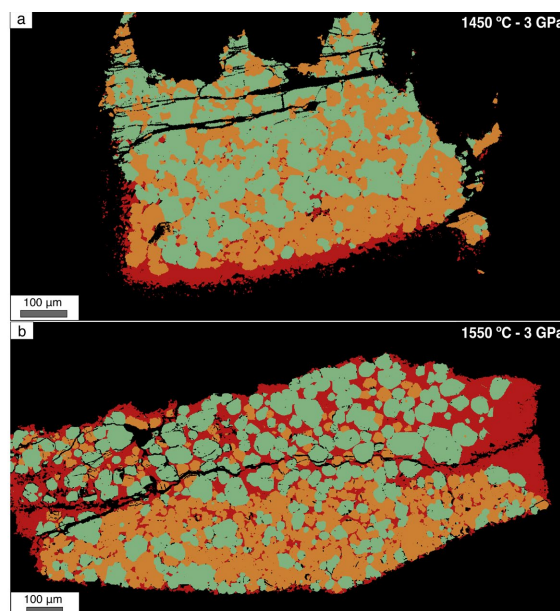


Figure 1. Reaction experiments (50% komatiite + 50% harzburgite).