

Insights on komatiite petrogenesis from anhydrous garnet peridotite melting experiments at 5 GPa

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The geodynamics of mafic and ultramafic melt formation in the deep Archean mantle continue to be debated, partly due to discrepancies between different experimental studies and thermodynamic modelling. Uncertainties include solidus temperature, exact phase relations, partial melt compositions at high pressure (>4GPa), and the absence/presence of hydrous fluids. Here we report an isobaric (5GPa) prograde suite (1400-1750°C) of piston-cylinder experiments performed on a nominally anhydrous, mildly depleted (in TiO₂ and Na₂O) lherzolite (GKR-001). Temperature gradients were minimised by using very small sample masses. Melt compositions were calculated from mass balance obtained with a novel way of estimating modal abundance.

The phase relations reproduced to a first order those of the seminal multi-anvil study of Walter [1] with some key differences. First, our solidus was encountered at 1575 ±15°C, 25-50°C lower than previous studies [1,2]. We attribute this to our machine learning-based phase analysis (on SEM-BSE and EDX images), which found very small (<5%) fractions of melt. Pressure calibration and temperature gradients may also explain some of the solidus T offset. Second, by contrast to earlier experiments, the stability field of coexisting ortho- and low-Ca clinopyroxene is much broader in our experiments both below and above the solidus. We attribute this in part to the higher CaO/FeO of our starting composition (0.52) compared to KR4003 (0.43), KLB-1 (0.42) and KH80-100 (0.23). With increasing T, the order of disappearance from the residue is clinopyroxene+garnet, orthopyroxene and olivine.

At 9% melting, the liquid is a microbasalt, changing to an Al-depleted komatiite at 27% melting, finally reaching an Al-undepleted composition at 46% melting. Until orthopyroxene-out, the experimental komatiites do not display the SiO₂/MgO variability seen in natural komatiites. This is likely because of the rather invariant pyroxene/olivine mode in the experimental harzburgite residues. Together with the observation that natural cratonic harzburgites generally have much higher orthopyroxene modes than those from high P experiments, this suggests that most Archaean komatiites formed via open-system reactions between resident harzburgite and high-MgO liquids arriving from greater depth. Thus, more realistic 'sandwich' experiments are required to test an open-system origin of komatiite.

[1]Walter (1998), *J. Petrol.*39,29-60;

[2]Canil (1992), *EPSL.*111,83-95.