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An experimental study of liquid compositions in equilibrium with plagioclase + spinel lherzolite at low pressures (0.75 and 0.5 GPa): an experimental approach to the evolution of basaltic melt during mantle refertilisation at shallow depths

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The project (Chalot-Prat et al., 2010; Chalot-Prat et al., submitted) is a contribution towards understanding the melting behaviour of the Earth's upper mantle, focussed on liquid compositions formed at near-solidus temperatures from plagioclase-spinel lherzolites at low pressure (0.75 and 0.5 GPa). Porous flow during mantle upwelling can lead either to melt extraction or to melt refertilisation, a process invoked for many natural occurrences of plagioclase $\pm$ spinel lherzolites. As compositions of mineral phases are pressure dependent, our results may be used also to quantify the P-T and compositional evolutionary paths of both liquids and residues during mantle refertilisation at shallow depths.

New experimental data on mineral and melt compositions, in the (Cr+Na+Fe+Ca+Mg+Al+Si) system, demonstrate covariant relationships between oxides in melt compositions, in partition relationships between mineral pairs and between minerals and melts. Normative projections demonstrate that liquids on the 5-phase+liquid cotectic occupy a narrow well defined compositional range at both 0.75 and 0.5 GPa. The plagioclase composition has the major control on liquid compositions which vary from silica-undersaturated at the sodic end (oligoclase) to orthopyroxene + quartz normative at the calcic end (anorthite) of the cotectic. Cr-Al spinel has limited variation. It is very Cr-rich at the sodic end and has limited compositional variation from 50 to 20 in Cr/(Cr+Al) at the calcic end. With fixed plagioclase composition, melt compositions show small compositional shifts with Fe-Mg (at Mg# between 85 and 95) and with Cr/(Cr+Al).

The mineral compositional data provide a good template for comparison with natural plagioclase+spinel refertilised lherzolites from an oceanic lithosphere (Piccardo et al., 2007). It appears that our experiments reproduce the natural mineral assemblages in all the inter-related solid solutions. Our comparison of experimental and natural mineral compositions leads us to infer that the refertilisation process of infiltration of magma by reactive porous flow within the lithospheric mantle took place at depths of 25-30 km (0.75 GPa<P<1 GPa) beneath the sea floor.

These experimentally defined melt compositions (magnesian quartz tholeiites at the calcic end) in equilibrium with plagioclase+spinel lherzolite are unlike Mid-Ocean Ridge quenched basaltic glasses. This mismatch between compositions of melts in equilibrium with plagioclase $\pm$ spinel lherzolite at low pressure and natural MORB glasses argues that the processes which give rise to primitive or parental MOR basalts or picrites occur deeper than 30km ($P \geq 1$ GPa).