Experimental melting of a modally heterogeneous mantle

V. K. Bulatov¹, A. V. Girnis², and G. P. Brey³

¹Vernadsky Institute of Geochemistry and Analytical Chemistry, Russian Academy of Sciences, Moscow, Russia
²Institute of the Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry, Russian Academy of Sciences, Moscow, Russia
³Institut für Mineralogie, J. W. Goethe-Universität Frankfurt, Frankfurt/M, Federal Republic of Germany

With 5 Figures

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Summary

Melting of a spinel lherzolite with a spinel clinopyroxenite layer was investigated experimentally from 3.5 to 20 kbar and from 1200 to 1450 °C. The melt fraction in the spinel pyroxenite layer increases rapidly, and clinopyroxene disappears leaving olivine-spinel residua according to the reaction Cpx + Sp = Ol + Liq. The melt in the pyroxenite layer reacts with the surrounding lherzolite resulting in the formation of an essentially monomineral (olivine) zone with interstitial melt near the former pyroxenite. Melt compositions in the central melt pool are similar to those produced by other authors in melting experiments with peridotites similar to the bulk compositions of our samples. It is suggested that similar small-scale mantle heterogeneities (i.e. thin pyroxenite layers in lherzolite) may exert significant influence on mantle rheology and melt segregation, whereas melt compositions are not strongly affected and controlled by the dominating lherzolite lithology.

Introduction

Considerable experimental work has been dedicated to equilibrium melting of mantle peridotite and generation of primary basalt magmas (Ito and Kennedy, 1967; Jaques and Green, 1980; Stolper, 1980; Sen, 1982; Takahashi and Kushiro, 1983; Fujii and Scarfe, 1985; Falloon and Green, 1987, 1988). Recent studies demonstrated the complex nature of initial magmas (e.g. Langmuir et al., 1977, 1992; O’Hara, 1985; Plank and Langmuir, 1992) including polybaric melting and mixing of melts from different mantle zones and lithologies. There is increasing
evidence on the heterogeneity on various scales in the source regions of mid-ocean ridge and oceanic island basalt. Peridotite xenoliths and massifs often contain veins and zones of pyroxene-rich rocks including pyroxenite and eclogite (Irving, 1980; Sautter and Fabries, 1990; Jackson and Wright, 1970; Kornprobst, 1969; Bodiner et al., 1987; Kumar et al., 1996). These veins are usually 1–10 cm, occasionally up to 2 m thick. They could be formed either by recycling and stretching of oceanic crust (Allegric and Turcotte, 1986; Kellogg and Turcotte, 1990) or crystal segregation along magma conduits in the mantle (Kornprobst, 1969; Irving, 1980; Bodiner et al., 1987; Kumar et al., 1996). Smaller scale mantle heterogeneity includes millimetre-sized patches and lenses of spinel or plagioclase pyroxenites, which might represent crystallised melts (e.g. Jousselin and Mainprice, 1998). Heterogeneities on a similar scale are found in sheared mantle xenoliths, where they could form below the mantle solidus in response to deformation (e.g. Witt and Seck, 1987).

Melting of such heterogeneous material will differ from that of homogeneous lherzolite, and certain features of oceanic magmatism can be explained in this way. Hirschmann and Stolper (1996) discussed the possible role of pyroxenite zones (veins) in mantle lherzolite for the genesis of mid-ocean ridge basalts. Melting of an inhomogeneous mantle was also considered to be crucial for the origin of Hawaiian magmas (e.g. Sen, 1988; Yang et al., 1998). The solidus of clinopyroxenite or eclogite may be lower than that of lherzolite (pyrolite) (Campbell, 1998), whereby the experimental evidence on pyroxenite melting is limited and the dependency on clinopyroxene composition is not adequately known. Another important process is the interactions of the melt formed in the pyroxene-rich zones with the enclosing lherzolitic or harzburgitic material. In order to study this process in more detail we undertook experimental melting of layered lherzolite/spinel pyroxenite samples at pressures from 3.5 to 20 kbar.

**Experimental methods**

Sample configuration (Fig. 1) was similar to that used in the basalt-peridotite sandwich experiments (e.g. Stolper, 1980). Samples consisted of a clinopyroxene-spinel disk, 2 mm in diameter and 0.5 mm high, surrounded by an olivine-orthopyroxene-clinopyroxene-spinel matrix. The disk and matrix were pressed from

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**Fig. 1.** Schematic drawing of the experimental setup