High pressure melt impregnation in a mantle peridotite

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Geochemical analysis of an abyssal peridotite from the Southwest Indian Ridge reveals the presence of high pressure melt impregnation in the mantle. Rare earth element and trace element patterns in clinopyroxenes identify a zone of chemical reaction between a depleted peridotite and an impregnating melt with MORB-like composition. The absence of plagioclase signatures in the REE patterns in the cores of both reacted and unreacted clinopyroxenes indicate that the melt impregnation occurred at pressures higher than the stability field of plagioclase.

The abyssal peridotite was collected during a submersible dive at the inner corner of the ridge-transform intersection of the Southwest Indian Ridge with the Atlantis II fracture zone. Ion probe analyses of the clinopyroxenes reveal two distinct groups. Type 1 clinopyroxenes have depleted REE patterns, typical of normal, depleted abyssal peridotites. Type 2 clinopyroxenes are enriched in the incompatible LREE relative to type 1, e.g. by a factor of 100 for La. The rims of both types of clinopyroxenes have negative Eu anomalies, but the cores do not.

Variations of other trace elements correlate with the REE variations. The wider range of Zr concentrations than Ti suggest that the chemical heterogeneity in the clinopyroxenes did not result from various degrees of melting or direct precipitation from various melt compositions. It was likely produced by chromatographic reaction with an impregnating melt.

The impregnation occurred at pressures greater than the plagioclase stability field. Plagioclase is present in the sample, but is interpreted as forming from breakdown of the high-pressure mineral assemblage to plagioclase plus olivine.

The equilibrium melt composition for the type 2 clinopyroxenes is similar to REE compositions of spatially associated basalts from the Atlantis II fracture zone. The calculated melt is more enriched in LREE, suggesting that the impregnating melt was formed by a low degree of melting, probably less than a few percent. In contrast, the peridotite is estimated to be the residue of roughly 8% melting. Several explanations are possible for a melting regime which depleted the peridotite before it was impregnated by a MORB-like melt. On-axis melting may have depleted the peridotite, followed by an off-axis lower degree melt impregnation of this residue. Such a model suggests that melt and mantle transport are three dimensional phenomena.

Ar-Ar ages in xenolith phlogopites –information on the Earth's lithospheric mantle and kimberlites

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Kimberlites are extraordinary natural phenomena, ascending through the Earth's lithosphere to erupt at the surface within hours to days of their inception deep within the lithospheric mantle. Geological study of the products of these eruptions is intense, not least because they are the primary source of diamonds on Earth. Entrained in gas-rich, magma poor eruptions are a plethora of xenoliths from the crust and lithospheric mantle.

Recent studies have shown that Ar-Ar phlogopite grain core ages are indicative of geological events (Pearson *et al.*, 1997; Kelley and Wartho, 2000; Kempton *et al.*, 2001). High spatial resolution Ar-Ar dating of phlogopite grains in xenoliths and megacrysts from southern Africa and Russian diamond-bearing kimberlites, and non-diamondiferous diatremes from the Solomon Islands and the Kola Peninsula, Russia, preserve a series of old grain core ages suggesting a series of multiple events within the lithospheric mantle.

Modelling of Ar diffusive loss profiles from the grain boundaries to cores provide information on lithospheric mantle events, kimberlite eruption ages, and the duration of outgassing within the kimberlite magma, and hence yield estimates on the rate of kimberlite ascent within the lithospheric mantle.

The kimberlite ascent durations are very similar for all the southern African pipes studied, 1-7 days, assuming a kimberlite magma temperature of 1000 °C. Assuming initial xenolith depths of 100-150 km, this equates to ascent rates of 0.3-0.5 m s^{-1}. These rates can be compared to Russian kimberlites, which yield ascent durations of 2-15 hours, and ascent rates of 2-21 m s^{-1}, assuming magma temperatures of 1000 °C, and xenolith depths of 100-150 km. Therefore, the Russian kimberlite ascent rates are an order of magnitude faster than their southern African counterparts. This may account for the higher degree of diamond resorption observed in southern African diamonds.

References

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