# Reactive melt transport in the oceanic lithosphere: Implications to MORB thermobarometry

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Basalt compositions reflect physico-chemical factors controlling magma generation, transport, and emplacement, and it is widely thought that, if chemical variables are known (e.g. Mg# and $fO_2$ in source peridotites) or properly corrected for (e.g. olivine fractionation), then the P-T conditions of mantle melting can be reasonably constrained. In this respect, mid-ocean ridge basalts (MORB) are of major interest: they encapsulate information regarding the present thermal state of Earth's mantle. Thermobarometry based on Si and Mg in basalts indicates that fractionation-corrected 'primary' MORB form a narrow P-T array between 1300-1400 °C and 0.7-1.7 GPa, overlapping the 10-15% melting isopleths of dry lherzolite [1]. This P-T array is evident even at short lengthscales, making it difficult to explain the spread by variations in mantle potential temperatures ($T_p$). More likely, short-lengthscale MORB temperature variability is the result of melt-rock reactions in the oceanic lithosphere, and reflects differences in axial lithosphere thickness [2].

Here we assess to what extent the 'primary' MORB P-T array can be caused by reactive melt transport in oceanic lithosphere. Using Adiabat_1ph [3] with pMELTS [4], we calibrate a synthetic Mg-Si thermobarometer for basalts equilibrated with peridotite at P < 3 GPa, analogous to experiment-based calibrations [1]. We apply this thermo-barometer to aggregated melts obtained by simulating polybaric fractional melting of peridotite along relevant $T_p$ and show that, in the absence of low-P melt-rock reaction, MORB P-T values reflect the conditions of mean extent of melting. However, our simulations of percolation of aggregate melts through residual harzburgites at low-P show that reactive melt transport in the oceanic lithosphere decreases Mg and increases Si in melt such that thermobarometry will produce P-T arrays overlapping those observed in MORB. These results render $T_p$ variability unnecessary for explaining most of the global MORB P-T, corroborate the view that short-scale MORB P-T variability is a measure of reactive melt transport, and help constrain geotherms beneath mid-ocean ridge axes.

[1] Lee *et al*. (2009) *EPSL* **279**, 20–33. [2] Collier & Kelemen (2010) *J. Pet*. **51**, 1913-1940. [3] Smith & Asimow (2005) *G-cubed* 6/Q02004. [4] Ghiorso *et al*. (2002) *G-cubed* 3/1030.

# Re-Os and Lu-Hf dating in Letlhakane peridotite xenoliths (Botswana)

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In order to better understand the lithosphere structure and evolution under the Paleoproterozoic Magondi Belt (NW margin of Zimbabwe craton), 11 peridotites from the Letlhakane diamondiferous kimberlite were studied for HSE, Lu-Hf and Re-Os isotope systematics. These peridotites experienced both high degrees of partial melting and metasomatism as evidenced by the presence of phlogopite and significant enrichments in incompatible trace elements. Their HSE systematics show progressive metasomatic Pt and Pd enrichments, with CI-normalised patterns ranging from those typical of residues of high partial melting degree (PdN/IrN<0.03, PtN/IrN<0.1) to patterns having chondritic to suprachondritic PtN/IrN and PdN/IrN (0.9-1 and 1.06-1.4, respectively). All but 1 sample show Re enrichments (ReN/PdN=0.3-7.6). Re depletion ages range from 2.2 to 2.8 Ga, clearly indicating the presence of Archean mantle beneath this area [1]. Whole-rock Lu-Hf isotope systematics show significant scatter in 176Hf/177Hf vs. 176Lu/177Hf space, but 3 samples yield a ca. 2.1 Ga errorchron age (MSWD = 4.8) with a radiogenic initial 176Hf/177Hf ratio. Apart from 1 peridotite yielding a Lu-Hf model age of 2.5 Ga, the Lu-model ages of Letlhakane peridotites cluster at 0.7-1.1 Ga. Moreover, a clinopyroxene-garnet pair from a single sample defines a 2-point isochron age of 132±38 Ma, within error of the eruption age of the Orapa kimberlite (93 Ma, [2]), which is assumed to be erupted in the same phase of magmatic activity as Letlhakane kimberlite [3].

None of the Lu-Hf isotope systematics is consistent with the Archean depletion event indicated by the Re-Os isotope system. The Lu-Hf isotopic systematics have been highly disturbed by the petrological modifications experienced by the lithospheric mantle under Letlhakane and thus indicate the vulnerability of the Lu-Hf isotopic system in metasomatised peridotites for dating depletion age and formation of the mantle root.

[1] Carlson *et al*. (1999) *Proceedings 7th IKC*, 99–108. [2] Davies (1977) *2nd IKC*, unpaginated. [3] Stiefenhofer *et al*. (1997) *CMP* **127**, 147–158.