Contrasting lithospheric mantle across the suture between the Eastern and Western Dharwar Cratons, central India

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Introduction and Methods

The Dharwar craton consists of two major blocks: in the Western Dharwar (WDC) 3.3-2.6 Ga supracrustal rocks overlie a 3.4-2.9 Ga basement; in the Eastern Dharwar (EDC) 2.6-2.5 Ga calc-alkaline granitoids enclose narrow belts of 2.7 Ga supracrustals. The EDC appears to have been thrust westward over the WDC prior to 2.5 Ga; the suture may be represented by a major mylonite zone (the Chitradurga schist belt) or by the Closepet Granite, a narrow batholith that runs N-S for ca 300 km, 40-50 km E of the schist belt. Garnet concentrates and mantle-derived xenoliths from 1.0-1.1 Ga kimberlite clusters in Andra Pradesh provide images of the subcontinental lithospheric mantle (SCLM) along a traverse extending SW-NE across the E margin of the Closepet Granite (Fig. 1).

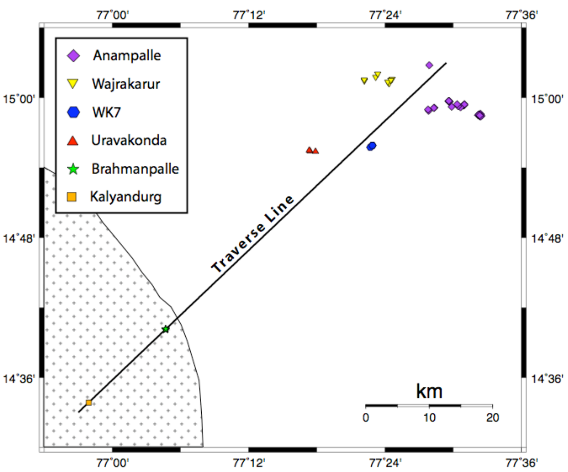

Figure 1. Locations of kimberlite clusters studied with traverse line. Igneous pattern indicates the Closepet Granite.

Geotherms for the SCLM beneath each cluster have been derived from major- and trace-element compositions of peridotitic garnets as described by Ryan et al. (1996). The calculation of X_{Mg} in olivine coexisting with individual garnet grains is described by Gaul et al. (2000) and the derivation of whole-rock (WR) Al_2O_3contents from garnets by Griffin et al. (1998). Eclogite data used here are from this work (n=18), Ganguly and Bhattacharya (1987; n=4) and Patel et al. (2006; n=10). Depth estimates for eclogites are defined by the intersection of P-T trajectories (Krogh, 1988) with the garnet geotherm, assuming that eclogites and peridotites have equilibrated to a common geotherm (Griffin and O'Reilly, 2007).

Results

The Kalyandurg and Brahmanpalle clusters at the SW end of the traverse sampled typical Archean SCLM, with a low geotherm (35 mW/m^2) and harzburgitic to lherzolitic rocks with median $X_{Mg}^{olivine} >$ 0.93 and median whole-rock Al_2O_3 <1%. The base of the depleted lithosphere at 185-195 km depth is marked by a 10-15 km layer of strongly metasomatised peridotites ($X_{Mg}^{olivine}$ ≈88). The Anampalle and Wajrakarur clusters 60 km to the NW show a distinctly different SCLM; it has a higher geotherm (37.5-40 mW/m^2), contains few subcalcic harzburgites, and has median $X_{Mg}^{olivine} \leq 0.925$ and median whole-rock Al_2O_3 ≈ 2%. Kimberlites of the Uravakonda and WK-7 clusters, midway along the traverse, sampled a quite fertile (median $X_{Mg}^{olivine}$ ≈ 0.915, median WR Al_2O_3 ≈3%) SCLM with an elevated geotherm (>40 mW/m^2).

The data from >1080 peridotitic garnet xenocrysts have been used to map the vertical and lateral variations in key chemical parameters (Figs 2-4). The techniques used for gridding and contouring the data are described by Kobussen et al. (2008).

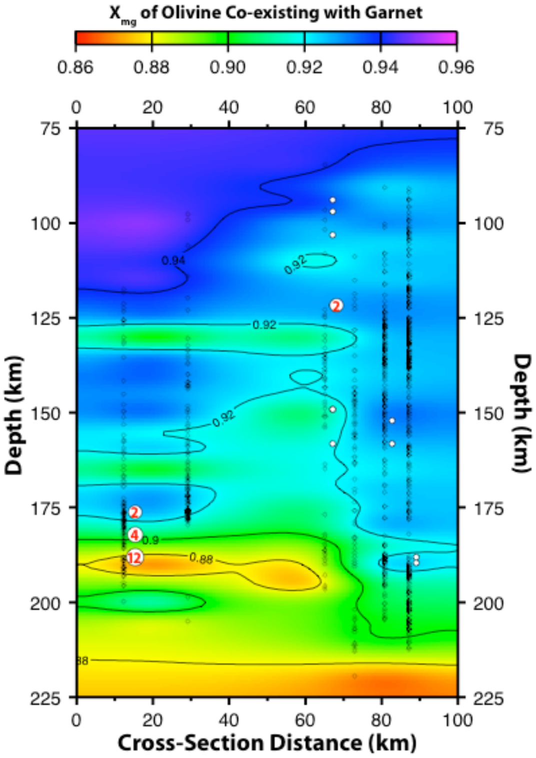

Figure 2. Distribution of median calculated X_{Mg} of olivine coexisting with Cr-pyrope garnets. Diamonds, individual data points. Circles, eclogites (numbers show >1 sample with similar depth estimate. The gridding and filtering algorithm elements used are 20 km wide by 5 km deep.

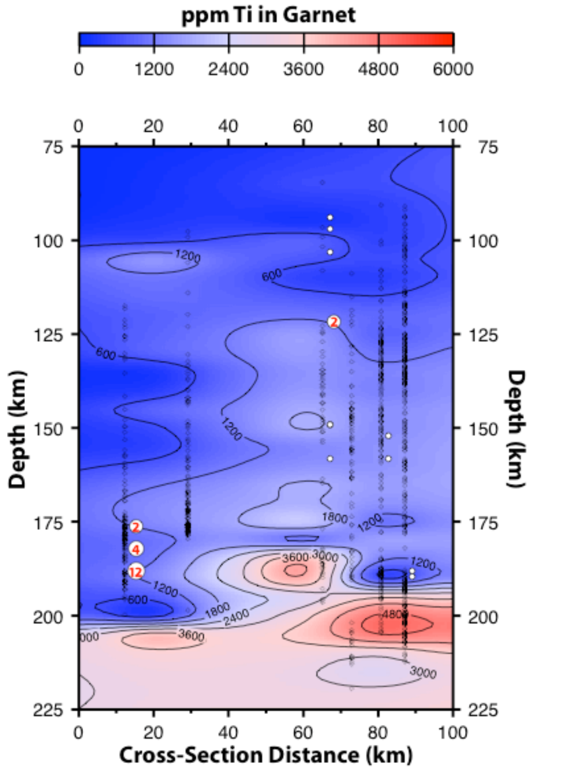

Figure 3. Distribution of median Ti contents (ppm) of Cr-pyrope garnets.

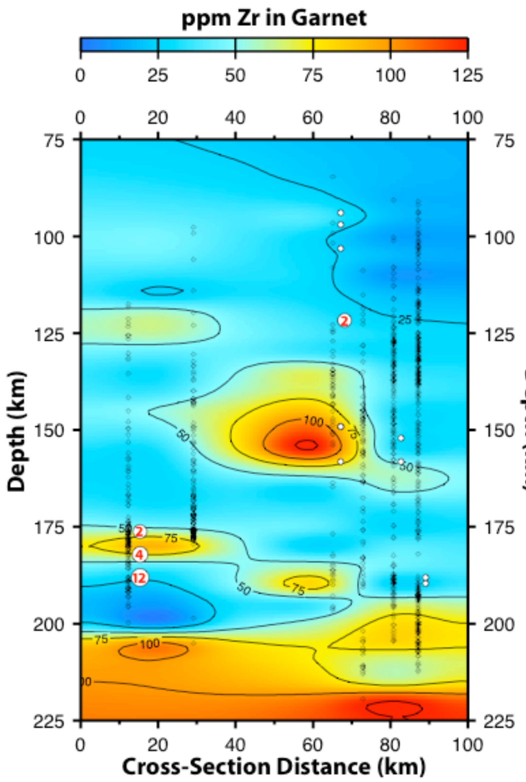

Figure 4. Distribution of median Zr contents (ppm) of Cr-pyrope garnets.

The X_{Mg} of olivine (Fig. 2) shows marked vertical and lateral variations. In the Kalyandurg (16 km on the traverse) and Brahmanpalle (29 km) sections, relatively depleted material (X_{Mg} > 0.93) is interspersed with bands of lower X_{Mg}, and median X_{Mg} drops to ≤ 0.88 between 180-195 km depth. This Fe-enriched layer corresponds to a strong concentration of eclogites. The section beneath the Uravakonda and WK-7 clusters (65-75 km) is strikingly less magnesian, with few values of X_{Mg} ≥ 0.92. The available data suggest that eclogites are distributed throughout the section from ca 85-160 km. The SCLM beneath the most northerly clusters (80-90 km) is more uniform in composition, but is significantly less magnesian than the SW end of the traverse, especially at depths <125 km. The few eclogite data from these fields spread between 150-190 km depth.

Figure 3 shows sharp rises in the Ti contents of garnets at depths varying from ca 180 km in the middle of the traverse to ca 190 km at the NE end. This pattern is typical of many SCLM sections worldwide, and the chemistry of these higher-Ti garnets can be correlated with the garnets of high-T sheared, meltmetasomatised garnets. We take this signal as defining the base of the depleted SCLM, and a level of magma ponding and infiltration. This increase in Ti is not well-defined beneath the SW end of the traverse; the intense Fe-metasomatism at 180-195 km depth is accompanied by only a relatively modest rise in the median Ti in garnet. The section beneath the Uravakonda and WK-7 clusters is generally higher in Ti than the SCLM at the NE or SW ends of the traverse. The distribution of median Zr in garnet (Fig. 4) tends to mirror that of Ti, with two marked differences: a large increase at ca 150 km depth in the middle of the traverse, and another at 175-180 km depth beneath the SW end.

Beneath the Kalyandurg cluster (16 km), there is a strong correlation between the distribution of eclogites and enrichment of the peridotites in Fe and Zr. We suggest a genetic connection, with the peridotites being metasomatised by mafic melts and associated fluids. The strong concentration of eclogites in a 10-20 km layer beneath the Kalyandurg cluster is similar to that seen in many SCLM sections (Griffin and O'Reilly, 2007) and contrasts with the broader depth distribution of eclogites beneath the fields to the NE. There is also a marked difference in eclogite types: many of the Kalyandurg eclogites are kyanite-bearing (±coesite), and the bimineralic eclogites tend to have the high-Ca garnet that is characteristic of the kyanite eclogites, suggesting they belong to the same suite. The eclogites from the pipes to the NE are more typical bimineralic eclogites with generally higher Mg# and lower-Ca garnets.

Conclusions

(1) The striking differences in the SCLM (100-200 km depth) along the traverse suggest that the NE and SW ends of the traverse represent distinct lithospheric blocks, corresponding to the EDC and WDC.
(2) At 100-200 km depth, the EDC - WDC suture lies near the E margin of the Closepet Granite, suggesting that the batholith is the crustal expression of a lithosphere-scale boundary.
(3) The SCLM near the suture is strongly refertilised, perhaps during craton assembly.
(4) The differences in the SCLM beneath the WDC and EDC suggest that each cratonic block carried its own "root" at the time of their collision; the root beneath the margin of the EDC may already have been less depleted, or it may have been refertilised by fluids moving along the suture.
(5) The scarcity of kyanite eclogites beneath the EDC margin suggests that the WDC eclogites were emplaced before craton assembly.

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