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

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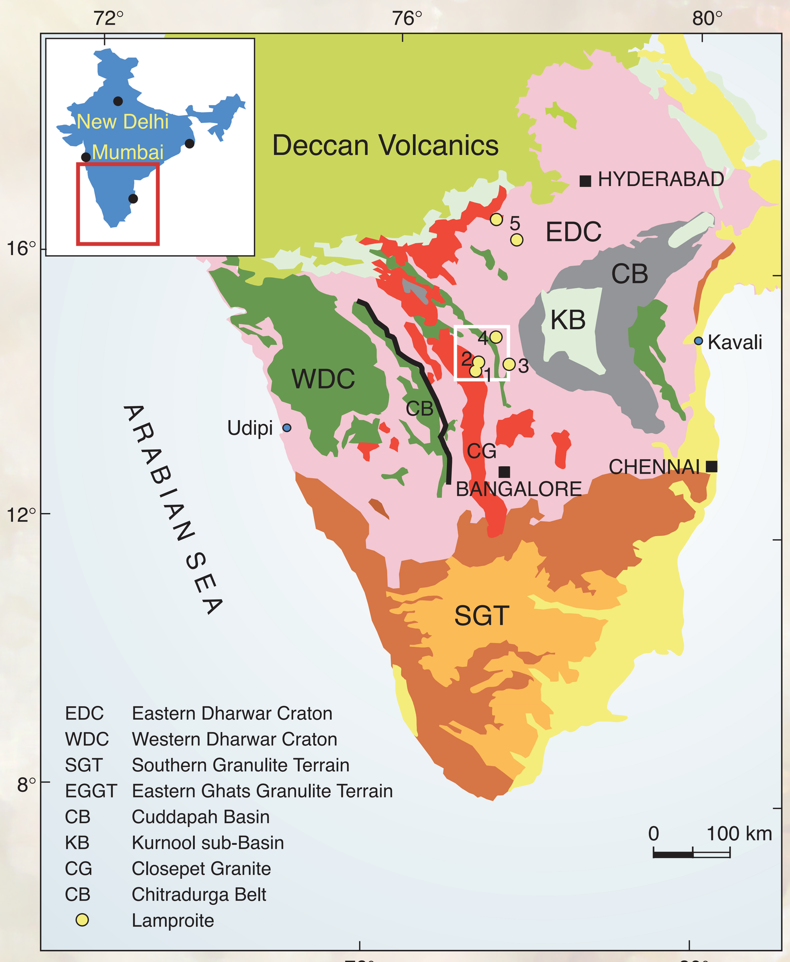


Figure 1. Geological sketch map of India, showing the location of the Dharwar craton; box outlines the area shown in Fig. 2.

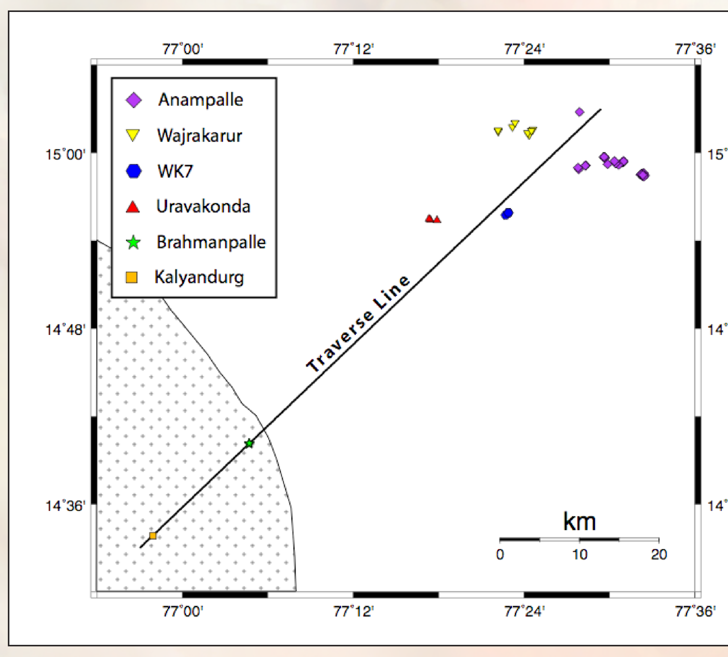


Figure 2. Locations of kimberlite clusters studied.

The Dharwar craton (Fig. 1) consists of two major blocks.

- Western Dharwar (WDC): 3.3-2.6 Ga supracrustal rocks overlie a 3.4-2.9 Ga basement
- Eastern Dharwar (EDC): 2.6-2.5 Ga calc-alkaline granitoids with belts of 2.7 Ga supracrustals

The suture may be (1) a major mylonite zone (the Chitradurga schist belt) or (2) the Closepet Granite, a long narrow batholith 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. 2).

Geotherms for the SCLM beneath each cluster (Fig. 3) 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 (Fig. 4) is described by Gaul et al. (2000) and the derivation of whole-rock (WR) Al_2O_3 contents 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).

Mapping the lithosphere

Data from >1080 peridotitic garnet xenocrysts have been used to map the vertical and lateral variations in key chemical parameters (Fig. 5), as described by Kobussen et al. (2008).

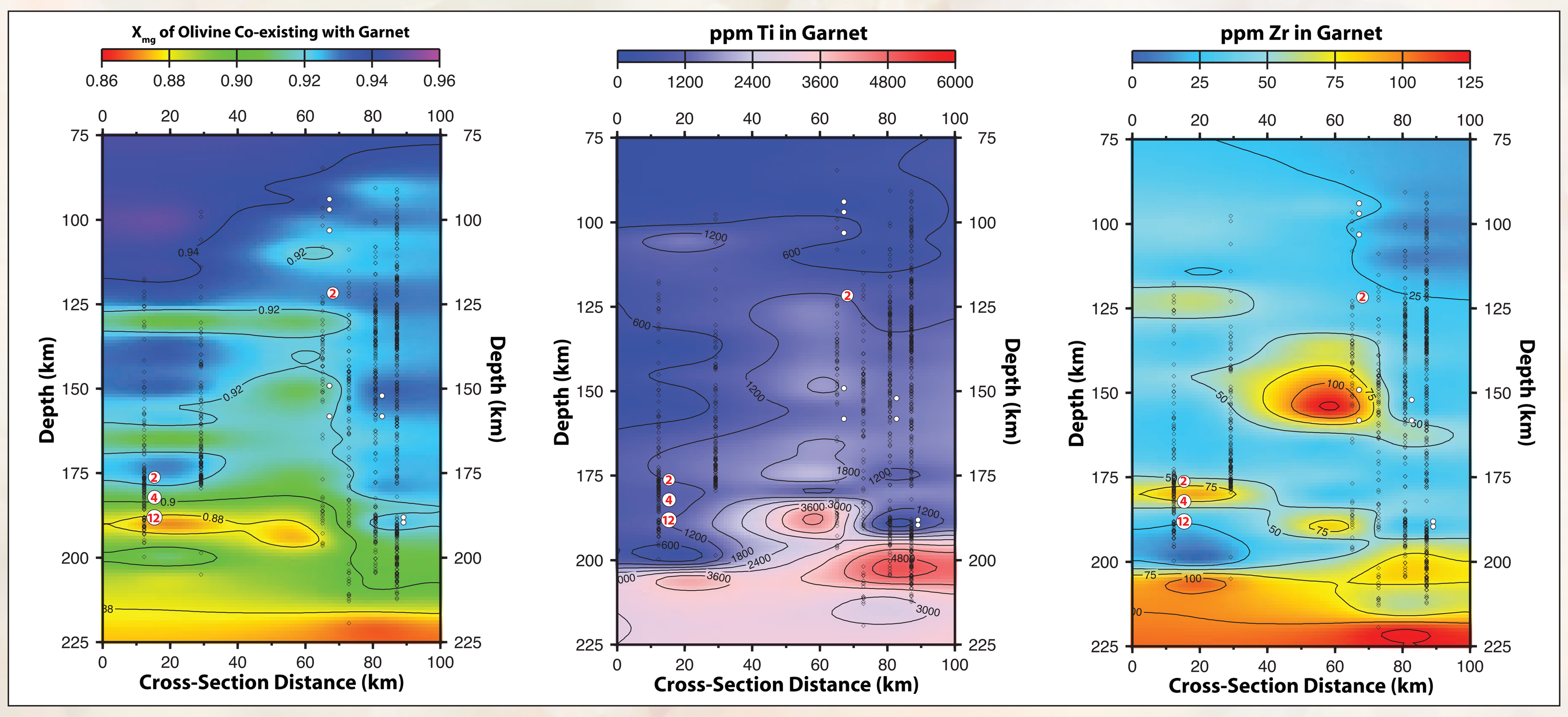
Kalyandurg – Brahmanpalle (16-30 km): depleted material (X_{Mg} > 0.93) interspersed with bands of lower X_{Mg}; median X_{Mg} drops to ≤ 0.88 between 180-195 km, coinciding with a strong concentration of eclogites.

Uravakonda and WK-7 (65-75 km): SCLM is strikingly less magnesian. The available data suggest that eclogites are distributed throughout the section from ca 85-160 km.

NE clusters (80-90 km): SCLM is more uniform, but less magnesian than the SW end of the traverse, especially at <125 km. The few eclogite data from these fields spread between 150-190 km depth.

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 are taken as defining the base of the depleted SCLM, and a level of magma ponding and infiltration. The section beneath Uravakonda - WK-7 is generally higher in Ti than the SCLM at either end of the traverse. The distribution of median Zr in garnet mirrors 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.

Figure 5. Lithosphere mapping. (a) Distribution of median calculated XMg of olivine coexisting with Cr-pyrope garnets. Diamonds, individual data points. Circles, eclogites (numbers show >1 sample with similar depth estimate. Contour filtering blocks are 20 km wide by 5 km deep. (b) Distribution of Ti in peridotitic garnets. (c) Distribution of Zr in peridotitic garnets.



The Kalyandurg and Brahmanpalle clusters at the SW end of the traverse sampled typical Archean SCLM, with a low geotherm (35 mW/m²) and harzburgitic to lherzolitic rocks with median $X_{Mg}^{olivine}$ > 0.93 and median whole-rock Al_2O_3 <1% (Figs. 3, 4). 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 at the NE end show an SCLM with a higher geotherm and few subcalcic harzburgites; it has median $X_{Mg}^{olivine}$ ≤ 0.925 and median whole-rock Al_2O_3 ≈ 2%. 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/m²).

Figure 3. Garnet geotherms (after Ryan et al., 1996) and Y contents of peridotitic garnets, showing determination of the thickness of the depleted SCLM. Note that this is a minimum value for the Kalyandurg-Brahmanpalle section.

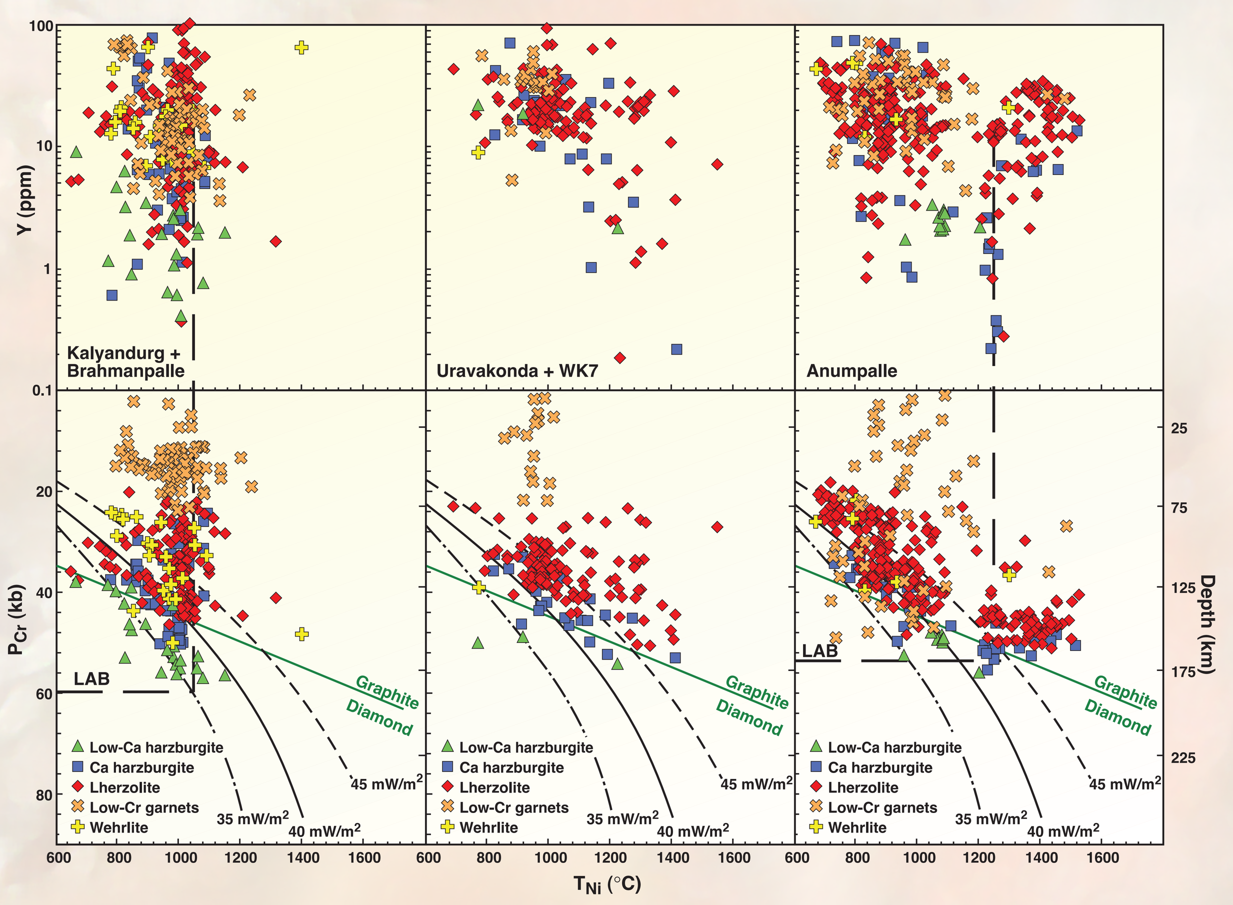
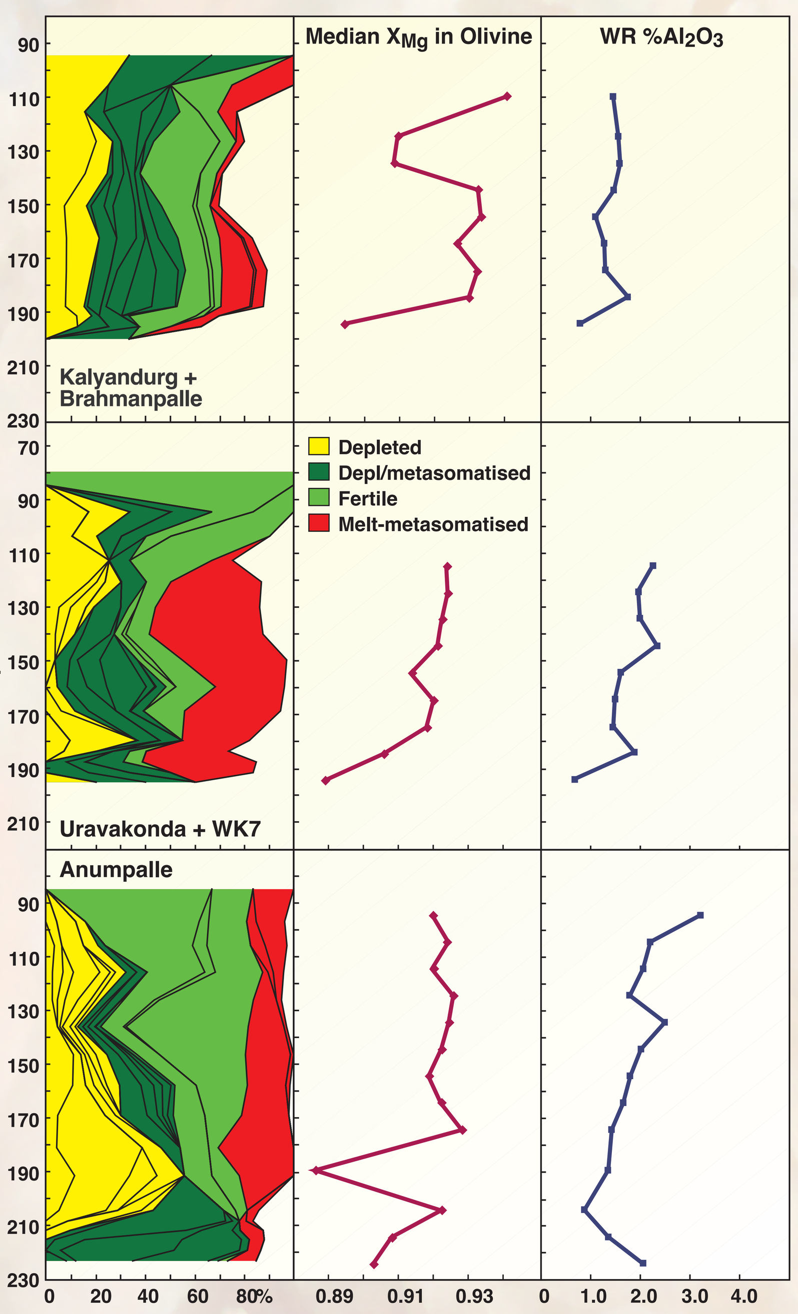


Figure 4. Chemical Tomography sections, illustrating the vertical distribution of geochemical signatures in peridotitic garnets. The mean XMg of coexisting olivine and the mean whole-rock Al_2O_3 content are calculated from garnet data as explained in the text.



Eclogites and metasomatism

Beneath Kalyandurg (16 km), the distribution of eclogites (Fig. 5) coincides with enrichment of the peridotites in Fe and Zr, suggesting metasomatism by mafic melts and associated fluids (as in many kimberlite fields; Griffin and O'Reilly, 2007). This 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 NE pipes contain only bimineralic eclogites with higher Mg# and lower-Ca garnets.

Conclusions

(1) The NE and SW ends of the traverse represent distinct lithospheric blocks, which may correspond to the EDC and WDC. The strongly metasomatised SCLM in the middle of the traverse is interpreted as the suture, which focussed metasomatising melts and fluids.

(2) At 100-200 km depth, the (E-dipping?) suture lies near the E margin of the Closepet Granite, suggesting that the batholith was controlled at the crustal level by this lithosphere-scale boundary.

(4) The differences in the SCLM beneath the WDC and EDC suggest that each block carried its own "root" at the time of 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 apparent scarcity of kyanite eclogites beneath the EDC margin suggests that the WDC eclogites were emplaced before craton assembly.

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