# Regional variation in mantle heat flow within the Tanzanian Craton

Tainton, Kenneth M.[1], Seggie, Amanda G.[1], Bayly, Barry A.[2], Tomlinson, Ian[3], Quadling, Kevin E.[1]

1. Anglo American Research Labs. (Pty) Ltd., PO Box 106, Crown Mines, 2025, South Africa
2. De Beers Prospecting Botswana (Pty) Ltd., PO Box 90, Lobatse, Botswana
3. TANEX Ltd., P.O. Box 9020, Dar Es Salaam, Tanzania.

Regional exploration of central Tanzania in the early Twentieth Century resulted in the discovery of numerous kimberlites, culminating in the discovery of the Mwadui pipe by Williamson in 1940. Although diamonds are present in several other intrusions, none have been shown to be of economic significance. Petrographically, these are typical Group-1 monticellite kimberlites, and occur as crater, diatreme and hypabyssal facies intrusions. The available geochronological database for the Tanzanian kimberlite province is scanty. The Mwadui kimberlite has been dated at 41 ±2 Ma, whereas the Nzega kimberlite has been dated at 53 ±7 Ma (Davis, 1977). In the course of this study, it has been assumed that the central Tanzanian kimberlite province represents a coherent suite of intrusions emplaced over a restricted time period.

TANEX Ltd., a subsidiary of De Beers Consolidated Mines Ltd., embarked on a prospecting programme over a licence area of approximately 24 000 km$^2$, centred on the Mwadui kimberlite, in 1992. Recent sediments deposited by the greater Lakes Victoria and Eyasi overlie much of the area prospected (Fig. 1). Numerous kimberlite intrusions have been discovered through detailed loam sampling and aeromagnetic surveys. Treatment of drill-chip and core samples from selected intrusions yielded representative indicator mineral populations for further study.

The garnet population recovered from the Mwadui kimberlite is comprised of a dominant G09 lherzolitic suite, with lesser G10 garnets (Fig. 2). The compositions of the peridotite garnets reflect a moderate degree of depletion of the lithospheric mantle, with strongly subcalcic garnets (<2.0 wt.% CaO) being absent. Eclogitic grains are present in the garnet population, but comprise a minor proportion of the overall assemblage. The major-element compositions of garnets recovered from other kimberlites in central Tanzania are broadly comparable to those from the Mwadui kimberlite, although the proportion of G10 garnets is generally lower.

Selected peridotitic garnets were analysed for trace elements, by LA-ICP-MS. Ni concentration data for these garnets were used to calculate equilibration temperatures (Ryan et al, 1996). The garnet barometry calculations of Ryan et al (op cit) were used to estimate the local conductive geotherm at the time of emplacement of each kimberlite (Fig. 2).

Trace-element analyses of peridotitic garnets from Mwadui constrain a conductive geotherm of 36 mW/m$^2$ at the time of kimberlite emplacement. The temperature interval over which peridotite entrainment occurred lies largely within the diamond stability field, which is consistent with the known presence of diamond in this kimberlite. Analysis of garnet grains from a number of intrusions defining a W-E traverse, originating from Mwadui, demonstrated a progressive increase in the conductive geothermal gradient towards the east. Garnet concentrates from kimberlites in the east of the TANEX Ltd. licence area define a conductive geotherm of 38-40 mW/m$^2$ (Fig. 2, X005). This may be correlated with shoaling of the lithosphere on approaching the margin of the craton.

Analysis of garnets from kimberlites south of Mwadui revealed a more complex pattern. This N-S traverse transects the Manonga Depression, the westward extension of the Eyasi Basin. This depression is filled with Quaternary lake sediments. Garnet populations from kimberlites on the northern flank of the Manonga Depression display evidence for strong metasomatic overprinting, which prevents accurate estimation of the conductive geotherm. However, the data indicate a disturbance of the conductive thermal profile observed at Mwadui. The majority of intrusions discovered within the axis of the depression are free of garnet, with the rare garnet populations recovered defining strongly inflected geothermal gradients (Fig. 2, X100). The trace-element chemistry of these grains is characteristic of fertile mantle sources, indicating that the lithosphere underlying this region has been extensively enriched, or replaced, by fertile asthenospheric mantle. Garnets from the Nzega kimberlites, intruded south of the Manonga Depression, reflect a cratonic geothermal gradient, although sampling of mantle peridotite occurred predominantly within the graphite stability field.

These data strongly indicate that the Manonga Depression is the surface expression of a region of lithospheric thinning or reworking. By analogy, the increase in geotherm east of Mwadui could be attributed to the approach to the Eyasi Basin. The close spatial association of the zone of elevated geothermal gradient with subsidence basins begs correlation with stretching within the East African Rift System. However, this signature is reflected in the garnet populations of kimberlites inferred to have been emplaced at 40-55 Ma. Current models of the development of this rift indicate that southward extension of the rift into Tanzania occurred subsequent to 5 Ma, and that much of the faulting has occurred within the last 1-2 Ma (Dawson, 1992, Foster et al, 1997). Dawson et al (1997) concluded, on the basis of thermobarometry of garnet peridotite xenoliths from Neogene volcanics, that the perturbation of the geotherm in N. Tanzania is at an incipient stage. However if, as indicated by the results of this study, the kimberlites of central Tanzania represent the earliest manifestation of the East African Rift, fundamental rethinking of the impetus for development of this rift system is required.

**References**


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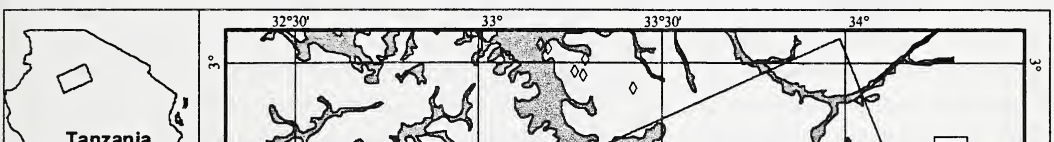


Figure 1: Locality of the TANEX licence, showing the kimberlites from which garnet concentrates were recovered. The extent of recent sediment cover (Tinde Beds and Mbuga Clay) is shown.

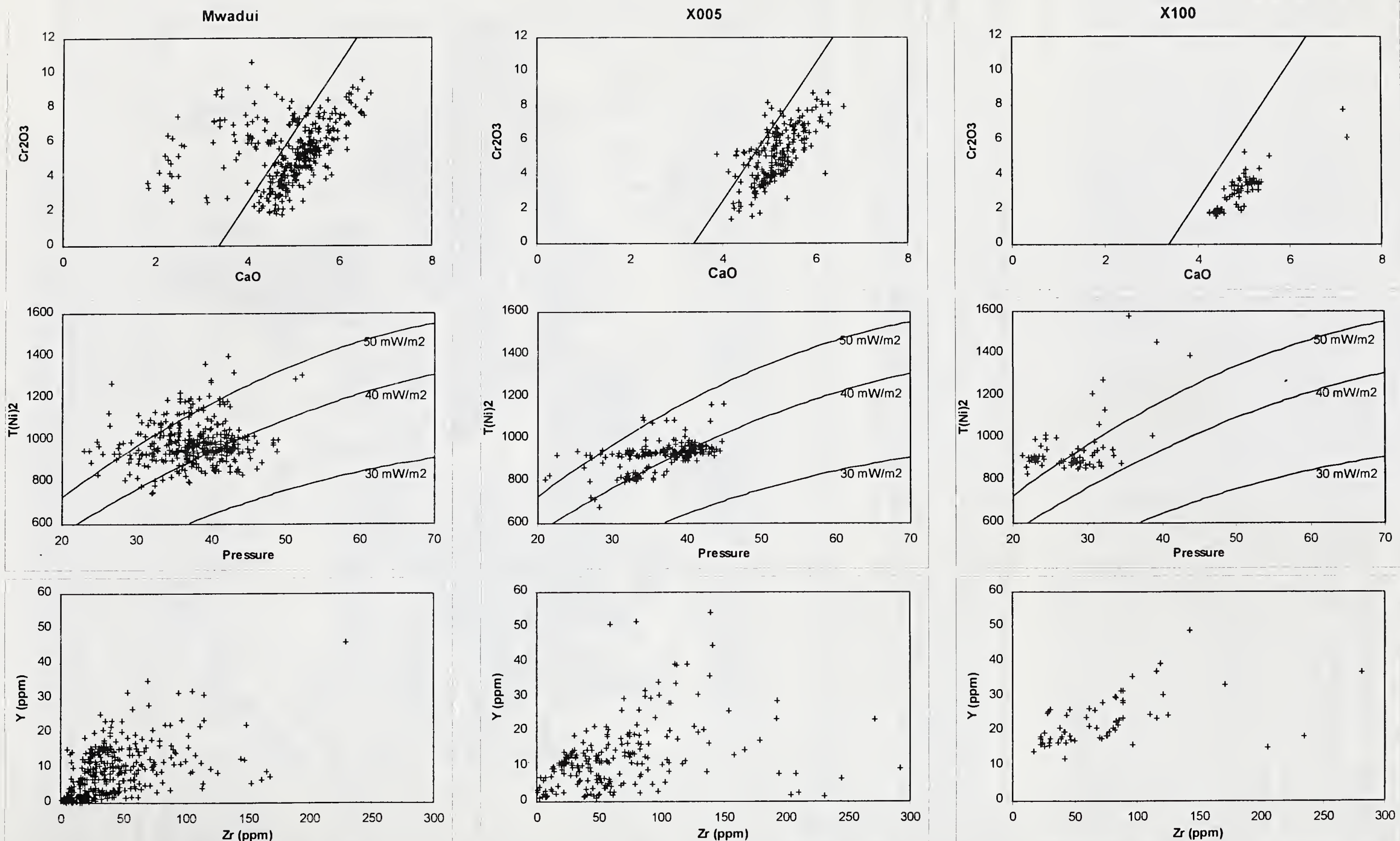


Figure 2: Plots of $Cr_2O_3$ vs CaO, $T_{(Ni2)}$ vs Pressure and Y vs. Zr for garnets from the Mwadui, X005 and X100 kimberlites, respectively.