THERMAL ANOMALY IN THE UPPER MANTLE BENEATH A PROPAGATING CONTINENTAL RIFT: EVIDENCE FROM MANTLE XENOLITHS FROM THE LABAIT VOLCANO, NORTHERN TANZANIA.

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There are now models for the structure and magmatism of well-developed rifts[1], but little is known about the thermal structure of the mantle at the actual onset of rifting. Moreover, because they are small ephemeral cinder-cones and lava flows, and often blanketed by later formations, the volcanic rocks erupted at the initiation of continental rifting are only rarely available for sampling. The initiation of faulting and magmatism in the Gregory Rift Valley of East Africa has progressed systematically from north to south, beginning at around 35-40 Ma in Ethiopia , at around 25 Ma in Kenya and at 8 Ma in northern Tanzania[2]. Thus there appears to be a relative southwards movement into the African continent of the underlying mantle perturbation, with the youngest volcanic province being in northern Tanzania where volcanism is now well developed[3]. Moreover, here at its southern end in north-central Tanzania, the rift depression is asymmetric, being bounded by a major fault only on its western side which breaks up into a series of subdued faults of small magnitude. A further feature of this southernmost area is that it has low surface heat-flow (39-46mW m^{-2})[4] and deep seismic activity[5]; which suggests that the rift fractures are in the process of penetrating thick cold lithosphere, in contrast to the well-developed rift further north where there is high heat-flow and evidence for thinned lithosphere[6].

The magmatism in this most southerly area is isolated from the main Tanzanian volcanic province to the north and belongs to the youngest episode of Tanzanian rift volcanism dated at <1Ma.[3]. The volcanics comprise two major carbonatite/nephelinite volcanoes, Kwaraha and Hanang, composed of tuffs and agglomerates of evolved olivine-free nephelinitic composition, with interbedded flows and tuffs of calcic carbonatite. Both volcanoes are surrounded by numerous small explosion craters and tuff-cones, and rare lava flows of olivine nephelinite and melilitite which, together with the carbonatites, are magma types typically generated during incipient melting of volatile-rich mantle[7].

One of the minor volcanic features is Labait Hill (4° 34'S, 35° 26'E), a small cratered cone south-east of Hanang. Labait consists of scoria and one small flow of olivine melilitite which has high magnesium (MgO 24.46 wt%), nickel (974 ppm) and chromium (Cr 1249 ppm) concentrations indicating that it consolidated from primitive, unfractionated magma[8]. Labait is also unusual in that the lava flow and scoria contain xenoliths of peridotite, the mineralogy, density and bulk chemistry of which are typical of rocks derived from the earth's upper mantle. Labait is thus an addition to the very few localities in East Africa providing samples that can directly constrain geophysical models of the mantle along the Rift Valley[6] The extrusives contain xenoliths of garnet lherzolite, garnet harzburgite, spinel lherzolite, spinel dunite, spinel mica-lherzolite and spinel-mica harzburgite. Primary phases are olivine (Fo_{88-90}), low-Al-Ca enstatite (En_{89-92}), Cr pyrope (Cr_2O_3 ~6%, CaO ~6%), Cr-endiopsides (Ca/(Ca+Mg) ~0.4), spinel (Cr_2O_3 ~45%,MgO 12-16%), and Ti-phlogopite (TiO_2 ~ 4%, MgO ~22%). In the garnet-bearing lherzolites and harzburgites, garnets are surrounded by spinel-2 pyroxene coronas, and other rocks contain veins or patches of glass that has precipitated diopside, mica, high-Fe zoned spinel, calcite, harmotome and unknown high-Ba phases; glass compositions are highly variable and range from high-Ba, to high-Fe and high-K varieties.

Element partitioning in the garnet lherzolites (2-pyroxene solvus and Al contentof orthopyroxene in equilibrium with garnet [9], gives their equilibration conditions as 1275^{o}C and 40kb. This temperature is greater than those calculated for other garnet lherzolite xenoliths that occur in contemporary small volcanoes away from the rift valley at Lashaine in the Mozambique Fold Belt 170 km to the north-east (1050-1100^{o}C, 40-44kb[10,11]), and at the Igwisi Hills on the Tanzania Craton some 400 km to the west of the Rift Valley (850^{o}C, 36 kb[12]). Because all these garnet lherzolite xenoliths have been derived from the same depth range in the upper mantle, those brought to the surface at Labait signal a thermal anomaly beneath the southern tip of the East African rift system. Moreover the reaction coronas around the garnets are consistent with substantial decompression in a rising mantle diapir.Finally, some of the spinel peridotite xenoliths at Labait have been partly melted and metasomatised, with the development of a variety of K-, Fe- and Ba-rich glasses and minerals. The thermal anomaly signalled by the garnet lherzolites is apparetly accompanied by melting and metasomatism in the spinel peridotite xenoliths that are derived from shallower depths in the upper mantle.

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