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Combined U-Pb and Lu-Hf analysis of megacrystic zircons from the Kalyandurg-4 kimberlite pipe, S. India: Implications for the emplacement age and Hf isotopic composition of the cratonic mantle

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Introduction

The occurrence of zircon in most igneous, sedimentary and metamorphic rocks is not unique. However, the occurrence of the zircon megacrysts ranging upto cm-size grains hosted by kimberlite is considered enigmatic (Griffin et al. 2000, Page et al. 2007 and reference cited therein). Since zircon is one of the most refractory minerals, it preserves a robust record of trace elemental abundances, oxygen, U-Pb, Lu-Hf isotopic compositions unique to its geological history from genesis to post-formational changes (Hanchar and Hoskin, 2003, Valley, 2003). Texturally, the kimberlite-borne mantle-derived megacrystic zircons display unique characters in terms of appearance compared to their crustal varieties. They are colorless and glassy for external appearance (see Page et al. 2007 for a recent review). The published data further suggests that in most occurrences, U-Pb geochronology of these zircons record the emplacement of the kimberlite host (see Griffin et al. 2000 for an exhaustive data set). As parental melts of the kimberlites originate from the sub-continental lithospheric mantle, the Hf isotopic composition of the zircon megacrysts, if any would help in tracing out the Hf isotopic composition of this major isotopic reservoir of the Earth.

Here we report a combined U-Pb and Lu-Hf isotopic study on the megacrystic zircon xenocrysts from the Kalyandurg-4 kimberlite (KL-4) of the Eastern Dharwar Craton, S. India. The aim is to decipher the hitherto unknown emplacement age of the Kalyandurg kimberlite cluster and constrain the Hf isotopic composition of the subcrustal mantle at the time of emplacement. The Kalyandurg kimberlite cluster is the western-most of the kimberlite clusters in the Eastern Dharwar Craton, South India intruding the ca. 2.5 Ga Closepet Granite Complex (Figure 1). This zone forms part of the Neoarchaean accretionary complex between the Eastern and Western Dharwar Cratonic blocks.

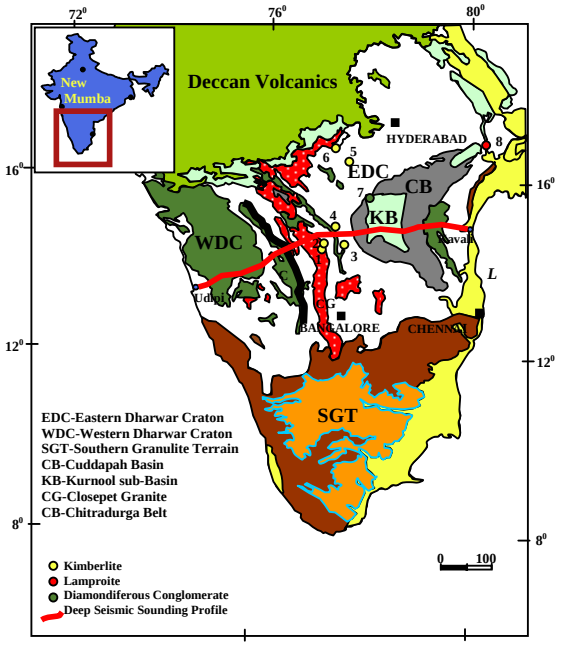

Figure 1. Location map of the Dharwar Craton Kimberlites and Lamproites in the southern India. 1. Kalyandurg, 2. Brahmanapalli, 3. Chigicherla, 4. Wajrakarur, 5. Riachur, 6. Mahaboobnagar, 7. R. Kota, 8. Krishna Lamproite

Materials, Methods and Results

10 fragments of megacrystic zircons were separated from the kimberlite matrix and were subjected to EPMA, LAM-ICPMS and LAM-MC-ICPMS analysis for the determination of major, trace elemental abundances and U-Pb and Lu-Hf isotopic determinations respectively following the methods described in Belousova et al. 2002 and Griffin et al. (2004). The analysed zircon fragments range in size from 1 to 2.3 mm in longer dimension. The grains are colorless, glassy and do not show any zoning in

Cathodoluminscence (CL) and Back Scattered Electron (BSE) imaging (Figure 2).

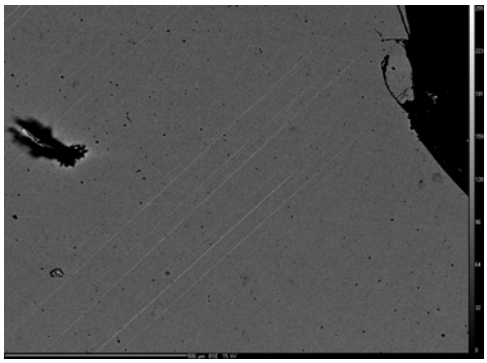

Figure 2. CL image of a KL-4 zircon fragment.

LAM-ICPMS Trace element compositions of KL-4 zircons show very low U (1-3 ppm) and Th (4-8 ppm) and REE concentrations are typical of other worldwide kimberlitic zircon occurrences. U-Pb data determined by LAM-ICPMS gave two sets of concordant ages 1097 ± 5.7 Ma (MSWD=0.92) and 1154 ± 5.1 (MSWD=0.105) for the analysed KL-4 kimberlite zircons (Figure 3). Both the age estimates fall within the limits established for the other kimberlite clusters of the Dharwar Craton in S. India. (see Anil Kumar, 2007).

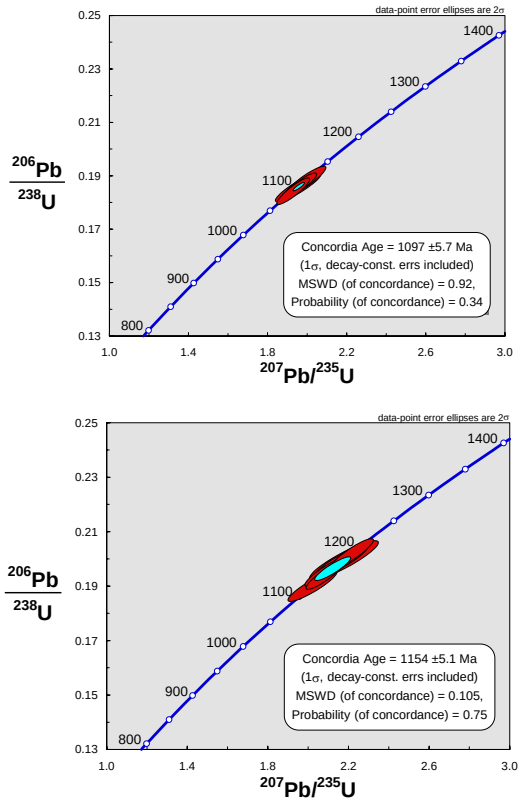

Figure 3. U-Pb Concordia diagram for the KL-4 zircons.

εHf values fall in a range from 3.88 ± 0.60 to 6.78 ± 0.56 and Hf T_{DM} (Ga) model ages range from 1.33 to 1.45 Ga. The $^{176}Hf/^{177}Hf_i$ ratios of the Kalyandurg zircons range from 0.282163 to 0.282254, falling between values expected for a chondritic reservoir and those of from magmas with a depleted-mantle (DM) source (Figure 4).

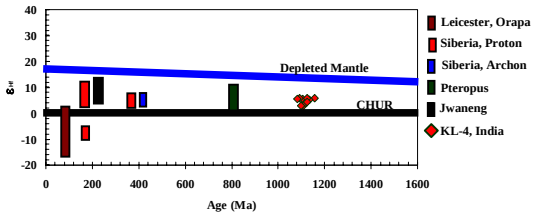

Figure 4. ε_{Hf} of the analysed zircons from KL-4 plotted against intrusion age of the host kimberlite. Comparisons shown with the other localities (data from Griffin et al. 2000)

This pattern is characteristic of most kimberlitic zircons with ages of 0.1-2.5 Ga worldwide; it probably represents either the long-term Hf-isotopic composition of the cratonic lithospheric mantle, or a very consistent pattern of interaction between the (low-Lu/Hf) lithospheric mantle and melts derived from the DM source.

Conclusions

1. KL-4 pipe intrusion age derived from the U-Pb data of zircons suggests that it is contemporary to the other ~ 1.1 Ga kimberlite intrusions within the Dharwar Craton.

2. Hf isotopic data of the megacrystic KL-4 zircons show similarities with the other world occurrences suggesting a long-term Hf-isotopic composition of the cratonic lithospheric mantle, or a very consistent pattern of interaction between the (low-Lu/Hf) lithospheric mantle and melts derived from the DM source.

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