

Geochemistry and Zircon Geochronology of the Kalyandurg Kimberlites from the Eastern Dharwar Craton, Southern India: Evidence for Mantle Metasomatism and Crustal Recycling

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Kimberlites from the Kalyandurg cluster of the Wajrakarur Kimberlite Field (WKF) within the Eastern Dharwar Craton (EDC) of southern India exhibit unique geological characteristics compared to other occurrences. They are emplaced within the Closepet Granite, which represents a continental arc setting and was presumably formed in a subduction-accretion environment during the late Archean. These kimberlites are of significant geological interest as they potentially preserve evidence of crust-mantle interactions associated with Archean geodynamic events.

The mineral assemblage includes olivine, phlogopite, garnet, perovskite, spinel, serpentine, and carbonates. Phlogopite exhibits a wide range of Al₂O₃ contents, from 3 to 18 wt.%, and TiO₂ up to 5 wt.%. Olivine is predominantly forsteritic, with MgO ranging from 45 to 52 wt.%, and very low CaO contents (< 0.15 wt.%). Spinel displays a broad range of Fe²⁺/(Fe²⁺ + Mg) ratios from 0.4 to 1.00 and Ti/(Ti + Cr + Al) ratios between 0.1 and 0.9. The mineralogical features indicate their kimberlitic as well as affinity to lamproitic (var. Kaapvaal) magmas.

Geochemically, the Kalyandurg kimberlites are enriched in whole-rock Zr and Hf, a characteristic atypical for kimberlites but observed in lamproites derived from mantle sources modified by ancient subduction events. While typical subduction-related geochemical signatures are absent, the distinctive Zr-Hf enrichment indicates metasomatic imprints on the mantle source regions, likely linked to ancient subduction processes.

Zircon geochronology identifies two distinct populations. The first comprises mantle-derived zircons with ages around ~1100 Ma, corresponding to the emplacement age of the host kimberlite. These zircons crystallized within a metasomatized mantle domain enriched in crustal elements such as Zr and Hf. They exhibit low U and Th contents, with Th/U ratios between 0.3 and 0.5, and a restricted $\delta^{18}\text{O}$ range (4–5 ‰), confirming their mantle origin. The second population consists of relict crustal zircons with ages ranging from 2.5 to 2.7 Ga and older, correlating with Archean crustal fragments from the Western Dharwar Craton. The presence of both mantle- and crust-derived zircons, alongside distinctive geochemical signatures, suggests a complex magmatic history involving subduction-related