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Zircon U–Pb–Hf Petrochronology of Mg–Al Granulites from the Eastern Ghats Province and Tectonic Implications

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We present new zircon petrochronology from Mg–Al granulites of the Eastern Ghats Province (India) to constrain protolith formation, ultra-high-temperature (UHT) metamorphism, and crust–mantle interaction processes during orogenesis. Ti-in-zircon thermometry yields a mean temperature of ~916 °C consistent with UHT conditions of the studied samples. Zircon U–Pb results define two dominant $^{207}Pb/^{206}Pb$ age populations: (i) oscillatory-zoned magmatic cores peaking at ~1600 Ma, interpreted as crystallization of the igneous precursor, and (ii) compositionally homogeneous rims exhibit peaks at ~ 900–930 Ma, reflecting zircon growth during high-grade metamorphism. Lu–Hf isotopes for the ~1600 Ma cores span εHf(t) = −9.16 to +0.815 with TDM2 = 2656 – 2080 Ma, indicating derivation from mixed Neoarchean–Paleoproterozoic crust with limited juvenile input. Zircon rims (~930 Ma) show more evolved signatures (εHf(t) = −19.175 to −11.568) and older model ages (TDM2 = 2745–2314 Ma), implying enhanced reworking during metamorphism, likely aided by fluids. Trace-element systematics exhibit variable zircon sources: most analyses plot in mantle-derived fields on the $\log_{10}(Ce/U)$–$\log_{10}(Th/U)$ discrimination diagram, whereas a subset of rim analyses trends toward a metapelitic affinity. Negative Eu anomalies and moderate Dy/Yb ratios indicate zircon crystallization from residual melt at shallow crustal levels. Strongly negative rim εHf(t) values point to fluid-assisted zircon growth during the 0.93–0.90 Ga UHT event. The ~1600 Ma zircon population documents a concealed crustal basement, whereas Neoproterozoic rims record reworking of the Neoarchean - Mesoproterozoic crust, during Rayner orogeny.