Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.33824

Formation of Eo-Paleoarchean continental crust through intracrustal reworking of Hadean crust in the Sukma terrane, Bastar Craton, India

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Earth's earliest continental Eo-Paleoarchean tonalite-trondhjemite-granodiorite (TTG) rocks, generated by multi-stage partial melting of mantle-derived hydrated basalts, record complex magmatic histories involving both juvenile inputs and the reworking of older crustal components. In the less-studied Bastar Craton of central India, the distribution of Paleoarchean TTG domains and associated supracrustal rocks reveals discrete crustal blocks, herein referred to as the Sukma, Kapsi and Kondagaon terranes [1]. The extensive ~20,000 km^2 Sukma terrane (Fig. 1a) comprises layered orthogneisses that represent deformed synplutonic complexes (Fig. 1b). Primary melts of the Sukma orthogneisses, with high Sr/Y, La/Yb, and Nb/Ta ratios, were formed by high-pressure partial melting of mafic rocks and tonalites in equilibrium with rutile-bearing eclogite residues, followed by plagioclase fractionation [1]. Therefore, the Sukma terrane is interpreted as a deeply exhumed lower-crustal section, providing a key archive for evaluating magma source characteristics and early continental crust-forming processes.

Here we present new zircon U–Pb–Hf isotope data from the layered Sukma orthogneisses, which reflect isotopically heterogeneous TTG magmatism. Hafnium isotopic compositions of 3.8–3.7 Ga magmatic zircon are highly evolved, with $\varepsilon_{Hf(3.8–3.7Ga)}$ values from −12.5 to −1.2 defining a subchondritic $\varepsilon_{Hf}(t)$–age array bracketed by Archean felsic crust and oceanic plateau isotopic evolution trajectories (Fig. 2). Furthermore, whole-rock $\varepsilon_{Nd(3.8–3.7Ga)}$ values (from −6.9 to −0.7) and crustal residence times (~0.4 Ga) indicate reworking of older crust by juvenile input as a mechanism for TTG generation. These data suggest that Eo-Paleoarchean TTG magmatism in the Sukma terrane was predominantly driven by partial melting of differentiated Hadean crust. Collectively, our findings support intracrustal melting, not juvenile arc magmatism, as the dominant mechanism for TTG generation in this region of the Bastar Craton, consistent with a stagnant- or squishy-lid geodynamic regime on early Earth.

[1] Nandi et al. (2026) Lithos, 522–523, 108377.



