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From TTGs to High-K Granitoids: Constraints on Archean Crustal Differentiation and Mantle Metasomatism in the Southern Bundelkhand Craton

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The Madawara domain of the Southern Bundelkhand Craton preserves a pivotal record of late Archean magmatic evolution. This study integrates field observations, petrography, mineral chemistry, whole-rock geochemistry of tonalite–trondhjemite–granodiorite (TTG) suites, sanukitoids, and high-K granitoids, alongside U–Pb zircon geochronology of the high-K granitoids, to illuminate successive magmatic episodes reflecting progressive crustal differentiation and stabilisation within the craton. Zircon U–Pb dating constrains high-K granitoid emplacement to 2.47 Ga, marking the terminal phase of Archean magmatism and signalling the onset of long-term crustal stabilisation in the Southern Bundelkhand Craton. This study also reports the first documented occurrence of sanukitoids in the southern Bundelkhand Craton, spatially confined to shear zones and granite–greenstone sequences within the Madawara domain. These low-Ti sanukitoids (TiO2 = 0.59–0.63 wt%) display a hybrid mantle–crust signature, characterised by high Mg# values (60–66), elevated Ba+Sr contents (1198–1261 ppm), and enrichment in Cr, Ni, and V, indicating a metasomatized lithospheric mantle source. The results support a model wherein TTG melts interacted with peridotite and were homogenized at shallow crustal levels, with their sporadic distribution suggesting formation within a microplate tectonic setting characterised by warm, shallow subduction. The TTGs display adakitic geochemical affinities, with low to moderate Sr/Y ratios (8–88) and chondrite-normalised (La/Yb)CN values of 15–30, consistent with partial melting of a garnet–amphibolite source. Negative Eu anomalies indicate either plagioclase fractionation during magma evolution or residual plagioclase in the source region. In contrast, the high-K granitoids (SiO2 = 72–75 wt%) exhibit low Mg# values (16–31) and low Sr contents (9–123 ppm), with pronounced negative Eu and Ti anomalies pointing to a dominantly crustal origin. Their REE patterns—marked by LREE enrichment, sharp negative Eu anomalies, and flat HREE distributions—are consistent with A-type granite signatures. Collectively, these data bridge the compositional continuum between TTGs and high-K granites, capturing a critical evolutionary transition in crust-forming processes and documenting the shift from primitive Archean geodynamic regimes toward modern-style plate interactions, providing new insights into the progressive stabilisation and reworking of continental crust.