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Petrology, geochemistry and petrogenesis of Stenian alkaline intrusions from the Chhotanagpur Gneissic Complex, Eastern Indian shield

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The Kankarkiari, Kusumda, and Sayalala intrusions were investigated to shed light on the late-Stenian post-collisional alkaline magmatism within the North Purulia Shear Zone, Chhotanagpur Gneissic Complex of the Eastern Indian Shield. The plutons are lenticular and show a prominent gneissic texture. The intrusions comprise silica-undersaturated rocks such as nepheline syenite, nepheline monzonite, nepheline diorite, and nepheline gabbro. The principal mafic minerals identified in nepheline syenites include amphibole (ferropargasite) and biotite, with clinopyroxene (diopside) and kaersutite present in nepheline gabbros. Geochemical analysis reveals that the foid-syenites and related rocks exhibit a mildly alkaline (shoshonitic) affinity, showing intermediate SiO_2 levels (46.47–59.70 wt%), low MgO (0.33–3.38 wt%), and low Mg# (7–25). Notably, they display high concentrations of Al_2O_3 (17.77–22.69 wt%) and K_2O+Na_2O (5.78–14.59 wt%) alongside variable Na_2O/K_2O ratios (0.92–4.55). The intrusions are generally metaluminous and rarely weakly peraluminous, indicated by an aluminum-saturation index (ASI) between 0.62 and 1.1. Geochemical features similar to arc-related rocks characterize most samples, marked by the enrichment of large ion lithophile elements (LILE) and light rare earth elements (LREE) alongside a depletion in high field strength elements (HFSE). Chondrite-normalized REE patterns generally show positive Eu anomalies (Eu/Eu*= average 1.6) and elevated $(La/Yb)_{CN}$ values (17.25–94.2). The high $(Tb/Yb)_{CN}$ ratios (3.18 to 6.59) indicate smaller melt fractions, or garnet, as the main residual phase at the source. LA-ICPMS zircon U-Pb dating suggests a crystallization age of 1013 ± 4 Ma and a metamorphic overprint at 981 ± 5 Ma, indicating a Stenian-Tonian post-collisional period in the Satpura Orogenic Belt. Their zircon in-situ εHf(t) values have a wide range (-8.86 and -3.13; Hf $T2_{DM}^{C}$ = 1.94–2.39 Ga). Pseudosection analysis indicates these undersaturated rocks were metamorphosed at 5 kb and 700°C. The magma appears to have evolved under high oxygen fugacity (ΔFMQ: +3.74 to +4.34), suggesting a mantle source affected by subduction processes, with melting linked to a post-collisional extension during the Stenian, likely due to slab break-off events. A chemically enriched sub-continental lithospheric mantle source composed of garnet-spinel-lherzolite that has undergone a low degree of partial melting (<5%) could generate the parental magma of the nepheline-syenites.

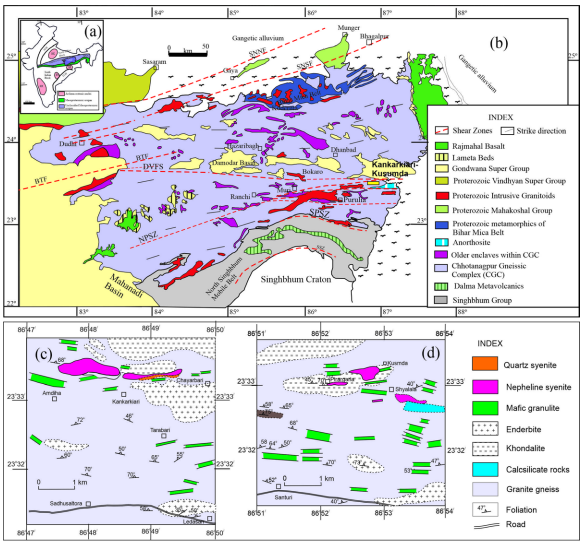

Figure 1