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Geochemical record of subduction initiation to arc maturation from the Paleoproterozoic Malangtoli lavas, Singhbhum Craton, eastern India

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The Singhbhum Craton of eastern India preserves distinct signatures of ultramafic-mafic-intermediate-felsic magmatism of diverse geodynamic affiliations spanning from Paleo-Mesoarchean to Proterozoic. We investigate the 2.25 Ga Malangtoli volcanic rocks that are predominantly calc-alkaline in nature, have basalt - basaltic andesite compositions, and preserve geochemical signatures of subduction zone magmatism. The Malangtoli basalts show porphyritic texture with clinopyroxene and plagioclase phenocrysts. The primitive igneous mineralogy of these rocks has been transformed to chlorite-tremolite-actinolite assemblage reflecting greenschist facies metamorphism. Major, trace and rare earth element characteristics classify the Malangtoli volcanic rocks as arc basalts, boninites, high magnesian andesites (HMA) and Nb enriched basalts (NEB). The typical LILE enriched-HFSE depleted geochemical attributes of the arc basalts corroborate a subduction-related origin. The boninitic rocks are characterized by low SiO_2 (<45 wt.%), high Mg# (0.80), MgO (>25 wt.%), Ni and Cr contents, high $Al2O_3/TiO_2$ (>20), Zr/Hf and (La/Sm)n (>1) ratios with low (Gd/Yb)N (<1) ratio, TiO_2, and Zr concentrations. The HMA samples are marked by SiO_2 (>54 wt.%), MgO (>6 wt.%), Mg# (0.47) with elevated Cr, Co, Ni and Th contents, depleted (Nb/Th)N, (Nb/La)N, high (Th/La)N and La/Yb (<9) ratio, moderate depletion in HREE and Y with low Sr/Y. The studied NEBs have higher Nb contents (6.3-24 ppm), lower magnitude of negative Nb anomalies with high (Nb/Th)pm=0.28 - 0.59 and (Nb/La)pm=0.40-0.69 and Nb/U=2.8-34.4 compared to normal arc basalts [Nb= <2 ppm; (Nb/Th)pm=0.10-1.19; (Nb/La)pm 0.17-0.99 and Nb/U=2.2-44 respectively] and HMA. These compositional varieties from Malangtoli volcanic suite of the Singhbhum Craton are geochemically analogous to their Archean and Phanerozoic counterparts. Arc basalts and boninites are interpreted to be the products of juvenile subduction processes involving shallow level partial melting of mantle wedge under hydrous conditions triggered by slab-dehydrated fluid flux. The geochemical signatures of HMA preclude the role of subducted eclogitic crust melting with residual garnet in the source. Interaction between mantle wedge and slabs melts are conformable with partial melting of mantle wedge metasomatized by slab-dehydrated fluids and sediments in the intermediate stage of subduction. Extraction of arc basalts, boninitic and HMA melts and slab melting at matured stages of subduction rendered the mantle wedge hybridized and enriched in HFSE which on low degree partial melting with residual garnet generated NEB. This arc basalt-boninite-HMA-NEB association from Malangtoli preserve signatures of an entire spectrum of Paleoproterozoic active convergent margin magmatism in the Singhbhum Craton spanning from subduction initiation to arc maturation.