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Tectono-magmatic evolution of the Barabar Hill anorthosite–gabbronorite suite (CGGC, eastern Indian Shield) inferred from integrated geochemical, mineral-chemical, and isotopic data.

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Massif-type anorthosite intrusions preserve important records of Proterozoic mantle–crust interactions, crustal growth, and reworking. These voluminous, plagioclase-rich cumulates were emplaced predominantly during the Statherian–Tonian interval (1.8–0.9 Ga) and are broadly associated with the assembly of the Columbia and Rodinia supercontinents. Despite their widespread occurrence within this restricted time frame, the origin of massif-type anorthosites remains debated, with proposed models involving mantle-derived magmas, partial melting of the lower crust, or subduction-related arc magmatism.

Small bodies of anorthosite along with associated gabbronorite occur near the Barabar Hills and form part of the Chotanagpur Granite Gneiss Complex (CGGC) of eastern India. The anorthosite is dominated by plagioclase, which constitutes more than 90 vol%, while mafic minerals such as amphibole and mica are present only in minor amounts. The associated gabbronorite differs in composition and contains abundant mafic minerals, with orthopyroxene making up more than 40 vol%, together with plagioclase (40–50 vol%) and clinopyroxene (>20 vol%). Both lithologies are interpreted as cumulate rocks; the anorthosite commonly shows adcumulate textures, whereas the gabbronorite displays mesocumulate textures.

Plagioclase in the anorthosite ranges in composition from anorthite to labradorite ($An_{60–96}$). In contrast, plagioclase in the gabbronorite varies from oligoclase to bytownite ($An_{50–70}$). Clinopyroxene in the gabbronorite ranges from diopside to augite ($En_{36–43}$ $Fs_{12–15}$ $Wo_{43–47}$), while orthopyroxene corresponds to hypersthene ($Wo_{39–40}$ $En_{46–50}$ $Fs_{10–21}$). Thermobarometric calculations indicate clinopyroxene crystallization in gabbronorites at ~1100–1175 °C and 0.04–2.30 kbar, whereas zircons in anorthosites crystallized at ~600–765 °C under FMQ-buffered conditions. Equilibrium Distribution Method modeling constrains parental melt fractions of ~0–20% for anorthosites and ~15–30% for gabbronorites, while AFC modeling suggests derivation from depleted mantle–derived basaltic magmas with significant upper crustal assimilation. U–Pb zircon ages of 1760 ± 7.3, 1762 ± 3.8 Ma emplacement in the Statherian period, representing the first Paleoproterozoic anorthosite reported from the eastern Indian Shield. These results support a hybrid mantle–crust origin for anorthosites.