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Crystallization history of a massif anorthosite in the eastern Indian shield margin based on borehole lithology

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Abstract

The Bengal anorthosite occurs as a large tadpole-shaped pluton (250 km²) in the granulite facies terrain of the Proterozoic Chotanagpur Gneiss Granulite Complex at the northeastern edge of the Indian peninsular shield. Its axis of elongation conforms to the general strike (ENE–WSW) of the country rocks. It is bounded by a (Gondwana) basin margin fault in the north and it shows an interfingering contact with the country rocks at its eastern and western edges.

Deep drilling, attaining a maximum depth of 622.85 m, reveals a cyclic order of grey, white and mottled anorthosites of variable thickness. The possibility of anorthosite extending further below contradicts the 200 m thickness of anorthosite previously estimated from gravity modeling. Chemical data also indicate a cyclic variation of elemental concentrations and their ratios with depth. In each chemical cycle, the grey plagioclase megacrysts apparently floated over a relatively denser white granular plagioclase with higher anorthite contents. The base of a chemical cycle also contains higher concentrations of transition elements—a feature arising plausibly by sinking of Fe–Ti oxides. The chemical cyclicality possibly indicates derivation of melt in batches and emplacement of the crystal laden-melt by impulses. Minor presence of orthopyroxene in the anorthosite suggests a tholeiitic source.

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1. Introduction

One of the major processes of the growth of continental crust in the Proterozoic era is the emplacement of large anorthosite massifs in shield areas. An understanding of geological and geochemical characteristics of massif anorthosite emplacement is, therefore, one of fundamental importance in tracing the evolutionary history of a continental shield. The Chotanagpur granite-gneiss complex (CGGC) forms part of a Proterozoic mobile belt lying to the north of the Singhbhum craton (> 3.2 Ga, Saha, 1994) at the Eastern Indian shield margin. The CGGC has been subjected to three distinct episodes of anorthositic magmatism ranging in age from Late Paleoproterozoic to the Early

Mesoproterozoic period (Mukherjee and Ghose, 1992) in association with metamorphosed layered mafic–ultramafic sequence, as a product of differentiated gabbro, and massif anorthosite intrusion in amphibolite-granulite country rocks. Most of these anorthosite occurrences in the CGGC spread across the eastern Indian states of Bihar, Jharkhand and West Bengal (Ghose and Mukherjee, 2000) (Fig. 1). The anorthosite occurring near Saltora, known as the 'Bengal Anorthosite' (Chatterjee, 1937), is the largest body of massif anorthosite (250 km²) at the eastern Indian shield margin. Modeling of gravity data indicated a 200 m thick anorthosite body over a dense 3.3–5.5 km thick mafic body (Verma et al., 1975). The present study, based on drill core samples from depths up to 622.85 m from the surface, indicates that the anorthosite body continues to greater depths. This investigation aims at establishing the subsurface mineralogical and chemical changes in the borehole profiles of the Bengal anorthosite massif to ascertain its crystallization history.

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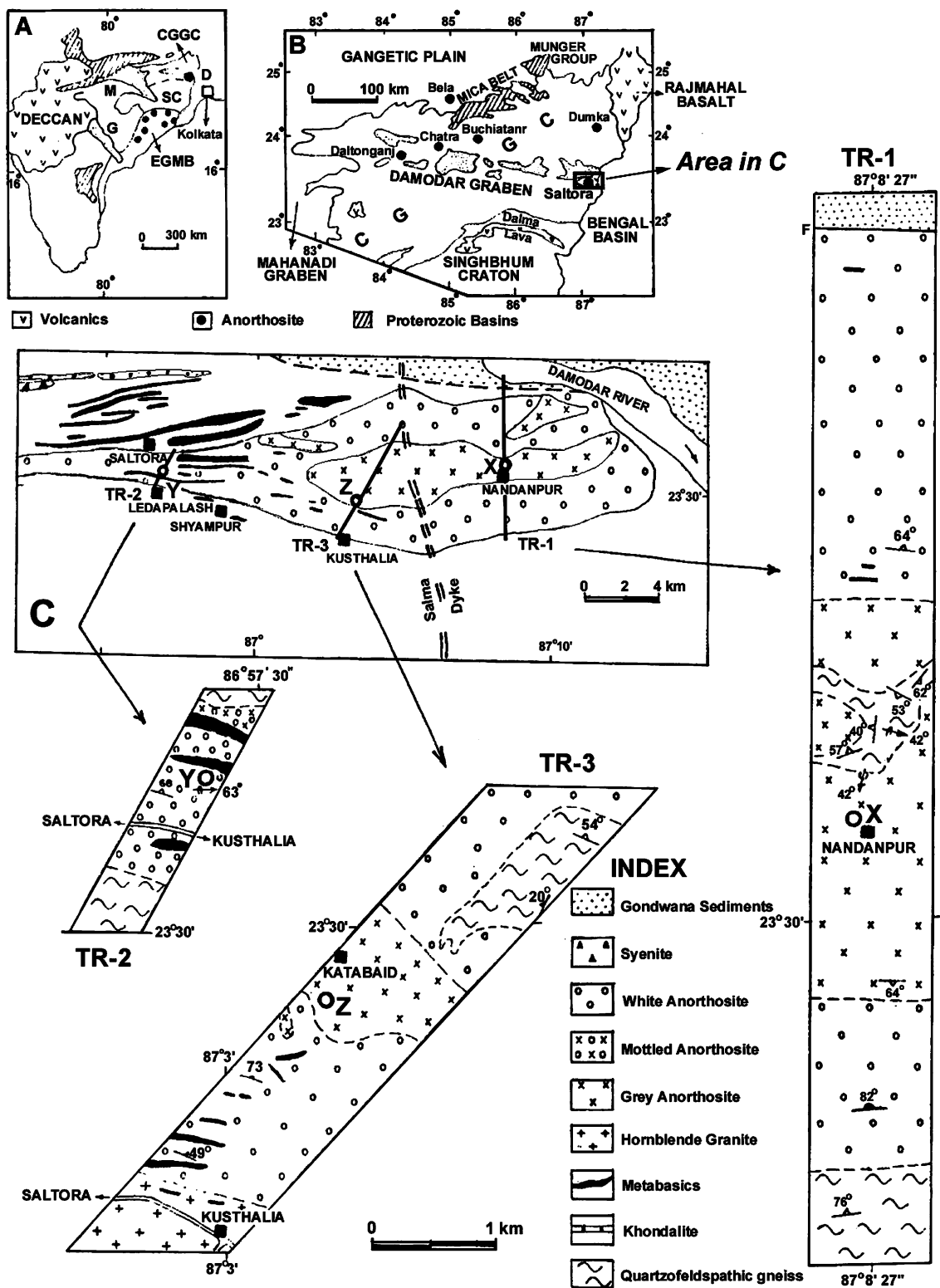


Fig. 1. A simplified geological map of the Bengal anorthosite (modified after Bhattacharyya and Mukherjee, 1987) showing location of the transect lines (TR-1, TR-2 and TR-3) and site of the boreholes (X, Y and Z). The geological maps of the three transect lines are shown by arrows. Inset maps (top) (A) Major geological units of the Indian shield and the position of the Chotanagpur Gneiss Granulite Complex (CGGC), Proterozoic basins (inclined bars), Gondwana basins (stippled area: G, Godavari basin; M, Mahanadi basin; D, Damodar graben), Deccan basalt (V), EGMB: Eastern Ghats Mobile Belt, SC: Singhbhum craton, and solid circle: anorthosite occurrences in EGMB and CGGC (Bengal anorthosite). Inset (B) The mobile belt of the CGGC showing location of the Bengal anorthosite at Saltora and other anorthosite occurrences in this belt (solid circle), Gondwana basins along Damodar graben (stippled), Rajmahal volcanics (V), and Younger Proterozoic basins in the north (inclined bars). The Singhbhum craton along with Dalma volcanics have been demarcated in the south. The area in map C is enclosed in a rectangle.

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