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Extensive Early Neoproterozoic high-grade metamorphism in North Chotanagpur Gneissic Complex of the Central Indian Tectonic Zone

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ABSTRACT

The Indian Shield was assembled through a Proterozoic collision between the northern and southern Indian continental blocks along the ENE–WSW Central Indian Tectonic Zone (CITZ). Chemical dating of monazite, xenotime and uraninite, and thermobarometric analysis are carried out to determine the spatial extent and assess the significance of Early Neoproterozoic high-grade metamorphism in the northern sector of the Chotanagpur Gneissic Complex (CGC), a Proterozoic belt of granite and granitic gneiss in the eastern part of CITZ. In northwest CGC, xenotime in granitic gneiss crystallized at 975 ± 67 Ma along foliation that developed at high metamorphic temperatures (788–861 °C). Thus Grenvillian metamorphism in northwest CGC may be correlated with the high-grade Grenvillian metamorphic terranes in northeast and north–central CGC, and similar terrane in central India. In the area northwest of the NE–SW boundary fault of CGC, monazite crystallized at 1697 ± 17 Ma in porphyritic granite that lacks <1.6 Ga thermal imprint. Thus the Grenvillian metamorphic front did not extend across the boundary of the CGC. Furthermore, the lithological association of granite and country schist/phyllite, and the timing of granite intrusion are similar to those in the Son–Narmada Graben, a major ENE–WSW lineament comprising the northern part of CITZ in central India. Therefore, the graben most probably extends in a northeasterly direction along the NE–SW boundary of the CGC. In the northeastern corner of the CGC, a 768 ± 11 Ma age of uraninite in biotite–gneiss may be related to mid-Neoproterozoic high-grade metamorphism along the eastern margin of the CGC. Pervasive high-grade Grenvillian metamorphism in the entire northern sector of the CGC may be related to a terminal Grenvillian assembly of the Indian Shield in the Rodinia supercontinent.

1. Introduction

Geological, chronological and paleomagnetic data indicate that continental blocks collided to form at least two supercontinents in the Proterozoic: Columbia at ~1.8 Ga and Rodinia at ~1.0 Ga, (Rogers and Santosh, 2003, 2009; Zhao et al., 2004; Li et al., 2008; Meert et al., 2010). On the Indian Shield, the manifestation of a Proterozoic collision between the northern and southern Indian blocks is an ENE–WSW orogenic belt across India known as the Central Indian Tectonic Zone (CITZ, Radhakrishna, 1989) (Fig. 1A). However, the timing and mechanism of the collision are poorly constrained. According to some researchers, the subduction of the northern plate under the southern plate between 2.1 and 1.8 Ga resulted in the suturing of the two continental blocks along the southern boundary of CITZ in Early Mesoproterozoic (Yedekar et al., 1990; Mishra et al., 2000). Others contend that the subduction was northward (Roy and Prasad, 2003; Mall et al., 2008). Another recent model based on the geophysical data suggests a double-sided subduction history of the CITZ (Naganjaneyulu and Santosh, 2010). According to this model, northward of the southern Indian block and southward of the northern Indian block resulted in the development of a paired collision-type orogen similar to the present day scenario in the western Pacific region (Santosh and Kusky, 2010; Isozaki et al., 2010). The ENE–WSW Son–Narmada Graben in the northern part of CITZ may have originated as a back-arc rift basin during the northward subduction of the southern plate (Roy and Prasad, 2003), but the geophysical evidence suggests that the graben may have originated as an intracratonic rift related to mantle upwelling (Das and Patel, 1984; Shankar, 1991; Sharma, 2009). The >1.5 Ga low-grade metasediments of the Son–Narmada Graben may have been deformed during the early stages of subduction (Nair et al., 1995; Roy and Devarajan, 2000; Acharyya and Roy, 2000).

Metamorphic P–T path modeling in the high-pressure granulite belts of central India indicate complex multi-stage interactions between the northern and the southern plates (Bhowmik and Roy, 2003; Acharyya, 2003; Bhowmik et al., 2005; Roy et al., 2006; Sarbadhikari and Bhowmik,

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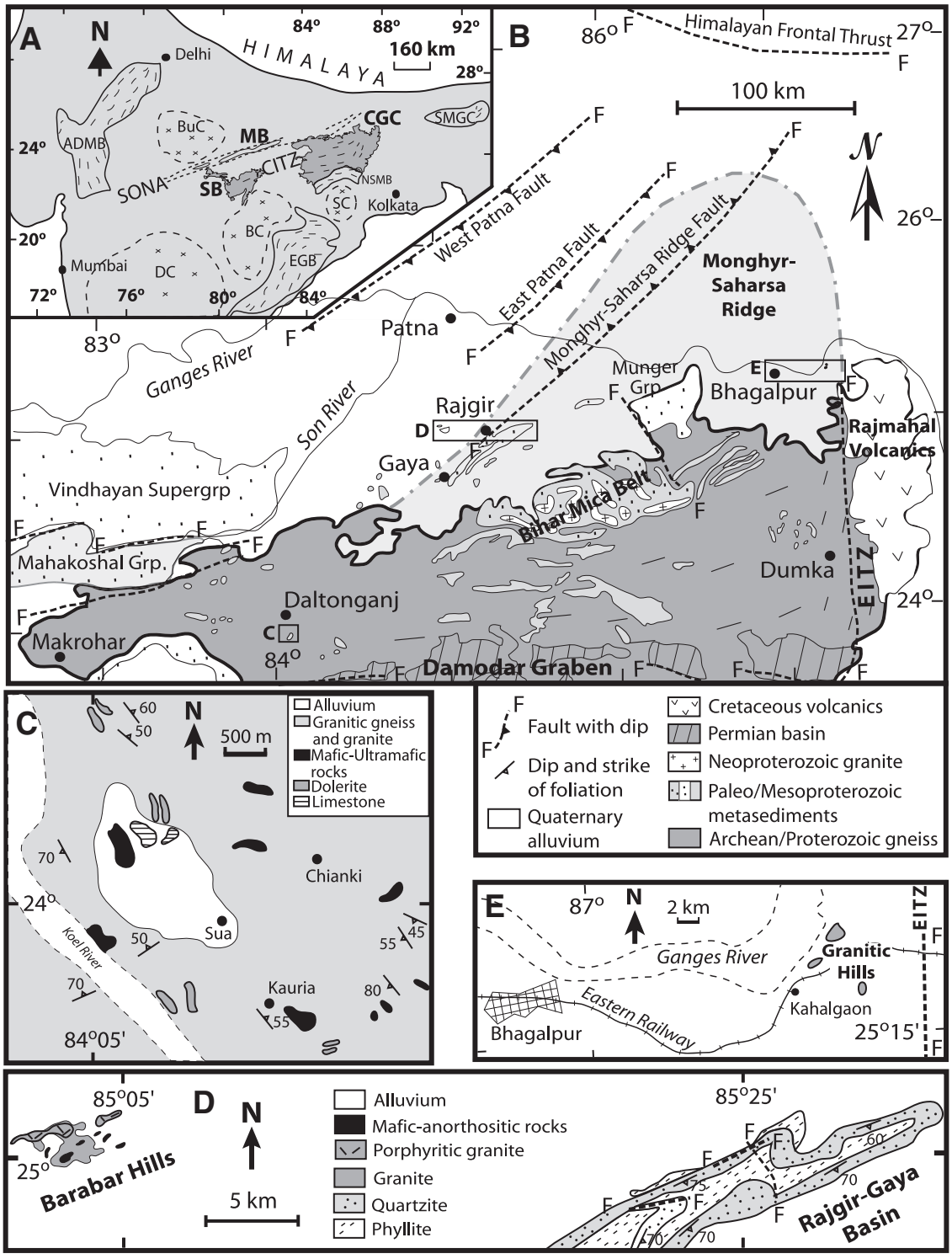

Fig. 1. (A) Location of the Central Indian Tectonic Zone (CITZ) comprised of Chotanagpur Gneissic Complex (CGC), Satpura Belt (SB) and Mahakoshal Belt (MB). The MB is located within the Son–Narmada (SONA) Graben bounded by two parallel ENE–WSW faults shown in dashed lines. Other Proterozoic complexes on the Indian Shield include Aravalli–Delhi Mobile Belt (ADMB), North Singhbhum Mobile Belt (NSMB), Eastern Ghats Belt (EGB), and Shillong–Meghalaya Gneissic Complex (SMGC). The major foliation trends are shown by small line segments. The Archean cratonic nuclei (crosses) are Bundelkhand Craton (BuC) in the northern Indian block, and Singhbhum Craton (SC), Bastar Craton (BC) and Dharwar Craton (DC) in the southern Indian block. (B) Geological map of the northern part of CGC and adjoining regions (after GSI, 1998). The Monghyr–Saharsa Ridge, a sub-surface promontory of the CGC and the major NE–SW faults are after Sastri et al. (1971), Rao (1973), Valdiya (1976) and GSI (2000). The Eastern Indian Tectonic Zone (EITZ) at the eastern boundary of CGC is from Chatterjee et al. (2010). Study areas are shown in boxes marked C, D, and E. (C) Details of the area southeast of Daltonganj showing major lithounits and foliation trends (after Srivastava and Ghose, 1992). (D) Barabar Hills (after Sinha and Bose, 1977) and the northern part of the Rajgir–Gaya Basin (after Srivastava and Sengupta, 1967) showing major lithounits, faults and foliation trends. The faults at the eastern, NE–SW boundary of Rajgir–Gaya Basin are extensions of the Monghyr–Saharsa Ridge Fault. (E) Small granitoid hillocks east of Bhagalpur in close proximity to the EITZ in the northeast corner of CGC.

2008; Bhandari et al., 2010). According to these studies, the extension between the two plates was followed by compression and UHT metamorphism in Late Paleoproterozoic–Early Mesoproterozoic, and a terminal continental collision leading to the final assembly of the Indian shield occurred during the Late Mesoproteozoic–Early Neoproterozoic Grenvillian orogeny. Alternatively, the terminal collision occurred in