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Proto-India was a part of Rodinia: Evidence from Grenville-age suturing of the Eastern Ghats Province with the Paleoarchean Singhbhum Craton

Sabyasachi Chattopadhyay[a], Dewashish Upadhyay[a,*], Jayanta Kumar Nanda[b], Klaus Mezger[c], Kamal Lochan Pruseth[a], Jasper Berndt[d]

[a] Department of Geology and Geophysics, Indian Institute of Technology, Kharagpur, India
[b] S-4/113, Niladrivihar, Chandrasekharpur, Bhubaneshwar 751021, India
[c] Institute for Geology and Center for Space and Habitability, University of Bern, Baltzerstrasse 1+3, CH-3012 Bern, Switzerland
[d] Institute for Mineralogy, Westfälische Wilhelms-University, Corrensstrasse 24, 48149 Münster, Germany

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ABSTRACT

The timing of amalgamation of the Eastern Ghats Province with the Indian shield is central to the correlation between proto-India and east Antarctica in reconstructions of the supercontinent Rodinia. In this study, the metamorphic and geochronological evolution of the Malayagiri supracrustal belt in the Rengali Province, a wedge-shaped Neoarchean cratonic terrane located between the Paleo-Mesoarchean Singhbhum cratonic nucleus and the Meso-Neoproterozoic Eastern Ghats Province has been used to constrain the suturing of the Eastern Ghats Province with the Singhbhum Craton. The Malayagiri supracrustal rocks were deposited in the Neoarchean between 2.79 and 2.42 Ga. The ~2.80 Ga Pal Lahara-Kamakhyanagar Gneiss served as the basement to the supracrustal sequence. The supracrustal rocks were affected by three major tectonothermal events at ~2.42 Ga, 0.98–0.94 Ga, and 0.57–0.54 Ga and a minor thermal event at ~0.82 Ga. The Grenville-age metamorphism reached upper amphibolite facies conditions along a clockwise P-T path. The Eastern Ghats Province granulites in the vicinity of the Malayagiri supracrustal belt are characterized by major tectonothermal events at ca. 1.22 Ga, ~0.98 Ga, ~0.81 Ga, and ~0.62–0.50 Ga. The Malayagiri supracrustal rocks and the Eastern Ghats Province granulites had a common geological history since the early Neoproterozoic with both terranes sharing the 0.98–0.94 Ga, 0.85–0.80 Ga and 0.62–0.50 Ga tectonothermal events. The earliest event shared by the two terranes corresponds to the suturing of the Eastern Ghats Province granulites with the southern margin of the cratonic Rengali Province. Thus, the docking of the Eastern Ghats Province with cratonic India first took place during the Grenvillian and not during the Pan-African orogeny implying that proto-India was welded together with east Antarctica along the Grenville-age Eastern Ghats Province-Rayner complex orogen.

1. Introduction

The position of proto-India in reconstructions of the supercontinent Rodinia is controversial. Paleomagnetic results from the 771 to 751 Ma Malani Igneous Suite in north western India (Torsvik et al., 2001a; Gregory et al., 2009; Meert et al., 2013) place India at much higher latitudes west of Australia rather than forming a conjugate margin with east Antarctica in the Mid-Neoproterozoic (e.g., Torsvik et al., 2001a; Gregory et al., 2009). Torsvik et al. (2001a,b) proposed that India was either not a part of Rodinia or was adjacent to the northwestern margin of Australia (Fig. 1). This view has been supported by Powell and Pisarevsky (2002) who argued that India could not have been a part of Rodinia since paleomagnetic data from the Harohalli dykes, purported to have an age of 810 Ma (Radhakrishna and Mathew, 1996), also place India at a higher paleolatitude position. However, U–Pb dating of zircons by Pradhan et al. (2008) gives a concordant age of 1192 ± 10 Ma for the Harohalli dyke that is far older than all previously published ages, implying that the Harohalli dyke paleopole cannot be used to constrain the position of proto-India in Rodinia. Furthermore, on the basis of correlatable Neoproterozoic silicic magmatism in the Malani Igneous Suite, Seychelles and the northern part of

* Corresponding author at: Department of Geology and Geophysics, Indian Institute of Technology, Kharagpur, 721302 Kharagpur, West Bengal, India. Tel.: +91 3222 283398; fax: +91 3222 282268.
E-mail address: dewashish@gg.iitkgp.ernet.in (D. Upadhyay).

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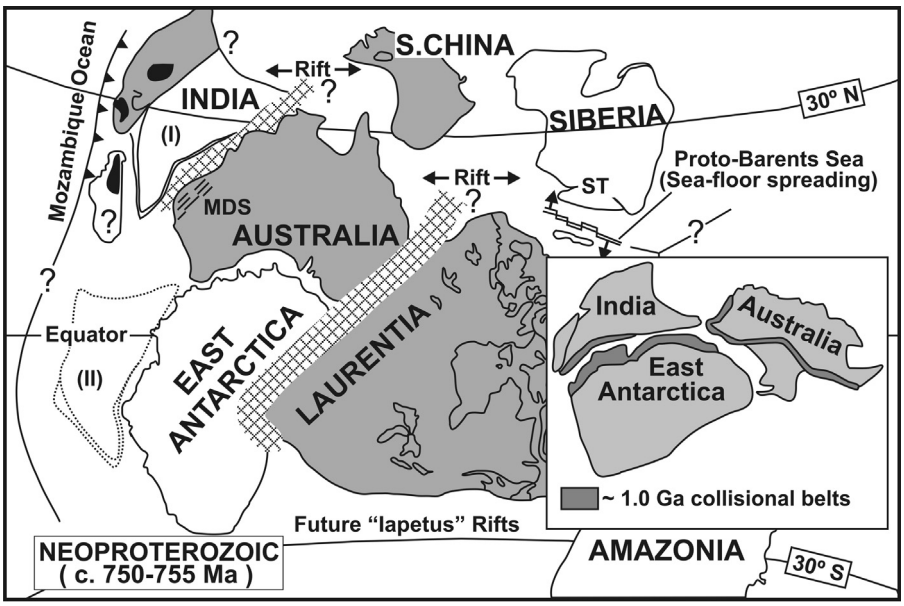

Fig. 1. Reconstruction of a part of the Rodinia supercontinent at 750–755 Ma (from Torsvik et al., 2001a) showing the probable positions of India. Based on paleomagnetic data from the 771–751 Ma Malani Igneous suite in western India, Torsvik et al. (2001a,b) suggest that India was located at latitudes comparable with those of Western Australia (position I). However, in conventional paleogeographic reconstructions of Rodinia, India is juxtaposed against east Antarctica (position-II, stippled outline), the two cratons being welded together along the Grenville-age Eastern Ghats Province-Rayner complex orogen.

Madagascar, Tucker et al. (1999) suggested that NW India, Seychelles and North Madagascar may have constituted a separate terrane in the Neoproterozoic. Thus, the 771–751 Ma paleopole of the Malani Igneous Suite may not have been representative of India (c.f. Torsvik et al., 2001a) and therefore, cannot be used to infer the position of proto-India in Rodinia. New paleomagnetic results for ~1.1 Ga Mesoproterozoic kimberlites from Wajrakarur, Narayanpet and Raichur within the Eastern Dharwar Craton, place India at lower paleo latitudes, much separated from Australia. Clearly, the paleomagnetic studies are inconclusive in establishing the position of India during Rodinia assembly at ~1.0 Ga (Li et al., 2008).

Based on geometric fit of the coastlines, paleomagnetic constraints, and similarities in the geological histories of the Eastern Ghats Province and the Rayner complex, many paleogeographic reconstructions of Rodinia at ~1.0 Ga (e.g., Moores, 1991; Hoffman, 1991; Dalziel, 1997) link proto-India with east Antarctica, the two cratons having been welded together along the Grenville-age Eastern Ghats Province-Rayner complex orogen (e.g., Yoshida et al., 1992; Mezger and Cosca, 1999; Dalziel, 1997, Shaw et al., 1997; Li et al., 2008) (Fig. 1). Implicit in these correlations is the assumption that the Eastern Ghats Province had amalgamated with proto-India during the Neoproterozoic Grenville-age orogeny between 1.1 and 0.9 Ga (Dobmeier and Raith, 2003; Dasgupta et al., 2013). While most authors support such a paleo-geodynamic model, Dobmeier et al. (2006) argue, based on the apparent lack of Grenvillian ages along the southeastern margin of the Indian craton, that the Eastern Ghats Province-Rayner Complex crustal block constituted an exotic terrane that became a part of peninsular India only in the early Paleozoic during the Pan-African orogeny. This view is supported by Das et al. (2008) and Biswal et al. (2007) who correlate the Pan-African high-grade metamorphism and ductile deformation along the contact between cratonic India and the Eastern Ghats Province with the amalgamation of the two terranes. This would imply that the Eastern Ghats Province-Rayner Complex terrane was a part of Rodinia while the rest of the Indian subcontinent was not (Dobmeier et al., 2006); in accordance with the model that places India outside Rodinia (e.g., Torsvik et al., 2001a,b; Powell et al., 2001; Powell and Pisarevsky, 2002).

Thus, the timing of amalgamation of the Eastern Ghats Province with the Indian shield is central to the correlation between proto-India and east Antarctica in Rodinia reconstructions. A Grenville-age for the juxtaposition would support the conventional paleogeographic reconstruction models that position proto-India adjacent to east Antarctica while an early Paleozoic amalgamation of the two terranes would be consistent with the hypotheses that India was not a part of Rodinia (Fig. 1).

In this study, we characterize the metamorphic and geochronological evolution of the Malayagiri supracrustal belt and its gneissic basement at the northern contact of the Eastern Ghats Province. The basement and the overlying metasedimentary rocks are part of the Rengali Province, a wedge-shaped Neoarchean cratonic terrane, located between the Paleo-/Mesoarchean Singhbhum cratonic nucleus and the Eastern Ghats Province. The Malayagiri supracrustal rocks preserve records of the geologic events related to the amalgamation of the Indian shield with those of east Antarctica during the Grenvillian and Pan-African orogenic episodes, thereby supporting a Grenville-age for the juxtaposition of the two terranes in consonance with conventional paleogeographic reconstruction models.

2. Regional geologic setting

2.1. The Eastern Ghats Province

The Eastern Ghats Province is a Neoproterozoic Grenville-age orogen along the east coast of India. The orogen is a part of the Eastern Ghats Belt of rocks and is widely considered to have been at the forefront of collisions and amalgamation involving the Indian shield with those of east Antarctica and Australia (Fig. 2). The province represents a polycyclic granulite facies terrane (Shaw et al., 1997; Mezger and Cosca, 1999; Upadhyay and Raith, 2006a,b; Upadhyay et al., 2006a,b; Simmat and Raith, 2008; Upadhyay, 2008; Korhonen et al., 2011, 2013a,b; Bose et al., 2011; Dasgupta et al., 2013) comprising charnockitic gneisses, megacrystic garnet- and orthopyroxene-bearing granitoid plutons (0.98–95 Ga; Paul et al., 1990; Kovach et al., 1998) and massif-type anorthosite complexes intrusive into a granulite facies supracrustal package (Ndt_{DM}: