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Evolution of the Chilka Lake granulite complex, northern Eastern Ghats Belt, India: First evidence of ~780 Ma decompression of the deep crust and its implication on the India–Antarctica correlation

S. Bose [a,*], K. Das [b], J. Torimoto [c], M. Arima [d], D.J. Dunkley [e]

[a] Department of Geology, Presidency University, Kolkata 700073, India
[b] Department of Earth Systems Science, Hiroshima University 739-8526, Japan
[c] Ore Genesis Research Unit, Project Team for Development of New-generation Research Protocol for Submarine Resources, JAMSTEC, Japan
[d] Graduate School of Environment and Information Sciences, Yokohama National University, Yokohama 240-8501, Japan
[e] Department of Applied Geology, Curtin University, Australia

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ABSTRACT

High-grade para- and orthogneissic rocks near the Chilka Lake granulite complex, northern part of the Eastern Ghats Belt show complex structural and petrological history. Based on field and petrographic characters, five (M_1–M_5) metamorphic events could be identified. The earliest metamorphic event (M_1) produced amphibolite grade mineral assemblage which produced the peak granulite (M_2) assemblages at 900–950 °C, 8.5–9.0 kbar. The third metamorphic event caused decompression of the deeper crust up to 700–800 °C, 6.0–6.5 kbar. This was followed by cooling (M_4) and subsequent thermal overprinting (M_5). Fluid-composition during M_3 was dominated by high-density CO_2 and changed to low-density mixed CO_2–H_2O during the M_3. Zircon U–Pb SHRIMP data suggest 781 ± 9 Ma age for M_3 event. Texturally constrained monazite U–Th–Pb EPMA data, on the other hand, yield a group age of 988 ± 23 Ma from grain interior, which can signifies the age of M_2 event. Few spots with younger dates in the range of 550–500 Ma are also noted. This interpretation changes the existing tectonothermal history of northern Eastern Ghats Belt. Our data show that the two adjacent crustal domains of the Eastern Ghats Belt show distinctly contrasting Neoproterozoic histories. While the central Domain 2 evolved through early anticlockwise *P*–*T* path culminating in ultrahigh temperature, the northern Domain 3 evolved through a clockwise *P*–*T* path. It appears that the Domain 3 was contiguous to East Antarctica and became part of the Eastern Ghats Belt during the assembly of Gondwana. The ca. 780 Ma decompression event in the northern Eastern Ghats Belt opens up new possibilities for interpreting the breakup of Rodinia.

1. Introduction

Precambrian orogenic belts are black boxes of extinct supercontinents whose fragments are now dispersed in present day continents. The supercontinent Rodinia is interpreted to have assembled, stabilized and broken up during the ca. 1300–780 Ma time frame (Li et al., 2008 and references therein). A key component to the assembly of Rodinia is the erstwhile contiguous terranes of Rayner Complex–Eastern Ghats Belt (R-EG), which represents the orogenic belt during ca. 1140–900 Ma suturing landmasses of India and East Antarctica (Boger, 2011; Fitzsimons, 2000; Mezger and Cosca, 1999). Although the initiation of Rodinia went back to ca. 1300 Ma, the R-EG became part of this supercontinent only during the final stage of the assembly at ca. 900 Ma (Li et al., 2008). Recent metamorphic and geochronological data both from the Eastern Ghats Belt and Rayner Complex identified similar pressure–temperature–time evolutionary histories endorsing the veracity of the proposed correlation (Bose et al., 2011a; Das et al., 2011; Harley et al., 2013; Korhonen et al., 2011, 2013, 2014; Morissey et al., 2015). The anticlockwise *P*–*T* evolutionary path of Eastern Ghats Belt (Dasgupta et al., 1995; Korhonen et al., 2011, 2013; Sengupta et al., 1990) that has reasonable similarity with that of the Rayner Complex (Clarke et al., 1989; Fitzsimons and Harley, 1992; Halpin et al., 2007; Thost and Hensen, 1992) within the broad time frame of c. 990–970 Ma (Morissey et al., 2015 and references therein). The unique UHT condition of Eastern Ghats Belt over a protracted period (~100 m.y.), however, has no matching counterparts in RC which possibly implies that the exhumed section of the R-EG orogenic system in India was much deeper (Morissey et al., 2015). This long-lived hot orogenic system eventually relaxed and stabilized at ~900 Ma when the complete Rodinia configuration was achieved (Condie, 2003; Li et al., 2008). Apart from stray reports of isothermal decompression of the deeper crust along clockwise *P*–*T* path from East Antarctica (c. 940–900 Ma events in Kemp Land, Kelly et al., 2002; Halpin et al., 2007), there is hardly any evidence for large-

* Corresponding author.
E-mail address: sankar.bose@gmail.com (S. Bose).

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scale exhumation of the R-EG crust in India. The deep crustal section of East Antarctica was eventually exhumed to near surface level much later during the Pan-African orogeny (ca. 550–500 Ma), which caused widespread tectonic and thermal rejuvenation of Rayner Complex (Boger et al., 2002; Kelsey et al., 2008a; Liu et al., 2009). On the other hand, published literature from Eastern Ghats Belt shows no clear record of deep crustal exhumation while it was reported that Pan African orogeny caused only localized thermal rejuvenation along the boundary shear zones (Dobmeier and Raith, 2003). The geologically complex Eastern Ghats Belt thus concealed this history over the years creating ambiguity on the post-Rodinia history of the belt. One major reason for this lacuna is be the dearth of comprehensive *P–T–t* study in the Indian counterpart compared to that of the East Antarctica (Halpin et al., 2007).

Eastern Ghats Belt (EGB) is interpreted as a collage of several crustal domains each having unique isotopic characters and style of evolution (Dobmeier and Raith, 2003; Rickers et al., 2001). This lithologically varied and structurally complex belt reveals three important events of supercontinent juxtaposition (Dasgupta et al., 2013). The southern part of the belt (Domain 1A) recorded important tectonothermal history in the time span of ca. 1760–1600 Ma (Bose et al., 2011a; Mezger and Cosca, 1999; Vijaya Kumar et al., 2011) which possibly relates the assembly of Columbia (Bose et al., 2011a; Dasgupta et al., 2013). The central part (Domain 2) evolved during ca. 1000–900 Ma (Bose et al., 2011a; Das et al., 2011; Korhonen et al., 2011, 2013; Upadhyay et al., 2009) as a part of Rodinia. The northern part (Domain 3) preserves tectonothermal history spanning the entire Neoproterozoic eon (Dobmeier and Simmat, 2002; Simmat and Raith, 2008), although the age interpretations are fraught with ambiguities. There has been sporadic evidence of Pan-African (ca. 550–500 Ma) orogeny from northern and western boundaries of the EGB, which united India and other continents within the broad framework of Gondwana. It is therefore possible to trace the exhumation history of the R-EG crust from fringe areas of the EGB. In this study, we made a comprehensive *P–T–t–Fluid* study from a suite of granulites of northern EGB to understand the post-Rodinia evolution. We also discuss the large-scale implication of this evolution in the context of possible India–Antarctica–Australia correlation.

2. Geological background

The Chilka Lake granulite complex (Fig. 1) comprises of high-grade paragneisses and orthogneisses surrounding a large anorthosite massif. This area is situated at the northern part of EGB (Domain 3) and preserves multiple stages (D_1–D_4) of folding and foliation/lineation development, the majority of which show WSW–ENE trend. The earliest (M_1–D_1) stage of metamorphism is identified by the development of biotite-bearing internal foliation within garnet porphyroblasts of aluminous granulite (Das et al., 2012). Subsequent tectonic event (M_2–D_2) produced the peak granulite mineral assemblages that are aligned along the S_2 regional gneissic fabric. The gneissic foliation is further folded during the M_3–D_3 event and the axial planar S_3 fabric is tectonically transposed parallel to S_2 to show the regional structure of the area. The last tectonic event (M_4–D_4) produced open upright F_4 folds without any development of foliation in the rocks except few spaced cleavages that developed in the quartzite/garnet-sillimanite gneiss. Presence of transposed S_2/S_3 fabric within the anorthosite arguably suggests that the pluton was emplaced before the M_3–D_3 event. Field-based large-scale and microfabric analyses of the granulites reveal that this granulite complex evolved through superposed folding events with two broadly perpendicular compression directions (Das et al., 2012). Tectonothermal history of these granulites spanning in Neoproterozoic time period is dominated by compressional tectonics with associated metamorphism at deep crust. Aluminous granulites and charnockites were previously studied by Sen et al. (1995) who documented multistage "decompression followed by cooling" retrogressive path ensued from UHT (~1100 °C) high-*P* (>10 kbar) peak. The

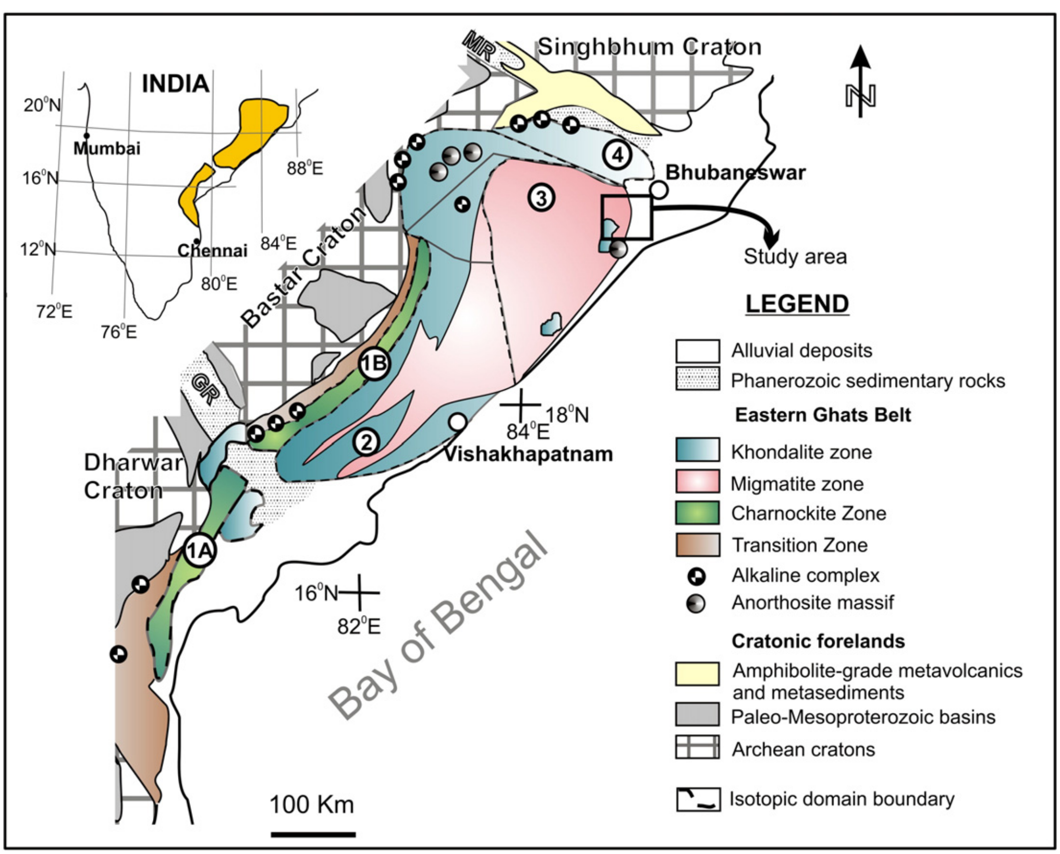

Fig. 1. Generalized geological map of the Eastern Ghats Belt showing the study area. The lithological zones shown in the map are after Ramakrishnan et al. (1998). Isotopic classification of crustal domains are marked after Rickers et al. (2001). Inset shows the position of Eastern Ghats Belt in India. Abbreviations used GR — Godavari Rift, MR — Mahandi Rift.