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U–Th–Pb monazite geochronometry of the Eastern Ghats Belt, India: Timing and spatial disposition of poly-metamorphism

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Abstract

The Eastern Ghats Belt of peninsular India exposes the deeply eroded high-grade parts of a composite orogenic belt that, including the Rayner Complex in Antarctica, once formed an important crustal component of Proterozoic East Gondwana. Recent work established four major crustal units separated by tectonic boundaries: the Late Archaean Jeypore and Rengali Provinces (northwest and north), the Late Palaeoproterozoic Ongole Domain (southwest) and the Meso-Neoproterozoic Eastern Ghats Province (east). To identify the timing and regional distribution of tectonothermal events within the composite belt, monazites in 66 pelitic and felsic granulite samples from 26 localities were studied with the electron microprobe chemical dating technique. In most cases the monazites are polygenetic with rock- and grain-scale chemical and chronological heterogeneities that document growth during episodes of partial melting and significant modifications through strain- and fluid-induced recrystallisation and replacement.

In the Ongole Domain, monazite apparent age populations show that the fabric-defining high- to ultrahigh-grade metamorphism occurred between 1650 and 1590 Ma, after the emplacement of basic and felsic plutonic complexes into the supracrustal granulites at ca. 1.7 Ga. The monazites do not record pre-intrusion tectonothermal events, but give evidence of later imprints of ductile to brittle deformation accompanied by hydration between 1450 and 1350 Ma that are correlated with Mesoproterozoic crustal extension, rifting and alkaline plutonism along the eastern cratonic margin. The Ongole Domain was not involved in Grenvillian crustal reworking, and Pan-African tectonism (~520 Ma) was focused in shear zones, especially at tectonic boundaries.

In the Eastern Ghats Province, monazite apparent age populations in the time span between 1260 and 500 Ma witness a prolonged and polyphase tectono-metamorphic evolution during Mesoproterozoic and Neoproterozoic–Early Phanerozoic times. Apparent ages of high-Y monazite grains armoured in garnet of khondalites and high-MgAl granulites bracket the timing of early ultra-high temperature metamorphism between 1250 and 1100 Ma. Dominant and comparable apparent age populations of matrix monazites in metapelitic and felsic granulites indicate that the fabric-defining granulite facies metamorphism and anatexis of the entire terrane occurred between 980 and 940 Ma, synchronous with the intrusion of voluminous megacrystic granitoid plutons. The easternmost Chilka Lake domain experienced renewed pervasive deformation and high-grade metamorphism and melting at ca. 800 Ma coeval with emplacement of massif-type anorthosite, and further high-grade reworking during Neoproterozoic tectonism (680–650 Ma).

Apparent ages of 530–470 Ma recorded in matrix monazites of strongly sheared mylonitic granulites indicate that the internal segmentation and structural configuration of the Eastern Ghats Belt and its cratonic forelands occurred during late Neoproterozoic–Early Phanerozoic times through W- to NW-directed intracratonic deformation focussed on major shear zones and terrane boundaries, when the Grenvillian Eastern Ghats Province–Rayner Complex terrane collided with India.

Keywords: U–Th–Pb monazite geochronology; Eastern Ghats Belt; India; Rodinia; Gondwana

1. Introduction

The Eastern Ghats along the east coast of Peninsular India expose a deep section through a composite orogenic belt (Eastern Ghats Belt, EGB) of multiply deformed, metamorphosed and migmatized granulite units that are bounded and segmented by shear zones and thrusts (Fig. 1). The belt has been interpreted

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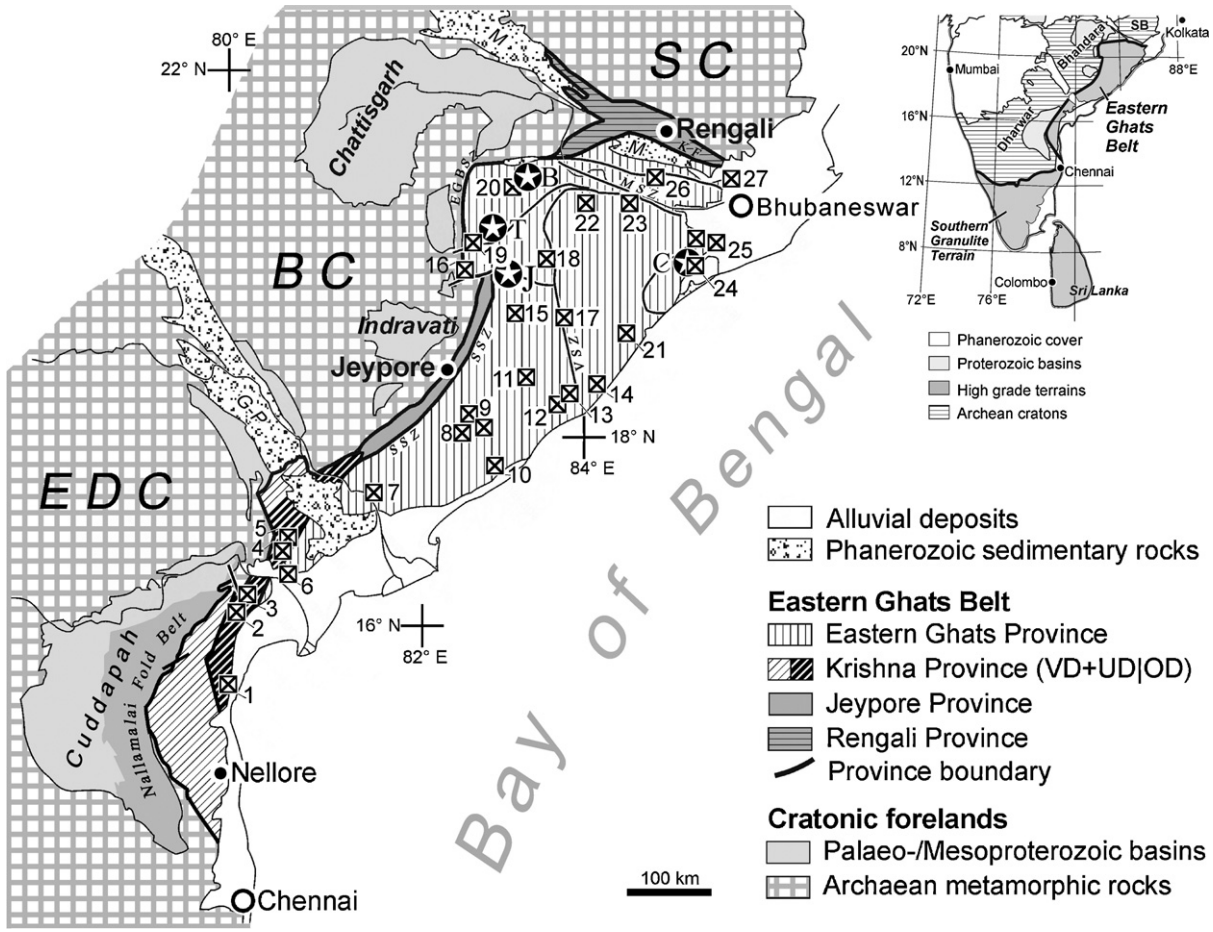

Fig. 1. The Eastern Ghats Belt of eastern peninsular India, showing subdivisions into crustal provinces separated by major shear zones (adopted from Dobmeier and Raith, 2003). Chemical monazite dating was done on granulite samples from the following locations: 1—Ongole; 2—Edlapadu; 3—Guntur; 4—N' Vijayawada; 5—Konduru; 6—Vijayawada; 7—Gokavaram; 8—Paderu; 9—Araku valley (Sunkarametta, Anantagiri); 10—Anakapalle; 11—S′ Bobbili; 12—Chipurupalle; 13—Srikakulam; 14—Tekkali; 15—SE Rayagada; 16—Deobogh; 17—Podmapur; 18—Kutragada; 19—Khariar; 20—Bolangir; 21—Brahmapur; 22—Phulbani; 23—Dashapalla; 24—Chilka Lake (Balugaon, Raja Ranapur); 25—Khurda; 26—Angul; 27—Chandhikhol. Abbreviations: EDC, BC and SC—Archaean granitoid-gneiss terrains of the Eastern Dharwar, Bhandara and Singhbhum cratons; VD, UD and OD—Vinjamuru, Udayagiri and Ongole Domains of the Krishna Province; G–P and M: Godavari–Pranhita and Mahandi graben; Province boundaries: SSZ—Sileru shear zone, EGBSZ—Eastern Ghats boundary shear zone, VSZ—Vamsadhara Lineament, MSZ—Mahanadi shear zone, KF—Kerajang Fault. Rifts: G–P—Godavari–Pranhita graben, M—Mahanadi graben. Massif-type anorthosite complexes: B—Bolangir, C—Chilka Lake, J—Jugsaipatna, T—Turkel.

as part of an extended middle Proterozoic collisional orogen where a northern branch (Satpura and Delhi belts) assembled the Archaean to Palaeoproterozoic Dharwar–Singhbhum protocontinent with the Bundelkhand protocontinent (Radhakrishna and Naqvi, 1986; Naqvi and Rogers, 1987), while its eastern branch (Eastern Ghats Belt and Rayner Complex of East Antarctica) formed a Grenvillian-age collisional orogen that welded Proto-India with Eastern Antarctica during the assembly of Rodinia (cf. Moores, 1991; Hoffmann, 1991; Meert, 2003; Condie, 2003). It is believed that the Eastern Ghats Belt–Rayner Complex terrane was not separated during the breakup of Rodinia and remained an entity until the fragmentation of Gondwana during Neoproterozoic to Cambrian times (Fitzsimons, 2003).

Recent isotopic studies shed new light on the internal framework and evolution of the Eastern Ghats Belt, and allowed to scrutinize Rodinia–Gondwana correlations (Shaw et al., 1997; Kovach et al., 1998, 2001; Krause, 1998; Simmat and Raith, 1998; Mezger and Cosca, 1999; Rickers et al., 2001a; Simmat, 2003; Upadhyay et al., 2006a,b; Upadhyay and Raith, 2006a,b; Dobmeier et al., 2006). The updated synthesis by Dobmeier and Raith (2003) demonstrates that the Eastern Ghats Belt represents a composite orogenic belt comprising several high-grade crustal terranes that are characterised by distinct geological histories and separated from each other by tectonic boundaries. The regional disposition of these terranes gives clear evidence for an east-directed crustal growth of Proto-India during several major orogenic events, from late Archaean to Early Phanerozoic times.

As a step towards a better characterization of the polyphase metamorphic history of terranes in the Eastern Ghats Belt, we have undertaken a detailed geochronological study applying monazite electron microprobe geochronology to a large set of granulite samples from active quarries that offer representative exposures of the individual litho-tectonic units and cover the entire belt (Simmat, 2003). Since Suzuki and Adaki (1991) and Montel et al. (1996) developed the electron microprobe dating of monazite as a non-destructive in situ technique for high