Journal of Asian Earth Sciences 78 (2013) 39–53

Contents lists available at SciVerse ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Proterozoic orogens in southern Peninsular India: Contiguities and complexities

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ARTICLE INFO

Article history:
Available online 14 March 2013

Keywords:
Proterozoic orogens
Structure
Transpressional tectonics
Supercontinents
Southern Peninsular India

ABSTRACT

The Precambrian terranes of southern Peninsular India have been central to discussions on the history of formation and breakup of supercontinents. Of particular interest are the Proterozoic high grade metamorphic orogens at the southern and eastern margins of the Indian shield, skirting the 3.4 Ga Dharwar craton which not only preserve important records of lower crustal processes and lithospheric geodynamics, but also carry imprints of the tectonic framework related to the assembly of the major Neoproterozoic supercontinents – Rodinia and Gondwana. These Proterozoic orogens are described as Southern Granulite Terrane (SGT) in the southern tip and the Eastern Ghats Mobile Belt (EGMB) in the eastern domains of the peninsula. The contiguity of these orogens is broken for a distance of ~400 km and disappears in the Bay of Bengal. These orogens expose windows of middle to lower crust with well-preserved rock records displaying multiple tectonothermal events and multiphase exhumation paths.

Recent studies in these orogens have led to the recognition of discrete crustal blocks or terranes separated by major shear zone systems, some of which represent collisional sutures. The SGT and EGMB carry several important features such as fold-thrust tectonics, regional granulite facies metamorphism of up to ultrahigh-temperature conditions in some cases, multiple P–T paths, development of lithospheric shear zones, emplacement of ophiolites, presence of alkaline and anorthositic complexes, development of crustal-scale "flower structures", transpressional strains, and reactivation tectonics. A heterogeneous distribution of different metamorphic and magmatic assemblages with distinct spatial and temporal strain variations in shaping the fabric elements in different blocks is identified. Both EGMB and SGT share a common transpressional deformation history during the latest Neoproterozoic characterized by the steepening of the initial low angle crustal scale structures leading to a subvertical grain conducive to reactivation tectonics. Our synthesis of the spatial distribution, geometry, kinematics and the transpressional strain of the shear zone systems provides insights into the tectono-metamorphic history of the Proterozoic orogens of southern India and their contiguity and complexities. Recent understanding of subduction, accretion and collisional history along these zones together with a long lived transpressional tectonic regime imply that these orogens witnessed identical tectonic regimes at different times in Earth history, although the major and common structural architecture was built during the final assembly of the Gondwana supercontinent.

1. Introduction

Orogens in space and time provide critical information on plate tectonic cycles, continental growth and destruction, opening and closing of ocean basins and global material circulation on a whole mantle scale (e.g., Gerya, 2012; Sizova et al., 2013). The Proterozoic orogens of southern India (hereinafter abbreviated as POSI) such as the Eastern Ghats Mobile Belt (EGMB) in the east coast, and the Southern Granulite Terrane (SGT) in the south represent classic examples to address the evolution of Peninsular India, as well as its role in global supercontinental assemblies through Earth history. The Precambrian terranes of Peninsular India preserve important rock records and structural and tectonic history relating to the three major Proterozoic supercontinents – Columbia, Rodinia and Gondwana. The Proterozoic high grade terranes occurring at the eastern and southern margins, skirting the ~3.4 Ga old Dharwar craton (Fig. 1), are of paramount significance and are also relevant to the understanding of the exhumation of continental lower crust and lithospheric geodynamics. These terranes expose Precambrian deep continental crust consisting of complexly deformed Archean to Neoproterozoic high grade metamorphic and magmatic assemblages. Recent studies have led to the recognition of discrete crustal blocks or terranes separated by major shear zones often with

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http://dx.doi.org/10.1016/j.jseaes.2013.02.021

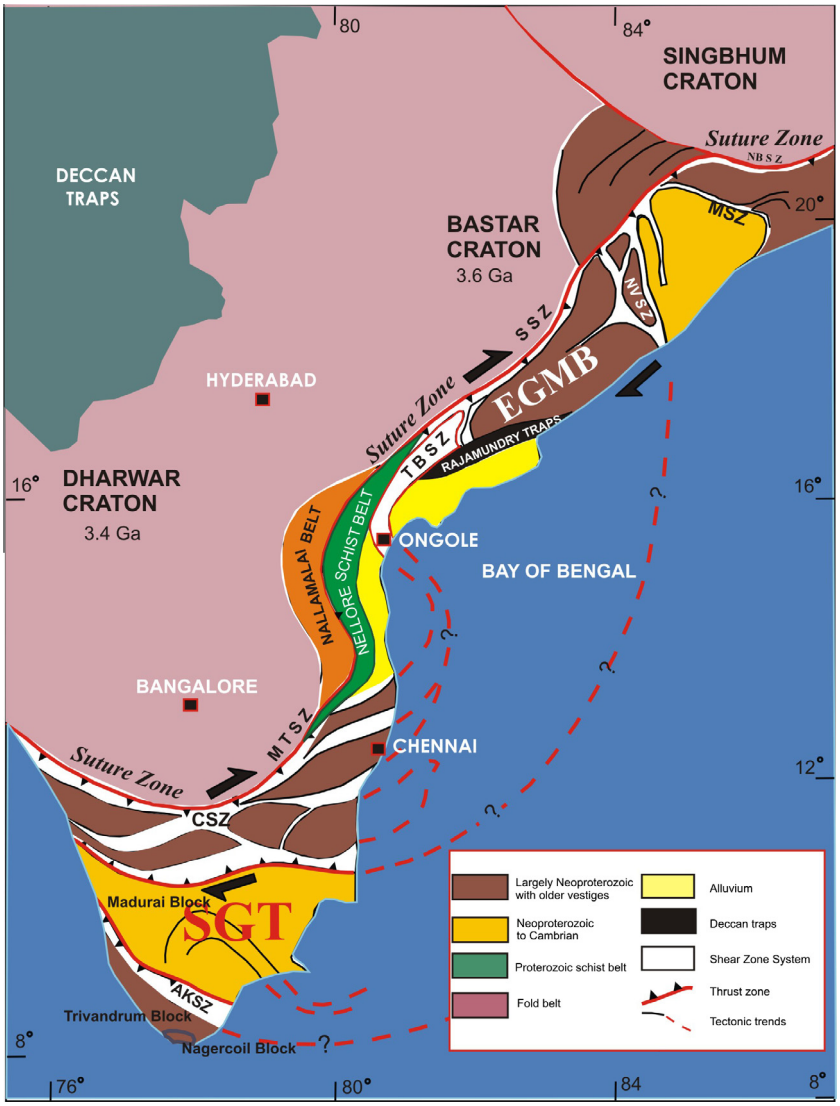

Fig. 1. Tectonic framework of the Proterozoic orogenic belts of southern India (POSI), showing major crustal blocks and tectonic trends like suture zone, thrust zones, shear zone system, major geological units and extended trend lines. EGMB – Eastern Ghats Mobile Belt; SGT – Southern Granulite Terrane; CSZ – Cauvery suture zone; AKSZ – Achankovil shear zone; TBSZ – Terrane Boundary shear zone; NVSZ – Nagavali–Vamsadhara shear zone; NBSZ – Northern Boundary shear zone; MTSZ – Mettur Shear Zone; SSZ – Sileru Shear Zone.

boundaries hitherto unsuspected both within and around the margins of these orogenic belts, with plate tectonic history analogous to that of modern orogenic belts (e.g. Chetty and Murthy, 1994; Drury and Holt, 1980; Chetty et al., 2003a, b; Santosh et al., 2009; Vijayakumar and Leelanandam, 2008; Chetty, 2010; Rajesh, 2012; Collins et al., 2013).

The lithological assemblages in both EGMB and SGT are high grade metamorphic rocks comprising charnockites, khondalites, leptynites and migmatites as the dominant units, invaded by a variety of younger intrusive rocks. However, the continuity of these two orogens on the continental surface is broken for a distance of ~400 km and disappears in the Bay of Bengal near Ongole at the east coast and reappears at Chennai (see Fig. 1). Therefore, some workers believe that these two orogens were not contiguous and that they belong to two independent orogenies (e.g. Naqvi and Rogers, 1987; Ramakrishnan, 2003). In this contribution, we show that the end Precambrian tectonothermal events shaped the present architecture of these orogens and that they share many similarities. In order to address the issue, we evaluate the geology and re-examine the spatial distribution, geometry and kinematics of the shear zones, crustal blocks, and transpressional strain and associated geophysical signatures. We also synthesize results from recent studies that report Precambrian ophiolite suites in both these orogens and evaluate their significance in relation to subduction–accretion–collision tectonics. Our study emphasizes the importance of identifying the continuation and correlation of these orogens and associated shear zone systems into the adjacent fragments in understanding the tectonic processes associated with the assembly of the Gondwana supercontinent.

2. Proterozoic orogenic belts in southern Peninsular India

Fig. 1 shows the broad tectonic trends and structural framework of POSI displaying major structural elements such as suture zones, shear zones, fold patterns, thrust zones and different crustal blocks and other major tectonic trends. Two distinct domains could be recognized from the map: the Achaean Dharwar Craton the center, and the Proterozoic high grade metamorphic belts skirting the three cratons of Dharwar, Bastar and Singhbhum. The interface between the cratons and the orogenic belts is a curvilinear high strain zone, which has been well established as a Precambrian suture