Precambrian Research 275 (2016) 406–428

Contents lists available at ScienceDirect

Precambrian Research

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

Archean tectonics and crustal evolution of the Biligiri Rangan Block, southern India

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ARTICLE INFO

Article history:
Received 5 January 2015
Received in revised form 1 January 2016
Accepted 14 January 2016
Available online 23 January 2016

Keywords:
Tectonics
Zircon geochronology
Subduction
Arc magmatism
Thermodynamic modeling
Crustal thickness

ABSTRACT

The Southern Granulite Terrain in India is a collage of crustal blocks ranging in age from Archean to Neoproterozoic. This study investigate the tectonic evolution of one of the northernmost block – the Biligiri Rangan Block (BRB) through a multidisciplinary approach involving field investigation, petrographic studies, LA-ICPMS zircon U–Pb geochronology, Hf isotopic analyses, metamorphic *P–T* phase diagram computations, and crustal thickness modeling. The garnet bearing quartzofeldspathic gneiss from the central BRB preserve Mesoarchean magmatic zircons with ages between 3207 and 2806 Ma and positive εHf value (+2.7) which possibly indicates vestiges of a Mesoarchean primitive continental crust. The occurrence of quartzite-iron formation intercalation as well as ultramafic lenses along the western boundary of the BRB is interpreted to indicate that the Kollegal structural lineament is a possible paleo-suture. Phase diagram computation of a metagabbro from the southwestern periphery of the Kollegal suture zone reveals high-pressure (~18.5 kbar) and medium-temperature (~840 °C) metamorphism, likely during eastward subduction of the Western Dharwar oceanic crust beneath the Mesoarchean BRB. In the model presented here, slab subduction, melting and underplating processes generated arc magmatism and subsequent charnockitization within the BRB between *ca.* 2650 Ma and *ca.* 2498 Ma. These results thus reveal Meso- to Neoarchean tectonic evolution of the BRB. The spatial variation of crustal thickness, derived from flexure inversion technique, provides additional constraints on the tectonic linkage of the BRB with its surrounding terrains. In conjunction with published data, the Moyar and the Kollegal suture zones are considered to mark the trace of ocean closure along which the Nilgiri and Biligiri Rangan Blocks accreted on to the Western Dharwar Craton.

1. Introduction

Continental growth in the early Earth is mostly dependant on variables including shallow or steep subduction, the contrast in composition of the mantle in Archean and Phanerozoic, the debate over thin or thick crust or plate, and the existence of microblocks and microcontinents (*e.g.*, Windley, 1984; Wilde et al., 2011; Kawai et al., 2009; Condie et al., 2009; Condie and Kröner, 2013; Hawkesworth et al., 2012; Korenaga, 2013; Nance et al., 2014; Polat, 2012; Santosh et al., 2015, 2016; Yang et al., 2015). Amalgamation of arcs through multiple parallel subduction and collision, and subsequent vertical growth and lateral accretion is considered as a major contributor to the growth of continents (*e.g.*, Windley, 1984; Windley and Garde, 2009; Xiao et al., 2013, 2010; Santosh, 2013; Xiao and Santosh, 2014). Investigations in Precambrian terrains have importance in gaining insights into the evolution of ancient microcontinents.

The Indian Shield has a complex tectonic framework with different tectonic provinces including cratons, orogens, volcanic provinces, mobile belts and shear/suture zones developed through a long history from Archean to Cenozoic (Ratheesh-Kumar et al., 2014). Earlier studies have identified several distinct tectonic blocks in southern India (Fig. 1), separated by transcrustal shear/suture zones (*e.g.*, Drury and Holt, 1980; Nutman et al., 1992; Peucat et al., 1993, 2013; Harris et al., 1994; Chetty et al., 2003; Bhaskar Rao et al., 2003, 2008; Ghosh et al., 2004; Tomson et al., 2006; Santosh et al., 1992, 2003, 2009, 2012, 2013, 2015; Clark et al., 2009; Ishwar-Kumar et al., 2013; Collins et al., 2014). The

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http://dx.doi.org/10.1016/j.precamres.2016.01.022
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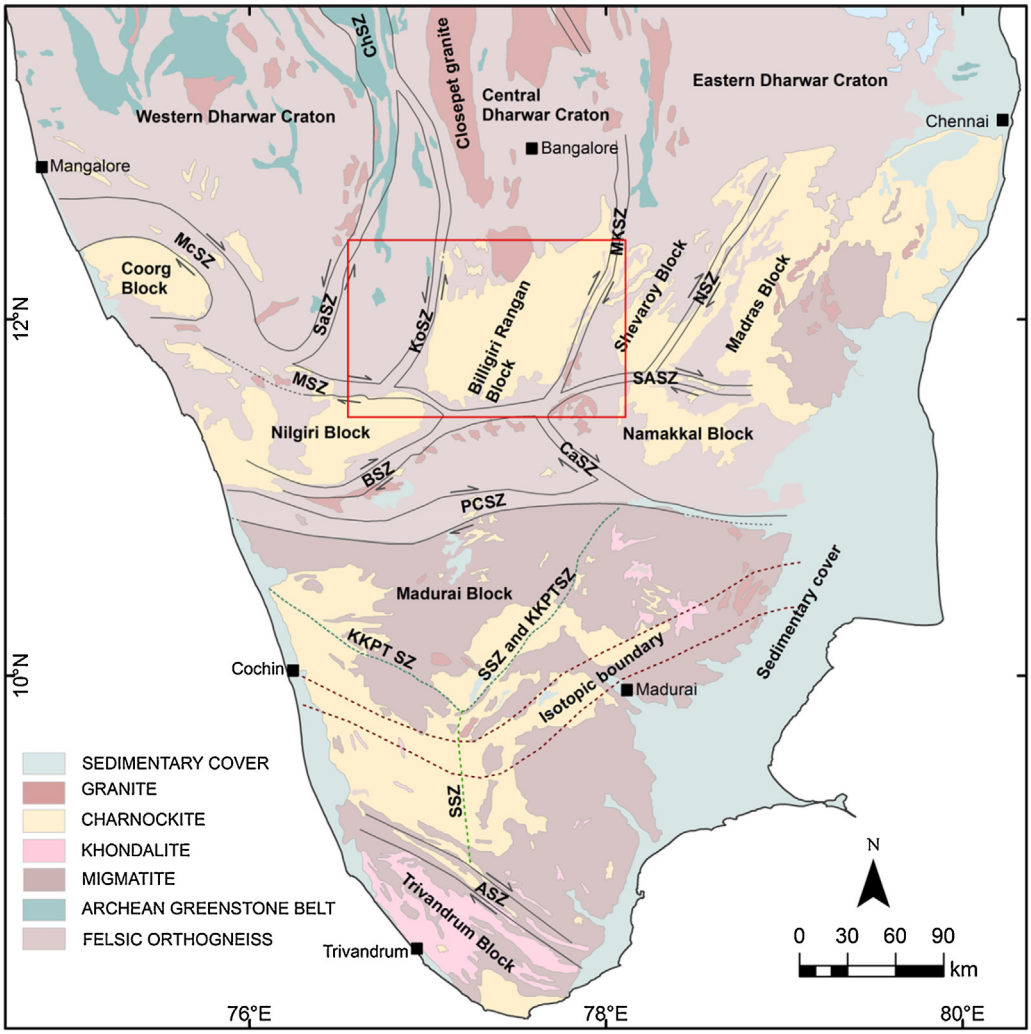

Fig. 1. Regional geology and tectonic framework map of southern India showing the major shear/suture zones and crustal blocks (after, Geological Survey of India, 1993; Ishwar-Kumar et al., 2013). The rectangular box depicts location of the Biligiri Rangan Block (BRB). *Acronyms*: ChSZ – Chitradurga Shear Zone, McSZ – Mercara Shear zone; SSZ – Sargur Shear Zone; KoSZ – Kollegal Shear Zone; MeSZ – Mettur Shear Zone, NSZ – Nallamalai Shear Zone, MSZ – Moyar Shear Zone, SASZ – Salem-Attur Shear Zone; BSZ – Bhavani Shear Zone, CaSZ – Cauvery Shear Zone, PCSZ – Palghat-Cauvery Shear Zone; KKPTSZ – Karur-Kambam-Painavu-Trichur Shear Zone, ASZ – Achankovil Shear Zone.

tectonic units have been redefined in recent studies based on their distinct protolith origin and tectonothermal histories. Thus, the Archean Dharwar Craton in southern India has been classified into older Western Dharwar (3300–2700 Ma) and younger Eastern Dharwar (3000–2500 Ma) segments, bound by the Chitradurga shear zone (SwamiNath and Ramakrishnan, 1981; Chardon et al., 2008; Peucat et al., 2013, and references therein). The southern part of the Dharwar Craton, south of the Fermor Line (Fig. 1), is characterized by the increase in metamorphic grade (Drury et al., 1984; Hansen and Harlov, 2007), exposing the lower crustal section which consists of orthogneisses, metasedimentary rocks, and charnockites that extend south as far as Palghat-Cauvery shear system (PCSS) which have been previously termed as the Salem Block. The Salem Block is made up of different tectonic provinces including the Biligiri Rangan (BR) Hill, Male Mahadeshwara (MM) Hill, Shevaroy Hill and Namakkal domains. The BR-Hill, MM-Hill and Shevroy Hill domains were collectively known as the Northern Block. Based on the older ages obtained from the BR Hill-MM Hill domain, Peucat et al. (2013) further classified the Eastern Dharwar Craton (EDC) into two sub-provinces such as the older Central Dharwar Province (>3000 Ma) and the younger Eastern Dharwar Province (2700–2600 Ma). However, only a very limited age, petrological and geochemical distinction is established so far for the BR Hill-MM Hill domain, and hence its crustal evolution and tectonic linkage to the surrounding crustal provinces remain ambiguous. The present study addresses the structure and evolution of the BR Hill-MM Hill crustal province (Fig. 2).

Recent studies demarcated new crustal blocks in and around the Western Dharwar Craton. The Nilgiri Block has now been clearly defined as a discrete tectonic block that evolved through Neoarchean arc magmatism in a convergent margin setting (Samuel et al., 2014). Similarly, Santosh et al. (2015) demarcated the Mesoarchean Coorg Block south of the Western Dharwar Craton through the Mercara Suture Zone, and defined it as an exotic micro continent. Ishwar-Kumar et al. (2013) defined the Karwar Block from the northwest of the Western Dharwar bounded together by the Mesoproterozoic Kumta Suture, later supported by the geophysical observations of Ratheesh-Kumar et al. (2015) through their paleo-fit configuration of India and Madagascar. These studies prompt further evaluation of the Archean-Paleoproterozoic granulite terranes in and around the Dharwar Craton.

In this contribution, we attempt a multidisciplinary approach that discuss field relations, petrography, mineral chemistry, thermodynamic modeling of metamorphic *P*–*T* evolution, and LA-ICPMS U–Pb and Lu-Hf analyses of zircons on representative rocks from the BR Hill-MM Hill domain together with crustal thickness