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Full length article

Petrological and geochemical evolution of the Central Gneissic Belt, Rengali Province, eastern India: Implications for the Neoarchean growth and orogenesis

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A B S T R A C T

This study focuses on the evolution of the Central Gneissic Belt of the Archean Rengali Province which evolved as a craton-margin orogenic belt. The Central Gneissic Belt is constituted of charnockite gneiss, migmatitic hornblende gneiss and granite gneiss often showing gradational contacts. While mafic granulite occurs as enclave within the charnockite gneiss, amphibolite and calc-silicate granofels enclaves are present within the granite gneiss. Mafic granulite shows peak metamorphic assemblage of garnet + clinopyroxene + plagioclase + quartz ± orthopyroxene which was stabilized at 10.6 ± 0.5 kbar and 860 ± 20 °C. Charnockite gneiss with the peak assemblage of orthopyroxene + quartz + plagioclase + K-feldspar was metamorphosed at 792 ± 48 °C and 7.6 ± 0.4 kbar. Amphibolite and migmatitic hornblende gneiss contain hornblende along with plagioclase and garnet and these rocks were metamorphosed at 800 ± 20 °C, 8.5 ± 0.2 kbar and 695 °C, 8 kbar respectively. Later meta-dolerite dikes exhibit relic igneous textures which are slightly modified by greenschist-facies metamorphism. Charnockite gneiss, migmatitic hornblende gneiss and granite gneiss show similar trace and REE characteristics (moderate fractionation in terms of La and Yb, LREE enrichment and flat HREE pattern) implying the same protolith composition for these rock groups. Based on the field, petrographic and geochemical data, we propose that the protoliths for the charnockite gneiss, the migmatitic hornblende gneiss and the granite gneiss crystallized as fractionated magma in within-plate syncollisional setting during the ca. 2860–2780 Ma orogeny at the Rengali Province.

1. Introduction

Craton-margin mobile belts evolve through orogenesis with several phases of deformation and metamorphism and record the complex growth history of continents (Ennih and Liégeois, 2008; St-Onge et al., 2009). Growth histories of many cratonic margins are obscured due to multiple episodes of reworking, fragmentation and amalgamation (Möller et al., 1995; Stern, 2005; Ghosh et al., 2016), but preserved craton-margin mobile belts provide the best evidence of continental growth (Karlstrom et al., 2001; Gray and Foster, 2004; Cawood, 2005; Condie, 2007; Kröner et al., 2008). Growth of continents in an orogenic belt involves several phases of metamorphism, deformation and magmatic intrusion. As a result, craton-margin mobile belts are characterized by structurally complex rock suite of widely variable magmatic and metamorphic characters. Quartzofeldspathic rocks of broadly granitoid composition constitute an important member associated with the granulite-amphibolite facies rocks in such rock suite (Bhattacharya et al., 2001; Li et al., 2016). Chemical characterization of these rocks provides important clues about the source lithology, thermal regime and tectonic setting during evolution of the orogenic system. The important members of such quartzofeldspathic rocks include charnockite, Na-rich tonalite-trondhjhemite-granodiorite (TTG), K-rich granitoids (granodiorite to monzogranite) among others. Charnockite-granite association in many Archean mobile belts provides important information regarding the orogenic cycle(s) responsible for crustal growth (Windley and Garde, 2009 and references cited therein).

The Central Gneissic Belt of the Rengali Province, eastern India is an example of craton-margin orogenic belt which evolved through complex processes of magmatism, metamorphism and deformation during the Neoarchean time due to southward growth of the Singhbhum Craton (Bose et al., 2016; Ghosh et al., 2016). Although some recent data on the metamorphic and deformation histories of this belt are

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Neoarchean tectonothermal imprints in the Rengali Province, eastern India and their implication on the growth of Singhbhum Craton: evidence from zircon U–Pb SHRIMP data

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ABSTRACT A detailed zircon U–Pb (SHRIMP) geochronological study of the amphibolite to granulite-grade rocks of the Rengali Province of eastern India records the growth history of the southern margin of the Singhbhum Craton. Pelitic and mafic granulites from the gneissic belt exhibit contrasting styles of metamorphism. Zircon of the pelitic granulites from the eastern segment yields *c*. 3528–3064 Ma detrital ages. Charnockitic gneiss from the eastern segment has protolith age of 3058 ± 15 Ma while that from the central segment has protolith age of 2861 ± 30 Ma. The latter rock records high-grade metamorphism at 2818 ± 15 Ma. Hornblende gneiss from the central sector has a protolith age of 2828 ± 9 Ma. Deformed leucogranite in the central and undeformed granitoid in the eastern segment were emplaced at 2807 ± 13 and 2809 ± 13 Ma respectively. The protolith of felsic gneiss from the central sector was emplaced at 2776 ± 24 Ma. Most of the zircon samples contain overgrowths of *c*. 2500 Ma, inferred to be the age of reworking of the gneissic belt. Our data suggest that the Rengali Province evolved as an orogenic belt in the Neoarchean time (*c*. 2800–2500 Ma) during southward growth of the Singhbhum Craton. These tectonothermal imprints at the margin of the Singhbhum Craton are possibly related to its inclusion within the supercontinent Ur.

Key words: continental growth; monazite; Rengali Province; SHRIMP; Singhbhum Craton; zircon.

INTRODUCTION

Cratons are the building blocks of continents that incrementally grew by repeated accretion-collision orogenic processes at least since the Neoarchean time (Condie, 2005; Cawood *et al*., 2009). The exact nature of the cratonization process and time frames are best studied in the bounding orogenic belts, albeit with geological complexities. High-grade gneissic rocks of the bounding orogenic belts provide direct insights to the responses of middle and lower crust undergoing the early Earth tectonic processes. They also provide important constraints on the nature of heat flow which ultimately help in evaluating whether Archean plate tectonics was viable. For example the Northern Marginal Zone of the Limpopo Belt preserves the growth history of the bordering Zimbabwe Craton (Blenkinshop, 2011). The geological histories of such orogenic belts additionally provide important clues about the configurations of widely dispersed supercontinents that formed during Precambrian time. The earliest supercontinent 'Ur' is postulated to be constituted of cratonic blocks of Australia (Pilbara Craton), Africa (Kaapvaal Craton) and India (Dharwar and Singhbhum Craton) that united at *c*. 3000 Ma (Santosh *et al*., 2009). As the reconstruction of Ur is speculative due to paucity of data, the addition of new geological data from its erstwhile components will testify the viability of its reconstruction.

Peninsular India contains a mosaic of cratons with surrounding cratonized orogenic belts. Eastern India's Singhbhum Craton (Fig. 1) is a granite-greenstone terrane that records a remarkable Archean growth history (Saha, 1994; Mukhopadhyay *et al*., 2012). The southern margin of the craton is composed of high-grade granulites along with medium-grade metasedimentary and metavolcanic rocks collectively termed as the Rengali Province (Mahalik, 1994; Crowe *et al*., 2003; Mahapatro *et al*., 2012; Bose *et al*., 2015). On its southern flank, the Rengali Province is bordered by the Eastern Ghats Belt with its characteristic Proterozoic-age high-grade metamorphism (Bose *et al*., 2011; Das *et al*., 2011; Korhonen *et al*., 2011, 2013; Gupta, 2012; Dasgupta *et al*., 2013 and references therein). Limited studies from the Rengali Province identify it as a major lineament-bound terrane having contrasting

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Transpression and juxtaposition of middle crust over upper crust forming a crustal scale flower structure: Insight from structural, fabric, and kinematic studies from the Rengali Province, eastern India

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Deformational, metamorphic, monazite age and fabric data from Rengali Province, eastern India converge towards a multi-scale transpressional deformational episode at ca. 498–521 Ma which is linked with the latest phase of tectonic processes operative at proto-India-Antarctica join. Detailed sector wise study on mutual overprinting relationships of macro-to microstructural elements suggest that deformation was regionally partitioned into fold-thrust dominated shortening zones alternating with zones of dominant transcurrent deformation bounded between the thrust sense Barkot Shear Zone in the north and the dextral Kerajang Fault Zone in the south. The strain partitioned zones are further restricted between two regional transverse shear zones, the sinistral Riamol Shear Zone in the west and the dextral Akul Fault Zone in the east which are interpreted as synthetic R and antithetic R' Riedel shear plane, respectively. The overall structural disposition has been interpreted as a positive flower structure bounded between the longitudinal and transverse faults with vertical extrusion and symmetric juxtaposition of mid-crustal amphibolite grade basement gneisses over low-grade upper crustal rocks emanating from the central axis of the transpressional belt.

1. Introduction

In orogenic belts involving oblique convergence (Dewey et al., 1998), the complexities of development of meso-scale geometric and kinematic characteristics and resultant strain partitioning have led to various numerical and analogue models of transpressional systems (Sanderson and Marchini, 1984; Fossen and Tikoff, 1993, 1997; Tikoff and Fossen, 1993; Lin et al., 1998, 1999; Jones et al., 2004; Sengupta and Ghosh, 2004) which help in understanding the natural processes in a comprehensive way. Critical comparisons of observations from natural settings with the existing kinematic models help to assess their validity. It not only refines these models to apply in more complex natural settings (Holdsworth et al., 1998, 2002; Lin et al., 1998, 1999; Tavernelli et al., 2004; Jiang, 2007; Sullivan and Law, 2007; Jiang and Bentley, 2012; Massey and Moecher, 2013; Jiang, 2014; Ellero et al., 2015), but also helps to test the strict boundary conditions of these models.

Transpressive deformation along exhumed and active orogens is characteristically heterogeneous with major displacements localized along interconnected fault or shear zones typically separating blocks of heterogeneously deformed crustal fragments (Dewey et al., 1998). Regional-scale studies of both ancient and modern single-scale transpressional systems suggest partitioning of the general noncoaxial strain into wrench and contraction influenced zones (Molnar, 1992; Tikoff and Teyssier, 1994; Jones and Tanner, 1995; Dewey et al., 1998; Lin et al., 1998, 1999; Jiang et al., 2001;

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