ABSTRACT

The Proterozoic Eastern Ghats Belt of eastern India is a key terrane to understand the evolution of the India-East Antarctica blocks of the supercontinent Rodinia. This belt is known for lower crustal rocks that experienced ultrahigh temperature (UHT) metamorphism. Because of its geological diversity, this belt has been subdivided into several crustal provinces and domains each having discrete tectonometamorphic characters. Most of the petrological history of this belt is reported from the domains located at the central (Visakhapatnam domain) and the southern (Ongole domain) parts and while the vast area covering the northern part of this high-grade terrane remains unexplored. The present work has been carried out on the Phulbani domain which occupies a major portion of the north-western part of the belt. Apart from some isolated geochronological data, no systematic petrological, geochronological, structural and fluid investigation has been carried out from this domain. This poses severe constraints on the overall metamorphic history of the northern part of the Eastern Ghats Belt (Eastern Ghats Province) and its connection with the supercontinent Rodinia. In the present study, an attempt has been made to overcome these issues by constraining the geological history of the Phulbani domain in a holistic manner.

Phulbani domain is composed of migmatitic felsic gneiss, felsic augen gneiss, fine-grained charnockite gneiss, aluminous granulite, calc-silicate granulite and mafic granulite which was metamorphosed at UHT condition and subsequently intruded by coarse-grained charnockite. The mineral assemblage formed at the peak-UHT metamorphic condition is best documented in the aluminous granulite as spinel+quartz-bearing mineral assemblage. Using textural, thermobarometric and phase equilibria data, it is inferred that the latter mineral assemblage stabilized at 950°C (at approximately 8 kbar) from a corundum-bearing mineral assemblage by

chemical reactions during prograde heating. Scapolite-clinopyroxene-wollastonite-plagioclase bearing mineral assemblage in the calc-silicate granulite also indicates temperature in excess of 800°C which is corroborated by high anorthite content of scapolite. After attainment of peak-UHT condition, all the rocks including coarse-grained charnockite experienced pronounced phase of near-isobaric cooling along an almost isobaric prograde and retrograde path and produced coronal garnet in aluminous granulite, calc-silicate granulite, fine-grained charnockite gneiss and coarse-grained charnockite. From the fluid inclusion analyses, it is inferred that the peak- to post-peak metamorphic evolution of the Phulbani domain dominantly occurred in a CO_2-dominated fluid regime as high-density (up to 1.03 gm/cm^3) CO_2-rich fluid inclusions are documented in aluminous granulite, coarse-grained charnockite and migmatitic felsic gneiss. Textures like K-feldspar micro-veins in migmatitic felsic gneiss, myrmekite-like intergrowth, Th-rich veins in monazite and the presence of pegmatoidal metasomatic rock at the contact of calc-silicate granulite and coarse-grained charnockite further point towards the presence of an additional fluid phase which was capable to transfer elements in micro- to mesoscopic-scale. In the present study such fluid phase is interpreted to be brine which escaped from the rock record perhaps due to its greater mobility.

Phulbani domain is characterized by five phases of deformations (D_1-D_5) and related fabric developments (S_1-S_{5S}). Of these, the S_1 fabric is found only as inclusion within porphyroblastic phases of aluminous granulite and migmatitic felsic gneiss and produced during D_1. Being common in the aluminous granulite, calc-silicate granulite, migmatitic felsic gneiss and fine-grained charnockite gneiss, the S_2/S_3 gneissic fabric is interpreted to be the earliest recognizable planar fabric of the study area and resulted by successive D_2-D_3 deformations during UHT metamorphism. The S_2/S_3 gneissic fabric was transposed during D_4 to form S_4 and

S_{4S} fabrics which dominantly occur parallel to the axial plane of the folded S_2/S_3 fabric. The S_4 fabric later on folded during D_5 to form mylonitic fabric (S_{5S}) of the Ranipathar shear zone. Pseudotachylite veins are always associated with this S_{5S} fabric and dominantly occur parallel to this fabric. Outcrop-scale sheath folds also developed during ductile shearing in the Ranipathar shear zone and played a critical role during exhumation of the high-grade rocks of the Phulbani domain. Microstructural investigation of quartz grains of the migmatitic felsic gneiss showing the S_{4S} fabric suggest dominant deformation by prism<a> and rhomb<a> slips. Quartz ribbons in the S_{5S} mylonitic foliation suggest deformation by prism<a> slip in the quartz grains. Microstructures in pseudotachylite veins of the Ranipathar shear zone indicate its origin by melt crystallization following development of mylonititic foliation. Deformed pseudotachylite matrix suggests at least one stage of deformation after pseudotachylite formation during reactivation of the RSZ.

Zircon U-Pb (SHRIMP) and monazite U-Th-total Pb (EPMA) analyses obtained in the present study additionally put precise time constraints on the tectonothermal evolution of the Phulbani domain. Zircon from the coarse-grained charnockite shows crystallization age of ca. 970 Ma. Aluminous granulite possibly suffered UHT metamorphism at ca. 987 Ma as revealed from monazite included in porphyroblastic garnet. Monazite in the aluminous granulite and the migmatitic felsic gneiss grew dominantly at 966 ± 4 Ma and 968 ± 4 Ma ages respectively, which are interpreted as the cooling ages subsequent to the peak metamorphism. Oscillatory-zoned zircon grains of the felsic augen gneiss yield ca. 1173 Ma age which is interpreted as the crystallization age of the granitic protolith. This ca. 1173 Ma age granite possibly composed a part of the Proterozoic basement of the Eastern Ghats Province. Monazite age of ca. 781 Ma from aluminous granulite exposed at the N-S trending ductile shear zone and dates within the range of ca. 558–535 Ma from felsic augen gneiss exposed at the RSZ indicate localized shear-induced thermal process in the Phulbani domain. The presently studied rock suite thus recorded four distinct events (ca. 1173 Ma, ca. 1000–900 Ma ca. 781 Ma and ca. 558–535 Ma) of magmatism, metamorphism and deformation of the Eastern Ghats Belt.

The tectonometamorphic and tectonothermal histories of the Phulbani domain during the time-frame of 1000–900 Ma appear to be similar if compared with the adjacent Visakhapatnam domain which argues against the domain-based classification of the Eastern Ghats Belt. Based on this, it is inferred that the shear zones marking the boundaries of the domains possibly formed during latter time and cannot be considered as domain boundaries. The metamorphic and the magmatic histories during the time-frame mentioned above additionally matches well with the Rayner complex of the East Antarctica indicating the contiguous nature of these terranes during the inferred ca. 950-900 Ma Rayner-Eastern Ghats orogeny.