LITHOLOGY AND METAMORPHIC EVOLUTION OF GRANULITE-FACIES SEGMENTS OF KERALA, SOUTHERN INDIA*

G. R. Ravindra Kumar
Centre for Earth Science Studies, Akkulam, Trivandrum – 695 031
Email: grrkumar@md4.vsnl.net.in

EXTENDED ABSTRACT

The Precambrian crust of southern India shows a transition from amphibolite to granulite-facies conditions. Earlier workers interpreted this classic feature as presenting variably uplifted crustal sections of a continuous progressively deeper mid to lower crust of Archaean age. The granulite-facies region, beginning from the southern part of the Moyar shear zone down south up to the tip of the Indian subcontinent, is designated as Southern Granulite Terrain (SGT). Understanding the geological history of SGT and building of chronology of tectono-metamorphic events is hindered by lack of clear primary field relations and evidence for earlier history due to deformation and high grade of Pan-African metamorphism. Recent geochemical and isotopic studies indicate complexities in composition, geochronology and architecture of the southern Indian granulite terrain, in variance to earlier opinion. We know now that most of the Peninsular India exposes Precambrian crust, which evolved, was reworked and consolidated over several major crust-building events, and SGT is an assembly of crustal blocks of contrasting composition and tectono-thermal evolution.

Geological Importance of Kerala Region

Kerala region constitutes a substantial part of the Southern Granulite Terrain. Several crustal scale shear zones with strong signatures in the Kerala region transect the SGT. Massifs of charnockite-enderbite in the north and central parts (Kodaikanal-Cardamom massif) to retrogressed belt made of gneiss - migmatites terrains (Palghat) to regions dominated by high-grade granulite grade supracrustal sequences (khondalites, calc granulites of Kerala khondalite belt) to the south are characteristic of Kerala. In the last two decades a large amount of field, petrological and geochronological data have become available from this region to address various facets in the evolution of the SGT. From these studies we know that the Kerala region preserves vestiges of two predominant strands of evolutionary history, with areas north of Palghat belonging to Archaean period and the regions to the south dominantly representing the Proterozoic crustal building event. Detailed geological studies in Kerala, therefore, provide important geological constraints in understanding the ancient crustal history and reconstruction of the East Gondwana supercontinent. Kerala region also provides some excellent examples of close spatial association of arrested charnockite and regional granulite (charnoenderbite) thereby providing an ideal situation to study the factors controlling the dehydration processes in the context of local arrested *versus* pervasive regional-charnockite development. I intend to discuss the knowledge we have gained from our studies in this region, especially with reference to the petrology and metamorphic development of charnockite and its variants.

Arrested Charnockite in Contrasting Geological Domains

One of the interesting aspects of Kerala region is the spectacular occurrence of arrested charnockite in contrasting geological domains (granulite-facies supracrustals of the Kerala khondalite belt, retrogressed gneiss domains of the Palghat and massif charnockites of Cardamom regions; Fig. 1). Arrested charnockite development represents the transition of hydrous amphibolite-facies assemblage of biotite (±amphibole/garnet) gneiss to an anhydrous granulite-facies assemblage of orthopyroxene (±garnet) along restricted zones (0.25 to 1 m and at times to few meters) of shears, fractures, foliation planes and boudin necks, subsequent to penetrative deformation (Fig.2). First few studies elsewhere (Kabbaldurga, Karnataka) documented them as initial stages in the pervasive granulite formation. Opinions were also expressed that the regional granulites developed at depth (~800°C, 7-9 Kbar; cf. Nilgiri charnockite) where as the arrested charnockites formed at relatively shallower levels (750°C, 5-7 Kbar; *cf.* Kabbaldurga, Ponmudi etc.), at a later stage, through prolonged dehydration of gneiss domains. Detailed studies and widespread occurrence of arrested charnockite in granulite terrains of different ages (1000 to 2600 My) were at variance to this simplified notion. Petrological results from Palghat region, one of the well-developed and ideal locations to study spatio-temporal relation between arrested charnockite and regional granulite, suggest that change in the metamorphic aspects of the rock, within the lower crustal conditions, was triggered by fluid channelled mineral-fluid reactions. Further, the study

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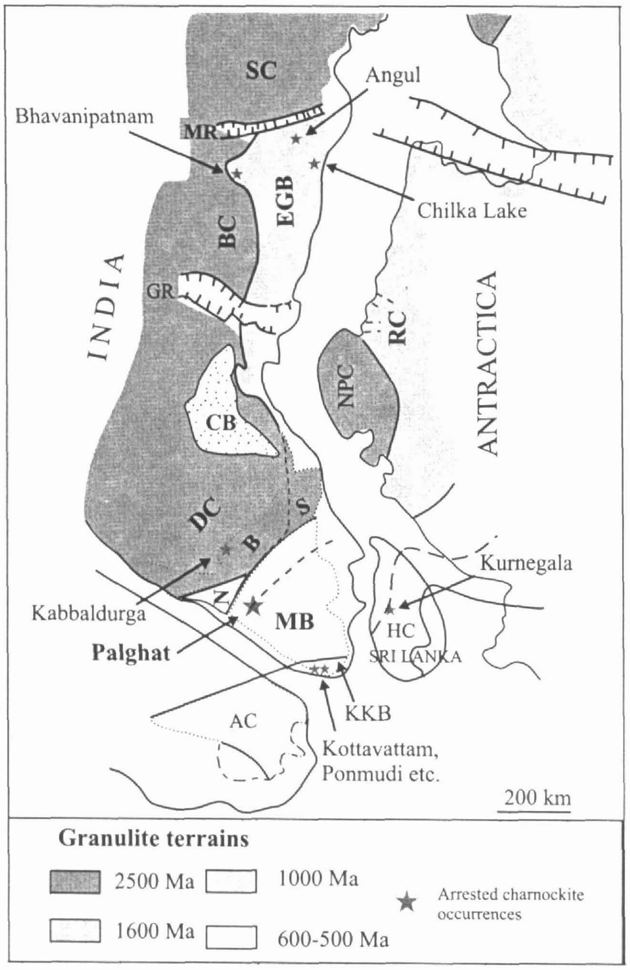

Fig.1. Occurrences of arrested charnockites in granulite terrains of different ages.

documented bi-directional element exchange, control of mineral/bulk composition of precursor rocks, significance of early structures, role played by fluids. These studies suggested that various types of gneiss-charnockite transitions in rocks of broadly similar bulk compositions and between different bulk compositions are due to varying development and action of fluids and varying aspect of fluid-rock interaction, respectively.

Origin of Cardamom Charnockite Massif

One of the problem being addressed in SGT concerns on the origin of the charnockite massif, whether or not it represents one single magmatic emplacement. Tectonic setting of formation, role in the metamorphic evolution etc are also not well understood. Our studies in Kodaikanal-Cardamom massif recognises that the charnockite-enderbite massifs, such as Cardamom types, presumably formed during an episode of Late Archaean to Early Proterozoic magmatism. Hornblende-biotite and biotite gneisses (*cf.* in Palghat zone) may represent retrogressed amphibolite-facies

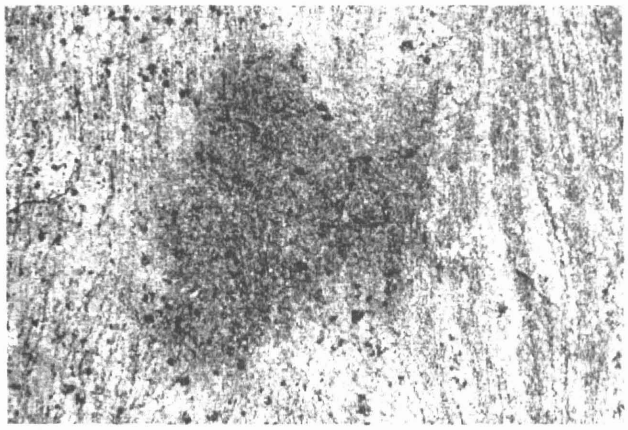

Fig.2. Arrested charnockite developing over garnet-biotite gneiss at Kottavattam, Kerala. Note absence of migmatitic fabric and coarse grained nature of charnockite.

equivalents of the highland granulites. They are magmatic in origin with a distinctive chemical composition (high K, Ba, Zr, P Ti, and LREE). Polyphase nature of the Cardamom massif and possibilities for at least two types of charnockite are apparent in the field and by petrographic studies. Our new chemical and isotopic data document a chemical division of the highland Cardamom charnockites into two major groups, well illustrated by Zr concentration and Epsilon Nd (T) data. U-Pb zircon and monazite geochronology and chemical dating of monazites are in agreement with the chemical classification, further supporting different times in their formation.

Conclusions

Field and petrological data suggest diversity in precursor composition, geological association and development in different P-T-t regime for the formation of arrested charnockites. Arrested charnockite are suggested to have formed as a result of varying, local, response of rock types to changing physico-chemical conditions (e.g., PT and fluid regime), with no spatio-temporal relations.

The petrological and geochemical data of regional granulites/charnockites from Palghat, Cardamom massif and Nagerkovil block suggest that they represent polyphase magmatic activities witnessed by SGT from Late Archaean to late Proterozoic periods (2900, 2115, 800 and 600 my) and Cardamom massif to be a home for at least two of these crust building events

The assembly of the Southern Granulite Terrain and its amalgamation with the Archaean blocks to the north may have taken place in Late Proterozoic time. More structural and isotopic data are required to help recognise distinct tectono-metamorphic evolution, if any, of regions to the north and south of the Achenkovil shear zone.