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P–T history and geochemical characteristics of mafic granulites and charnockites from west of Periya, North Kerala, southern India

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ABSTRACT

The study region forms the northern part of Kerala (south India) and constitutes part of granulite–facies rocks of the exhumed Proterozoic south Indian Granulite Terrain (SGT). The SGT consists of a large variety of rock types with a wide range of mineral parageneses and chemical compositions, namely charnockite, mafic granulite, gneiss, schist, anorthosite, granite and minor meta-sedimentary rocks. Garnet–bearing mafic granulites occur as small enclaves within charnockites. We report for the first time *P–T* constraints on the prograde path preceding peak metamorphism in the northernmost part of Kerala. An increase of the Mg, Fe and decrease of Ca and Mn contents from the core towards the rim of garnet in the mafic granulites suggest prograde garnet growth. The prograde path was followed by peak metamorphism at a temperature of c. 800 °C and a pressure of c. 7.5 kbar as computed by isopleths of X_{Mg} garnet, X_{Ca} garnet and X_{An} plagioclase. The resorption of garnet in various reaction textures and the development of spectacular orthopyroxene–plagioclase, biotite–quartz and hornblende–plagioclase symplectites characterize the subsequent stages of metamorphism. The PT path is characteristically T-convex suggesting an isothermal decompression path and reflects rapid uplift followed by cooling of a tectonically thickened crust. Diffusion modeling of Fe–Mg exchange between garnet and hornblende suggests a near-peak cooling rate of 10–70 °C/myr. Such cooling rates are too high to be accounted for by normal isostatic uplift and erosion and suggest that the terrain was tectonically exhumed. Charnockites are richer in SiO_2 and lower in MgO and CaO when compared to mafic granulites. Their REE patterns are relatively flat and show prominent negative europium anomalies. The mafic granulites are metamorphosed tholeiitic basalts as revealed by major- and trace-element geochemistry.

1. Introduction

Kerala is located on the southernmost tip of India and embraces the coast of the Arabian sea in the west and is bounded by the western Ghats in the east (Fig. 1a–c). Northern Kerala predominantly consists of charnockite, mafic granulite, schists, gneisses, anorthosite, granite and syenites (Ravindra kumar and Srikantappa, 1989; Nambiar et al., 1992; Radhakrishna et al., 2003; Rajesh, 2000, 2006; Fig. 1d). Mafic granulites of the study area that preserve their metamorphic histories in the form of reaction textures and symplectites have high potential to elucidate the conditions of metamorphism. Mafic granulites have been reported from several Precambrian regional terrains of the world, including the Eastern Ghats Belt (India), Rauer and Sostrene islands (Antarctica), Northern Labrador (Canada), Varpaisjarvi (Finland), Hoggar (Algeria) and Saxon (Germany) (Dasgupta et al., 1993; Holtta and Paavola, 2000; Zhao et al., 2000; Ouzegane et al., 2001; Rotzler and Romer, 2001; Bose et al., 2003; Prakash et al., 2007, 2010; Gross et al., 2009).

Northern Kerala can be divided into different lithological provinces (Nambiar et al., 1992): (1) Northern Schist–Gneiss province, (2) Northern Charnockites province, (3) Wynad Schist–Gneiss province and (4) southern Charnockites province (Fig. 1d). The present area of investigation covers parts of the Wynad Schist–Gneiss province. The area around Periya shows large exposure of massive retrogressed charnockite.

The northern Kerala is a key area in understanding the geochemistry and *P–T* conditions in the evolution of the granulites that have received less attention. The charnockites and mafic granulites were studied because garnet in these rocks is useful for thermodynamic modeling. In the present paper we present petrological, mineralogical and geochemical data on the charnockites and mafic granulites from northern Kerala in order to establish their petrogenesis and crustal evolution.

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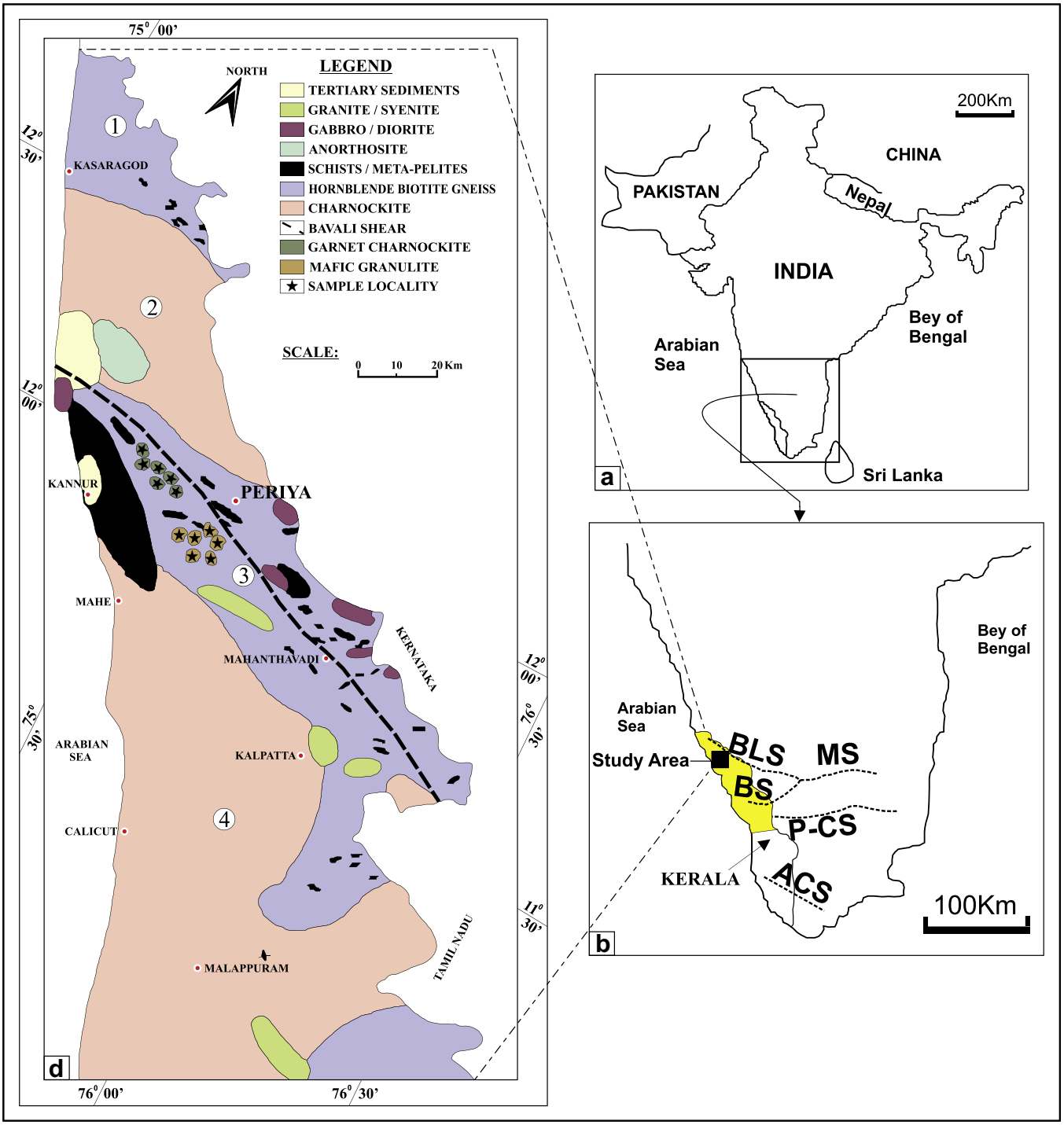

Fig. 1. (a) Inset shows the reference map of India. (b) Map of South India showing major shear zones (dashed lines). The abbreviations used are: BLS, Bavali Shear Zone; MS, Moyar Shear Zone; BS, Bhavani Shear Zone; P-CS, Palghat Cauvery Shear Zone; ACS, Achankovil Shear Zone. (c) Google satellite picture of the study area. (d) Geological map of northern Kerala showing the four petrologic provinces (1. Northern Schist–Gneiss province; 2. Northern Charnockites province; 3. Wynad Schist–Gneiss province; and 4. Southern Charnockites province) and major rock types (modified after Nambiar et al., 1992).

2. Geological setting

The Precambrian shield of southern India represents an example of Archaean continental crust, where differential uplift, erosion, and tectonic fragmentation made it possible to observe different crustal levels. The northern part of Kerala includes the south Indian high-grade terrain and the south-western portion of the Dharwar Craton and abodes the rare association of granite–greenstone and granulite terrains. The dominant rock type is charnockite and its retrogressed products and mafic granulites occur as enclaves within charnockites.

Charnockite is typically coarse-grained, gray in color and of felsic composition. It shows pervasive gneissic foliation (S_1). Mafic granulites occur as small lenticular patches (up to 40 cm long and 8 cm wide) along the gneissic foliation in the host charnockite, and, hence, could be syngenetic (Fig. 2). The rock is medium- to