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Nature of fluids and timing of metamorphism of the regional high-grade granulite terrain of Biligirirangan hill, Dharwar craton, Southern India

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The Biligirirangan (BR) hill charnockite massif in the southern part of the Dharwar craton consists of massive to banded/foliated charnockite with enclaves of basic granulites and metasediments (banded magnetite quartzite, quartzite and pelites). The BR hill granulite indicates a protolith age of about 3.4 Ga with regional high grade metamorphism around 2.5 Ga. The lithologies of the Biligirirangana hill terrane show a prominent N-S trend, which is a major trend prevalent during the Archean period. Field and petrographic studies have revealed evidence of strong deformation and high-grade metamorphic events. The banded/foliated charnockites are medium- to coarse-grained consisting of potash feldspars, quartz, plagioclase, orthopyroxene, clinopyroxene, hornblende, biotite and accessories of zircon and rutile. Plagioclase is generally antiperthitic with bent twin lamellae indicating progressive deformation. The development of symplectites of clinopyroxene–plagioclase on early-formed hornblende and hornblende–plagioclase on orthopyroxene, and the formation of boudin structures characterize the subsequent stages of metamorphism.

The geochemical signatures of BR hill charnockite indicate trondhjemitic composition and are of low Mg number. Rb and Sr data reveals that their magmatic protoliths originated from mantle to lower crust. The P–T conditions of BR hill charnockite were estimated using Fe-Mg exchange thermometry for equilibrium between mineral pairs of garnet–clinopyroxene, garnet–orthopyroxene and orthopyroxene–clinopyroxene, and garnet–orthopyroxene–plagioclase–quartz barometry. It reveals temperature of 723ºC to 785ºC and pressures of 7.3 to 8.2 kbar. EPMA studies of seven monazite grains yielded concentrations of UO_2 (0.03 to 0.12 wt%), ThO_2 (3.3 to 4.56 wt%) and PbO (0.33 to 1.11 wt%). The mean chime age recorded for the monazite grains is 2513 ± 25 Ma, which is akin to the ages reported by different systematics, assigning the time of regional high-grade metamorphism which lead to the genesis of massive charnockites at regional scale. This event is widespread in Dharwar and Southern granulite terrain.

Primary fluid inclusions in quartz and plagioclase comprise two distinct type of inclusions, mainly carbonic (CO_2) inclusions and aqueous carbonic ($H_2O + NaCl + CO_2(L) + CO_2(V) \pm CH_4$) inclusions. All the carbonic inclusions show melting temperature in the range -59.2 to -56.6°C, suggesting a dominantly pure CO_2 with minor traces of CH_4 and other gases. These inclusions show high density (1.162 to 1.021 g/cm^3; Th_{CO2} = -51.9 to -17.8°C), which is also confirmed by the shift in the CO_2 peak (1281 cm^{-1}) by Raman spectroscopy studies. The aqueous carbonic inclusions indicate salinity of 1.15 to 3.2 wt.% NaCl equivalent. The estimated CO_2 isochore for primary inclusions in quartz and plagioclase minerals intersects with the peak P–T conditions of the granulites derived form mineral phase equilibria.

The field, petrographic, geochemical and fluid inclusion studies indicate that the timing of high-grade metamorphism is around 2.5 Ga and the high density CO_2 fluids imply synmetamorphic origin of mantle-derived fluids pervasively influxing from the lower continental crust and were present during the peak metamorphism. So these fluids were the dominant fluid species for granulite facies transformation on a regional scale and might be responsible for the formation of regional charnockites. These carbonic fluids are probably derived either from internal sources or during dehydration-melting processes.