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Phase equilibrium modeling of Pan-African incipient charnockite from southern Madagascar

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Dark brownish patches and/or veins of coarse-grained orthopyroxene-bearing felsic granulite (charnockite) within foliated amphibolite-facies gneiss/migmatite, are considered as examples of 'metamorphic' charnockite, and represent the transformation of amphibolite-facies rocks to dry granulites on a local scale. Such 'incipient' charnockites have been reported so far from many localities in southern India and Sri Lanka which corresponds to the central part of the East African – Antarctic Orogenic Belt related to the assembly of the Gondwana Supercontinent. Detailed petrological investigations of incipient charnockites therefore provide important insights into granulite-forming processes in the lower crust during Neoproterozoic to Cambrian. Here, we report the first occurrence of incipient charnockite from Ihosy area in southern Madagascar, and discuss the petrogenesis of granulite formation in an arrested stage on the basis of petrography, geothermobarometry, fluid inclusion study, and mineral equilibrium modeling.

In the study area, patches of brownish charnockite (Pl+ Qtz + Kfs + Bt + Grt + Opx + Ilm + Mag) of about 20 to 50 cm in length occur within host orthopyroxene-free garnet-biotite gneiss (Pl + Qtz + Kfs + Bt + Grt + Ilm + Mag). The application of mineral equilibrium modeling on charnockite assemblage in NCKFMASHTO system to constrain the conditions of charnockitization defines a $P - T$ range of 8-10.5 kbar and 820-880˚C, which is broadly consistent with the results from the conventional geothermobarometry (820-880˚C at 9 kbar) on Grt-Bt gneiss. The result of T versus mole H_2O (M(H_2O)) modeling demonstrated that orthopyroxene-free assemblage in Grt-Bt gneiss is stable only at M(H_2O) $>$0.1 mol.%, while orthopyroxene in charnockite occurs as a stable mineral at very low M(H_2O) condition of $<$0.1 mol.%, which is consistent with the petrogenetic model of incipient charnockite related to the lowering of water activity and stabilization of orthopyroxene through dehydration reaction/melting of biotite. The dominant occurrences of CO_2-rich fluid inclusions in charnockite compared to host Grt-Bt gneiss indicate that the dehydration could have been caused by infiltration of CO_2-rich fluid possibly from external sources.