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Metamorphic reaction to describe local-scale difference in mineral assemblage stable under different conditions

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Mineral assemblage of metamorphic rocks varies according to temperature, pressure and fluid composition. In regional metamorphic belts, we have a common understanding that the difference of mineral assemblage stems from the difference of temperature and pressure. In contrast, it is not so uncommon that the mineral assemblage varies in local scale (several decimeters). It is unlikely that temperature and pressure differ in these scales. Fluid composition, instead, could vary in local scale. Local variation of fluid composition could explain the change of the mineral assemblages that are mutually described by any dehydration reactions. Few researches have estimated the relevant reaction based on the difference of mineral composition and occurrence between the adjacent rocks. This study clarified the reactions to produce orthopyroxene in arrested charnockites from central Sri Lanka based on compositional difference of hornblende and biotite between charnockites and surrounding gneisses.

Biotite in charnokites is enriched in Fe+Mg and depleted in Ti as compared with that in the host gneisses. This compositional difference is expressed as the following substitution with a site vacancy, [ ],

$[\,]\mathrm{Ti} = (\mathrm{Fe+Mg})_2$

The charnockites contain hornblende that is rich in K, Fe+Mg and Si, and poor in Na, Ti and Al relative to those in the surrounding gneisses, which is described by the substitution,

$[\,]_{0.5}\mathrm{Na}^{M4}\mathrm{Ti}^{M1-3}\mathrm{Al}_{0.5} = \mathrm{K}_{0.5}(\mathrm{Fe+Mg})^{M4}(\mathrm{Fe+Mg})^{M1-3}\mathrm{Si}_{0.5}$

Using these substitutions, the reactions responsible for the formation of orthopyroxene can be estimated as,

Ti-rich biotite + quartz = Ti-poor biotite + orthopyroxene + ilmenite + alkali feldspar + H_2O (1)

Ti-rich holnblende + quartz = Ti-poor hornblende + orthopyroxene + ilmenite + anorthite + albite + alkali feldspar + H_2O (2)

Each reaction contains either biotite or hornblende. Changes of the modal abundance of biotite and hornblende reflect the amount of orthopyroxene produced by reaction (1) and (2), respectively. The amounts of orthopyroxene in the estimated reactions well agree with the modal abundance of orthopyroxene in charnockites. These reactions are dehydration reactions, indicating that the mineral assemblage observed in the charnockites is stable under conditions of CO_2-rich fluid. We conclude that the difference of mineral assemblage between charnockites and gneisses can be ascribed to the difference of fluid composition.

Keywords: charnockite, hornblende-biotite gneiss, Sri Lanka, metamorphic reaction