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Origin of peak and retrograde assemblages during Grenvillian orogeny from garnet-staurolite bearing mica schist of Bhilwara Supergroup, NW India: constraints from pseudosection modelling

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Fractionation of components due to formation of garnet porphyroblasts during prograde metamorphism, have been constrained from pseudosection analyses. Such fractionation process leads to changes in the effective bulk composition within the rock, which can be modelled with well-preserved growth zonation patterns in garnet porphyroblasts. On the contrary, textures and mineralogy in metamorphic rocks can be far more complex with different textural domains within a single rock preserving assemblages formed along different segments of the P-T paths or during different metamorphic events. Examples of such textures include pseudomorphs, reaction rims or coronae, symplectites formed by breakdown of both cores and rims of porphyroblasts. Apart from pressure and temperature, availability of fluids during metamorphic reactions plays important roles in defining mineral assemblages and textures.

In this study we have constrained formation of garnet porphyroblasts and paragonite-albite-sillimanite-quartz-staurolite bearing domains within the mica schist from the Rajpura-Dariba sequence of the Bhilwara Supergroup in NW India. The mica schist is inter-layered with calc-silicates and quartzite and together the units form a NE-SW trending Grenvillian orogenic belt in southern part of Bhilwara Supergroup sequence.

Within the mica schist, three distinct textural domains have been observed: (i) muscovite-biotite-quartz-feldspar bearing matrix foliation, (ii) garnet porphyroblasts within the matrix foliation, (iii) staurolite-paragonite-albite-staurolite-sillimanite-quartz bearing domains. Paragonite, albite and sillimanite occur exclusively in the pseudomorph domains. Garnet porphyroblasts show variation in compositions from cores (Spessartine0.14 Grossular0.10 Pyrope0.12 Almandine0.72) to rims (Spessartine0.09Grossular0.15Pyrope0.12Almandine0.75). The average XMg contents of staurolite and matrix biotite are 0.21 and 0.57 respectively.

Pseudosections have been constructed from the bulk compositions of the three different textural domains with distinct mineral assemblages. In each case, effective bulk compositions have been determined from the volume proportions of different mineral phases and their chemical compositions. P-T pseudosection (NCKFMASH) constructed from the bulk composition of the muscovite-biotite-quartz bearing domainin matrix helps to constrain the garnet-in and staurolite-in isograds. Intersections of compositional isopleths of garnet cores and rims with that of prograde biotite grains in textural equilibrium constrains the peak P-T condition (9kbar and 600°C) and the prograde P-T path. In order to constrain chemical fractionation during prograde metamorphism, T-X pseudosections (NCKFMASH) at reference pressures varying from 4 kbar to 8 kbar have been constructed with bulk compositions varying from that of the matrix and garnet core compositions. The pseudosections help to determine fractionation of elements into the garnet porphyroblasts along the prograde P-T path constrained earlier. P-T pseudosection constructed from the bulk composition of the pesudomorph domains indicate stability of staurolite-sillimanite-quartz-albite-paragonite bearing assemblage (P-T ranges of 4-6 kbar, 550-575°C), formed by breakdown of garnet, biotite and muscovite along a near-isothermal decompression path, post to peak metamorphism. Thus a clockwise P-T path indicative of collisional tectonics can be constrained for the Grenvillian orogeny in the study area.

The study hence indicates that in order to constrain stability of mineral assemblages from distinct textural domains in complex metamorphic rocks pseudosection analyses with microdomain bulk compositions are most apposite.