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Channelized fluid controlled metamorphism–metasomatism: A study from calc silicates of the Mahakoshal Group of rocks in Central India

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The Palaeoproterozoic Mahakoshal Group of rocks occurs in the northern part of the Central Indian Tectonic Zone. The portion of Mahakoshal Group exposed near the city of Jabalpur is chiefly composed of dolomitic marble, calc-silicate, metapelite, psammopelite, minor quartzite, BIF and deformed granite. Calc-silicates exposed in this area can broadly be categorized as: [1] foliation parallel calc silicate veins within dolomitic marble and [2] a narrow thinly banded calc silicate unit with alternate calcite -rich and calc-silicate rich layers.

Based on field studies, we identify three sets of folds (F_{1-3}) that are correlated with three deformational phases (D_{1-3}) with extensive shearing during D_1 and foliation development in both D_1 and D_2. Based on development of calc-silicate veins along both S_1 and S_2 foliation planes, the dolomitic marble can broadly be divided from north to south into talc-calcite zone, tremolite zone and diopside-dolomite-tremolite-calcite zone. The tremolite zone can further be subdivided into a northern talc-tremolite subzone and southern tremolite-dolomite-calcite subzone.

Textural interpretations followed by deduction of reaction relations in the different mineralogical zones suggest both S_1 and S_2 parallel aqueous fluid flux in large quantities resulting in temperature dependent syn- to post-deformational development of both hydrous and anhydrous calc silicate phases. Geothermometric considerations suggest temperature of ≤ 370°C for talc-calcite zone, 370-530°C for tremolite zone and ~ 530-580°C for diopside-dolomite-tremolite-calcite zone. Pressure deduced from adjoining metapelites is around 3 kbars. Isobaric T-X_{CO2} diagram construed in CMSV system fixes fluid composition below $X_{CO2} \leq 0.4$. Modal studies indicate low silica content in major part of dolomitic marble. Large scale foliation controlled calc silicate formation therefore requires fluid controlled silica flux for silica-metasomatism of carbonates. Also preservation of thick calcite-absent talc-rich bands within talc-tremolite subzone of tremolite zone is possible through Ca^{+2} removal in solution and resultant extreme Mg-enrichment of the rocks. Isobaric T-X_{MgO} diagrams demonstrate the effect of bulk magnesium on talc stability. Calculation of time integrated fluid flux following the methods of Ferry (1993) suggest fluid-rock ratio of 1.78-3.18 for talc-zone, 0.57-0.67 for talc- tremolite subzone, 1.2-1.99 for tremolite-dolomite-calcite subzone and 0.63-0.71 for diopside-dolomite-tremolite-calcite zone during metamorphism.

The adjoining thinly banded calc-silicate unit is constituted of alternate calcite-rich and silicate-rich layers with porphyroblasts of garnet and muscovite. It is evident from the textural considerations that quartz + calcite + muscovite$_1$ + magnetite stabilized early. Biotite and epidote joined the assemblage afterwards and were followed by the growth of muscovite$_2$ + garnet. Thermobarometry suggests P-T range of 480 ± 20ºC at ~ 3 ± 0.5 kbar. Mineralogical evolution, studied in isobaric T-X_{CO2} diagram in the system KFCASV, suggest large infiltration of aqueous fluid as causative factor for evolution of successive phase assemblages.

Our studies thus provide evidences on large scale fluid controlled metamorphism and metasomatism in calc silicates.

References:

[1] Ferry, J. M. (1994) American Mineralogist 79: 719-736