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Reaction textures in a suite of clinohumite - forsterite bearing marbles from parts of the Grenvillian South Delhi Fold Belt, India: Evidence of Ti mobility during regional metamorphism

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The South Delhi Fold Belt (SDFB) of western India exposes an interlayered supracrustal rock sequence consisting of metapelites, marble, calc-silicate rocks and minor amphibolite. This rock ensemble underwent at least three distinct sets of folding events (D1 – D3) and developed a pervasive schistosity synchronous to the D1 folding. In many places, numerous ramifying veins of pegmatite cut across this pervasive schistosity. Metamorphism of this belt culminated at staurolite-sillimanite (fibrolite) grade during the transcontinental Grenvillian orogenesis (c.1.0 Ma; U-Pb zircon date). In the studied area (26o16.4´E, 74o33.8´N) which is situated at the central part of the SDFB, off-white color marble essentially contains sub equal proportion of dolomite and calcite. In places, the rock develops 2-5 cm thick compositional layers showing the following mineralogy:

Forsterite (XMg (Mg / Mg + Fe) = 0.94-0.95, 20-30vol%) - spinel (XMg= 0.86 – 0.89, 5̃ vol%, TiO20̃ – 0.04)-calcite (30-35vol%)-dolomite (XMg= 0.97-0.98, 20-30 vol %) -chlorite (XMg= 0.97-0.98, Al2O3=0.58 - 0.64; 5-10 vol%)

The forsterite-rich bands are parallel to the regional schistosity. Many of these forsterite-rich veins show brick red color clinohumite (up to 20 vol%). Textural features and the compositions of the minerals demonstrate that clinohumite (XMg = 0.94-0.95, TiO2= 3.04 $\pm$ 0.3, F =1.2 $\pm$ 0.09, MTi= 9.3-9.5, MTi/Si =2.2-2.3) grew under static condition and preferentially replaced the deformed grains of olivine. Chlorite too developed under static condition and replaced dolomite, forsterite and clinohumite (where present). Clinohumite is the sole phase in the forsterite-rich layers that can accommodate significant amounts of Ti and F. Interpreting the observed textural features in combination with matrix operation on the representative phase compositions, following chemical reactions have been construed to explain the growth of clinohumite and chlorite:

a. 800 Fo + 443 Dol + 134 H2O + 64.4 Ti + 113 F + 212.5 SiO2(aq) + 189.5 Mg = 243.2 Chu + 886.4 CO2 + 1 Mn + 450.7 Ca

b. 811 Fo + 25.2 Cal + 435.2 Dol + 135.8 H2O + 65.2 Ti + 114.5 F + 214.2 SiO2 (aq) + 201.6 Mg = 246.2 Chu + 895.5 CO2 + 1 Mn + 466.2 Ca

c. 17.2 Chu + 2034.4 Cal + 56 Spl + 185.8 H2O + 1 Mn + 70.4 SiO2 (aq) + 886.3 Mg = 24.4 Chl + 1017.2 Dol + 4.3 Ti + 8 F + 871.2 Ca

d. 75.3 Fo + 2045.2 Cal + 14.8 Spl + 105.4 CO2 + 51.5H2O + 1Mn + 819.5 Mg = 6.4Chl + 1075.3 Dol + 37.4 SiO2 (aq) + 822.6 Ca

From the thermodynamic analyses of the mineral assemblages of the marble and its silicate bands, it is inferred that the clinohumite-bearing assemblage was formed within a P-T range of 5 $\pm$ 1 Kbar and 550o $\pm$ 50o C and in presence of a hydrous fluid (XCO2<0.1).

Integrating all the petrological features it is demonstrated that
a. clinohumite was formed due to infiltration driven metamorphism of the forsterite-rich layers
b. the Ti and F that were necessary for the growth of clinohumite were supplied to the forsterite-rich bands by the permeating aqueous fluids
c. fluid flow was highly channelized and was restricted within the 2-5 cm silicate-rich bands

The post-tectonic pegmatite veins appear to be the source of the aqueous fluids that metasomatized the marble and augmented the growth of clinohumite and chlorite.