P-T evolution of the Mahneshan Metamorphic Complex, Zanjan, NW Iran; Study of metapelitic rocks

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Petrography and geothermobarometry

The Precambrian Metamorphic Complex of the Mahneshan in northwestern Iran underwent the two metamorphism phase's (M_1 and M_2) and at least two phases of deformation (D_1 and D_2). Dominant peak metamorphic amphibolite facies assemblage (M_1) of metapelitic rocks is muscovite, biotite (I), garnet (I), staurolite, andalusite (I) and sillimanite. The decrease of temperature and pressure during exhumation produced post-peak metamorphic assemblages (M2).

Peak metamorphism took place at 600-620°C and ~7 kbar, corresponding to a depth of ca. 21 km. This was followed by decompression during exhumation of the crustal rocks up to the surface. Secondary phases such as garnet (II) biotite (II), andalusite (II) constrain the temperature and pressure of post-peak metamorphism (M_2) as 520-560°C and 2.5-3.5 kbar respectively. The geothermal gradient obtained for the peak of regional metamorphic phase (M_1) is 33°C km^{-1}, which show that peak metamorphism has occurred under medium pressure condition (Barrovian-type metamorphism).

Dicussion of Results

The clockwise P-T path for the Mahneshan Metamorphism Complex is characteristic of the metamorphic evolution from most orogenic belts. The bulk chemistry of the metapelites indicates that their protoliths were deposited at an active continental margin. All these features and the presence of paleo-suture zones and ophiolitic rocks around the high grade metamorphic rocks of the Mahneshan Complex show that an island-arc type cratonization formed the Iranian Precambrian basement.

Magnesite growth rates as function of temperature and saturation state: An HAFM study

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Magnesite growth rates and step velocities have been measured systematically as a function of temperature (from 80 to 105°C) and saturation state in 0.1 M NaCl solutions using hydrothermal atomic force microscopy (HAFM). The observations indicate that at these conditions magnesite precipitation is dominated by the coupling of step generation via spiral growth at screw dislocations and step propagation away from these dislocations. As these two processes occur in series the slowest of these dominates precipitation rates. At 100°C magnesite growth rates (***r***) determined by HAFM are consistent with $\boldsymbol{r} = \boldsymbol{k}(\Omega\text{-}1)^2$, where ***k*** is a constant equal to 6.5×10^{-16} mol/cm^2/s and Ω is the saturation index with respect to magnesite. Thus indicating step generation by spiral growth to be rate controlling. Corresponding magnesite precipitation rates measured using mixed-flow reactors are shown to be consistent with both the rates measured by HAFM and the spiral growth theory, confirming the rate limiting mechanism. Step propagation, however, is observed to decrease by far faster than step generation with decreasing temperature; the activation energy for step advance is 159 kJ/mol whereas step generation rates have an estimated activation energy of ~60 kJ/mol. Extrapolation of step advancement rates to lower temperature suggests that this process becomes so slow at ambient temperature that it inhibits step generation via spiral growth, effectively stopping magnesite precipitation.