Hydration and retrograde metamorphism during exhumation of the Kokchetav massif, Kazakhstan

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Discoveries of the ultrahigh-pressure metamorphic (UHPM) rocks from many orogenic belts of the world during the last decade have provided new insights about preservation of the peak metamorphic conditions and the effect of retrograde metamorphism, which is one the most fundamental issues of the metamorphic petrology. In many cases, UHPM index minerals (i.e. coesite and diamond) were found as inclusions of zircon, garnet or other rigid minerals from the gneiss of quite low-pressure (i.e. amphibolite to granulite facies) mineral assemblages (e.g. [1]). This implies that hydration during exhumation of the metamorphic belt is more intensive than expected, which causes an almost complete retrograde recrystallisation. On the other hand, some rocks which avoid retrograde hydration preserve coesite in their matrix (e.g. [2]). This infers that aqueous fluid also has a role as a catalyst in retrograde recrystallisation.

For the reasons mentioned above, it has become a new theme in the tectonometamorphic studies to evaluate the role of the aqueous fluid on retrograde metamorphism more properly. We have estimated the amount of the infiltrated water during exhumation stage for the Kokchetav UHPM rocks. The mode and extent of the retrograde hydration are highly variable by lithology. Mafic rocks such as eclogite show limited and localised hydration features along their margins of the body and fractures. On the contrary, ortho- and paragneisses and schists show more pervasive retrograde recrystallisation. The volume of the infiltrated water during the retrograde hydration was calculated by comparison of the peak and the present mineralogy. Intact eclogite are characterised by typical bimineralic assemblage and is completely dry. On the other hand, amphibolite taken from the margin of the same body (i.e. amphibolitised eclogite) has mineral assemblage of Hbl (40%) + Grt (30%) + Pl (20%) + Qtz (10%). Hence 0.1wt% of water infiltration was calculated associated with this mineralogical change. In case of metapelite, peak mineral assemblage and the modal abundance were thermodynamically estimated from the present composition using a computer program UniEQ [3] with internally consistent thermodynamic datasets [4], as its peak mineralogy has completely been lost. The present mineral assemblage is Qtz (27%) + Bt (32%) + Sil (17%) + Pl (14%) + Grt (9%) + Ms (1%). The thermodynamic estimation has yielded the peak mineralogy of Coe (23%) + Grt (37%) + Phn (34%) + Jd (6%) + Ky (1%) and 0.4wt% of extra water which was added at the retrograde stage. Other major constituent of the massif, such as orthogneiss, leptite (felsic gneiss) and quartzite yielded no change in water content associated with retrograde recrystallisation.

Based on the change in water content and areal coverage of each lithology, the volume of the infiltrated retrograde water to the HP-UHPM unit was calculated as about 0.5% of the total volume of the massif. This result has a good concordance with the amount of released water from the underlying Daulet Suite [5], suggesting a major source of the retrograde fluid infiltrated to the Kokchetav HP-UHPM unit. We suppose such extent of water infiltration may occur commonly in HP-UHPM terranes, which is enough to cause a complete retrograde recrystallisation. Hence the effect of retrograde metamorphism may have been underestimated in traditional metamorphic petrology.

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