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Role of partial melting in formative process of UHT metamorphic rocks: Melting experiments of anhydrous garnet felsic gneisses

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Mineral assemblage of sapphirine + quartz [e.g. 1] is known as the most important indicator of ultrahigh-temperature (UHT) metamorphism, which is an evolutional process in the lower part of continental crust. Primary experimental studies of Hensen and Green [2, 3 and 4] suggested that this mineral assemblage is found from only specific UHT metamorphic regions that have undergone very high-grade UHT metamorphism exceeding 1030 degree-C. In general, UHT metamorphism is regarded as almost anhydrous crustal evolutional process. If small amount of H2O corresponding to 1.0 wt % is even contained in the chemical system, K-feldspar should be molten at lower temperature. However, even if the system is situated under anhydrous condition, dry melt can be generated spending the feldspathic components at high temperature corresponding to 1100-1150 degree-C [e.g. 5, 6, 7 and 8]. We noted that this melting temperature is very close to the former temperature that can stabilize the sapphirine + quartz. On the basis of new experimental data, here we mention that the essential factor for formation of the sapphirine + quartz is partial melting under UHT metamorphic condition.

In this study, melting experiments were performed at P = 12 kbar and T = 1100-1325 degree-C at 25 degree-C intervals using two natural rocks of sapphirine-free garnet felsic gneiss and sapphirine-bearing garnet felsic gneiss, which were collected from very high-grade UHT region within Napier Complex, East Antarctica [9]. Bulk Mg# [= Mg/(Fe+Mg)] values of these gneisses are not high as 0.45 and 0.50, respectively. The former does not contain any orthopyroxene, spinel, cordierite and hydrous minerals. The latter does not have these minerals, but it has very rare amount of phlogopite. Boyd-England type piston-cylinder apparatus housed at Tokyo Institute of Technology was used in the experiments. Each pulverized specimen was put into a double capsule of inner rhenium foil and outer platinum tube. Edges of the outer tube were welded by carbon arc after dry up at 110 degree-C. In the case of this double capsule, internal oxygen fugacity condition can be nearly regarded as the Fayalite-Magnetite-Quartz (FMQ) buffer [e.g. 10].

As experimental results, stability of phases in run products with increasing temperature was characterized as follows: (1) K-feldspar melts at over 1150 degree-C, (2) Chemical composition of the melt is changed depending on the experimental temperature, (3) Garnet decreases with the increase of temperature and it disappears at over 1275 degree-C, and: (4) Crystallization of sapphirine at 1225 degree-C to 1275 degree-C is caused spending garnet and other phases (i.e. melt etc.). In the cases of majority of natural occurrences, the sapphirine + quartz is found from UHT metamorphic rocks of quartzo-feldspathic bulk composition [e.g. 11]. Therefore, we believe that the present experimental data obtained from UHT felsic gneisses is available for discussion on stability field of the sapphirine + quartz.

References: [1] Dallwitz (1968) Nature, 219, 476-477. [2] Hensen and Green (1971) Contrib. Mineral. Petrol., 33, 309-330. [3] Hensen and Green (1972) Contrib. Mineral. Petrol., 35, 331-354. [4] Hensen and Green (1973) Contrib. Mineral. Petrol., 38, 151-166. [5] Whitney (1975) Jour. Geol., 83, 1-31. [6] Presnall (1995) in: Mineral Physics and Crystallography. A Handbook of Physical Constants. American Geophysical Union Reference Shelf 2, 248-268. [7] Hokada and Arima (2001) Polar Geosci., 14, 39-52. [8] Sato, Miyamoto and Kawasaki (2004) Jour. Mineral. Petrol. Sci., 99, 191-201. [9] Yoshimura, Motoyoshi, Grew, Miyamoto, Carson and Dunkley (2000) Polar Geosci., 13, 60-85. [10] Matsukage and Kubo (2003) Am. Mineral., 88, 1271-1278. [11] Osanai, Toyoshima, Owada, Tsunogae, Hokada, Crowe and Kusachi (2001) Polar Geosci., 14, 1-24.