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Experimental Investigation on the Exsolution of Pyroxene from Majoritic Garnet at High Pressure and Temperature

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Garnet containing exsolved pyroxene is generally recognized as the breakdown product of former majoritic garnet formed in the deep upper mantle. Majoritic garnet has been recognized in various natural ultrahigh-pressure metamorphic rocks representing the exhumed remnants of past subduction zones or mantle from depths greater than 200-300 km. The most convincing evidence for former majoritic garnet is the strong crystallographic topotaxy between oriented pyroxene rods and garnet host. However, such a crystallographic topotaxy is not clear for interstitial pyroxene, which is more important for the determination of depth origin of former majortic garnet due to its relatively large volume comparing to intracrystalline pyroxene. To characterize quantitatively the decompression process of majortic garnet, we have conducted systematic annealing experiments using a 1000T uniaxial hydraulic multianvil at China University of Geosciences (Wuhan). The starting material is a mixture of reagent-grade powders that are equivalent to 20 vol.% Opx + 80 vol.% Grt. The starting material was heated at 1450 ºC for 2 hours at 1 atm pressure with a fixed oxygen fugacity (fO_2=10^{-11}MPa) before synthesis at 15 GPa and 1400 °C. The synthesized polycrystalline majoritic garnet (Si=3.21, grain size = 20-30 μm) was used for subsequent decompression experiments. The decompression experiments were conducted at 5, 7, 10 GPa and 1300-1400 °C for ~40 hours. The experimental results show that the interstitial pyroxene precipitation is an earlier stage exsolution from majoritic garnet at higher pressures comparing to the intracrystalline precipitation. Temperatures higher than 1200 ºC are needed for exsolution during our decompressing experiments. EBSD analyses show a characteristic topotaxial relationship of $(100)_{px}$ // $(112)_{grt}$, $(001)_{px}$ // $(111)_{grt}$ and $(010)_{px}$ // $(110)_{grt}$ for the majority of interstitial and intracrystalline pyroxene precipitations. Furthermore, many intracrystalline pyroxene precipitations have the same crystallographic orientation as interstitial pyroxene precipitations, indicating a possible exsolution origin. The same orientation of intracrystalline and interstitial pyroxenes can be additional evidence demonstrating their exsolution origin when the characteristic topotaxial relationship is obscured or destroyed by garnet recrystallization.

Key words: majoritic garnet, pyroxene exsolution, crystallographic topotaxy, EBSD

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