Sound velocities in $MgSiO_3$ garnet up to 13 GPa

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Seismological studies recognize much steeper velocity-depth profiles in the transition zone of the Earth's mantle. Majorite rich garnet is one of the important mineral phases in the transition zone, and it may have a responsibility of the steeper phenomena proposed by Gwanmesia et al. (1998). Thus it is very important to know the elastic properties of majorite garnet under high pressure and high temperature conditions.

We tried to fabricate the dense isotropic polycrystalline specimens of $MgSiO_3$ garnets, which is a end member of majorite grnet, at pressure of 18-19.5 GPa, and at temperature of 2073-2193 K by MA8-type (Kawai-type) high pressure apparatus (Orange 3000). Some experimental parameters such as starting material, heating rate, temperature holding time, cooling rate and the cell assembly focused on the hydrostatic condition were changed to test the quality of the polycrystalline specimen. The recovered samples were examined by micro-Raman spectroscopy and EPMA for mineral identification, and by BEI (back-scattered electron image) for grain size and textural observation. The ideal densities were calculated using the lattice parameters obtained by micro-focused X-ray diffraction measurement, and the bulk densities were measured by Archimedes method.

As the results, we clarified that it is better to use glass material for starting material, and high heating rate may be better to achieve rapid nucleation in the stability region of $MgSiO_3$ garnet. Temperature holding time is important to control the grain size and to achieve the textural equilibrium. Cooling rate is not so important for preventing the specimen from the crack, but the important factor may be hydrostatic condition of cell assembly.

Using a good quality specimen, which porosity is less than 1 %, we measured the elastic wave velocity of $MgSiO_3$ garnet by phase comparison ultrasonic interferometry under high pressure up to ~13.0 GPa by MA8 type high pressure apparatus (Orange 2000). The obtained bulk (K) and the shear (G) moduli, and their pressure derivatives ($K'=dK/dP$, $G'=dG/dP$) are as follows: K=162.4 (GPa), G=88.5 (GPa), K'=4.7, G'=1.3.

The bulk and shear moduli are quite consistent with the previous values proposed by some authors (e.g. Yagi et al., 1992; Sinogeikin et al., 1997; Pacalo and Weidner, 1997; Gwanmesia et al., 1998, 2000), but the pressure derivatives are quite different from Gwanmesia et al. (1998). This result strongly shows that the steeper velocity-depth profiles in the transition zone cannot be explained by the majorite contribution with uniform composition. Thus successive smeared-out transitions of pyroxene-garnet, wadsleyite-ringwoodite, garnet-$CaSiO_3$-rich and $MgSiO_3$-rich perovskites should be responsible for the steeper velocity-depth profiles. Some compositional variation in the mantle transition zone may also contribute to the observed steep velocity gradients in the mantle transition region.