Phase relations in harzburgite under lower part of the mantle transition zone and the uppermost lower mantle

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We studied phase relations in harzburgite at pressures of 20.5 - 24 GPa and at a temperature of 1873 K, corresponding to the lower part of the mantle transition zone and the uppermost lower mantle. Experiments were carried out by traditional quench method using a Kawai-type press, Orange-2000, installed in Geodynamics Research Center, Ehime University. A starting material with harzburgite composition was prepared by initially mixing oxides and carbonates compounds, forming a pellet, and firing for 24 hours at 1273 K in a controlled atmosphere where fayalite is stably formed. In high PT experiments, we used semi-sintered (Mg,Co)O as pressure medium, a cylindrical LaCrO3 as a furnace, and gold tube and disk as sample capsule. The recovered samples were examined by micro-focus X-ray diffractometer to identify the phases present in the run charge. Back-scattered electron imaging and chemical composition analyses of each phase were performed using a SEM with an EDS detector. At 20.5 GPa, we observed presence of ringwoodite (Rw) with 82 vol%, stishovite (St) with 14 vol%, and garnet (Gt) with 4 vol%. At 21 GPa, presence of Rw with 70 vol% and Gt with 30 vol% was observed with minor akimotoite. These observations indicate that transformation from Rw+St to Gt occurs at a pressure between 20.5 and 21 GPa. This interpretation is supported by chemical compositions of garnet phases. Al content of Gt at 21 GPa is less than that at 20.5 GPa. At 21.5 GPa, presence of Rw with 72 vol%, MgSiO3-rich perovskite (MgPv) with 27 vol%, and CaSiO3-rich perovskite (CaPv) with 1 vol% was observed, indicating that transformation of Gt to MgPv+CaPv (post-garnet transition) occurs at this pressure within a narrow pressure range (less than 0.5 GPa). We observed that this mineral assemblage (Rw+MgPv+CaPv) is stable at pressures between 21.5 and 23 GPa. At 23 GPa, dissociation transition of Rw to MgPv+ferropericlase (Fp) (post-spinel transition) occurs, resulting in formation of an mineral assemblage of MgPv+Fp+CaPv, which is the typical lower mantle mineral assemblage in peridotite compositions, above this pressure. In harzbugite, the pressure of post-garnet transition is lower than that of post-spinel transition by about 1.5 GPa, and the pressure interval where the post-garnet transition occurs is narrower than 0.5 GPa. Whereas, in pyrolite, the onset pressure of post-garnet transition is higher than that of post-spinel transition (Nishiyama et al., 2004) and the post-garnet transition occurs in a wide pressure range between 24 and 27 GPa (Irifune et al., 1994). Presence of harzburgite in the lower part of the mantle transition zone as stagnant slabs can explain a complicated structure of 660-km seismic discontinuity (single and double reflections, Deuss et al., 2006) and discrepancy between 1-D seismological models (i.e., PREM, ak135) and an experimentally determined seismic velocity model in pyrolite (Irifune et al., 2007).