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Phase relation in harzburgite: an interpretation of splitting of 520 km seismic discontinuity

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We studied phase relation in harzburgite at pressures between 15 and 24 GPa at a temperature of 1673 K. The starting material was a synthetic harzburgite that was made by firing a mixture of oxides and carbonates at 1273 K. Experiments were carried out using a Kawai-type apparatus installed in Geodynamics Research Center, Ehime University. Generated pressures were estimated using a load vs. pressure curve obtained at room temperature with high temperature correction using high-P cpx to wadsleyite + sthishovite transition in MgSiO3 (P ~ 16 GPa at 1673 K). At 15.5 GPa, we observed a mineral assemblage of wadsleyite (Wd) + clinopyroxene (CPx) + garnet (Gt). At 16.5 GPa, we observed Wd + stishovite (St) + garnet (Gt) indicating that pyroxene compoment (CPx and a part of Gt) transformed to Wd and St. As a result of this transition, Gt enriches in Ca, Al, and Cr. At 17.5 GPa, we observed transition from Wd to ringwoodite (Rw) resulting in a mineral assemblage of Rw + St + Gt. These results indicate that, in harzburgite, the transition in pyroxene component is followed by that in olivine component, Wd to Rw. The pressure interval between these two transitions is 1-2 GPa. We measured chemical compositions of the constituent minerals and determined their volume fractions using mass balance calculation. Mineral proportions at 16.5 GPa are 87.5 vol% for Wd, 7 vol% for St, and 5.5 vol% for Gt. We calculated sound velocities of harzburgite between 15 and 20 GPa at a temperature of 1673 K using the present data and mineral physics parameters determined in previous studies. The increase of P-wave velocity accompanied with the transition of pyroxene component producing Wd + St is 3.8% whereas that with Wd-Rw transition is 1.4%. The large velocity increase in transition of pyroxene component is attributed to high velocity of stishovite. The successive transitions in harzburgite within 2 GPa at the middle of mantle transition zone can explain the seismically observed splitting of 520-km discontinuity.

Keywords: harzburgite, phase relation, mantle transition zone, high pressure and temperature, sound velocities