Accurate determination of the akimotoite-bridgmanite transition and dissociation of ringwoodite to bridgmanite plus periclase and a new interpretation for the depression of the 660-km discontinuity under cold subduction zones

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The 660-km seismic discontinuity is the boundary between the Earth's lower mantle and transition zone and is commonly interpreted as the dissociation of ringwoodite to bridgmanite plus ferropericlase. A distinct feature of the 660-km discontinuity is its depression to 750 km, corresponding to 27 GPa, beneath cold subduction zones. Nevertheless, *in situ* X-ray diffraction studies using large-volume high-pressure-temperature presses (LVP) have demonstrated negative but gentle Clapeyron slopes of the ringwoodite dissociation that do not allow a significant depression. Since the akimotoite-bridgmanite transition produces a substantial jump in seismic wave velocities and previous studies proposed steeper Clapeyrons slopes, this phase transition might be responsible for the depressed 660-km discontinuity. Since conventional high-pressure experiments face difficulties in accurate phase identification due to inevitable pressure changes during heating and the persistent presence of metastable phases, the boundaries of phase transitions essential for mantle dynamics must be reinvestigated.

For these reasons, we determined the phase boundaries of the ringwoodite dissociation and akimotoite-ringwoodite transition by our advanced *in situ* X-ray diffraction technique using LVP's strictly based on the definition of phase equilibrium. The results show that the ringwoodite-dissociation boundary is slightly curved upward but has almost no temperature dependence. On the other hand, the akimotoite–bridgmanite transition boundary is strongly curved downwards. The Clapeyron slope is as steep as -8 MPa/K at temperatures to 1200 K but gradually becomes less steep to -3 MPa/K above 2000 K. The ringwoodite dissociation and akimotoite-bridgmanite transition boundaries intersect at a temperature of 1260 K and a pressure of 23.8 GPa. Hence, the akimotoite-bridgmanite transition causes the 660-km discontinuity below this temperature instead of the ringwoodite dissociation. An extrapolation of the phase boundary suggests that the transition pressure should be 27 GPa at a temperature of 900 K. The akimotoite–bridgmanite transition thus interprets the large depressions of the 660-km discontinuity in cold subduction zones. The steep negative boundary of the akimotoite-bridgmanite transition should cause slab stagnation due to significant upward buoyancy.