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Olivine-wadsleyite transition and the 410-km discontinuity

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We have precisely determined phase relations of the olivine-wadsleyite transition in the system (Mg,Fe)2SiO4 have been determined at 1600 and 1900 K using the quench method in a Kawai-type high pressure apparatus, where pressure was determined at a precision of better than 0.2 GPa using in situ X-ray diffraction with MgO as a pressure standard. Using these experimental results, we discuss the nature of the 410-km seismic discontinuity (D410). By comparing the depth of the discontinuity with the transition pressure, the temperature at 410-km depth is estimated to be 1760+-45 K for a pyrolitic upper mantle. Mantle potential temperature is estimated to be in the range of 1550 to 1650 K. The temperature at the bottom of the upper mantle is estimated to be 1800~1900 K. It is suggested that the depth of D410 should be varied by temperature with a rate of 0.1 km/K. However, the topography of D410 is not correlated with the anomalies of the seismic wave velocities, which is also believed to be caused by the temperature variation. Therefore, the topography and velocity anomalies are not consistently explained in a simple pyrolitic mantle model. The thickness of the olivine-wadsleyite transition in a pyrolitic mantle is determined to be between 7 and 13 km for a pyrolitic mantle, depending on the efficiency of latent heat removal. Regions of rapid vertical flow (e.g. convection limbs) in which thermal diffusion is negligible should have a larger transition interval than in stagnant regions where thermal diffusion is effective. This is in apparent contradiction to short-period seismic wave observations that indicate a maximum thickness of smaller than 5 km regardless of mantle setting. An upper mantle in the region of the 410 km discontinuity with about 40% olivine and an Mg# of at least 89 can possibly explain both the transition thickness and velocity perturbation at the 410 km discontinuity.