Phase relations and density changes for pyrolite and MORB by in-situ X-ray diffraction measurements at depths of 600-1200 km.

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Pyrolite is widely accepted as a representative mantle composition. MORB constitutes oceanic lithosphere and descends into the mantle. Phase relationships and density changes for these rocks have been reported elsewhere (e.g., Irifune, 1993; Ono et al., 2001; Hirose, 2002). Density changes for pyrolite as a function of depth can explain that for the 410 km and 660 km discontinuity (e.g., Irifune, 1993). However, some recent seismological studies show seismic discontinuities are observed around 900-1080 km (Kawakatsu and Niu, 1994; Niu and Kawakatsu, 1997). Thus, we have investigated the density changes for pyrolite at depths of 600-1200 km and for MORB around 660 km seismic discontinuity and some implications for these discontinuities were discussed.

In-situ X-ray diffraction measurements were conducted at SPring-8, BL04B1 (Utsumi et al., 1998). Cell assemblies are basically same as those reported in Nishiyama et al. (2004) and Irifune et al. (2002). Sintered diamond anvils were used as second stage-anvils for the experiments in pyrolite at pressures of more than 30 GPa. Starting materials for pyrolite and MORB were same as those used in Irifune (1994) and Irifune and Ringwood (1987). Pressure marker was a mixture of MgO, Au and NaCl (with a 50:1:50 volume ratio). Generated pressure was calculated using the equations of state for gold (Anderson et al., 1989; Jamieson et al., 1982; Shim et al., 2002; Tsuchiya, 2003). Temperature was estimated from W25%Re-W3%Re thermocouple and no pressure effect on the e.m.f. was made. Experimental temperatures were 1873 and 2073 K and run durations at constant temperature were 2-5 hours.

Recovered samples were mounted on an epoxy resin and polished. Chemical composition analyses were conducted using SEM-EDS, WDS and FE-SEM-EDS. In some recovered samples, focused ion milling apparatus was used to prepare a thin foil. Chemical composition analyses for grains with the sizes of a few hundred nanometers were conducted by ATEM. Procedures for chemical composition analyses using ATEM were basically same as those for Fujino et al. (1998).

Almost all obtained X-ray diffraction patterns at high P, T and ambient conditions were fitted using the Le Bail method (e.g., Le Bail, 1992) to calculate lattice parameters for each phase. Using obtained lattice parameters and chemical compositions data, these densities at high P, T and ambient conditions were calculated on the basis of the definition for X-ray density.

Except for a pressure scale uncertainty, phase relationships for pyrolite and MORB were consistent with those for previous studies (e.g., Irifune, 1994; Ono et al., 2001). Density changes for pyrolite were comparable to those for PREM and density jump at post-spinel transformation was about 9%, which was also comparable that in PREM model. Density difference between pyrolite and MORB was harmonized with that for Irifune (1993).

We observed MgPv, CaPv and Mw in pyrolite under lower mantle conditions up to 1200 km. Thus no significant density jumps were observed in our in-situ X-ray diffraction measurement in pyrolite. Recent seismological studies indicate the presence of seismic discontinuities at depths of 900-1080 km beneath subduction zones (Kawakatsu and Niu, 1994; Niu and Kawakatsu, 1997), which may be due to the local compositional differences between MORB and pyrolite under lower mantle conditions, as discussed in Ono et al. (2001).

We were also successful to constrain the density changes for pyrolite and MORB around 660 km seismic discontinuity and lower mantle conditions up to 1200 km in pyrolite mantle. In the present study, there are no uncertainties on thermoelastic parameters in the present calculation, since no density calculation at high P, T conditions using equations of state was made. Present study will contribute to constrain the mantle composition and dynamics between basaltic rock and surrounding mantle around 660 km.