Density changes of Pyrolite and MORB around the 660 km seismic discontinuity by in-situ X-ray experiments.

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Pyrolite is widely accepted as a representative mantle composition. MORB constitutes oceanic lithosphere and subducts into the mantle. Density changes of these rocks should give us important information about the mantle compositions and the dynamics of subducted slabs. In previous studies, density changes such representative bulk rocks were determined on the basis of quench experiments and density calculations using equations of state of each mineral at high P, T conditions.

However, the mineral physics parameters should change dependent on pressures, temperatures and chemical compositions, the previous calculations of densities of minerals with complex chemical compositions in this manner have significant uncertainty because chemical composition dependences of mineral physics parameters have not been well reported.

In this study, we have developed technique to simultaneously observe phase transitions and density changes in two different samples with multi-component systems by in situ X-ray diffraction measurements, and have studied the phase and density changes in pyrolite and MORB.

The cell assemblies with truncated edge length of 3 and 2.5 mm were used in high pressure experiment with a combination of synchrotron radiation source and SPEED-1500 at SPring-8. Pressure medium was composed of (Mg, Co)O, ZrO2, and LaCrO3 was used as heater. The sample chamber and window were made of graphite to minimize X-ray absorption. Pyrolite, glass with MORB composition and pressure marker, which is a mixture of MgO, Au and NaCl (in a 50 : 1 : 50 volume ratio), were enclosed in the sample chambers. The press load was increased first to the target value and then temperature was increased to 1873 K. Heating duration was 5 hours, which is sufficient for the attainment of chemical equilibrium. X-ray diffraction data were acquired, keeping at constant temperature. We applied Le Bail whole-powder pattern fitting (Le Bail 1992) for analyses of the X-ray diffraction patterns from pyrolite and MORB.

The quenched samples were polished and the chemical compositions of coexisting phases were determined by SEM-EDS and WDS. Some samples were prepared as thin sections with a thickness of ~ 100 nm by a focused ion beam system (FIB) for ATEM.

All observed phases in pyrolite and MORB were consistent with the results in previous studies (e.g. Irifune, 1993; 1994, Irifune and Ringwood, 1993) based on quench experiments. For pyrolite sample at 1873 K, the cation changes in the garnet were examined. With increasing pressure, Mg and Si slightly decrease and Al increases sharply compared with those of Irifune (1994), which is the phase relation study on pyrolite along the geotherm around 660 km. However the tendencies of such cation changes indicate the garnet composition changes a majorite to a stoichiometric garnet components with increasing pressure, which is consistent with the result in Irifune (1994). Unfortunately, we did not constrain the stability region of garnet well, but taking cation changes in garnet of this study and Irifune (1994) as a function of pressure into consideration, the stability field of the garnet in pyrolite may shift slightly to a lower pressure, compared with that of Irifune (1994). A mass balance calculation was applied to determine the mineral proportion changes as a function of depth in pyrolite on the basis of chemical composition analyses of coexisting phases. The mineral proportions in pyrolite as a function of depth agree well with Irifune (1994), except for the garnet stability field. Density changes of pyrolite as a function of depth agree well with Irifune (1993) within error. Density jump in pyrolite at the 660 km was estimated as approximately 8%, which is comparable to that in PREM.

We are currently calculating density and also seismic velocities in MORB. Combining the density data of pyrolite and MORB, some geophysical implications will be discussed.