Direct density determination of Pyrolite and MORB by in situ X-ray experiments.

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Pyrolite is a hypothetical rock which is representative of the Earth interior, while MORB constitutes upper part of typical oceanic lithosphere. Phase relations and density changes of these rocks under the Earth interior conditions thus should give us crucial information about the dynamics of the oceanic lithosphere in the deep mantle (e.g.Irifune 1993, Ono et al., 2001).

Density determinations in such rocks at high pressure and temperature have been studied by two steps; 1) determination of mineral proportion of high pressure phases based on quench experiment, 2) calculation of density using equation of state of each mineral.

In this study, we conducted direct determinations of densities of each mineral in Pyrolite and MORB by in situ X-ray experiment and chemical composition analysis of quenched samples and compared direct density measurement with previous method as discussion.

The cell assembly with truncated edge length of 3, 2.5 mm were used in high pressure experiment with a combination of synchrotron radiation and SPEED-1500 in SPring-8. Pressure medium was composed of (Mg, Co)O, ZrO_2 and $LaCrO_3$ 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 was a mixture of MgO, Au and NaCl (in a 50 : 1 : 50 volume ratio), were enclosed in graphite. Pressure was calculated by using equation of state of Au (Anderson et al., 1989).The press load was increased first to the target value and then temperature was increased to 1873 K. Heating duration was 5 hours, except for one run of 1.5 hours. X-ray diffraction data were acquired during keeping at constant temperature. The quenched samples were polished and the chemical compositions of coexisting phases were determined by SEM-EDS.

Five experiments were conducted and the results of high pressure phase relations were mainly consistent with previous studies (e.g.Irifune 1993). For discussing calculation of density, we focused on comparison the result of direct density measurement of each phase, especially Mj, MgPv, which have complex chemical composition and mainly constitute mantle and slab, with that of calculation of density using equation of state of each phase. And precision of calculation of density using equation of state of such phases was discussed.

1 MgPv

Density of MgPv by direct measurement was consistent with the both result using equation of state of $MgSiO_3$-Pv (e.g. Funamori et al., 1996, Fiquet et al., 1998, Wang et al., 1994) and that of Fe, Al-bearing MgPv (Nishiyama 2001). While the result of density using equation of state of Al-bearing MgPv (Zhang and Weidner 1999) was about 3% higher than that of direct measurement. Recently the effect of Al on the equation of state of MgPv has been in debate, Andrault et al., (2001) reported the bulk modulus of Al-bearing MgPv is about 2-5 % higher than that of $MgSiO_3$-Pv, while that of Zhang and Weidner (1999) being about 10 % lower than that of $MgSiO_3$-Pv. This discrepancy may cause complex substitution mechanism of Al in MgPv (e.g. Navrotsky 1999, Brodholt 2000), but there is no good explanation about it so far. But we think use of equation of state of $MgSiO_3$-Pv or Fe, Al bearing MgPv is good way for discussing the density of MgPv with complex chemical composition such as the Earth interior.

2 Mj

The result of density using Py62Mj38 equation of state (Wang et al., 1998) is the most consistent with that of direct measurement. The result of density using Py20Mj80 (Morishima et al., 1999) is about 1% lower than that of direct measurement. But both results are close to that of direct measurement, then the effect of other component such as Fe, Ca on the equation of state of Mj may be low.