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Phase transformations in MORB and related materials in the lower mantle conditions using LHDAC and synchrotron radiation

Maiko Isshiki[1), Ayako Kurio[2)], Shizue Sakamoto[2)], and Tetsuo Irifune*[2)]
[1)]JASRI, [2)]Geodynamics Research Center, Ehime Univ.

Diamond anvil cell is capable of generating pressures in Mbar region, equivalent to depths of the lower mantle ~ core of the Earth. However, the very limited specimen volume in DAC hindered studying phase transformations in complex chemical compositions relevant to the Earth's deep interior. The present study aims to clarify the nature of phase transformations in subducted oceanic crust and mantle lithologies as a function of pressure and temperature, down to depths of the base of the lower mantle, using a combination of laser heated DAC and synchrotron radiation.

MORB and pyrolite compositions were used as the starting materials of the in situ X-ray diffraction measurements at high pressure and high temperature using the laser-heated DAC. These samples was mixed with a small amount of Gold powder, which was used as a pressure marker at high temperature. NaCl powder was used as a thermal insulator between the sample and the diamond. The sample enclosed in a hole of the Re gasket. The x-ray beam was monochromatized to the wavelength of 0.4133 Å and was collimated to 0.02mm in a diameter.

Runs were conducted at pressures between 20 and 60 GPa, at a fixed temperature of 2000K. Heating time was 30 minutes for all of runs. Both of the MORB and pyrolite starting materials were efficiently heated by YAG laser (~ 20 W for this temperature), and phase transformations took place during the above heating time.

An example of the X-ray diffraction profile for the MORB sample heated at 40 GPa and retrieved to the ambient condition is shown in Fig. 1. The presence of $MgSiO_3$-perovskite, stishovite, and a calcium ferrite-type was confirmed from the X-ray diffraction profile, which is consistent with the estimations based on multianvil experiments.

The analyses of the phases present at high pressure and high temperature and their volume changes are currently being proceeded. We also plan to carry out chemical analyses of the quenched samples by means of an analytical transmission electron microscope. A combination of the chemical data with those of the unit-cell volume at high pressure and high temperature should provide precise variations of densities of MORB and pyrolite under the lower mantle condition. This enables to evaluate the density relations between these two lithologies, which is important to address the behaviour of the subducted oceanic crust in the deep mantle.

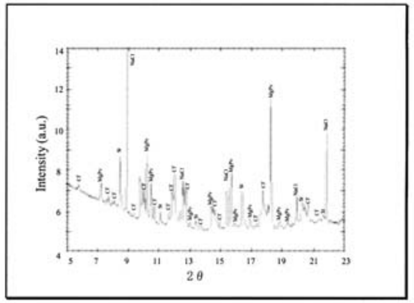

Fig. 1 An example of the X-ray diffraction profile of the MORB sample, quenched to the ambient condition from 40 GPa, 2000K.

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High temperature and high pressure phase transition of $(Mg_{0.9},Fe_{0.1})_2SiO_4$ under lower mantle conditions

M. Isshiki[1)] 1528, A. Kurio [2)] 5811, S. Sakamoto[2)] and T. Irifune[2)] 1224
[1)] SPring-8/JASRI, [2)] Geodynamics Research Center, Ehime Univ.

Introduction

$(Mg_{0.89},Fe_{0.11})_2SiO_4$ olivine, the most abundant mineral in the upper mantle, transforms to modified spinel and spinel structures at high pressure and high temperature. Then it decomposes into an assemblage of MgSiO3-rich perovskite and (Mg,Fe)O ferro-periclase. The olivine-to-modified spinel and the postspinel transformations are believed to underlie the two major seismic discontinuities at 410- and 660-km depths in the mantle, respectively.

The experimental determination of the phase boundary between the spinel and MgSiO3-rich perovskite + (Mg,Fe)O ferro-periclase (the postspinel transformation) was made by *in situ* x-ray diffraction measurements under high pressure and high temperature, which combined a synchrotron radiation source with a multianvil apparatus. [1] According to this study, the boundary of the postspinel phase transformations was ~2GPa lower than earlier estimates based on the other high pressure studies and the thermodynamic analyses. On the other hand, the other experiment was made to determine it by *in situ* x-ray diffraction measurements under high pressure and high temperature, which combined a synchrotron radiation source with a laser-heated diamond anvil cell (DAC). [2] It was suggested that the boundary of the postspinel phase transformations determined by situ x-ray diffraction measurements was inconsistent with a multianvil apparatus and a laser-heated DAC experiments.

To confirm this inconsistency, we have performed the *in situ* x-ray powder diffraction experiment using the laser-heated DAC.

Experimental and result

Natural Olivine with a composition of $(Mg_{0.89},Fe_{0.11})_2SiO_4$ were prepared as the starting materials of the *in situ* x-ray diffraction measurements at high pressure and high temperature using the laser-heated DAC. These samples was mixed with a small amount of Gold powder, which was used as a pressure marker at high temperature. NaCl powder was used as a thermal insulator between the sample and the diamond. No absorber of a laser radiation for heating was used. The sample enclosed in a hole of the Re gasket. The x-ray beam was monochromatized to the wavelength of 0.4133 Å and was collimated to 0.02mm in a diameter.

In the first beam time, we performed a preliminary study to calibrate the working of this cell assembly with the powdered carbon sample. The second beam time, we tried to perform the *in situ* x-ray observation of the postspinel phase transformation of natural olivine. Although we prepared the cells of this experiment, we could not carry out this experiment due to the undulator trouble of ID22.

[1] Irifune et al., Science (1998) 279:1698-1700
[2] Shim et al., Nature (2000) 411:571-574