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In situ X-ray observations in $NaMgAl_3SiO_8$ under the lower mantle condition

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Introduction

Seismological observations have demonstrated that mid ocean ridge basalt (MORB) would subduct to the deep mantle and reach to the bottom of the lower mantle. On MORB compositions at the lower mantle conditions, the high pressure experiments reported that aluminous phase is one of the major high pressure phases under these conditions, and takes $CaFe_2O_4$-type structure (CF-phase). At the upper part of the lower mantle, on the other hand, some recent studies reported that the aluminous phase takes the hexagonal NAL-phase rather than CF-phase (e.g. Hirose and Fei, 2002[1]; Sanehira et al., 2005[2]).

In the present study, we conducted in situ X-ray observations of NAL-phase using laser heated diamond anvil cell. We investigated the phase relations of NAL-phase and CF-phase

Experimental

Starting material is NAL-phase ($NaMgAl_3SiO_8$ composition), which was synthesized at 20 GPa and 1773 K by Kawai-type multianvil apparatus. High pressure was generated using lever-type diamond anvil cell equipped with the anvils of 0.25 or 0.35 mm in the culets size. The sample was heated by irradiating Nd:YAG laser for Pt foils (thickness of 2-3 μm), which was sandwiching the sample. X-ray diffraction spectra were obtained using imaging plate with the exposure time of 20 minutes at BL-13A beam line, PF.

Results and discussion

The variations of X-ray diffraction pattern in $NaMgAl_3SiO_8$ are shown in Fig. 1. NAL-phase was compressed up to 55.7 GPa under room temperature and was heated under constant load. After heating, some amount of CF-phase was formed. Then we compressed the sample and heated at 80.0 GPa. It was found that NAL-phase and CF-phase coexist even at this pressure. In another run, we studied the onset pressure of the formation of CF-phase, and determined it to be about 37.5 GPa (Fig. 2).

Previous studies reported that aluminous phase is rich in NAL-phase at the upper part of the lower mantle. Our results show that the proportion of NAL-phase in aluminous phase decreases at 37.5 GPa. On the contrary, CF-phase increases in the proportion and becomes the major high pressure phase in aluminous phase at the middle and lower part of the lower mantle.

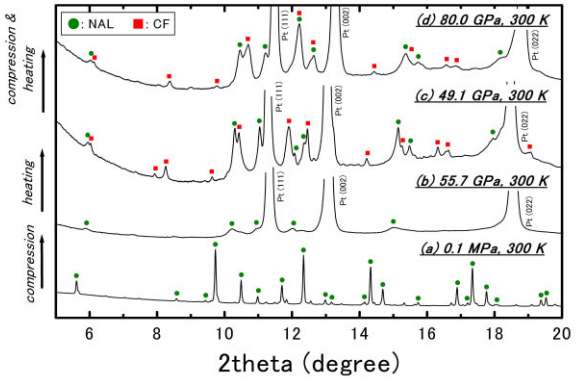

Fig. 1 The variation of the X-ray diffraction profile in $NaMgAl_3SiO_8$.

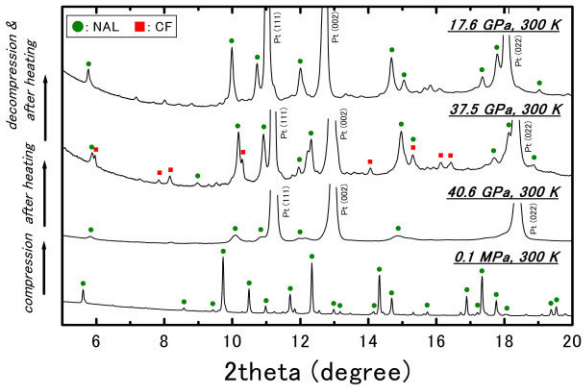

Fig. 2 The onset pressure of the formation of CF-phase.

References

[1] K. Hirose and Y. Fei, Geochemica et Cosmochimica, 2099-2108 (2002)
[2] T. Sanehira et al., Phys. Chem. Miner., DOI 10.1007/s00269-005-0043-0 (2005)

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