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Stability of hydrous phase δ-AlOOH and reaction between δ-AlOOH and Iron at High Pressure and temperaure

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Introduction

Water is one of the most important volatile materials in the Earth. Although water is transported into the earth's deep interior, the detailed process of the water transportation into the deep mantle is not yet clarified. Water can be transported into the mantle by the hydrous minerals existing in the slab at high pressure. In order to discuss the water transport into the deep mantle, the stability of hydrous minerals is the most important factor. δ-AlOOH is one of the most important high pressure hydrous mineral expected to exist stable into the transition zone and lower mantle. In this work, we have studied the high pressure stability of δ-AlOOH under the pressure and temperature conditions corresponding to the deep lower mantle.

The reaction of the hydrous minerals and metallic iron is also important for incorporation of hydrogen into the metallic core during Earth Core formation stage and also at the present Core-Mantle boundary. Therefore, we also studied the nature of the reaction between δ-AlOOH and Metallic Iron at high pressure and temperature in this work.

Experimental procedure

Powdered gibbsite or natural diaspore from Turkey was used as a starting material. It was mixed with different type of metals, such as platinum, iridium, and iron, as a laser absorber. We mixed platinum black or metallic iron with a grain size less than 3 micrometers with the sample as a laser absorber.

The sample mixed with the metal was loaded into the hole of a Re gasket sandwiched by the powdered starting material without metal, which serves as a thermal insulator. Pressure was calculated from the volume of the unit cell based on the equation of state of platinum [1] when we used platinum as a laser absorber, whereas we used the Raman T_{2g} mode of the diamond anvil surface [2] in the experiments with the iron as a laser absorber. Nd: YAG laser operated by a multimode was introduced into the sample from one side of the diamond anvil cell to generate high temperature. Temperature was measured by the spectroradiometric method and its fluctuation during heating was 100-200 K.

Synthesized phases were determined at high-pressure during heating or after temperature was quenched by means of *in-situ* angle-dispersive X-ray diffraction at the beam lines of BL13A and BL18C.

Results and discussion

We conducted both *in-situ* X-ray diffraction experiments at high pressure and temperature, and the temperature quenched experiments at high pressure using the starting materials mixed with metals. In an *in-situ* X-ray diffraction experiments using platinum as a laser absorber, we observed formation of δ-AlOOH at 63 GPa and 1300 K after the duration of 10 min. δ-AlOOH survives up to 1700 K and 63 GPa and there was no change in the diffraction pattern after the duration of 10 min at 1700 K.

In the runs conducted at higher pressures using the same starting material, formation of δ-AlOOH was observed coexisting with platinum hydrate PtH_x. [3]; δ-AlOOH started to grow at 1350 K and 95 GPa, whereas the intensity of diffraction peaks from platinum became weak with the appearance of $PtH_{x,}$ suggesting the reaction of platinum with H_2O derived from gibbsite starting material. δ-AlOOH was observed after further heating from 1550 K and 103 GPa to 1700 K although the diffraction peak of platinum disappeared at 1600 K The run made at 95-103 GPa and 1350-1550 K reproduced formation of δ-AlOOH and PtH_x.. We also used iridium as a laser absorber, and observed formation of d-AlOOH without hydrite: d-AlOOH was stable at 116 GPa and 2000K.

We conducted *in situ* X-ray diffraction experiment at 63 GPa and high temperatures using the mixtures of metallic iron and diaspore as a starting material. We observed formation of δ-AlOOH at around 1000 K, whereas we observed dhcp FeH, FeO, and corundum at temperatures around 1500 K. This result revealed that there is a reaction of metallic iron and δ-AlOOH to form FeH, FeO, and corundum at high pressure and temperature.

In situ X-ray diffraction experiments revealed that δ-AlOOH, is stable in the pressure range from 18 GPa at least 116 GPa at 2000K. Thus, δ-AlOOH can transport hydrogen into the deep lower mantle.

References

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