Report for the Joint Use/Research of the Institute for Planetary Materials, Okayama University for FY2024

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Category: ☑International Joint Research ☐General Joint Research ☐Joint Use of Facility ☐Workshop

Name of the research project: Determination of the Al2O3 solubility in $MgSiO_3$ bridgmanite

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Collaborator

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Research report:

Purpose of the research:

The purpose of this project was to extend the calibration of Al_2O_3 solubility in $MgSiO_3$ bridgmanite coexisting with corundum to pressures of up to 70 GPa and temperatures of 2000-2300 K. This calibration is critical for the indirect evaluation of sample pressures in in-house multi-anvil press (MAP) experiments where in situ X-ray diffraction (XRD) is not available. Currently, the calibration is limited to 52 GPa, but the pressure capability of MAPs has been extended to over 70 GPa at room temperature and ~52 GPa at 2000 K using carbide anvils. To fully exploit this potential, a reliable pressure scale based on chemical solubility at higher pressures is needed.

Actual research conducted:

Experiments were conducted using the multi-anvil press at beamline BL04B1 of SPring-8. A total of 9 high-pressure, high-temperature runs were performed: four with 14 mm sintered diamond (SD) anvils and five with 26 mm tungsten carbide (WC) anvils. A glass with the composition $En_{50}Cor_{50}$ ($MgSiO_3$-Al_2O_3, 50 mol% each) was used as the starting material, and MgO + Pt (10:1 wt%) served as the pressure marker.

The experimental assemblies consisted of Cr_2O_3 doped MgO octahedra, cylindrical BDD heaters, TiC electrodes, and $LaCrO_3$ or ZrO_2 thermal insulators. Temperature was monitored with D-type thermocouples. Stepwise compression and heating-cooling cycles were used to mitigate blowouts and ensure accurate in-situ XRD measurements.

Research Results:

The SD anvil runs reached a maximum of 54.7 GPa and 2200 K (run M4309), although several experiments were interrupted by blowouts or thermocouple failures. The WC anvil runs achieved more stable high pressure conditions, with the highest pressure of 51.8 GPa (Run M4313) and the longest high temperature stability achieved in Run M4316: 8 hours at 1700 K and 39.7 GPa. Post-quenching XRD analysis revealed the presence of bridgmanite, corundum and stishovite, confirming successful synthesis under the target conditions.

These results demonstrate that the experimental setup is capable of producing bridgmanite + corundum assemblages at pressures close to the desired target of 70 GPa. However, further optimization is required to consistently achieve and maintain higher pressures and temperatures, particularly to prevent blowouts and improve thermocouple reliability.