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: Synthesis of $(Mg,Fe)_2GeO_4$ Spinels

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Research report:

1) Please write the research report with free format, but include followings: research purpose, actually conducted research, and research outcomes. If necessary, you can add another page.

Research Purpose

The mineralogy of super-Earth planets, especially the Mg/Si and Fe/Si ratio, is expected to vary over a considerable range, reflecting the compositional variability of their host stars and planet forming processes. As a result, it is necessary to understand phase relationships in the MgO-FeO-SiO_2 system at ultrahigh pressures across a broad compositional range. The Th_3P_4-type phase of magnesium germanate is the first experimentally observed phase in which germanium adopts eight-fold coordination with oxygen, and, by analogy, has important implications for the corresponding silicates. The coordination number affects the equation of state, thermodynamic behavior, diffusivities, geochemical affinities, and other geophysically relevant properties.

Research Conducted

The $(Mg,Fe)_2GeO_4$ spinel starting materials with a wide range of compositions (Fe# = 0, 20 and

50) were compressed to pressures > 200 GPa. Samples were loaded in diamond anvil cells with 300/50 beveled anvils. Au was mixed into the sample to enhance laser coupling and provide a pressure calibrant. Angle dispersive x-ray diffraction was carried out using a 2-circle diffractometer optimized for DAC experiments. Laser-heating experiments were performed covering a wide P-T range up to pressures of ~200 GPa and 4000 K.

Research Outcomes

We carried out a total of 7 experimental runs with the samples with Fe # = 0, 20 and 50. The pure Mg2SiO4 samples were consistent with our previous experiments. For the Fe bearing samples, the stable phase beyond 150 GPa was consistently post-perovskite and (Mg, Fe)O. At lower pressures, perovskite was the stable germanate phase. Phase transitions to an unknown phase was observed at low-temperature and high pressure. This structure is not consistent with any of the expected post-spinel phases. Computational studies are being carried out to characterize this phase. In the next APS cycle, we aim to carry out similar experiments on the samples with higher Fe content.