reached its yield point. By multiplying the strain by an appropriate elastic modulus, the strain can be converted to elastic stress. Using 226 GPa as the elastic modulus (the value for Py59%Mj41% -garnet), the yield strength of Py50%Mj50% -garnet is calculated as *ca.* 6 GPa.

The micro-scopic strain decreased with time at each step of the heating, initially very fast and then much slower in the later stage. Even after heating to 750˚C, the micro-scopic strain did not become zero, which indicates the sample still had elastic strain.

We have previously conducted the relaxation experiments on Py50%Mj50%, Py100%, Py68%Al18%Gr14%Sp1% and Py23%Al48%Gr28%Sp1% -garnets at 7 GPa and 10 GPa by the same technique as used at Brookhaven National Laboratory. Here, Al, Gr and Sp denote almandine, grossular, and spessartine garnets, respectively. A comparison of all these data along with the current results suggests that the rheological behavior of silicate garnet strongly depends on its composition, namely that the plastic strength increases with an increasing component of either pyrope or majorite and with pressure.

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PRECISE DETERMINATION OF THE SPINEL-POSTSPINEL BOUNDARY IN Mg_2SiO_4 BY DIFFRACTION MEASUREMENT AT HIGH-PRESSURE AND HIGH-TEMPERATURE

Mg_2SiO_4 olivine is the most abundant mineral in the upper part of the Earth s mantle. By increasing pressure, this mineral is transformed in stages. The sequence is olivine, modified spinel, spinel structures, and finally two phases, *i.e.*, $MgSiO_3$ perovskite and MgO periclase (postspinel phase). The decomposition of Mg_2SiO_4 spinel to the postspinel phase is thought to be responsible mainly for the seismic discontinuity at the 660 km depth in the mantle. This speculation is supported by the experimental findings (*e.g.* [1]) that point out the coincidence between the transformation pressure and the pressures at the 660 km discontinuity. However, the pressure determinations in these studies have significantly large uncertainties because the pressures were indirectly estimated on the basis of calibrations using some fixed pressure reference points.

We have determined the P/T conditions of the spinel-postspinel phase boundary in a wide range of pressures and temperatures using a combination of white X-ray and a multianvil apparatus (SPEED-1500) [2] at the beamline **BL04B1** (Figure 1). A mixture of Mg2SiO4 olivine and gold powders was used as the starting material of the high pressure-temperature runs.

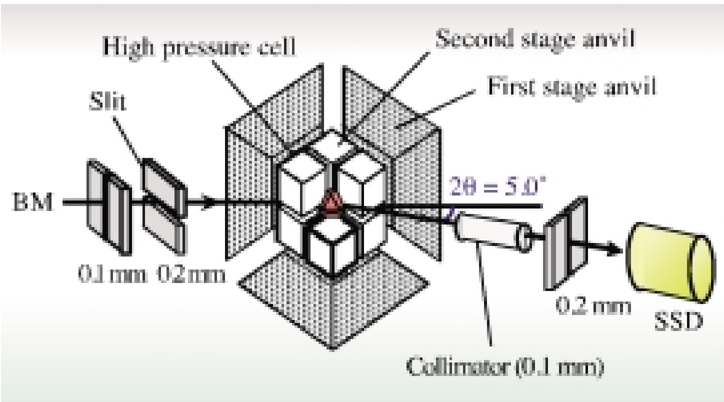

*Fig.1: Configuration of X-ray optics and multianvil apparatus (**SPEED-1500**).*

In the experiments, the pressure was increased first, and then X-ray diffraction data were acquired as increasing temperature. The phase at each P/T condition was identified from the X-ray diffraction patterns, the pressure was simultaneously determined by the molar volume of gold using an equation of state [3], and the temperature was measured by the thermocouple. Further details of the experimental conditions are given in Irifune et al. [4].

Figure 2 shows some examples of the X-ray diffraction patterns at various pressures and temperatures. In this run, we were able to observe the transformation from olivine (Fig. 2(**a**)) to the postspinel phase (Fig. 2(**c**)) through the metastable spinel phase (Fig. 2(**b**)). The postspinel phase transformed to the spinel phase when temperature was slightly changed near the phase boundary. A partial reverse transformation back to the postspinel phase was also confirmed by further experiments with different P/T conditions. In this manner, we precisely constrained the phase boundary between spinel and postspinel phases for the first time based on *in situ* X-ray diffraction measurements.

Figure 3 illustrates the spinel-postspinel phase boundary in Mg_2SiO_4 determined in this study. The transformation pressures were determined at temperatures up to 2000°C, whereas they were not well constrained at temperatures below 1000° C due to kinetic problems. The phase boundary has a negative Clapeyron slope of dP/dT = - 0.0025 GPa / °C , which is consistent with earlier results based on quench experiments [1]. However, it was found that the transformation pressures shift toward the low pressure side by more than 2 GPa compared with those of quench experiments.

The present results suggest that the spinel to postspinel transformation should occur at a depth of about 600 km in the Earth. This is inconsistent with the seismological observations, which show that the major seismic discontinuities in the Earth s mantle are only located at depths of 410 km and 660 km. It has been fairly well established that the 410 km discontinuity is caused by the olivine-modified spinel transformation on the basis of both quench and *in situ* X-ray diffraction experiments [5,6]. The present results, however, indicate the latter discontinuity is not due to the phase transformation in the mantle olivine.

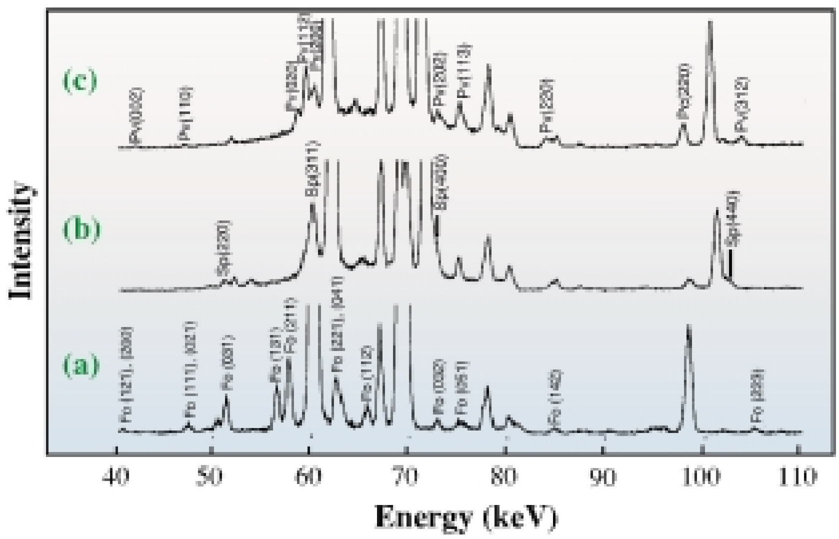

*Fig.2: Examples of X-ray diffraction data obtained at **(a)** the ambient pressure and temperature, **(b)** at 23.9 GPa, 1100°C, and **(c)** 21.5 GPa, 1500°C in one of the in situ X-ray observations. Fo: Mg_2SiO_4 olivine; Sp: Mg_2SiO_4 spinel; Pv: $MgSiO_3$ perovskite; Pc: MgO periclase. Other lines are diffraction and characteristic peaks of gold, which was mixed with the olivine sample for pressure reference.*

The above inconsistency may be reconciled if some additional elements, such as Fe and Al, which are present in the actual Earth s mantle, significantly increase the transformation pressure.
Alternatively, the pressure scale based on the equation of state of gold may not be accurate enough to be applied to the P/T regimes of the present study. Although our results suggest that the conventionally accepted model for the cause of the 660 km discontinuity might be incorrect, these issues should be addressed before we reach a final conclusion.

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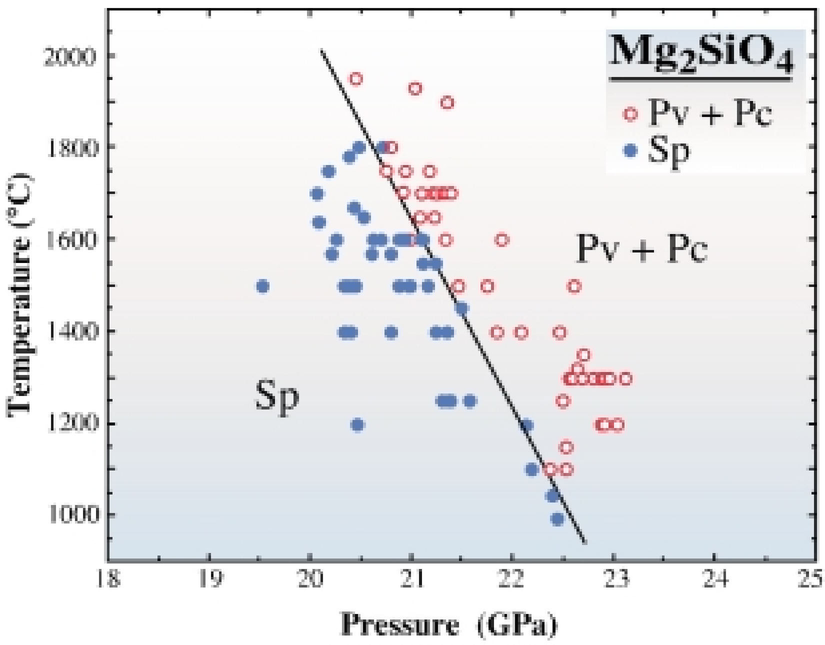

Fig.3: Phase boundary between the spinel and the postspinel phases. Closed circles denote P/T conditions where stability of the spinel phase was confirmed. Open circles show P/T conditions where the postspinel phase was stable.