IN-SITU MEASUREMENT ON RHEOLOGY OF SILICATE GARNET

We have examined the rheological properties of silicate garnet under *in-situ* mantle conditions with a multi-anvil high-pressure apparatus (SPEED-1500) equipped at the beamline **BL04B1**. One of the most important subjects of mantle rheology is to analyze the plastic behavior (*e.g.* flow law) of the mantle constituent minerals. In particular, the pressure effect on their plastic behavior is a major interest in the recent studies on mantle rheology. However, ordinary deformation apparatuses cannot directly elucidate the pressure effect due to the limitations of pressure ranges they generate.

Weidner *et al.* [1,2] have recently measured the yield strength and plastic behavior of diamond and $MgAl_2O_4$ spinel under *in-situ* mantle conditions by using a multi-anvil high-pressure apparatus with the aid of a synchrotron X-ray. This method is essentially a stress relaxation experiment. They focused on changes in the X-ray diffraction peak width from polycrystalline samples. The micro-scopic strain and stress, then the mechanical data of plasticity in samples can be evaluated from this observation. The most excellent point of this method is elucidation of the time-dependence on the micro-scopic strain while keeping high pressure and temperature. This method provides a measurement of plastic behavior of high-pressure minerals under the corresponding *in-situ* mantle conditions.

In this way we can estimate the pressure effect on plastic behavior of mantle constituent minerals. In the current study, we applied this method to the measurement of plastic behavior of silicate garnet, which is a major constituent mineral in the mantle transition zone and subducting slub, under high-pressure conditions.

We used ground Py50%Mj50% -garnet (50% pyrope and 50% majorite) which was synthesized with the multi-anvil high-pressure apparatus (ORANGE-2000) at Ehime University. The sample was compressed to 17 GPa at room temperature and heated stepwise to 450˚, 550˚, 650˚ and finally 750˚C in 300-, 240-, 180- and 60-minute intervals, respectively. The pressure increased from 17 to 19.5 GPa just after heating to 450˚C due to the thermal expansion of the sample; this pressure was kept constant throughout the heating treatment. Maintaining the pressure at 19.5 GPa and the temperature at the respective values, we analyzed the relaxation processes with time.

We estimated micro-scopic strains from the peak broadening and sharpening of (400), (420), (332) and (642) diffraction lines (Figure 1). During the pressurization at room temperature, the micro-scopic strain became nearly constant (ca. 0.025) over 10 GPa, which indicates that the sample

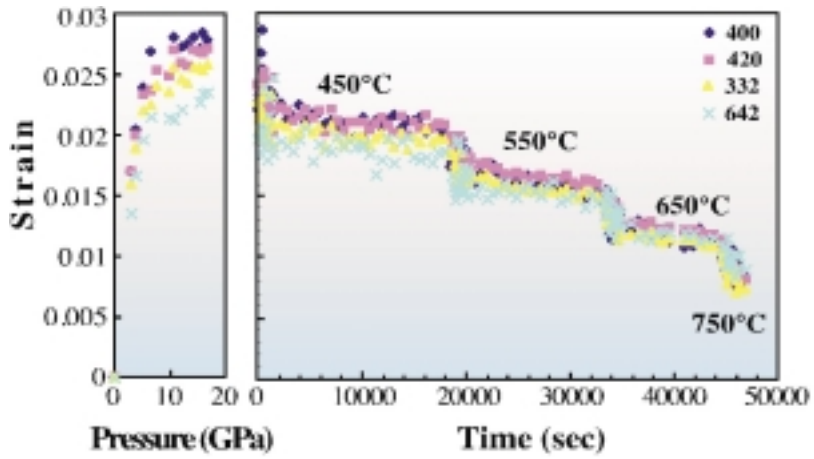

Fig.1: Microscopic strain in Py50%Mj50% -garnet as a function of load pressure, followed by heating at constant load.

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.

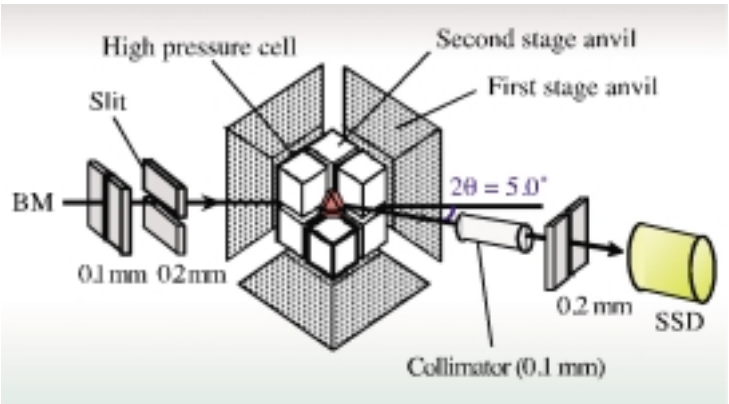

*Fig.1: Configuration of X-ray optics and multianvil apparatus (**SPEED-1500**).*