High Pressure Phases found in Yamato 790729. Yukako Kato[1], Toshimori Sekine[1], and Akira Yamaguchi[2], [1]Department of Earth and Planetary Systems Science (DEPSS), Hiroshima University, [2]National Institute of Polar Research

Introduction: It has been generally recognized that high-pressure minerals are found in shock veins of L6 ordinary chondrites. Ordinary chondrites have a large volume percentage of chondrules and a small amount of fine-grained matrix as well as the oxygen isotopic compositions plotted above the terrestrial fractional line. Most type 6 chondrites are subjected to extensive shocks. The shocked meteorites have records of shock-induced deformations and phase transformations which may give detailed information about the mechanism of formation of shock vein and high pressure phases. It is essential to unravel the shock history in meteorites and the parent planet in order to understand the collisional process during the formation of planetary accretion. In this study, therefore, we investigate the high pressure phases in the chondrite: Y-790729.

Methods and Sample: A thin section of Y-790729 chondrite classified as L6 was investigated in this study. It consists mostly of olivine and pyroxene and has shock veins. We used optical microscopy and scanning electron microscopy (SEM) to observe the textures. To determine the structure and composition of phases present, we used Raman spectroscopy and electron probe microanalysis (EPMA), respectively. There are Raman data available for ringwoodite [1], majorite [2], high-pressure clinopyroxene [3], merrillite [4] and maskelynite [5] and we refer them to identify phases. EPMA measurements for maskelynite were carefully used with a large beam diameter (~3-5 μm) and low beam current to prevent a damage.

Results: Some distinctive formations are perceived on the optical microscope observation. In the host rock, some olivine display planar deformations. In addition, brecciated structure and sub-grain structure of olivine are observed. Many minerals present in this meteorite have shock induced fractured but maskelynite has the smooth surface.

Almost all high pressure phases in Y-790729 chondrite were found in the shock vein. Ringwoodite displays distinctive blue color under the transmitted light (Fig. 1). The Raman spectrum differs from that of olivine outside the shock vein, although there is no difference in composition between them ($Mg_{1.5}Fe_{0.5}SiO_4$). In addition to ringwoodite, we observed some high pressure phases such as majorite, high pressure clinoenstatite, maskelynite, and merrillite. High pressure clinoenstatite shown in Fig.1 is contacted with majorite. Figure 2 shows their spectra, indicating a clear difference between them. The compositions of clinoenstatite is $Fe_{0.2}Mg_{0.8}SiO_3$. We observed these high pressure phases in shock vein. The low pressure phases outside the shock vein also were analyzed to compare the compositions with those oh the high pressure phases. Maskelynite are present not only in the shock vein, but also outside it and the compositions of maskelynites display significant deviation from the stoichiometry of plagioclase. The total cation number based on 24 oxygens is 13.4-13.8. If the composition remains as plagioclase or alkali feldspar, the total cation and the sum of Si + Al will be 15 and 12, respectively. The EPMA data indicate that the sum of Si+Al is about 12.5. Therefore there seems to be a cation deficiency of the sites of K+Na+Ca in maskelynite. We cannot rule out the possibility that the deviation is caused by damaged by electron beam. We confirmed this deficiency for the maskelynites produced from alkali feldspars in the experimentally shocked samples. Merrillite, the high pressure phase of apatite was found in the shock vein, and the Raman spectrum is compared with that of apatite outside the shock vein.

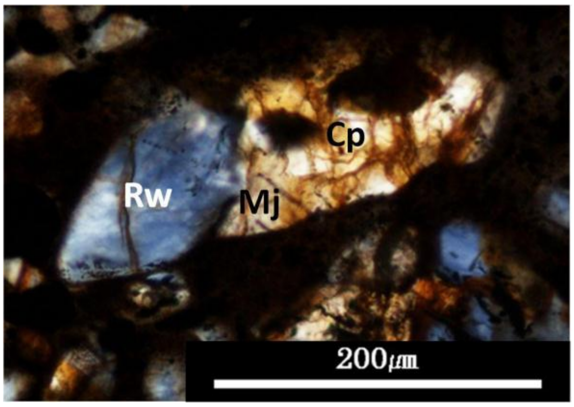

Fig. 1. Transmitted light microphotograph of part of the shock vein of Y-790729. Rw=ringwoodite; Cp = high pressure clinoenstatite; Mj = majorite.

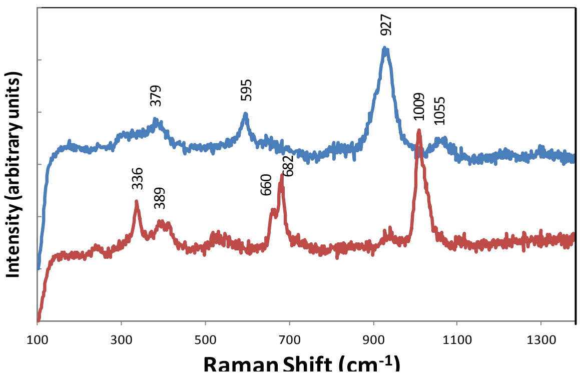

Fig. 2. Raman spectra of high pressure clinoensatite (lower red one) and majorite (upper blue one) in Fig. 1.

Raman spectra also reveal the existence of merrillite in the shock vein and apatite in the host rock. Outside the shock vein, characteristic coexistence of clinoensatite and diopside is present.

The typical compositions of clinoenstatite and diopside are $Fe_{0.2}Mg_{0.8}SiO_3$ and $Ca_{0.9}(Fe_{0.2}Mg_{0.9})Si_2O_6$. They are distinguished by not only the composition but also the Raman spectra. The Raman spectrum of majorite is shown in Fig. 2.

Discussion: Maskelynites are found near and in the shock vein, and all of the other high pressure phases of ringwoodite, high-pressure clinoenstatite, majorite, maskelynite, and merrillite also present in the shock vein. From these facts, it is obvious that the shock vein experienced the high pressure and high temperature generated by shock wave. If those high pressure minerals formed under conditions similar to the equilibrium, we may estimate the P-T condition. However, the local P-T of the shock vein relative to those of the parental body must be kept for their nucleation and growth. Shock wave travels several km/s in meteorite, and the time required for their formation needs relatively longer. Such high P-T conditions are subjected to rarefaction wave and drop adiabatically. In order to keep the required high P-T conditions longer, we need a large impactor and a large planetary body, respectively.

The assemblage of high pressure phases is valuable to presume P-T condition. Assuming that the temperature rise by the impact event was about 1000℃ and that equilibrium was achieved for an enough time for their formation, pressure can be estimated. The stable range of pressures for ringwoodite $Mg_{1.5}Fe_{0.5}SiO_4$, high-pressure clino-enstatite $MgSiO_3$, and merrillite are 14-25 GPa, 8-16 GPa, and above 12 GPa, respectively. Therefore, a pressure range of 14-16 GPa is obtained by the three high pressure phases. It will not be out of the stability for majorite and maskelynite, although we need to know the composition of majorite. Regarding makelynite, shock wave data is available.

In comparison with the previous study, the composition of high-pressure clinoenstatite is very similar to the composition of Ca-poor clinopyrocene in Y-000047 [3]. The compositions of diopside and ringwoodite in this chondrite are also similar to those in ALH78003 [8]. For maskelynite, the composition is slightly different from that of maskelynite in the other chondrite [5]. The total cation number in the previous study is 14.2-15 on based on 24 oxygens. However the total cation numbers of maskelynites in Y-790729 are 13.4-13.8. Their composition shows slightly larger Si cation number and slightly smaller Na cation number than that in the previous study. Although we did careful analysis to prevent alkali loss during EPMA measurements, we may need rechecking. But our EPMA data for maskelynite show a range of the total percentage between 97 and 100 and it is addressed that the cation deficiency was seen even in measurements with the little alkali loss.

In addition, we are planning to investigate by cathode luminescence to clarify the shock metamorphism from the point of defect formation in minerals by shock wave.

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