Collision condition indicted by High Pressure Phases in a Chondrite. Y. Kato[1], T. Sekine[1], M. Kayama[1], M. Miyahara[2] and A. Yamaguchi[3], [1] Earth and Planetary Systems Science, Hiroshima University, [2]Graduate School of Science, Tohoku University, [3]National Institute of Polar Research.

It has been generally recognized that there were many collisions during planetary accretion. Chondrites include the materials at the time of formation of the solar system. It is essential to unravel the shock history in meteorites and the parent planet in order to understand such collisional processes. In this study, we investigate a thin section of ordinary chondrite Y-790729 classified as L6 in which high-pressure minerals are found in the about 620-µm-wide shock vein. The mineralogical and chemical features give us detailed information to constrain the shock conditions. We have tried to constrain the P-T condition from the viewpoints of the mineral assemblage and cathodoluminescense (CL) spectroscopy.

Y-790729 consists mostly of olivine and pyroxene and has shock veins. To identify high pressure phases, we used an optical microscope, a scanning electron microscope (SEM), micro Raman spectroscopy, and electron probe micro analyzer (EPMA). There are Raman data available for ringwoodite [1], majorite [2], high-pressure clinopyroxene [3], akimotoite [4], merrillite [5] and maskelynite [6] and we refer them to identify phases. EPMA measurements for maskelynite were carefully used with a large beam diameter (~3-5 μm) to prevent a damage. In addition, scanning electron microscopy-cathodoluminescence (SEM-CL) analysis, detectable shock-induced defect centers, was used to characterize the shock metamorphism in feldspar minerals.

The presence of shock vein, maskelynite, and high pressure phases confirms shock record. 7 high pressure phases of ringwoodite, high-pressure clinoenstatite (HPC), majorite, merrillite, lingunite, high-pressure chromite and akimotoite were found in this section. All of them exist only in a shock vein, but maskelynite occurs everywhere in the section. From these observations, it is obvious that the shock vein experienced the high pressure and high temperature generated by shock wave. If some of the high pressure minerals are equilibrated, the P-T condition can be estimated. Based on the equilibrium phase diagram of $MgSiO_3$ polymorphs [7], the P-T conditions for crystallization of majorite, HPC and akimotoite is about 17 GPa and 1600 ^{o}C, because the compositions of the three phases are close to $MgSiO_3$. It is consistent with the stability fields for ringwoodite, merrillite and diopside. Employing the shock properties of an ordinary chondrite [8] and the impedance match method, an impact velocity of 1.74 km/s is obtained for a symmetrical head-on impact.

CL spectroscopy of experimentally shocked sanidine gives us a linear correlation between integral intensity of emission components at 2.948 eV and the applied peak shock pressure. Then, a pressure over 15 GPa can be estimated based on these relationships and the intensities at 2.948 eV derived from maskelynite in Y-790729, covering the value estimated from the high pressure phase assemblage.

We plan to investigate the detailed microstructures and the particle sizes of the high pressure minerals in the shock vein by transmission electron microscope (TEM). By examining minerals in the shock vein in detail, it is expected that the formation mechanism of the high pressure phases will be understood and that the collisional process will be unraveled from the material evolution. In addition, the shock duration, the parent body size, and the time required for the crystal growth need to be estimated as further development.

References:

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