EXPERIMENTAL SHOCK METAMORPHISM OF THE MURCHISON CM CARBONACEOUS CHONDRITE. K. Tomeoka, Y. Yamahana, and T. Sekine, 1Department of Earth and Planetary Sciences, Faculty of Science, Kobe University, Nada, Kobe 657-8501, Japan, 2National Institute for Research in Inorganic Materials, 1-1 Namiki, Tsukuba, Ibaraki 305, Japan.

Carbonaceous chondrites are expected to respond to high-shock compression differently from other types of meteorites, because of their intrinsic porous nature and high volatile contents. However, highly shocked carbonaceous chondrites are rare [1], and thus how they respond to high shock pressure is not well known. In order to understand the shock history of carbonaceous chondrites, we have carried out a series of shock-recovery experiments of the Murchison CM chondrite using a single-stage propellant gun. The Murchison samples were shocked at 7, 11, 26, 28, 30, 34, 36, and 49 GPa. All the known CM chondrites have been estimated to be shock stage S1-S2 (<5–10 GPa) [1], thus the pressures higher than 10 GPa have never been experienced by these meteorites.

Impact at 7–30 GPa: Chondrules are flattened nearly perpendicular to the compression axis in the pressure range 7–30 GPa. The mean aspect ratio of chondrules increases from 1.17 to 1.57 roughly in proportion to the intensity of shock pressure in the pressure range <26 GPa. This indicates that chondrule flattening and foliation are important characteristics of shock compression for CM chondrites and that the mean aspect ratios of chondrules can be used for quantitative estimates of shock intensities in this pressure range. However, at 26–30 GPa, chondrules do not show any further flattening but show increasingly higher variations in aspect ratio and orientation. Increasing proportions of olivine and pyroxene in chondrules are finely fractured with increasing shock pressure, and almost all olivines and pyroxenes are fractured with subgrains of <5 µm at 30 GPa. Local melting occurs as melt veins and pockets at 21–30 GPa. The melts are mostly produced from the matrix but consistently more enriched in Fe, S, and Ca. The melts contain tiny spherules of Fe-Ni metal and sulfides and abundant bubble-like voids. At 21 GPa, thin, subparallel fractures begin to form in the matrix in directions perpendicular to the compression axis. Their number density increases greatly at 26 GPa, and they extend in high density throughout the matrix at 30 GPa. Thus, at 26–30 GPa, the sample is increasingly comminuted and becomes fragile.

Impact at 34–49 GPa: The samples are strongly flattened and taper off toward the peripheries, where melted materials fill fractures produced in the stainless steel containers. At 34 and 36 GPa, the samples are converted to an assemblage of rounded to irregularly-shaped blocks of 50–200 µm in dimension, thus exhibiting a breccia-like texture. They are found to be even more fragile than the 30-GPa sample. Most chondrules are disintegrated and show no preferred orientations. Incipient melts occur randomly on a scale of 10–50 µm. Thus the matrix becomes a complex mixture of incipient melts and fine grains. At 49 GPa, the matrix is totally melted, and the general texture becomes chaotic; isolated grains of olivine and pyroxene are scattered in the melts. Some olivine grains are partially melted. The melts contain bubble-like voids that are much larger in size (50–200 µm in diameter) than those in the samples shocked at lower pressures, which indicates that much intenser evaporation and gas volume expansion took place in this sample.

The great increase in degree of comminution of the Murchison sample, thus in degree of fragility, and the simultaneous generation of strong expansive force at 25–35 GPa testify the hypothesis of Scott et al. [1] that the volatile-rich carbonaceous chondrites shocked above 20–30 GPa escaped from the parent body on pressure release and formed particles that are too small to survive as meteorites.