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First discovery of a heavily shocked CM carbonaceous chondrite

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Collisional impact events are a fundamental process for the evolution of solar-system small bodies. The impacts on the asteroids result in shock deformation and localized melting in chondritic meteorites. We are able to elucidate the nature of shock events based on the analysis of shock-induced features in meteorites. Cracking, deformation, and phase transformation by impacts are commonly observed in ordinary chondrites. However, carbonaceous chondrites are known to have escaped intensive shock metamorphism. One of plausible explanations for this difference is that large amounts of volatiles in carbonaceous chondrites promote destructive explosion upon impacts and therefore the impacted materials fragmented into small pieces and do not become meteorites (Tomeoka et al.1999).

Some of CV3 chondrites show chondrule flattenning and a preferred orientation due to impacts (Nakamura et al., 1992). Experimental impacts on a CV3 chondrite reveals that ~10GPa impact is needed to reproduce recognizable chondrule flattening (1995; 2000). On the other hand, CM chondrites that are more enriched in water than CVs are almost free of shock metamorphism (Scott et al. 1992) and thus no CMs have been found to show chondrule flattening. In the present study, we found CM chondrite MET01072 shows chondrule flattening and high densities of cracking of matrix materials perpendicular to compaction axis. In addition to chondrules, PCPs are heavily compacted and deformed, exhibiting flow-like texture along with chondrule surface. The cracks normal to shock compression axis was reproduced in the impact experiments on Murchison CM chondrite (Tomeoka et al. 1999). The cracks might have been generated due to dehydration of water-bearing minerals during pressure release, but synchrotron X-ray diffraction (S-XRD) analysis indicates that serpentine is still dominant in the matrix of MET01072.

In order to estimate shock temperature, a small piece of PCP (30x15x15 microns) was separated using FIB and exposed to X-rays for diffraction. Tochilinite in PCP has a very low decomposition temperature (~250C) and thus it is the most sensitive temperature indicator. S-XRD analysis showed that tochilinite in the PCP is not completely decomposed and gave broad diffractions. This result suggests that shock temperature might have exceeded tochilinite decomposition temperature, but the duration was too short for complete decomposition.

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Scott E. R. D. et al (1992) GCA 56, 4281-4293.
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