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Analysis of volatile components and recovery samples of laser-shocked Murchison meteorite

NAKABAYASHI, Makoto[1*], YABUTA, Hikaru[1], SAKAIYA, Tatsuhiro[1], KONDO, Tadashi[1], OHNO, Sohsuke[2], KADONO, Toshihiko[3], SHIGEMORI, Keisuke[3], HIRONAKA Yoichiro[3], YAMANAKA, Takamitsu[4]

[1]Earth and Space Sci., Osaka Univ., [2]PERC, Chiba Institute of Technology, [3]Inst. of Laser Engineering, Osaka Univ., [4]Geophysical Laboratory, Carnegie Inst.

It has been suggested that organics in meteorites and comets has delivered building blocks of life to the early Earth during the late heavy bombardment [1]. However, there has remained a missing link in the subsequent chemical evolution of these small bodies via their interaction with the early Earth. Although the shock experiments have been reported by using gas gun (e.g. [2]), which is an efficient method for consideration about impacts of meteorites and comets, these are performed under a closed system at lower impact velocities due to the experimental restrictions. Recently, the shock experiments using high-power laser have been available [3] under an open system at higher impact velocities ($>$ 10 km/s). In this study, we have conducted a laser-shock experiment for Murchison meteorite under more realistic condition of impact events in order to identify the produced volatile components that might have been contributed to abiotic synthesis of organics and chemical composition of atmosphere in the early Earth.

Finely ground Murchison meteorite, CM2 chondrite, was used as starting material. Silica powder, which did not contain organics, was also used as a standard sample. Both samples were pressed into pellets in a diamond anvil cell. The thickness and diameter of pellets were about 100 um and about 300˜850 um respectively. The aluminum foil of 50 um thickness was located in front of the sample as the ablator for the laser and for preventing the sample from blowing out. The laser-shock experiments were conducted using GEKKO XII/HIPER laser at Institute of Laser Engineering, Osaka University, Japan [4]. The laser wavelength, pulse duration, and spot diameter were 1053 nm, 20 ns, and 0.4 mm, respectively. The experimental shock pressures were about 400 GPa and 200 GPa. The shocked sample was recovered by aluminum box or double glass vial. The ejected volatile components were analyzed on site by quadrupole mass spectrometry (QMS). The recovered material inside of the cell was extracted in solvent, and it was analyzed by gas chromatograph mass spectrometry (GC-MS).

The produced volatiles were the components with mass numbers of 16 and 26 at 400 GPa, and of 34 at 200 GPa, which could be identified as CH_4, C_2H_2, and H_2S, respectively. Although small amounts of tiny solid particles have been recovered in the cell, some of them were possibly derived from aluminum foil, and it is not sure whether they are indigenous from the meteorite. No compounds were identified by GC-MS analysis of the solvent extracts of the cell. The product, CH_4, in this study is partly consistent with the discussions by [5] that an atmosphere generated by impact degassing would tend to CO- or CH_4- rich composition derived from the impacting bodies. These impact-induced volatiles were reducing species and might have worked effectively for abiotic synthesis of organics in the early Earth.

References

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