Laser-shock evolution of organic molecules in carbonaceous meteorite

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It has been hypothesized that extraterrestrial organic compounds were delivered to the early Earth by meteorites and comets during the Late Heavy Bombardment (LHB). There have been several experiments that simulated the shock synthesis of organic compounds during the LHB. However, in the past studies using gas guns, it is difficult to perform an open system experiment at higher impact velocities than Earth's escape velocity (> 17 km/s). In order to understand what compositions of meteoritic organic molecules were produced by the shock energy of LHB and delivered to the Earth, we carried out a high power laser compression experiment (up to 400 GPa) of carbonaceous chondritic meteorite, which contains 2wt% of organic carbon.

Pellets of Murchison carbonaceous meteorite was prepared by diamond anvil cell, respectively. Pellets of the meteorites in 3mm diameter and 1mm thickness were prepared. The titanium foil was located in front of the sample as the ablator for the laser and for preventing the sample from blowing out. The laser-shock experiment was carried using GEKKO XII/HIPER laser system, Institute of Laser Engineering, Osaka University. The laser wavelength, pulse width, and spot diameter were 1053 nm, ~20 ns, and ~0.4 mm, respectively. The shock pressures were 20, 50, and 400 GPa. The collected meteorite samples were extracted with dichloromethane and methanol. The extracts were concentrated and analyzed by a gas chromatography coupled with mass spectrometry (GCMS).

Molecular compositions of polycyclic aromatic hydrocarbons (PAHs) in Murchison meteorite are not changed before and after the shock experiment at 20 GPa, except that the concentration of naphthalene was depleted. At 50 and 400 GPa, the concentrations of pyrene and fluoranthene increased, while those of biphenyl, fluorenone, and anthracene decreased. Molecular compositions of *n*-alkanes (C_{14} – C_{24}) are not largely changed before and after the shock experiment at 20 GPa. However, at 50 GPa, the concentrations of short chain *n*-alkanes (C_{14} - C_{17}) decreased and those of long chain *n*-alkanes (C_{18} - C_{24}) relatively increased. These results indicate that impact processes promote aromatic ring condensation and elongation of carbon chains of *n*-alkanes.