GENERATION OF REDUCED CARBON COMPOUNDS BY "LOW" VELOCITY IMPACTS. K. Ishibashi[1*], K. Kurosawa[1], T. Okamoto[1] and T. Matsu[1], [1]Planetary Exploration Research Center, Chiba Institute of Technology, 2-17-1 Tsudanuma, Narashino, Chiba 275-0016, Japan, *ko.ishibashi@perc.it-chba.ac.jp.

Introduction: Impacts are common phenomena through the history of the solar system. Some evidence shows that there was a period of extremely high impact flux that is called late heavy bombardment occurred approximately 3.8-4.1 Ga [e.g., 1, 2]. In this period impacts might have affected the surface environment of planets significantly. Impactors in this period may include a large amount of carbon. The redox state of carbon-bearing gas species released after impacts is important for early Earth and early Mars. For example, precursors of life on early Earth (and early Mars) must have preferred a reductive environment to an oxidative one. However, simulated impact vaporization experiments using laser irradiation to vaporize meteorites and/or meteorite analogs have shown that the impact-generated gas is oxidative because of oxygen released from silicates [3, 4].

In this study we focused on relatively "low" velocity impacts. In general the required velocities for incipient vaporization and complete vaporization of silicates are approximately 10 km/s and a few tens of km/s, respectively [5]. Thus, impacts with the velocity where silicates does not evaporate or partially evaporate might generate reductive chemical species.

Experiments: We conducted impact experiments using a two-stage hydrogen gas gun to investigate the composition of the impact-generated gas at an impact velocity lower than 10 km/s.

Experimental system. The experimental system was composed of a two-stage hydrogen gas gun, a gas analysis chamber, and a quadrupole mass spectrometer (QMS), being able to carry out open system impact experiments (Figure 1). The gas analysis chamber was placed at the downrange of the two-stage hydrogen gas gun. The sample was set in the chamber and was shot with an alumina sphere of φ2 mm accelerated by the gun. The chamber was separated from the gun with a thin film and was filled with 1000-Pa argon gas before the shots, and was closed with a gate valve immediately after the shots to prevent the contamination of both hydrogen gas and gunpowder from the gun. The QMS had been calibrated using standard gases to convert the measured values to the amounts of gas species.

Samples. The samples used in the impact experiments were pressed mixtures of SiO_2 powder and polyethylene powder, which were used as simplified carbonaceous chondrite analogs. The compositions of the samples were C/H/O/Si = 0.25/0.25/1/0.5 (i.e., C/O = 0.25) and 1/1/1/0.5 (i.e., C/O = 1). An SiO_2 only sample was also prepared for a blank shot.

Shot conditions. Three shots were conducted. The impact velocities were approximately 6.5 km/s. Shots #1 (6.6 km/s) and #2 (6.7 km/s) were with the C/O = 0.25 and 1 samples, respectively. Shot #3 (6.3 km/s) was a blank shot with the SiO_2 sample.

Results: Figure 2 shows the raw QMS data around the shots. This indicates that gases were generated by the impact to the carbon-bearing sample, while only a small amount of gases were generated in the blank shot.

Composition of the generated gas. Figure 3 shows the relative amount of the generated gas species to the background argon gas in the chamber. A large amount of hydrocarbons were generated as expected even when the sample contains excess oxygen over carbon (i.e., C/O = 0.25). This might be because SiO_2, the oxygen source in the sample, vaporizes only partially when the impact velocity is low.

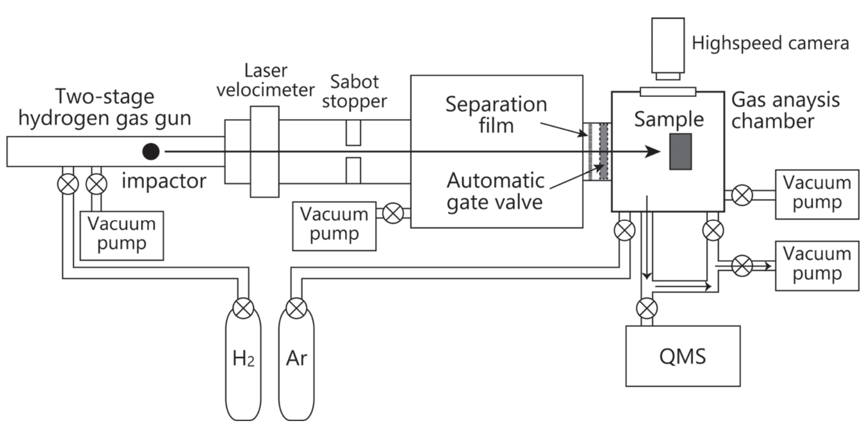

Figure 1: Schematic illustration of the experimental system.

Comparison with previous results. Figure 4 compares the results of this study with those of a previous laser irradiation experiment that simulates high velocity impacts (i.e., several tens to a hundred km/s) [4]. These indicate that the fraction of reductive species increases when the impact velocity is low.

Conclusions: Impacts with a velocity of approximately 6.5 km/s generated a large amount of hydrocarbons such as CH_4, which suggests that the composition of the impact-generated gas under the condition that silicates do not vaporize is reductive.

References: [1] Chyba *et al.* (1990) *Science 249*, 366-373. [2] Morbidelli *et al.* (2012) *Earth Planet. Sci. Lett. 355-356*, 144-151. [3] Gerasimov *et al.* (1998) *Earth Moon Planets 80*, 209-259. [4] Ishibashi *et al.* (2013) *Earth Planets Space 65*, 811-822. [5] Ahrens and O'Keefe (1972) *The Moon 4*, 214-249.

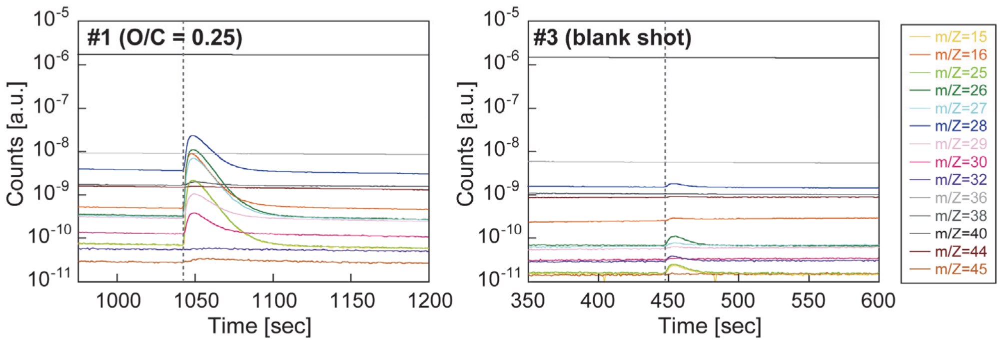

Figure 2: QMS data around the shots. Left panel shows shot #1 (SiO_2-PE sample, O/C = 0.25). Right panel shows shot #3 (SiO_2, sample blank shot). The dashed lines indicate the time of shots.

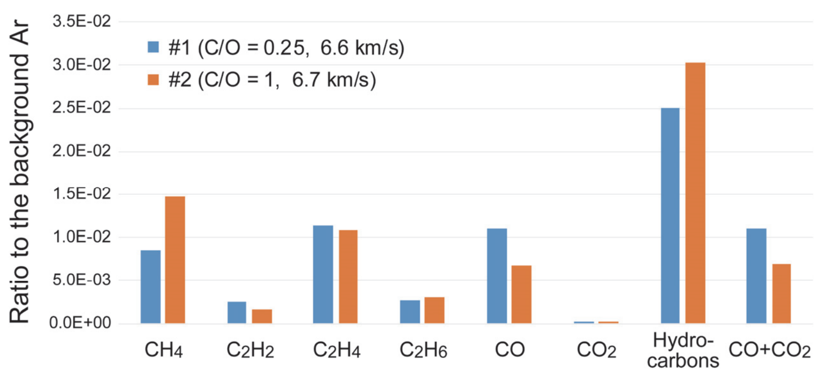

Figure 3: Relative amount of the generated gas to the background argon gas for shots #1 and #2. Hydrocarbons represents the sum of C1 and C2 hydrocarbons.

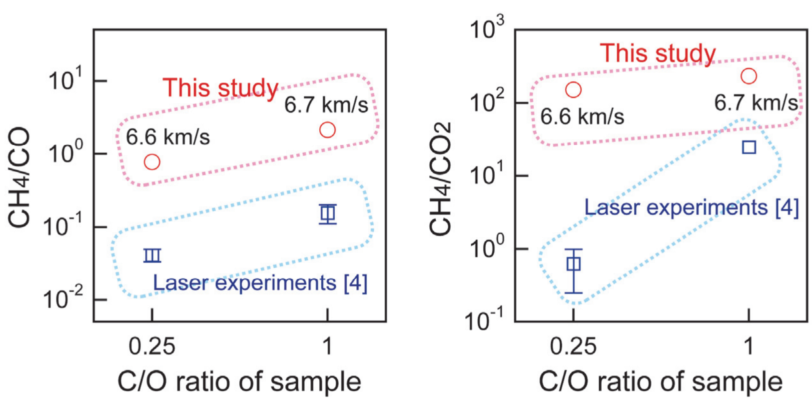

Figure 4: Comparison of the results of this study with those of the previous laser experiment that simulates high velocity impacts (i.e. several tens to a hundred km/s).