Impact-driven volatile loss from C-type chondrite-like materials

*Kosuke Kurosawa[1], Ryota Moriwaki[1], Hikaru Yabuta[2], Ko Ishibashi[1], Goro Komatsu[3], Takafumi Matsui[1]

1. Planetary Exploration Research Center, Chiba Institute of Technology, 2. Department of Earth and Planetary Systems Science, Graduate School of Science, Hiroshima University , 3. International Research School of Planetary Sciences, Università d'Annunzio

It is widely believed that C-type asteroids are parent bodies of carbonaceous chondrites, which include a plenty of water and carbon. C-type asteroids would be the main carrier of water and organics into the inner Solar System. Recently, two C-type asteroids, Ryugu and Bennu, have been explored by Hayabusa2 and OSIRIS-REx, respectively. According to the remote-sensing observations, Ryugu and Bennu have suffered a number of impacts with a variety of impact energies. Shock features in recovered samples should be identified and investigated extensively. The accurate understanding about responses of C-type asteroid-like materials against impact shocks is necessary to maximize the scientific results from the returned samples. In this study, we conducted hypervelocity impact experiments using a simulant of CI carbonaceous chondrite as an analog of the constituent material of C-type asteroids. We measured the amount and the composition of shock-generated gas from the analog.

The impact experiments were conducted using a two-stage light gas gun placed at Planetary Exploration Research Center of Chiba Institute of Technology (PERC/Chitech), Japan. We made pellets from the CI simulant and used as targets. In order to investigate the devolatilization behavior of the CI simulant, we used the two-valve method developed by Kurosawa et al. (2019). The method allows us to measure the chemical compositions of the shock-generated gas in an open system with a small risk of chemical contamination from the gun operation. The generated gases were measured by a quadrupole mass spectrometer (QMS). We performed 3 shots at nearly identical impact velocities around 5.8 km/s. An Al_2O_3 sphere was used as a projectile. We detected a variety of gases, which are H_2, CH_4, CO, H_2S, and CO_2, after the shots. The main product was CO_2 at all the shots. The mass of produced CO_2 was calculated to be 1-2 wt% of the projectile mass after the calibration of the systems. The results suggest that impact-driven volatile loss from C-type asteroids may not be so efficient if the assumption that CI simulant is a good analog of the constituent materials of C-type asteroids is correct.

Acnowledgement: We used the iSALE-2D shock physics code to interpret the experimental results. We appreciate the developers of iSALE, including G. Collins, K. Wünnemann, B. Ivanov, J. Melosh, and D. Elbeshausen. We also thank Tom Davison for the development of the pySALEPlot.

Keywords: C-type asteroids, Shock-induced devolatilization, Hypervelocity impact phenomena

