Capture of Cosmic Dusts on the International Space Station by the Japanese Astrobiology Mission (TANPOPO)

H. Yabuta[1], K. Okudaira[2], M. Tabata[3], H. Mita[4], K. Kobayashi[5], H. Yano[6], H. Hashimoto[6], S. Yokobori[7], E. Imai[8], H. Kawai[3], Y. Kawaguchi[6], D. Aoki[9], Y. Ishibashi[10], K. Fukushima[9], K. Hamase[10], Y. Ikemoto[11], M. Ito[12], Y. Kebukawa[5], T. Mikouchi[13], T. Moriwaki[11], T. Nakamura[14], S. Nakashima[1], H. Naraoka[10], T. Noguchi[10], A. Tsuchiyama[15], A. Yamagishi[5], TANPOPO working group[6]

ISS and the Japanese Experiment Module "Kibo" (http://iss.jaxa.jp/en/kibo/)

[1] Department of Earth and Space Science, Osaka University, Japan (1-1 Machikaneyama, Toyonaka, Osaka 560-0043 Japan)
E-mail address: hyabuta@ess.sci.osaka-u.ac.jp
[2] University of Aizu, [3] Chiba University, [4] Fukuoka Instute Technology, [5] Yokohama National University, [6] ISAS/JAXA, [7] Tokyo University of Pharmacy and Life Science, [8] Nagaoka University of Technology, [9] Nagoya University of Technology, [10] Kyushu University, [11] JASRI/SPring-8, [12] JAMSTEC, [13] Tokyo University, [14] Tohoku University, [15] Kyoto University

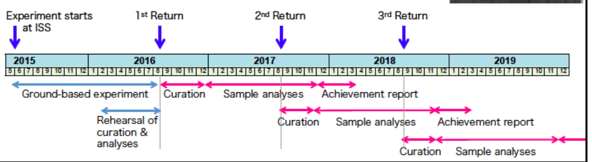
Tanpopo (Launched in April 17, 2015)

Japanese Astrobiology project at ISS

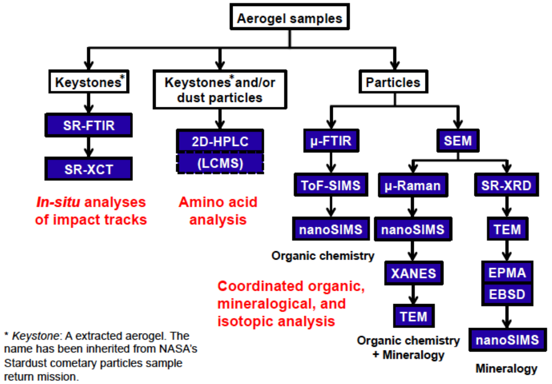
(Credit: NASA)

include a capture experiment of cosmic dusts (or micrometeoroids) for further understanding of the compositions and formation mechanisms of extraterrestrial organic compounds that might have been delivered to the early Earth as life's building blocks. Advantage of this project is that we will be able to investigate the cosmic dusts that did not experience the atmospheric entry heating and terrestrial contamination.

Low density silica aerogel (0.01 g/cm³) (Tabata et al. 2014) is used as a capture material to prevent a possible alteration of the chemical composition of organic matter in cosmic dusts upon their high velocity impact to ISS.



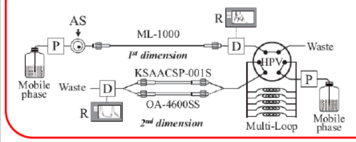
Analytical strategy



* *Keystone*: A extracted aerogel. The name has been inherited from NASA's Stardust cometary particles sample return mission.

Two-dimensional (2D) chiral HPLC for amino acid analysis

Flow diagram of 2D-HPLC system (Hamase et al. 2014)



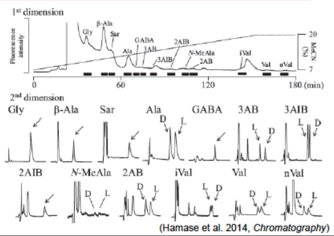
In the 1st dimension, a capillary ODS column (ML-1000) was used. In the 2nd dimention, narrowbore-enantioselective columns (OA-4600SS and KSAACSP-001S) were used.

P: pump, AS: auto sampler, D: detector, R: integrator, HPV: high pressure valve

2D-HPLC separation of extraterrestrial amino acid enantiomers in 20 µg of the Yamato 791191 meteorite (*right*).

In the first dimension, peaks of the amino acids were not clearly observed except Gly and Ala. However, in the second dimension, most of the amino acids were sharply separated (Hamase et al. 2014).

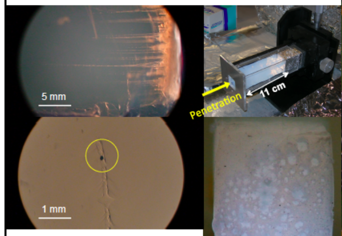
The technique has successfully reduced a background for the analysis of amino acids in a micrometeoroid.

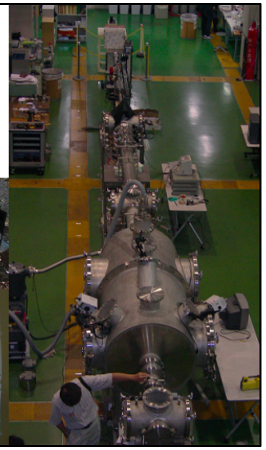


(Hamase et al. 2014, *Chromatography*)

Hypervelocity impact experiment by a two stage light gas gun

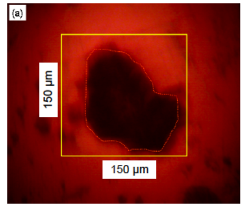
One concern in this project is a possible alteration of organic matter in cosmic dusts upon their high velocity impact to the aerogel. As a ground-based experiment, we conducted an experiment of aerogel capture of Murchison meteorite powder (~ 500 µg) of a particle diameter of 30-100 µm at **4 km/s** for evaluating the extent of alteration of organic matter in the meteorite.



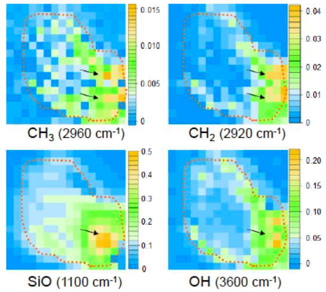


Experiments were conducted at JAXA/ISAS

µ-FTIR imaging (Reflection) of terminal particles



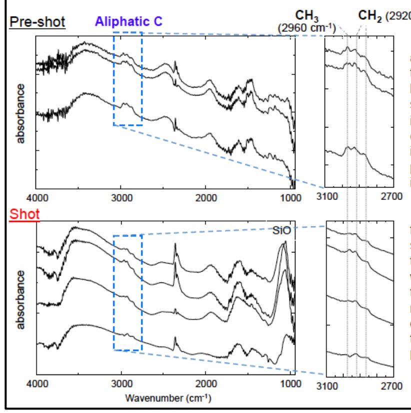
Murchison terminal particle (150 x 150 µm) extracted from the aerogel and pressed between two Al foils



CH_3 (2960 cm^{-1}) CH_2 (2920 cm^{-1}) SiO (1100 cm^{-1}) OH (3600 cm^{-1})

- The regions of aliphatic carbons (CH_3 and CH_2) detected within the terminal particles indicates the survival of organics through the cosmic dusts' high velocity impact of 4 km/s to the aerogel
- Distributions of aliphatic carbon and phyllosilicates (SiO, OH) are similar to those in the pre-shot carbonaceous chondrite
-> Mineral-organic relationship is not modified by high velocity impact

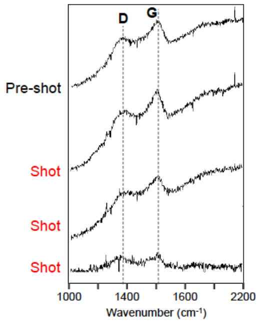
µ-FTIR spectra of preshot and shot particles

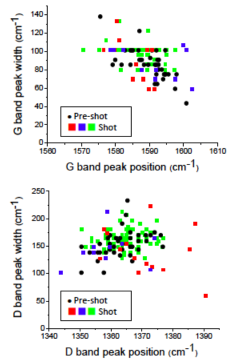


The spectral intensities of aliphatic carbons in the terminal particles are slightly lower than those in the pre-shot Murchison meteorite. This is likely due to loss of aliphatic carbon by impact or difference in thickness of the meteorite particles before and after impact.

The CH_2/CH_3 ratios obtained from the IR spectra of the shot samples were 0.3–3, while those of the pre-shot sample were 1.3–2. The difference in the ratios may be reflected by modification of aliphatic chains of organic macromolecules in the meteorite due to the hypervelocity impact heating.

µ-Raman spectroscopy

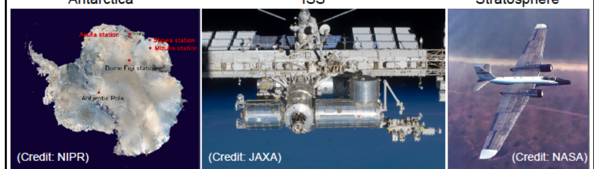




The Raman spectra of pre-shot and shot Murchison meteorite particles are very similar (left). Peak widths and positions of the two bands showed similar values to those for pre-shot Murchison meteorite (right). This result shows that the organic aromatic structures are not largely modified by the impact velocity of 4 km/s to the aerogel.

Toward a consortium of organics in cosmic dusts

Antarctica ISS Stratosphere



The studies of cosmic dusts will unveil the chemical compositions and distributions of organic matter and minerals in the early stage of planetesimal formation within the protoplanetary disk, which is rarely recorded in the chondritic meteorites that experienced parent body processes. Combination of the insights from the cosmic dusts from the stratosphere, Antarctica, and ISS, will constrain the origin and evolution of organic matter in the early Solar System.

We cordially welcome international collaboration through the Tanpopo cosmic dust capture experiment. Please contact Dr. Hikaru Yabuta (hyabuta@ess.sci.osaka-u.ac.jp)