HAYABUSA2 SAMPLE COLLECTION AT RYUGU. S. Tachibana[1,2], H. Sawada2, R. Okazaki3, Y. N. Miura4, Y. Takano5, K. Sakamoto[1], and H. Yano[2], [1]UTokyo Organization for Planetary and Space Science (UTOPS), University of Tokyo, 7-3-1 Hongo, Tokyo 113-0033, Japan. tachi@eps.s.u-tokyo.ac.jp. [2] Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (JAXA). [3]Department of Earth and Planetary Sciences, Kyushu University. [4]Earthquake Research Institute, University of Tokyo. [5]Biogeochemistry Program, Japan Agency for Marine-Earth Science and Technology (JAMSTEC).

Hayabusa2 at Ryugu: Hayabusa2, JAXA's asteroidal explorer, arrived at a near-Earth C-type asteroid (162173) Ryugu on June 27, 2018. Ryugu is expected to record a long evolutionary history of the Solar System from the beginning to the present. Since its arrival, Hayabusa2 has been investigating the asteroid [1-3] with a telescopic optical camera with 7 band filters (ONC-T), a near-infrared spectrometer (NIRS3), a thermal infrared imager (TIR), and a laser altimeter (LIDAR), two rovers (MINERVA-II1; HIBOU and OWL), and a MASCOT lander [4, 5].

It has been found that Ryugu has a top shape with an equatorial ridge (mean radius of 448 ± 2 m), having a retrograde rotation with a period of 7.6326 hours and an obliquity of 172° [1]. Its bulk density is estimated to be 1.19 ± 0.03 g/cm^3, suggesting that the asteroid has a large macro-porosity of ~50–60 % [1]. One of the striking surface geological features is the presence of many large (>20 m) boulders with a number density twice as large as that of Itokawa, and there is no smooth terrain as seen in Itokawa [2]. These observations (low bulk density and boulder-rich surface) lead to the conclusion that Ryugu is a rubble-pile body [1]. It has been also found that the surface has a very low geometric albedo, darker than most of meteorite samples [2], and that the surface has uniformity in visible and near infrared spectra with a weak 2.72-μm absorption feature [2, 3]. The 2.72-μm absorption feature suggests the ubiquitous presence of hydrous phases [3].

The MASCOT lander found that the surface is not covered with fine grained dust, and that the surface rock with inclusions could be similar to carbonaceous chondrites [4] but with a lower thermal conductivity [5].

Sample collection at Ryugu: The basic concept and design of the Hayabusa2 sampler are the same as the original Hayabusa [6-8] (Fig. 1). In order to collect sufficient amount of samples (100 mg) compliant with both monolithic bedrock and regolith targets, a 5-g Ta projectile is shot at an impact velocity 300 m s^{-1} at the timing of touchdown. The ejecta are put into a sample catcher through an extendable sampler horn and a conical horn under a microgravity condition (1.5 x 10^{-4} m s^{-2} [1]). One-gravity laboratory experiments using the 1:1 scale of the sampling system with 1 mm glass spherules at one gravity shows that 150-250 mg of samples can be collected with a projectile shooting, which is expected to be increased under microgravity because eject with low velocities can be collected. Three projectiles are equipped for sampling at three different surface locations.

The sample catcher of the Hayabusa2, located at the top-end of conical horn, has three chambers to store samples obtained at three locations separately [7] (Fig. 2). An inlet to the sample catcher is rotatable to select a chamber to store samples at each location. The size of sample catcher is almost the same as that of the original Hayabusa with two chambers, and the total volume is ~45 cm^3. The sample catcher has a design that is easier to be taken apart during curation at ISAS/JAXA] than that of the original Hayabusa.

A back-up sampling method is also prepared [7]; The tip of the sampler horn is turned up like the teeth of a comb (Fig. 1), and surface pebbles will be lifted up by the turn-up part during touch down. The lifted pebbles will be put into the sample catcher by deceleration of the spacecraft.

On February 22, Hayabusa2 landed at a location on the equatorial ridge, and the projectile was successfully shot to the Ryugu surface. After the SCI impactor experiment in April, the spacecraft made another successful landing nearby the artificial impact crater to collect sub-surface material excavated by the impact. There is no way to monitor the amount of collected samples, but the images taken during the landing operations (Fig. 3) imply that samples were collected at two locations.

After the sampling operations, the sample catcher that stored samples at two locations separately was transported into the sample container inside the Earth re-entry capsule and sealed on August 26 (Fig. 4). The aluminum metal sealing system [8] will avoid the terrestrial air contamination (Fig. 2), which was designed to allow only a leak of 1 Pa air for 100 hours at atmospheric pressure. To avoid further potential contamination, volatile components released from the samples will be extracted prior to the opening of the container. The container will be attached to a vacuum line, and the bottom of the container, a part of which is thinned, will be pierced with a needle to extract volatiles (Fig. 2).

References: [1] Watanabe S. et al. (2019) *Science* **364,** 268-272. [2] Sugita S. et al. (2019) *Science* **364,** eaaw0422. [3] Kitazato K. et al. (2019) Science *Science* **364,** 272-275. [4] Grott M. et al. (2019) *Nature Astronomy* doi.org/10.1038/s41550-019-0832-x. [5] Jaumann R. et al. (2019) *Science* **365,** 817-820. [6] Tachibana S. et al. (2014) *Geochem. J.* **48,** 571-587. [7] Sawada H. et al. (2017) *Space Sci. Rev.* **208,** 81-106. [8] Okazaki R. et al. (2017) *Space Sci. Rev.* **208,** 107-124.

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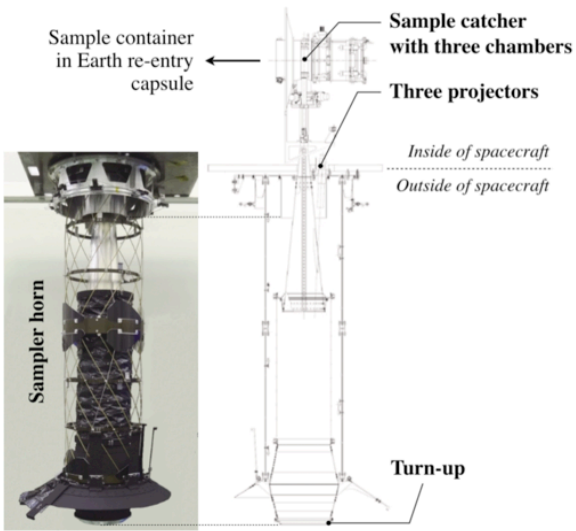

Fig. 1. Photograph of the Hayabusa2 sampler horn and schematic illustration of the Hayabusa2 sampler [7].

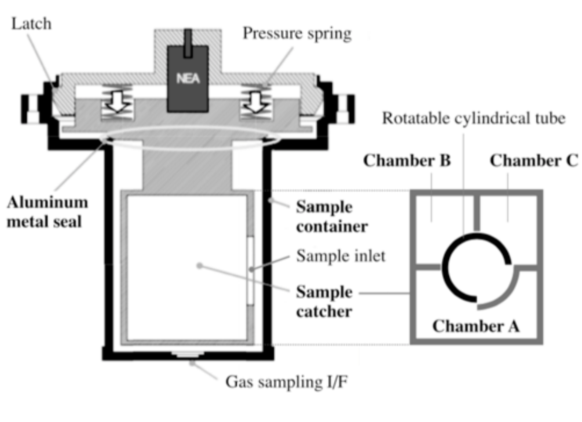

Fig. 2. Schematic illustration of the Hayabusa2 sample catcher and container [7].

Fig. 3. The images of the sampler horn after the first and second touchdown operations

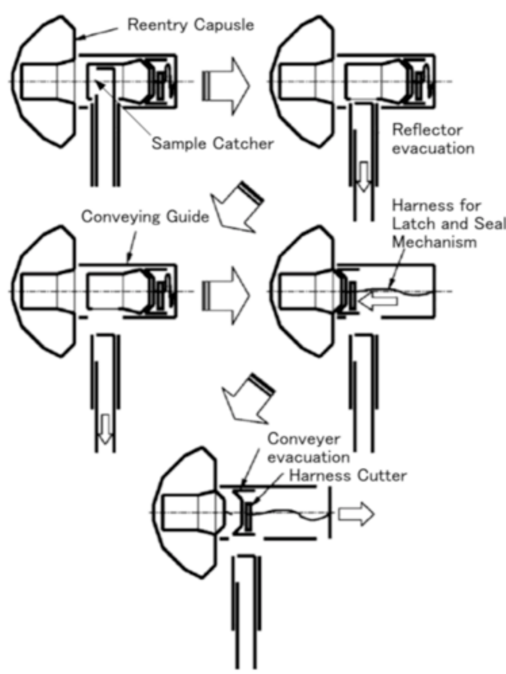

Fig. 4. Transfer of the sample catcher to the sample container inside the Earth re-entry capsule [7].