HAYABUSA2 REENTRY CAPSULE RETRIEVAL AND SAMPLE CONTAINER OPENING OPERATIONS. S. Tachibana[1,2], H. Sawada[2], R. Okazaki[3], Y. Takano[4], K. Sakamoto[2], Y. N. Miura[5], H. Yano[2], T. R. Ireland[6], M. Nishimura[2], S. Furuya[2], S. Yamanouchi[3], T. Maruyama[2], T. Yada[2], A. Nakato[2], K. Yogata[2], K. Kumagai[2], K. Hatakeda[2], A. Miyazaki[2], M. Abe[2], T. Usui[2], M. Fujimoto[2], S. Nakazawa[2], and Y. Tsuda[2], [1]UTOPS, U. Tokyo (e-mail: tachi@eps.s.u-tokyo.ac.jp), [2]ISAS, JAXA, [3]Dept. Earth Planet. Sci., Kyushu U., [4]Biogeochem. Res. Center, JAMSTEC, [5]Earthquake Res. Inst., U. Tokyo, [6]Research School Earth Sci., ANU.

Introduction: C-type asteroids have been considered to be parent bodies of carbonaceous chondrites, which contain pristine materials formed in the early Solar System. Carbonaceous chondrites also contain hydrated minerals and organic matter that could be a source of volatiles in the rocky planets including the Earth. The JAXA's Hayabusa2 spacecraft explored C-type near-Earth asteroid (162173) Ryugu [e.g., 1–10] and landed on Ryugu at two different surface locations for sample collection.

The Ryugu samples are expected to provide us with an opportunity to explore the origin and early evolution of the Solar System, the origin of water on the Earth, and the diversification of prebiotic molecules in space along with the entire history of the asteroid [11].

The Hayabusa2 spacecraft delivered its reentry capsule on Dec. 6, 2020 to Woomera, South Australia. The capsule recovery operation team transported the capsule securely back to ISAS/JAXA with generous assistance from the Australian partners. Here we summarize the reentry capsule retrieval operation and the sample container opening operation at ISAS/JAXA.

Reentry Capsule Retrieval Operation: The reentry capsule retrieval operation was carried out complying strictly to the Australian COVID-19 regulations. The landing area of the capsule was determined by receiving a beacon signal transmitted from the capsule using five antennas installed at different locations. The Marine radar systems and two Drones were also used for this retrieval operation of the capsule, the heat shields, and the parachute.

The reentry capsule was located nearby the parachute, which was found from the helicopter observation (Fig. 1). The safety check of the capsule was first completed at the landing location because pyrotechnic devices were used for the parachute deployment and separation (Fig. 2). No damage to the capsule was observed, and the capsule was transported back to the Quick Look Facility (QLF) in the Woomera Prohibited Area with a permission from the Australian safety officer.

Operation at Quick Look Facility: The sample container [12, 13] was carefully taken out of the reentry capsule at the QLF. The temperature monitor attached to the sample container indicated that the container was never heated up to 65°C, which is lower than the maximum daytime temperature at the Ryugu surface. The container was cleaned in the clean booth at the QLF and was installed onto the Hayabusa2 GAs Extraction and Analysis system (GAEA) (Fig. 3). After the overnight evacuation of the vacuum line of GAEA, on Dec. 7, the bottom of the sample was pierced with a tungsten carbide needle to release sample volatile components held inside the sample container [13]. The container was in vaccum, indicating the container seal held during reentry and therefore low terrestrial contamination. The gas extracted from the sample container was split into four gas tanks at room temperature, and the residual gas in the system was then trapped into two gas tanks cooled at liquid nitrogen temperature. A fraction of the gas was analyzed by a quadrupole mass spectrometer (WATMASS, Tokyo Electronics). The obtained mass spectrum was distinctly different from the terrestrial air, and the detailed analysis is still being performed for the gas stored in the tanks. The sample container was put into a nitrogen-purged anti-vibration transportation box and was safely transported to ISAS/JAXA on Dec. 8, 2020 (~57 hours after the capsule landing).

Sample Container Opening Operation at ISAS, JAXA: The Hayabusa2 sample container was sealed with the metal-to-metal sealing system (Fig. 4) [12, 13]. The container lid was pressed against the container edge with a pressure load of ~2700 N through pressure springs. To open the container in the clean chamber designed for Ryugu samples in vacuum [14], the container was installed into the container opening system. The pressure springs and the outer lid with latches were then taken apart from the container while keeping the pressure load constant. The container with the opening system was the attached to the clean chamber, designed to maintain the Ryugu samples in vacuum, on Dec. 11 (Fig. 5) and was opened on Dec. 14 after the chamber evacuation [14].

Particles in the Sample Container: Initial description of the samples inside the sample container by the ISAS/JAXA curation [14] found that the samples have the following characteristics: (1) Particles were found in two separate chambers used for two landing operations at Ryugu, indicating that the samples at the different surface locations were obtained successfully. (2) The particles were black in color, consistent with the color of Ryugu boulders [e.g., 2]. (3) Millimeter- to centimeter-sized pebbles are present. Centimeter-sized grains, close to the maximum obtainable size [12], are found in the sample obtained during the second landing operation nearby the artificial crater. (4) The total weight of the sample exceeds 5 g [14], which is far more than the mission requirement (0.1 g) [11].

All the sample characteristics suggest that the Hayabusa2 sampler system worked efficiently and effectively at the Ryugu surface.

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 364,* 272–275. [4] Arakawa M. et al. (2020) *Science 368,* 67–71. [5] Okada T. et al. (2020) *Nature 579,* 518–525. [6] Jaumann R. et al. (2019) *Science 365,* 817–820. [7] Grott M. et al. (2019) *Nat. Astron. 3,* 971–976. [8] Morota T. et al. (2020) *Science 368,* 654–659. [9] Tatsumi E. et al. (2020) *Nat. Astron.* doi.org/10.1038/s41550-020-1179-z. [10] Kitazato K. et al. (2021) *Nat. Astron.* doi.org/10.1038/s41550-020-01271-2. [11] Tachibana S. et al. (2014) *Geochem. J. 48,* 571–587. [12] Sawada H. et al. (2017) *Space Sci. Rev. 208,* 81–106. [13] Okazaki R. et al. (2017) *Space Sci. Rev. 208,* 107–124. [14] Yada T. et al. (2021) *LPS XXXXXII,* this meeting.

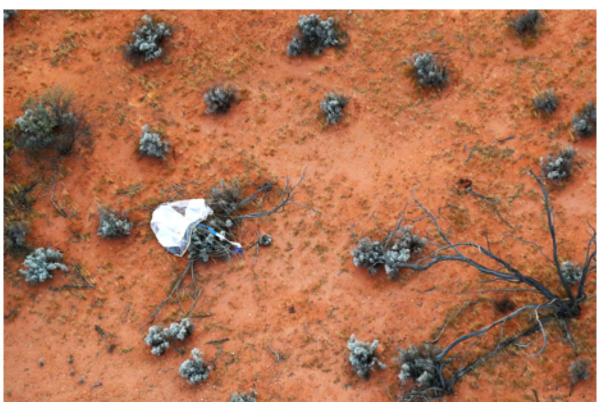

Fig. 1. The Hayabusa2 reentry capsule landed on Woomera, Australia in the morning of Dec. 6, 2020.

Fig. 2. Investigation of the reentry capsule at the landing site.

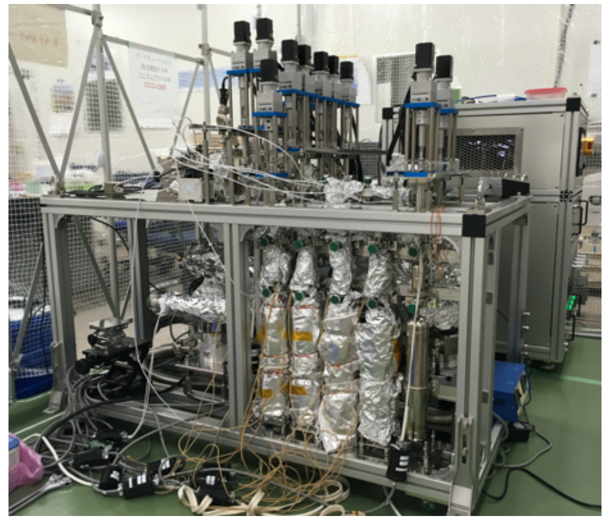

Fig. 3. The Hayabusa2 GAs Extraction and Analysis system (GAEA).

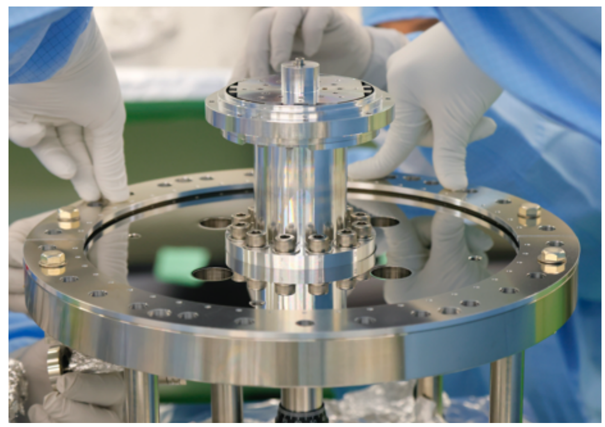

Fig. 4. The Hayabusa2 sample container attached to an ICF356 vacuum flange. The flange was used to install the container into the clean chamber.

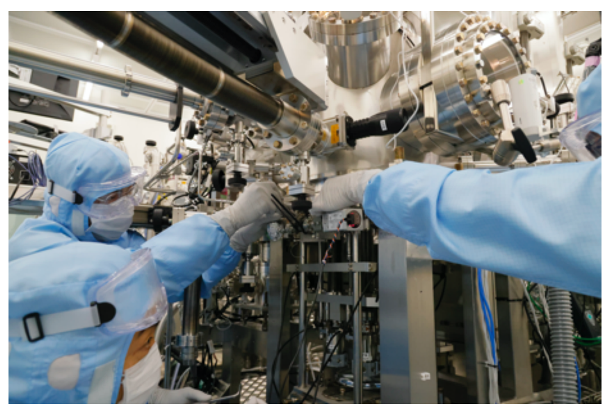

Fig. 5. Installation of the sample container into the Hayabusa2 clean chamber (CC3-1) at ISAS, JAXA [14] (Dec. 11, 2020).