Preparation for curation of Hayabusa2-returned samples in JAXA

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Introduction: Volatile components like water/ice, gases and organic matters might have been brought in the form of small bodies to the inner Solar System from the outer Solar System [1, 2]. One of the remnants of such bodies would be C-, B-, D-, and T-type asteroids, which show spectral features of low albedo with or without absorptions of H_2O/OH [3, 4]. Carbonaceous chondrites containing hydrous silicates and organic matter, could have originated from such bodies [5]. However, it has not yet been proved that C-, B-, D-, and T-type asteroids are parent bodies of carbonaceous chondrites. A straightforward way to prove/disprove this hypothesis is to return samples from those bodies. In order to accomplish this scientific goal, Hayabusa2, which launched in 3 December 2014, made two successful touchdowns on the near-Earth C-type asteroid 162173 Ryugu in February and July 2019, and will return the first C-type asteroid samples to the Earth at the end of 2020 [6, 7].

New features of the Hayabusa2 sample container: Volatile components such as water and organic matter are one of essential science targets for sample analysis [8]. To return volatile-containing samples without terrestrial contamination, a new metal sealing system was developed for the Hayabusa2 sample container [8, 9, 10] (Fig. 1). Although the sealing system using two Viton O-rings for the Hayabusa container could not prevent terrestrial air contamination perfectly [9], the Hayabusa2 metal sealing system is expected to keep the air leak less than 1 Pa for 100 hour in the air [9, 10]. Furthermore, volatiles released from the samples inside the container can be extracted by putting the container to the gas extraction vacuum line prior to the container opening before installation into clean chambers in Extraterrestrial Sample Curation Center (ESCuC) in the JAXA Sagamihara Campus [9, 10].

Procedures in the landing area: Hayabusa2 spacecraft will return its reentry capsule including samples obtained on Ryugu to the Woomera Prohibited Area (WPA) in central Australia at the end of 2020. As the capsule will land on the ground in the WPA, it will go through a series of securing works before it will be enclosed into its transportation box. And then it will be transferred to the Quick Look Facility (QLF) which will be prepared close to the landing site. In a clean booth set in the QLF, the capsule will be decomposed to expose the bottom part of the sample container, which will be cleaned and attached to the gas sampling system. Then the volatile components inside the sealed sample container will be released to the gas extraction vacuum line to be analyzed in-situ by quadrupole mass spectrometers, recovered to gas sampling tanks in room temperature and then gathered into cold trap tank of liquid nitrogen temperature, -196˚C. After the volatile component sampling with the gas sampling system, the container will be sealed with a valve and enclosed into a double-shielded transportation box with nitrogen gas condition.

Procedures after its arrival to Japan: The sample container will be enclosed in the transportation box and will be sent back from Australia to Japan by air. The sample container will be taken out from the box at the class 10,000 clean room at ESCuC, followed by removal of the heat shield, made of carbon fiber reinforced plastic, on the top of the container, using a milling machine in the clean room. The container surface will then be cleaned and connected to the container opening system. An outer lid of the container, springs and a non-explosive actuator for the metal sealing system, and a frame for the container latches will be removed sequentially. The container opening system with the sample container will then be installed into the clean chamber (CC). The entire sample-handling system consists of five chambers (CC3-1, CC3-2, CC3-3, CC4-1 and CC4-2; Fig. 2). The returned sample container will be first connected to CC3-1 to open the sample container and take out the sample catcher that encapsulates Ryugu grains. The extracted sample catcher will be transferred to CC3-2. The sample catcher has three chambers to keep samples collected at different surface locations separately [9, 10], and a lid of the chamber for samples obtained at the first sampling location will be taken apart to pick up a small fraction (<5 %) of grains. The picked-up samples will be kept in CC3-2 for future generations under a vacuum condition. We performed a rehearsal of this process with a copy of sample container including aluminum particle simulants. After the transfer of the catcher to CC3-3 under a vacuum condition, a gate valve between CC3-2 and CC3-3 will be closed. CC3-3 will then be purged with purified nitrogen. The catcher will be transported to CC4-1 and CC4-2 to take out grains from three chambers of the container in purified nitrogen.

The initial description of samples (phase-1 curation) will be done under a purified nitrogen environment in CC, and the grains will be weighed, observed with a stereomicroscope, and examined with visible to near-infrared spectrometers in CC3-3, CC4-1 and CC4-2.

Sample distribution plan: Some fractions of Ryugu samples are planned to be delivered to the initial sample analysis team of the Hayabusa2 project and phase-2 curation teams in six months after the capsule recovery [11]. Ten-percent of the samples will be delivered to NASA after 12 months from the capsule recovery following the MOU (Memorandum of Understanding) between JAXA and NASA. After 18 months from the capsule recovery (summer in 2022), the sample catalogue will be released with the international announcement of opportunity for the samples. The samples will be available to the community through a proposal-based competition.

References

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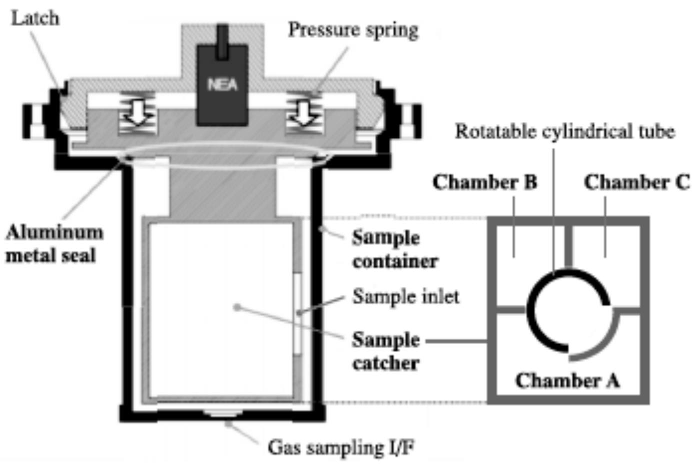

Fig. 1. A schematic illustration of the Hayabusa2 sample catcher and container, which is referred from Fig. 6 of [8].

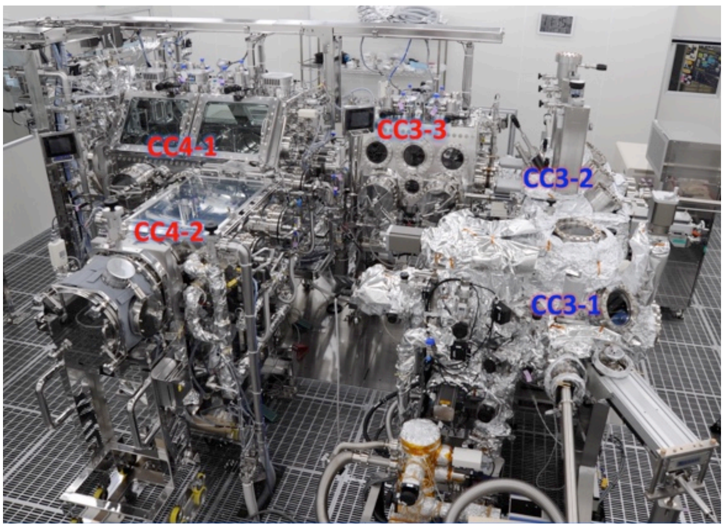

Fig. 2. A bird-view image of the sample-handling system for Ryugu samples. The system consists of five chambers; CC3-1, CC3-2, CC3-3, CC4-1 and CC4-2.