PRELIMINARY ANALYSES ON BULK AND INDIVIDUAL RYUGU SAMPLES RETURNED BY HAYABUSA2.

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Introduction: Hayabusa2 spacecraft, which accomplished successful touchdowns onto the Ryugu surface in Feb. and Jul. of 2019 [1, 2], returned its re-entry capsule encapsulating Ryugu's surface samples back to the Earth on Dec. 6, 2020.

The recovered sample container was immediately transferred to the Extraterrestrial Sample Curation Center of JAXA. It was cleaned on its outer surface, and its unnecessary parts were removed. Then it was introduced into the clean chamber (CC) to be evacuated. It was opened in vacuo and the sample catcher inside it was extracted and transported to the next CC. In the chamber, the lid of the chamber A of the catcher was removed and a few particles of mm-size were recovered in the vacuum condition. After the recovery, the catcher containing the rest of the samples was transported into the next CC and exchanged to be purged under purified N_2 condition. In the next three CCs of nitrogen condition, samples were recovered from the catcher into the sapphire dishes and analyzed for primary descriptions.

Analytical methods of initial descriptions on Hayabusa2 returned samples: Bulk samples in the sapphire dishes were analyzed for their weights with a balance, micrographs with an optical microscope, infrared spectra with a Fourier Transform Infrared Spectroscopy (FT-IR) and the MicrOmega, an infrared hyperspectral microscope developed by the Institut d'Astrophysique Spatiale, Université Paris-Saclay, CNRS, Orsay, France [3-6], and visible reflectance spectra with a six-bands visible camera [7]. After the descriptions of the bulk samples were completed, individual Ryugu particles of >1mm in size have been handpicked from the bulk samples into the small sapphire dishes using a vacuum tweezer and described in the same manner with the bulk samples. So far, more than 400 of individual particles have been handpicked and described. Hereafter, we mention to results of the optical microscopic observations and the FT-IR analyses.

Results of preliminary analyses on bulk Ryugu sample: Their results indicate that they are comparable to that of global Ryugu surface obtained by onboard infrared spectrometer NIRS3 [8], representing surface materials of Ryugu [9]. And they show spectral absorption features in 2.72μm, 3.1μm and 3.4μm, which correspond to OH, NH, and CH or carbonates, respectively, indicating presence of phyllosilicates, organics and carbonates in them [3-6, 9].

Results of preliminary analyses on individual Ryugu particles: Based on the optical observations using the microscope, individual Ryugu particles are classified into two groups of angular and rounded shapes (Fig.1a-b)[10]. Among 404 observed individual Ryugu particles excluding three apparent artificial contaminants, their occupancies are 4:6, respectively. The angular shapes of the particles might have result from their recent destruction on the asteroid's surface or during and/or after the sampling, whereas the round-shaped ones might not have experienced such destruction recently and preserved surfaces of regolith gardening on the asteroid's surface. Based on the surface morphologies of the individual Ryugu particles, they are classified into smooth and rough types (Fig.1a-b)). Their occupancies are 2:8, respectively. Those contain white inclusions and/or transparent crystals occupy ~12%, and those containing shiny areas account for ~23% (Fig.1c-d)).

Based on infrared reflectance spectra of individual Ryugu particles by the FT-IR, they show absorption features at 2.7 μm (deep), 3.05 μm, 3.4 μm, and 3.95 μm, corresponding to presence of hydroxyl (-OH), N-H rich compound, presence of carbonate in sub-mm scale or C-H rich compounds, and possible carbonates, respectively (Fig.2)[11]. Among 151 analyzed particles, those showing 2.7μm absorption occupy 100%, 3.05μm do 42%, 3.4μm for 62%, and 3.95μm for 40%. This indicates that hydrous minerals are ubiquitously distributed in Ryugu samples whereas abundances of organics and carbonates in them should be heterogeneous, or simply their absorption features are so weak that they might be scarcely detected in the small Ryugu particles.

Data archive and sample distributions: Those obtained data for the bulk and individual Ryugu samples are archived in the Hayabusa2 sample database [12]. The database for the Ryugu samples will be in public in the near future, to be useful for researchers applying for the announcement of opportunity (AO), which will start in early 2022. Any

researcher can apply for the AO, and Ryugu samples will be distributed to Principle Investigators (PIs) of the selected proposals in the middle of 2022.

References: [1] Watanabe S. et al. (2019) Science 364, 268. [2] Tsuda Y. et al. (2020) Acta Astron. 171, 42. [3] Pilorget C. et al. (2021) Nat. Astron. doi: 10.1038/s41550-021-01549-z. [4] Pilorget C. et al., this meeting. [5] Loizeau D. et al., this meeting. [6] Yogata K. et al., this meeting. [7] Yumoto K. et al., this meeting. [8] Kitazato K. et al. (2019) Science 364, 272. [9] Yada T. et al. (2021) Nat. Astron. doi: 10.1038/s41550-021-01550-6. [10] Miyazaki A. et al., this meeting. [11] Hatakeda K. et al., this meeting. [12] Nishimura M. et al., this meeting.

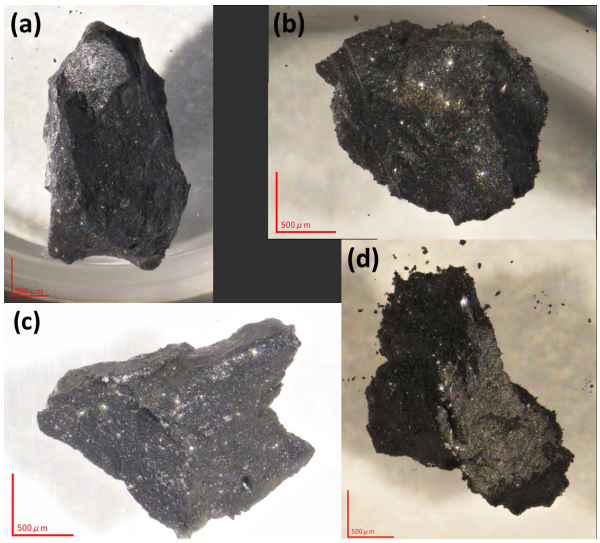

Fig. 1. Optical microscopic images of individual Ryugu particles. Each red scale bar denotes 500 μm. (a)A0005, an angular-shaped particle with smooth surface. (b) C0034, a round-shaped particle with rough surface. (c) A0163, an angular-shaped, smooth surface particle containing white inclusions. (d) C0079, an angular-shaped, rough surface particle containing shiny area.

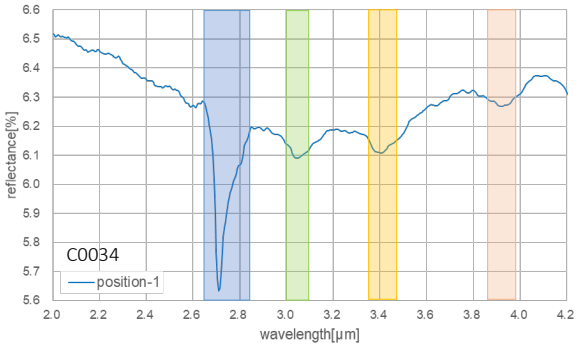

Fig. 2. An infrared reflectance spectrum obtained by the FT-IR for one of the individual Ryugu particles, C0034, also shown as Fig.1b in the optical microscopic image. A blue highlighted region denotes 2.7 μm deep absorption feature corresponding to O-H group, ubiquitously distributed in Ryugu samples. A green region denotes 3.05 μm absorption feature corresponding to N-H group. A yellow region denotes 3.4 μm absorption corresponding to carbonates and/or C-H rich compounds. A red region denotes 3.95 μm absorption corresponding to possibly carbonates.