PROGRESS REPORT OF INITIAL DESCRIPTION OF INDIVIDUAL RYUGU PARTICLES RETURNED BY HAYABUSA2.

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Introduction: Hayabusa2 spacecraft returned samples from near-Earth C-type asteroid 162173 Ryugu to the Earth on 6 Dec. 2020 [1]. Since the samples had been returned, we continue describing individual Ryugu particles for their images, weights, visible and infrared spectra with the optical microscope Nikon SMZ1270i, the balance Mettler-Toledo XP404s, the monochronic digital microscope Kiralux CS895MU with six-bands filters for incident light, the FT-IR Jasco VIR-300 and the infrared microscope MicrOmega, respectively [1, 2]. So far, 404 individual Ryugu particles have been handpicked and described for all or some of the methods [3-11].

Surface morphologies and bulk densities of individual Ryugu particles: As mentioned in [3, 4], individual Ryugu particles have been grouped into angular or rounded in their shapes and smooth and rough in their morprologues. In total, those having rounded-shape (59%) and rough-surface (80%) are dominant in them. The relationship with their optical morphologies and surface mineralogizes were confirmed for the four individual Ryugu particles with an electron microscope [12], indicating those showing smooth surfaces showing space-weathering features on their surfaces. Although it is still poor in statistics, surface morphologies might reflect their mineralogical feature such as space weathering. Bulk densities of individual Ryugu particles were calculated based on the volume estimated from their three-dimensional size and to be 1283 ± 231 kg m^{-3} in an average of 156 individual Ryugu particles [1]. All the bulk densities of 404 individual Ryugu particles were plotted in the viewgraph of [4], showing the same tendency as reported in [1]. As pointed before, individual Ryugu particles vary from 500 to 2500 kg m^{-3} in bulk densities, indicating their porosities should vary largely from particles to particles, or errors in volume estimation are large [8]. More accurate volume evaluation such as three-dimensional imaging [8] or X-ray computed tomography [13] should be applied more for individual Ryugu particles to reveal their “real” bulk and grain densities.

Infrared and visible reflectance spectra of individual Ryugu particles: So far, 244 of individual Ryugu particles have been analyzed for their infrared reflectance spectra with the FT-IR. 2.7μm absorption, corresponding to presence of -OH, have been detected from all of them, indicating ubiquitous presence of hydrous minerals in Ryugu samples. 3.4 μm absorption features, corresponding to presence of carbonate or -CH, have been detected from 48% of them. As pointed before [3], this should be partially due to their heterogeneous distribution of carbonate and/or organic components in them, and that the spectral feature in 3.4 μm is much weaker than 2.7 μm. It is difficult to detect spectral feature other than 2.7 μm for the particle comparable to or smaller than effective beam size of FT-IR, ~2 mm. The MicrOmega will help to detect minor spectral features from such small particles, even though there is limitation of number of analyses per day (2 individual particles per day). Visible spectra of individual Ryugu samples have been also analyzed with the digital microscope of muti-band filters [7]. The average spectrum of 69 individual Ryugu particles are comparable to that of bulk Ryugu samples, indicating there is no spectrally different particle among them. Due to the schedule of analyses, not all of the individual Ryugu particles have been analyzed for the visible spectra, but we should proceed the analysis to understand overall spectral features of Ryugu samples.

Ryugu sample database and international announcement of opportunity (AO) for Ryugu samples: All the obtained initial description data shown above is open in public by the Ryugu Sample Database System (https://darts.isas.jaxa.jp/curation/hayabusa2/) [14]. The first international AO is ongoing based on this database, and the samples will be distributed to principal investigators of selected research proposals from this June (see detail in https://jaxa-ryugu-sample-ao.net/). Additionally, the second AO will be released in this summer.

References: [1] Yada T. et al. (2021) *Nature Astron.* 6: 214. [2] Pilorget C. et al. (2021) *Nature Astron.* 6: 221. [3] Yada T. et al. (2022) *LPS LIII*, Abstract #1831. [4] Miyazaki A. et al. (2022) *LPS LIII*, Abstract #1816. [5] Hatakeda K. et al. (2022) *LPS LIII*, Abstract #1828. [6] Yogata K. et al. (2022) *LPS LIII*, Abstract #1767. [7] Yumoto K. et al. (2022) *LPS LIII*, Abstract #1326. [8] Yabe Y. et al. (2022) *LPS LIII*, Abstract #2371. [9] Pilorget C. et al. (2022) *LPS LIII*, Abstract #2088. [10] Carter J. et al. (2022) *LPS LIII*, Abstract #2017. [11] Loizeau D. et al. (2022) *LPS LIII*, Abstract #1495. [12] Nakato A. et al. (2022) *LPS LIII*, Abstract #1810. [13] Tsuchiyama A. et al (2022) *LPS LIII*, Abstract #1858. [14] Nishimura M. et al. (2022) *LPS LIII*, Abstract #1731.