

# FT-IR SPECTRAL CHARACTERISTICS OF RYUGU RETURNED SAMPLES AS A RESULT OF INITIAL DESCRIPTION IN JAXA CURATION.

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**Introduction:** A total of ~5.4 g of sample was collected at the surface of the C-type asteroid 162173 Ryugu and successfully returned to the Earth [1]. The collected samples were transported to the curation facility in ISAS, Sagami-hara, Japan, and stored in clean chambers with purified nitrogen, except for a few grains picked up under vacuum condition, to keep the samples as physically and chemically pristine as possible. Returned samples in Chamber A, uppermost centimeter-scale layer of Ryugu collected during the first touch-down sampling (TD1), and in Chamber C, surface to subsurface layer (~1 m) of Ryugu collected close to the artificial crater during the second touch-down sampling (TD2) were separately transferred to the “bulk” dishes made of sapphire glass with stainless steel container. Then, initial descriptions, such as weighing, optical imaging, FT-IR spectroscopy in 1-5  $\mu\text{m}$  range, MicrOmega as a hyperspectral NIR microscope, and visual multispectral imaging, have been performed [2][3].

Individual grains for each of Chambers A and C have been picked up from the bulk dishes, and initial descriptions were performed in the same manner as the bulk samples. Here we present the preliminary result of FT-IR spectral analysis for individual grains.

**System overview:** The FT-IR measurement system consists of the spectrometric unit (VIR-300, JASCO) and the sample chamber. The standard light generated in the spectrometric unit passes through the sapphire glass viewport and illuminates the sample in the sample chamber with an incidence angle of  $14^\circ$ , then reflects on the surface of the sample. A spot size of the incident light beam on the sample is approx. 1 mm diameter when the smallest aperture is used. Reflected light is detected by the InSb detector in the spectrometric unit cooled with liquid nitrogen. The sample chamber is connected to the clean chamber and kept in purified nitrogen condition so that samples can be measured without atmospheric and particulate contamination. The spectrometric unit is exposed to the air, and purified nitrogen is installed by flowing in the unit to reduce the influence of absorption in atmosphere.

**Measurement procedure:** Background spectrum was obtained using an Infragold. Immediately after the

background measurement, Infragold was measured as reference sample to confirm that the reflectance value was approx. 100%. The sample was placed under the light spot and measured. More than one area were measured when the sample was enough larger than the spot size. After the sample measurement, Infragold was measured again to check the influence of absorption in atmosphere.

**Influence of atmosphere and sample dish:** The background signal contains four absorption bands at 1.85  $\mu\text{m}$ , 2.6-2.8  $\mu\text{m}$ , 3.1  $\mu\text{m}$ , and 4.2  $\mu\text{m}$ . The former three bands indicate the presence of O-H originated from vapor water etc., and the latter one indicates the presence of C-O from  $\text{CO}_2$  in atmosphere inside the spectrometric unit. The same four absorption bands often appear in the spectrum of Infragold obtained after sample measurement. Depths of these absorption bands tend to increase with time after the background measurement probably because the atmospheric condition in the spectrometric unit changes with time from that at the background measurement.

Depending on the size and shape of the grains, the incident light beam partly reflects on the surface of a sample dish made of sapphire glass, which apparently affects the reflectance spectral feature from a sample. With increasing the effect of reflectance from a sapphire dish, reflectance in entire wavelength range increases, the spectral slope especially in wavelength of 1.0-2.5  $\mu\text{m}$  changes from positive to negative, and the absorption band depth decreases.

**Results and Discussion:** In total of 206 individual grains picked up by March 2021, spectral analysis was conducted using 119 grains, 65 from Chamber A and 54 from Chamber C, whose spectral features were less influenced by reflectance from a sapphire dish. In the measurable wavelength range of 1.0-5.0  $\mu\text{m}$ , we extracted the spectral range of 2.5-4.1  $\mu\text{m}$  for the analysis in this study, because the spectrum was highly disturbed by the effect of sapphire dish at 1.0-2.5  $\mu\text{m}$ , remarkably influenced by the absorption originated from atmospheric  $\text{CO}_2$  at 4.2  $\mu\text{m}$ , and very noisy at 4.5-5.0  $\mu\text{m}$ .

Reflectance spectra of Ryugu individual grains are highly homogeneous but with some variations in

absorption band depth. There are four absorption bands detected at 2.7, 3.05, 3.4, and 3.95  $\mu\text{m}$ . The deep asymmetrical band peaked at 2.7  $\mu\text{m}$  is typical characteristics of asteroid Ryugu, reported in the bulk sample analysis by FT-IR [2] and MicrOmega [3], and NIRS3 remote sensing data as well [4], indicating the presence of hydroxyl group (-OH). The band at 3.05  $\mu\text{m}$  is interpreted as N-H rich phase found in sub-millimeter scale components in bulk samples by MicrOmega [3]. The band at 3.4  $\mu\text{m}$  is also globally observed spectral feature in bulk samples and corresponds to both carbonate and C-H rich phase [2]. The band at 3.95  $\mu\text{m}$  is more prominent in individual grains than in bulk samples. The fact that the absorption band at 3.95  $\mu\text{m}$  always appears together with that at 3.4  $\mu\text{m}$  indicates the presence of carbonate.

Heterogeneity in reflectance spectra of individual grains is only observed in ~5% of total grains. One example is the spectra with strong absorption at 3.3-3.5  $\mu\text{m}$  and 3.9  $\mu\text{m}$  whose spectral profile well corresponds to that of carbonate. The other is the spectra with significantly high reflectance (more than 10%) and the spectral profile is variable depending on the grains. Both grains can be recognized in the optical microscopic images: the former is observed as white-colored inclusion, and the latter as metallic faced inclusion.

**Summary:** In spite of the effect of absorption in atmosphere and reflectance from sample dish, more than half of the individual grains could be used for FT-IR spectral analysis with keeping them in purified nitrogen condition. Reflectance spectra of individual grains showed high homogeneity and basically consistent with the bulk sample analysis by FT-IR and MicrOmega. Only a little heterogeneity (~5%) was observed and they were recognized as inclusions by optical microscopic images.

#### References:

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