The C-type asteroid Ryugu: A first detailed look by Phase2 Curation Kochi (Ph2K)

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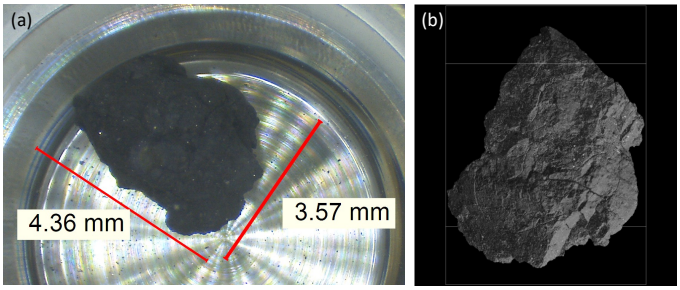
The Hayabusa2 spacecraft successfully returned to Earth surface materials from the C-type asteroid 162173 Ryugu on December 6th 2020. The sample capsule contained a large number of small grains (a few to several mm in size), collected from touchdown sites 1 and 2 on Ryugu, with a total mass of ~5.4 g [1, 2]. After initial characterization of the grains by JAXA curation (e.g., size, weight, FTIR and MicrOMEGA spectroscopic survey), we received eight grains (four from Room A and four from Room C) on June 17, 2021 (Figure 1 and Table 1). Detailed study of the materials returned from Ryugu will provide critical information about the origin and early evolution of the Solar System and in particular, the nature of the asteroid-meteorite connection, water-rock interactions on asteroids, the evolution of organics on small bodies, the diversity and history of asteroid families in the main belt.

Figure 1. Largest Ryugu sample (A0002) for the Phase 2 curation Kochi. (a) optical and (b) 3D-reconstruct images



On June 19, 2021, we started initial characterization studies of all our samples using synchrotron radiation-based CT and XRD at the SPring-8. An air-tight sealed carbon nano-tube sample holder was used for CT analysis. In order to avoid degradation and contamination due to interaction with the terrestrial atmosphere (water vapor and oxygen gas) [3], all of the sample preparation (chipping by a chisel, cutting by a counter balanced diamond wire saw, and epoxy mount preparation) was conducted in a glove box in an atmosphere of pure, dry N_2 (Dew point: -80 to -60˚C, O_2 ~50 to 100 ppm). Once we had acquired high-resolution, detailed three-dimensional structural and crystallographic information (0.85 µm/pixel for CT) for each of our samples, we were able to define a priority list for the next phase of the analytical campaign, which involved coordinated micro and bulk analysis.

The micro-analysis plan proposed by Ph2K involves the use of a wide range of multi-beam instruments to acquire detailed micro-textural and chemical information about the samples at a sub-micrometer scale. Ongoing studies have involved the use of FIB, STXM-NEXAFS, NanoSIMS and TEM [4]. In parallel, we are conducting bulk analysis of the samples using SEM-EDS, EPMA, Raman spectroscopy, XRD, large geometry type SIMS, high precision O isotopic analysis by laser fluorination and INAA. We have used air-tight containers (a facility-to-facility transfer container, FFTC [4]) for sample transportation to nation-wide institutes by hand carry. With the assistance UK embassy in Tokyo, a few representative grains were delivered to the Open University without any potentially invasive inspection (i.e., X-ray).

In this talk, we will present the preliminary results of the Ph2K coordinated micro-analysis and systematic bulk chemical analysis campaign, which is focused on providing a detailed understanding of these precious Ryugu returned samples.

References: [1] Morota T. et al. 2020. Science 368, 654–659. [2] Yada et al. 2021. Abstract#2008, 52nd LPSC. [3] Uesugi M. et al. 2020. Rev. Sci. Instrum. 91, 035107. [4] Ito M. et al., 2020. Earth, Planets and Space 72, 133.

Table 1. The Ryugu samples for the Phase2 curation Kochi

Sample No.	mg	µm	SPring-8	Microanalysis (STXM, NanoSIMS, TEM)	Bulk Analysis (SEM-EDS, EPMA, Raman)	High Precision O isotopes	SIMS	INAA	XRD
A0002	19.3	4,092	HR-CT, XRD, XRD-CT	Y				Y	
A0029	9.1	3,069	HR-CT, XRD, XRD-CT	Y	Y			Y	Y
A0037	7.8	3,129	HR-CT, XRD, Phase-contrast CT	Y	Y		Y	Y	Y
A0098	1.9	1,868	HR-CT			Y		Y	
C0009	11.1	3,520	HR-CT, XRD, XRD-CT	Y	Y		Y		
C0014	6.8	3,527	HR-CT		Y	Y			
C0068	1.68	1,980	HR-CT	Y	Y	Y		Y	
C0087	2	3.242	HR-CT			Y			Y