

Hayabusa2 returned samples: Unique and pristine record of Solar System materials from asteroid Ryugu

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The Hayabusa2 spacecraft successfully returned surface materials from the C-type asteroid 162173 Ryugu to Earth on December 6th, 2020. The sample capsule contained many small grains (a few to several mm in size), collected from touchdown (TD) sites 1 and 2 on Ryugu, with a total mass of ~5.4 g [1]. After initial characterization of the grains by JAXA curation [1, 2], eight Ryugu particles (approximately 60 mg), four from Chamber A and four from Chamber C, were allocated to the Phase2 curation Kochi team (Ph2K). The principal goals of the research are to elucidate the nature, origin, and evolutionary history of asteroid Ryugu, and to document the similarities to and/or differences from other known extraterrestrial samples, such as chondritic meteorites, interplanetary dust particles (IDPs) and returned cometary samples collected by the NASA Stardust mission.

On June 19th, 2021, we started initial characterization studies of the allocated particles using a synchrotron radiation-based CT and XRD at the SPring-8. An air-tight sealed carbon nano-tube sample holder was used for CT analysis. To avoid degradation and contamination due to interaction with the terrestrial atmosphere (water vapor and oxygen gas) [3], all 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 nitrogen. Once we had acquired high-resolution, detailed three-dimensional structural and crystallographic information (0.85 $\mu\text{m}/\text{pixel}$ 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 Ph2K's coordinated micro- and bulk analysis [4].

All petrological, mineralogical, isotopic and elemental characteristics [5-9] indicate that the allocated

Ryugu particles are remarkably similar to CI chondrites [10-11]. These findings are consistent with the results from the initial non-destructive examination of the Ryugu particles undertaken in a contamination-free and pure N₂ filled chamber at the JAXA curation facility [1, 2]. Using a combination of STXM-NEXAFS –NanoSIMS –TEM techniques, we have been able to establish the spatial distribution of organics with an aliphatic-rich carbon structure that are associated with phyllosilicates at sub-micrometer scale in the C0068-25 FIB section.

Systematic investigations as part of the first six months of Ph2K activity include studies of detailed bulk petrology, high-resolution mineralogy, high-precision O isotopic compositions of selected particles, and in-situ SIMS oxygen isotopic analysis of anhydrous and carbonate minerals. This work has provided powerful constraints on the origin and evolution of the materials collected from Asteroid Ryugu by the Hayabusa2 spacecraft.

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