Initial analysis of Hayabusa2 returned samples from asteroid (162173) Ryugu

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The JAXA's Hayabusa2 spacecraft explored C-type near-Earth asteroid (162173) Ryugu from June 2018 to November 2019, during which two touchdown operations were made to collect surface and subsurface samples. The Hayabusa2 delivered its reentry capsule on December 6, 2020 to Woomera, South Australia [1]. The sample container inside the reentry capsule was opened in the clean chamber system dedicated to Ryugu samples at ISAS, JAXA. Dark particles were found in both chambers A and C, which were used for the storage of the samples collected at the first and second touchdown, respectively. The total amount of the samples exceeds 5 g, which is much larger than the minimum requirement of 0.1 g [2]. Many millimeter-sized particles were present with fine powdery materials, and centimeter-sized grains, close to the maximum obtainable size [3], were found in the chamber C. The color, morphology, and spectroscopic features of the grains indicates that they well represent the surface materials of Ryugu.

The initial analysis of a fraction of returned samples, led by the Hayabusa2 project, has begun in June 2021 after the 6-month sample description at the ISAS curation facility without exposure to the air. The initial analysis aims at maximizing the scientific achievement of the project with answering important fundamental questions such as what materials Ryugu consists of, how Ryugu evolved from its formation to the present, and how similar or different Ryugu samples are to the known meteorites. The findings from Ryugu samples are expected to invoke cosmochemical discussion on the origin and evolution of the Solar System architecture such as the isotopic dichotomy in the early Solar System, the delivery of water and organics to the inner Solar System, and the asteroid-comet continuum. The initial analysis also aims at providing the ground truth for the remote sensing data obtained by the Hayabusa2 spacecraft.

The initial analysis team consists of six sub-teams for 1) chemistry (elements and isotopes) (Lead: Hisayoshi Yurimoto, Hokkaido University), 2) petrology and mineralogy of coarse grains (mm-sized grains [stone]) (Lead: Tomoki Nakamura, Tohoku University), 3) petrology and mineralogy of fine grains (<100 μm-sized grains [sand]) (Lead: Takaaki Noguchi, Kyoto University/Kyushu University), 4) volatiles (Lead: Ryuji Okazaki, Kyushu University), 5) insoluble organic matter (macromolecular organics) (Lead: Hikaru Yabuta, Hiroshima University), and 6) soluble organic matter (organic molecules) (Lead: Hiroshi Naraoka, Kyushu University). The total number of teams members is nearly 300 from fourteen countries. The initial analysis will continue for 12 months. The data obtained during the initial analysis will be archived in the JAXA curatorial sample database to prove the potential of the samples to the community.

Three hundred milligrams of Ryugu samples (6 % of the total samples by mass) have been allocated from JAXA to the initial analysis team; Twenty two grains, which were individually photographed, weighed, and spectroscopically examined in the clean chamber system, and ten aggregate samples that mainly consist of particles smaller than 1 mm in diameter (Table 1).

Table 1. Samples allocated to the Hayabusa2 initial analysis team.

Individual grains (Chamber A)	Individual grains (Chamber C)	Aggregates (Chamber A)	Aggregates (Chamber C)
A0026 3.9 mg	C0002 93.5 mg	A0104 0.3 mg	C0105 0.4 mg
A0040 3.0 mg	C0023 5.0 mg	A0105 4.0 mg	C0106 4.0 mg
A0055 5.9 mg	C0025 5.6 mg	A0106 38.4 mg	C0107 38.8 mg
A0058 3.3 mg	C0033 2.4 mg	A0107 31.0 mg	C0108 33.0 mg
A0063 3.8 mg	C0040 4.9 mg	A0108 3.5 mg	C0109 3.7 mg
A0064 6.7 mg	C0046 2.6 mg		
A0067 3.6 mg	C0055 0.8 mg		
A0080 1.4 mg	C0057 0.9 mg		
A0086 0.9 mg	C0061 1.3 mg		
A0089 1.0 mg	C0076 4.7 mg		
A0094 1.8 mg	C0103 1.5 mg		

The allocated samples have been individually investigated by each sub-team or by collaboration of multiple sub-teams. The C0002 grain from the chamber C is the third largest particle (~9 x 5 x 4 mm) among all the returned particles (Table 1). This grain has been analyzed by all six sub-teams.

In this presentation we discuss the goals and overall activities of the initial analysis of Ryugu samples. Preliminary results of elemental and isotopic analyses, mineralogical and petrological observation, and analyses of volatiles and organic components will be presented from each sub team at the meeting [e.g., 4–22].

References

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