Asteroid explorer, Hayabusa2, Press briefing

2021/6/17

JAXA Hayabusa2 Project Initial analysis team
ISAS Astromaterials Science Research Group

Sample transport container
(credit : JAXA)

Summary and contents of the press conference

Overview

- Since the return of the sample in December of last year, curation activities have been conducted for the initial analysis of the sample.
- Curation activities are aimed at cataloguing the sample without compromising the scientific value in order to provide information that contributes to further detailed scientific analysis.
- Today's report is that part of the catalogued sample is ready for delivery.

Contents

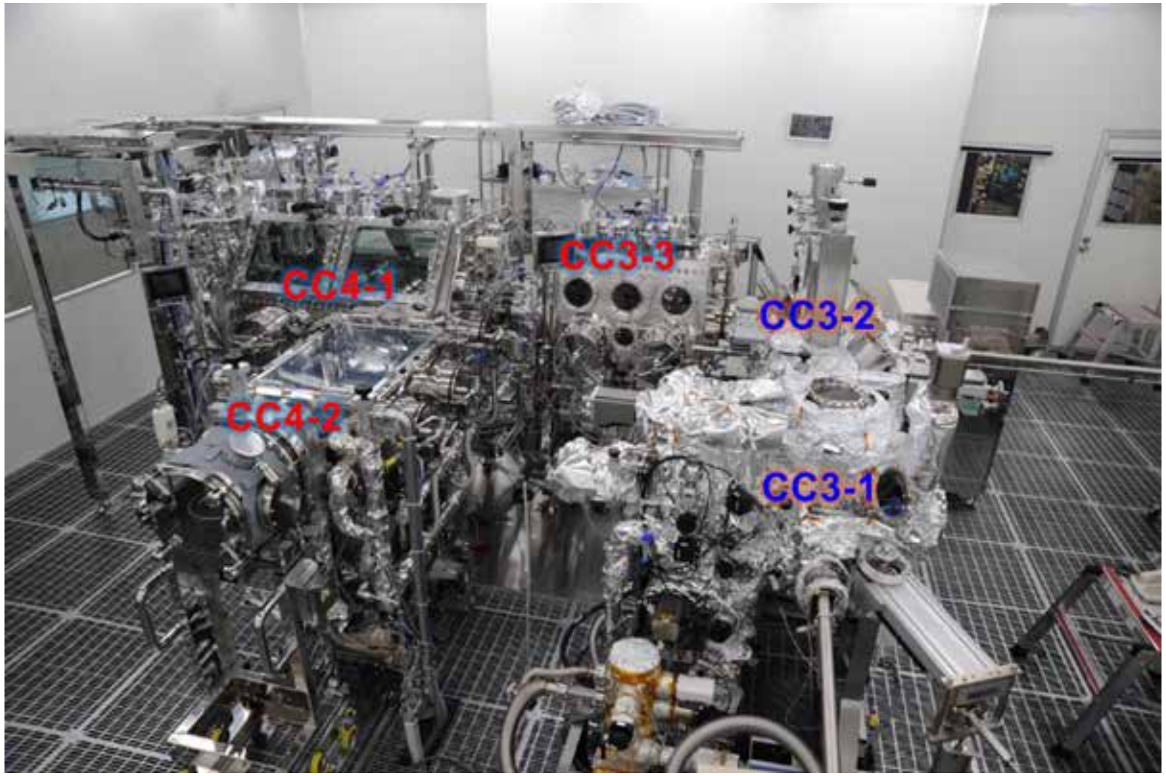
1. Report from the curation team (T. Usui, E. Nakamura, M. Ito)
2. Report from the initial analysis team （S. Tachibana・H. Yurimoto・T. Nakamura・T. Noguchi・R. Okazaki・H. Yabuta・H. Naraoka）

Report from the curation team

Tomohiro USUI（JAXA）
Eizo NAKAMURA（Okayama University）
Motoo ITO（JAMSTEC）

Ryugu sample curation work

The initial description of the Ryugu sample was performed without removing the sample from the clean chamber, in order to avoid contamination from the global environment

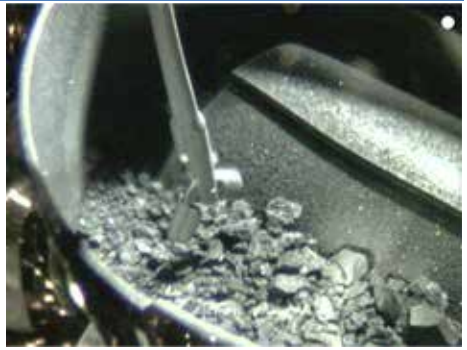


CC3-1 :
Opening the sample container under vacuum environment
CC3-2 :
Sample collection under vacuum
CC3-3 :
Transition from vacuum to nitrogen environment
CC4-1 :
Handling of submillimeter-sized particles
CC4-2 :
Handling / observation / sorting of relatively large particles (> mm)

Achievement of the world's first sample collection and storage of asteroid samples under vacuum conditions

Samples collected under vacuum on December 15, 2020 will not be distributed at this time, but continued to be stored under vacuum (CC3-2) for future analysis.

Moment when the vacuum storage sample was successfully collected (image from clean room camera)



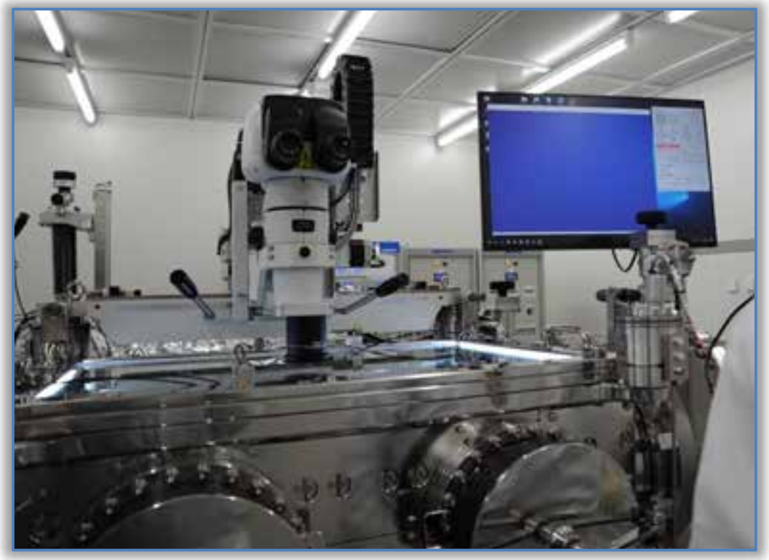
↑process of vacuum sampling

↓Vacuum collected particles

Initial description by curation team

Acquisition of information needed for sorting the samples for initial analysis and higher curation
Optical microscope image (colour, shape, size), spectroscopic data (mineral species), weight

Equipment set for the initial description in CC3-3 & CC4-2



Optical microscope

Weighing scale

Infrared spectrometer

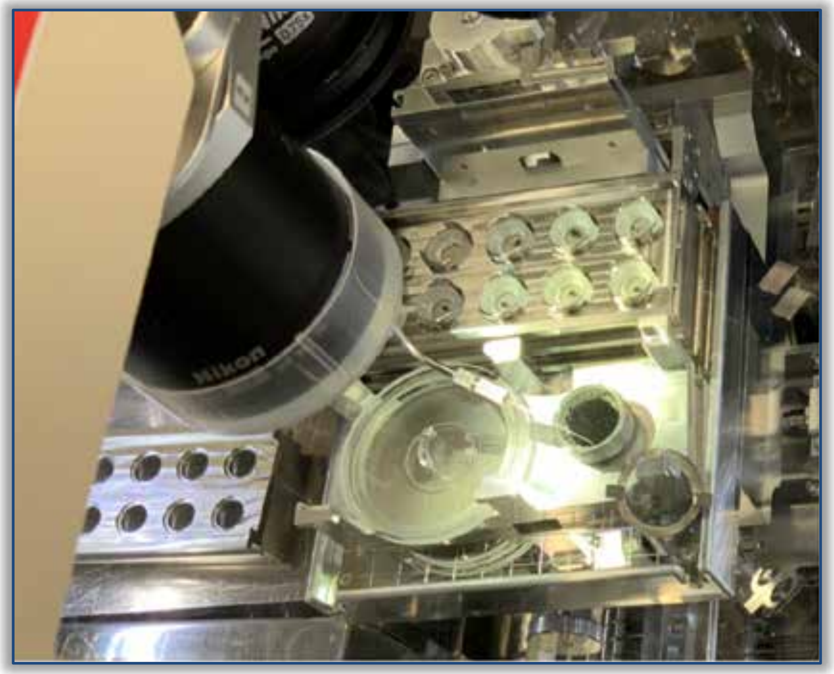
Infrared spectrometer microscope

(credit：JAXA)

Sorting of the aggregate and individual samples

- Large particles (203) are selected from chambers A and C and described individually
- Aggregate samples (sorted into 7 containers) are described for each container

Optical microscope image of the chamber A sample (before individual particle selection)

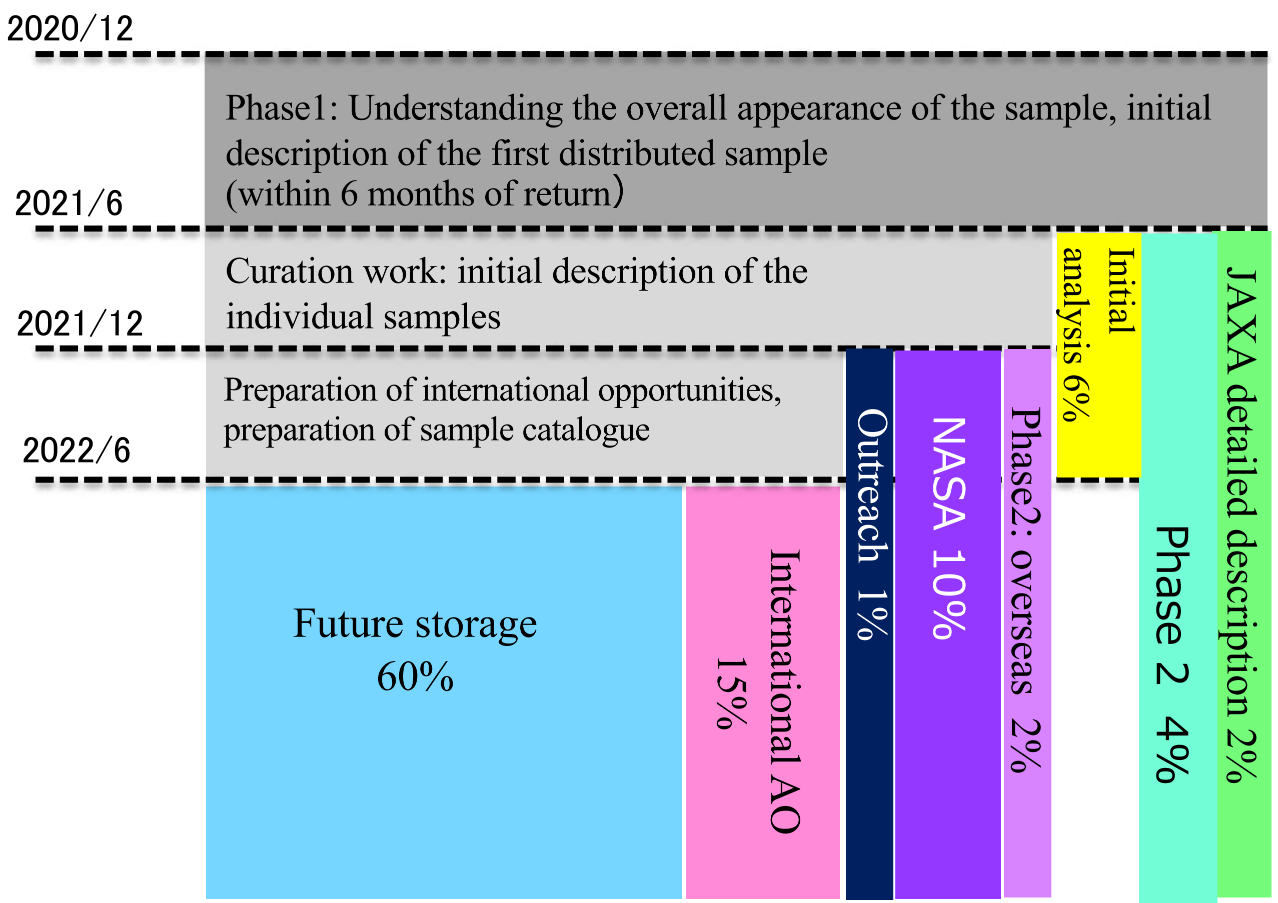


Sample sorting (image from outside the chamber)

Photo of individual particles

Sample quantity / distribution ratio / distribution schedule

（Approved by the Hayabusa-2 Sample Allocation Committee）



Total sample：~5.4 g

- Chamber A：3.2 g
- Chamber B：<0.1 g
- Chamber C：2.0 g
- Other：~0.2 g

Current sample distribution

Initial analysis：~0.3 g

Phase 2：~0.2 g

*All distribution is by weight %

Sample distribution

<u>5/31～6/28、samples distributed to the initial analysis team and Phase 2 team</u>

6/1: Stony material analysis team
Tomoki Nakamura（Tohoku Uni) (on left)

6/2: Chemical analysis team
Hisayoshi Yurimoto（Hokkaido Uni) (on right)

6/2: Phase2 curation Misasa team
Eizo Nakamura（Okayama Uni) (on right)

6/3: Sandy material analysis team
Takaaki Noguichi（Kyoto Uni/Kyushu Uni) (on right)

6/7: Organic macromolecule analysis team
Hikaru Yabuta（Hiroshima Uni）
(received by Tachibana, right)

6/15: Soluble organics analysis team
Hiroshi Naraoka（Kyushu Uni) (on right)

Curation team introduction

Curation：Returned sample characterizations・secure storage・allocation management・sample distribution to world-wide community＋research and development

＊JAXA is undertaking curatorial activities in cooperation with other institutes.

Phase-1@ISAS

Sample recovery・initial description （optical image, weight, size, shape etc.）・distribution

sample

sample

Initial detailed description, catalogue creation・Technology / R&D including storage . distribution

Phase-2 lead：Eizo Nakamura

Okayama University, Institute for Planetary Materials

higher-order detailed description data / provision of curation technology

- Establish analysis method based on the Comprehensive Analytical System for Terrestrial and Extraterrestrial Materials (CASTEM)
- Development and technology licensing of the Depository for References of Earth and Analytical Materials (DERAM).
- Provision of multi-element / isotope analysis and age data.

Phase-2 lead：Motoo Ito

JAMSTEC Kochi Institute for Core Sample Research

R&D for future and current curatorial work, Detailed characterizations of the samples

- R&D of universal sample holders for multi-analytical instruments under a none air exposure system.
- To acquire the detailed characteristics of the Ryugu samples without terrestrial contaminations.
- R&D of a linkage analysis (microbeam and bulk chemical) with multi-institute (NIPR, UVSOR, JASRI/SPring-8 etc.)

Initial detailed description, catalogue creation・Technology / R&D including storage . distribution

Future of JAXA's sample return exploration and curation

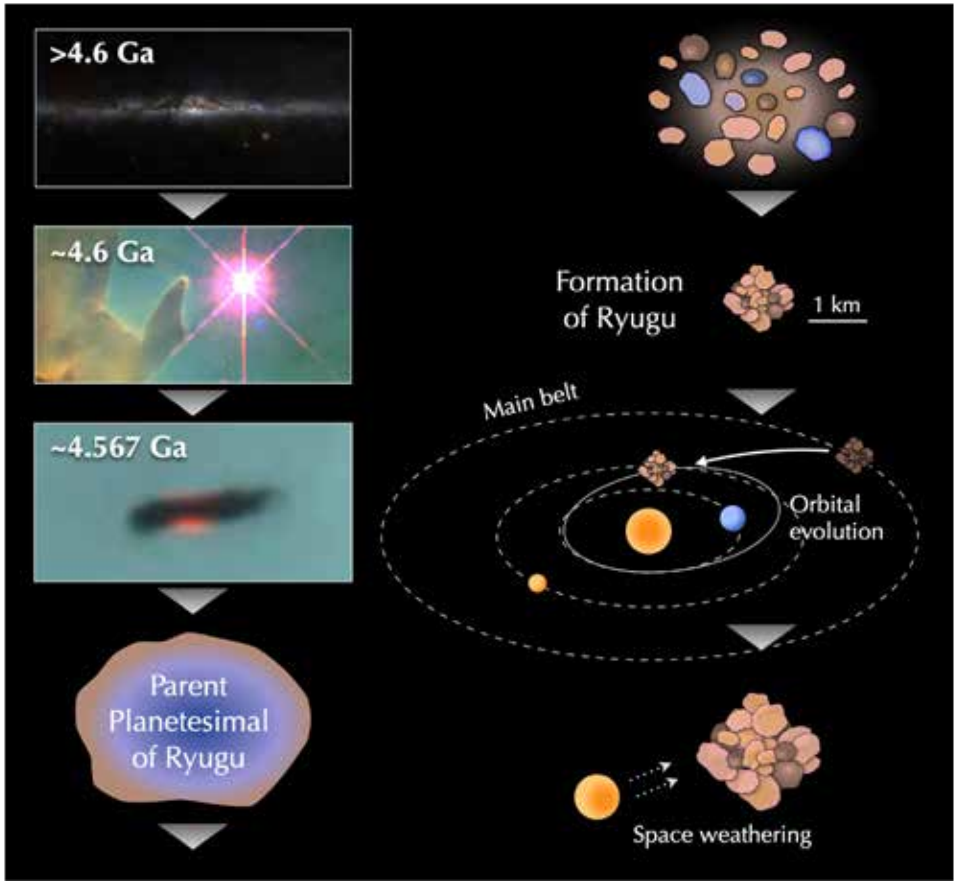
- Based on the experience gained from Hayabusa/Hayabusa2, JAXA has formed a partnership with NASA and other institutes for world leading exploration and curation activities in the 2020s.
- To continue to push the boundaries of sample return exploration, the **Martian Moons eXploration (MMX) mission will be launched in 2024 FY**, with the aim of **returning the first sample from the Martian sphere** during the 2020s.

Report from the initial analysis team

Shogo Tachibana（Tokyo U／JAXA）

Hisayoshi Yurimoto（Hokkaido U）・Tomoki Nakamura（Tohoku U）・
Takaaki Noguchi（Kyoto U）・Ryuji Okazaki（Kyushu U）・
Hikaru Yabuta（Hiroshima U）・Hiroshi Naraoka（Kyushu U）

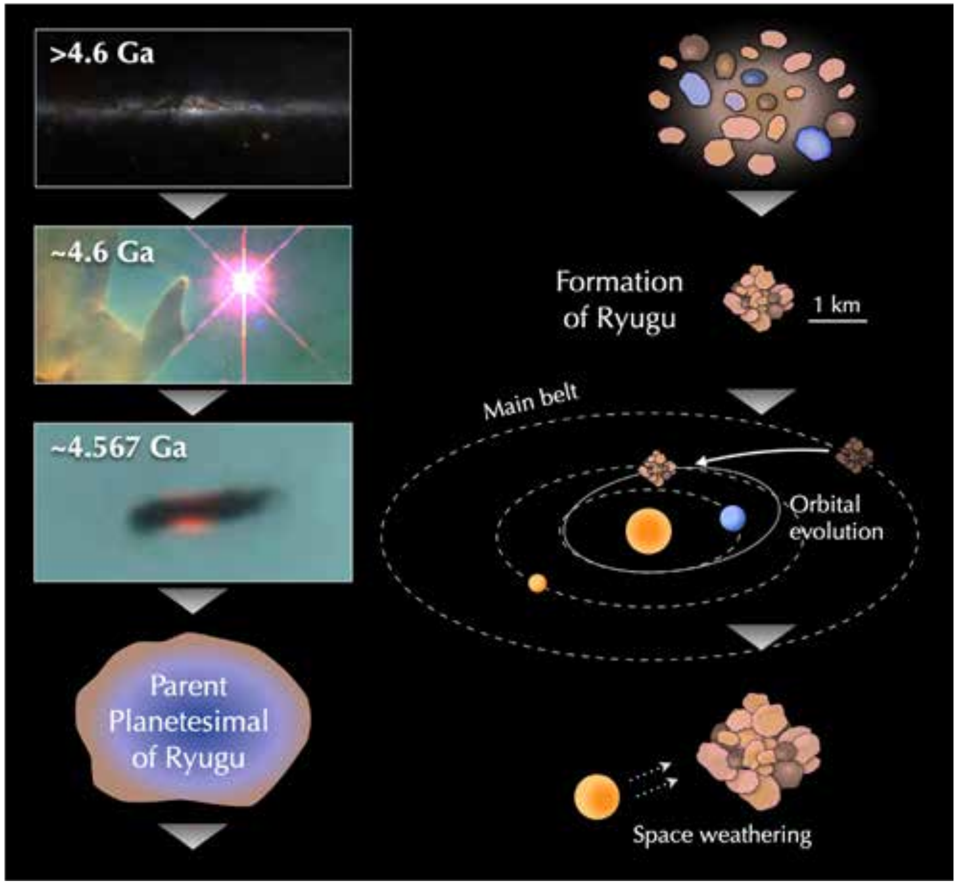
Initial analysis summary



(image credit Shogo Tachibana)

The Hayabusa2 project initial analysis team will conduct a one-year analysis, aiming to achieve results related to the scientific goals for the project, including the origin and evolution of the Solar System, the oceans on Earth and the raw materials for life.

Initial analysis summary



(image credit Shogo Tachibana)

・Supervisor	Shogo Tachibana（U. Tokyo）
・Chemical analysis team	Hisayoshi Yurimoto（Hokkaido U.）
・Stoney material analysis team	Tomoki Nakamura（Tohoku U.）
・Sandy material analysis team	Takaaki Noguchi（Kyoto U. / Kyushu U.）
・Volatile component analysis team	Ryuji Okazaki（Kyushu U. ）
・Organic macromolecule analysis team	Hikaru Yabuta（Hiroshima U.）
・Soluble organics analysis team	Hiroshi Naraoka（Kyushu U.）

109 universities and research institutes in 14 countries, 269 people.

Initial analysis team introduction

Chemical analysis team

Investigation of the chemical characteristics of the sample from Ryugu. For this, the bulk elemental and isotopic compositions are determined. Additionally, variations in the isotopic composition and the formation age of components within the sample are analyzed.

These results will allow clarification of the relationship between asteroid Ryugu and the types of meteorites that fall to Earth, and probe the formation and origin of Ryugu itself.

Fluorescent X-ray spectrometer for chemical composition analysis（©Rigaku, Horiba）

Thermal ionization mass spectrometer for isotope analysis and dating (© Tokyo Institute of Technology)

Isotope microscope for observing element and isotope distribution (© Hokkaido U)

Initial analysis team introduction

Stony material analysis team

Obtain the light reflection spectra of the coarse-grains recovered from the sample, and estimate the material distribution over the surface of asteroid Ryugu. Perform non-destructive material analysis using the synchrotron radiation high-energy beam and obtain the 3D internal structure and element distribution of the recovered sample. Observe the sample’s microstructure using a high-resolution electron microscope. Physical properties such as thermal conductivity are also measured.

Integrate all data to model the formation process of asteroid Ryugu.

World-wide synchrotron network

(image credit is from each institution)

Initial analysis team introduction

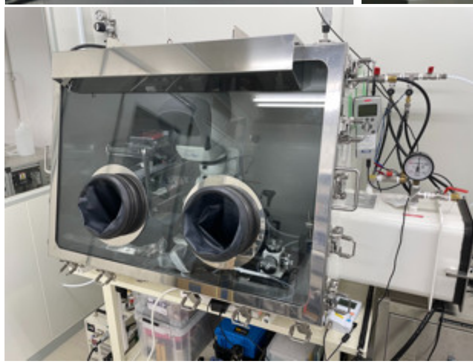
Sandy material analysis team

The surface of celestial bodies without atmospheres is directly exposed to outer space. The surface of Ryugu is therefore continuously exposed to the flow of plasma known as the solar wind that is constantly streaming from the Sun. Additionally, very small meteorites collide with the surface at speeds much faster than from rifles.

The sand material analysis team focuses on how the surface material on Ryugu changes when exposed to this harsh environment.

Sample processing will take place at Kyushu University and Kyoto University, where the sample will be observed with a transmission electron microscope, and the samples distributed to researchers in Japan and overseas to proceed with research.

Left: The latest plasma FIB sample processing observation device. Observe, analyze and process asteroids samples.
Right: A scanning transmission electron microscope used to investigate the kind of substances Ryugu is made from.
Both devices allow samples to be taken in and out without coming into contact with the atmosphere.



Glove box for handling samples without exposure to the atmosphere. This is filled with purified nitrogen gas before use.

Initial analysis team introduction

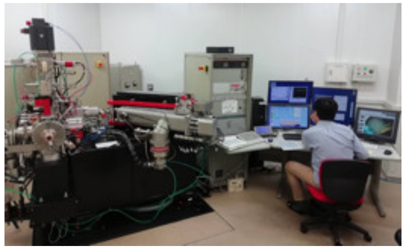
Volatile component analysis team

Analysis of the elemental and isotopic compositions of the volatile substances enclosed within the Hayabusa2 sample catcher and the volatiles within the Ryugu solid sample. Through analyzing the various volatile substances such as hydrogen, nitrogen, oxygen, and noble gases, we will obtain information on the origin and geological age of the parental materials of Ryugu.

The Ryugu solid samples will be analyzed without exposure to the atmosphere at domestic and overseas research institutes, with the aim of obtaining 'raw' information about Ryugu. Additionally, neutron irradiation at Kyoto University Research Reactor Institute for Nuclear Science allows trace element analysis, such as iridium, and Ar-Ar age. Through these combined analyses, we will obtain a variety of material science information from these valuable samples at the same time.

Neutron irradiation / trace element analysis
（©Kyoto U. /
Research Reactor Institute)

Light element isotope analysis
（©U. Tokyo, Atmosphere and Ocean Research Institute)



Rare gas isotope analysis
（©Kyushu U. ）

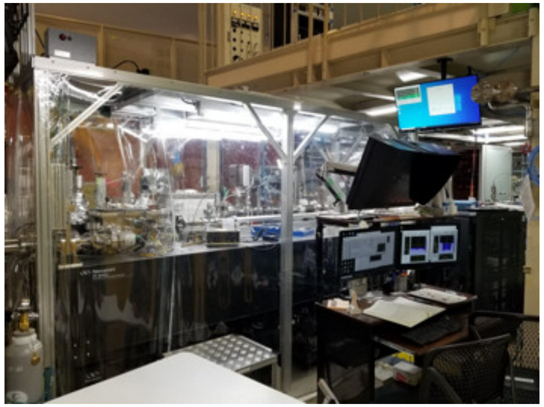
Initial analysis team introduction

Organic macromolecule analysis team

In order to understand the formation process of the the life's building blocks in the early Solar System, the molecular and isotopic compositions and the distributions of the organic macromolecules in the asteroid Ryugu samples will be investigated through combining a variety of microspectroscopy techniques (infrared, Raman, synchrotron soft X-ray), electron microscopy and isotope microscope.

We aim to understand the diverse origin and evolution of extraterrestrial organic matter by observation of the chemical heterogeneity of the organic macromolecules from the intact (unprocessed) asteroid samples. Analysis of the insoluble organic matter that is recovered by acid treatment of the asteroid sample will reveal the bulk composition of the organic macromolecule, which characterizes Ryugu.

Organic macromolecular solids purified by acid treatment of carbonaceous chondrites. The chemical history of the early Solar System is recorded in its complex molecular structure (photo: Yabuta).



Synchrotron-based scanning transmission X-ray microscopy（BL19A, Photon Factory, KEK, Tsukuba, Ibaraki, Japan）

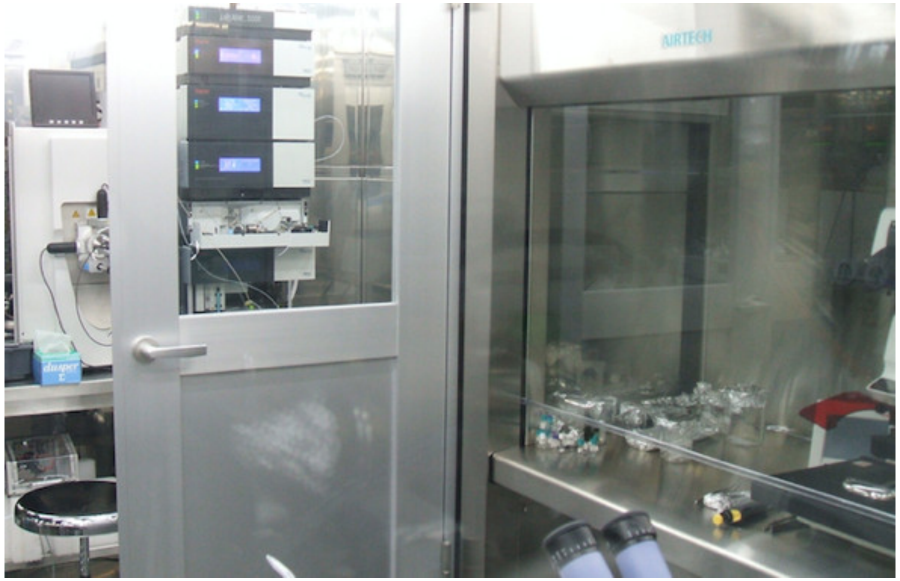
With a high spatial resolution of about 30 nm, one can reveal the functional group chemistry of the submicron-sized organic matter (Photo: Yabuta)

Initial analysis team introduction

Soluble organics analysis team

The kinds of organic compounds are clarified in asteroid Ryugu.

Samples are extracted with a variety of solvents, and organic molecules are identified and quantified using mass spectrometry coupled with chromatography. The main target compounds are amino acids and nitrogen-containing cyclic compounds, but all detectable molecules are comprehensibly analyzed by ultra-high resolution mass spectrometry. Additionally, the spatial distribution of soluble organic compounds and the abundance and isotope ratio analysis of carbon, nitrogen, sulfur etc., will be determined. This is conducted by an international collaborative research team in Japan, the US, Germany and France.

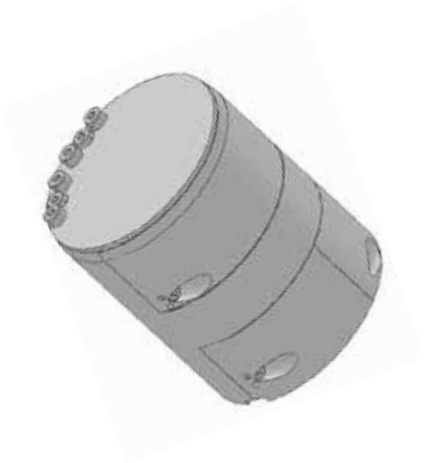


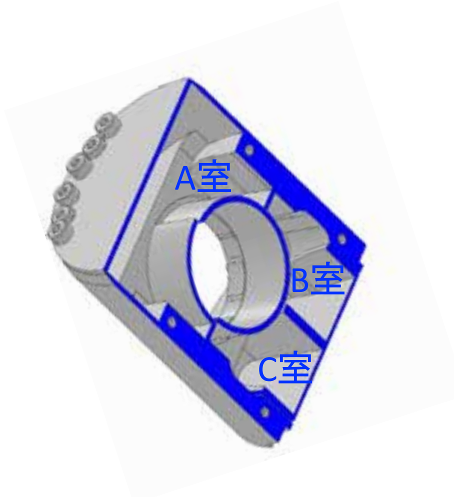
Kyushu University clean room and liquid chromatograph-high resolution mass spectrometer (top) and rehearsal analysis (bottom)

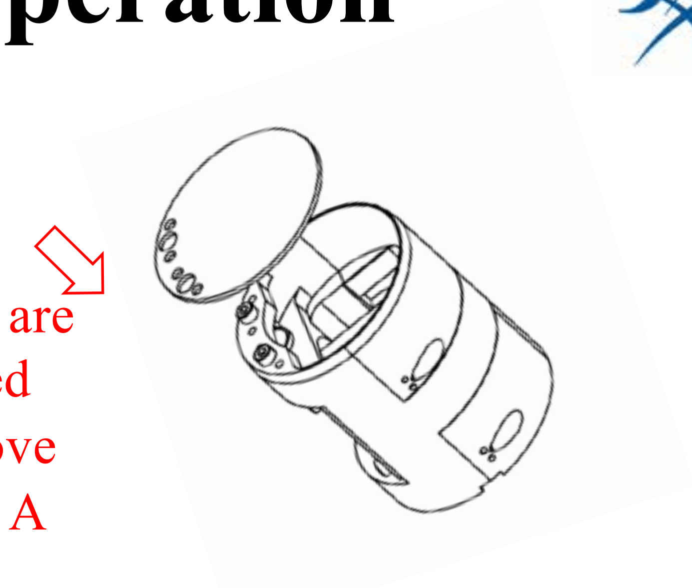
（image credit：Kyushu University）

Reference

Catcher opening operation







- The sample catcher was moved to clean chamber CC3-2, and the lid of sample catcher chamber A was opened in vacuum conditions.
- Many particles are confirmed to be in chamber A. This is thought to be the sample collected during Touchdown #1 on Ryugu.
- Part of the sample was picked up in Chamber A to be stored in vacuum in its present condition.
- From here, we will move to chamber CC3-3, remove the samples from chamber A in a nitrogen environment, and open chambers B and C.

（image credit：JAXA）

MMX <https://www.mmx.jaxa.jp/>

Uncovering the origin of life, Advancement from Hayabusa2

Martian Moons eXploration (MMX): A crucial mission in JAXA's small-celestial-body exploration strategy following Hayabusa 1 and 2. Samples from the Martian moon, Phobos, will investigate the transport of water and organic materials through the Solar System, and explore how life and habitable environments were created.

Bringing back Mars samples, Collaboration with NASA Perseverance

In addition to the Phobos samples, in JFY2029, MMX will bring back samples from Mars itself that were ejected from the Mars surface in meteorite impacts and deposited on the surface of Phobos. Originating from all over the Mars surface, these samples are expected to complement the samples collected by the NASA Perseverance Rover from the Jezero region.

Pioneering crewed Mars exploration, Phobos as a bridgehead to Mars

MMX will explore the possibility of using Phobos as a natural space station by establishing the technology required for a round-trip to the Martian sphere--essential for crewed Mars exploration--and by conducting detailed observations of Phobos's surface topography, ground information, and surface and surrounding environment.