Guidebook for proposers responding to the Announcement of Opportunity for Ryugu and Bennu samples, 2025

February 2025

The Astromaterials Science Research Group (ASRG) of JAXA will handle the Announcement of Opportunity (AO) with a peer-review process in which Ryugu and Bennu sample investigation proposals will be selected. This guidebook is intended to help researchers who plan to submit proposals in response to the AO.

This AO marks the first opportunity for JAXA to allocate the Bennu sample. Proposers can request both Ryugu and Bennu samples simultaneously with a single proposal. This AO encourages comparative studies between the Ryugu and Bennu samples.

Key milestones

- Call for proposals for the AO: February 7, 2025
- Deadline for Notice of Intent to propose (mandatory): February 26, 2025 (UTC 23:59)
- Deadline for submission of sample requests: March 18, 2025 (UTC 23:59)
- Decision announcement: Late June, 2025
- Sample distribution: July, 2025

Related Links

- AO Web Site: https://curation.isas.jaxa.jp/ao/
- Ryugu Sample Database System: https://darts.isas.jaxa.jp/app/curation/ryugu/
- Bennu Sample Database System (by JAXA): https://darts.isas.jaxa.jp/app/curation/bennu/
- Reference list of Ryugu sample analytical results: https://curation.isas.jaxa.jp/publications/ryugu/

Contact Information

For inquiries or assistance regarding the AO, please contact the AO Administration Office: jaxa-curation-ao@jaxa.jp

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1. Background of the Ryugu Sample

1.1 The Hayabusa2 mission and its scientific goal

The Hayabusa2 spacecraft brought back surface samples of a near-Earth C-type asteroid (162173) Ryugu in December 2020. C-type asteroids have reflectance spectra that are similar to carbonaceous chondrites, and are therefore highly likely to record the long history of the solar system from the beginning to planet formation including the supply of volatiles to terrestrial planets. Hence, the main scientific goals of the Hayabusa2 mission are to carry out investigations of (I) the origin and evolution of the solar system and (II) the formation process(es) and structure of the asteroid. To fulfill the scientific objectives, a tight linkage between on-site geologic observations (kilometer to millimeter scale) and returned sample analyses (down to atomic scale) is crucial. The scientific instruments on board the spacecraft at the rendezvous were a laser altimeter (LIDAR), a multi-band telescopic camera (ONC-T), wide-angle cameras (ONC-W1 and -W2), a near-infrared spectrometer (NIRS3), a thermal infrared imager (TIR), a small carry-on impactor (SCI), a deployable camera (DCAM3), a sampler (SMP), and a lander (MASCOT).

1.2 Overview of proximity operations at Ryugu

Hayabusa2 explored Ryugu for seventeen months (June 2018–November 2019) including two landing operations for sample collection. Ryugu (mean radius of 448 ± 2 m) has a retrograde rotation with a period of 7.6326 hours and an obliquity of 172° (Watanabe et al., 2019). It has a distinct spinning-top shape with an equatorial ridge (diamond-shaped lateral profile and circular as viewed top down). Its bulk density of 1.19 ± 0.03 g cm^{-3} suggests that Ryugu is a rubble-pile body with a large macro-porosity of ~50–60 % considering a typical density of carbonaceous chondrites. Many decameter-sized boulders, which are too large to be impact ejecta from craters found on Ryugu, are present at the surface with a number density twice as large as that of Itokawa, and no smooth terrain like Muses Sea on Itokawa is found (Sugita et al., 2019). The abundant large boulders on the surface also suggest that Ryugu is a rubble-pile body.

The surface has a very low geometric albedo (~0.02) (Sugita et al., 2019), darker than most of the meteorite samples in the terrestrial collection, and shows a weak but ubiquitous 2.72-μm absorption feature related to O-H vibration in hydrous minerals (Kitazato et al., 2019). The absorption feature at 2.72-μm is weaker than that of hydrated carbonaceous chondrites.

The in-situ observation of the Ryugu surface by the MASCOT lander showed that the surface is not covered with fine regolith particles (Jaumann et al., 2019) and that a ~3-cm pebble has a thermal inertia of ~280 J m^{-2} K^{-1} $s^{-1/2}$, which is much lower than chondritic meteorites (Grott et al., 2019). Thermal imaging of the surface also suggested low thermal inertia of surface boulders (Okada et al., 2020).

Hayabusa2 made its first landing operation on the equatorial ridge on February 22, 2019 to collect surface samples. The second landing operation was close to the artificial crater made by the small carry-on impactor (Arakawa et al., 2020) on July 11, 2019 to collect both surface samples and impact ejecta that contain sub-surface samples. A 5-gram tantalum projectile was shot through a 1-m long sampler horn at an impact velocity of 300 ms^{-1} at the contact time of each touchdown, triggered by bending and/or shrinkage of the sampler horn (Sawada et al., 2017). The firing of projectiles was confirmed for the two landing operations through the temperature rise near the projector due to firing. The ejecta is transferred into a sample catcher through an extendable sampler horn and a conical horn under a microgravity condition.

The sample catcher of Hayabusa2, located at the top end of the conical horn, has three chambers to store samples separately, as acquired at different surface locations (Sawada et al., 2017). A rotatable inlet, connected to the conical horn, was rotated after the first landing operation to change the chamber for sample storage.

On August 26, 2019, the sample catcher, inside which all chambers were closed, was transported into the sample container inside the Earth reentry capsule and sealed. The container sealing method adopted for Hayabusa2 is an aluminum metal seal, where the sample catcher is sealed in the sample container by deformation of the curved surface lid with the edge of the sample container (Okazaki et al., 2017).

1.3 Reentry capsule retrieval operation

Hayabusa2 delivered the reentry capsule to Earth on December 6, 2020. The landing area of the capsule was determined by receiving a beacon signal transmitted from the capsule using five antennas installed at different locations along the reentry path. The Marine radar systems and two Drones were also used for the location of the capsule, the heat shields, and the parachute.

The reentry capsule was located nearby the parachute, which was found from helicopter observation. A safety check of the capsule was first completed at the landing location because pyrotechnic devices were used for the parachute deployment and separation. No damage to the capsule was observed, and the capsule was transported back to the Quick Look Facility (QLF) in the Woomera Range Complex with permission from the Range Safety Officer.

The sample container was carefully taken out of the reentry capsule at the QLF. The temperature monitor attached to the sample container indicated that the container was never heated over 65°C, which is lower than the maximum daytime temperature at the Ryugu surface.

The container was cleaned in the clean booth at the QLF and was installed onto the Hayabusa2 GAs Extraction and Analysis system (GAEA). After overnight evacuation of the vacuum line of GAEA, on December 7 the bottom of the sample was pierced with a tungsten carbide needle to release sample volatile components held inside the sample container. The container was in vacuum, indicating the container seal held during reentry and therefore little to no terrestrial contamination had occurred. The gas extracted from the sample container was split into four gas tanks at room temperature, and the residual gas in the system was then trapped into two gas tanks cooled at liquid nitrogen temperature. A fraction of the gas was analyzed by a quadrupole mass spectrometer. The sample container was put into a nitrogen-purged anti-vibration transportation box and was safely transported to ISAS/JAXA on December 8, 2020 (~57 hours after the capsule landing).

1.4 ISAS Curation facility for the Hayabusa2 samples

The policy of sample curation is that all the materials (gases, dust, rock) returned from Ryugu are stored, handled, and allocated to maximize the scientific information extracted during sample analysis. Under this policy, the Haybabusa2 curation facility in the JAXA Extraterrestrial Sample Curation Center (ESCuC) aims to produce a sample catalog with basic sample information (e.g., size, shape, weight, optical images, and NIR spectroscopic data) to enable allocation of the most appropriate materials without degrading the sample characteristics. The Hayabusa2 curation system, situated in a Class-1000 cleanroom at ESCuC, consists of five chambers: 1) CC3-1 for opening the returned container in vacuum, 2) CC3-2 for vacuum handling of samples, 3) CC3-3 for changing the handling environment from vacuum to purified nitrogen gas, 4) CC4-1 for retrieving the samples in the container, and 5) CC4-2 for processing and observing samples in a purified nitrogen gas environment. CC-4-2 is equipped with an optical microscope and an FTIR spectrometer. An infrared hyperspectral microscope (MicrOmega provided by CNES) is attached at CC3-3.

1.5 Sample container opening operation and initial sample description

The Hayabusa2 sample container remained sealed with the metal-to-metal sealing system. The container lid was pressed against the container edge with a pressure load of ~2700 N through pressure springs. To open the container in the clean chamber designed to receive the Hayabusa2 samples in vacuum, the container was installed into the container opening system. The pressure springs and the outer lid with latches were then taken apart from the container while keeping the pressure load constant. The container with the opening system was attached to the clean chamber (CC) 3-1, designed to maintain the Hayabusa2 returned samples in vacuum, on December 11.

After CC3-1 was evacuated to reach a high vacuum (<10^{-5} Pa), the container was opened on December 14 inside CC3-1 under a static vacuum condition while monitoring the chamber atmosphere with a quadrupole mass spectrometer. The chamber was re-evacuated after the container opening, and the sample catcher, where samples are supposed to be stored, was taken out of the container using the opening system. Black powdery materials were observed at the bottom of the container. These are most likely to be residual particles from the sampler catcher.

The extracted sample catcher was rotated in CC3-1 to place chamber A in the up-position and transferred to CC3-2, which was also kept under vacuum. CC3-2 was isolated by closing a gate valve between CC3-1 and CC3-2. The chamber A cover was cleaned with a Teflon spatula. Screw bolts of the cover were removed with a hex key rotation system, and the cover was taken apart with an electrostatic chuck system. Two particles inside chamber A (a few mm in size) were picked up from those samples with a sample picking tool in vacuum and put into a quartz glass dish for further storage under vacuum in CC3-2. After picking a couple of particles, chamber A was covered with a quartz glass to transport to CC3-3.

After the transfer of the catcher to CC3-3, CC3-3 chamber was isolated by a gate valve and purged slowly with purified nitrogen. Further handling of the sample catcher and samples was performed in pure nitrogen gas using Viton-coated butyl gloves.

The catcher was then transferred to CC4-2 through CC4-1 to measure the weight with a microbalance. Based on the design weight of the catcher and a tare weight of an attached jig, the total weight of samples inside the catcher is determined to be ~5.4 g. The catcher was then transferred back to CC4-1, where the catcher was dismantled to recover samples from chambers A, B, and C. Particles in chamber C included cm-sized pebbles as well as metallic particles. Particles smaller than 1 mm were also observed in chamber B. The samples in each chamber were separated into sapphire glass dishes.

The samples in each dish were weighed and photographed, followed by non-destructive spectroscopic observation in the visible to near-infrared wavelength range. A MicrOmega spectroscopic imager, which is identical to that onboard the MASCOT lander, was also used for spectroscopic observation in the near-infrared wavelength range. The optical observation with ONC-T filters was also carried out to obtain multi-band images of the bulk samples. After the initial description of the samples in the dishes, individual pebbles and particles were picked up from the bulk samples with a vacuum tweezer for further description.

1.6 Particles in the sample container

The initial description of the samples inside the sample container by the ISAS/JAXA curation team found that the samples have the following characteristics: (1) Particles were found in two separate chambers used for the two landing operations at Ryugu, indicating that the samples at the different surface locations were obtained successfully; (2) The particles were black in color, consistent with the color of Ryugu boulders (Sugita et al., 2019); (3) Millimeter- to centimeter-sized pebbles are present. One centimeter-sized grain, close to the maximum obtainable size (Sawada et al., 2017), was found in the sample obtained during the second landing operation nearby the artificial crater; and (4) The total weight of the sample exceeds 5 g, which is far more than the mission requirement of 0.1 g (Tachibana et al., 2014). All the sample characteristics suggest that the Hayabusa2 sampler system worked efficiently and effectively to collect representative surface samples of Ryugu.

There were a few metallic materials, most likely to be pure aluminum metal that was used for the sampler system. Because the sample container and the sample catcher are made of aluminum alloy, the incorporation of pure aluminum metal from the sampler system is distinct and will not have a large impact on the returned samples.

1.7 Analytical results of Ryugu samples

Analysis of Ryugu particle by the curation team and the initial analysis team has shown that the returned sample well represents the surface of Ryugu from spectroscopic and morphological points of view (Yada et al., 2021; Pilorget et al., 2021; Tachibana et al., 2022) and that Ryugu, belonging to one of the most common asteroid groups, is a parent body of CI chondrites that are the least fractionated from the Sun's elemental abundance but the rarest group of carbonaceous chondrites (e.g., Yokoyama et al., 2022; Nakamura et al., 2022). It has also been found that CI chondrites on the Earth suffered alteration in the Earth's surface environment since their fall, and the Ryugu sample is recognized as the freshest (terrestrial weathering-free) CI-type material.

Details of the analytical results can be found in the following papers:

Yada, T., et al. (2021). *Nature Astronomy*, https://doi.org/10.1038/s41550-021-01550-6

Pilorget, C., et al. (2021). *Nature Astronomy*, https://doi.org/10.1038/s41550-021-01549-z

Tachibana, S., et al. (2022). *Science*, https://doi.org/10.1126/science.abj8624

Yokoyama, T., Nagashima, K., et al. (2022). *Science*, https://doi.org/10.1126/science.abn7850

Nakamura, E., et al. (2022). *Proceedings of the Japan Academy, Ser. B*,
https://doi.org/10.2183/pjab.98.015

Nakamura, T., et al. (2022). *Science*, https://doi.org/10.1126/science.abn8671
Okazaki, R., et al. (2022a). *Science*, https://doi.org/10.1126/science.abo0431
Okazaki, R., et al. (2022b). *Science Advances*, https://doi.org/10.1126/sciadv.abo7239
Ito, M., et al. (2022). *Nature Astronomy*, https://doi.org/10.1038/s41550-022-01745-5
Noguchi, T., et al. (2023). *Nature Astronomy*, https://doi.org/10.1038/s41550-022-01841-6

The latest reference list of Ryugu sample analytical results is available:
https://curation.isas.jaxa.jp/publications/ryugu/.

2. Background of the Bennu Sample

2.1 The OSIRIS-REx mission and Bennu sample

OSIRIS-REx (Origins, Spectral Interpretation, Resource Identification, Security-Regolith Explorer), NASA's third New Frontiers mission, is a sample return mission that retrieved pristine carbonaceous regolith from the B-type near-Earth asteroid (101955) Bennu (2016–2023).

Bennu is a ~500-meter-sized asteroid with a spinning top shape (Lauretta et al., 2019a). The presence of many large boulders and a low bulk density (1.19 ± 0.013 g cm–3) of Bennu suggest that it is a rubble-pile body (Lauretta et al., 2019a). The surface appeared to be compositionally diverse. Two major populations of boulders have been identified: dark boulders with normal reflectance values of 3.5–4.9% and bright boulders with normal reflectance values of 4.9–7.4% (DellaGiustina et al., 2020). Some boulders feature bright veins attributed to the presence of carbonates (Kaplan et al., 2020). Ejection of 1–10 cm particles from Bennu's surface occurred several times, indicating the active nature of its surface (Lauretta et al., 2019b). Sample collection was conducted at the Nightingale site, located in the 20-meter-diameter Hokioi crater, on October 20, 2020 (Lauretta et al., 2022). The crater appears to be one of the younger craters on Bennu and is situated in the mid-latitude region, where the daytime peak surface temperature (~360 K) is lower than at the equator (~390 K) (Lauretta et al., 2022). Spectroscopic observations showed the presence of hydrated phyllosilicates, magnetite, organic molecules, and carbonates at this site (Lauretta et al., 2022 and references therein).

The Touch-and-Go Sample Acquisition Mechanism (TAGSAM) was used for sample collection. One second after contact with Bennu's surface, nitrogen gas was released from the TAGSAM head, fluidizing surface material and guiding it into the collection chamber (Lauretta et al., 2022). By the time the spacecraft began retreating from the asteroid, the TAGSAM head had penetrated 48.8 cm into the subsurface. In addition to the bulk samples stowed in the collection chamber of the TAGSAM head, fine particles from the asteroid's surface were captured using 24 "contact pads" made of stainless-steel Velcro® on the TAGSAM baseplate (Lauretta, Connolly et al., 2024).

2.2 Bennu sample curation

The Sample Return Capsule (SRC) landed at the Utah Test and Training Range on September 24, 2023. The SRC was transported to a temporary cleanroom, where the science canister was extracted. The canister was then stored in a high-purity nitrogen purge environment (Lauretta, Connolly et al., 2024).

The canister was transported to the OSIRIS-REx cleanroom at Johnson Space Center (JSC), NASA the day after the SRC landing. Upon opening the canister on September 26, dark powder and sand-like particles were observed on the exterior of the TAGSAM head and the canister lid. The OSIRIS-REx Sample Analysis Team (SAT) collected particles from the avionics deck for "quick-look" (QL) analysis. The curation team then collected particles from the top of TAGSAM's Mylar flap and retrieved the samples from the collection chamber by holding down the Mylar flap. After completely disassembling the TAGSAM head, the curation team continued retrieving the samples. In January 2024, all samples were retrieved, and the total mass of the returned samples was announced to be 121.6 g, twice the mission requirement.

In the OSIRIS-REx curation chamber, the samples underwent initial characterization in a glovebox, including non-destructive imaging using the Advanced Imaging and Visualization of Astromaterials (AIVA) system. Results were shared with SAT, JAXA, and other partner organizations to guide sample distribution decisions. The initial characterization results were published as a sample catalog in March 2024 (https://curator.jsc.nasa.gov/osirisrex/sample_search.cfm), and a research proposal campaign based on the catalog was held in May 2024.

2.3 Analytical results of Bennu samples

Lauretta, Connolly et al. (2024) presented the first report on the Bennu sample analysis conducted by the OSIRIS-REx mission. The Bennu sample exhibits a bulk elemental composition close to the solar system abundance, except for highly volatile elements. Approximately 80% of the sample consists of Mg-rich phyllosilicates (serpentine and smectite), along with magnetite (framboidal and rosette forms), carbonates (calcite, dolomite, Fe-Mn-bearing magnesite), sulfides (pyrrhotite, pentlandite), and some Mg-Na phosphates. Minor phases include olivine, pyroxene, and spinel (chromite and ilmenite). These characteristics indicate that the Bennu sample is similar to CI chondrites and Ryugu.

The total average bulk carbon content ranges between 4.5 and 4.7 wt%, which is higher than that of chondrites and the bulk C abundance of Ryugu (Naraoka et al., 2023). The isotopic ratios of H and N differ from those of other carbonaceous chondrites and Ryugu. Organic globules were observed through UV fluorescence imaging, and microprobe two-step laser mass spectrometry identified two-to-four ring PAHs.

Bennu particles typically exhibit hummocky or angular morphologies, with some particles showing mottled surfaces due to the presence of bright materials.

Further reports on the sample analysis, including the detection of amino acids, oxygen isotope compositions of anhydrous phases, and other findings, can be found in conference abstracts from LPSC, MetSoc, and related meetings. Detailed results will be published in journals.

2.4 Curation of Bennu samples at ISAS/JAXA

JAXA received 0.5 weight percent of representative and unprocessed Bennu samples, along with a contact pad material, under the terms of the Memorandum of Understanding (MOU) and Letter of Agreement (LOA) agreements between NASA and JAXA. JAXA curation personnel visited JSC multiple times before and after the sample arrival to JSC to observe curation activities and discuss the sample allocation procedure. The final sample selection by the JAXA curation team was based on AIVA images of the retrieved samples.

Table 1: Received Bulk Samples and Contact Pad in JAXA

Name	Type	Sample Weight (g)
OREX-800058-0 (ORX-19000)	Bulk sample on Mylar flap	0.178
OREX-800111-0 (ORX-29000)	Bulk sample	0.139
OREX-800116-0 (ORX-39000)	Bulk sample	0.150
OREX-800120-0 (ORX-49000)	Bulk sample	0.049
OREX-800125-0 (ORX-59000)	Bulk sample	0.147
OREX-464000-0 (ORX-09000)	Contact Pad	-

Note: The names enclosed in parentheses are assigned by JAXA.

JAXA received bulk samples, stored in five containers, and one contact pad (Table 1). The total mass of the bulk sample was 0.663 grams.

The OREX-800058-0 sample was collected from the top of TAGSAM's Mylar flap, outside of the sample collection chamber (Lauretta, Connolly et al., 2024). Note that the sample on the Mylar flap is a 'bulk sample,' similar to the other four aggregate samples, and is not the same as the sample on the avionics deck. These samples were individually placed in 23-mm-diameter sapphire glass dishes prepared by JAXA in a nitrogen-purged glovebox at JSC/NASA. The dishes were then containerized in nitrogen-purged atmospheric isolation containers made of stainless steel, provided by JSC/NASA.

On August 21, 2024, the samples were transported to ESCuC/JAXA by the NASA curation team. Oxygen concentration measurements, conducted on a blank transport container on August 22, confirmed that the nitrogen environment had been maintained during transportation. In the afternoon of August 22, the samples were transferred to a dedicated nitrogen-purged clean chamber, CC5, for Bennu samples within a Class-1000 cleanroom. The containers were opened in a nitrogen atmosphere, and the sapphire glass dish with supporting holders were removed. The samples were examined and photographed with a digital microscope, weighed, and confirmed to have been transported in pristine condition.

At ISAS/JAXA, the received Bennu samples undergo non-destructive analysis and analysis with no atmospheric exposure, including digital microscope observation, weighing, FTIR, MicrOmega, and ONC-T analyses, following the curation process used for Ryugu samples at JAXA. In bulk-scale observation, the Bennu samples exhibit dark reflectance in the visible range and a prominent 2.7 μm absorption band, similar to Ryugu samples (Fukai et al., in prep). The bulk samples on the 23-mm dishes were further subdivided into smaller portions in the dishes (15-mm or 10-mm diameter) containing particles or aggregates. The initial description data for each individually named sample are available in a database.

2.5 References

OSIRIS-REx Blog. NASA, https://blogs.nasa.gov/osiris-rex/.

Lauretta, Dante S., et al. "Asteroid (101955) Bennu in the Laboratory: Properties of the Sample Collected by OSIRIS-REx." *Meteoritics & Planetary Science*, First published on June 26, 2024, https://doi.org/10.1111/maps.14227.

Righter, K., et al. "Curation Planning and Facilities for Asteroid Bennu Samples Returned by the OSIRIS-REx Mission." *Meteoritics & Planetary Science*, First published on April 8, 2023, https://doi.org/10.1111/maps.13973.

Bennu Asteroid Samples and Returned Flight Collection. NASA, https://curator.jsc.nasa.gov/osirisrex/.

3. Samples Available for this AO

3.1 Sample distribution policy

The samples provided through the AO are rare and valuable scientific assets. Therefore, regardless of how outstanding a proposal may be, please understand that the requested sample may not always be allocated as desired. These samples are a shared scientific asset and must be distributed fairly and utilized effectively. Specifically, selected proposers may be consulted regarding adjustments to the type and quantity of samples or potential sharing with other proposers. ISAS/JAXA would appreciate it if proposers could indicate the minimum required sample amount and whether sharing is acceptable in the proposal format. Additionally, curation staff work tirelessly, day and night, to preserve the samples and contribute to research. However, due to limited human resources, please understand that requests for pre-processing (e.g., cutting or dividing samples) generally cannot be accommodated. Exceptions may be made if special processing is necessary to maximize the scientific value of a rare sample. ISAS/JAXA appreciates the proposers' cooperation in ensuring the appropriate distribution and effective utilization of these valuable samples.

In this AO, samples from two asteroid return missions will be provided. These samples are invaluable scientific assets, and their allocation will be carefully managed to maximize research opportunities.

3.2 Ryugu samples

The available Ryugu samples for AO are indicated in the Web-based catalog with detailed information (https://darts.isas.jaxa.jp/app/curation/ryugu/). Four types of samples will be available from the Ryugu sample:

1) **30 pristine particles** are individually described non-destructively inside the clean chamber. The typical size of the particles is 1-2 mm.
2) **12 sets of pristine aggregate samples** (5 mg each). These samples have been described as aggregates, and only bulk information is available.
3) **Gas samples** were collected from the sample container using the GAEA gas extraction and collection system (Miura et al., 2022, *Earth Planet. Space* DOI: 10.1186/s40623-022-01638-x). More information on gas sample distribution will be included in the sample database.
4) **Previously allocated samples** returned from the initial analysis, Phase 2 curation, and previous AOs. They include polished sections, particle fragments, FIB sections, and so on.

3.3 Bennu samples

The available Bennu samples for AO are indicated in the Web-based catalog with detailed information (https://darts.isas.jaxa.jp/app/curation/bennu/). Two types of samples will be available from the Bennu sample:

1) **20 pristine particles** that are individually described in non-destructively inside the clean chamber. The typical size of the particles is 1-2 mm (including one 2.4 mm particle).
2) **6 sets of pristine aggregate samples** (5 mg each). These samples have been described as aggregates, and only bulk information is available.

These particle and aggregate samples are from OREX-800058-0 (ORX-19000) and OREX-800111-0 (ORX-29000) (Table 1). The samples available from OREX-800058-0 (ORX-19000) are selected from ORX-10001 to ORX-10068 in this AO, and those from OREX-800111-0 (ORX-29000) are selected from ORX-20001 to ORX-20045.

4. Proposal Submission

4.1 Notice of Intent (NOI)

Applicants will submit a NOI by the specified time. All applicants must be preceded by the NOI. The material in an NOI is confidential and will be used to prepare for the review process.

The following information is required for the NOI:

- A title of the anticipated proposal
- A brief description of the anticipated proposal and its objective(s) (up to 150 words)
- The names of (potential) co-investigators. Note that when a student requests sample(s), his/her supervisor must be included as a co-investigator.
- Early Career status (select one of the following options): Not applicable, Graduate Student, Undergraduate Student, Early Career Scientist (less than 7 years after Ph.D.)

An NOI shall be submitted from the AO website (https://curation.isas.jaxa.jp/ao/) with the required information listed above. For a detailed procedure, a quick manual is available online (https://data.darts.isas.jaxa.jp/pub/curation/AO/quick_manual.pdf).

After submitting the NOI, the applicant will automatically receive an email from the AO system confirming its receipt. The AO administration office will review the submission within three working days. Once the NOI is accepted, an email will be sent to the applicant (i.e., principal investigator) and the listed collaborators. If the applicant is a new user of the AO system, the applicant will also receive a separate email containing a password for logging into the AO system. The password can be changed at any time through the system.

4.2 Proposal style format

Proposals shall be written in English and be submitted in PDF format. The minimum font size of the main text shall be 11 points, and the text shall be single-spaced. Text within figures and tables may be a smaller font as long as it is legible.

The proposal's main body must not exceed 12 pages (including figures) when formatted on A4 paper. Only information in the first 12 pages of the proposal’s main body will be considered for evaluation. A Microsoft Word template can be downloaded from the AO website.

4.3 Required proposal elements

The following elements shall be provided as forms on the AO website. They will be included in the proposal cover.

- Title of proposal
- Name of proposer
- Proposer’s affiliation
- Co-investigators (their names, affiliations, and email addresses)
- Abstract (up to 200 words or 5,000 letters)
- Keywords that characterize the proposed work
- Analysis Methods
- ID number of requested samples (up to 10* samples with priority ranking). A request to combine Ryugu and Bennu samples is acceptable.

  *The limitation of the requested number of samples is only for pristine particles and aggregates, and there is no limitation for gas and previously allocated samples.
- Rationale for requested sample amount
- Minimum number (or weight) of samples to complete the proposed work
- Sample allocation flexibility (Descoping & Sharing Options)
- Effects on samples after the analysis
- Facilities or tools for sampling handling
- Transfer protocol of samples

The main body of the proposal (a Microsoft Word template) shall consist of:

1) **Scientific background and goals**. This section should include science question(s) and why the Ryugu and/or Bennu sample investigation is best suited to answer these questions. This section should also explain why the specified samples (and/or amount) are required. If the proposer has conducted research on the Ryugu or Bennu samples via the current or previous

AO(s), as part of the initial analysis team, or Phase-2 curation team, please briefly describe the research topic, sample(s), and results within one page. This AO encourages comparative studies between the Ryugu and Bennu samples.

2) **Research plan**. This section should also include the analytical capabilities and the roles of co-investigators.
3) **Sample History**. This includes sample preparation, as well as post-analysis alteration, the amount of samples to be returned, and their forms.
4) **References**. A reference list that relates to the proposed work and techniques should be included within the main body.

4.4 Submitting proposals through the AO website

The proposal must be submitted through the AO website. A proposer is required to provide the elements written in Section 4.3 using the web form. The main part of the proposal should be uploaded as a PDF file, and the file size must be less than 50 Mb. The information and the PDF file can be saved on the AO web server

4.5 Proposal receipt

A proposer will receive an auto-reply email from the AO system shortly after submission indicating that a proposal was successfully submitted. If a proposer does not receive the email, please contact the AO administration office (jaxa-curation-ao@jaxa.jp).

4.6 Revision of submitted proposal

The proposer may edit a submitted proposal at any time before the submission deadline. After the final submission deadline, the proposer must contact the AO administration office (jaxa-curation-ao@jaxa.jp) to submit the revised final proposal.

4.7 Withdraw of submitted proposal

The proposer may withdraw a proposal at any time for any reason on the AO website. The proposer may send a request to withdraw a proposal to the AO administration office (jaxa-curation-ao@jaxa.jp).

5. Proposal Review and Selection

5.1 Administrative review

Proposals will first be reviewed to see if they meet minimum administrative requirements. The requirements include (but are not limited to):

- Proposal is submitted by the due date
- Proposer is eligible to submit a proposal
- Proposal meets the editorial requirement (Section 4.2)

Proposals that do not meet the minimum administrative requirements could be returned to proposers without further evaluation.

5.2 Peer evaluation

Each proposal is expected to be reviewed by at least three reviewers who are invited from the community. Proposals will be scored on a 5-point scale for scientific merit and technical feasibility with comments on relevance, strength/weakness, feasibility, etc.

5.3 Panel review

After peer evaluation of each proposal, the AO review committee will convene to discuss the proposals and make a recommendation list of proposals to be selected and samples to be allocated.

The AO review committee may consist of ~10 scientists with a wide range of expertise (chemistry, mineralogy, petrology, volatiles, and organics) in cosmochemistry. A panel member is allowed to be a collaborator in a proposal, but he/she will not join the discussion on the proposal involved or the final vote. The AO review committee members will also provide peer evaluation of submitted proposals (Section 4.3).

The panel discussion will encourage early career scientists, promote gender equality, and reduce the impact of unconscious bias in an equitable and fair manner. Proposals from researchers in developing countries are also strongly encouraged.

5.4 Selection

The AO panel will submit the recommendation list to ASAC (Astromaterial samples allocation committee) for final approval. If ASAC requests reconsideration of the recommendation, the AO panel will resume discussing proposal selection.

Selected proposers will be informed by the AO administrator soon after the final approval. The ISAS will issue selection notices to the proposers. Names of selected proposers and research titles will be listed on the AO website.

6. Sample and Data Management

6.1 Transportation of samples to investigators

Selected proposers (investigators hereafter) should receive allocated samples within 6 months after the selection notification. Investigators are also responsible for arranging customs formalities for the sample transfer from ISAS to their institutions.

6.2 Return of samples from investigators to ISAS

Allocated samples should be returned to ISAS (nominally) one year after their delivery to the investigators.

Samples can be transported through commercial carriers (e.g., FedEx). Investigators are responsible for arranging customs formalities for the sample transfer from their institutes back to ISAS when required. The investigators should cover expenses for the sample transfer to ISAS.

Information on samples returned by investigators will be published in a database and subject to sample allocation in future AOs and others. Investigators should be aware that if there is an inquiry regarding the details of a returned sample, the investigator who returned the sample may be asked to explain.

6.2 Samples security

Investigators are responsible for the security of the samples allocated and will be held accountable, including the responsibility of compensation, in the event of sample loss. Investigators must not loan or transfer samples to anyone not listed as an investigator in the proposal.

Investigators shall make every effort to avoid unnecessary contamination of the samples. They must return the samples, except for those consumed and/or destroyed during analysis, immediately upon completing the approved investigation. If the sample is divided into multiple pieces or fractions, derivative samples shall have sub-numbers that will be used for future reports in journals and the sample catalog by JAXA. Investigators are requested to report to the AO administration office when the sample is divided into pieces.

Investigators are required to report to the AO administration office when there is a change in affiliation. Regardless of changes in affiliations, investigators also need to ensure that samples are secure and report the status of the samples. If any investigation plan is changed, including the principal investigator or co-investigators, please contact the AO Administration Office before the change.

6.3 Data management

Investigators must report the results of their analysis to the AO administration office in a timely manner. Research papers from AOs will be introduced on the AO website. Investigators are strongly encouraged to present reports on their work at the Hayabusa symposium.

Appendix

Material A: AO History

The Ryugu sample AO by JAXA began in 2022, and five terms of AO have been conducted so far (Table A1). This AO marks the first opportunity for JAXA to allocate the Bennu sample. The Astromaterials Sample Allocation Committee (ASAC) has authorized JAXA curation to allocate 15 weight percent (0.75 g out of the total mass of 5 g) of the total Ryugu sample in the previous AO activities. Similarly, approximately 0.05 g of the Bennu sample (the total mass of 0.66 g) will be allocated for the first AO.

Table A1. The number of proposals and allocated samples in the previous AOs.

Asteroid	AO		Proposals		Allocated samples					
	Year	No.	Submitted	Accepted	Particle		Aggregate		Gas	Previously Allocated
						(mg)		(mg)		
Ryugu	2022	1	57	40	74	229.04	-	-	0	-
Ryugu	2023a	2	47	38	53	102.04	10	115.16	0	132
Ryugu	2023b	3	23	17	12	34.66	10	82.38	5	23
Ryugu	2024a	4	30	22	27	20.18	23	124.02	0	22
Ryugu	2024b	5	24	17	22	13.34	10	49.22	0	4
Ryugu	2025	6	-	-	-	-	-	-	-	-
Bennu	2025	1	-	-	-	-	-	-	-	-

Material B: Terms and Conditions

Terms and Conditions for the Announcement of Opportunity for Astromaterial Sample Investigation

February, 2025

This agreement is made between the Japan Aerospace Exploration Agency (hereinafter referred to as "JAXA"), established under the provisions of the Japan Aerospace Exploration Agency Law, represented by its President and having its principal office at 7-44-1 Higashimachi, Jindaiji, Choufu-shi, Tokyo, Japan, and the Research Organization (hereinafter referred to as the “Research Organization”) that submitted the application form for this agreement to JAXA, hereinafter collectively referred to as “the parties.”

Recognizing that JAXA shall provide asteroid samples recognizing that JAXA issued the Announcement of Opportunity (hereinafter referred to as "AO"), the Research Organization submitted a proposal in response to the AO, and recognizing that JAXA has selected that proposal, the parties hereto agree to the Terms and Conditions as follows. The Terms and Conditions may not be modified depending on the proposer's circumstances.

1. Definitions

As used in this agreement, the following terms shall have the meanings indicated. “Astromaterial sample” means materials retrieved by sample return missions such as Itokawa, Ryugu, or Bennu samples by the Hayabusa, Hayabusa2, or OSIRIS-REx missions, respectively.

A “PI” is the person who has been selected to perform the AO activities and who belongs to the Research Organization, and whose name is shown on the Work Plan as being responsible for the research. A “Co-investigator” (Co-I) is a person named in the proposal who supports the PI in performing the research defined in this agreement with approval by the Research Organization and JAXA.

“Research” is defined in the AO and further detail is provided in the Work Plan. “Research Results” means the results derived from the implementation of the work plan submitted to the AO.

2. Purpose and Scope

The purpose of this agreement is to establish the terms and conditions under which the Research Organization shall conduct the AO activities. The Research is described in the Work Plan.

3. Period of Performance

This agreement shall come into force upon issuance of a confirmation sheet prescribed by JAXA and shall continue in effect during the sample loan period, unless terminated as described in Article 22. Notwithstanding the foregoing, Articles 9, 10, 11, 12, 18, 19, 20, 21, 25, and 26 shall remain in effect after the expiration of the loan period.

4. Affiliation

1. If the Research Organization wishes to add Co-Is to the Research Plan after the proposal selection, the Research Organization shall first obtain the consent of JAXA for such personnel. The Research Organization shall submit to JAXA a list of such candidate Co-Is in order to obtain JAXA's consent. If JAXA does not agree to the proposed list of candidate Co-Is, then JAXA will send notification to the Research Organization within seven (7) days of receiving the list of candidate Co-Is.

2. The Research Organization shall supervise the PIs and Co-Is engaging in the Research Projects and shall ensure that all PIs and/or Co-Is engage in the Research Projects in accordance with the terms and conditions of this agreement. For avoidance of doubt, with regard to this agreement, the PIs and Co-Is shall not be deemed a third party.

3. If a PI dies, retires from the Research Organization, takes a leave of absence from work, or is no longer engaged in the Research Projects, the Research Organization shall immediately notify JAXA. JAXA and the Research Organization may either terminate this agreement, or, the Research Organization may designate a researcher who belongs to the Research Plan as PI.

4. If the Research Organization appoints a new PI, the researchers can continue AO activities following notification to JAXA. If JAXA does not agree to the proposed new PI, then JAXA will notify the Research Organization within fourteen (14) days of receiving the notification proposing the new PI.

5. JAXA's Responsibilities

JAXA will make reasonable efforts to:

a) Prepare a list of astromaterial samples and make it available on the website, and,

b) Allocate the astromaterial sample to the PI that the PI requested. If multiple requests are made for individual samples, JAXA will take all reasonable efforts to provide a sample that closely matches the original request.

6. Research Organization's Responsibilities

The Research Organization will make reasonable efforts to:

a) Develop a work plan for the AO activity providing for the astromaterial sample to be returned to JAXA soon after the AO activity is completed,
b) Conduct and complete AO activities in accordance with the work plan,
c) Establish an adequate security system for the astromaterial sample,
d) Deliver the Research Results as a summary by the end of the performance period as described in Article 3, and
e) Account for the condition of the astromaterial samples prior to returning them to JAXA.

7. Rights and Obligations Related to Astromaterial Samples

a) The PI shall not use the astromaterial sample for any other purposes than those defined by the work plan.
b) The PI shall keep the sample as uncontaminated as possible.

8. Transportation of Astromaterial Samples

a) JAXA will use commercial transportation for delivery of the astromaterial sample to the Research Organization and will accept scientific risks such as X-ray inspection, opening of the container in the airport, and its loss.
b) If required, the PI is entitled to propose a delivery method to JAXA.

9. Transfer of Technical Data

Except as otherwise provided in this Article, each party under this agreement shall transfer all technical data considered necessary to fulfil the Research Plan, to the extent feasible.

The parties will undertake to handle expeditiously any request for technical data presented by the other party for the purpose of this agreement. Neither party shall have any right to require the other party to transfer any data if such transfer would violate the laws or regulations of the country having jurisdiction over such transfer.

The furnishing party shall mark with a notice, or otherwise clearly indicate, any technical data that are to be protected as proprietary or for export control purposes. Such a notice shall indicate any specific conditions regarding how such technical data may be disclosed or used by the receiving party including, for export control (a) that such technical data shall be used or disclosed only for fulfilling the receiving party's responsibilities under this agreement, and, for proprietary rights; (b) that such technical data shall not be disclosed, duplicated, or used by persons or entities other than the receiving party, or for any other purpose, without the prior consent of the furnishing party.

Each party shall observe any clearly indicated limitation on the handling of transferred technical data.

According to the directives of the furnishing party, the receiving party shall return or otherwise dispose of technical data provided under the Agreement upon completion of the activities specified under the Agreement.

10. Intellectual Property Rights

If the Research Organization solely generates Potential Intellectual Property Rights in the course of the Research Projects (Solely-Owned Intellectual Property Rights), the party shall notify the other party immediately. In this case, the Research Organization may take steps to apply for registration of the resulting Intellectual Property Rights as solely-owned ones at its own expense, provided that it shall obtain prior confirmation of the other party. For the avoidance of doubt, only if Potential Intellectual Property Rights are generated or created by the Research Organization's sole work and sole funding shall such Potential Intellectual Property Rights be deemed to be solely generated or created by the Research Organization.

11. Usage of Research Results

The Research Organization solely owns the Research Results and may utilize them exclusively. However, if JAXA wishes to utilize the Research Results, JAXA shall obtain written permission from the Research Organization in advance.

12. Publication of Research Results

1. The results obtained through the performance of these AO activities by the Research Organization will be made available to the general public in a timely manner. If the Research

Organization intends to publish the Research Results, the Research Organization should inform JAXA prior to submission.

2. The Research Organization shall add a statement to the publication that indicates as appropriate that the Research Results have been obtained through the cooperation between the Research Organization and JAXA.

13. Language

All communications between the Research Organization and JAXA under this agreement shall be in English.

14. Force Majeure

Neither party is liable for failure, delay, or suspension in performing its part of this agreement when such failure is due to reasons including, but not limited to, fire, war, inevitable accident, act/policy of government, and legal restrictions beyond the control of either party.

15. Taxes and Customs

If any customs fees and/or taxes of any kind are levied on the transactions necessary for the implementation of this agreement, such customs fees and/or taxes shall be borne by the party of the country levying the fees and/or taxes.

16. Funding

There will be no exchange of funds under this agreement. Each party shall bear the costs necessary to fulfill its own responsibilities under this agreement.

17. Limitations on Liabilities

JAXA and the Research Organization each agree to waive any claim against the other with respect to any injury or death of its employees or the employees of its related entities, or with respect to damage of any kind, or any loss of its own property or property of its related entities arising out of activities under this agreement (hereinafter referred to as “Damages”), excepting such Damages which arise through willful misconduct and gross negligence and excepting intellectual property rights.

18. Privacy Policy

JAXA will not use personal information including name, affiliation, and email address other than for implementing this AO. JAXA also may provide this information to JAXA's contractor supporting this AO. In that case, JAXA will ensure that the contractor will adhere to the same privacy policy.

19. Inventions and Patents

Nothing in this agreement shall be construed as granting or implying any right to, or interest in, patents owned by or inventions that are independently developed by the parties to the agreement or their contractors or subcontractors.

20. Confidentiality

1. In this agreement, "Confidential Information" means any information that a party discloses or presents in writing or by other media to the other party in the course of these Research Projects. However, Confidential Information does not include the following:

a) Information that is already known to the public when disclosed by the disclosing party;
b) Information that becomes known to the public after disclosure by the disclosing party without intentional misconduct or negligence of the receiving party;
c) Information that the receiving party already had before the disclosure by the disclosing party;
d) Information that the receiving party acquires from a duly authorized third party not subject to confidentiality obligations;
e) Information that the receiving party independently develops without utilizing information obtained from the disclosing party;
f) Information with prior written consent of the disclosing party for disclosure and publication; or
g) Information that is required to be disclosed by applicable laws, judgment, or order of a competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.

2. The receiving party shall keep Confidential Information secret, and shall not disclose or divulge any Confidential Information to a third party without the prior written consent of the disclosing party.

3. The confidentiality obligation under this Article shall remain effective for a period of five (5) years after the termination of the Agreement. However, this period of keeping confidentiality may be extended or shortened by mutual agreement.

21. Government Approvals

Each party shall obtain such permits, licenses, and other government authorizations as required for it to perform its responsibilities under this agreement, and shall comply with all applicable laws and regulations.

22. Suspension

If the Research Organization fails to meet the purposes of this agreement or to comply with the terms of this agreement, JAXA may suspend execution of this agreement, in whole or in part, pending corrective action by the Research Organization or a decision by JAXA to revoke this agreement.

23. Termination

1. Either party may terminate the Agreement

a) When the other party commits a dishonest and/or inequitable act that irreparably harms the mutual trust between the Parties, provided that the breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after receiving a demand for corrective action from the harmed party;

c) When the other party violates any of the terms and conditions of this Agreement, provided that the breaching party fails to offer any effective and/or satisfactory remedial measures within seven (7) days after receiving a demand for corrective action from the harmed party; and,

c) When both Parties consent to termination.

2. Upon termination of the Agreement, the Research Organization shall promptly return the samples to JAXA, and deliver to JAXA all work including, but not limited to, all work in progress and all work that is completed and otherwise ready for delivery.

3. The preceding paragraph shall apply to termination upon the occurrence of the events contemplated in Article 4, Paragraph 3.

24. Special Agreement

Any supplement, modification, or amendment of this Agreement shall only be binding if made under a mutual written agreement between the Parties which makes specific reference to this Agreement.

25. Dispute Resolution

The Parties agree to make their best efforts to solve amicably any dispute, controversy, or difference arising out of, in connection with, or resulting from this Agreement.

26. Arbitration

All disputes that cannot be amicably settled by the method defined in the previous paragraph hereof will be settled by arbitration in Tokyo in accordance with the Commercial Arbitration Rules of the Japan Commercial Arbitration Association.

Material C: Statement of Agreement for the terms and conditions

STATEMENT OF AGREEMENT

I, the undersigned, have read and fully understood the above “Terms and Conditions for the Announcement of Opportunity for the Astromaterial Samples Investigation” and agree to abide by the rules contained therein.

____ (Signature)

____ (Full Name in Block Letters)

____ (Full Name of Organization)

____ (Signature from Organization)

_________ _______, ___________

MONTH DAY YEAR