# Guidebook for proposers responding to the Announcement of Opportunity for Hayabusa2 samples

January, 2022

The Astromaterials Science Research Group (ASRG) of JAXA will handle the Announcement of Opportunity (AO) with peer-review process in which Hayabusa2 sample investigation proposals will be selected. This guidebook is intended to help researchers who plan to submit proposals in response to the AO.

**Key milestones for the Hayabusa2 AO**

- Call for proposals for the 1st AO: December 17, 2021
- Notice of Intent to propose (mandatory): Due mid March, 2022 (TBA)
- Sample request submission: Due mid April, 2022 (TBA)
- Decision announcement: Late May, 2022
- Sample distribution: June, 2022

- Call for proposals for the 2nd AO: June, 2022 (TBA)

## 1. Mission overview

### *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), and included 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 $1.19 \pm 0.03$ 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 those 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 11 July 2019 to collect both surface samples and impact ejecta that contains sub-surface samples. A 5-gram tantalum projectile was shot through a 1-m long sampler horn at an impact velocity 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 Dec. 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 Dec. 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 Dec. 8, 2020 (~57 hours after the capsule landing).

*1.4 ISAS Curation facility for the Hayabusa2 samples*

The policy of the 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 Extraterrestial Sample Curation Center (ESCuC) aims at producing a sample catalogue 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 picking and observations in a purified nitrogen gas environment. The 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 Dec. 11.

After the CC3-1 was evacuated to reach a high vacuum (<$10^{-5}$ Pa), the container was opened on Dec. 14 inside the 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 the CC3-1 to place chamber A in the up-position and transferred to CC3-2, which was also kept under vacuum. The CC3-2 was isolated by closing a gate valve between the 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, the 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 a metallic particle. 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. (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, which are 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.

## *2. Samples available for the AO and database*

### *2.1 Amount and type of samples*

Fifteen mass percent of the returned sample (about 0.75 g out of 5 g) will be available for the first several AOs, which will be open twice a year. This was recommended by the Hayabusa2 sample allocation committee (HSAC) to the ISAS curation steering committee for final approval.

In this AO, about fifty particles that are individually described in a non-destructive way inside the clean chamber will be available. The typical size of the particles is 1-2 millimeters. The particles have not been exposed to the air after their recovery from the sample container. The available particles are marked in the database (https://jaxa-ryugu-sample-ao.net).

*2.2 Duration of sample loan*

Allocated samples will be available for a period of one year following the arrival of the sample(s). Extension of this period could be possible but only with approval by the ISAS curation steering committee.

*2.3 Ryugu sample database*

The Ryugu sample database (DBS) provides a list of Ryugu samples available for research to aid researchers to request samples through the AO.

The Ryugu DBS is run using open-source technologies, such as PHP, PostgresSQL, and Apache, and data servers on Data ARchives and Transmission System (DARTS) at ISAS/JAXA. The Ryugu DBS provides information on each individual grain (typically larger than 1 mm along the longest dimension) and on aggregate samples. Aggregate samples consist of fine grains (mostly smaller than 1 mm) put in a single dish and are documented in bulk.

The basic information listed in the DBS includes photomicrographs, weight, size, and spectroscopic data, all of which are obtained in the clean chamber system without exposure to air as described in Section 1.5. The spectroscopic data can be downloaded with CSV format. Along with basic information, the analysis history and data obtained in previous analysis cycles can also be found for each sample. The data obtained by the project-led initial analysis and that from curation work outside JAXA will also be archived in the future.

When a sample is divided into multiple pieces, each piece will have a sub-number after the original number, so that users can easily find the relation among different samples in the list.

The web interface of Ryugu DBS has three different view modes: Table style, Thumbnail style, and Detailed list style. Users can select the view mode depending on their purposes. The DBS also has a search function.

The final update of the Ryugu DBS is planned immediately prior to the release to increase database fields, to include more data obtained at ISAS/JAXA, and to meet Digital Object Identifier (DOI) demands. The release of the Ryugu DBS will be in January 2022.

## 3. Proposal Preparation and Organization

*3.1 Notice of Intent (NOI) to propose*

Proposers will submit a NOI by the specified time. All proposals must be preceded by the NOI. The material in an NOI is confidential and will be used for preparing for the review process.

The following information is requested for the NOI:

- A title of the anticipated proposal
- A brief description of the anticipated proposal and its objective(s)
- The names of (potential) co-investigators. Note that when a student requests the sample, his/her supervisor must be included as a co-investigator.

*3.2 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 point and the text shall be single-spaced. Text within figures and tables may use 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. Template will be available at the AO website (https://jaxa-ryugu-sample-ao.net).

*3.3 Required proposal elements*

The following elements shall be provided online to the AO website. They will be included in a cover of the proposal.

- Title of proposal
- Name of proposer
- Proposer's affiliation and e-mail address
- Co-investigators (their names, affiliations, and e-mail addresses)
- Abstract (up to 250 words)
- Keywords that characterize the proposed work
- ID number of requested samples (up to 5 samples with priority ranking)
- Minimum number (or weight) of samples to complete the proposed work

The main body of the proposal shall consist of:

1) **Scientific background and goals**. This section should include science question(s) and why Ryugu sample investigation is best suited to answer these questions. This section should also explain why the specified samples (and/or amount) are required.
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.

*3.4 Letter of support from research organizations*

Proposals must be submitted with support letters from research organizations where PIs and collaborators belong to. The support letters should be in PDF formats.

## 4. Proposal Submission

*4.1 Submission of NOI at the AO website*

An NOI shall be submitted from the AO website with the required elements listed in Section 3.1. After the NOI submission, an email from the AO system will be promptly sent to the proposer indicating the receipt of NOI. The AO administrative office will check the submission within three working days, and an email will be sent to the main proposer and listed collaborators when the NOI is accepted. The main proposer will receive another email to provide a passcode for a registered user to log into the AO system to submit a proposal. The registered user can change the passcode at any time through the AO website.

*4.2 Submitting proposals through the AO website*

The proposal must be submitted through the AO website. A proposer is required to provide the elements in Section 3.3 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 in the AO web server. The information on the required elements is editable and the pdf file is replaceable prior to final submission before the submission date.

*4.3 Proposal receipt*

A proposer will receive an 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 administrative office.

*4.4 Renewal of submitted proposal*

The proposer may renew a submitted proposal at any time before the submission deadline. After the final submission deadline, the proposer must contact the AO administrative office for a renewal.

*4.5 Withdraw of submitted proposal*

The proposer may withdraw a proposal at any time for any reason. The proposer may send a request to withdraw a proposal to the AO administrative contact listed in the AO website.

## 5. Proposal Review and Selection

*5.1 Administrative review*

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

- Proposal is submitted by the due
- Proposer is eligible to submit a proposal
- Proposal meets the editorial requirement (Section 3.2)
- Proposal is submitted with support letters from research organizations

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 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 and so on.

*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 the field of cosmochemistry. A panel member is allowed to be a collaborator of 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 5.2).

The panel discussion will be made with encouragement to early career scientists and promotion of gender equality in an equitable and fair manner to reduce the impact of unconscious bias. Proposals from researchers in developing countries are also strongly encouraged.

*5.4 Selection*

The AO panel will submit the recommendation list to HSAC and the ISAS curation steering committee for final approval. If HSAC and/or the ISAS curation steering committee requests reconsideration of the recommendation, the AO panel will resume their discussion on proposal selection.

Selected proposers will be informed from the AO administrator soon after the final approval. Names of selected proposers and research titles will be listed in the AO website.

## 6. Award Notification

After the recommendation from the AO review committee is approved by the HSAC and the ISAS curation steering committee, the ASRG will issue award notices to the proposers. It is scheduled to occur in late May 2022.

## 7. Sample and Data Management

*7.1 Responsibility*

Selected proposers (investigators hereafter) are responsible for the security of the samples allocated and will be held personally accountable in the event of sample loss. Investigators shall make every effort to avoid unnecessary contamination of the samples and must return the sample, except for that consumed and/or destroyed during analysis, immediately upon completion of the approved investigation.

Investigators are also responsible for arranging customs formalities for the sample transfer from ISAS to their institutions and from their institutes back to ISAS when required.

*7.2 Sample identification management*

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 in the AO website. Investigators are requested to report to the AO administrator when the sample is divided into pieces.

*7.3 Data management*

Investigators must report the results of their analysis to ISAS/JAXA in a timely manner. Investigators are encouraged to present reports on their work at the Hayabusa symposium, having being held annually since 2013, during or after the sample loan. Some travel expenses may be supported by ISAS upon request. The data obtained from the allocated sample(s) shall be archived and listed in the Ryugu DBS no later than one year from the end of the sample loan. Data format and date of data release can be discussed between the investigator and the AO administrator.

*7.4 Return of samples to ISAS*

Allocated samples should be returned to ISAS (nominally) one year after their delivery. Samples can be transported through commercial carriers (e.g., Fedex). Expense for the sample transfer to ISAS should be covered by the investigators.