Future perspective of sampling and curation for extraterrestrial materials in JAXA's small body exploration

Ryota Fukai[1]
[1]*ISAS/JAXA*

Introduction

Japan Aerospace Exploration Agency (JAXA) successfully completed the sample return planetary exploration missions for the small bodies Itokawa (Hayabusa; 2003–2010) and Ryugu (Hayabusa2; 2014–2020). JAXA is preparing to receive the next return samples to Institute of Space and Astronautical Science (ISAS) and planning new missions for the next decade. I introduce the concept and tentative plan for the curation of the Bennu sample returned by Origins, Spectral Interpretation, Resource Identification, Security, Regolith Explorer (OSIRIS-REx; NASA), the Phobos sample collected by Martian Moon Exploration (MMX; JAXA), and the comet sample collected by Next-Generation Small Body Sample Return (NGSR; JAXA). The concept of curation in the future is threefold: ground truthing of remote-sensing and in-situ data, certification for the curation data, and in-house contamination control. Subsequently, I introduce the scientific scopes and the key techniques for sampling the comet materials in the NGSR mission.

Curation

Ground truthing of remote-sensing and in-situ data. Ground truthing for remote-sensing and in-situ analysis data obtained by the mission instruments should be done to complete the mission objectives in the sample return mission. The curation phase of the return samples is the chance for ground truthing without any sample biases. In the MMX curation, the initial description will be done with the ToF-type mass spectrometer, visible/infrared spectral imager, and Raman spectrometer, corresponding to the mission instruments in the MMX spacecraft [1]. In addition, the simulator of Optical RadiOmeter composed of CHromatic Imagers (OROCHI), an optical camera of the MMX spacecraft, will be installed in the Bennu clean chamber to help plan the MMX's curation strategy [2].

Certification for the curation data. Whereas the observation in the clean chamber is useful to characterize the bulk-scale return sample, the analytical method is limited to a totally non-destructive way. For instance, we estimated the bulk density of Ryugu grains with the information from the weight and optical image [3]. To confirm the accuracy of the curation data within the clean chamber, we will conduct the coordinated analysis for the return sample (e.g., Ryugu, Bennu) outside the clean chamber, such as X-ray Computed Tomography (XCT) and Scanning Electron Microscope- Energy Dispersive Spectroscopy (SEM-EDS). This dataset is available as additional information for outreach and allocation in the Announcement of Opportunity (AO).

In-house contamination control. Regular monitoring for the contamination of clean environments is essential to maintain cleanliness levels. We newly introduce the method for sampling the metal particles within clean rooms and chambers by Gas Exchange Device- Inductively Coupled Plasma- Mass Spectrometer (GED-ICP-MS). We can count the number of metal particles without any biases in the sample preparation. We can attain the cross-check for possible contamination in the return samples by mass spectrometric techniques developed with in-house contamination control.

Next-generation sample return mission

Scientific scopes. Following small-body explorations such as the Hayabusa and Hayabusa2 missions, we should explore more primitive targets in the Solar System. Our target for the next sample return is a comet, which potentially possesses the record of the early Solar System and "presolar" system in the Milky Way Galaxy, avoiding the secondary alteration within the parent body. Kurokawa et al. [4] will report the scientific concept of NGSR in detail.

Subsurface sampling. The surface of a comet should have non-primitive layers such as recondensed and/or consolidated surfaces up to ~1 m depth [5]. Therefore, subsurface sampling for the comet is critical to attain the scientific objectives in NGSR. We are developing the subsurface sampling system using a Small Carry-on Impactor (SCI) and bullet-system sampler.

References: [1] Fukai, R. et al. *in revision*. [2] Fukai, R. et al. (2023) *METSOC*. [3] Yada, T. et al. (2021) *Nature Astronomy*, **6**, 214–220. [4] Kurokawa, H. et al. (2023) *this symposium*. [5] El-Maarry, M. R. et al. (2019) *Space Science Review*, **215** (36).