Implementation of the environmental assessments of metal element abundances at the JAXA curation facility

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Introduction

The quantitative analysis of metal elements is useful for identifying the sources of contamination in semiconductor and geological samples from synthetic materials and the natural environment. Consequently, this method is widely utilized in the field of environmental monitoring. The JAXA Extraterrestrial Sample Curation Center operates clean rooms (CRs) for the storage and description of returned samples. The returned samples (Itokawa, Ryugu, and Bennu) are stored under high-purity nitrogen conditions and atmospheric pressure within stainless steel clean chambers (CCs), which are installed in each Class 6 (ISO 14644-1) CRs. Environmental monitoring of all the CRs and CCs has been conducted regularly, with the analysis outsourced before receiving Bennu samples from NASA [1–2]. However, the sampling and analysis have been limited to once or twice a year due to the difficulty in scheduling. This is insufficient for tracking the environmental changes resulting from several events such as machine installation, machine trouble, human error, and natural disasters. Therefore, a triple quadrupole ICP-MS instrument (Agilent 8900) and a Gas Exchange Device (GED: IAS Inc.) were installed into the CR in 2023 to enable sampling and subsequent analysis within the curation center. Surface and airborne contaminants in the CRs and CCs are targeted for monitoring. In this presentation, we report on the current status of the development of the monitoring method of the metal elemens and the results of the environmental monitoring of the newly established CR and CC for Bennu samples.

Methods

Surface contaminants were analyzed through the dish exposure method, whereas airborne contaminants were assessed using the impinger collection method. Surface contaminants were collected by placing quartz glass petri dishes in the CR and CC for Bennu samples a certain period. The dish was then rinsed with diluted nitric acid. Elemental concentrations in the solution were determined with the ICP-MS instrument. Airborne contaminants in CRs for Ryugu and Bennu samples were collected through ultra-pure water using the Teflon impingers. Subsequently, concentrated nitric acid was added to ultra-pure water including airborne contaminants to achieve a solution with a nitric acid concentration of 1 %. Then, elemental concentrations in the solution were determined with the ICP-MS instrument.

Results and discussion

The results obtained so far show that Mg and Zn were detected in surface contaminants in the CC for Bennu samples. These elements have been also detected in previous environmental monitoring from the CC for Ryugu samples [1-2]. Mg might be derived from phyllosilicate minerals (e.g., talc, chlorite), which are minor constituents of the gloves used for sample handling in CCs [3].

The evaluation of the ambient air in the CRs for Ryugu and Bennu samples revealed the presence of elements including B, Na, and K. Atmospheric concentrations of B between previous observations [1-2] and this study were comparable to each other, confirming our protocol of sampling. B was exclusively detected through airborne contaminants monitoring whereas it was absent in the surface contamination assessment. Therefore, the results in this study combined with the previous observations suggest that B is present in the form of nanoscale particles or gaseous substances suspended in the ambient air of CRs constantly. Na and K were identified in nearly all ambient air samples. A moderate positive correlation was observed between the atmospheric concentrations of Na and K ($R^2 = 0.25$). The monitoring results obtained from various locations within the CR for Bennu samples in the same time frame indicate that the highest concentrations of these two elements were observed in the samples collected in the area close to where curators work. The results of previous environmental assessments on the CR for Ryugu samples suggest that the concentrations of these elements increased in association with an increase in curation activity [2]. Therefore, Na and K in the ambient air in the CR may be derived from human activities. In the future, environmental monitoring will be conducted under a variety of conditions (e.g., human activity, sampling location), and the airborne particles will be analyzed directly using GED to determine the sources of contaminants.

References

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