

Preparation for the cold curation of Artemis-returned samples

*Toru Yada¹, Takuya Ishizaki¹, Seiya Kawasaki¹, Masanao Abe¹, Tomohiro Usui¹

1. Japan Aerospace Exploration Agency

In these two decades, JAXA has led the world in asteroid sample return missions with the asteroid probes Hayabusa and Hayabusa 2 (Fujiwara et al., 2006; Watanabe et al., 2019). At the same time, JAXA has established facilities, technologies, and experiences in curating asteroid return samples, and has produced many scientific results by distributing asteroid return samples to researchers around the world without exposure to the atmosphere or contamination (Yada et al., 2014; Yada et al., 2023). Future missions are expected to return samples from outer planet regions with lower surface temperatures, such as sample return from the Martian moon Phobos by the Martian Moon eXploration (MMX) and sample return from the depleted comet nucleus 289P/Blanpain by the Next Generation Sample Return (NGSR) (Kuramoto et al., 2022; Sakatani et al., 2025). On the other hand, after September 2027, Artemis III is scheduled to return about 80 kilograms of samples from the south pole of the moon (Peña-Asensio et al., 2025), and in particular, Artemis IV and later will be carrying the first Japanese astronaut to land on the moon, and it is expected that the samples returned from the south pole of the moon will be allocated to Japan. Even if JAXA's allocation is only a few percent, it will be necessary to handle samples in kilograms, whereas JAXA has handled asteroidal samples which are pebbles and powdery samples weighing less than grams to milligrams. Furthermore, it is assumed that there is several to a few tens of percent water ice in the Permanently Shaded Region (PSR) of the lunar polar regions, so it will also be necessary to handle low-temperature samples. JAXA will begin technical development and preparation in the fiscal year 2025 for the curation of samples returned from the lunar south polar region by the Artemis IV spacecraft, which is expected to return to Earth at the end of 2028 and be distributed to JAXA around 2030.

The lunar south polar region samples expected to be returned have been reported to have a maximum temperature of -110K or less based on remote sensing of the PSR. In addition, the presence of H₂O, H₂S, NH₃, SO₂, C₂H₄, and CO₂ has been confirmed as a result of observations of the plume generated by the LCROSS impact experiment on the Cabeus crater at the lunar south pole (Colaprete et al., 2010), and it is thought that they will need to be stored at -110°C or less, where methane (-103.7°C), which has the lowest boiling point of these molecules, is maintained.

The lunar south pole returned samples allocated to JAXA are expected to be classified into three categories based on their use, purpose, and contamination control. Category 1 samples are intended to be exhibited and displayed as a memento of the first Japanese lunar landing, and no temperature or contamination control is expected for these samples. Category 2 samples are intended for technological development related to in-situ resource utilization (ISRU) on the moon, and although contamination control will be performed, temperature control is not expected except for technological development aimed at the use of volatile substances. Category 3 samples are intended for scientific research on the moon and require strict contamination control and storage at the low temperature mentioned above. Of these three categories of samples, which categories and how much of each will be under JAXA's management will be decided in future discussions and adjustments, and it is not clear at this time.

The conditions required for JAXA's lunar polar region return sample curation will be storage and handling at low temperatures (<-110°C) and room temperature under contamination control. In addition, the

curation of samples in kilogram units requires techniques for dividing and processing samples (such as processing for polished thin sections) under contamination control. These techniques for low-temperature storage and handling, and techniques for dividing and processing samples under contamination control have not been established in JAXA curation, and they need to be developed and established in the next five years. Considering that it will take two years to build the facility and manufacture glove boxes after the specifications are decided, and about one and a half years to evaluate the performance and rehearse the completed facility, it is necessary to aim to organizing a consulting committee for Artemis curation facility specification and fix the specification within this fiscal year.

Keywords: sample return, curation, Artemis mission, Lunar sample, cryo-sample