CRYOGENIC CURATION: ISOLATION TECHNOLOGY AND MISSION OPERATIONAL REQUIREMENTS FOR SAMPLE RETURN.

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Introduction: Future lunar, Mars, asteroid, and comet sample return missions may collect samples that have been preserved at sub-freezing or even cryogenic temperatures. For such samples, the study of volatiles and temperature-sensitive minerals will have high priority. Valuable geochemical and mineralogical information will be lost if such samples are allowed to reach ambient temperatures on Earth. The ability to store, document, subdivide, and transport extraterrestrial geologic samples while maintaining sub-freezing or cryogenic temperatures, possibly as low as 40 K, is required for the complete scientific study of samples from cold environments.

Cryogenic Technology: A cryogenic sample return mission might require a combination of passive cooling during collection and cruise and active cooling during and after re-entry for maintaining desired temperatures. Once on Earth, cryocontainment must be maintained through delivery to a cryogenic chamber in the curatorial facility. This cryogenic curation chamber would include cameras and robotic manipulators for preliminary examination, subdivision of samples, and specialized sample allocation containers for shipment to laboratories world-wide. A hypothetical design might be similar to a 40 K Thermal Vacuum Curation Chamber with a helium heat sink shroud at 1 x 10^{-6} Torr. In addition, the ability to reduce inorganic and organic cross-contamination in the facility will also be a requirement for maintaining the long-term preservation and scientific integrity of the samples.

Feasibility: Cryogenic curation is feasible with current technologies developed for the superconductor industry. However, significant research and development costs would be required to tailor these technologies to the task of sample return and long term curation of volatile samples at low temperatures. JSC currently has thermal vacuum chambers that could potentially be used for testing cryogenic curation technologies, if future missions and resources were secured.

Future: The planetary science decadal submitted to NASA highlighted two notable sample returns that will require technology for cryogenic curation: (1) Comet Surface Sample Return (CCSR) and (2) Lunar South Pole-Aitken Basin Sample Return [1]. The CCSR white paper concluded that sample temperatures must be no higher than 125 K from collection to curation facility on Earth. In addition, a Mars Sample Return Flagship mission may also require curation of samples below ambient temperatures. Critical cryogenic curation technological development is also aligned with several NASA Technology Area Roadmaps and NASA Space Technology Grand Challenges. For JSC curation, cold curation at 250 K is the next step for developing advanced curation technologies for future missions with minimal investment, while monitoring the development of cryogenic technologies that could be used for future sample return missions that wish to preserve samples at very low temperatures.

References: [1] Committee on the Planetary Science Decadal Survey, SSB, NRC. (2011). Vision and Voyages for Planetary Science in the Decade 2013–2022.