Preparing for Lunar Volatile-Rich Cryogenic Return Sample Transport & Analysis

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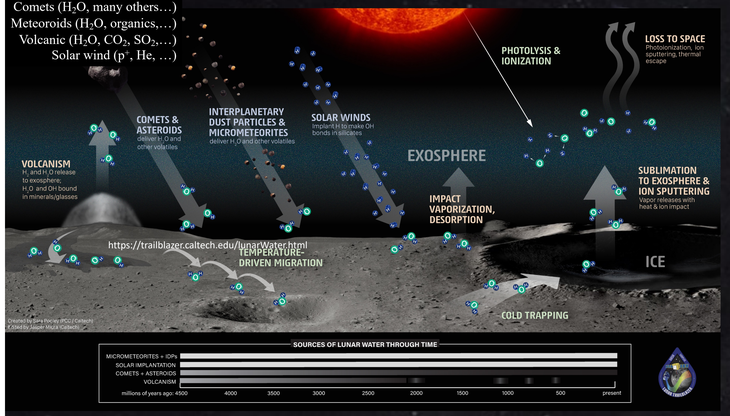
GOAL: To design, build, and test a container to enable the transport of a volatile-bearing cryogenic lunar return sample between NASA JSC curation and laboratory facilities at other institutions

1. Motivation: Enable ground-based analyses to understand the processes for volatiles' sources & sinks



2. Requirements: Maintain thermal environment in order to preserve volatiles' physical and chemical states

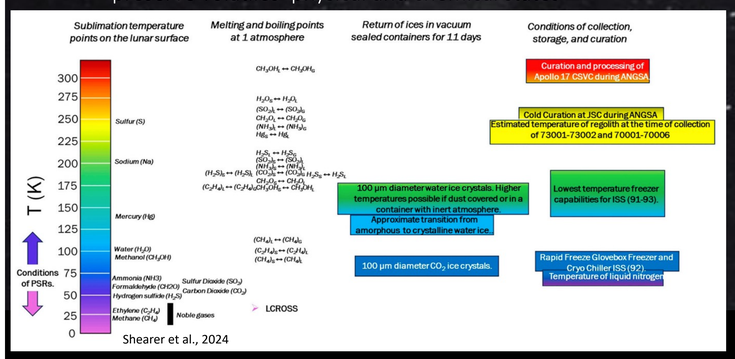


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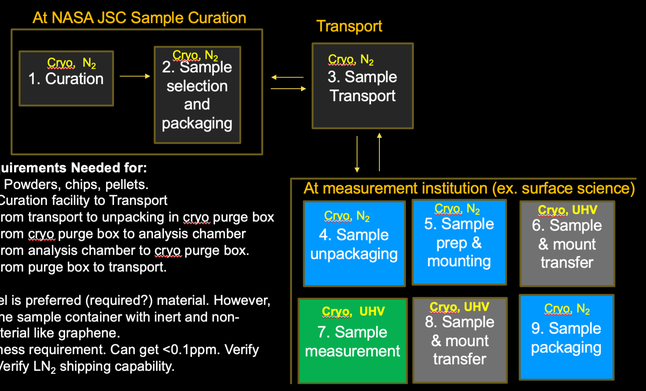
Figure 2. Volatiles from H_2O to CH_4 can exist in various physical states (e.g. ice, adsorbed molecules) at various temperatures. The temperature at which a volatile-rich sample is maintained will determine the physical state of the volatiles and thus the preservation of science

3. Requirements: Chain of Custody

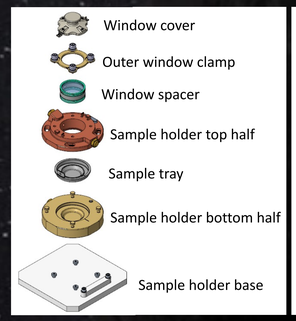


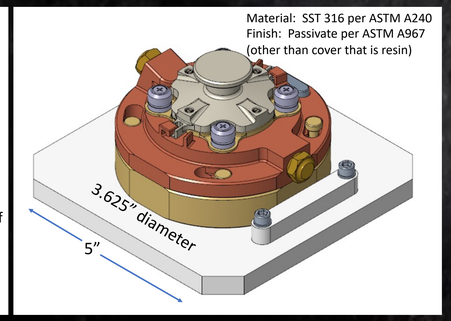
Interface Requirements Needed for:
Sample Form: Powders, chips, pellets.
From 2 to 3. Curation facility to Transport
From 3 to 4. From transport to unpacking in cryo purge box
From 5 to 6. From cryo purge box to analysis chamber
From 7 to 8. From analysis chamber to cryo purge box.
From 9 to 3. From purge box to transport.

*Stainless steel is preferred (required?) material. However, may want to line sample container with inert and non-adsorptive material like graphene.
*N_2 purge dryness requirement. Can get <0.1ppm. Verify requirement. Verify LN_2 shipping capability.

Figure 3. The sample container will need to :
- **Preserve the cryogenic volatile-rich sample under conditions equivalent to those at JSC Cold curation** beginning with (2) preparing at JSC to (3) shipping, (4) receipt and unpacking at the receiving institution; and then (9) sample repackaging and sending back to JSC.
- **Maintain knowledge of the thermal conditions**
- Enable a means for **evaluating possible changes in the sample**
  - Physical changes - window
  - Chemical/state changes – window and gas sampling

5. The Cryogenic Sample Transfer Device





6. Manipulating the Transfer Device

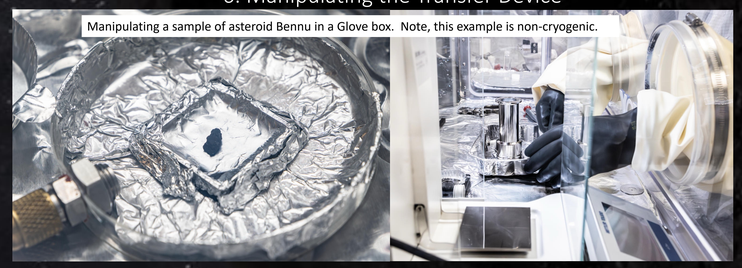


Figure 6. The sample transfer device will need to be able to be easily manipulated in a 'cold box' via gloves. Thus, the number of small pieces and fine manipulations is minimized.

Take-Aways

1. Capability requirements for sample transfer driven by laboratory science analyses needs. – Preserve the physical, chemical, and stratigraphic state of volatiles (to the greatest extent practical.
2. Sample transfer unit(s) requirements must represent a community consensus to ease and facilitate adoption.
   - Minimize impact CONOPS would impose on institutions' protocols in order to maximize participation of institutions' cutting edge analyses of samples
3. Coordination with JSC Cold Curation facilities.
   - Transfer unit will need to be compatible with JSC Cold Curation procedures and maintain similar conditions under Cold Curation although some limited short duration excursion is allowable if proven benign.
   - The transfer unit from Curation to Institution must be simple
4. FUTURE WORK: The transfer sample from this device to analytical equipment within an institution is a separate issue although some analyses can be done through the device's windows and via the gas sampling port.
   - will have a universal component but will also need to be tailored to specific analyses capabilities
   - The 'final 3 feet' remains a challenge.
   - A common protocol is required and a recommended approach/procedure is recommended

4. Notional transfer routes of volatile rich cryogenic samples

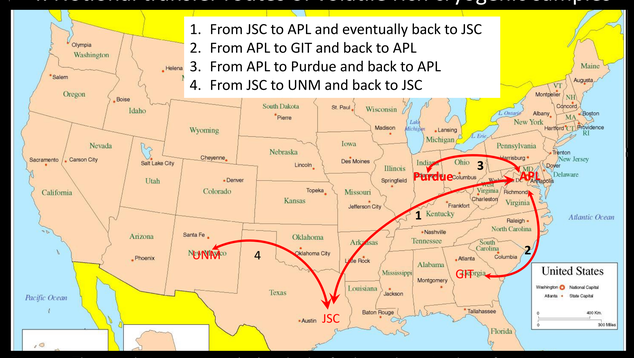
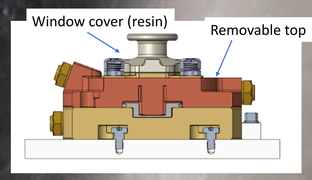
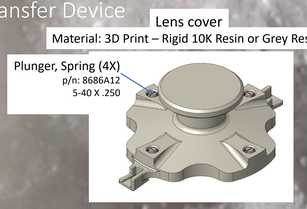
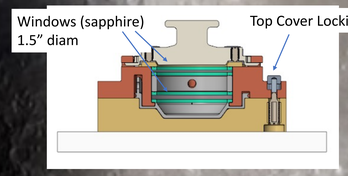


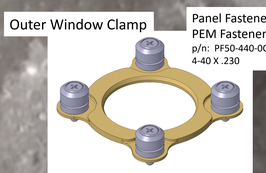
Figure 4. The sample transport can be hundreds of miles and require days of maintaining cryogenic temperatures.

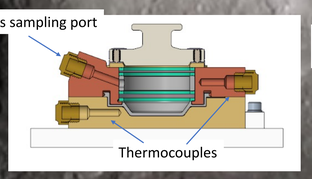
7. Cross-sections and Individual Components of the Sample Transfer Device

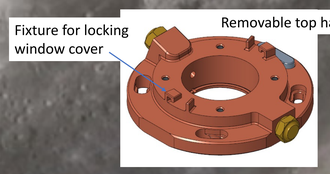


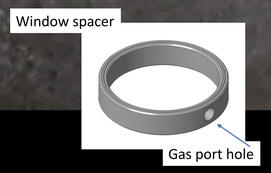


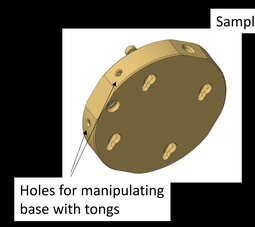


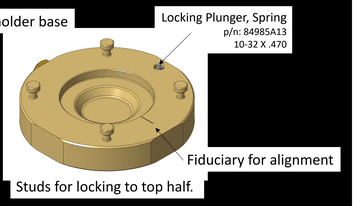


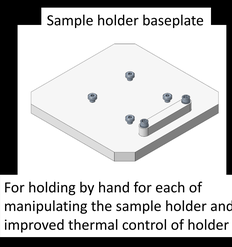












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