Evolution of the Lunar Receiving Laboratory to the Astromaterial Sample Curation Facility: Technical Tensions Between Containment and Cleanliness, Between Particulate and Organic Cleanliness

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The Lunar Receiving Laboratory (LRL) was planned and constructed in the 1960s to support the Apollo program in the context of landing on the Moon and safely returning humans [1]. The enduring science return from that effort is a result of careful curation of planetary materials. Technical decisions for the first facility included sample handling environment (vacuum vs inert gas), and instruments for making basic sample assessment, but the most difficult decision, and most visible, was stringent biosafety vs ultra-clean sample handling. Biosafety required handling of samples in negative pressure gloveboxes and rooms for containment and use of sterilizing protocols and animal/plant models for hazard assessment. Ultra-clean sample handling worked best in positive pressure nitrogen environment gloveboxes in positive pressure rooms, using cleanable tools of tightly controlled composition. The requirements for these two objectives were so different, that the solution was to design and build a new facility for specific purpose of preserving the scientific integrity of the samples. The resulting Lunar Curatorial Facility was designed and constructed, from 1972-1979, with advice and oversight by a very active committee comprised of lunar sample scientists. The high precision analyses required for planetary science are enabled by stringent contamination control of trace elements in the materials and protocols of construction (e.g., trace element screening for paint and flooring materials) and the equipment used in sample handling and storage. As other astromaterials, especially small particles and atoms, were added to the collections curated, the technical tension between particulate cleanliness and organic cleanliness was addressed in more detail. Techniques for minimizing particulate contamination in sample handling environments use high efficiency air filtering techniques typically requiring organic sealants which offgas. Protocols for reducing adventitious carbon on sample handling surfaces often generate particles. Further work is needed to achieve both minimal particulate and adventitious carbon contamination [2]. This paper will discuss these facility topics and others in the historical context of nearly 50 years’ curation experience for lunar rocks and regolith, meteorites, cosmic dust, comet particles, solar wind atoms, and asteroid particles at Johnson Space Center.


Keywords: astromaterial curation facility, biosafety containment, ultra-clean sample handling
<table>
<thead>
<tr>
<th>Year</th>
<th>New Facility Planning, Construction, Check-out</th>
<th>Sample Handling &amp; Curation Facility Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>B. 31N</td>
<td>B. 31N Lunar Curation, 1979 +</td>
</tr>
<tr>
<td>1975</td>
<td></td>
<td>Lunar Thin Section</td>
</tr>
<tr>
<td>1985</td>
<td>Meteorite Curation 1977 +</td>
<td>Meteorite Curation 1977 +</td>
</tr>
<tr>
<td>1990</td>
<td>Meteorite Thin Section 1977 +</td>
<td>Cosmic Dust Curation 1981 +</td>
</tr>
<tr>
<td>2005</td>
<td>Stardust Curation 2006 +</td>
<td>O-REx Reference Curation 2015 +</td>
</tr>
<tr>
<td>2010</td>
<td>Hayabusa Curation 2012</td>
<td>N2 glovebox in ISO Class 5 Laminar Flow Room 2012 +</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sample Handling Environment**

- Positive Pressure Dynamic Nitrogen Glovebox 1970 +
- Positive Pressure Static Nitrogen Long-Term Storage 1970 +
- ISO Class 5 (Class 100) Laminar Flow Room 1981 +
- ISO Class 4 (Class 10) Laminar Flow Room 1998 +
- Freon 113 Final Cleaning for Containers & Tools 1968-1984
- Ultrapure Water Final Cleaning for Containers & Tools 1994 +
### Sample Handling Environment

<table>
<thead>
<tr>
<th>Year</th>
<th>Environment Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>Positive Pressure Static Nitrogen Long-Term Storage 1970+</td>
</tr>
<tr>
<td>1980</td>
<td>ISO Class 5 (Class 100) Laminar Flow Room 1981+</td>
</tr>
<tr>
<td>1985</td>
<td>ISO Class 4 (Class 10) Laminar Flow Room 1998+</td>
</tr>
<tr>
<td>1990</td>
<td>N2 glovebox in ISO Class 5 Laminar Flow Room 2012+</td>
</tr>
</tbody>
</table>

### Samples Types Curated, Handling Techniques Developed

<table>
<thead>
<tr>
<th>Year</th>
<th>Sample Type</th>
<th>Handling Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>Mixed sample, mostly fines for biohazard testing</td>
<td></td>
</tr>
<tr>
<td>1970</td>
<td>Large rocks: subdivision by chipping, bandsawing under nitrogen, thin section</td>
<td></td>
</tr>
<tr>
<td>1975</td>
<td>Bulk regolith: subdivision by fines splitter, hand-picking grains under nitrogen, thin section</td>
<td></td>
</tr>
<tr>
<td>1980</td>
<td>Regolith cores: opening tubes by milling or extrusion under nitrogen, examination and subsampling under nitrogen, thin section</td>
<td></td>
</tr>
<tr>
<td>1985</td>
<td>Micron-size grains captured in silicone oil: glass needle for handling, composition via SEM</td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>Solar atoms captured in silicon, etc.: wafer fragment handling, cleaning with UPW, characterization via FT-IR</td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>Micron-size rocky material captured in aerogel: subdivision of aerogel to isolate particles, embedding and sectioning small grains</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>Micron-size grains handled dry</td>
<td></td>
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<tr>
<td>2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2015</td>
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