Accessing and Assessing Lunar Resources with PROSPECT

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PLATFORM FOR RESOURCE OBSERVATION AND IN-SITU PROSPECTING IN SUPPORT OF EXPLORATION, COMMERCIAL EXPLOITATION & TRANSPORTATION
PROSPECT GOALS: Understanding Resources

1. Water ice
   a. Abundance, distribution, form and extraction

2. Grain surface bound volatiles
   a. Composition, abundance, distribution, extraction

3. Oxygen in regolith
   a. Thermochemical extraction efficiency (reduction and oxidation reactions)

Paige et al. 2010
Objectives

1. **Drill** to access volatiles
2. **Remove samples** of volatile bearing material
3. **Extract** volatiles from samples thermochemically
4. **Identify** the volatiles released
5. **Quantify** the volatiles released
6. **Isotopic** characterisation:
   - a. Measured precisely against agreed international standards
   - b. % accuracy → sources of volatiles
   - c. ‰ accuracy → sources, transport, processes, distribution, fate e.g. water cycle
7. Relate all of the above back to the **original nature** of the volatiles in the regolith
Prospect: Drilling and Sampling

- Drill and sample from up to 2m
- Ice form and preservation
- Material Properties
- Sample size and handling requirements for different users

Potential forms of ice inclusion in lunar regolith (Gertsch, 2013)

Strength of pure polycrystalline ice as a function of temperature (Arakawa and Maeno, 1997)
PROSPECT: Sample Processing and Analysis

Prospect-Processing & Analysis system (Pros-PA)
**Extract**
Stepped heating to 1000°C
Introduction of reactant gasses
  \( \text{O}_2, \text{H}_2, \text{CH}_4, \text{F}_2 \)

**Identify**
Ion trap mass spectrometer against standards

**Quantify**
Determine total yield

**Isotopes**
Gas processing and magnetic sector mass spectroscopy against standards

<table>
<thead>
<tr>
<th>Isotopic ratio</th>
<th>Associated molecular species</th>
<th>Expected Precision</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \delta^D )</td>
<td>( \text{H}_2, \text{H}_2\text{O}, \text{hydrocarbons} )</td>
<td>10‰</td>
</tr>
<tr>
<td>( \delta^{13}\text{C} )</td>
<td>( \text{CO, CO}_2, \text{hydrocarbons} )</td>
<td>0.1-1‰</td>
</tr>
<tr>
<td>( \delta^{15}\text{N} )</td>
<td>( \text{N}_2, \text{NH}_3, \text{nitrogen oxides} )</td>
<td>0.1-1‰</td>
</tr>
<tr>
<td>( \delta^{18}\text{O} )</td>
<td>( \text{H}_2\text{O}, \text{CO and CO}_2 )</td>
<td>0.1‰</td>
</tr>
</tbody>
</table>
Some Important Areas Where Science Community Inputs are Needed

1. Sample size
   a. Size Vs extraction efficiency and handling
   b. Size Vs measurement requirements

2. Alteration
   a. What level of sample alteration is acceptable?
   b. What are the implications for the sample chain (e.g. temperature)?

3. Contamination
   a. What are the potential risks posed by contamination?
   b. How can these be characterised?
   c. How can they be understood and mitigated?
      - By design
      - By operation

4. Analogues for verification
   a. What analogues could be used to verify sub-system and system performance?