Simulating Lunar Ice

Abstract #1815

Formerly: A Comparison of Volatile Release Rates During a Simulated Extraction from Lunar Ice Mixed with Highland or Mare Regolith

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Background

In-situ extraction of volatiles from lunar ices for the production of rocket fuel and other critical materials is instrumental in a sustainable return to the Moon. It is imperative that some exploratory experiments are conducted to characterize any potential interactions of lunar ices with differing host regolith during the extraction process.

This experiment was intended to identify potential differences in the physical progress of volatile extractions from lunar ice caused by the presence of Highland or Mare regolith in the samples. However, what we actually learned was the difficulty in simulating lunar ice and that there are notable physical differences between ices in Highland and Mare regolith.

It is important to remember that this is information from a single location on the Moon and that the ices in other locations may have differing chemical compositions and physical characteristics.

LCROSS Data

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Gas</th>
<th>Ice</th>
<th>Dust mass (g)</th>
<th>Total water %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-25</td>
<td>24.4</td>
<td>61</td>
<td>133 ± 1.8</td>
<td>4.5 ± 1.7</td>
</tr>
<tr>
<td>33-100</td>
<td>57.5</td>
<td>2.6</td>
<td>15.8 ± 2.2</td>
<td>7.2 ± 1.9</td>
</tr>
<tr>
<td>Average</td>
<td>53.1</td>
<td>15</td>
<td>68 ± 10</td>
<td>5.6 ± 2.9</td>
</tr>
</tbody>
</table>

Table 1 from Colaprete, A. et al. [2], Summary of the total water vapor and ice and ejecta dust in the NIR instrument I/OV.

Simulants Used

Lunar regolith simulates:
- OPRH1N (Off Planet Research Highland Group 1 Non-Agglutinate)
- OPRL1N (Off Planet Research Mare Group 1 Non-Agglutinate)

Lunar ice simulant created:
- OPRFLCROSS1 based on the data gathered from the LCROSS impact

Note: SO₂ and OH components were not included in the simulated lunar ice for safety reasons.

The specifications for these simulants can be found at Offplanetresearch.com.

Sample Preparation

Samples of Highland and Mare simulants of equal dry mass were placed into stainless steel containers. Liquid nitrogen was used to cool the regolith simulants and equipment and to freeze the components of the simulated lunar ice as they were mixed into the regolith simulants.

The simulated lunar ice/regolith mixtures were produced using LCROSS impact data (Tables 1 & 2). The ice and regolith were mixed as described by PI Anthony Colaprete: “It is likely water ice is interspersed between dirt particles on the lunar surface” [2].

Enough OPRFLCROSS1 was made for 10 trials of both Highland and Mare mixtures.

A 125 ml sample was placed into a vacuum chamber and warmed. The mass was recorded as the components sublimated off.

Results

The vacuum chamber suffered a structural failure approx. 23 minutes into the first Highland trial.

Volatilization of Ice Components Indicated by Loss of Mass Over Time

![Graph showing volatilization of ice components over time]

Table 2 from Colaprete, A. et al [1]. Relative abundances of ice constituents. The uncertainty in each derived abundance is shown in parenthesis.

Future Studies/Recommendations

Lessons Learned:
- Notable differences between ices formed in Highland and Mare regolith
- Changes in the geotechnical characteristics of super-cooled regolith
- Making lunar ice is difficult
- Volatiles seem to come off in stages

Next Steps:
- Physical nature of volatile species (e.g. pure concentrations, inter-granular, globular)
- More consistent distribution of volatiles in each trial
- Geotechnical and mechanical testing
- Material handling characteristics
- Catalogue differences between Highland and Mare ice regolith mixtures
- Develop methods for ice storage

Resources Needed:
- NIR sensors (Ask us about our SBIR proposal!)
- Measurement equipment
- Long-term ice storage
- Improved thermal vacuum capabilities

Contact Information

If you are interested in learning more:
Find us on Facebook @OffPlanetResearch
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Haiku

Out of the loop left
To talk haikus required
Present we cannot

References


Accessed Jan 6, 2017 from https://www.space.com/7530-significant-amount-water-moon.html