The Resource Prospector Near-Infrared Volatile Spectrometer System
NIRVSS
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Why NIR Spectroscopy?

- Proven Technique
- Provides information on a range of solid volatiles, but also mineralogy
- Can provide additional information on the form (e.g., crystalline vs. amorphous ice) and grain size
- Instrumentation can have a relative small Project and Mission “foot print”, including low cost, mass, volume and power
- Can provide rapid evaluation of samples for cortical decision making
Volatile search

- Species include: H$_2$O, NH$_3$, CO$_2$, CH$_4$
- Ample vibrational fundamental absorptions at near- to shortwave-infrared wavelengths (1.5-4 µm)
- Spectral resolution required:
  - H$_2$O: 20-30 nm
  - NH$_3$: 10-20 nm
  - CO$_2$: 10-20 nm
  - CH$_4$: 20-30 nm
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How Sensitive to H$_2$O Ice?

Data points convolved to NIRS sampling and resolution

- Lun$ar$ Soil (LS) = 70 $\mu$m
- H$_2$O ice = 10 $\mu$m, LS= 70 $\mu$m
- H$_2$O ice = 70 $\mu$m, LS= 70 $\mu$m
- H$_2$O ice = 200 $\mu$m, LS= 70 $\mu$m
- H$_2$O ice = 10 $\mu$m, LS= 10 $\mu$m

Granular mixture 0.5% H$_2$O ice

<table>
<thead>
<tr>
<th>Ice ($\mu$m)</th>
<th>Soil ($\mu$m)</th>
<th>BD$_{2000}$ (%)</th>
<th>SNR, 3$\sigma$</th>
<th>BD$_{3000}$ (%)</th>
<th>SNR, 3$\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10</td>
<td>5.0</td>
<td>49</td>
<td>20.1</td>
<td>14.5</td>
</tr>
<tr>
<td>10</td>
<td>70</td>
<td>4.0</td>
<td>75</td>
<td>19.4</td>
<td>15</td>
</tr>
<tr>
<td>70</td>
<td>70</td>
<td>3.5</td>
<td>86</td>
<td>2.7</td>
<td>111</td>
</tr>
<tr>
<td>200</td>
<td>70</td>
<td>2.9</td>
<td>103</td>
<td>0.6</td>
<td>500</td>
</tr>
</tbody>
</table>
1. **Monitor** the surface during rover traverses and at excavation sites for water and other volatiles.
   - Identify surface bound H$_2$O/OH
   - Constrain mineralogical/geological context
   - Measure surface temperatures

2. **Observe** the immediate vicinity of the drill site before and during drill operations to look for near real-time changes in the properties of the exposed materials.
   - Identify volatiles, including water form (e.g., ice vs. bound)
   - Identify gasses evolved during drilling activity
   - Constrain the volatile presence in top ~20-30 cm of regolith: provides constraints on neutron measurements of H-abundance
   - Constrain surface/subsurface temperatures
### NIR Volatiles Spectrometer System

#### Key instrumental characteristics for NIRVSS, Bracket Assembly

<table>
<thead>
<tr>
<th>Property</th>
<th>Spectrometer</th>
<th>NIRVSS Bracket Assembly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (mm)</td>
<td>202 x 154 x 82</td>
<td>204 x 130 x 151</td>
</tr>
<tr>
<td>Mass (kg)</td>
<td>1.97</td>
<td>1.14</td>
</tr>
<tr>
<td>Native Resolution</td>
<td>N/A</td>
<td>2048 x 2048</td>
</tr>
<tr>
<td>Image Scaling Options</td>
<td>N/A</td>
<td>2048 x 2048, 1024 x 1024, 512 x 512, 256 x 256, 128 x 128</td>
</tr>
<tr>
<td>Wavelength range, sampling, (mm)</td>
<td>1.6-2.4, 0.009, 2.3-3.4, 0.012</td>
<td>N/A 410, 540, 640, 740, 905, 940, 1025 nm</td>
</tr>
<tr>
<td>Power (W)</td>
<td>Nominal (n): 6.8</td>
<td>BA Electronics: 1.68 (n), 1.75 (p)</td>
</tr>
<tr>
<td></td>
<td>Peak (p): 7.4</td>
<td>12.3 0.3 (n) 1.0 (p), 7.14 (LED flash)</td>
</tr>
<tr>
<td>IFOV, (°)</td>
<td>≈24° each</td>
<td>=26° camera, 55° LEDs, 90-100°</td>
</tr>
<tr>
<td>Thermal (°C) Survival:</td>
<td>-25 &gt; T &gt; +75 -20 &gt; T &gt; +45</td>
<td>-50 &gt; T &gt; +120 -20 &gt; T &gt; +110</td>
</tr>
<tr>
<td>Operational:</td>
<td>-20 &gt; T &gt; +45</td>
<td>-30 &gt; T &gt; +70 -20 &gt; T &gt; +60</td>
</tr>
<tr>
<td>Data Interface, rate (kbaud)</td>
<td>2 - RS-422, 115.2</td>
<td>NA RS-422, 230.4 RS-422, 9.6</td>
</tr>
<tr>
<td>Input Voltage</td>
<td>28 +/- 6V</td>
<td>28 +/- 6V</td>
</tr>
</tbody>
</table>

- **Spectrometer**
  - Lamp Assembly
  - Drill Ops Camera (DOC)
  - Fiber Optics to Spectrometers
  - LCS
  - LEDs

- **Bracket Assembly**
  - Drill Ops Camera (DOC)
  - Fiber Optics to Spectrometers
  - LCS
  - LEDs

No ITAR/EAR export materials herein.
NIRVSS Components

Spectrometer
• Sufficient wavelength range and resolution to identify key volatiles (solid and gas)
  – 2 optical Engines; ShortWave (SW) ≈1600-2400 nm and LongWave (LW) ≈2300-3400 nm
  – Spectral sampling SW ≈9 nm LW ≈12 nm
  – Full spectrum approximately every 0.7 sec
• Achieve SNR > 100 at 2 μm and 3 μm while roving and drilling

Bracket Assembly
• IR emitter
  – Enables observations while roving and drilling, in dark
  – Bright enough to meet SNR requirement while in shadow
• Drill Observation Camera (DOC)
  – Image drill area with sufficient FOV to observe cuttings
  – Sufficient resolution to identify 0.15 mm regolith structure
  – 8 LEDs for multi-spectral imaging
• Longwave Calibration Sensors (LCS)
  – thermal emission correction for 3 μm band; required for determining concentrations of OH/H2O
  – Measure radiance at 8, 10, 14 and 25 μm
NIRVSS Testing

RP15 Porotype rover with payload

RP15 Remote Ops at ARC

GRC VF13 TVAC Chamber
NIRVSS Testing

RP15 Rover Testing

GRC TVAC Testing
NIRVSS - Summary

- NIRVSS spectrometer & illumination source provide sensitivity to changes in soil water content while roving and as drilling progresses
  - Can provide a “quick” assay of drill cuttings for volatile content

- Relatively modest “footprint” at around 3kg and 15W

- NIRVSS DOC captures morphology and behavior during drilling and LEDs provide compositional recognition

- NIRVSS LCS designed for correction of surface T’s > 200° K, and can measure the scene temperatures between 80 to 400 K