The Resource Prospecting Mission Drill

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Background: The Resource Prospector (RP)

Goal:
• ISRU demo: Prospecting for volatiles, extraction of O2 from lunar regolith

Instruments:
1. **The Neutron Spectrometer Subsystem (NSS)**
   1. Localizing elevated H2 concentration
2. **The Drill Subsystem**
   1. Capture samples from up to 1 m
3. **The Near InfraRed Volatiles Spectrometer Subsystem (NIRVSS)**
   1. Characterize hydrocarbons, mineralogical context for the site, nature of water ice
4. **The Oxygen and Volatile Extraction Node (OVEN) Subsystem**
   1. Evolve the volatiles in sample by heating and transfer to LAVA
   2. Demo hydrogen reduction process (H2 reacts with iron oxide to produce water)
5. **The Lunar Advanced Volatiles Analysis (LAVA) Subsystem**
   1. quantites and species of volatiles via GC/MS
   2. Water Droplet Demonstration (WDD)

Andrews et al., 2014
The Drill Subsystem: Background

- **The Icebreaker drill**
  - Developed for acquisition of Ice/Ice Cemented Ground at the Mars Poles
  - 1 m depth, 10 kg
  - Tested in Antarctica, Arctic, Greenland
  - Tested in Mars Chamber
  - TRL 5/6

- **Goal:**
  - “Turn” Mars drill into Lunar drill

- **Mars vs Moon Drill**
  - Mars:
    - Planetary Protection
    - Perchlorate in Ice (freezing point depression)
    - Sticky Sample (Relative humidity up to 100%)
    - Full autonomy (long communication delay)
  - Moon
    - Extreme Temperatures (40K - 400K)
    - Hard Vacuum (Ice sublimation >106 K)
    - Teleop/supervised autonomy
Some Considerations and Trades
Drilling Approaches

SONIC

ULTRA SONIC

PERCUSSIVE

ROTARY

Final Selection: ROTARY-PERCUSSIVE

Lander

Rover

40 kg

10 kg

40 kg

12 kg
1. **Embedded Sensor**
   - Step 1: Drill
   - Step 2: Acquire Sample
   - Step 3: Analyze

2. **Sniffer Auger**
   - Step 1: Drill
   - Step 2: Acquire Sample
   - Step 3: Analyze

3. **Sampling Auger**
   - Step 1: Drill
   - Step 2: Transfer Cuttings
   - Step 3: Analyze

4. **Bit Sampler**
   - Step 1: Drill
   - Step 2: Pull Out
   - Step 3: Transfer Cuttings
   - Step 4: Analyze

5. **Core**
   - Step 1: Drill
   - Step 2: Break-off core
   - Step 3: Capture Core
   - Step 4: Pull out
   - Step 5: Eject core
   - Step 6: Process core
   - Step 7: Analyze
“Bite” Sampling Concept

- Drill to 1 meter in short (~ 10 cm) “bites”
- Preserve stratigraphy in “bites”
- Lower risk (“graceful failure”) – if drill stuck at 60 cm, 5 bites done
- Time for analysis while drill in ‘safe’ place (above the hole)
- Time for subsurface to cool down
Implementation of “Bite” Sampling

1. Drill “Bites” into ice-bearing material

2. Retract auger with captured cuttings

3. Inspect cuttings with Infrared Sensor and Camera. If ice bearing material is detected, proceed to next step. Otherwise continue taking “Bites”

4. Rotate and retract auger to deliver ice-bearing material still within sampling system
Lunar Chamber Demonstration
Tests at NASA GRC

Background:
- Lunar chamber converted to ‘dirty’ chamber tests
- Soil:
  - NU-LHT-3M with 4-5 water wt%,
  - Vibratory compacted to ~1.5 g/cc
  - Temp: -140 C to - 90 C
- Chamber P: ~10^-6 torr
- Crucible T: -85 C to -50 C (+10 C)

Goal:
1. Capture sample from 40 - 50 cm
2. Deliver to crucible
3. Seal
Setting up

Sample Bin  Drill Assembly  LN2 Shroud  Top Lid
Cameras
Seek-Drill-Dump-Close

Speed x4
Seek-Drill-Dump-Close

Speed x4
Seek-Drill-Dump-Close

Speed x16
Seek-Drill-Dump-Close

Speed x1 (real time)
Drill holes and crucible
Results

- Water wt% = function(Temperature)
  - Can preserve all water if T kept low

See Kleinhenz et al. 2015, AIAA SciTech
Drill Data

- Bit T was dropping during drilling because soil T was lower with depth
- Approx. 10 min to capture 10 cm “bite”
Drill Data

- Drilling Power ~20 Watt (percussion hardly ever used)
- Weight on Bit < 30 N
- Left drill in a hole for 45 min - no problem
Testing from the JSC RP Rover
Drill tests at JSC
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