Volatile Extraction and Detection From Frozen Lunar Regolith Simulants in Preparation for the LUVMI Rover

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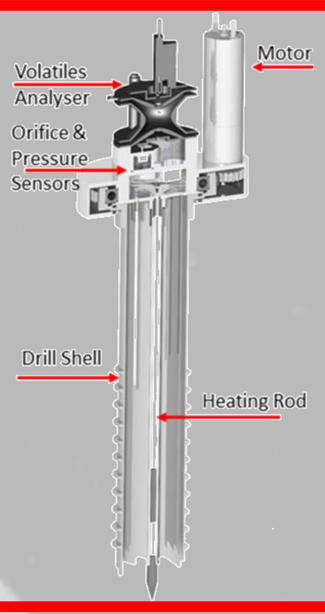
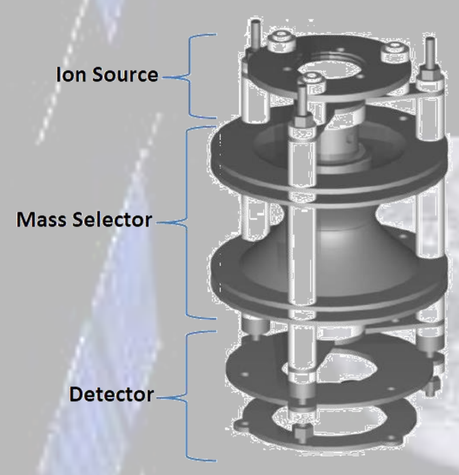
The Lunar Volatiles Mobile Instrumentation (LUVMI) is a novel lightweight mobile platform designed for operations at the lunar South Pole, comprised of the Volatiles Sampler (VS), Volatiles Analyser (VA) and surface and sub-surface imaging instruments. LUVMI will prospect and extract volatiles from permanently shadowed regions up to a depth of at least 10cm [1]

Volatiles Extraction

- The VS is a combined hollow rotating drill shell and heating rod
- Penetrates >10cm into regolith, with a goal of 20cm [2]
- Regolith enclosed in shell heated by rod to release bound volatiles
- ~50% of volatiles will pass through into the VA



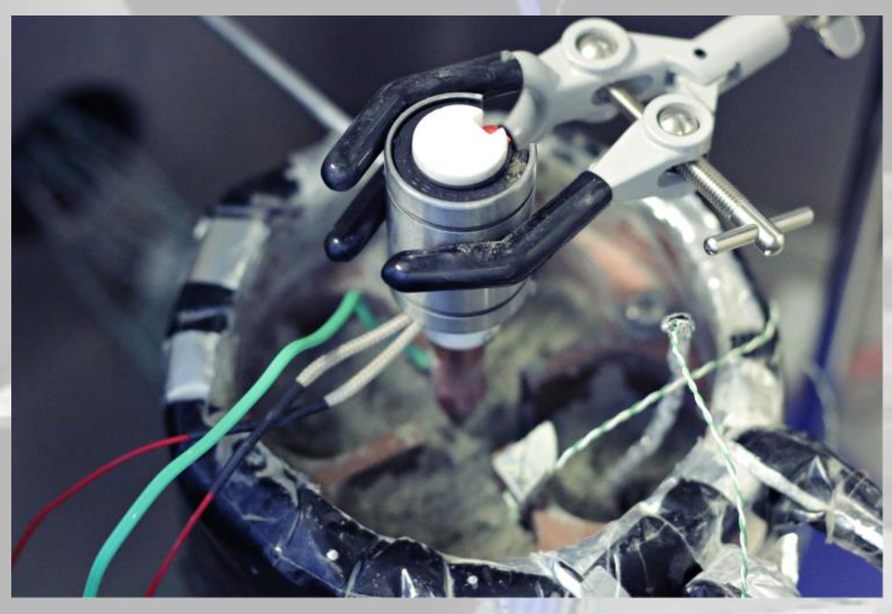


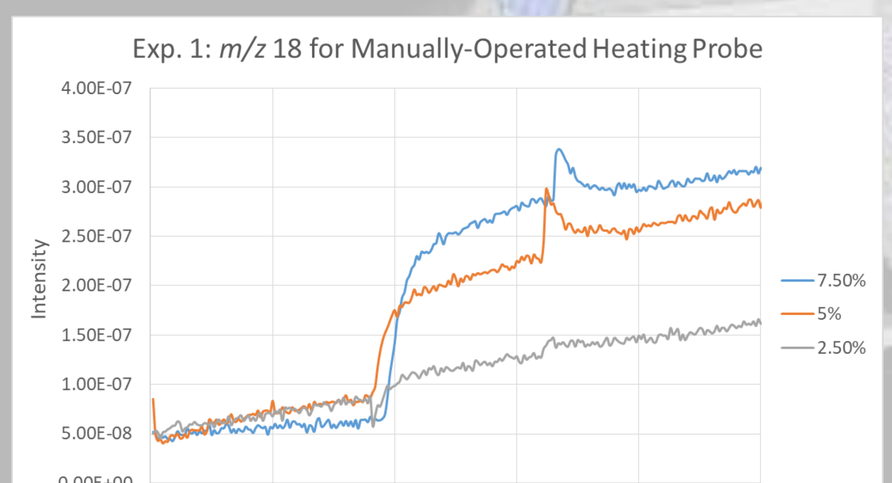
Volatiles Analyser

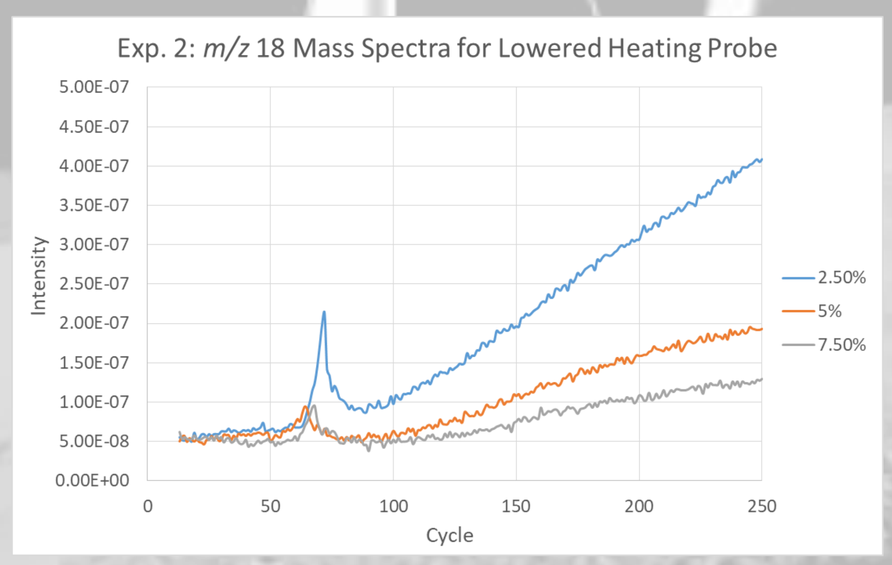
- Ion trap mass spectrometer based upon flight-proven Ptolemy and MoonLite penetrator instruments
- Capable of rapid detection of masses in the *m/z* 10 – 150 range
- Consists of an ion source, mass selector, detector and reference gas system [3]

Volatile Extraction Study

- Developed protocols for studying volatile preservation and extraction under cryogenic and vacuum conditions, to be used for tests with flight-representative VA
- A custom-built, manually-operated thermal probe was used to penetrate and heat frozen lunar regolith
- Highlands simulant NU-LHT-2M mimics lunar South Pole regolith [4]
- 200g samples were mixed with 5, 10 and 15ml of water respectively (approx. 2.5, 5 and 7.5% water mass), similar to 5.6 ± 2.6% water mass contents observed by LCROSS [5]
- Regolith cooled to -150°C in N_2-rich atmosphere in vacuum chamber, and evacuated to approx. $1x10^{-4}$ mbar
- Spectra measured using quadrupole mass spectrometer, focusing on *m/z* 18 as an indicator for the presence of extracted water
- Two experiments performed:
  1. Probe heated above regolith to 160°C, manually inserted into regolith at spectra cycle 80, removed at cycle 160
  2. Probe held within regolith throughout, heated from cycle 50, reaching 160°C at cycle 150
- Demonstrated water extraction from cryogenically-cooled regolith
- Exp. 1 measured increase in water sublimation when probe is inserted and removed, indicating the importance of mechanical movements in volatile extraction

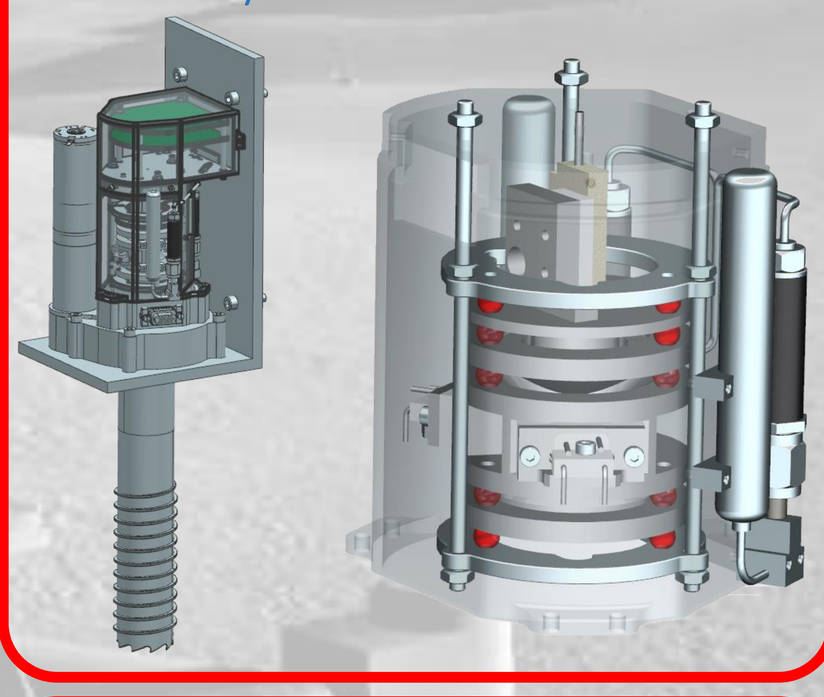






Integration with VS

- VA assembled within custom enclosure
- Electronics located close to VA
- System to be connected to VS developed by TUM and OHB
- Final manufacture and assembly underway



Conclusions

- Developed a bespoke lunar thermal vacuum system
- Protocols developed for handling cryogenic volatile-rich simulants
- Demonstrated extraction of water from frozen regolith
- Measurements performed with COTS mass spectrometer

References

[1] Gancet J. et al. (2017) *ASTRA 2017.* [2] Biswas J. et al. (2017) *ELS V*. [3] Urbina D. A. et al. (2017) *IAC LXVIII* [4] Stoeser D. et al. (2010) *NASA Tech. Mem. 2010-216438*. [5] Colaprete A. et al. (2010) *Science, 330*, 463-467.

Acknowledgements

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