Mobile In-Situ Exploration of Lunar Volatiles with the LVS on LUVMI

Conference or Workshop Item

MOBILE IN-SITU EXPLORATION OF LUNAR VOLATILES WITH THE LVS ON LUVMI

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Introduction: Lunar volatiles are considered as a potential resource for future exploration efforts. Remote observations have confirmed the existence of volatiles deposits in permanently shadowed regions (PSRs) near the lunar poles [1], but in-situ measurements of local abundances are necessary to determine the economic viability of future exploitation. Currently existing or proposed instruments for volatiles prospecting, such as the ESA PROSPECT payload for the Luna-27 lander [2], consist of many different subsystems, like sampling drill, sample distribution systems, gas extraction ovens, and an analysis instrument suite, resulting in comparably high overall mass and complexity. The Lunar Volatiles Scout (LVS) [3,4] heats soil samples in-situ inside the drill, thus avoiding the need for extensive sample logistics and reducing the associated risks of sample degradation. Its drill can sample volatiles on the lunar surface as well as in the shallow subsurface [5] up to a depth of 20 cm. With an overall instrument mass of less than 2.0 kg, the LVS will be carried by the Lunar Volatiles Mobile Instrumentation (LUVMI) [6], a 20 – 40 kg class rover, capable of operating in and around PSRs. LUVMI is currently under development by a consortium of Space Applications Services, The Open University, Technical University of Munich, OHB Systems, and Dynamic Imaging Analytics in the European Horizon 2020 framework.

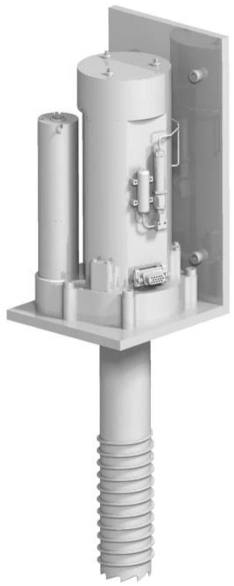

Figure 1: CAD image of the LVS

System Description: Figure 2 shows a schematic of the LVS: The hollow drill shell of the Volatiles Sampler (VS) encloses sample volume of regolith (max. 218 cm^3) and a heating rod in its center, which can heat the sample up to 400 K to extract present volatiles. Extracted gases either accumulate inside the sample volume, diffuse out through open bottom of the shell or flow through a calibrated orifice. Monitoring the pressure profile over time inside the sample volume allows the inference of the original abundance of volatiles in the sample. A miniature mass spectrometer, the Volatiles Analyser (VA), identifies the chemical species and relative concentrations for extracted volatiles with a m/z ratio between 10 and 150. The drill shell is equipped with an auger and is rotated by a brushed DC motor to ease insertion, while maintaining a low rotational speed to reduce heating through friction.

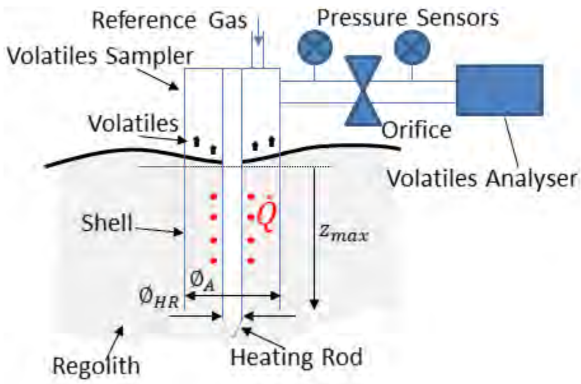

Figure 2: Schematic of the LVS

Prototypes and Testing: As part of the preparatory tests for the development of the VS, a mechanical prototype was designed and manufactured to determine the necessary vertical insertion force and the optimal drill shell geometry. It was found that no more than 30 N were required to reach a minimum depth of 10 cm. A static gas extraction prototype was built and tested in a dust tolerant ("dirty") thermal-vacuum chamber to demonstrate gas extraction and sample preparation procedures.

Currently, an integrated prototype is being manufactured (Figure 1) that will allow end-to-end testing with cryo-cooled samples and mechanical insertion in thermal-vacuum conditions. This will allow a full characterisation of the integrated LVS in a relevant environment with the goal to raise the instrument technology readiness level to TRL 6.

Expected Results: The LVS enables in-situ extraction of volatiles from undisturbed lunar regolith samples near and inside PSRs. With the mobile platform LUVMI, a high number of repeated measurements at different locations, different depths, as well as over longer periods of time will be possible. This allows the characterisation of volatile species

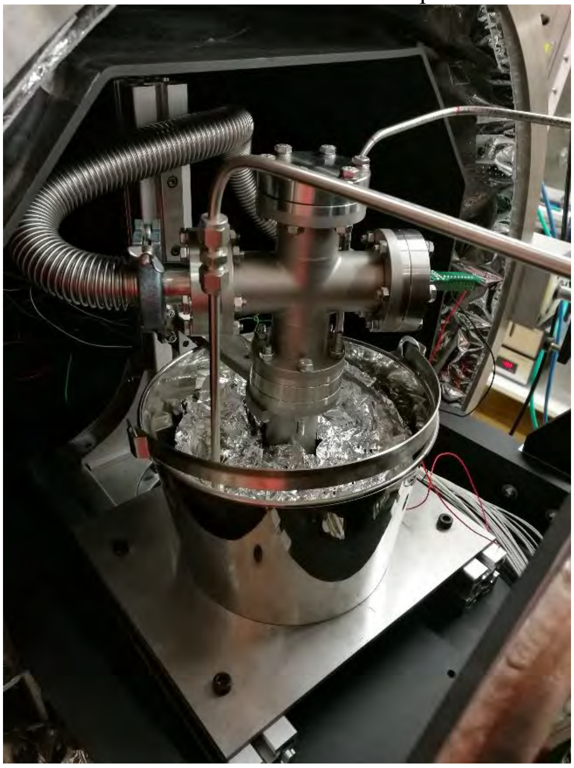

Figure 3: Static gas extraction prototype during thermal-vacuum testing

and their distribution, abundance, and variation over time. LVS on LUVMI therefore represents an ideal precursor instrument for future lunar exploration and can identify locations of interest for the exploitation of volatiles as a resource.

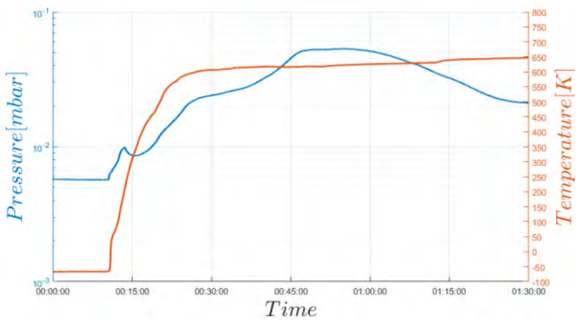

Figure 4: Examplary gas extraction test result with a JSC-1A sample with approximately 0.25 wt% water

References: [1] Colaprete A. et al (2010) *Science, 330,* 463–468. [2] Carpenter J. et al. (2017) *European Lunar Symposium 2017*. [3] Biswas J. et al (2017) *European Lunar Symposium 2017.* [4] Reiss P. et al (2016) *European Lunar Symposium 2016.* [5] Beyer R. et al (2011) *LPSC XLII #2735*. [6] Urbina D. et al (2017*) IAC-17,A3,2B,10,X41392*