Characterization of the Lunar Volatiles Scout for In-Situ Volatiles Extraction and Analysis. J. Biswas[1], P. Reiss[1], S. Sheridan[2], S. Barber[2,], C. Pitcher[2], M. Reganaz[3], L. Richter[3] [1]Institute of Astronautics, Technical University of Munich, Boltzmannstr. 15, 85748 Garching, Germany, (j.biswas@tum.de), [2]The Open University, Milton Keynes, MK7 6AA, UK, [3]OHB System AG, Manfred-Fuchs-Str. 1, 82234 Weßling, Germany,

Introduction: Multiple remote sensing missions have confirmed the existence of volatiles on the lunar surface and have provided data on the global distribiution, possibly indicating significant deposits near the lunar poles. However, ambiguities remain in the interpretation of this data and local distribution, chemical composition, physical state, and extractability of this potential resource remain unkown [1]. Future surface investigations need mobility to address expected heterogenous volatiles distribution and be affordable enough to justify exposure to hazards inherent to polar permanently shadowed regions.

The Lunar Volatiles Scout (LVS) is a small and compact instrument for the in-situ extraction and analysis of volatiles that can be accommodated on small lunar rovers [2]. Recent thermal-vacuum testing of an integrated prototype of the LVS successfully demonstrated the extraction of volatiles from icy regolith simulants, the determination of their abundance, and the analysis of chemical species.

Instrument Description: The instrument consists of core drill of 15 – 20 cm length that allows sampling of the shallow lunar subsurface. The regolith sample is heated in-situ inside the drill shell to extract enclosed volatiles. The pressure inside of the drill shell is monitored by two Pirani sensors to determine the abundance of released volatiles. A small orifice connects the sample volume to a miniature ion trap mass spectrometer, which allows to determine the released chemical species and their relative concentrations. The m/z range is 10 to 150, which allows the detection of all species that were present in the LCROSS ecejta plume [3]. The total instrument mass is 1.9 kg.

Thermal Vacuum Analogue Testing: A thermal vacuum test setup was established at Technical University of Munich to allow testing of the instrument under simulated lunar conditions. In this setup, the LVS is suspended on a vertical actuator above a lunar regolith simulant sample. For the experiments, the simulant JSC-1A was hydrated by mixing with water and subsequent freezing to -50 °C. A total of 20 experiments were performed with water contents between 0.1 wt% and 5.3 wt%. After drilling into the sample, the heating rod of the LVS prototype was activated for 90 min at 15 W constant power. After heating, the drill was retracted and residual soil in the drill shell was measured to assess cross-contamination.

Results:

Volatiles Abundance: To assess the ability of the LVS to determine the volatiles abundance in a sample, a test series was conducted with frozen moisturized samples of variying water content. Figure 1 shows the development of the pressure inside the drill shell for different water contents. Expectedly, higher water content lead to higher pressures inside the sample volume. Although the sample volume is only sealed by the regolith, the pressures rise to at least 10 mbar, above which the Pirani sensors become insensitive.

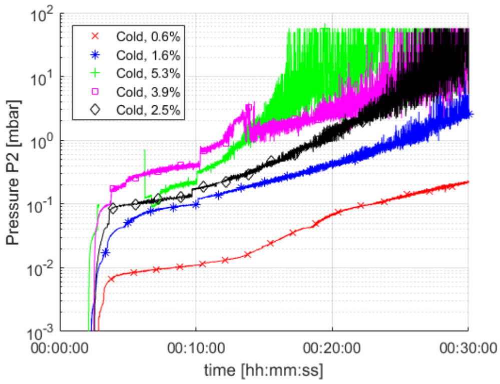

Figure 1: Pressure in LVS drill shell for different water contents of the sample

Volatiles Analysis: A sample with 0.2 wt% water was prepared for the combined gas extraction and analysis test. The mass spectrometer was able to continuously scan for the 90 min heating duration. An image of the mass spectra after 600 s is shown in Figure 2. A clear peak at m/z 18 is visible, along with a small signal at m/z 16 and 17, proving the release of water. A maximum pressure of $2 \cdot 10^{-3}$ mbar was measured inside the volume of the mass spectrometer.

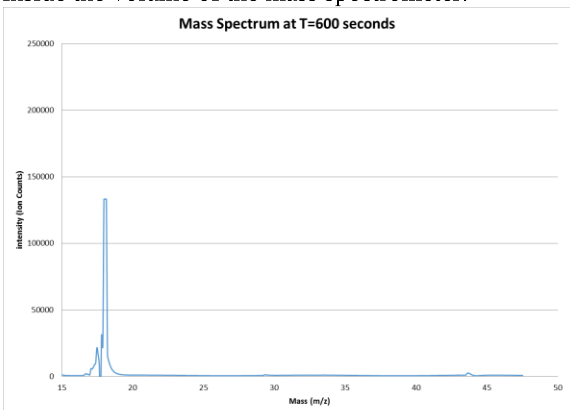

Figure 2: Mass spectra of a moisturized sample after 600 s of heating

Conclusion & Future Work: The presented results demonstrate the ability of the LVS to extract and analyse volatiles in a representative scenario under Moon-like conditions. With the LVS it is possible to distinguish measurements of different volatile contents. For a more conclusive determination of the volatiles abundance, further characterization measurements are planned that take into account the effect of soil bulk density and temperature. In addition, the LVS prove to identify the released chemical species during heating. In an next step it will be investigated to what extent the LVS can also determine relative concentrations of chemical species to increase the scientific output. Further thermal-vacuum experiments are planned to achieve a full characterization of the instrument and to further increase its maturity. The LVS currently currently has a technology readiness level of 5-6 and will be available for near-future flight opportunities.

Acknowledgements:
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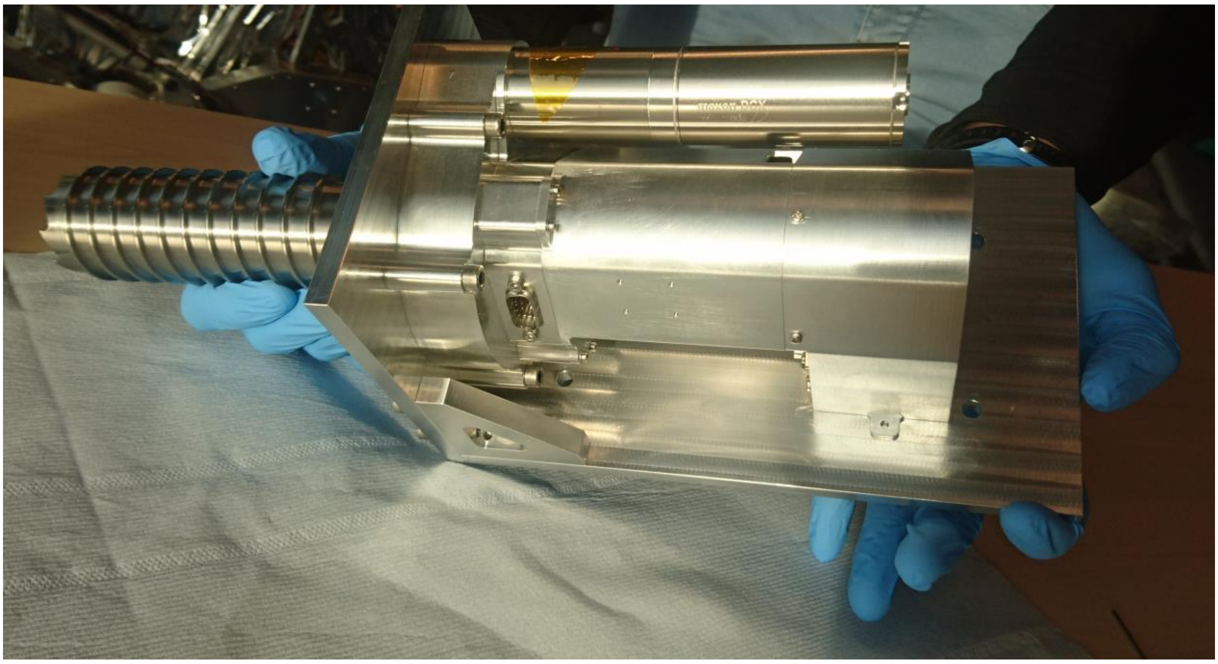

Figure 3: Image of the Lunar Volatiles Scout (LVS) prototype