Extracting Volatile Water from Lunar Regolith with the Lunar Volatiles Scout

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Investigation of Transient Volatile Migration in Lunar Regolith for the Lunar Volatiles Scout

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About

- **Lunar Volatiles Scout** [1], see **Figure 1**, is a novel soil sampling and analysis instrument
- Plan to investigate **volatile water** trapped at the lunar poles
- Utilizes **thermal extraction** by powering the central heating rod once inserted about 100–150mm into the regolith
- **Mass spectrometer** and **pressure sensors** analyzes desorbed volatiles
- Simulation of **numerical model** implemented in COMSOL Multiphysics, based on **Reiss, 2018** [2], to verify method

Studies

- **Adsorption rate study**
  Investigation of the influence of k_a, implemented through **Langmuir's Adsorption Theorem** [3], on the extraction, mainly on the **molar flux** over the regolith's surface, see **Figure 2**.

- **Correlation study**
  Based on prior experimental results, fitting the **adsorption rate** k_a and the **desorption energy** E_d [4,5], see **Arrhenius Equation**, of the simulation to match the transient temperature and pressure behavior, see **Figure 3**.

Conclusion

- Increasing adsorption rate shifts the molar flux peak to **later times and higher maximum values**
- **Significant positive correlation** found with the factors $k_a = 4.5 \times 10^{-8} Pa^{-1} s^{-1}$ and $E_d = 0.99 eV$, shown in **Figure 3**
- Pressure offset and temperature inertia due to data generation

[1] **J. Biswas**, S. Sheridan, C. Pitcher, L. Richter, M. Reganaz, S. J. Barber, and P. Reiss, "*Searching for potential ice-rich mining sites on the Moon with the Lunar Volatiles Scout,*" vol. 181, p. 104826, 2020.
[2] **P. Reiss**, "*A combined model of heat and mass transfer for the in-situ extraction of volatile water from lunar regolith,*" vol. 306, pp. 1-15, 2018.
[3] **I. Langmuir**, "*The adsorption of gases on plane surfaces of glass, mica and platinum.,*" J. Am. Chem. Soc., vol. 40, pp. 1361-1403, 1918.
[4] **M. J. Poston**, G. A. Grieves, A. B. Aleksandrov, C. A. Hibbitts, M. D. Dyar, and T. M. Orlando, "*Water interactions with micronized lunar surrogates JSC-1A and albite under ultra-high vacuum with application to lunar observations,*" vol. 118,pp. 105-115, 2013
[5] **C. A. Hibbitts**, G. A. Grieves, M. J. Poston, M. D. Dyar, A. B. Alexandrov, M. A.Johnson, and T. M. Orlando, "*Thermal stability of water and hydroxyl on the surface of the moon from temperature-programmed desorption measurements of lunar analog materials,*" ICARUS, vol. 213, pp. 64-72, 2011.

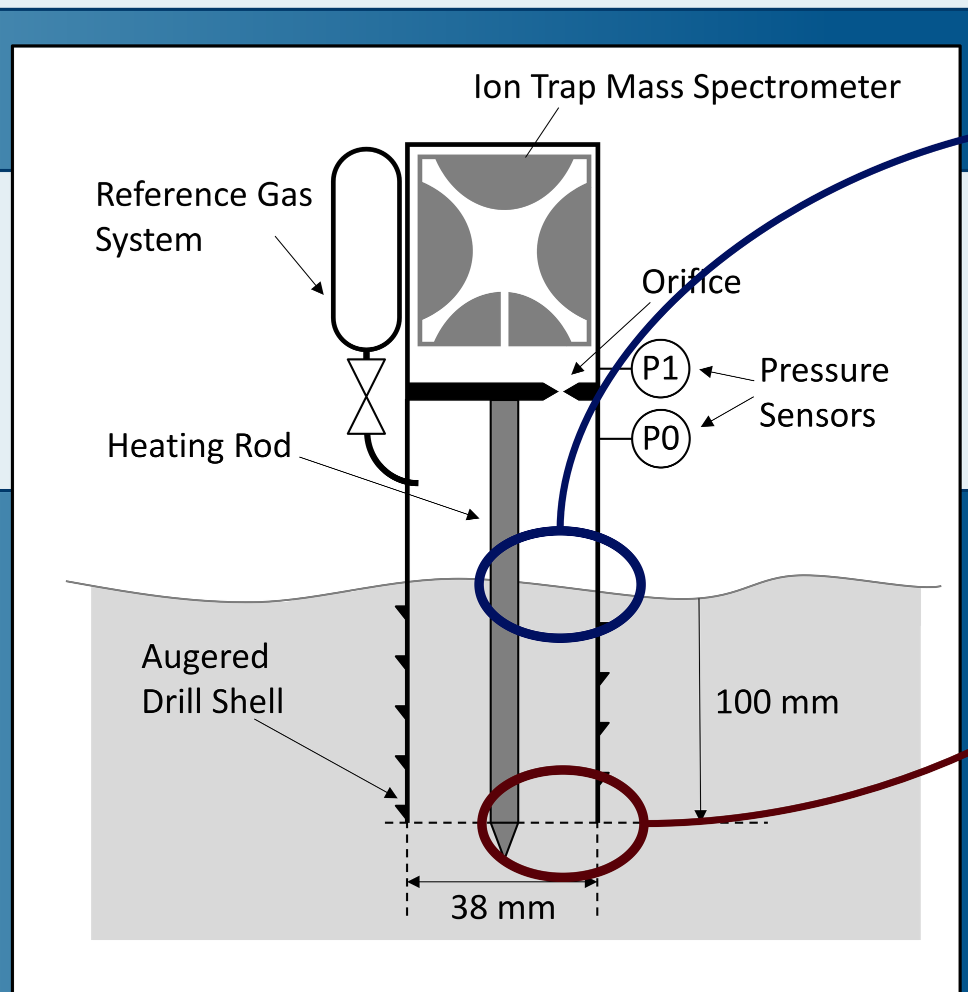

Figure 1 Schematic of the **Lunar Volatiles Scout**.

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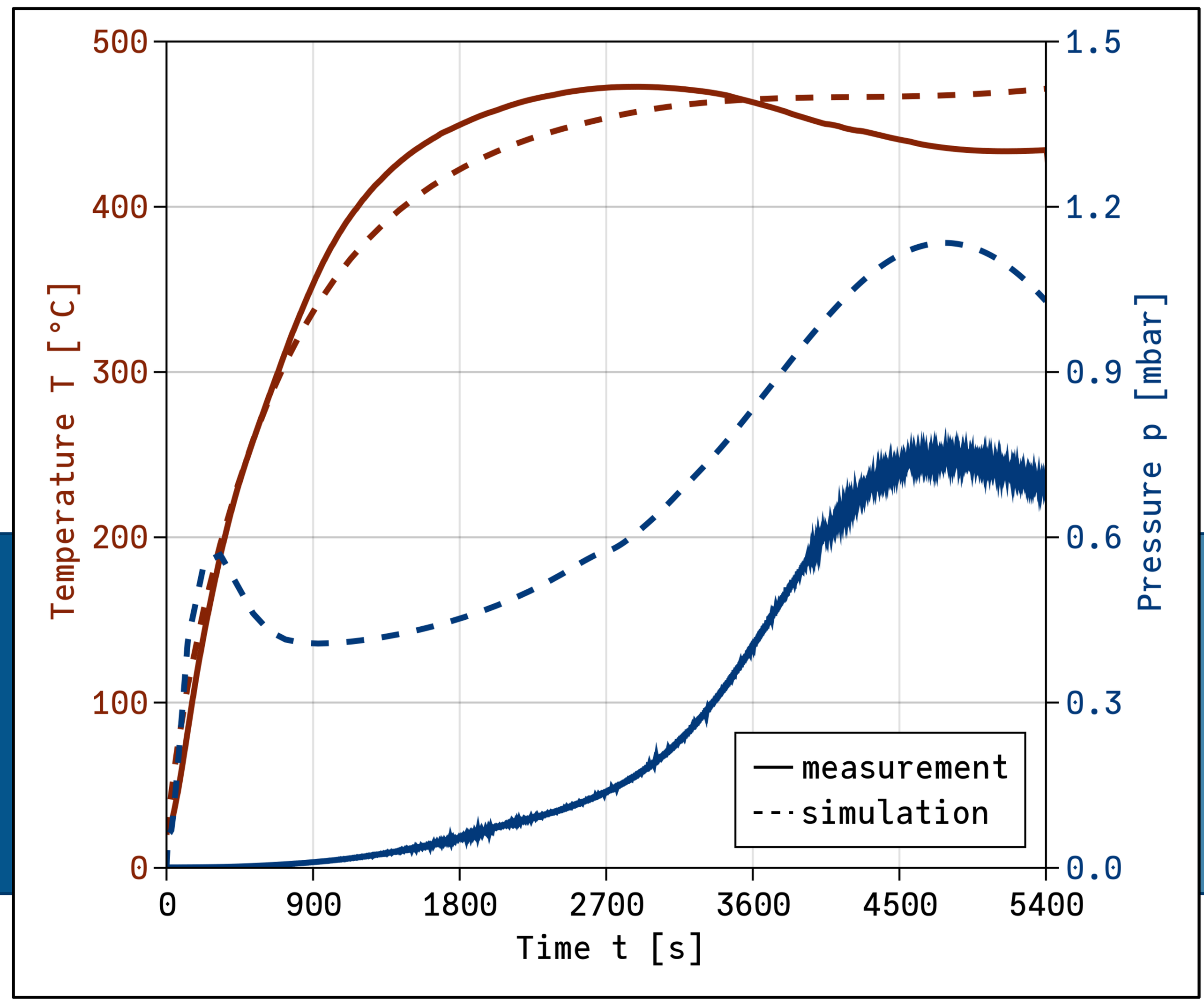

Figure 3 Comparison of simulation results with data from **end-to-end testing** [1] for the correlation study.

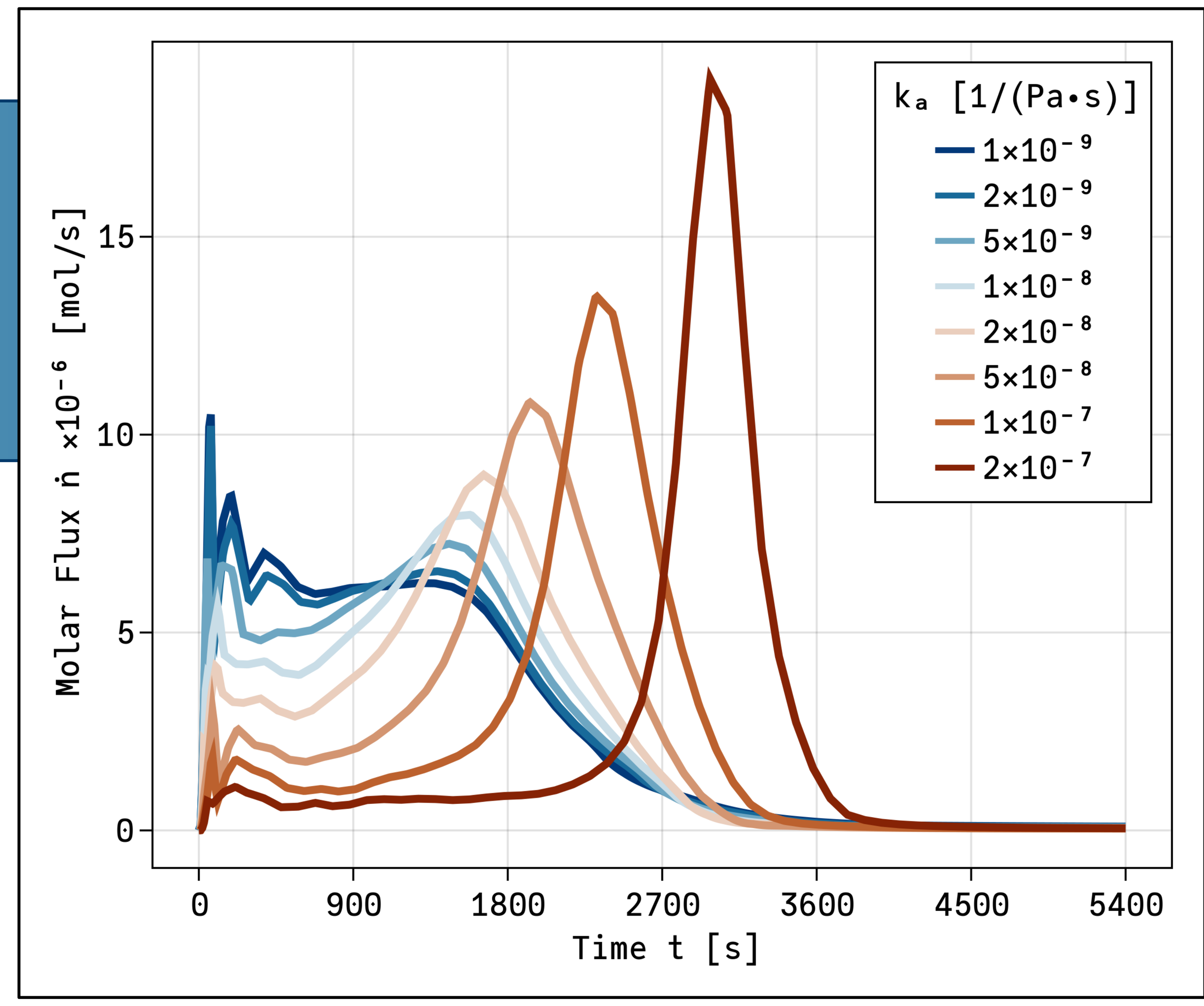

Figure 2 Molar flux over LVS' enclosure regolith surface, see **Figure 1 [A]**, for varying **adsorption rates**.

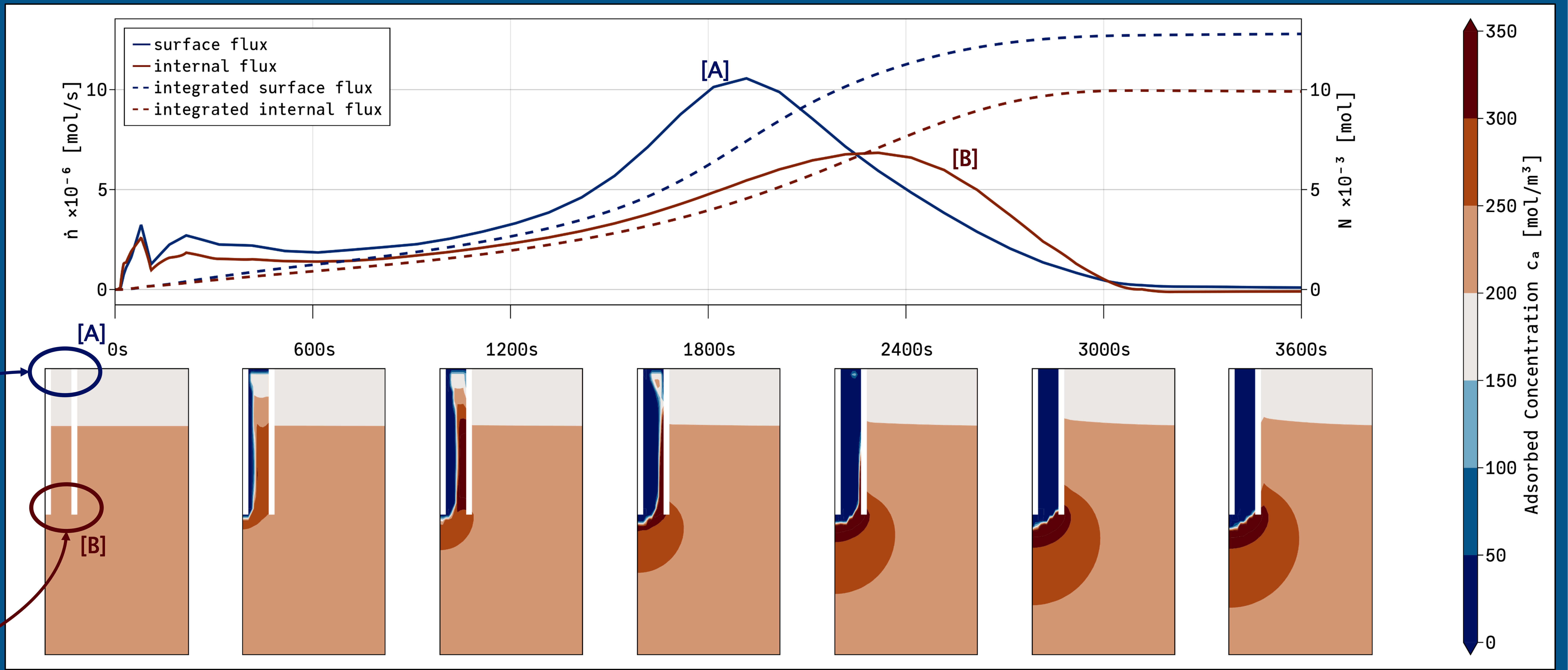

Figure 4 *(Top)* **Molar flux of desorbed volatile water** over the **regolith's surface [A]** over the inside of the LVS' enclosure and over the **internal regolith boundary [B]** leading into the enclosure. The dashed lines show the **integrated values** for the molar flux. *(Bottom)* Distribution of the **adsorbed water** in and around the LVS' enclosure. The timestamps are matching with the time axis of the above graph.