Investigation of Transient Volatile Migration in Lunar Regolith for the Lunar Volatile Scout. A. Smolka[1], C. Gscheidle[1] and J. Biswas[1], [1]Chair of Astronautics, Technical University of Munich (Boltzmannstr. 15, 85748 Garching, Germany, c.gscheidle@tum.de)

Introduction: The Lunar Volatile Scout (LVS) [1], a novel soil sampling and analysis instrument developed jointly by the Institute of Astronautics at the Technical University of Munich, OHB Systems AG, and the Open University, aims to shed light on spatial distribution of volatiles at the Lunar poles. It is an in-situ tool to access and characterize lunar volatiles consisting of two main sections, the hollow drill acting as a sampler, and the attached volatile analyzer, a mass spectrometer. A heating element is mounted in the center of the drill, which will be driven into the soil to a depth of 100-150 mm. Thus, the regolith inside will be mostly undisturbed inside of the hollow drill-shell, which is advantageous in contrast to other sampling instruments. Through heating, the volatiles bound to the regolith will desorb [2] and diffuse through the surrounding sample. A mass spectrometer analyses those that travelled upwards to the top of the instrument.

Motivation: Lunar resources are considered the key for future, long-duration explorations of the Moon. Its regolith [3] contains significant quantities of oxides, metals, and highly volatile elements including water. In-situ extraction of the volatile components from regolith involves thermal processing and strongly depends on the heat and mass transfer inside of the lunar soil. While these processes are influenced by many physical properties like the porosity and the tortuosity of the sample, the respective gas density, and its temperature and pressure, the description of the interaction between heat and gas transfer and sorption mechanisms poses a difficult problem.

Numerical Setup: The current study uses the LVS as baseline for a computational model to further analyze the extraction mechanism of water in lunar regolith. With the software COMSOL Multiphysics and MATLAB, a combined model for the heat and mass transfer as well as the desorption mechanism, was developed based on the model by Reiss [4]. The physics were modelled in COMSOL using partial differential equations in coefficient form, based on the diffusion-convection equation. The evaluation of the temperature and pressure dependent thermal conductivity and gas diffusivity at every time step was done externally in MATLAB.

Results: The main study used the numerical model to simulate the volatile transport inside of the lunar regolith. The results show the transient temperature and pressure distribution as well as the extraction of the water vapor from the soil. Results were produced for numerous parameters including initial water content and desorption energy.

Fig. 1 shows the results of the baseline study for the three dependent variables: the temperature, and the desorbed and adsorbed species of the volatile water. The high gradients of the temperature distribution result from the poor thermal conductivity of the regolith and the empty patch of the adsorbed water concentration shows that the method successfully extracted the volatiles around the instrumentation. Further results show that the general direction of the mass flow, while strongly depending on the water content of the soil, is pointing upwards with little to no water escaping from the LVS' enclosure during the process.

References: [1] J. Biswas, et al. (2020) *Planet. Space Sci., 181*. [2] M. J. Poston, et al. (2013) *J. Geophys. Res. Planets, 118*, 105-115 [3] P. O. Hayne, et al. (2007) *J. Geophys. Res. Planets, 122*, 2371– 2400. [4] P. Reiss (2018) *Icarus*, 306.

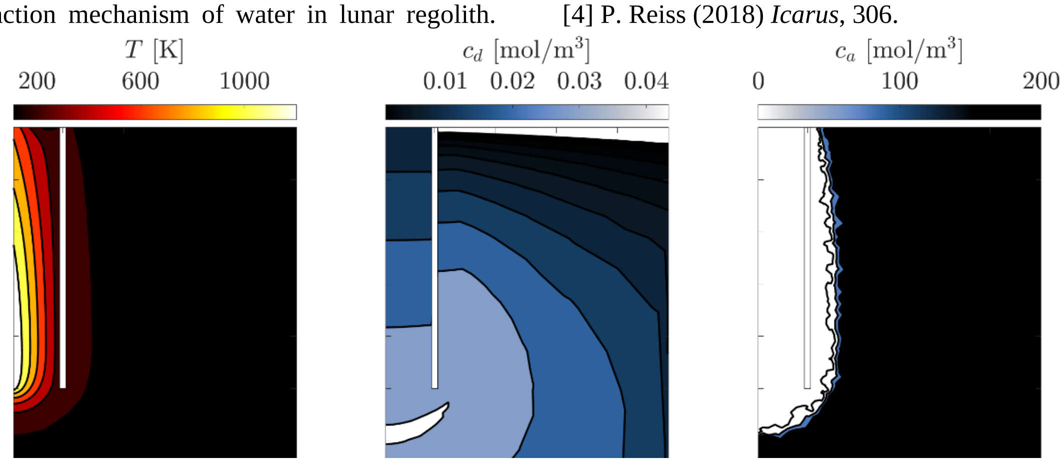

Fig 1:Baseline results for temperature (left), desorbed water concentration (center), and adsorbed water concentration (right), after one hour of continuous heating.