**Experimental evaluation of heat transfer and mass transfer for the development of lunar thermal $H_2O$ mining.**

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**Introduction:** Understanding $H_2O$ transport through lunar regolith is important to further the scientific understanding of phenomena on the lunar surface and for designing *in-situ* resource utilization (ISRU) systems. Several hydrogen sources have been identified on the moon, including ice trapped below the surface at the poles and in dark craters. The focus of this work is to characterize the transport of $H_2O$ vapor through regolith, under lunar conditions.

**Preliminary study:** A promising technology to harvest $H_2O$ in shadowed craters is by thermal extraction (thermal mining) [1]. Gas transport is an important aspect to the thermal extraction of $H_2O$, and it was the focus of a preliminary study [2]. An experimental apparatus was fabricated to study gas transport in regolith under lunar-like conditions. The preliminary study evaluated Ar and $N_2$ gas flow within a lunar relevant porous medium. It provided a framework for moving towards complex volatiles like $H_2O$. The advection diffusion model, typically applied to bulk volatile transport for ISRU needs to be verified even for the simplified cases (Ar and $N_2$) studied, and model improvements are necessary.

**Current experimental study:** To bridge this knowledge gap, an experimental campaign is underway to study $H_2O$ transport based on the preliminary work. The experimental apparatus was modified to allow for $H_2O$ transport study. The experimental apparatus is schematically depicted in Figure 1. $H_2O(l)$ is injected into a heated portion via a high precision syringe infusion pump. The heating ensures rapid evaporation of the $H_2O$. Pressure is measured by several pressure transducers. The system is heated to simulate the transport conditions of the thermal extraction of volatiles.

**Heat transfer modeling and experimentation:** Heat transfer is key for the thermal extraction of volatiles. Literature has indicated that high temperature gradients are expected [1]. Concentrated solar irradiation is an ideal source of process heat for the thermal extraction of volatiles. An experimental demonstration in which a sample of regolith simulant will be exposed to concentrated solar radiation in vacuum will be conducted utilizing an existing experimental apparatus [3].

**Conclusions:** An experimental research effort is underway to study heat and mass transfer of $H_2O$ in lunar regolith. A preliminary study of $H_2O$ mass transport within regolith simulant was conducted. It is expected that the experimental campaign will lead to insights into designs of solar-mediated thermal mining technologies. The results will be an important step in paving the way towards the realization of lunar ISRU.

**References:** [1] P. Reiss (2018) *Icarus, 306,* 1-15. [2] G.L. Schieber, et al., (2020) *Acta Astronautica, 169,* 32-39. [3] H.E. Bush, et al., (2017) *Solar Energy Engineering*, 139(5)

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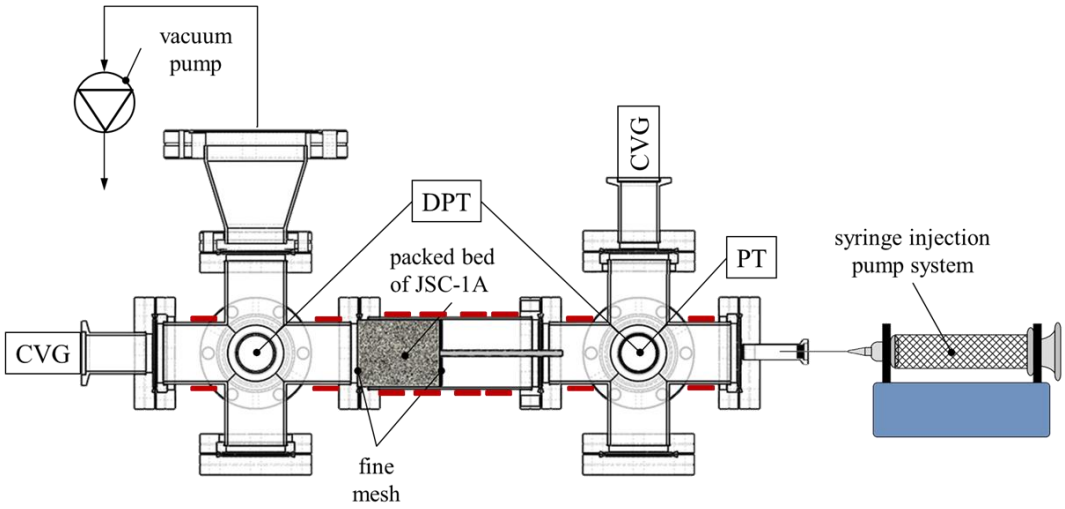


**Figure 1:** Schematic of the experimental apparatus used to measure transport of $H_2O$ through a heated packed bed of lunar regolith simulant. $H_2O$ delivery is accomplished with a syringe infusion pump. PT/CVG: Pressure transducer/convection gauge, DPT: Differential pressure transducer.