EXPERIMENTAL STUDY AND MODELING OF GAS TRANSPORT WITHIN REGOLITH FOR EXAMINING ISRU/SAMPLING SCENARIOS. G. L. Schieber[1], B. M. Jones[2], T. M. Orlando[2], P. G. Loutzenhiser[1], [1]George W. Woodruff School of Mechanical Engineering and [2]School of Chemistry and Biochemistry, Georgia Institute of Technology

Introduction: Understanding gas transport within regolith is important for both fundamental and applied science applications. A basic understanding is required as it allows for predictive modeling and provides the foundation for examining different scenarios involving in-situ resource utilization (ISRU) and sample collection during extended missions to near Earth destinations such as the Moon. The design of thermal H_2O extraction devices requires a fundamental understanding of gas transport within regolith, at pressures not yet studied [1, 2]. This work considers the flow of noncondensing gases (Ar, N_2) as a first step towards ultimate study of more intricate interactions between molecules with permanent dipoles and regolith, namely H_2O. The goal of this work is to experimentally assess the properties of porous media and gas species that impact transport, providing an experimental validation to the commonly applied advection diffusion model for low pressure H_2O transport within lunar regolith.

Theory: The Knudsen number (Kn) is defined as the ratio of the mean free path to a length scale and represents the relative likelihood of molecular collisions with other gas molecules or with a solid surface. For Kn << 1, the flow is dominated by intermolecular collisions, and is assumed to behave in a continuum. The flow for Kn >>1 is dominated by wall-molecular collisions where the continuum assumption does not capture the phenomena [3]. The flows can be divided into four different regimes: (1) continuum ($Kn<10^{-2}$), (2) slip ($10^{-2}<Kn<10^{-1}$), (3) transition ($10^{-1}<Kn<10$), and (4) Knudsen ($Kn>10$) regimes [4]. In this study, three regimes, were experimentally examined: (1) the slip flow regime, (2) the transition regime, and (3) the Knudsen regime, corresponded to average N_2 pressures of 100 to 30,000 Pa within a packed bed of JSC-1A regolith simulant at ambient temperature. These regimes are relevant to both ISRU and sampling missions.

Results: The results indicate that the advection diffusion model fit the data when Kn<1 and began to deviate when Kn>1. Based on the results for the Knudsen regime, the predictive model for Knudsen diffusivity corresponded well to experimental measurements as the average Kn approached 10. Model refinement would be provided by further study to determine a relationship for tortuosity of non-uniform packed beds of particles. An investigation of tortuosity is underway, utilizing the computational method as outlined in *Sobieski et. al* [5].

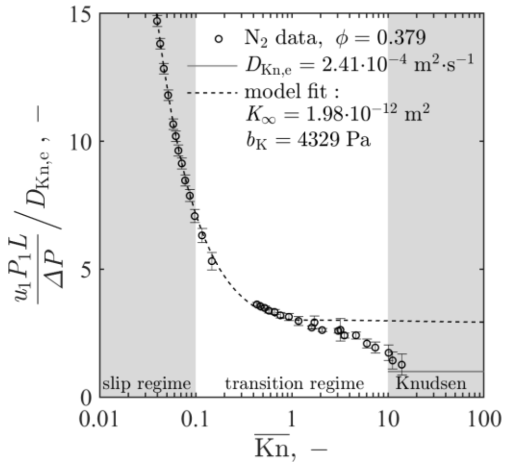

Figure 1: Experimentally observed simplified N_2 mass flow rate over total pressure gradient (circles with 95% confidence limits), normalized to the Knudsen diffusivity (dotted line) is shown for the average Knudsen number. The model fit, utilizing the advection diffusion model, is displayed (dashed).

Conclusion: This study has evaluated gas flow with in a lunar relevant porous medium and provides the framework for moving to more complex volatiles such as H_2O. We show that the advection diffusion model, typically applied to bulk volatile transport for ISRU, needs to be verified, as even for the simplified case presented, model improvements are necessary. If thermal extraction of H_2O for ISRU is to be realized, a model for the transport of the evolved volatiles is a critical component for system design.

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