

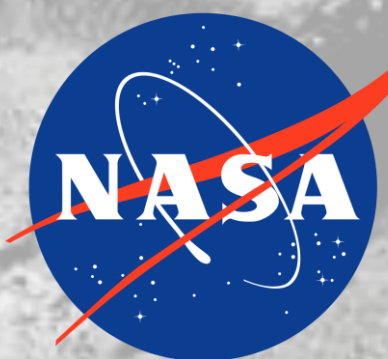
Parameters Impacting Columnated Granular Soil Pneumatic Seal Performance

Exploring viability of ‘valveless’ regolith reactor systems sealed with soil plugs

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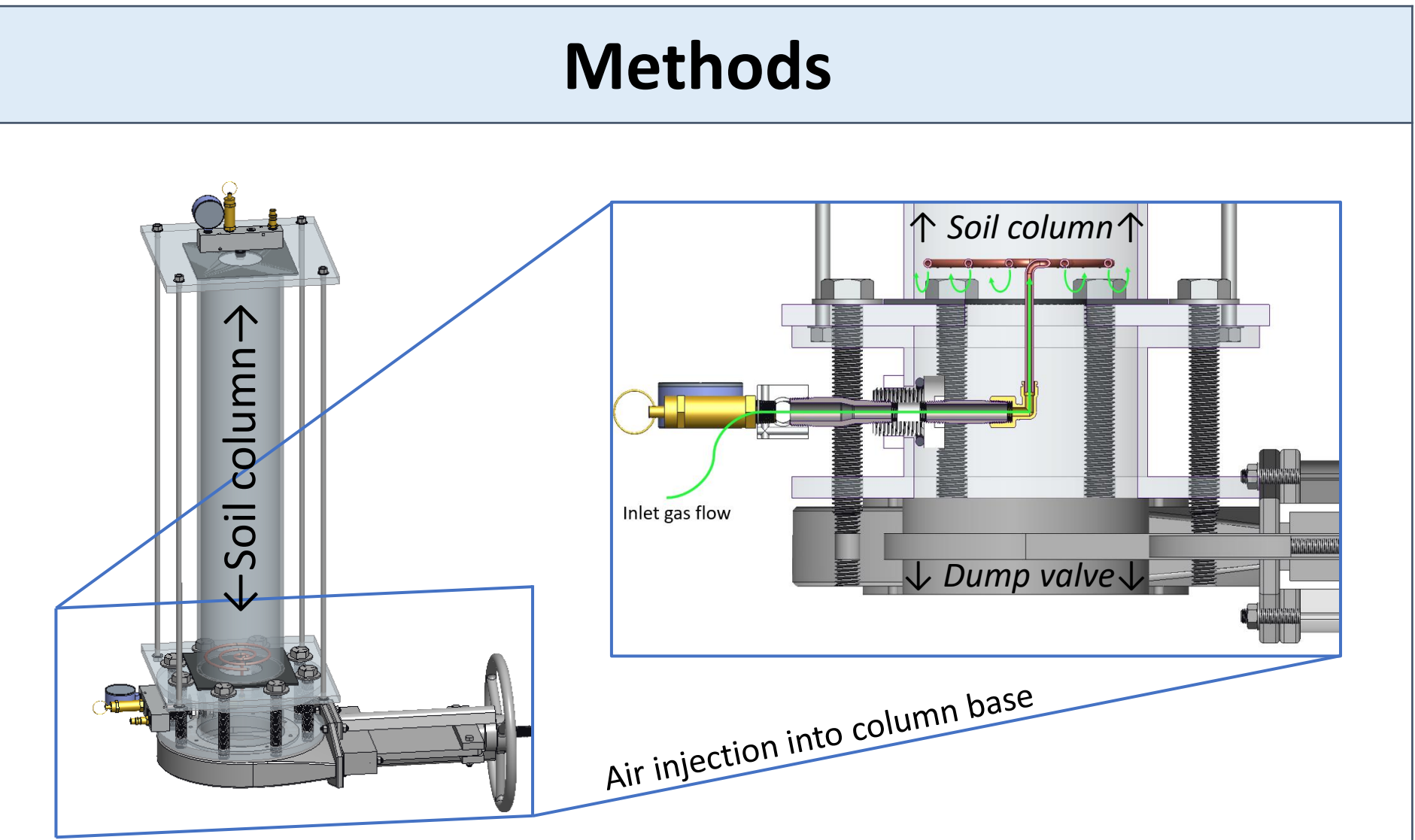
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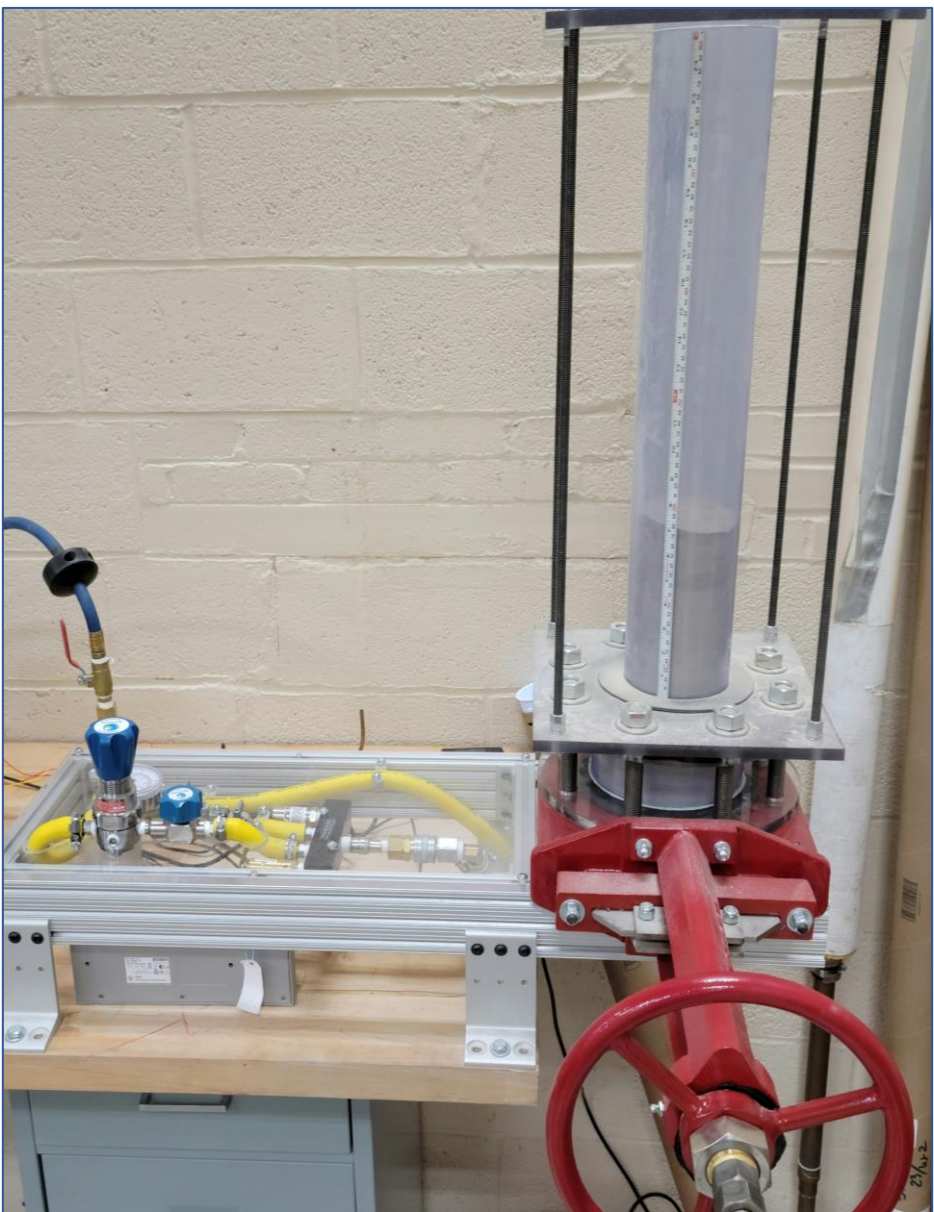
Introduction

The ability of a column of loose granular soil to form a pneumatic seal was investigated by varying the diameter of the soil column, the effective column height, and the level of compaction in the soil. The data generated by this test campaign is intended to inform the design of various volatiles-extracting regolith reactor systems by investigating the viability of sealing system inlets using the soil hopper and feed tube without the use of any mechanical valves. This ‘soil column seal’ concept could be applied regardless of reactor geometry or process.

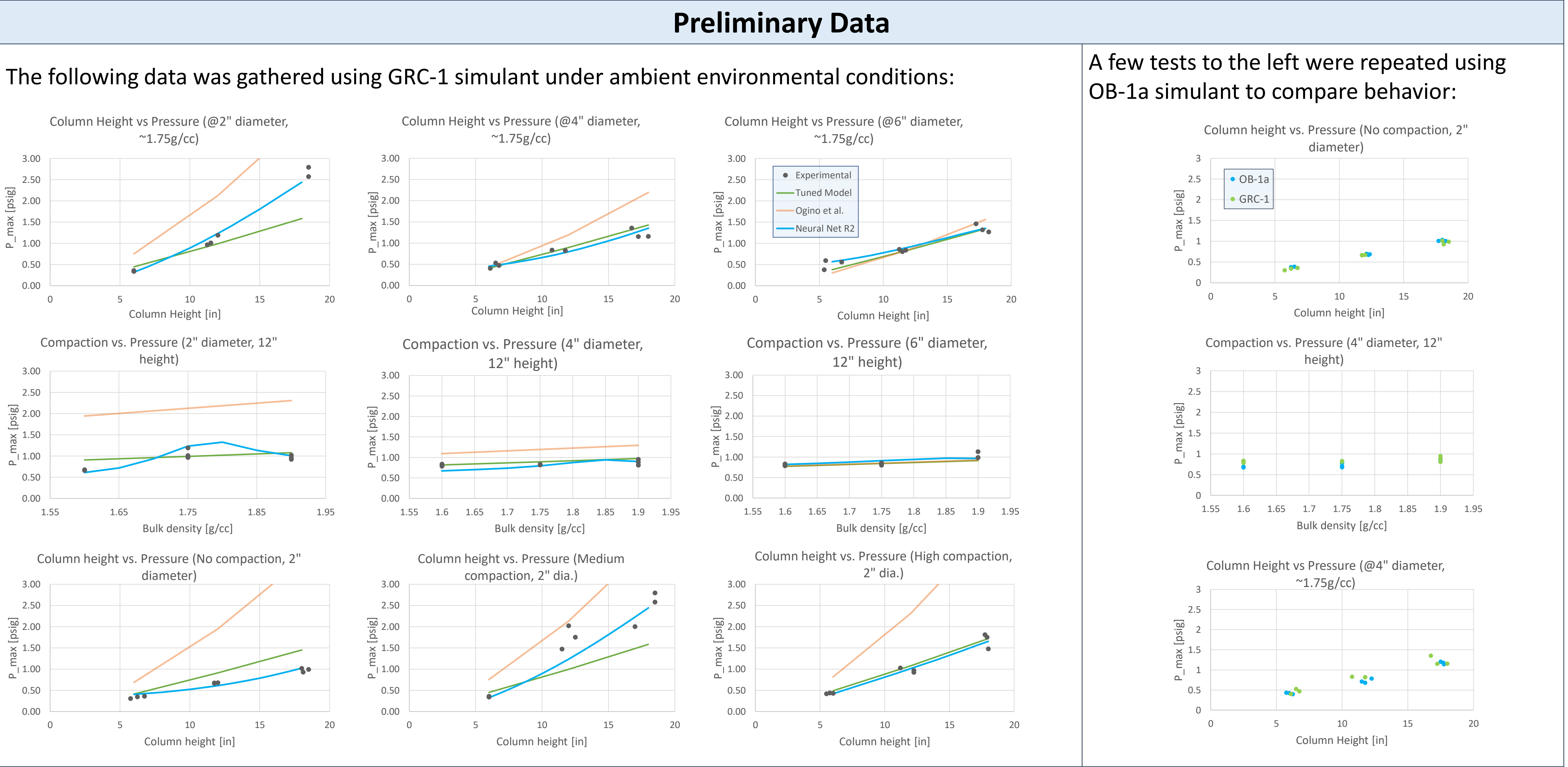
Initial data was collected in ambient lab conditions using both GRC-1 and OB-1a regolith simulants. This data is intended to serve as a baseline –no attempt has been made yet to begin optimizing column parameters to achieve highest possible ΔP .



Once a random combination of column height, diameter, and level of compaction were configured, soil was poured in through the open column top. Soil mass and initial height were recorded to verify bulk density was near target value. Air pressure was then increased quasi-statically via precision regulator through the entire fluidization regime. MATLAB script detected the ‘knee’ in the pressure trace indicating onset of seal failure and recorded this ΔP_{max} value.



Test rig: Controls (left) and soil column (right)



Discussion

Preliminary Analysis

- Analysis of Variance (ANOVA) results indicate **column height** and **interaction between column height and soil compaction** are statistically significant factors at 95% confidence level
- Analytical model developed by Ogino et. al was **tuned with optimized $R^2=0.902$**
- Neural Network was trained with preliminary test data yielding **model with $R^2=0.954$**
- GRC-1 and OB-1a lunar regolith simulants qualitatively compared using limited initial data; both performed similarly and repeatably.
- Visual and instrumented precursors to blowout identified to mitigate potential loss of volatiles
- Highest ΔP_{max} value measured so far was 2.79 psig

Likely Next Steps

- Down-select tests to repeat under higher-fidelity vacuum conditions
- Use initial data to optimize seal performance by testing additional configurations

Referenced: Ogino, F.,Zhang, L., Maehashi. (1993). Minimum rate of spouting and peak pressure drop in spouted bed. Int. Chem. Eng. 33:2, 265-272.