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Gas flow through porous media with regard to comets and asteroids

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Abstract

In order to understand the gas diffusion through a porous cometary surface layer in a better way, we performed gas flow measurements to investigate the permeability of several different analogue materials that were chosen to mimic cometary surface properties. A dependence of the grain size distribution and the packing density of the sample has been seen in the experiments. The measured permeability values are ranging from 10^{-13} to 10^{-10} m². This work is part of the CoPhyLab project.

1. Introduction

Over the last few decades, our picture of comets has been continuously growing by the successful operation of several space missions, as well as cometary simulation projects (e.g. KOSI project 1987-1992). The CoPhyLab project is a cooperation between six partners based in Europe. It is funded jointly by DFG, FWF and SNF under the D-A-CH program and aims to further study cometary properties in the laboratory. In this particular work gas diffusion through a porous cometary surface has been investigated.

2. Materials

Several sample materials have been chosen to imitate cometary surface properties. The first material we selected were glass beads made of soda lime glass by the German company Lindner, which were sieved into separate fractions to obtain distinct grain size ranges from 45 µm up to 4.3 mm. Secondly, the Mars simulant JSC-Mars 1 was used in the experiments, as well as JSC-1 as a lunar soil simulant. Furthermore, the Exolith Lab [1] in Florida provided us with an Asteroid analogue material named UCF/DSI-CI-2. Additionally, a quartz sand called UK4 mined at a local quarry in Graz was investigated. Via sieving the particle size distribution of the materials is established.

A grain size distribution replica of the Asteroid simulant was created by mixing different grain size fractions of the glass beads. Variations of this grain size distribution have been created by modifying the small size component abundances. Thus, the effect of the smallest fractions on the gas permeability was investigated.

3. Packing experiments

To establish the basic properties of the materials a shaker table was used to compress the samples. After testing variations of amplitude and shaking durations, a fixed protocol was established to obtain the respective minimum porosity of the materials. The samples used for the gas flow experiments were then either loosely packed or compressed.

4. Gas Flow experiments

The actual gas flow experiments were following a standard procedure. A cylindrical container, which is 4 cm in diameter, is filled with the sample (typical 5 mm in height) and placed inside of the vacuum chamber at the interface in between of two separate volumes (see Figure 1). Pressure sensors (CMR1, CMR2, PKR1, and PKR2) operating in different pressure ranges were monitoring the gas pressure in the different volumes. A vacuum pump in the lower volume was removing gas from the chamber and trough a gas inlet a test gas was inserted into the upper volume. Thus, we established a dedicated gas flow, which can only pass through the sample material. To avoid particle fluidisation and thus a texture change in the sample the gas flow was directed downwards through the sample. The gas flow was controlled by regulators (GFL) from 0.15 mg/s up to 19.2 mg/s. Via the measured pressure difference between the upper and lower volume, in equilibrium flow, the gas permeability of the sample material is obtained. See also [1].

[1] (https://sciences.ucf.edu/class/)

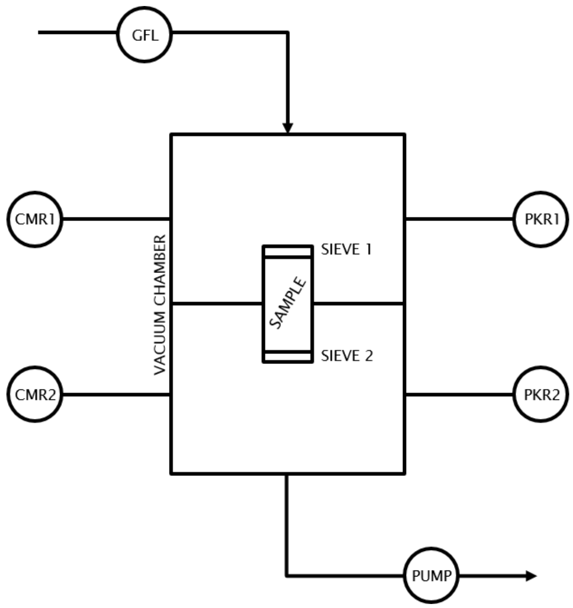

Figure 1: Scheme of the Gas Flow experiment

5. Summary and Conclusions

The gas flow experiments show that the grain size distribution and the packing density of the sample play a major role for the permeability of the sample. From the analysis of the permeability measurements it is clearly visible that the larger the grains the bigger the permeability. Variations of the fine grain content in the Asteroid replica show no significant changes in the permeability.

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References

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