EPSC Abstracts
Vol. 8, EPSC2013-431-2, 2013
European Planetary Science Congress 2013

Compaction of Lunar Regolith Simulants under Reduced Gravity

P. Reiss and U. Walter
Institute of Astronautics, Technische Universität München, Garching, Germany (p.reiss@tum.de)

Abstract

We present the results of experiments conducted on a series of parabolic flights to determine the compaction of lunar regolith samples under the influence of reduced gravity. The two regolith simulants, JSC-1A and NU-LHT-2M, showed decreased compaction in lower gravity. On average the sample volumes expanded up to 108 % under Martian and 114 % under lunar gravity, whereas the expansion of NU-LHT-2M was generally stronger than that of JSC-1A.

1. Introduction

The compaction of lunar regolith is important in understanding lunar surface evolution, such as sedimentation processes after impact [4]. Moreover, it affects the thermal inertia of the respective surface [1,3]. For sampling instruments that penetrate surfaces the compaction of regolith is crucial for the forces that need to be applied [2]. When transporting a regolith sample to an analysis instrument, e.g. by filling it from a scoop into a reservoir, the sample volume might be bigger than on Earth due to lower compaction and hence affect the analysis process. A series of experiments was conducted during the second ESA/CNES/DLR Joint European Partial-*g* Parabolic Flight Campaign (JEPPF-2) to investigate the sample flow through different feed hoppers [5,6]. It was observed that the sample volume increased visibly during the experiments in reduced gravity. The evaluation of this effect is presented here.

2. Methods

Two regolith simulants were used in the investigation, the mare simulant JSC-1A and the highland simulant NU-LHT-2M. Both materials have a similar particle size distribution with grain sizes ranging from 1 mm down to several µm. The simulants were filled into hourglass-like sample containers with different funnels on their top and bottom side (Figure 1). The sample mass in each container varied from 27 to 46 g, depending on its respective geometry.

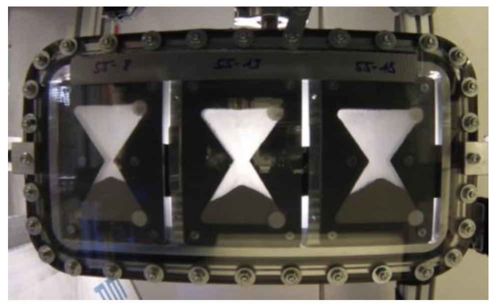

Figure 1: Three hourglass-shaped sample containers filled with NU-LHT-2M installed in a rotatable box.

The parabolic flights provided a total of 100 partial-*g* parabolas, including 52 parabolas with Mars-like gravity and 48 parabolas with Moon-like gravity. Prior to each flight the sample containers were evacuated to create a low vacuum. During each parabola the containers were rotated so that the regolith sample would flow from the top into the lower funnel. The material flow was repeated multiple times during each parabola, depending on the available duration of the partial-*g* phase. The experiments were recorded by two video cameras for post flight analysis. Based on the video data, the sample volume was evaluated. For this purpose the sample contour from a two-dimensional still image was traced using polygonal lines. Having defined the polygonal contour, the area covered by the sample was calculated.

3. Results

The sample volume of both regolith simulants was measured for the hyper-*g* phase (1.8 *g*), the Mars-*g* phase (0.38 *g*), and the Moon-*g* phase (0.16 *g*). For reference the sample volume was measured under terrestrial conditions (1 *g*) as well. In all cases the volume increased with lower gravity. NU-LHT-2M generally expanded more than JSC-1A. Figure 2 and 3 show the sample volume normalized to the reference 1 *g* conditions over the gravity level for both simulants. On average, the simulants expanded to 104 % (JSC-1A) and 108 % (NU-LHT-2M) under 0.38 *g* and 110 % (JSC-1A) and 114 % (NU-LHT-2M) under 0.16 *g*. The error and standard deviation for all measurements is given in Table 1 and 2.

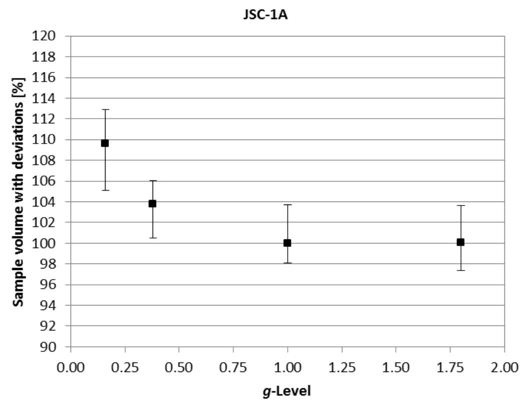

Figure 2: Volume of the JSC-1A sample over gravity.

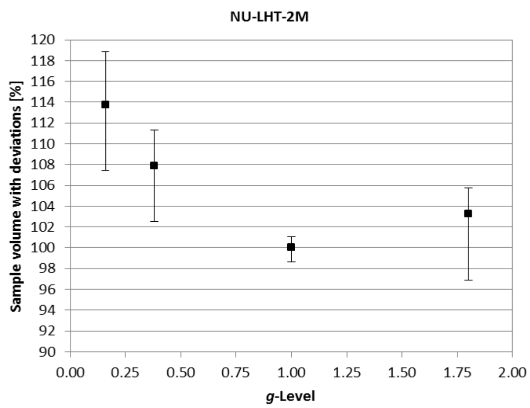

Figure 3: Volume of the NU-LHT-2M sample over gravity.

Table 1: Results for JSC-1A.

Gravity	**[*g*]**	**0.16**	**0.38**	**1.00**	**1.80**
Volume	[%]	109.59	103.80	100.00	100.04
Deviation	[%]	+3.32	+2.26	+ 3.74	+ 3.57
		- 4.53	- 3.31	- 1.88	- 2.70
Stand. Dev.	[%]	2.26	1.49	1.23	1.77
Data Points	[-]	18	37	25	22

Table 2: Results for NU-LHT-2M.

Gravity	**[*g*]**	**0.16**	**0.38**	**1.00**	**1.80**
Volume	[%]	113.71	107.87	100.00	103.23
Deviation	[%]	+ 5.14	+ 3.48	+ 1.03	+ 2.54
		- 6.29	- 5.32	- 1.35	- 6.39
Stand. Dev.	[%]	3.29	1.90	0.52	2.05
Data Points	[-]	21	51	26	28

4. Conclusions

We have shown that the sample volume of both simulants after sedimentation in lower gravity is higher, i.e. the compaction decreases. This effect is stronger for NU-LHT-2M than for JSC-1A. For both materials the sample volume seems to be a potential function of gravity. The measurements show deviations of up to 6.4 %. This is due to the negligence of residual material that remained sticking to the container walls in the partial-*g* phases (which was not the case in hyper-*g* phase, hence larger volumes were measured here), as well as depth variations of the material heap that could not be considered with the applied image analysis method. Further work will be necessary to quantify the influence of these perturbations.

Acknowledgements

This work was conducted as part of project LUISE (Lunar In-Situ Resource Experiment), supported by the German aerospace agency (DLR), under grant no. 50JR1210.

References

[1] Bauch, K. E. and Hiesinger, H.: Rock Concentration and Thermal Inertia of Selected Lunar Study Regions, EGU General Assembly, 2012.

[2] El Shafie, A., Chevrier, V. F. and Ulrich, R.: Penetration Testing for Subsurface Regolith Probes in Martian Analog Material, 7th International Planetary Probe Workshop, 2010.

[3] Hayne, P. et al: Thermophysical Properties of the Lunar Surface from Diviner Observations, EGU General Assembly, 2013.

[4] Langevin, Y. and Arnold, J. R.: The Evolution of the Lunar Regolith, Annual Review of Earth and Planetary Sciences, Vol. 5, p.449-489, 1977.

[5] Reiss, P. and Hager, P.: Investigation of the flow characteristics of lunar regolith simulants under reduced gravity and vacuum on a partial-g parabolic flight, EGU General Assembly, 2013.

[6] Reiss, P. et al: Hopper-Flow of Lunar Regolith Simulants in Reduced Gravity and Vacuum, ISTVS Symposium, 2013.