EPSC Abstracts
Vol. 5, EPSC2010-324, 2010
European Planetary Science Congress 2010

A simple method for the distinction of different combinations of grain size and porosity under Martian atmospheric pressure

T. Toyota, A. Iwasaki and K. Kurita
Earthquake Research Institute, Tokyo, Japan (toyota@eri.u-tokyo.ac.jp / Tel: +81-3-5841-5728)

Abstract

We propose that the variation of the bulk thermal conductivity under different Martian pressure (500 – 1000 Pa) can be important information to distinguish different combinations of grain size and porosity. We measured the thermal conductivities of glass beads, natural pyroclasts and hollow glass beads under Martian atmospheric pressure. We found that the ratio of the thermal conductivity under Martian atmospheric pressure to under atmospheric pressure (1013 hPa) mainly depends on the grain size.

1. Introduction

Thermophysical properties of Martian regolith are important clues to understand the surface geology. To characterize the surface materials by remote sensing, thermal inertia is used as an important parameter [1, 2]. Thermal inertia is defined by thermal conductivity, bulk density and specific heat capacity. Especially thermal conductivity strongly affects on thermal inertia [3]. Therefore, understanding of thermal conductivity of granular materials is a key in considering situations of planetary surfaces.

The bulk thermal conductivity of granular materials under Martian conditions around 6 hPa is quite sensitive to variations in grain size [4]. There are many studies on laboratory experiments for the thermal conductivity of both spherical glass beads and natural soils [e.g. 4, 5, 6]. Theoretical models also reproduced the bulk thermal conductivity measured in the laboratory [3, 7].

Porosity of the surface layer also affects the bulk thermal conductivity under Martian atmospheric pressure, although the grain size plays important roll. Surface layers that have different combinations of grain size and porosity could have same values of the bulk thermal conductivity.

In this paper, we will show a basic idea to distinguish different combinations of grain size and porosity with in-situ measurements. We measured the thermal conductivities of glass beads, natural pyroclasts and hollow glass beads under Martian atmospheric pressure. We found that the variation of the bulk thermal conductivity under different Martian pressure (500 – 1000 Pa) could be important information to distinguish different combinations of grain size and porosity.

2. Method

To measure the thermal conductivity of the granular materials under Martian atmospheric pressure, we used a measurement device in a vacuum chamber. Inside the measurement device, there is a nichrome wire as a heater and a chromel-almel thermocouple as a thermometer. So-called line heat method [8] is used to measure the bulk thermal conductivity of the sample.

We selected samples for two points of view: a pair of samples that have same size and different porosity, a pair of samples that have same porosity and different size. Table 1 shows the samples we used in this study.

Table 1: Samples measured in this study.

Sample name	Sample origin	Size (average) in μm	Porosity
Glass beads	Boronic-silicate glass beads	37 – 63 (50)	0.427
Q-CEL 7040S	Sodium boronic-silicate grlass beads	5-90 (45)	0.879
23A4C	Hachinohe pyroclastic flow deposit	1000-4000	0.893
Mt. Fuji	Pyroclastic fall deposit of Hoei eruption	1000-4000	0.739

5. Results

Figure 1 and 2 shows the result of our measurements. We couldn't distinguish 23A4C (grain size: large, porosity: large) from glass beads (grain size: small, porosity: small) with the absolute value of the thermal conductivity at 1000 Pa (Figure 1). However, those samples have different value of the normalized thermal inertia at 1000 Pa (Figure 2).

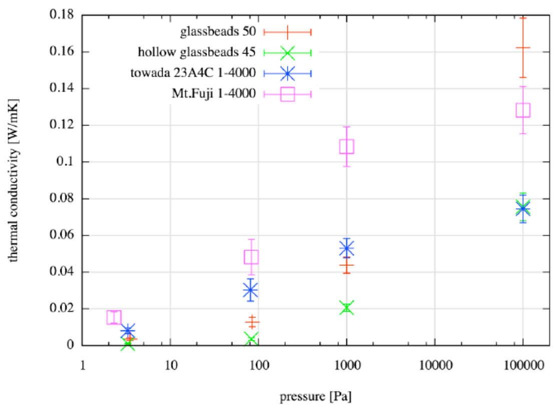

Figure 1: Thermal conductivity as a function of pressure. The pairs of glass beads and natural products have the same size respectively. The samples represented in blue and green plots have the same bulk porosity.

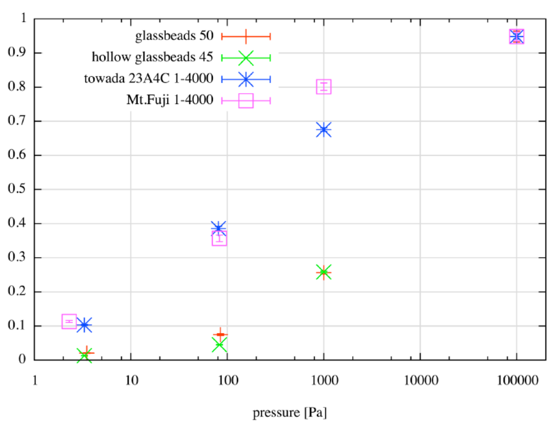

Figure 2: Normalized thermal conductivity under low pressures. The thermal conductivity under atmospheric pressure (1013 hPa) is standard. The pairs of glass beads and natural products have the same size respectively. The samples represented in blue and green plots have the same bulk porosity.

6. Discussion

As we mentioned in the introduction, thermal inertia is used as an important p arameter to characterize Martian surface materials by remote sensing [2] and is strongly affected by thermal conductivity [3].

Continuous observations of temperature of the Martian surface revealed the seasonal variation of the value of the thermal inertia [9]. Although surfaces with horizontal or vertical heterogeneity may yield apparent thermal inertia which varies with time of day and season [9], the origin of the variation is not completely understood.

The variation of the thermal conductivity under Martian atmospheric pressure could be responsible for the seasonal variation of the thermal inertia of Martian surface. Martian atmospheric pressure seasonally varies between 600 and 1000 Pa. Under this environment, the bulk thermal conductivity can vary with a factor of 2.

The seasonal variation of the thermal inertia could be used to distinguish different combinations of grain size and porosity if it is caused by the variation of the thermal conductivity under different atmospheric pressure. The results of the thermal observations by both orbiters and landers should be re-investigated with this point of view.

7. Summary and Conclusions

The ratio of the thermal conductivity under Martian atmospheric pressure to under atmospheric pressure (1013 hPa) mainly depends on the grain size. The normalized thermal conductivity of granular material could be a simple tool to distinguish different combinations of grain size and porosity under Martian atmospheric pressure. The seasonal variation of the thermal inertia could be used to distinguish different combinations of grain size and porosity if it is caused by the variation of the thermal conductivity under different atmospheric pressure.

Acknowledgements

This research was funded by Grant-in-Aid for Scientific Research from the Japan Society for the Promotion of Science.

References

[1] Putzig, N. E., Mellon, M. T., Kretke, A. K., and Arvidson, R. E.: Global thermal inertia and surface properties of Mars from the MGS mapping mission, Icarus, Vol. 173, pp. 325-341, 2005.

[2] Mellon, M. T., Jakosky, B. M., Kieffer, H. H., and Christensen, P. R.: High-Resolution Thermal Inertia Mapping from the Mars Global Surveyor Thermal Emission Spectrometer, Icarus, Vol. 148, pp. 437-455, 2000.

[3] Mellon, M. T., Fergason, R. L., and Putzig, N. E.: The thermal inertia of the surface of Mars, The Martian Surface, Cambridge University Press, 2008.

[4] Huetter, E. S., Koemle, N. I., Kargl, G., and Kaufmann, E.: Determination of the effective thermal conductivity of granular materials under varying pressure conditions, Journal of Geophysical Research, Vol. 113, E12004, 2008.

[5] Presley, M. A. and Christensen, P. R.: The effect of bulk density and particle size sorting on the thermal conductivity of particulate materials under Martian atmospheric pressures, Journal of Geophysical Research, Vol. 102, No. E4, pp. 9221-9229, 1997.

[6] Presley, M. A. and Craddock, R. A.: Thermal conductivity measurements of particulate materials: 3. Natural samples and mixtures of particle sizes, Journal of Geophysical Research, Vol. 111, E09013, 2006.

[7] Piqueux, S. and Christensen, P. R.: A model of thermal conductivity for planetary soils: 1. Theory for unconsolidated soils, Journal of Geophysical Research, Vol. 114, E09005, 2009.

[8] Jones, B. W.: Thermal conductivity probe: development of method and application to a coarse granular medium, J. Phys. E. Sci. Instrum., Vol. 21, pp. 832-839, 1988.

[9] Putzig, N. E. and Mellon, M. T.: Apparent thermal inertia and the surface heterogeneity of Mars, Icarus, Vol. 191, pp. 68-94, 2007.