THERMAL MEASUREMENTS ON LUNAR SIMULANTS IN SUPPORT OF CORE TUBE STUDIES, James A. Fountain and Edward A. West, Marshall Space Flight Center, AL 35812

The transfer of thermal energy in the lunar surface has been the subject of study by a number of investigators for some time. It is believed that the two main sources of thermal energy are (1) solar energy which impinges on the lunar surface and is absorbed, and (2) energy from the decay of long-lived radioisotopes in the lunar material. The program entitled "Comprehensive Study of Thermal Properties of Lunar Core Samples" (Dr. Ki-iti Horai and Dr. M. G. Langseth, Co-Principal Investigators) has as its objective to characterize and interpret the nature of heat flow in the lunar surface. The measurement program described in this paper is a part of this core sample measuring program. It is specifically designed to provide independent measurements of the pertinent properties, such as thermal conductivity and thermal diffusivity and to determine the effects on these properties of parameters such as sample bulk density, temperature, particle size, and interstitial gases.

The samples used in this program are granulated basalt rock of various particle size distributions. The measurements are made in an oil free ionization vacuum system and the method used is described in the literature.[1] In a previous study[2] it was shown that thermal conductivity of a basalt sample with a particle size of 37-62 micrometers varied with the initial temperature of the sample and this variation was described adequately by the equation $K = A + BT + CT^3$, where K is the thermal conductivity, A, B, and C are constants, and T is the absolute temperature. Thermal conductivity was also shown to increase with density in the following manner:

| Density (g/cm$^3$) | Thermal Conductivity (watt/cm$^o$K x $10^{-5}$) | |
|---|---|---|
| | @ 150$^o$K | @ 370$^o$K |
| 0.79 | 0.6 | 1.3 |
| 1.50 | 1.7 | 3.3 |

The measurements described in this paper were carried out with a sample with particle size of 74-149 micrometers. The minimum density which could be obtained with this sample was 1.25 g/cm$^3$ and the maximum was 1.95 g/cm$^3$. The results are shown in Figure 1. It is apparent that a change in density from 1.25 g/cm$^3$ to 1.75 g/cm$^3$ does not cause a significant change in thermal conductivity. However, at the higher densities, even small density changes (1.90 g/cm$^3$ to 1.95 g/cm$^3$) cause an increase in conductivity.

In the following discussion, figures are not shown in this abstract but will be presented. For each measurement of thermal conductivity, a value for thermal diffusivity is also determined. Thermal diffusivity is shown to be temperature and density dependent.

THERMAL MEASUREMENTS ON LUNAR SIMULANTS

Fountain, J. A., et al.

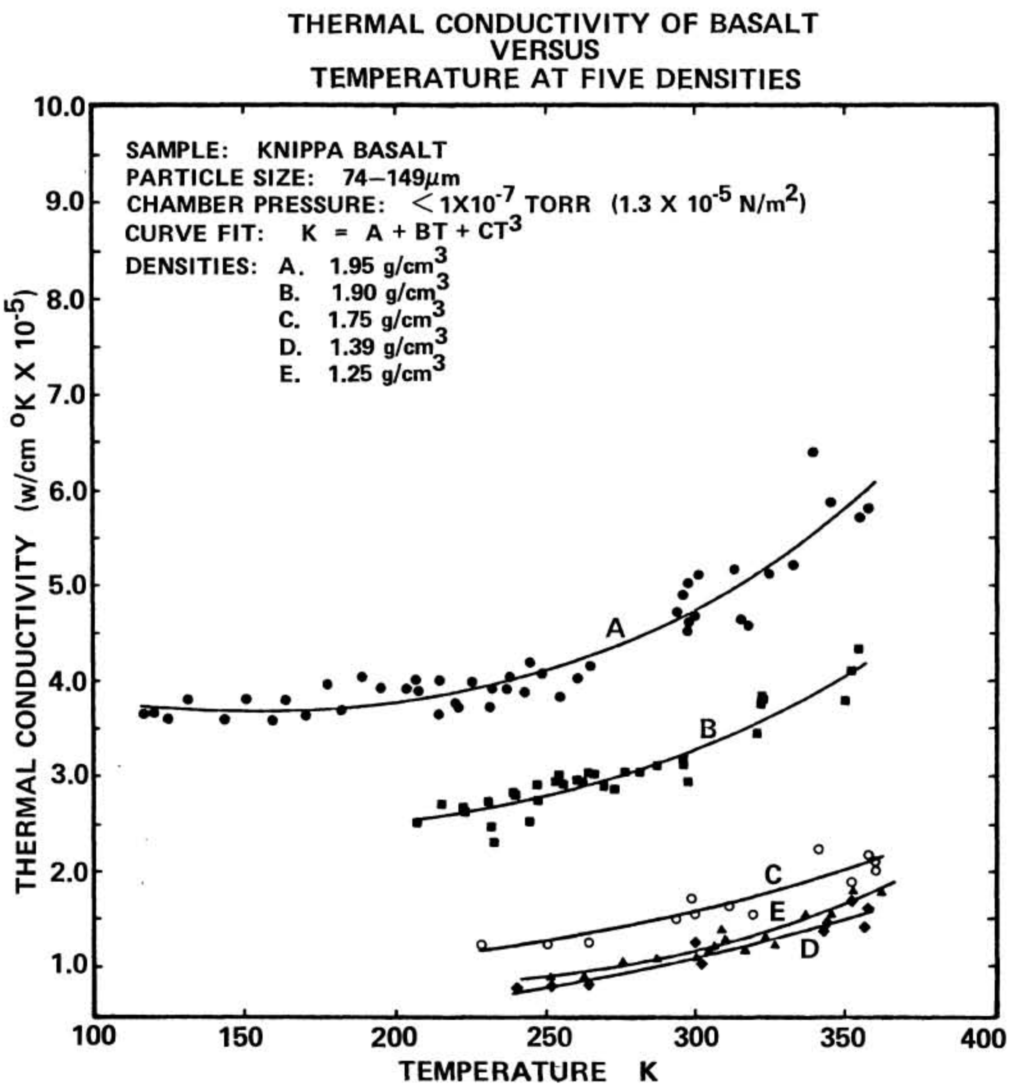
The values of thermal conductivity, thermal diffusivity and density are used to calculate specific heat for each measurement. Specific heat is shown to be slightly temperature dependent over the range tested and independent of density. The values are in good agreement with other investigations.

In order to make the measurements applicable to other astronomical bodies, such as planets, the dependence of the thermal properties of each sample on gas pressure was determined. Tests were taken periodically at specific pressures as each sample was being raised from vacuum condition to atmospheric pressure. The results show that thermal conductivity shows some density dependence at all pressures, and that conductivity is independent of pressure from $10^{-8}$ torr up to about $10^{-2}$ torr. In this vacuum regime, the conductivity values of the sample at the five densities lie in the range from $1 \times 10^{-5}$ watt/cm°K to $5 \times 10^{-5}$ watt/cm°K. In the pressure range from $10^{-2}$ torr to $10^{-1}$ torr the values of thermal conductivity begin to increase and at atmospheric pressure are about $1 \times 10^{-3}$ watt/cm°K.

References:

1. Scott, R. W., Fountain, J. A., and West, E. A., "A Comparison of Two Transient Methods of Measuring Thermal Conductivity of Particulate Samples," Review of Scientific Instruments, Aug. 1973, Vol. 44, No. 8, pp. 1058-1063.

2. Fountain, J. A. and West, E. A., "Thermal Conductivity of Particulate Basalt as a Function of Density in Simulated Lunar and Martian Environments," Journal of Geophysical Research, July 1970, Vol. 75, No. 20, pp. 4063-4069.


THERMAL CONDUCTIVITY OF BASALT
VERSUS
TEMPERATURE AT FIVE DENSITIES
SAMPLE: KNIPPA BASALT
PARTICLE SIZE: 74–149μm
CHAMBER PRESSURE: < 1X10-7 TORR (1.3 X 10-5 N/m2)
CURVE FIT: K = A + BT + CT3
DENSITIES: A. 1.95 g/cm3
B. 1.90 g/cm3
C. 1.75 g/cm3
D. 1.39 g/cm3
E. 1.25 g/cm3
THERMAL CONDUCTIVITY (w/cm °K X 10-5)
TEMPERATURE K
A
B
C
D
E
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
100
150
200
250
300
350
400