

THERMAL DIFFUSIVITY OF LUNAR ROCK SAMPLE 12002,85, K. Horai* and

J. Winkler**

*Lamont-Doherty Geological Observatory of Columbia University, Palisades, N.Y.
10964

**Lockheed Electronics Company, Houston, Texas 77058

The thermal diffusivity of 12002,85 as a function of temperature and interstitial gaseous pressure was measured by the modified Angstrom method. In this method, thermal diffusivity is determined from the amplitude decay and the phase lag of a sinusoidal temperature wave transmitted through the sample. Sample 12002,85 is a rectangular parallelepiped with dimensions of 0.33 x 1.50 x 1.60 cm. The temperature wave was propagated parallel to the 0.33 cm side. On the assumption that a plane temperature wave travels from one of the two parallel surfaces of the sample to the other, and is totally reflected and that the amplitude of the reflected wave at the original surface is negligibly small, the diffusivity κ is determined from the amplitude ratio $A_1/A_0 = 2 \exp(-\alpha \ell)$ and the phase lag $(\phi_1 - \phi_0) = -\beta \ell$ using the relation

$$\kappa = \pi / \alpha \beta T \quad (1)$$

where T is the period, A_0 and A_1 are the amplitudes of the temperature wave at the original and reflecting surfaces, ϕ_0 and ϕ_1 are the phases of the temperature wave at the original and reflecting surfaces and ℓ is the distance between the surfaces.^{1,2}

The relationship (1) is valid for a plane wave propagating in a two-dimensionally unbounded medium. It turned out that the thermal diffusivity determined by this relationship is dependent on the frequency of the temperature wave. The experimentally determined diffusivity is larger for longer period temperature waves. This is due to distortion of the wave form caused by finite sample dimensions. To avoid the uncertainty of this effect, several values for the period of the temperature wave were used. A single datum point in Figure 1 is the average of four determinations with temperature wave periods of 30, 40, 50 and 60 sec. Measurements were made in the temperature range between 85 and 450°K with interstitial atmospheric pressures of 1 atm and 10⁻⁵ torr.

Sample 12002 is a porphyritic basalt. Like other lunar basalt, the thermal diffusivity of 12002,85 decreases with temperature. However, the value of thermal diffusivity exhibited by sample 12002,85 is considerably lower than that of Apollo 11 and 14 basalts.^{3,4,5} An anomaly in mineral composition (for example, an unusually high concentration of plagioclase) is a possible cause of this smaller diffusivity. We plan to carry out a modal analysis on a small fragment of sample 12002,85 to test the hypothesis.

It has been noted that porous rock samples exhibit a lower thermal diffusivity with reduced interstitial gaseous pressure.^{4,5} Our result also shows that the diffusivity is decreased by 30% as the interstitial atmospheric pressure is reduced from 1 atm to 10⁻⁵ torr. The variation of thermal diffusivity with interstitial atmospheric pressure was measured at 85°, 315° and 450°K (Figure 2). In this measurement, the period of the temperature

Thermal diffusivity of 12002,85

K.Horai & J.Winkler

wave was fixed at 45 sec. A single datum point in Figure 2 represents the average of more than two determinations at a fixed pressure. The data show that at 315° and 450°K, the change in the thermal diffusivity occurs in the pressure range between 1 and 10^{-2} torr, contrasted to the result obtained by Fujii and Osako⁵ who found that the change in diffusivity occurs between 1 atm and 10^{-2} torr. At 85°K, our data show that the diffusivity decreases in the pressure range between 10^2 and 10^{-2} torr.

The decrease in thermal diffusivity at reduced interstitial gaseous pressure indicates that the gas filling the interstices of the porous rock sample is acting as a heat transporting medium. We want to determine whether conduction or convection is the principal mode of heat transfer in the interstitial gas. Thermal diffusivity as a function of temperature with 1 atm of He and Ar filling the interstices of the sample is shown in Figure 3. The data with He show higher diffusivity than that with Ar. Comparison with the data on thermal diffusivity and conductivity of gases given in Table 1 suggests that conduction is the dominant mode of heat transfer in the interstitial gas.

References:

- 1 Kanamori, H., N. Fujii and H. Mizutani, J. Geophys. Res., 73, 595, 1968.
- 2 Kanamori, H., H. Mizutani and N. Fujii, J. Phys. Earth, 17, 43, 1969.
- 3 Horai, K., G. Simmons, H. Kanamori and D. Wones, Proc. Apollo 11 Lunar Sci. Conf., Vol. 3, 2243, 1970.
- 4 Mizutani, H., N. Fujii, Y. Hamano and M. Osako, Proc. Third Lunar Sci. Conf., Vol. 3, 2557, 1972.
- 5 Fujii, N. and M. Osako, Earth Planet. Sci. Lett., 18, 65, 1973.

TABLE 1

T(°K)		100	200	300	400
He	k	1.76	2.77	3.61	4.35
	κ	0.27	0.92	1.79	2.88
Air	k	0.22	0.43	0.62	0.79
	κ	0.02	0.10	0.22	0.37
Ar	k	0.15	0.30	0.42	0.53
	κ	0.02	0.10	0.21	0.35

Thermal conductivity k in 10^{-4} cal/cm sec deg K.

Thermal diffusivity κ in cm^2/sec .

Thermal diffusivity of 12002,85

K.Horai & J.Winkler

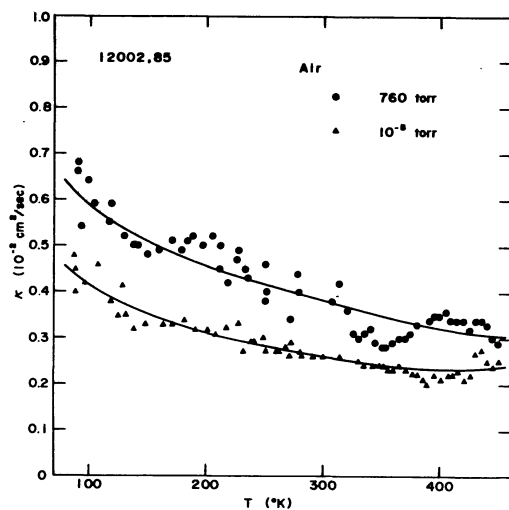


Fig. 1

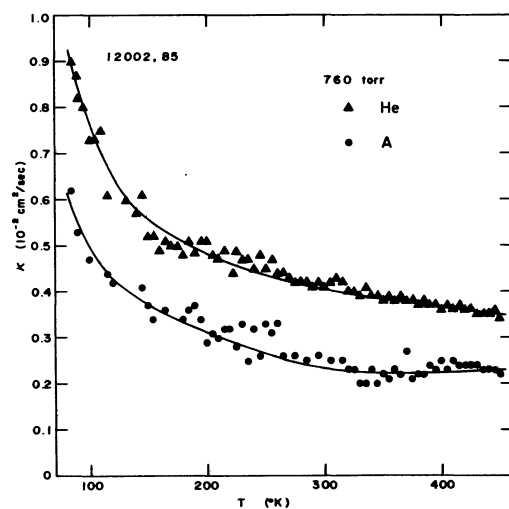


Fig. 3

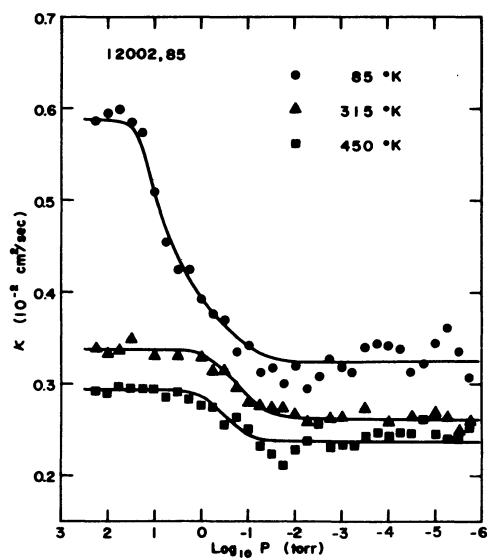


Fig. 2