THERMAL CONDUCTIVITY OF POWDERED SILICATES UNDER SIMULATED MARTIAN SURFACE CONDITIONS by K.Horai, Met.Res.Inst.,Tsukuba,305 Japan; C.Fujii, H.Nakagawa and T.Matsui, Dept.of Earth & Planet.Phys., Univ.of Tokyo, 113 Japan.

Thermal conductivity of powdered silicate rocks was measured in the temperature range between 200 and 300K under the environmental gaseous pressure of CO_2 ranging from 10 to 10^5 Pa. The purpose of the study is to provide basic data that are relevant to the project of Martian heat flow measurement that is expected in the near future. The measurement was conducted by the needle probe technique on a series of samples including bentonite that is used as a simulant of the Mars' surface material.

The main component of the Martian atmosphere is carbondioxide which constitutes more than 95% of it at the surface. On average, the surface pressure is about 7 hPa, but it varies according to the altitude and the season. In the experiment, the gaseous pressure of CO_2 was reduced from 10^5 Pa to 10 Pa. The Mars' surface temperature also experiences seasonal and diurnal variations. The experimental temperature was changed between 200 nad 300K, as the range was inferred from the direct observation by Viking landers that touched down on the middle latitude areas of the Martian surface.

For the measurement of thermal conductivity, an experimental set-up was constructed after Horai(1). Sample of granular montmorillonite (bentonite) with the grain size ranging from 1 to 10 μm was put into the cylindrical container, 76.3mm long and 25.4mm in diameter. Along its axis is placed a needle probe of Fenwall Electronics' K5304 series, the sensor of which is 63.5mm long and 1.65mm in diameter. The container is filled with the sample of powdered montmorillonite so as to cover the sensor totally. The container with the measuring needle is suspended in the vacuum chamber that is also of a cylindrical shape. The vacuum chamber was evacuated first to the lowest pressure of about 1 Pa, and then CO_2 gas was injected to change the sample's interstitial gaseous pressure stepwise from 10 Pa to 10^5 Pa. The sample temperature was controlled by immersing the cylindrical vacuum chamber into a bath of liquid nitrogen. In order to confirm the experimental result's validity by comparison, measurements were also made on the samples of granular material such as Appolo 12 simulant lunar soil and glass beads. The results generally agreed satisfactorily with those by Horai(1) and Presley and Christensen (2).

We first investigated the pressure dependence of thermal conductivity of dry montmorillonite. The desiccated sample was prepared by putting the sample in an oven kept 100°C for one day. The sample's bulk density during the measurement was 0.84 g/cm^3, which gave the porosity of 0.56 for the sample's assumed grain density of 2.0 g/cm^3. At all temperatures

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between 200 and 300K, the thermal conductivity of dry montmorillonite decreased with the decreasing pressure of CO_2 gas filling the interstices of the sample. Below 10 Pa, the conductivity becomes insensitive to the change of pressure and is virtually constant. In the range corresponding to the Mars' surface atmospheric pressure, the thermal conductivity varies with the change of pressure. For a fixed pressure, however, the conductivity is rather insensitive to the change of temperature. The data taken at the pressures of 5.3, 7.9 and 13 hPa show a slight increase of thermal conductivity as the temperature was raised from 200 to 300K.

Effect of moisture is another important factor to be considered in the Martian surface environment. The wet montmorillonite samples were prepared by spraying water evenly on the desiccated samples. Measurement result on the samples containing respectively 5 and 13 percent of water by weight showed a larger thermal conductivity and a stronger temperature dependency under the similar temperature and pressure conditions.

Summarising the present result, it was concluded that the thermal conductivity k=0.046 W/mK that was exhibited by the sample of powdered montmorillonite containing 13 weight percent of water at 290K under 7.9 hPa of interstitial gaseous pressure of CO_2 represents one of the highest thermal conductivities that the Martian surface layer can attain in the middle latitude area. Thermal diffusivity that is necessary for determining the Mars' thermal skin depth can be derived from the thermal conductivity. The value of thermal diffusivity corresponding to the above value of thermal conductivity was $\kappa = 3.30 \times 10^{-8}$ m^2/s. Contrary to the thermal conductivity, the thermal diffusivity of wet montmorillonite is less temperature dependent.

The thermal skin depth δ is the depth at which a periodic variation of surface temperature decays to e^{-1}. The values of δ obtained in the present study were, δ =3cm for the Mars diurnal variation and δ =79cm for the annual variation. These values serve as an indicator of the depth that is necessary to penetrate into the Martian regolith for measuring undisturbed temperatures that will enable a determination of heat flow.

Thermal inertia of the Martian surface material can also be estimated as a result of the present study. It was 253 $Jm^{-2}s^{-1/2}K^{-1}$ or 6.06×10^{-3} $cal/cm^2s^{1/2}K$. According to the Viking infrared thermal mapping by Kieffer et al.(3), the value is typical of the middle-latitude area on the Martian surface that has a relatively low albedo.

References: (1) Horai[1981], Phys.Earth Planet.Int., 27, 60-71. (2) Presley & Christensen[1994], LPSC, 24, 1175-1176. (3) Kieffer et al.[1977], J.Geophys.Res., 82, 4249-4291.

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