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Modelling apparent low thermal inertia by layered structure

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Thermal inertia of planetary surface is a physical property that controls the diurnal and seasonal cycles in the surface temperature. At the same time it provides a unique window into geologic structure of the surface and the nature of geologic processes that shapes the planetary surface. Especially on Mars, it has been extensively derived from spacecraft remote-sensing observations. It shows existence of the area with very low thermal inertia in the equatorial and middle latitudes, which at the same time display complicated heterogeneous characteristics(Putzig and Mellon, 2007). This is one of the enigma about the surface state of Mars. Physical interpretation about the origin of this heterogeneous nature of the thermal inertia is needed.

In this study, we discuss a possibility of apparent low thermal inertia when there exists a layered structure having contrasting thermal conductivities based on laboratory experiments.

The layered structure we examined in the experiments are an acrylic plate(3.2mm , 5mm , 10mm in thickness) on top of Polystyrene foam block or vesiculated particle layer. In both cases the lower layer has lower thermal conductivity. They are heated periodically by a infrared lump from above(period from 10 to 600 sec.). We measured the temperature at the surface, bottom of the acrylic plate and inside the lower Polystyrene foam and the granular layer using the thermocouples and infrared thermometer.
From amplitude of temperature variation, we estimated the thermal inertia.

The important controlling factor in this experimental design is a thermal relaxation time of the surface layer, which is controlled by period of the applied heating cycle and the thickness. At the fixed layer thickness thermal structure changes drastically between the periods below and above the relaxation time. We estimated variation of apparent thermal inertia with period. In a homogeneous semi-infinite layer the amplitude of variation of the surface temperature induced by periodic heating under controlled situation is proportional to square root of the period and inversely proportional to the thermal inertia(Wang et al 2010). We utilized their formula to determine apparent thermal inertia.

At the periods below thermal relaxation time unique value for thermal inertia was obtained while above the relaxation time it decreases even below the value of the lower layer. This is caused by the effect of finite layer thickness,which reduces thermal gradient in the surface layer. This leads to apparent low thermal inertia value. In our experiments we can demonstrate a simple layered structure; a thin layer having higher thermal conductivity on top of a layer with low thermal conductivity can produce apparent low thermal inertia. In the martian situation the thermal inertia is obtained mostly by diurnal heating cycle, which has a penetration depth(Thermal relaxation depth) of several to 10 cm. We discuss several geological processes to produce layered structure in this depth range in the presentation.