Thermal Conductivity Effect on Formation of Recent Gully on Mars

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Surface drainage features observed on Mars including valley networks and outflow channels indicate a possibility of former warm and wet climatic conditions. Small gully-like features reported by Malin and Edgett [2000] have been identified in high-resolution images by the Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) and suggest that liquid water has recently flowed on slopes primarily at middle and high latitudes of the southern hemisphere at least during Amazonian time.

Depths in which liquid water exists with stability can be estimated by geothermal gradient. The geothermal gradient depends on annual mean surface temperature, melting point of water, surface heat flow and effective thermal conductivity of the Martian regolith. The effective thermal conductivity of the Martian regolith is the most influential factor. However, almost all models treat the effective thermal conductivity as a constant, because composition and structure of the Martian regolith are unknown.

We assume that the Martian regolith is composed of solid rocks, fine-grained materials and interstices filled with carbon dioxide and/or water-ice and that the porosity is represented as an exponential function of depth. Furthermore, we express the effective thermal conductivity as a function of water-ice saturation degree and mixture ratio of solid rocks to fine-grained materials, and infer a possibility that the melting isotherm exists on an equal level with groundwater outlets which locate at depths from between 70 and 1000 m [Gilmore and Phillips, 2002].

When the annual mean surface temperature is 193 K, the melting point of water is 252 K and the surface heat flow is 30 mW/m^2, Martian regolith which is composed of about 50 % solid rocks and 50 % fine-grained materials requires an almost perfectly dry condition in order to stabilize liquid water at depths below 1000 m. If the Martian regolith has a few percent ice saturation, liquid water cannot be stable at depths below 1000 m.