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The Effect of Soil Cementation on the Thermal Conductivity

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The study presented here aims at a better understanding of consolidated porous media, such as sintered ice, which may be present in near surface layers of comet nuclei, and in the Martian polar deposits, or cemented Martian soil. Martian soil, for instance, may be consolidated either by interstitial water or carbon dioxide ice, or by clay minerals and salts. In either case the consolidation is a direct consequence of an increased grain-to-grain contact area. The cross section of these bonds are bottle necks for solid state heat conduction, which therefore improves with the growth of bonds.

We performed thermal conductivity measurements performed in vacuum on loose and consolidated synthetic samples. Small glass beads served as an analogue of soil grains and initially melted wax as the cementing agent, which creates, after mixing with the glass beads and subsequent solidification, a surprisingly hard but still porous material. Several samples with ranging from 0 to 11 % wax content have been produced and studied. A commercial probe, which employs a modified transient line heat source technique was used to measure the thermal conductivity. We found the thermal conductivity to grow with cementation, as expected. The sample with the highest degree of cementation conducts heat three times better than the unconsolidated, pure glass sample. A simple geometrical model, describing the size of the bonds as a function of wax content, is capable to predict the observed values reasonably well. The observed effect is significant, but not large enough to explain the wide range of thermal inertia values that have been measured by the TES instrument on Mars Global Surveyor. This result confirms that the thermal inertia variation of the Martian surface is at least partly due to rock abundance.