Effects of Fine Sediment Mantle on the Thermal Inertia Signature of underlying Materials.

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Introduction: Mars Odyssey THEMIS results show the exposed Martian surface to consist in part of kilometer-scale bedrock exposures, but elsewhere, the Martian landscape is mantled by a layer of airfall dust [1]. It would be a major contribution to the Mars exploration program to be able to characterize the physical thermal properties of materials underlying this dust; specifically, the thermal inertia of mantled materials. Unfortunately, most methods for estimating thermal inertia are derived from models based on horizontally and vertically homogeneity [2]. Although we have not advanced our study to the point that we could derive any algorithm that would model thermal inertia of such heterogeneity of Martian surface materials, we do believe that empirical thermal studies involving layered materials, such as the one we present here, have use in the ongoing study of the red planet. Thus, we have set out to observe what effects on thermal properties of materials an overlying layer of dust might have.

Analytical Approach: In order to simplify our experiment, we set out to remove as many variables that affect thermal properties as possible. All experimentation involved a constant heat source at a constant distance from our experimental setup; an attempt to remove seasonal variability. We used flat surfaces of materials to minimize the effects of slope. We also selected materials from a common source so as to minimize the effects of material albedo. To best accomplish this, we collected mixed river sediments of fairly uniform composition and color from a location formally occupied by a small dam on the Eno River in Durham, North Carolina. We separated these sediments into five different sizes: coarse gravel (greater than 4mm in diameter), fine gravel (2-4 mm in diameter), coarse sand (0.25-2 mm in diameter), fine sand (.063-.25 mm in diameter), and silt and clay (less than .063 mm in diameter). We also modeled the heating and cooling of sample of rock of basaltic composition showing surface weathering. This rock was rectangular in shape and was at least 20 cm in length, width and height. Materials were completely dried to rule out the effects of interstitial water. We then filled 30 cm diameter hemispheres with each size sediment, up to 3 cm from the top. This allowed there to be 10 cm thickness of sediment in all directions, which prevented thermal interference from the outside of the material inside the hemisphere.

We then positioned 90 watt bulbs 40 cm above the surface of the sediment, which allowed consistent heating of all the material samples. To measure material temperature during our experiments, we used calibrated infrared thermometers mounted on tripods. The tripods allowed us to keep the thermometer focused on one specific point in the sediment, and at a constant distance of 30 cm, without interfering with the sediment.

Once we set up our stations, all in the same room and with the same conditions, we were able to begin testing. After taking an initial temperature of all the sediments, we turned on the heat lamps. Every 30 seconds we would take a reading, until the temperature stabilized within 0.5 degrees Celsius for 10 minutes. After the temperatures stabilized, we turned off the heat lamps and continued to take temperature readings while the sediments cooled.

After testing each sediment size several times and receiving consistent results, we added a 0.5 cm layer of silt onto the other sediment sizes. Then, we repeated the experiment on the layered materials. When those experiments were completed, we added .5, 1 and 3 cm layers of silt on top of the setups, in order to test the effects of thicker silt and clay layers.

Results: We found that, no matter what material was underlying the silt and clay layer, that even a .5cm thick layer of sand and clay effectively masks the thermal signature of any underlying layer. Figures 1, 2 and 3 below demonstrate that the shapes of heating and cooling curves are similar with any thickness of clay overlying.

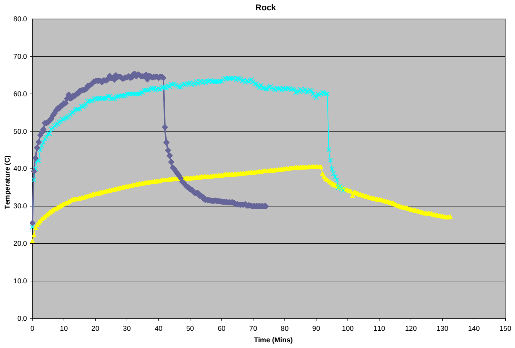

Figure 1: Thermal behavior of basaltic rock with

varying mantle thicknesses of silt/clay. Dark blue is the silt and clay; the light blue line is the rock with silt on top. The yellow line is the rock.

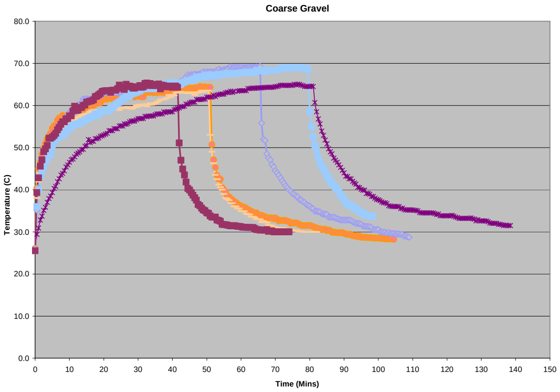

Figure 2: The small maroon is pure coarse gravel. The orange line has .5 cm of silt on top of coarse gravel; the tan is 1 cm of silt on top of the coarse gravel. The dark blue has 3 cm of silt, and the light blue has 5 cm. The large maroon line is pure silt and clay.

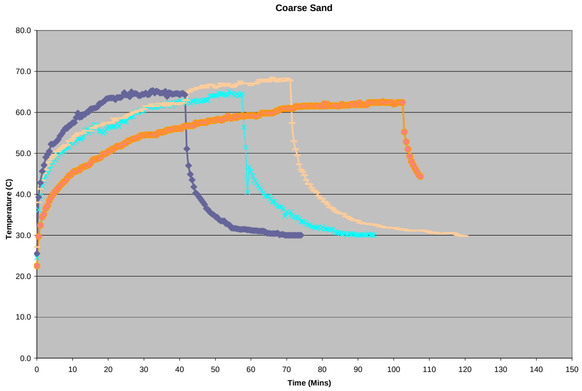

Figure 3: The orange line is pure coarse sand. The small, light blue line has a .5 cm layer of silt on top of coarse sand. The tan line has 1 cm of silt on top. The large, dark blue is pure silt and clay.

Our experiment suggests that the thermal inertia of any underlying material, and perhaps even underlying bedrock, might be extremely difficult to predict if mantled by any thickness of dust, even as little as .5 cm. If this thermal masking is a true phenomenon, then any thermal-based study of the entire Martian surface would be limited.

Future Work: We plan to further ponder the question of silt's impact on the thermal modeling of Mars. Future experiments will explore more of various materials thermal properties and of the affects of vertically mixing such materials. As our group's abilities improve, we intend to attempt to develop a capability to construct algorithms that might predict the nature of materials in Martian sedimentary systems, such as those found in fluvial deposits on the planet.

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References: [1] Christensen, P. et al. (2003) *Science*, 300, 2056-2061. [2] Putzig, N. and Mellon, M. (2007) *Icarus*, 52-67.