LABORATORY MEASUREMENTS OF THE SOLID-STATE GREENHOUSE EFFECT IN GLASS BEADS; Richard Dissly, Caltech, Robert Hamilton Brown and Dennis Matson, J.P.L.

Thermal models of planetary surfaces generally assume that incident insolation is completely absorbed at the immediate surface. However, if the insolation is able to penetrate the regolith, thereby depositing radiant energy below the surface, then the standard conductive temperature profile can be altered significantly (1). If such subsurface deposition of visible radiation happens in a medium that is opaque in the thermal infrared (e.g., water ice, glass), then a solid-state greenhouse can result. Such a greenhouse can produce average subsurface temperatures that are significantly higher than average surface temperatures. Thermal models of icy satellite surfaces suggest that greenhouse temperature inversions can be as much as 100 °K, over a scale of a few centimeters below the surface (2).

We designed a series of simple laboratory experiments to verify this greenhouse effect. The first experiments studied the temperature response of a layer of 800-μm glass beads at ambient atmospheric pressure and room temperature. Upon illumination by approximately 300 watts/m^2 of radiation from quartz-halogen incandescent bulbs, thermocouples spaced at approximately 1 cm intervals below the surface were used to record the temperature of the bed of glass beads as a function of depth and time. The evolving temperature profile was measured for as long as 3 days. Although the system did not reach thermal equilibrium during even our longest runs, there was clear evidence of subsurface energy deposition, and a significant deviation from a purely conductive temperature profile.

Our current experiments again study the temperature response of 800-μm soda-lime glass beads, but in a vacuum of about 10^{-5} torr with carefully monitored boundary conditions such as the effective temperature of the radiation field seen by the surface of the bead bed. By running the experiment at this pressure, the effective thermal conductivity of the glass bead bed decreases because gas conductivity in the pores of the medium becomes less important than radiative transfer as the dominant mode of heat transport (3). Vacuum conditions provide a more accurate simulation of the surface of an airless body, and the corresponding decrease in thermal conductivity can only enhance the magnitude of the greenhouse effect. Preliminary measurements under vacuum indicate that inversions in the subsurface temperature profile are significant and permanent, providing strong confirmation of the effect. Quantitative results from these experiments will be discussed.

REFERENCES:

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