MODELS FOR LUNAR SUBSURFACE HEAT STORAGES FOR SUPPORTING SURFACE SCIENCE INSTRUMENTS. S. Nagihara[1], P.E. Clark[2], M.B. Milam[2], B.G. Beaman[2], and J. Ku[2]. [1]Texas Tech University, Lubbock, TX 79409 (seiichi.nagihara@ttu.edu), [2]Goddard Space Flight Center, Greenbelt, MD 20711

Introduction: The large diurnal temperature swing on lunar surface makes it a harsh environment for operating highly sensitive science instruments such as broadband seismometers. At low-latitudes, surface temperature reaches ~380 K at the peak of a lunar day, while it falls below 100 K soon after the sunset [1]. It is a challenge to maintain stability of the instruments' performance between the day and the night, as well as to power them through the long, cold lunar night.

The large diurnal temperature swing is partly due to lunar regolith being a poor thermal conductor. During a lunar day, solar heat accumulates within a thin (~0.4 m) surface layer of regolith. At night, the heat radiates back into space. It might be possible to divert a portion of the energy released over night and use it either to help stabilize the temperature of an instrument package on the surface or to provide electric power by utilizing heat pipes or a stirling engine. The difficulty, though, is again the low thermal conductivity of regolith (<~0.01 W/mK). The power system would draw down heat much more quickly than the surrounding regolith could replenish it. However, if there is a way to artificially enhance thermal conductivity (and heat capacity) of regolith, a thermal power support system may be feasible.

The low thermal conductivity of near-surface lunar regolith can be attributed to its porosity (~40% [2]). One way of thermal enhancement might be to inject fluid into regolith to fill the voids. Thermal grease or ionic liquid [3] may be custom-manufactured so that their viscosity is low enough to percolate through the regolith matrix in the high temperature of the lunar day. When the fluid reaches ~0.4-m depth, it stops spreading by freezing or becoming more viscous.

Wengen et al. [4] previously coined the term "thermal wadi" in describing a lunar subsurface heat storage that utilizes thermally enhanced regolith. Their proposed enhancement techniques were elaborate, and the wadi system proposed was large and intended for supporting rover operations. Here we develop models for a much smaller, simpler thermal wadi system, which minimizes the mass, and is intended for supporting low-power surface science instruments.

Simulation Experiments: In the model presented here, the thermal wadi is a disk of regolith of 2-m diameter, 0.5-thickness, whose pore spaces are filled with conductive fluids so that the bulk thermal conductivity of the matrix is about ten times greater (0.1 W/mK) than untreated regolith (Fig. 1). Untreated regolith surrounding the wadi consists of two layers, similar to the previously proposed thermal models of regolith [1]. The top is a thin (0.02 m) layer of loose soil with very low thermal conductivity (0.001 W/mK). The lower layer is more consolidated and of greater thermal conductivity (0.01 W/mK). The surface heat input is determined as the difference between the solar input and the radiative output. The solar input in the model varies purely sinusoidal during the lunar day and stays at zero through the night. The model regolith extends to 5-m depth where a constant geothermal heat input of 20 mW/m^2 is assumed. The simulation is done in the 2-D cylindrical coordinate system with its vertical axis set at the center of the wadi disk. The finite difference code HEATING7 [5] was used.

Results: After regolith has been thermally enhanced, it begins to accumulate heat in the lower portion of the wadi and untreated regolith immediately below it (Fig. 1). Temperature within this hot zone can rise ~30 K above the surrounding regolith and is maintained through the diurnal cycle. By optimizing the wadi design, it may be possible to draw enough energy to support low-power surface instruments.

References: [1] Keihm S.J. and Langseth M.G. (1973) *LPSC* 2503-2513. [2] Carrier W.D. et al. (1991) *Lunar Source Book*, 475-594. [3] Wu B. et al (2001) *Proc. Solar Forum*. [4] Wengen R.S. (2008) *LEAG*, 4091.[5] Childs K. W. (2005) ORNL PSR-199.

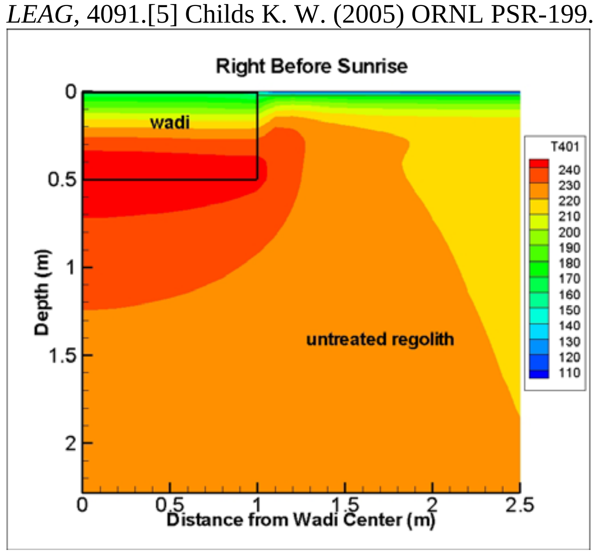

Fig. 1 A cross-sectional temperature distribution of the wadi (a disk of thermally enhanced regolith) and the surrounding. The timing is right before sunrise, when surface temperature is lowest in the diurnal cycle.