# Lunar Refueling Station

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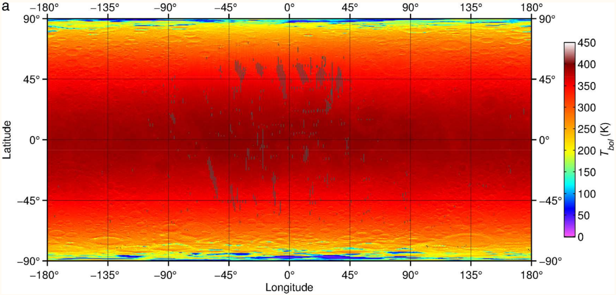
The temperature varies from a high of $213K$ and a low of $50K$. Despite a larger area of the Lunar south pole is permanently shadowed, the topography results in increased illumination on the slopes of ridges than the northern pole.[8].

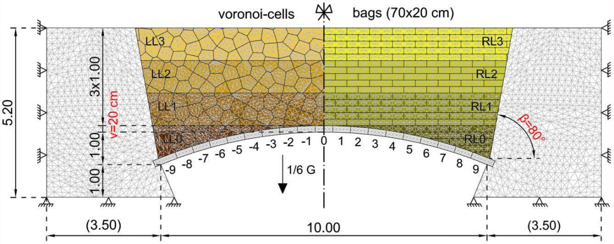


# Temperature variation on lunar south pole

Due to the sunlight being perpetually on the horizon the variations in illumination and temperature at the lunar south pole are functions of the topography, with some effects due to the moons distance from the sun and location in orbit around Earth [8].

# Using Lunar Regolith as Insulation

Since lunar regolith, (layers of dust and rock), is abundant on the surface any material use of it alleviates the need to import another substance. By using the regolith as a insulative material it may be possible to minimize the temperature variations inside the habitat and create a steady state temperature environment that could then be heated at a constant rate.



# Temperature dampening due to regolith layers

For a temperature on the surface, $z = 0$, varied with time,

$$\theta(0, t) = \theta_{avg} + \theta_0 cos(\omega t)$$

Where $\theta_0$ is half the difference between the high and low temperatures, and $\theta_{avg}$ is the average of the high and low.

# Temperature dampening due to regolith layers

As layers of regolith insulation surrounding the habitat increase less heat is diffused to the structure. We can find the characteristic penetration depth from the thermal diffusivity and omega,

$$\delta = \sqrt{\frac{D_t}{\omega}}$$

Where $D_t = \frac{K_t}{C_v}$

# Temperature dampening due to regolith layers

We now have a function of depth and time to use for temperature pulse analysis of the regolith,

$$\theta(z,t) = \theta_{avg} + \theta_0 e^{\frac{-z}{\delta}} cos(\omega t - \frac{z}{\delta})$$

# Temperature Dependent Thermal Conductivity

The thermal conductivity of the regolith changes with the temperature which we can models as,

$$K_t = k_c \left[ 1 + \chi \left( \frac{T}{350} \right)^2 \right]$$

where the solid conductivity, $K_c = 9.3 \times 10^{-3} \frac{W}{mK}$ and $\chi = 0.073$ and is the ratio of radiative to solid conductivity, these have been chosen in accordance with Vasavada et al.[9]

# Heat Capacity

The heat capacity is found from the bulk thermal inertia, $I = 0.019m^2s^{1/2}\frac{K}{J}$ which is set equal to the inverse root of the thermal conductivity, density, and heat capacity [10].

$$I = \frac{1}{\sqrt{K_t \rho C_v}} \quad \text{Solving for } C_v$$
$$C_v = \frac{1}{K_t \rho I^2}$$

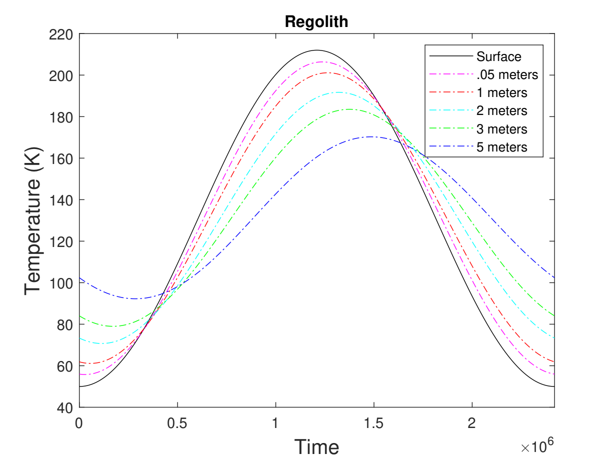
Where we tale the density of the regolith to be $1900\frac{Kg}{m^3}$ [11].

# Matlab Functions

We can use Matlab to generate numerical values for the thermal conductivity, which are used to find the heat capacity from the thermal inertial and density where we can then find the penetration depth. A Temperature pulse can then be simulated.

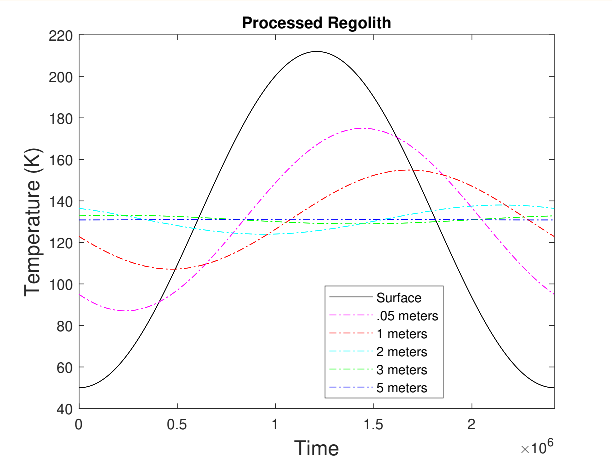
# Unprocessed Regolith

The the top layer of lunar regolith is decribed as a 'fluff' layer that comprises the top 2cm of the surface and has a lower thermal conductivity than the denser lower layers[11].



# Processed Regolith

Research has shown that by using a loose mixture of the top 'fluff' layer of lunar regolith which has a lower thermal conductivity and thus higher thermal shielding can be used as a strong insulator[11].



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