AN HISTORICAL SEARCH FOR UNFROZEN WATER AT THE PHOENIX LANDING SITE, Aaron Zent, NASA Ames Research Center, Moffett Field, CA 94035, Aaron.P.Zent@nasa.gov

The goal of this work is to explore the history of the high-latitude subsurface in the latitude range of the Phoenix landing site (65-75° N). The approach is to use time-marching climate models to search for times, locations, and depths where thick films of unfrozen water might periodically occur. Thick films of unfrozen water (as distinct from ubiquitous monolayer water) are interesting for two reasons. First, multi-layer films of water may be bio-available. Second, patterned ground may require the occurrence of thick films of unfrozen water to facilitate the migration of particles and the development of excess pore ice, as reported by the Odyssey Gamma Ray Spectrometer (GRS) results.

For the purposes of this work, we define conditions adequate to establish thick films of unfrozen water to be T> 268K, and $R_H > 0.5$. We start with the need to understand the atmospheric pressure. Because of the fact that we're looking at high-latitudes, the seasonal cap buffers surface temperature for some part of the year. That directly affects the subsurface thermal regime, at least in the uppermost meter where we will be searching with Phoenix. We estimate the atmospheric pressure history by assuming a total regolith abundance (depth and specific surface area), which represents an adsorbed reservoir of CO_2. In the present case, we have eliminated the high-latitude regolith as a reservoir for exchangeable CO_2, because of the high-latitude water ice that we assume prevents exchange of CO_2 between the atmosphere and underlying regolith. We also have to assume the total inventory of CO_2. We find the orbital configuration from the data of Lasker (1993). Calculating the annual average insolation as a function of latitude, we divide up the regolith into latitude/depth domains, and calculate the adsorptive covereage of each. This technique was used by Fanale et al. (1982).

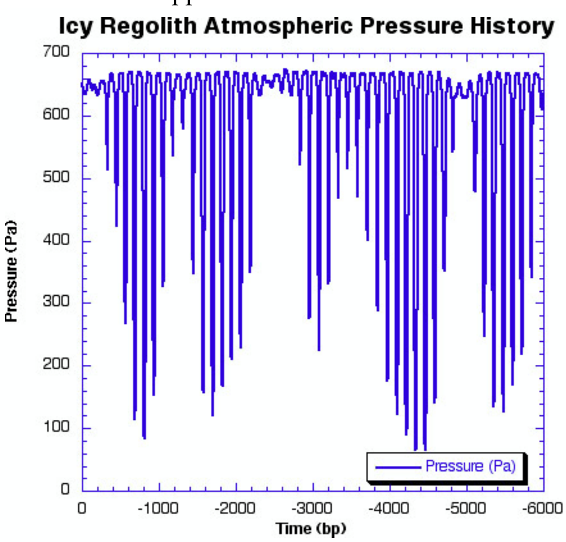

Fig.1 An ice-choked high latitude regolith precludes high pressure climate regimes.

The results are shown in Figure 1. They indicate that the current pressure is likely to have been near the maximum over the past 6 Ma. The maximum pressure is at obliquity just over 30 degrees, because all CO_2 is now adsorbed in the low-latitude regolith which actually cools as obliquity increases.

The domain in which we can search for unfrozen water is the regolith overlying the ice table (i.e. the uppermost level of regolith that is ice-cemented). There are considerable uncertainties in estimating the depth of the ground ice over timescales long enough to capture orbital variations. The most compelling is probably the behavior of the polar caps at other orbital configurations. Small variations in cap albedo, determined by variations in dust mixing ratios, can have non-linear effects on the absorption of solar radiation in the cap.

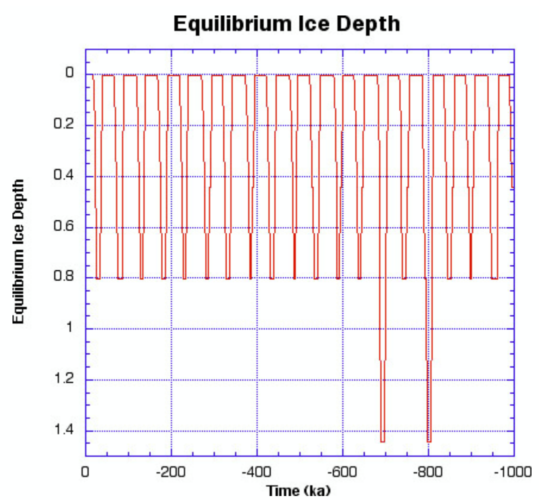

Fig 2. The *equilibrium* ice depth is modulated by the precession of the equinoxes.

In order to approximate the ice-free domain as a function of time, we need not only an estimate of the regolith temperature throughout the annual cycle, but also of the atmospheric H_2O that constitutes the upper boundary condition for H_2O

vapor. That is estimated straightforwardly by tracking the equilibrium H_2O over the polar caps, and assuming a linear pole-to-pole gradient. Although this assumption is occasionally in gross error, the intrgrated annual gradients at the current configuration approximate the zonally averaged atmospheric H_2O N-S profile.

Following the method of Mellon and Jakosky (1995) we calculate the equilibrium depth of the ice table as a function of time (Figure 2). The discrete levels reflect the finite difference grid used in the

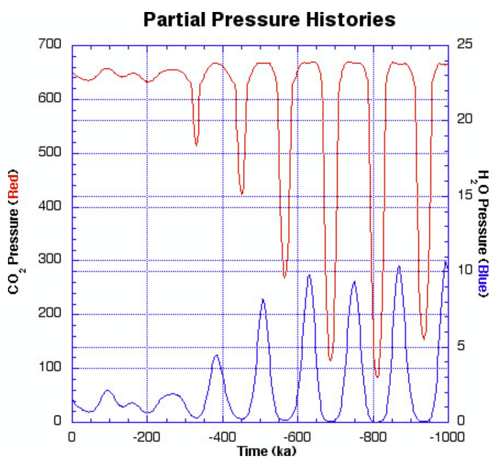

Fig. 3. The partial pressure history of CO_2 (red) and H_2O (blue) for the past 1 Ma.

calculation. These results indicate that the equilibrium depth of the ice table varies from within mm of the surface to depths greater than 1.5 m over the 1My timescale of the simulation. The high frequency of the signal suggests that the equilibrium depth of the ice table is responding to the $5x10^4$ year periodicity of the L_s precession. A study including transport kinetics suggests the table may actually oscillate at the lower frequency of obliquity oscillations (~10^5 years) (Mellon and Jakosky, 1995). However, the oscillation from the near-surface to ~1.5 m depth is common to both analyses. Given the orbital configuration, the partial pressures of CO_2 and water (Fig. 3), and the domain within which we must search for H_2O films, we use an annual climate model to calculate temperatures every half hour for the site. The model includes a simple energy balance CO_2 budget, and tracks the accumulation and sublimation of the CO_2 cap at the site. The subsurface temperatures are initialized at the averages that were calculated in the annaully-averaged model, and the planet is spun-up for two years

The current version of the model does not find subsurface thick films of water. The fundamental issue is shown in Figure 4. The simple one-dimensional energy balance model does not predict that the annual CO_2 cap (green line) fully sublimates until the annual peak insolation has passed. Therefore, subsurface temperatures cannot sustain thick-films.

A model that treats the physics of atmospheric heat trasnport and the expected variations in CO2 cap behavior will be presented, which will update the subsurface thermal regime.

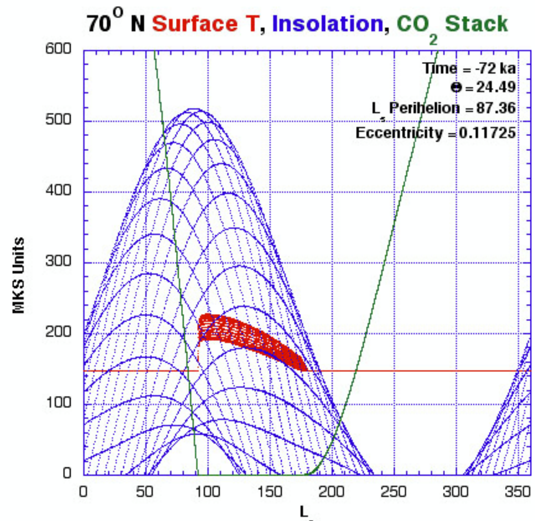

Fig. 4. The seasonal CO_2 cap history will largely control the subsurface thermal and H_2O regimes at the Phoenix site.