SIMULTANEOUS DETERMINATION OF DRY-LAYER THICKNESS AND SUB-SURFACE ICE CONTENT IN THE POLAR REGIONS OF MARS: IMPLICATIONS FOR THE PHOENIX LANDING SITE SELECTION. W. V. Boynton, D. M. Janes, M. J. Finch, and R. M. S. Williams, Department of Planetary Sciences, University of Arizona, Tucson AZ 85721 (wboynton@LPL.Arizona.edu)

Introduction: The 2001 Mars Odyssey Gamma-Ray Spectrometer (GRS) [1] has been a very useful instrument for estimating the amount of sub-surface ice in the polar regions. In our first preliminary look at ice content in these regions [2], we modeled the surface with two layers: a dry layer containing no ice over an ice-rich layer with a variable ice content. We used a plot of the fluxes of epithermal neutrons *vs.* thermal neutrons and a plot of H gamma-rays *vs.* thermal neutrons to estimate both the ice content in the sub-surface layer as well as the thickness of the dry layer in the south polar region. This analysis gave a result consitent with an ice content around 35% by mass, and a dry-layer thickness (DLT) of about 40 g/cm^2. This interpretation was based on some assumptions concerning a "ground truth" H_2O content in the lower latitudes that we have since shown to be erroneous. We recognized this potential problem at the time, and stated that the assumption, if incorrect, would yield a lower-limit to the ice content.

With a better calibration, we have been able to revise our estimates of ice content and depth, and indeed the ice content did go up from our original estimates. Currently we feel we have a solid calibration of the gamma-ray data and have limited our analyses to these data. We have previously shown, based on the flux of H gamma rays, that the DLT cannot be more than about 25 g/cm^2 over most of both polar regions [3]. This limit was set by assuming the buried ice was 100% H_2O. Similarly, we showed that the H_2O content of the ice-rich soil cannot be any less than about 30% H_2O by assuming the DLT = 0, i.e. the ice-rich soil is not buried at all.

If we use only the H gamma-ray flux, we have only one equation for the two unknowns of ice-content and DLT. We have shown that the flux of Si capture gamma rays provides another equation to address the issue [4] (see figure 1). In that work we concentrated on the four Phoenix candidate landing zones. We found that the Si data implied an H_2O content in the ice-rich layer of about 50%. Assuming this value of 50% applied everywhere in the north polar region, we found that the DLT over most of the north polar region was well under 10 g/cm^2.

Approach: In this work we extend the previous work to take into account another important variable. This variable is the total macroscopic thermal-neutron cross section of the H-free model soil. The data in figure 1 show the relationship between H and Si fluxes and the DLT and the H_2O content of the sub-surface layer. These calculations are only valid for a particular composition of the dry (H_2O-free) soil. Different amounts of Fe and Cl, both of which are strong absorbers of thermal neutrons (the excitation source of these gamma rays), can change the locations of the points. Higher amounts of these elements will lower the Si flux for otherwise identical H_2O contents and DLT values.

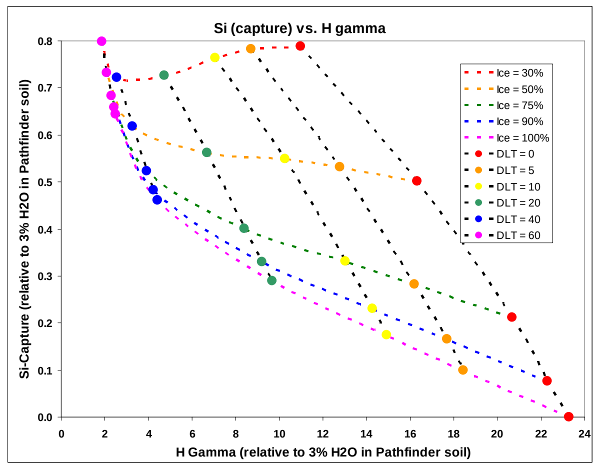

Figure 1. Plot of calculated values of Si and H flux (relative to our standard soil containging 3% H_2O. DLT is the dry layer thickness in g/cm^2 and the ice content refers to the total H_2O content of the sub-surface ice-rich layer. This array is calculate for a soil which is relatively low in Fe and Cl, two elements which significantly absorb thermal neutrons. A similar array for a high-Fe high-Cl soil, would plot with Si fluxes significantly lower.

Results: We have now adjusted these calculations for differnces in observed Fe and Cl content in the polar regions. Although the results are still preliminary in the sense of being sure we have properly accounted for the significant effects of these two elements and being sure we can properly ignore other elements which are not expected to vary much from place to place.

In figure 2 we show the DLT values for the north polar region. These values are similar to those found previously with the assumption that the H_2O content was 50% throughout the region [4]. They range from 0 to about 8 g/cm^2 over much of the region, but higher values up to 20 g/cm^2 are found between -75 and +90 E. longitude. Results for the south polar region are still being checked (they have very high Fe and Cl contents) but preliminary analysis (not shown) suggests that there are similar DLT values of 0 to 8 g/cm^2 over much of the region.

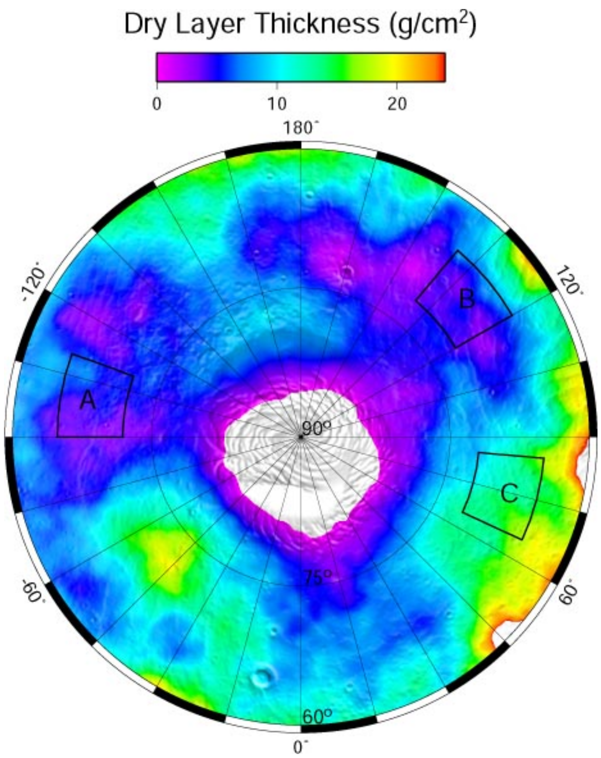

Figure 2. Map of the dry-layer thickness in the north polar region of Mars. The three different candidate Phoenix landing sites are shown by the lettered boxes.

Discussion:

Significance for Phoenix landing site selection. The 2007 Mars Scout Phoenix lander has selected three candidate regions for a more detailed examination of properties relevant for landing-site selection [5]. These regions are indicated in figure 2. It can be seen that region B, the currently preferred region, is similar to region A in terms of the thickness of the dry layer overlying the ice-rich soil. The low values, on the order of 6 g/cm^2 or less, imply a very thin dust cover over the ice. Though we don’t know the density of the dry layer, values on the order of 1.5 g/cm^3 are probably reasonable, implying a thickness of only 4 cm. It is recognized that this thin of an ice-free layer may present difficulties for those investigations interested in seeing gradients as a function of depth in the dry soil.

Region C, on the other hand, has a significantly thicker dry layer by this analysis. This region could be considered a potentially better landing site for those investigations based solely on the criterion of having a significant thickness of dry soil It is important to realize, however, that the GRS has a large footprint on the ground of about 200 km radius. The apparently higher DLT values could be due to a mixture within the GRS footprint of small areas with ice very close to the surface and other small areas with no ice or ice buried very much deeper. Because studying the sub-surface ice is also an important objective of the Phoenix mission [6], region C may not be favored for a landing site as it may just represent a region in which the chance on landing on a totally ice-free is greater.

References:

[1] Boynton *et al.* (2004) *Space Sci Rev. 110*, 37-83. [2] Boynton *et al.* (2002) *Science, 297*, 81-85. [3] Boynton *et al.* (2004) *6th Intl. Conf. on Mars,* Abstract #3259. [4] Boynton *et al.* (2005) *LPS XXXVI* Abstract #2154. [5] Arvidson R. E. (2006) *LPS XXXVII*. [6] Smith P. (2006) *LPS XXXVII.*