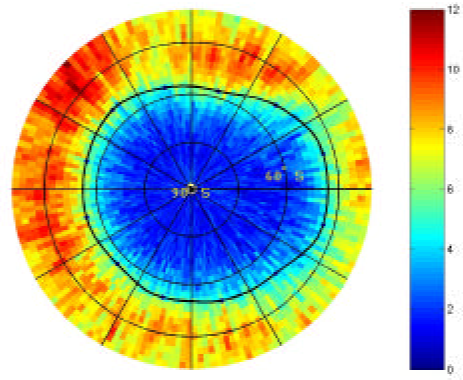
Correlation of Neutron-Sensed Water Ice Margins with Topography Statistics. R.L.Tokar[1], M.A. Kreslavsky[2,3], J.W.Head, III[3], W.C. Feldman[1], K.R. Moore[1] and T.H. Prettyman[1], [1]Space and Atmospheric Sciences, MS D466, Los Alamos National Laboratory, Los Alamos, NM, 87545, rlt@lanl.gov, [2]Kharkov Astronomical Observatory, Kharkov, Ukraine, [3]Department of Geological Sciences, Brown University, Box 1846, Providence, RI, 02912.

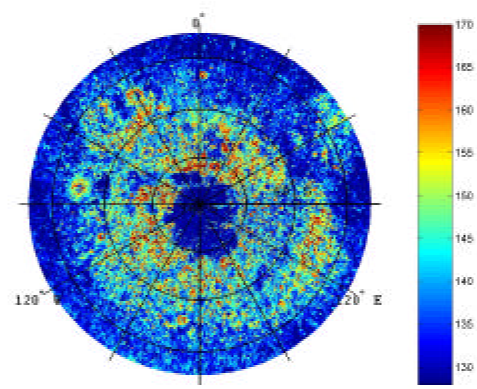
Introduction: In [1], surface roughness and curvature obtained from high resolution MOLA data are used to characterize a sedimentary mantle at high Martian latitudes, (poleward of ~40º-60º). The equatorward boundary of the mantle correlates with the locations of dissected terrain identified in MOC images [2]. The dissected terrain in [2] is thought to be degraded water cemented soil, and the mantle discussed in [1] is inferred to be water ice rich. This conclusion is given further support in [3], where a positive correlation of the results in [1] and [2] is made with Odyssey neutron sensing of high hydrogen content in the near surface soil at high southern latitudes. The Odyssey data are measured by the neutron spectrometer (NS) component of the gamma ray spectrometer (GRS).

In this study, the margins between the water ice rich mantle and the relatively dry equatorial region are studied for the northern and southern hemispheres using the Odyssey NS data and the MOLA roughness/curvature data. The position and extent in latitude of the margin is estimated via simulations of the NS data and the results are compared with average MOLA topography statistics. Preliminary results for two bands of longitude (120º-150º W and E) in the southern hemisphere are reported here.

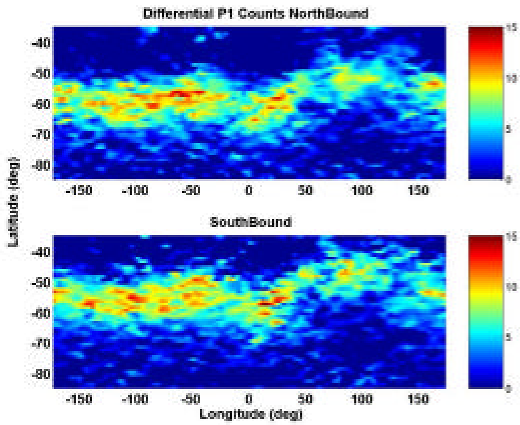
Results: The following figure shows a map of the epithermal (0.4 eV < E < 700 keV) NS counting rate measured over the south circumpolar region during southern summer, as in [3]. Recall that low epithermal neutron count rate (blue region) corresponds to high hydrogen content of the near surface soil. See [4] for a complete overview of NS hydrogen estimates both at the poles and in the equatorial region. The black curve is the nadir position of Odyssey when the epithermal counting rate falls to ½ the maximum measured before encountering the water ice rich region. The margin region studied here is the transition region near the black curve that delineates the water rich circumpolar mantle from the relatively dry equatorial region.



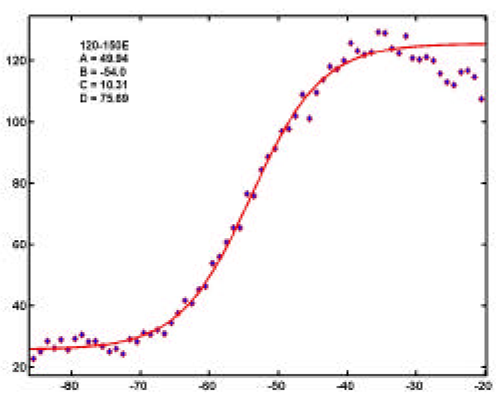
The following figure is a map of MOLA-derived 0.6 km curvature, calculated as in [1]. Mapped is the ratio of the median curvature to the interquartile width of the curvature-frequency distribution. The water ice rich mantle exhibits a prevalence of concave (> 128) as opposed to convex (< 128) curvature. As established in [3], the equatorward boundary of the ice mantle is in qualitative agreement with the NS boundary shown above, although the boundary obtained from the curvature often lay equatorward of the NS boundary.

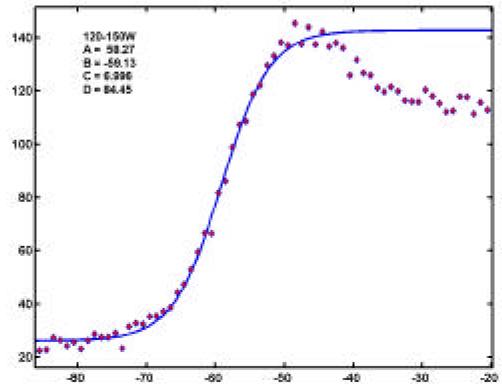


The figure below illustrates the gradient in epithermal neutron counting rate with latitude (counts/s/deg). Where the gradient is large and localized in latitude the margin is sharp whereas an extended margin has a relatively smaller gradient distributed over an extended range of latitude. The top frame corresponds to northbound Odyssey orbit segments, the bottom southbound, although this distinction will not be used in our preliminary analysis. Here we concentrate on the two longitudinal segments, -120º to -150º (west) and 120º to 150º (east). These regions have relatively small altitude variations, thereby simplifying the analysis of the NS data, as opposed to regions near the Hellas or Arygre basins. For both orbit directions, the gradient illustrates that for the west slice the margin between the water ice and dry soil is relatively sharp, while that in the east extends over a larger range in latitude.

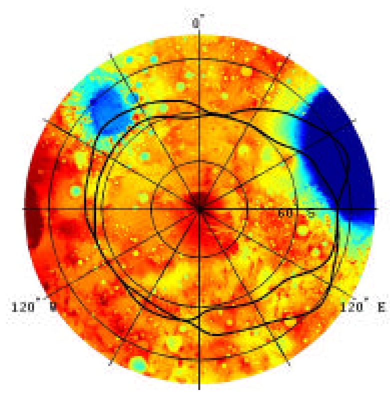


This point is illustrated further in the following two figures. Shown are averages of the NS count data over 30 degree longitude bins. The first is for the segment 120º - 150º E, the second 120º -150º W. The average NS epithermal counts in 19.6s are shown (data points), as are fits to the data (solid curves). The data is fit to the equation A*tanh ((latitude-B)/C) + D, with B a measure of the center of the margin and 2*C the characteristic width of the margin. For the east slice, B = 54ºS and C = 10.31º. For the west B = 59.13ºS and C = 7.0º, supporting the conclusion that the margin for the east slice is extended and the west slice sharp.





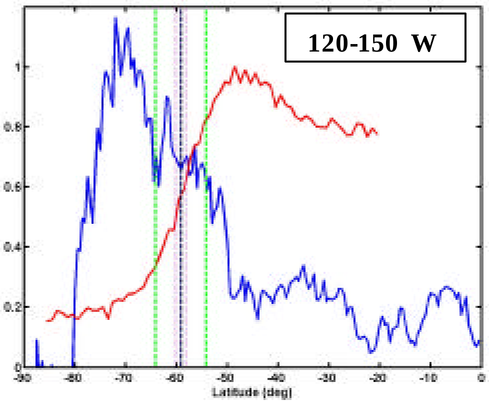
This observation is quantified by simulating the NS data for various models of the margin, using the simulation model described elsewhere [3], [5]. The simplest model assumes that the margin region is a uniform mix of the circumpolar water ice and dry equatorial soil. This yields the results shown in the following figure, where the estimated margin position is overlaid on MOLA topography. We perform this analysis at all longitudes, neglecting corrections to the NS counting data due to topography within the basins. The ice/dry margin region is between the black curves, and at latitudes where the curves coincide the NS data is consistent with a step discontinuity from water ice to dry soil. Due to the extent of the detector footprint (~10 deg FWHM) about the Odyssey nadir, the simulation model suggests that the detector can not distinguish between margins < ~7º in latitude. Note in this figure that the conclusions obtained from the gradient in NS counts and the fits to the counts with latitude are substantiated, namely that the margin is extended over the 120º-150º E slice and sharp over the 120º-150º W slice.

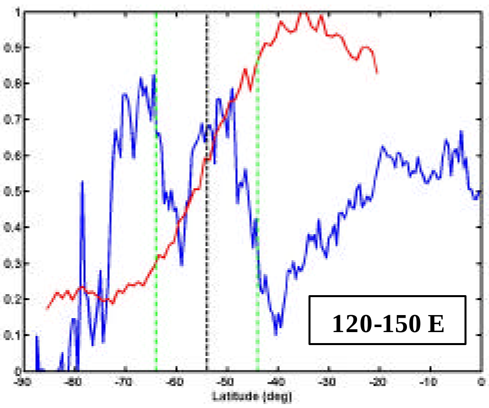


A more accurate model for the water ice margin than the 50/50 mixture of water ice and dry soil is one where the depth of the water ice below the surface decreases within the margin with decreasing distance from the pole. This is motivated by simulations yielding the depth to ice stability, e.g. [6]. We have performed a series of NS system simulations for margins with variable width in latitude; the source model in the simulation has three surface components, the water ice rich circumpolar mantle under a thin layer of dry dust, the margin with linearly varying ice depth that decreases in the poleward direction, and the dry soil equatorial region. The simulation results for the NS counting rate variation with latitude are fit to tanh functions, as above.

The following two figures illustrate the comparison of the NS data, the MOLA 0.6 km baseline curvature data, and the NS simulation results for both the 120º - 150º W (top) and E (bottom) slices. The red curve is the normalized NS epithermal neutron counting rate and the blue curve is the bin-averaged and normalized MOLA 0.6 km curvature. The vertical dashed lines are results of the simulations, with the black dashed line the center of the margin ("B") and the green dashed lines at B ± C degrees.

First note that, especially in the case of the sharp 120º-150º W slice at the top, the MOLA-derived curvature data shows the transition to the concave mantled topography almost exactly where the NS epithermal counts begin a sharp decrease. Although the details will be strengthened by further study for all longitudes and for the northern hemisphere margin, it appears that the MOLA curvature shows the concave ice mantle signature well into the NS sensed margin. Note that the margin center from the NS data is at ~59º S for the west slice and further that the uncertainty in this location is at most 1 or 2 degrees. Note that in the case of the west slice the NS can not distinguish between a step discontinuity and the extended margin between the green dashed lines. In the case of the east slice, again the NS counts begin to decrease almost exactly where the concave topography becomes more prevalent. However, the situation is more complicated both within and equatorward of the margin. Inspection of the margin suggests that the signature of concave/convex curvature may be quantitatively related to the mixture of ice and dry soil regions within the NS footprint. However, both the mantling process and the underlying geology influence the curvature.





References:

[1] Kreslavsky,M.H. and J.W.Head (2002)*GRL,29*, 10.1029/2002GL015392. [2] Mustard J.F. et al. (2001) *Nature, 412*,411-414. [3] Tokar R.L. et al. (2002)*GRL,29*, 10.1029/2002GL015691. [4] Feldman, W.C. et al., 2003, this meeting. [5] Tokar R.L. et al., GRL, submitted March,2003. [6] Mellon,M.T.and B.M.Jakosky, (1993) *JGR, 98*, 3345-3364.