Layering Structure of Water Ice Martian Permafrost: the Evidence from HEND/Odyssey and MOLA/MGS Data. I.G.Mitrofanov[1], W.V.Boynton[2], N.E.Demidov[3], D.A.Gilichinsky[3], M.L.Litvak[1], A.S.Kozyrev[1], A.B.Sanin[1], R.S.Saunders[4], D.E.Smith[5], V.I.Tretykov[1] and M.T.Zuber[6], [1] Institute for Space Research, Moscow 117997, Russia, *imitrofa@space.ru*, [2] University of Arizona, Tucson, USA, [3] Institute of Physical-Chemical and Biological Problems of Soil Science, Puschino, Russia, [4] NASA Headquarters, Washington D.C., USA, [5] NASA Goddard Space Flight Center, Greenbelt, USA, [6] Department of Earth, Atmospheric and Planetary Science, Massachusetts Institute of Technology, Cambridge, USA

Introduction. Neutron emission from the surface of Mars is known to be produced by bombardment by galactic cosmic rays. Efficiency of neutron moderation increases with increasing fraction of H in the bulk composition of the soil. The main substance on Mars with hydrogen is water: it could be either water ice, physically bound water on the surface of regolith grains, or chemically bound water in hydrated minerals. Measurements of neutrons and gamma-rays by instruments of Gamma Ray Spectrometer suite on Mars Odyssey provide an estimate of the content of water in the shallow subsurface of Mars (1-3). Two huge provinces of permafrost were discovered above 55°N and 55°S with the content of water ice in the soil up to 50-70 weight %, which means that water ice is the dominant soil material of the shallow subsurface.

There was indication in the HEND neutron data that southern permafrost has a two-layer structure with dry skin layer of about 10-20 cm on top of water-rich bottom layer, while for the northern permafrost the dry skin layer has not been resolved (4, 5). One needs to study additional data together with neutron data to resolve the vertical structure of water ice deposits in the provinces of permafrost on Mars .

Condensation and sublimation of subsurface water molecules to/from ice depend on temperature of the soil. Therefore, the depth of shield with stable water ice should depend on solar irradiation, on surface visual albedo and on thermal properties of the soil. The Martian surface albedo data for sunlight should be appropriate for joint analysis with neutron data, because visual albedo should determine the heating/cooling flux to/from the surface, and therefore could determine the thickness of dry skin layer above the shield of stable water ice.

Data Analysis. Joint analysis is performed on data for Martian neutron emission from the neutron spectrometer HEND on Mars Odyssey (2,4-6) and for Martian surface radiometry at 1064 nm from the laser altimeter MOLA on Mars Global Surveyor (7). Neutron albedo depends on the content of hydrogen within 1-2 meters of subsurface, and surface radiometry determines the flux of absorbed sunlight by the surface. The presence of cross-correlation was tested (8) between the two data sets, which were sampled individually along different latitude bands of Mars for excluding the difference of solar illumination at different latitudes.

Significant effect of strong negative correlation has been found (8) for pixels along 5° latitude bands between flux of neutrons and MOLA radiometry data at 1064 nm within two broad latitude belts at north (40°N – 80°N) and at south (40°S - 60°S).

Results. We use the two-layer model of subsurface soil (2,4,5) for interpretation of the observed correlation. Negative correlation between neutron emission f_n and surface radiometry A_{1064} for latitude belts (40°N–80°N) and (40°S-60°S) is thought to indicate that the thickness of a dry skin layer at these regions is determined by heating from absorbed sunlight. We have found out that content of water ice should remain practically constant along an individual latitude band at these belts, while variations of neutron flux result from the variable thickness of the dry thermal skin layer.

Simple empirical relation has been deduced from the observed cross-correlation, which relates the thickness of dry thermal skin layer h above the shield with stable water ice and the surface near-IR albedo A_{1064} for sunlight. For any spot within the belts (40°N–80°N) and (40°S-60°S), this relation allows us to predict the depth of stable water ice with sub-kilometer horizontal resolution, which is based on the accuracy of MOLA radiometry data (7). In particular, this relation is used to discuss the depth of water ice at potential landing sites of *Phoenix* and *MSL*.

The neutron data, as taken alone, points out that equatorward boundary of permafrost provinces is positioned at ~55° latitude both at north and at south. Significant correlation between neutron albedo and near-IR albedo at moderate latitude belts (40°-55°) at both hemispheres points out that stable water ice actually exists there, but its estimated content is smaller than that in the poleward parts of permafrost provinces >55°.

On the other hand, no significant correlation between the neutron flux and surface albedo is observed at southern latitude bands poleward from 60°S (see 8). Therefore, the thickness of skin dry layer at this permafrost region does not depend on the heating by absorbed sunlight. It could be formed by dust deposits from strong dust storms in the southern hemisphere. One may conclude that the water ice shield of permafrost at high southern latitudes >60°S should be thermally isolated from the surface and could remain stable, as it has been formed at some previous epoch of Mars with different climate conditions.

Refrences: [1] W.Feldman et al., *Science*, **297**, 75, 2002; [2] I.Mitrofanov et al., *Science*, **297**, 78, 2002; [3] W.Boynton et al., *Science*, **297**, 81, 2002; [4] I.Mitrofanov et al., *Solar Syst. Res.*, **38** (4), 253, 2004; [5] M.Litvak et al., *Icarus*, [6] W.Boynton et al., *Space Sci. Rev*. **110**, issue 1, 37, 2004; [7] Xiaoli Sun, G.A.Neumann, J.B.Abshire and M.T.Zuber, *Applied Optics*, vol. **45**, No.17, 2006; [8] N.Demidov et al., this issue.