MARS: DETACHING OF THE FREE WATER SIGNATURE (FWS) PRESENCE REGIONS ON THE BASE OF HEND/ODYSSEY DATA AND THEIR CORRELATION WITH SOME PERMAFROST FEATURES FROM MOC DATA.

R.O.Kuzmin[1], I.G. Mitrofanov[2], M.L. Litvak[2], W. V. Boynton[3], R. S. Saunders[4]. ***1 - Vernadsky Institute of Geochemistry and Analytical Chemistry, RAS, Moscow, 119991, Russia rok@geokhi.ru ; 2 - Institute for Space Research, RAS, Moscow, 117997, Russia; 3 - University of Arizona, Tucson, AZ 85721, USA; 4 – NASA HQ, Washington, USA..***

Introduction. The first results from global mapping of the neutron albedo from Mars by HEND instrument [1-3] have shown the noticeable deficit of both the epithermal (EN) and the fast (FN) neutrons counts rate in the high latitudes regions of both hemispheres of the planet. The deficit is indicative for high enriching of the surface regolith by hydrogen [2, 4], which may correspond to amount of any water's phases and forms. The objects of our study are the spatial and temporal variations of the free water (ice) signature in the Martian surface layer on the base of HEND/ODYSSEY data and their correlation with spatial spreading of some permafrost features, mapped on the base of MOC images. For the study we used the results of the global mapping (pixel 5°x5°) of EN and FN albedo, realized by HEND/ODYSSEY [2,4] in period from 17 February ($L_s \sim 329°$) to 10 December 2002 year ($L_s \sim 125°$).

Background. As it well known [5-8], at the modern climate of Mars a subsurface ground ice may to be stable thermodynamically only on the latitudes > 40°, while in the latitude belt ±40° (due to sublimation processes) the ice may to be stable only on some depth: about several meters on the latitude 40° and 100-300 m in the equatorial regions. It was shown before [8] that the relative ice content within the surface permafrost layer on the latitudes >40° (up to 200 m depth) is growing with the latitude and depth increasing, being at all notably higher in northern hemisphere than in southern. It is possibly that similar tendency of the ice content distribution could be preserved also within the superficial layer, which is equal to the layer of EN neutrons emission (1-2 m). In such context, the HEND data represents unique information about properties of the Martian ice-reached superficial layer in the high latitudes regions and hopefully with time will let to receive quantitative estimations of seasonal variations of water amounts within the surface material. The hydrogen enriching of the Martian regolith in the subpolar regions, discovered on the base of both the neutrons flux [1,2] and H-gamma ray flux [3] behavior, represents the first directly observing confirmation of the preceding theoretical predictions and qualitative model results, which have indicated on possible existing of the ice-reaching regolith in the regions.

Free water signature (FWS) detaching on the base of the HEND data analysis. Because the ground ice in the regolith on the middle and low latitudes regions may to exist only on a large depth [7, 8], the hydrogen signature mapped by HEND instrument may to associate mainly with bound water forms amount, while in the high latitudes regions it is associated rather with majority of the free water (ice) at minority of the bound water forms amounts [9]. Our analyses of the temporal dynamics of the neutrons flux versus the latitude for different mapping periods by HEND (N-winter, N-spring/summer transit and beginning of N-summer) show that their average counts rate values of EN and FN on the latitudes > 60° (in both hemispheres) are constantly lower than in other parts of the planets, except the winter time, when seasonal CO_2 –ice cover isolate the ice-reaching surface material (fig.1.). At that, the lower counts rates of EN (<0.12) has dominantly higher frequency distribution to pole ward from latitude 60°N and 60°S, while the higher counts values (> 0.14) dominate in area of the middle and low latitudes. Such distribution we consider as natural division of the neutron flux values on two populations: one representing rather the free water signature (values <0.12) and other - the signature of the bound water forms (values >0.14). The intermediate values (0.12-0.14) apparently may to represent the cases of the neutron signatures combination of both water types, whose relative portion may to be variable from place to place. Along with seasonal retrieving of the CO_2 –ice cover (during the spring-summer time) the minimum values of counts rate for EN and FN are consistently shifting to higher latitudes. Monotonous decreasing of the of the neutron flux on the latitudes > 45°, seen after complete disappearance of CO_2 –ice cover in summer time (see fig.1), apparently display the natural picture of the ice content increasing within exposed permafrost surface layer as function of the latitudes. In the period the average values of the neutrons flux on the latitudes > 60° are becoming < 0.10 and < 0.12 counts/s for EN and FN respectively. Statistical analyses of the neutrons flux behavior mapped by the HEND in the different periods (the winter/spring transit, end of spring and summer in the northern hemisphere) let us to separate the joint populations the neutrons counts values peculiar to the regions to pole ward from 60°N, 60°S and to the belt ±60°. As well seen from scatter plots on fig.2, the EN and FN counts values are grouping in distinct separate clusters, representing the counts populations for each of the studied regions. It is notably, that in summer time both subpolar regions characterized by similar average values of EN counts within the clusters (0.062±0.22 and 0.061±0.021 respectively), while the average value for FN counts is lower in northern (0.089±0.018) than in the southern (0.109±0.016) regions. Last is indicative to existing of relatively drier surface layer (to depth 20-30 cm) in southern subpolar area. During the northern winter/spring time the range of the counts values within the subpolar clusters is shifted in area of higher values due to influence of the CO_2-ice cover, existing in the time. During the northern spring/summer transit, when the seasonal CO_2-ice cover area in both regions is minimal, both subpolar clusters looks very similar and EN counts values are mostly < 0.12 counts/s. Similarity of EN counts range, seen within summer-time clusters for both subpolar regions, we consider as reliable indicator of similar ground ice content in the surface materials of the regions.

Correlation of FWS map with the permafrost features distribution. For comparison of the FWS presence area with spatial distribution of such permafrost features as the polygonal terrains (see fig.3) we attracted the data of polygonal terrains global mapping on the base of MOC images analyses [10]. In the permafrost zones on the Earth the polygonal terrains are most widespread features, which serve as the basic morphological indicator of ice-reaching deposits

presence [11]. Comparative analyses of the Martian polygonal terrain morphology, conducted recently on the base of high resolution MOC images analyses [12-14], have demonstrated their very close morphological and morphometrical similarity with the terrestrial polygonal ice-wedge structures, which are widespread in the permafrost areas. This let us to consider the Martian polygonal terrains as morphological indicator of ice-reaching material exposition on Mars surface. As seen from fig.4, between detached from HEND data the FWS presence area, and distribution areas of the polygonal terrains is existed sufficiently distinct correlation. From of 392 mapped locations with the polygonal terrains, their dominate part (90%) is directly matched with areas of the free water signature spreading, located in the both hemispheres. Only 10% of the polygonal terrains cases are located a little out side from the edge of the FWS presence area that may to be explained by location of ice-reaching materials here on a depth below of the surface layer (1-2 m) associated with the emission of EN.

Discussion. Following to the results of conducted statistical analyses of the temporal and spatial variations of the neutron albedo of Mars, the neutron signature of the free water (in ice form) may to be enough well detached against of the bound water forms signature when the counts rate values of EN are less or equal to 0.12 counts/s. The fact the areas of polygonal terrains distribution are very well matched with the areas of the FWS presence convince us in rightfulness of selected counts values range. The question about the water content and its phase and forms within the superficial layer (with thickness up to 30 cm) in the subpolar regions is very intrigued. Existing estimations of the water content in the layer on the base of GSM/ODYSSEY data [3] gave the value about 3-5%. However, if to accept that a salts content in the Martian regolith may to be equal to 8-25% [15] and the highly hydrated sulfates and chlorides of Mg and Ca (for example, MgSO4-7H2O and CaCl2-6H2O), as a rule, may to be stable on the latitudes >45° [16], the estimations seems fairly reduced. Following to suggestion that such hydrated minerals may to exist in the Martian soil on high latitudes, we estimated that the potential amount of the bound water within surface layer may to be variable from 4% to 12%. Future more detailed calculation of expected neutron signal strength for variety of layered regolith models let us to define the counts values for free water signature more precisely.

REFERENCES: [1] Feldman W. C. et al., *Science* 297, 2002, 75-78;[2] Mitrofanov I.G. et al., ibid, 78-81;[3] Boynton et al., ibid, 81-85; [4] Mitrofanov I. G. et al., *this Conference*;[5] Farmer C.B. & P. F. Doms, *JGR*, 84, 1079, 2881-2888; [6] Fanale F.P., *Icarus*, 28, 1976, 179-202; [7] Mellon, M.T. & B.M.Jakosky, *JGR*, 100, 1995, 11781-11800;[8] Kuzmin R.O. et al., *Solar System Res*., 22, 1988, 195-212;[9] Kuzmin R.O., *Workshop HEND, 2002 May 20-22* (www.iki.rssi.ru/eng/hendws.htm); [10] Kuzmin R.O. et al., *Proc.8th Intern Conf. on Permafrost,2003(in press)* ; [11] Romanovskiy N.N., Formation of ice-wedge structures,1977, *Novosibirsk, Nauka Press*; [12] Yoshikawa K., *Second Mars Polar Sci. Conf., 2000*, #4045;[13] Kuzmin R. O. et al, *LPlSC. XXXIII, 2002*, #2030;[14] Seibert N. M. and J. S. Kargel, *Geoph. Res Letters*, 28, 2001, 899-902; [15] Clark B.C. and van Hart D. C., *Icarus*, 1981, 45, 370-378; [16] Zolotov M .Y. et al, *LPSC. XXVIII*, 1997, 1633-1634.

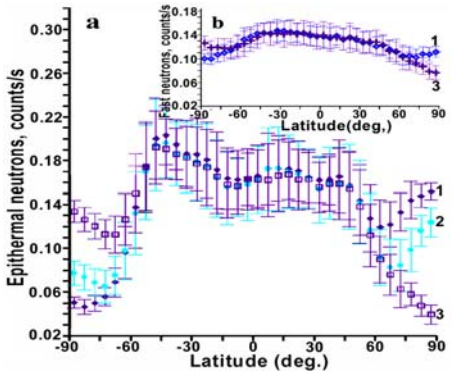

Fig.1. *Average counts rates of EN (a) and FN (b) vs. latitude for N-winter (1), N-spring/summer (2) and beginning of N-summer (3). The data are averaged over all longitudes.*

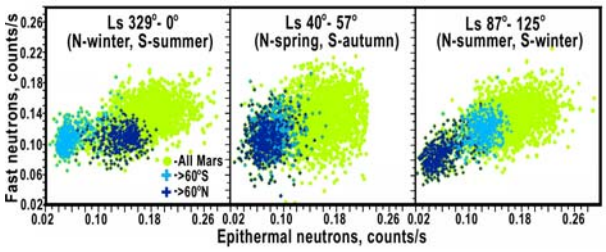

Fig.2. *Scatter plots of EN and FN counts rates for different periods of Mars mapping by HEND (for equal-area pixel 5°x5°).*

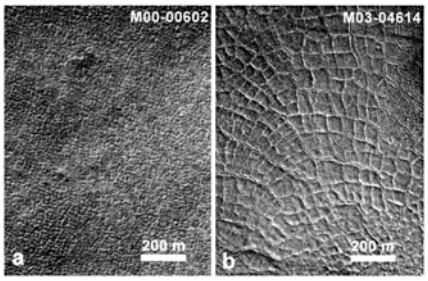

Fig.3*. Examples of the Martian small-(a) and large- scale (b) polygonal terrains seen on the high resolution MOC images M00-00602 and M03-04614.*

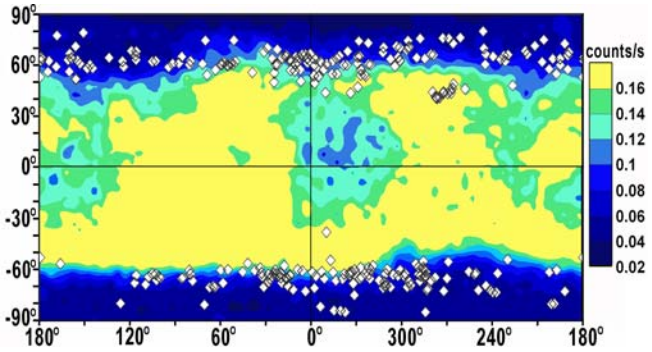

Fig.4. *Global map, showing spatial distribution of both the HEND free water signature in the summer period (counts <0.12) and the polygonal terrains (rhombus), mapped from high-resolution MOC images (NASA/JPL/Malin Space Science System).*