MAPPING OF THE WATER ICE AMOUNT IN THE MARTIAN SURFACE SOIL ON THE PERIPHERY OF THE RETRIATING SEASONAL NORTHERN POLAR CAP BASED ON THE TES DATA.

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Introduction: Knowledge of the water's role in the condensation and sublimation processes associated with evolution of the seasonal polar caps (as well as with the seasonal permafrost) on Mars represents one of the key aspects for understanding of the modern water cycle on the planet. The phenomenon of the water ice annulus formation on the periphery of the retreating seasonal polar caps has been suggested earlier based on the results of the Mars seasonal water cycle modeling [1]. Later this phenomenon has been discovered based on the TES and THEMIS observations [2, 3, 4], essentially by monitoring of the albedo and temperature seasonal changes within seasonal polar caps during recession period. It was found that the extent of a visible seasonal cap is always larger than one of a thermal infrared cap [2, 3]. Such difference was explained by the presence of the warmer and brighter annulus in the periphery of the retreating CO_2 ice cap and the water ice has been suggested as the primary constituent of the annulus [2, 3]. Recently, the appearance of the water ice annulus on the edge of the retreating seasonal polar caps was confirmed based on the near infrared spectral observations by OMEGA imaging spectrometer aboard Mars Express [5, 6, 7, 8, 9]. In accordance with OMEGA observations, the water ice annulus may represent the veneer of the water condensate on the periphery of the seasonal Northern polar cap with the thickness enough optically thick to mask the spectral signature of the CO_2 ice [7, 8].

In the work we present the results of both an analysis of the TES thermal inertia changes in the area adjoining to the edge of the seasonal Northern polar cap and estimation and mapping of the water ice amount in the surficial soil layer within the area at different stages of the cap's recession.

TES observations: To understand how the TES thermal inertia is sensitive to the water condensation and sublimation processes around the edge of the retreating Northern seasonal polar cap, we analyzed temporal and spatial changes of the parameter during the period from Ls=340° to Ls=70°. For this we used the database of the TES observations, accumulated during of the three Martian years. The thermal inertia mapping has been conducted within the latitude belt (15°-20° in the width) affiliated to the cap's edge through the time interval in the 20°Ls. The mapped thermal inertia values have been compared with their summer-time values. We found that very distinct annulus (5°-7° in the width) with sharply increased values of the thermal inertia arises around the cap's edge at each stage of the seasonal cap recession. The example of the high thermal inertia (HTI) annulus during recession stage Ls=0°-40° is shown on the Fig.1 in comparison with the summer-time thermal inertia map.

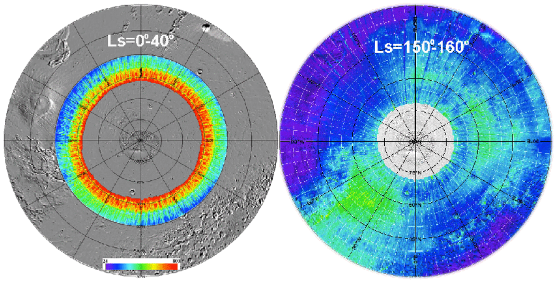

Figure 1: The HTI annulus around the Northern seasonal polar cap (left), forming in the spring-time, in comparison with the summer-time thermal inertia map (right).

Our mapping results show that during the recession period the HTI annulus follows the retreating seasonal polar cap and moves towards higher latitude as sublimation of the CO_2 ice cap progresses, becoming lesser in the diameter and tighter in the width (Fig.2).

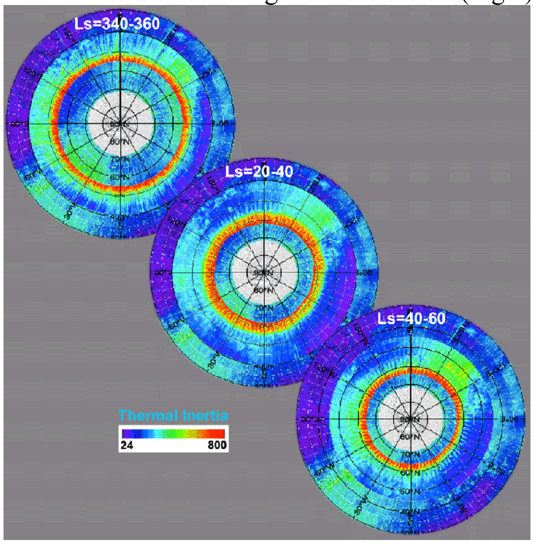

***Figure2:** The maps of the HTI annulus around of the Northern seasonal polar cap on the different stages of its recession. Background represents the summer-time thermal inertia map*

At that, the HTI annulus moves in the northern direction on the ~4°-6° in the Ls range ~20°. With each next stage of the seasonal polar cap recession the area of the previous HTI annulus completely disappears during indicated Ls range and the values of the thermal inertia within the area are decreased subsequently, approaching to the summer-time values. The general trend of the temporal evolution and spatial extent of both the HTI annulus and the water ice annulus (derived from the OMEGA [7, 9] and TES [2, 3] observations) is very similar. However, one distinction consists in their location difference with regard to the edge of the seasonal CO_2 ice cap. The water ice annulus is located much closer to the edge of the seasonal cap [6, 8], while the HTI annulus is usually shifted relatively of the water ice annulus edge on several degrees of latitude to south. In the Ls range from 30° to 70° the distance between the both type of annulus increase gradually, following to the similar trend as the spatial difference between the southern limit of the CO_2 ice cap and the external edge of the water annulus (see Fig.3).

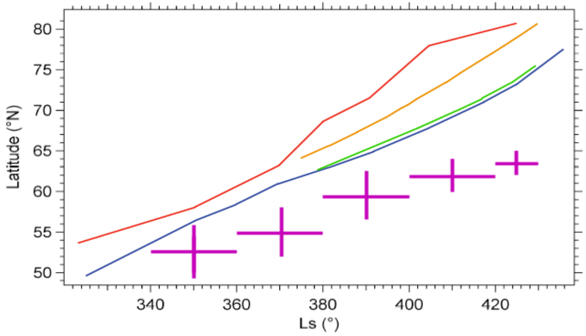

Figure 3: The seasonal dynamics of the CO_2 ice cap limit (red) and the water ice annulus limit (green) as seen by the TES ([3]) and the OMEGA (blue [7, 8]) and the HTI annulus (pink), derived from TES thermal inertia data. The plot is from [8] with modification.

As was shown recently [9, 10], the strong increase of the thermal inertia values observing during the winter in the area adjoining to the edge of the seasonal polar caps is indicative on the increase of the water ice amount in the surface layer (equal to daily thermal skin depth in 2-10 cm) due to formation of the seasonal permafrost layer. We suppose that the mapped HTI annulus represent the remnant of the sublimating seasonal permafrost layer, which follows behind the recessing CO_2 ice cap.

Mapping of the water ice amount around retreating seasonal cap: To estimate and map the water ice amount in the surface soil layer within the HTI annulus we used the method from [9, 10] recently developed for the mapping of the winter-time increase of water ice in the surface soil layer outside of the seasonal CO_2 ice caps. The water ice amount in the soil within the HTI annulus was estimated for all coincided summer- and spring-time TES TI surface footprints by solving of the quadratic equation, received at inclusion of the thermal parameters for two-component mixture (soil+ice) into the formula of thermal inertia [10]. In accordance with conducted estimations and mapping results (Fig.4), the average water ice amount in the surface soil layer (in 2-10 cm thickness) within the 5°-width HTI annulus varies from 5 to 7 vol. %. The higher mean value of the ice amount (7.2 vol. %) is observed during recession stage Ls=20°-40° and lesser (4.9 vol. %) at the Ls= 40°-60°.

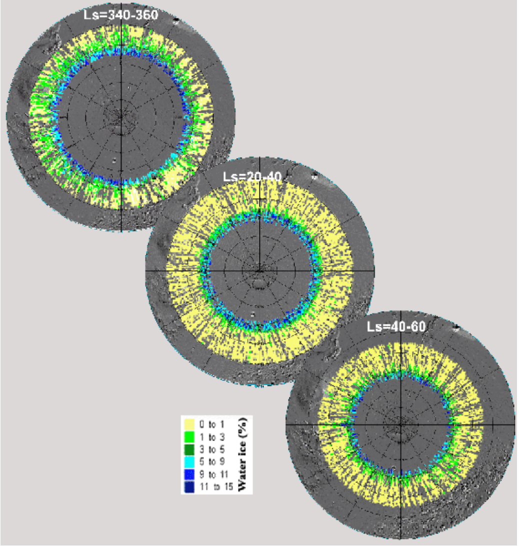

Figure 4: The water ice amount (vol. %) in the surface soil within the HTI annulus around the Northern seasonal polar cap estimated based on the TES TI data.

Summary: Observing character of the temporal and spatial relationship between the water ice annulus and the HTI annulus let to suggest very close interdependence between the natures of the annulus types. We suppose that during the seasonal polar cap recession period the sublimation of the water ice from the HTI annulus area serves as source of the water supply for formation of the water condensate veneer (the water ice annulus) on the edge of the retreating CO_2 ice cap. Apparently the sublimation of the water ice from seasonal permafrost layer is occurred some slower than from the seasonal polar cap that resulted to the gradual increase of the space between both types of the annulus in the recession period after Ls=40°.

References: [1] Houben et al., (1997), *JGR*, *102*, 9069–9083;[2] Kieffer, H.H., Titus, T.N., (2001), *Icarus 154*, 162–180;[3] Titus, T.N. et al., (2003), *Science* 299, 1048–1051; [4] Wagstaff, K.L. et al., (2008), *Planetary and Space Science, 56*, 256-265; [5] Bibring, J.-P. et al., (2005), *Science,*307, 1576–1581; [6] Schmitt B. et al.,(2005), *LPS* XXXVI Abstract,#2326; [7] Schmitt B. et al., (2008), *MWCW*, Abstract #S06_1245; [8] Appere T. et al., (2008), *MAMO*, Abstract # 9008; [9] Kuzmin R. O. et al., (2008), *LPS* XXXIX 39th *LPSC,* #1565;[10] Kuzmin R.O. et al, (2009), *JGR* (in press).