Constraints on the Structure and Composition of Sand Dunes within Olympia Undae using Mars Odyssey Neutron Spectrometer Data W.C. Feldman[1], M.C. Bourke[1], R.C. Elphic[2], S. Maurice[3], T. H. Prettyman[2], D. J. Lawrence[2], J.J. Hagerty[2], [1]Planetary Science Institute, Tucson, AZ USA (Feldman@psi.edu), [2]Los Alamos National Laboratory, Los Alamos NM USA, [3]Centre d'Etude Spatiale des Rayonnements, Toulouse, Fr

Introduction: The most extensive sand dune deposits on Mars completely encircle the residual water ice deposit. It has its largest contiguous areal extent between 155° and 230°E and 78° and 83°N. Although the dunes have been studied extensively using visible and infrared imaging data of the Viking orbiters, many fundamental issues regarding their origin, evolution, and internal structure sand sea remain unknown [1-3]. For example, its apparent thermal inertia is modest to low [4] indicating that the dunes are made up of irregularly-shaped cemented dust and sand fragments [5] or mixtures of ice and silicate dust [6,7] that are not cemented in bulk to form a cohesive mass. Alternatively, the erg is thought to be predominantly composed of sand sized andesite fragments [8-10]. In addition, the east end of Olympia Undae has a strong gypsum signature in OMEGA data [11]. Although sourced outside the dune field, this signature extends across the dunes and may indicate the surface deposition of gypsum dust or a separate sediment source region for those dunes. Newly acquired visible images from MOC and HIRISE indicate that some dunes are indurated and it has been suggested that they may contain niveo-aeolian deposits [12]. These deposits may be emplaced by diffusion or by precipitation of volatiles. See figure 1 in [13]. This induration may be partially responsible for the lack of movement observed in many of the larger dunes on Mars [14].

In order to help resolve some of these issues, we report here the results of a preliminary study of the water content of the north-polar sand dunes within Olympia Undae using the Mars Odyssey Neutron Spectrometer (MONS) epithermal neutron data. These data yield an estimate of the water-equivalent hydrogen (WEH) in near surface material and can provide limits on the degree of ice cementation of dune sand particulates given an assumption of the open pore volume within this formation.

The Olympia Undae Formation is relatively small (~200 x 800 km) and therefore cannot be well characterized by the MONS, which has an intrinsic spatial resolution of about 600 km. However, a spatially deconvolved version of the MONS data may attain a resolution of 250 km. We present here our preliminary deconvolved map of the water content of Olympia Undae for this purpose.

Deconvolution Technique: The deconvolution technique used here is very similar to the Jannson's method [15, 16], $I_{k+1} = I_k + r(O - p \otimes I_k)$, where I_{k+1} is the current estimate of the restored image, I_k is the previous estimate, r is a relaxation function, O is the original smoothed image, p is the total effective point spread function (equivalent to the Gaussian smoothed MONS response function) and $\otimes$ denotes a convolution operation. The iteration procedure was terminated just before the water content of the residual polar cap exceeded 100%.

Results: MONS epithermal neutron counts measured between Feb. 2002 and Dec. 2006 during CO_2 frost-free conditions were first summed into a 2 x 2 degree cylindrical grid to provide an overview of conditions within Olympia Undae. A meridional cut through the formation at longitudes between -155° and -150° E is shown in the top left panel of Fig. 1. This cut shows a clear relative maximum of counts at +80°N, which indicates a relative minimum in water content of near surface soils, as shown in the upper right hand panel. The counts were converted to water content (WEH) assuming a single semi-infinite deposit of water containing regolith having elemental abundances as measured using the Pathfinder Lander [17]. The minimum WEH mass fraction at 80°N is 0.25. This mass fraction corresponds to the complete filling of a pore volume between sand grains of 50% if the density of grain material is assumed to be 2.65 g/cm^3. Maps of deconvolved counting rates (lower left) and resultant WEH content (lower right) show that the minimum WEH mass fraction of the formation may be as low as 0.19 in a region between 180 and 240°E and centered on 80°N. Use of the same assumed density yields an open pore volume of 40%.

If the sand grains are composed of sediments containing hydratable minerals, then our estimated open pore volume will be lower. Specifically, if the sand-composition model of mixtures of ice and silicate dust [6, 7] is adopted, and an open pore volume of sand before ice cementation is chosen to be 50%, then our estimated WEH content of a single semi-infinite sand deposit could fit the current paradigm of these sand dunes. For example, our results are consistent with a fully ice-filled pore volume at depth covered over by a relatively desiccated, loose sand cover. Such a structure would then have a relatively low thermal inertia, as determined using Viking Orbiter data [4], yet be relatively immobile because it would be fully cemented at depth. This suggests that frozen water (ice or snow) is present in the polar sand dunes on Mars and supports the assertion that the dunes in the north-polar region are composed of niveo-aeolian deposits [12, 13]. The emplacement mechanism is still under discussion but may be diffusion, precipitation or a combination of both.

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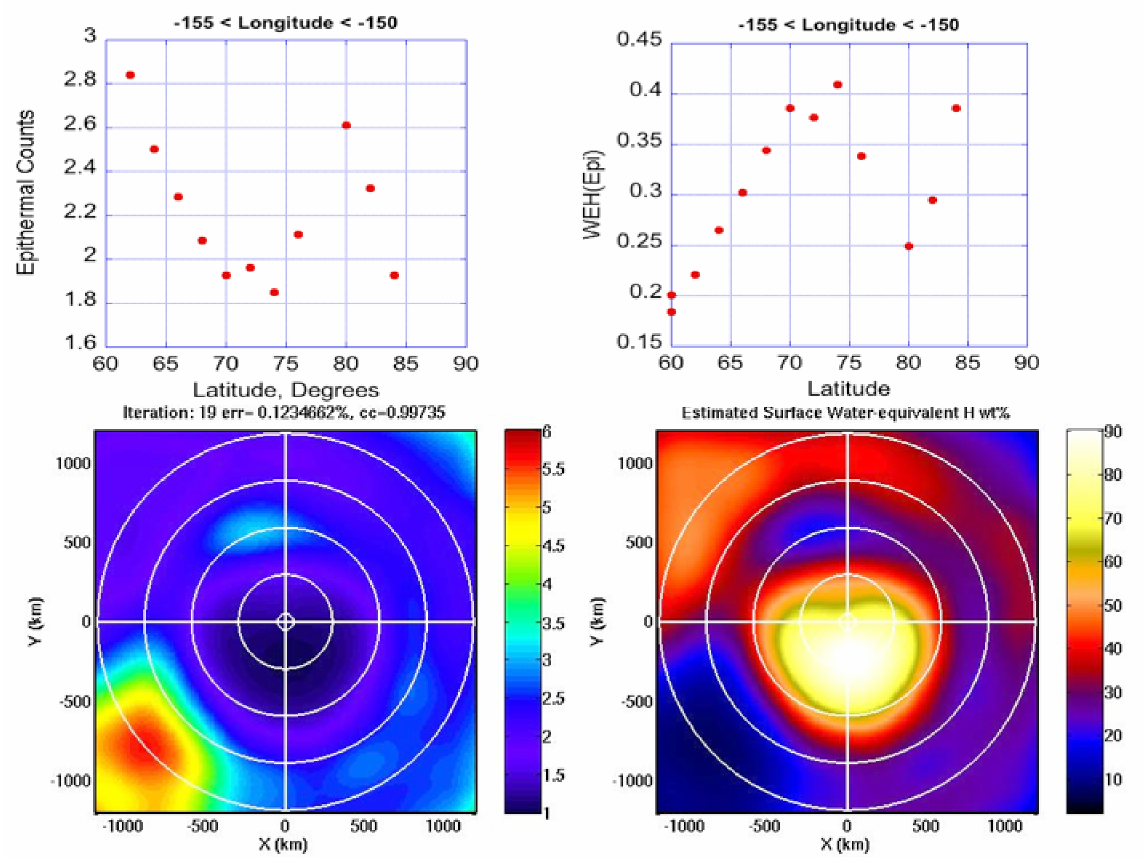

Figure 1 Meridional cuts through epithermal counts and derived WEH content at longitudes between -155 and -150 E within Olympia Undae are shown at the top left and right, respectively. Maps of the deconvolved counts and WEH content are shown at the bottom left and right, respectively