MARS ODYSSEY NEUTRON SPECTROMETER WATER-EQUIVALENT HYDROGEN: COMPARISON WITH GLACIAL LANDFORMS ON THARSIS. R. C. Elphic[1], W. C. Feldman[1], T. H. Prettyman[1], R. L. Tokar[1], D. J. Lawrence[1], J. W. Head, III[2], S. Maurice[3], [1]Space Science and Applications, Los Alamos National Laboratory, Los Alamos, NM 87545 (relphic@lanl.gov), [2] Department of Geological Sciences, Brown University, Providence, RI 02912, [3] Centre d'Etude Spatiale des Rayonnements (CESR), 31400 Toulouse, France.

Introduction: We have previously described an enhancement of water-equivalent hydrogen (WEH) derived from Mars Odyssey neutron spectrometer (NS) observations on the western slopes of Olympus Mons and the principal Tharsis Montes [1]. Recent results from the High Resolution Stereo Camera aboard Mars Express have reinforced the idea that relict water ice may still underlie certain landforms on the western slopes of Olympus Mons [2,3], and possibly the other volcanoes as well. There is abundant evidence of the past possible presence of cold-based mountain glaciers [4,5], resulting from significant snow/ice deposits in these locations during periods of high obliquity [6,7], based on global climate modeling. Here we investigate whether or not the NS data support enhanced WEH associated with previously identified glacial and periglacial landforms.

Neutron Spectrometer Observations: Measurements of the epithermal neutron leakage flux out of the martian surface and atmosphere have been analyzed and a minimum water-equivalent hydrogen (WEH) map (assumed to be homogeneously mixed with dry soil throughout the depth of sensitivity) has been derived [8]. For the Tharsis region, WEH ranges between 2 and 8 wt%. The western slopes of Olympus Mons, and the Tharsis Montes have higher WEH abundance than the eastern slopes. There are also enhanced WEH abundances centered on Noctis Labyrinthus and western Valles Marineris. Even higher WEH abundances are found further to the west, trending into Amazonis Planitia and the Medusae Fossae Formation, also potential sites of volatile-rich deposits on the basis of geological analyses [9,10].

NS Data Deconvolution: The NS footprint has a FWHM of ~600 km, or about 10° of arc on the surface. This response function smears out features that are smaller than the footprint, including possible water-bearing deposits considered here. Instead, we may see a smeared-out regional high.

The NS footprint for epithermal neutrons is large but well characterized, and the statistics of the data are good. So we can attempt to deconvolve the mapped epithermal fluxes in order to improve the spatial resolution of the inferred WEH. We initially sum a full Mars year of NS data in small spatial bins (15 km). These data have been normalized to cosmic ray and seasonal atmospheric variations [11]. We then smooth the raw, summed count rates with a gaussian filter of approximately 220-km FWHM. The final step is to 'sharpen' the smoothed map using an iterative deconvolution technique similar to Jannson's, $I_{k+1} = I_k + r\,(O - p \otimes I_k)$, 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 NS response function), and $\otimes$ denotes a convolution operation. The relaxation function r serves to constrain restored image estimates to physically reasonable values, for example non-negative values.

Geology and Relationship to WEH: The Tharsis Montes edifices consist mainly of lava flows and ash deposits (as well as eolian mantle) [12], but there are distinctive units to the west and northwest of the three major volcanoes that have been interpreted to be of glacial origin in part or in whole [4,12,13,14]. Models of snow and ice accumulation on the Tharsis Montes and resulting glacial transport have also been created [15,16]. The three facies of these Tharsis Montes glacial units relevant to our study are: R, the outer ridged facies, which may be ice-cored drop moraines; K, the knobby facies which may be sublimation till covering ice; S, the smooth facies which may be rock glacier deposits. The smooth facies may be the youngest, with the smallest depths-to-ice. The combined outlines of the three facies for each glacial unit are shown on panel D of Figure 1.

Panel A of Figure 1 shows the original smoothed map of epithermal count rates for most of central Tharsis, centered on 0º latitude and 115º W. Panel C shows the derived WEH map corresponding to panel A. Panel B shows the result of our deconvolution scheme, after 20 iterations, and Panel C is the corresponding WEH map. Note the considerable enhancement in WEH estimates in (D) vs. (C). Areas of comparable or higher WEH are found outside the glacial units. Nevertheless, apparent WEH values in excess of 6 wt% H_2O on the western flanks of the Tharsis Montes are consistent with the epithermal neutron flux data.

Discussion: If a simple stratigraphic model of pure ice overlain by relatively desiccated (2 wt% WEH) sublimation till is applied, the depth to ice consistent with these values is less than 60 cm. We are currently developing a forward model of the MO NS response to shallow buried ice limited to the facies discussed earlier. Clearly this modeling must include the effects of water ice or hydrous minerals in surrounding areas. However, our results suggest that the Neutron Spectrometer is detecting evidence of buried ice in these Late Amazonian aged tropical mountain glaciers. Higher resolution NS data (e.g., an aerial platform) and NS instrumentation on surface rovers provide promising avenues to further investigate these important resources.

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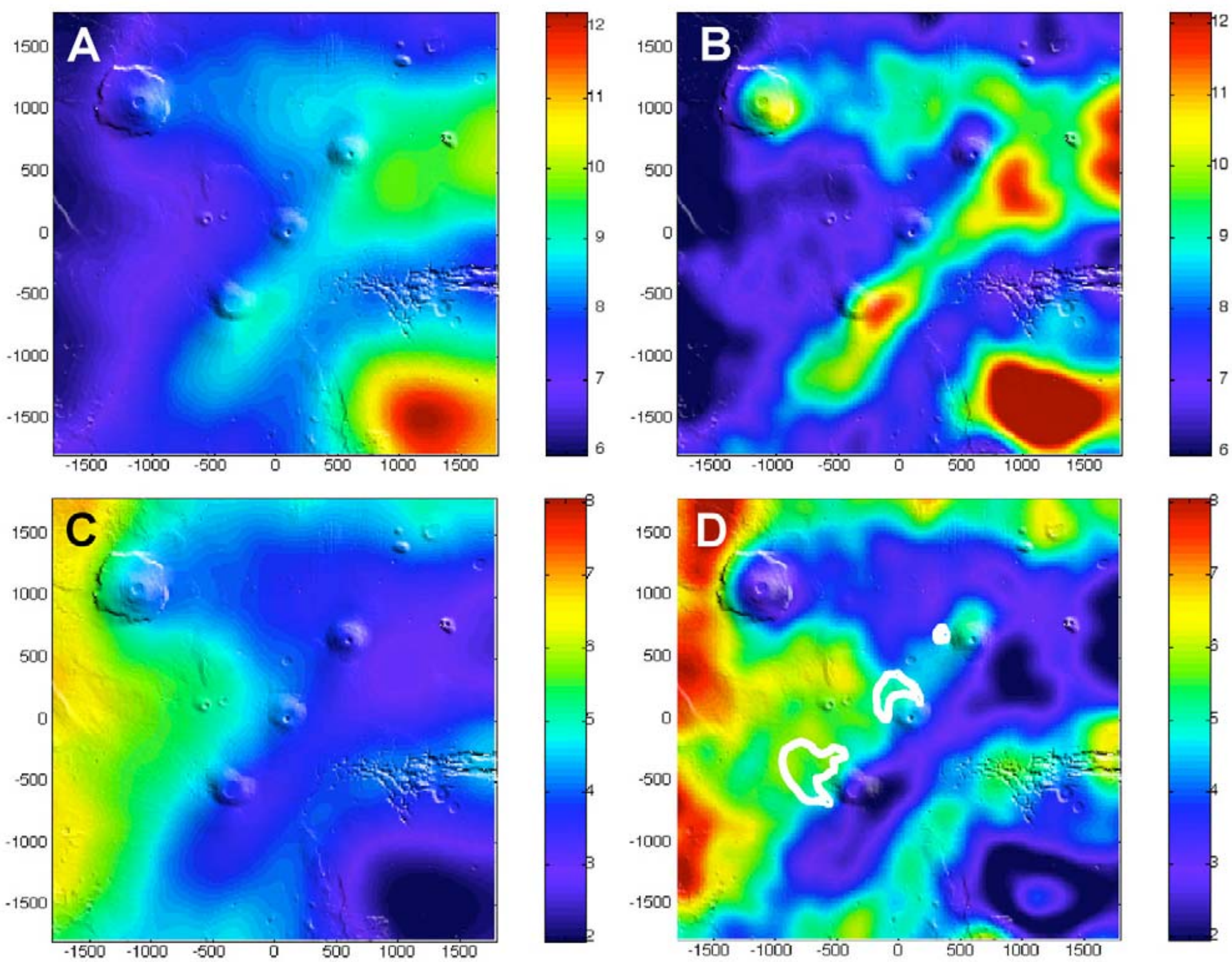

Fig. 1. (A) Original smoothed epithermal neutron count rate map superimposed on MOLA topography, centered on 115 W; (B) Deconvolved epithermal count rate map; (C) Corresponding WEH (wt%) for Panel A; (D) Corresponding WEH for Panel B, with outlines of the combined facies (S, R, K) of the glacial units shown in white.