EQUATORIAL LOCATIONS OF WATER ON MARS: IMPROVED RESOLUTION MAPS BASED ON MARS ODYSSEY NEUTRON SPECTROMETER DATA. J. T. Wilson[1*], V. R. Eke[1], R. J. Massey[1], R. C. Elphic[2], W. C. Feldman[3], S. Maurice[4], L. F. A. Teodoro[2]. [1]Institute for Computational Cosmology, Department of Physics, Durham University, South Road, Durham DH1 3LE, UK (j.t.wilson@durham.ac.uk). [2]Planetary Systems Branch, NASA Ames Research Center, Moffett Field, CA, 94035-1000, USA. [3]Planetary Science Institute, Tucson, AZ 85719, USA. [4]IRAP-OMP, Toulouse, France. [*]Now at The Johns Hopkins Applied Physics Laboratory, Laurel MD 20723, USA

Introduction: The main goal of the Mars Odyssey Neutron Spectrometer (MONS) is to determine the major near-surface reservoirs of hydrogen on Mars [1]. This task is important as it allows inferences about the past and present climate to be drawn, which, in turn, give information about the dynamic history of Mars and the possibility of the past, or present, existence of life. Additionally, understanding the small-scale distribution of water is necessary for landing site selection for missions looking for signs of life or exploring in-situ resource utilisation. MONS data have been used to map the hydrogen content of the Martian near-subsurface on ~ 550 km scales [1,2,3,4] and hydrogen rich deposits, with water equivalent hydrogen (WEH) content > 25 wt. %, were found poleward of ±60◦, which were interpreted as water-ice buried under a layer of desiccated soil [2]. Additional low-latitude hydrogen deposits were observed at Arabia Terra and Elysium Planitia [2] with 9.5±1.5 wt. % WEH [1]. Water ice should not be stable equatorward of ±30° [5], which has led to the suggestion that these equatorial hydrogen deposits are in the form of hydrated minerals [2].

The 550 km spatial resolution of the MONS instrument suppresses smaller-scale features in the MONS data, and the inferred hydrogen distribution. It also results in a reduction in the dynamic range of the data, leading to an underestimate in the wt. % WEH content of small hydrogen-rich areas. The previously inferred WEH abundances for equatorial features will have been underestimated because of this effect. We will develop and apply an image reconstruction technique based on the pixon method, which has been used to successfully reconstruct planetary data [6,7,8], to improve the resolution of the global MONS data set in a way that is robust to noise.

We will use these reconstructions to examine a few locations that have been proposed to contain water in the equatorial regions of Mars deposited in the geologically recent past.

Pixon Reconstruction: The pixon method is a spatially-adaptive image reconstruction process that aims

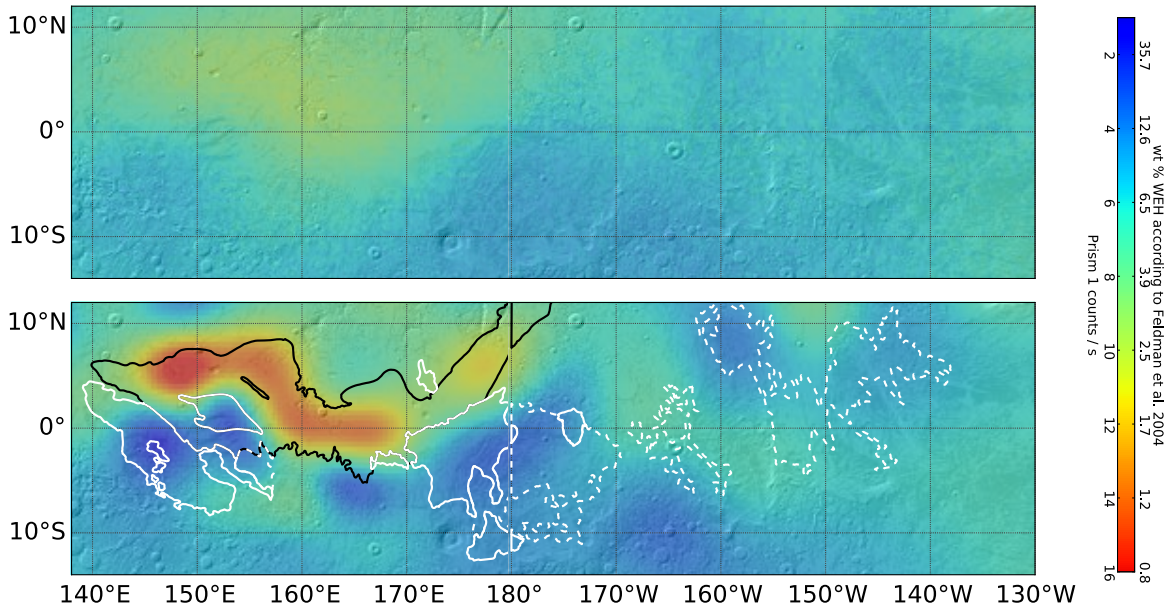

Figure 1. (Top) Raw MONS data and (Bottom) pixon reconstruction around the MFF. A MOLA shaded relief map is underlayed. The contours outline the young undivided channel material (black) and middle and lower members of the MFF (white solid and dashed, respectively) identified in [18].

to deconvolve the PSF from the observed data, to infer the simplest image consistent with the data [9]. Using this technique we have carried out the first global, Bayesian reconstruction of a remotely sensed planetary data set, some results of which are shown in Fig. 1.

The pixon method's adaptive smoothing algorithm works such that regions of the image containing more detail are given the freedom to vary on small scales and those without vary only on larger scales. This is done to create the simplest possible reconstruction that is still consistent with the data.

Results: The pixon reconstruction of the MONS data yields a near two-fold improvement in linear spatial resolution and a 50% increase in dynamic range. Below, using this new data, we examine two nearby features with possible water-based origins.

The Medusae Fossae Formation: Ice or dry, porous rock? The Medusae Fossae Formation (MFF) is a discontinuous geological unit of easily erodible material that stretches 1000 km across equatorial latitudes. Proposed origins include consolidated pyroclastic deposits [10] and aeolian sediments with ice-rich material [11]. Radar sounding has found the dielectric constant of the MFF material to be consistent with the feature containing either a large component of water ice or anomalously low density soil [12]. It may be possible to distinguish between these two mechanisms using neutron derived hydrogen abundances.

The topography and MONS reconstruction of the MFF are shown in Fig. 1. The western lobes, Aeolis, Zephyria and Lucus Plana, of the MFF are greatly enriched in hydrogen, with >10 wt. % WEH. At Aeolis Planum the neutron data imply a WEH abundance > 40 wt. %. This is too great an abundance to be explained as hydrous silicates, which have WEH abundances of 10-20 wt. % [1], so must be buried water ice or hydrated salts. However, the eastern lobes of the MFF contain little, if any, increased hydration. Geologically, the western lobes are associated with the lower members of the deposit, whereas the eastern lobes correspond to upper and middle members only.

At present water ice is unstable at any depth near the Martian equator [13]. However, Martian orbital obliquity has varied greatly over the past 20 Ma. During high obliquity periods the polar water ice caps become unstable and ice may be deposited down to equatorial locations [14]. Protection of this deposited ice by dust, perhaps containing cemented duricrust layers, could lead to its continued presence today [15].

Our result is consistent with the lower member of the MFF containing ice rich material, which lends weight to the theory that, at least part of, the MFF is a polar layered-like deposit. Salt hydrates could also explain the observations as they have up to 50 wt. % WEH, but their stability in the Martian regolith has not been demonstrated. No detections of hydrated minerals within the MFF are reported in either CRISM or OMEGA data sets.

Elysium Planitia: Ice or Lava? The Cerberus fossae are a 1600 km long set of parallel fissures at Elysium planitia, believed to be related to the Elysium Montes, located to their northwest. There is morphological evidence that they have been the source of both water and lava floods within the last 2-10 Myr.

It had been assumed that the water had sublimated away, leaving only fluvial channels as evidence of the water flows. However [16] identified, in Mars Express High Resolution Stereo Camera (HRSC) images, plate-like features that they argued must be the remains of a buried frozen sea 800 × 900 km across and up to 45 km deep, centred at 5° N, 150° E.

The locally adaptive pixon reconstruction of the region around the proposed, buried sea is shown in Fig. 1. The location of the water ice sea, 5° N, 150° E, corresponds to one of the locations with the highest epithermal neutron flux on the entire surface of Mars. This suggests that the top few tens of centimetres of soil, in this region, are unusually dry with < 1 wt. % WEH. The dry feature in the reconstruction extends beyond the region identified by [16] and covers much of the smooth plains that are believed to be young basaltic lavas from Cerberus fossae (outline with a black contour in Fig. 1). Additionally, in Mars Odyssey Gamma Ray Spectrometer data, this region is revealed to be enhanced in Fe [17]. Taken together, these results suggests that the plate-like features at Elysium Planitia are young, Fe-rich, volatile-poor basalts.

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