Structural Constraints on the Eastern Equatorial Hydrogen Concentration Inferred From MOLA, Crustal Thickness, and Infrared Imagery June. R. Clevy[1] and Simon A. Kattenhorn[2], University of Idaho, Department of Geological Sciences, PO Box 443022, Moscow, ID 83844-3022. [1]jrclevy@vandals.uidaho.edu, [2]simkat@uidaho.e-du.

Introduction: Since the 2002 determination [1] of large hydrogen concentrations at two locations along the Martian equator, research has focused on the possible composition [2] and genesis [3] of the hydrogen. Previously we have examined the topography of the Eastern Equatorial Hydrogen (EEH) concentration to determine a cause for hydrogen enrichment in the vicinity of Schiaparelli Basin. Steep, north-facing slopes and low-lying areas adjacent to these slopes were enriched, suggesting previous orographic precipitation and subsequent run-off. [4]. We also investigated the possibility of an active component in the hydrogen data by creating temporal divisions based on solar longitude to gauge seasonal variability [5]. Our current study seeks to constrain the spatial extent of the EEH concentration by examining the spatial relationship between areas with low epithermal neutron count rates and structural variables reflected in changes in elevation [6] and crustal thickness, both expressions of regional tectonic history. In addition, a statistical resampling method has been implemented that allows the mean epithermal neutron count rates (MENCR) to be displayed as high resolution rasters with a node spacing of 0.0039°. This resolution is equivalent to the day and night infrared mosaics created from Thermal Emission Imaging System (THEMIS) imagery [7]. Spatial relationships between the epithermal data, elevation, crustal thickness, and the infrared layers suggest a component of structural control over the extent of the Eastern Equatorial Hydrogen concentration.

Epithermal Neutron Count Rates: Los Alamos National Laboratory provided epithermal neutron data for this study. Included were count rate point data for the first two years of Mars Odyssey's Neutron Spectrometer (MONS) records. Displayed to emphasize areas with depressed Mean Epithermal Neutron Count Rates, MENCR maps become a corollary for enriched hydrogen content within the Martian regolith [8], and hence a potential indicator of hydrogen bearing molecules within a meter of the surface.

Raster creation. A statistical resampling technique was implemented to create a raster whose resolution approximated the infrared data. MONS measures radiation from the Martian surface by counting the number of epithermal neutrons detected over a 600 km diameter swath of the Martian surface in 19.7 seconds. The total count is then divided by 19.7 seconds and this count rate is recorded as point data. Due to the footprint size, a single data point is not a reliable estimate of local hydrogen abundance. Averaging multiple points approaches the true rate of epithermal neutrons reaching MONS from the target. Previous studies were conducted at larger scales using simple binning methods to create MENCR and Water Equivalent Hydrogen (WEH) raster maps with a few hundred kilometers resolution [9]. Here we have used the Neighborhood Statistics function in ArcMap's Spatial Analyst to populate a high resolution (0.0039° node spacing) MENCR raster. In order to create a weighted mean, two circular window sizes were chosen, a 2° (234 km) radius window, similar to the MONS footprint, and a smaller 1° (117 km) radius window chosen to emphasize data points closest to the center of each node. For each window size, a boxcar function sampled every data point that fell within the window for each node across the raster, tallying the number of data points per node and calculating the mean count rate of those points. These rasters were then averaged together to weight the final MENCR raster toward the center of each node.

Water Equivalent Hydrogen. The equation used to convert MENCR rasters to Water Equivalent Hydrogen (WEH) maps assumes all the hydrogen inferred by depressed epithermal counts is bound up as water. The assumption is not likely to be true, but the locations of relative maxima and minima would not change if the hydrogen were instead bound as OH (e.g. in hydroxylated surface minerals).

Methodology. Contouring the MENCR and WEH raster maps emphasized steep gradients within the hydrogen data indicative of a transition between relatively low and high epithermal neutron count rates, indicating adjacent enriched and depleted hydrogen levels in the regolith. Mapping these transitions gave emphasis to the boundaries between zones of low, moderate, and high epithermal neutron counts. Additional gradients were used to determine internal boundaries within these zones. The abrupt change in albedo tangential to Schiaparelli's topographic rim was mapped as well. In all, the map area was divided into 22 polygonal regions of interest (ROI) (figure 1). The outer five ROI have relatively high MENCR values relative to the other ROIs. Nine regions have moderate neutron levels, and eight regions appear to have as much as 17% WEH within a meter of the surface based on the low MENCR values. Comparing the interiors of these ROIs against one another and comparing the ROI perimeters against structural data layers allowed precise spatial comparisons between areas of enhanced and depleted hydrogen abundance.

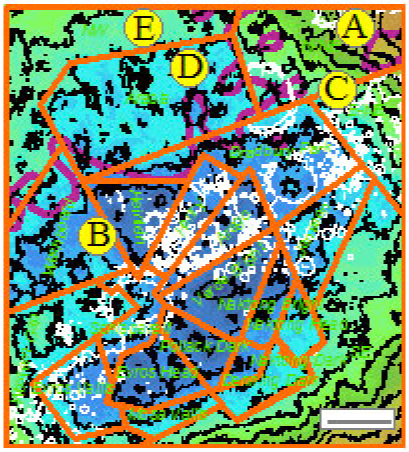

Figure 1. Orange lines indicate ROI boundaries. White line is 0 m elevation and purple line indicates crustal thickness of 39 km.

Structural components: MOLA data was selected to explore the relationship between MENCR and topographic expression of structural and geomorphic features at the Martian surface. Similarly, crustal thickness data highlights fault traces concealed by surface processes. Both datasets allow regional variations in hydrogen abundance to be viewed in the context of regional tectonics. Faulting may be expressed in the MENCR data as transitions from low epithermal count rates (enriched hydrogen) to adjacent regions with high count rates (indicating depleted hydrogen).

MOLA. Elevation data from the Mars Global Surveyor Mars Orbiter Laser Altimeter (MOLA) [6] were examined as both a raster and contour dataset. Congruence between MOLA contours and ROI perimeters was most prominent along the equipotential surface (0 m) (fig.1). Other MOLA contours occasionally follow ROI perimeters, but these areas of congruence are discontinuous where influenced by underlying structures.

Crustal Thickness. While MONS can only infer hydrogen abundance in the top meter of Martian regolith, the crustal thickness data available through the Planetary Interactive GIS-on-the-Web Analyzable Database (PIGWAD) [10] provided visual cues to regional faulting and subsurface structure. When compared to the MENCR and WEH maps, the majority of hydrogen enriched ROI appear to lay in areas where the crustal thickness exceeds 39 km (A, figure 1). Where the crust is thinner, ROI in the moderate MENCR zone may have a patchy, striped or washboard appearance (B, figure 1). A prominent east-northeast trending change in crustal thickness (C, figure 1) echoes a transition in the MENCR data, suggesting disparate surface geology on either side of the fault. As mapped, the ROI labled Arabia (D, figure 1) appears bounded by linear fault traces. However there is also an indication of arcuate structural control just north of the ROI boundary, as seen in a semi-circular region of moderate epithermal count rates (E, figure 1) centered on a low relief, degraded crater. A similar transitional area, dubbed Washboard (B, figure 1), displays a washboard pattern indicating uneven weathering of at least two disparate stratigraphic layers. The juxtaposion of high and low epithermal counts may be used to further define the nature and extent of the hydrogen source. This washboard region is unique in the density of wind-streak producing craters. The streaks are reminiscent of wind-blown playa sands trailing across the southwest rims of over a dozen craters within this ROI.

Infrared Imagery: Both day and night infrared mosaics show some congruence to the ROI perimeters. Variations in infrared energy from region to region are most evident in the Washboard region (F, figure 2) and associated with the streaks mentioned above.

Discussion and Conclusions: Spatial analysis of the MENCR and WEH rasters with respect to MOLA elevation and crustal thickness layers suggest structural control of the hydrogen into fault bounded areas created by repeated and overlapping impact fracturing and extensional tectonic events. Subsurface fluid mobility may increase in faulted and fractured bedrock. Associated chemical reactions may provide a mineralogical source of hydrogen responsible for the regionally depressed epithermal neutron count rate. There is also an indication of arcuate structural control coincident with impact-related ring structures. While most ROI appear fairly homogenous, the Washboard region can be further divided due to the close proximity of hydrogen enriched and depleted areas, also reflected in THEMIS data, indicating the importance of surface materials and near-surface geology for controlling epithermal neutron counts.

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