LOCALIZED SEASONAL VARIATIONS IN WATER EQUIVALENT HYDROGEN ON MARS AND POSSIBLE RELATIONSHIP TO RECENT IMPACTS. J. R. Clevy[1] and S. 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.edu.

Introduction: The HiRISE team [1] discovered a class of small impact structures in mid-latitudes that appear to expose an icy substrate below the dusty Martian surface [2]. The CRISM [3] team confirmed water ice within the largest of these craters.

In light of this discovery, we examined Water Equivalent Hydrogen (WEH) maps, calculated from epithermal neutron counts [4], searching for localized indications of impact-exposed hydrogen within the eastern equatorial region of Mars.

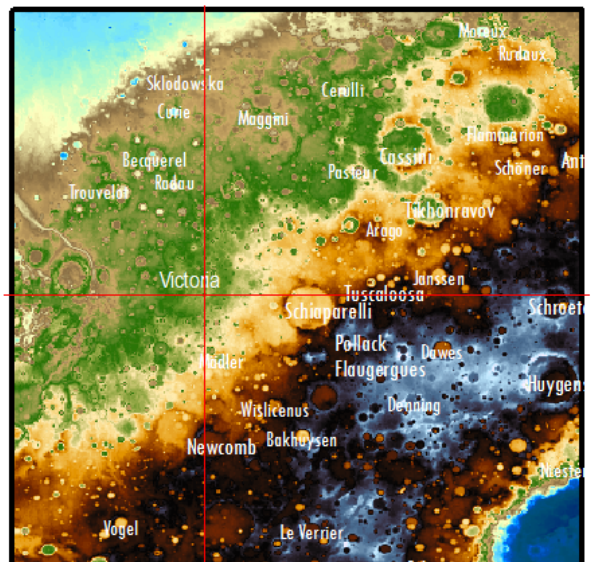

Figure 1. *Study area in eastern equatorial Mars. Schiaparelli Basin measures ~450 km diameter. Red lines denote 0° latitude and longitude.*

Background: Unlike CRISM, an electromagnetic spectrometer, Mars Odyssey Neutron Spectrometer (MONS) does not measure reflected wavelengths of light. MONS counts neutrally-charged particles as they escape from the Martian surface and collide with the detector onboard Mars Odyssey. Every 19.7 seconds MONS records the number and energy level of neutrons measured within its 600 km footprint. The presence and quantity of hydrogen within the upper meter of the Martian regolith strongly and rapidly slows neutrons down. These slowed neutrons never attain escape velocity and cannot reach the satellite. The quantity detected has an inverse relationship to the abundance of hydrogen within the footprint. Of the three neutron energy levels (thermal, epithermal, and fast) epithermal neutrons appear to have the best affinity for hydrogen. The data used in this study are counts of epithermal neutrons, recorded as point data at the center coordinates of each footprint. Single data points are not reliable estimates, so traditionally we bin and average the data to approach a true count rate for a given location. The bins must be large enough to incorporate multiple measurements, but as bin size determines pixel size, binning restricts the spatial resolution of the map output. To address this restriction our study implements a resampling technique frequently used in geographic information systems, a moving window.

Methodology: We created ten WEH maps for this study, each covering the same spatial extent (45°N to 45°S, 30°W to 60°E, Figure 1). Half of the maps were created using a neighborhood (also called a moving boxcar or moving window) function that averaged total neutron counts within a 50 km radius window at each node. The node spacing for this neighborhood function, 463 m, produces a map resolution of 463 m/pixel, comparable to Mars Orbiter Laser Altimeter [5] maps. For the remaining five maps we retrieved the median values for those same window/node settings. Map values were then converted to neutron count rates (Equation 1), which we used to calculate the weight percent of water equivalent hydrogen (Equation 2).

$$\mathit{Rate = total\ counts\ /\ 19.7\ seconds} \qquad \textbf{(1)}$$

$$\mathit{Wt\%\ WEH = 100*((29.306/(rate-1))/3)^{1.3275}} \qquad \textbf{(2)}$$

Static and seasonal divisions. Static reference maps for mean and median WEH values included data from the first two years of Mars Orbiter Neutron Spectrometer (MONS) data. We then divided the data points into seasons of 90° solar longitude (L_s) and followed the same processes to generate mean and median maps for (northern) spring, summer, winter, and fall.

Detection of recent impacts. According to the CRISM team, the signal from the ice inside the fresh craters slowly faded. This is consistent with the eventual sublimation of water ice at current temperatures and pressures. Keeping this in mind, we chose to compare the seasonal maps to locate fresh craters. As impact-generated hydrogen enrichment should only remain detectable for a short period of time, we could disregard localities that remained enriched for more than a season or two. For reference, we used the THEMIS daytime IR mosaic [6]. High WEH areas not associated with visible impact craters were not considered for this study.

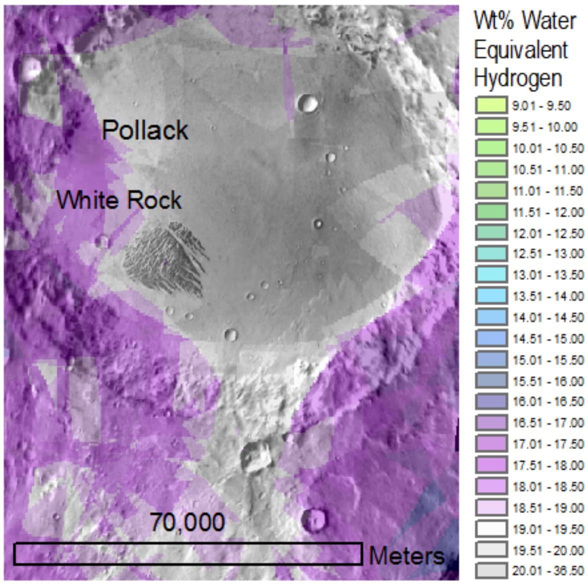

Figure 2. *Pollack Crater, a 96 km diameter crater located at 7.9°S, 25.2°E. THEMIS daytime IR and spring mean WEH.*

Findings: A preliminary search turned up over two dozen candidate craters. In some cases, the increased hydrogen appeared to be constrained by crater walls. One of these, Pollack Crater, known for the "white rock" formation [7] contains a well defined hydrogen signal in the fall mean and median WEH maps. The elevated hydrogen reading corresponds to a 6 km diameter irregular crater just south of Pollack's rim (22% mean WEH and ~24% median WEH). In the spring the enrichment falls to 19.5% mean and 21% median WEH. The spring map exhibits a second hydrogen-enriched area coinciding with a 3.5 km simple crater ~33 km northeast of "white rock" (19% WEH for both mean and median maps) (Figure 2). In the static WEH (all seasons combined), Pollack averages ~16 wt. % water equivalent hydrogen. Summer and fall map averages are ~15.5 wt. % WEH.

Other craters displayed increased hydrogen abundances in their ejecta. Summer median WEH values for a 5 km crater just east of Tuscaloosa crater read 20.9% WEH (19.6% mean WEH, Figure 3). Seasonal values here (0.5°S, 32°E) average 16 wt. % WEH.

Caveats: On the northern edge of the study area (45.2°N, 7°W), Esk crater stands out in the fall data with a 16.8% median WEH (15.75% mean WEH). The average mean WEH for the remaining months is ~9%. While this seems precisely the type of short-lived hydrogen enrichment one would expect from an impactor punching through surface debris to an ice-rich layer, Esk was named in 1976. It is possible that a smaller crater has formed inside Esk during the first two years of epithermal neutron measurements, but Esk itself dates back to the Viking era.

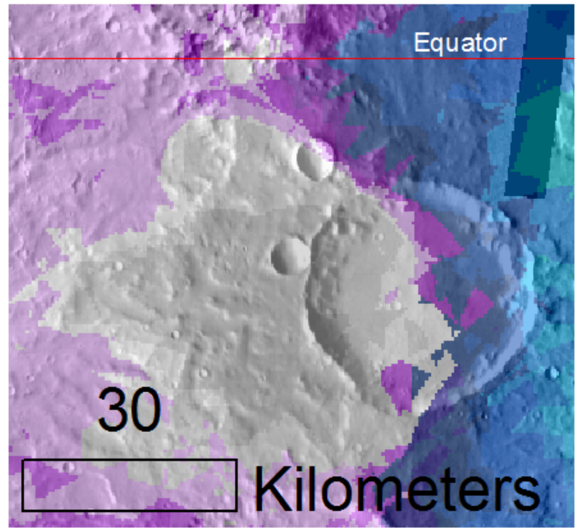

Figure 3. *This crater, east of Tuscaloosa Crater, displayed increased hydrogen in the ejecta blanket. Note how the ejecta drapes the adjacent crater's rim.*

Discussion & Conclusions: Comparing seasonal WEH maps to locate impact-exposed hydrogen sources produces mixed results, but may reveal a few surprises. While looking through the summer map, we found a paleo-drainage with a sinuous WEH signals (Figure 4a & b). Certainly not every crater with elevated WEH values represents a recent impact; however, our study highlights the advantages of using moving boxcar algorithms to process neutron spectrometer data. By increasing the spatial resolution to match existing Martian mosaics, mission planners benefit from detailed maps of hydrogen enrichment and the Science Directorate profits by receiving additional data products from existing missions.

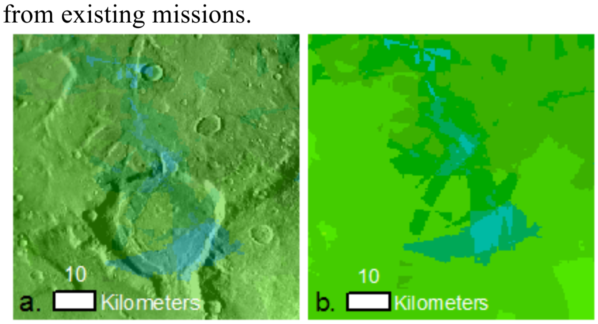

Figure 4. *Summer WEH median: a) draped over THEMIS daytime IR layer, and b) alone.*

References: [1] McEwen A. and the HiRISE Science Team (2008) *EPSC* Abstract #00309. [2] Tornabene L. et al. (2007) *7th Int. Mars Conf.*. [3] Murchie S. et al. (2004) *SPIE*. [4] Feldman W. C. et al. (2002) *Science*, 297, 75-85. [5] Smith D. et al.(1999) *NASA Planetary Data System*, MGS-M-MOLA-1-AEDR-L0-V1.0. [6] Christensen P. R. et al. (2004), *Space Science Reviews*, 110, 85-130. [7] Ruff S. W. et al. (2001) *JGR*, E10, 23921-23927.