UPDATED GLOBAL MAP OF MARTIAN VALLEY NETWORKS AND IMPLICATIONS FOR HYDROLOGIC PROCESSES. B.M. Hynek[1-2], M. Beach[1-2], and M.R.T. Hoke[1], [1]Laboratory for Atmospheric and Space Physics, [2]Dept. of Geological Sciences (392 UCB, Univ. of Colorado, Boulder, CO 80309) hynek@lasp.colorado.edu

Introduction: The valley networks of Mars have long been viewed as some of the best evidence that water flowed across the surface under climatic conditions that were much different in the past. However, many questions remain, including the timing and mechanisms of valley formation. To address these questions, Carr [1] and Carr and Chuang [2] produced a comprehensive Martian valley network map from Viking-based images covering ±65° of latitude. This product contained over 900 networks with over 8000 branches that generally appeared immature in planimetric form and contained large, undissected regions between networks. The authors used these attributes to suggest that only limited surface water was necessary for their formation. Mars Global Surveyor datasets have revealed many valleys that were not evident in the Viking images and correspondingly more mature drainage systems [3]. The Thermal Emission Imaging System (THEMIS) experiment [4] on the Mars Odyssey spacecraft provides an even higher resolution look at valley networks. In particular, the 100 m resolution daytime IR data is ideal for identification and analysis of valleys, which are generally a couple kilometers wide and hundreds of meters deep. Coregistered, ~0.5-km-resolution Mars Orbiter Laser Altimeter (MOLA) data [5] are also useful in mapping and studying the valleys' characteristics.

Methods/Results: We used the THEMIS daytime IR dataset [4] to remap valley networks on a global scale in an effort to better understand their distribution and to test hypotheses regarding their origin. The valleys were mapped using similar determining characteristics to those of Carr [1] for ease of comparison. The results were compared to other datasets including topography, thermal inertia, mineralogical/compositional data, etc. While a number of automated routines to map global valleys have been attempted with MOLA gridded data and other products, the resolution of these data is too poor to resolve many of the smaller features.

As expected, many more valleys were seen in THEMIS data compared to those detected in Viking images. Figure 1 shows an example of valleys mapped by Carr [1] compared to this study. In the original mapping, a few, often unconnected, valleys without many tributaries could be seen (Fig. 1a). Figure 1b shows that with higher resolution data, we can now resolve these valleys into a dense, mature drainage network. In this example, Carr mapped 16 valley segments totaling 1,492 km in length; giving a corresponding drainage density of 0.034 km^{-1}. In contrast, our updated mapping shows 462 valley segments totaling 6,031 km in length; giving a corresponding drainage density of 0.14 km^{-1}. In this case, the higher resolution mapping reveals a factor of 4 increase in stream length and drainage density. The characteristics of the originally mapped valleys are consistent with formation by groundwater processes. However, the updated map indicates that sustained precipitation and surface runoff were likely required due to the dense drainage, high stream order, and many small tributaries that reach right up to drainage divides.

In the preliminary updated global map, >4 times as many valleys have been identified, totaling a summed length ~2.5 times greater than Carr [1]. Drainage densities of networks are almost always much higher and a greater complexity of drainage is evident. Carr and Chuang [2] did not identify a single valley greater than 4^{th} order in the Strahler system (higher order equals more water and maturity) [6] yet we have found six 6^{th} order and twenty-five 5^{th} order networks. Many smaller tributaries are seen that were not evident with Viking data as well as structure within the valleys including braided channels and terraces indicative of sustained flow.

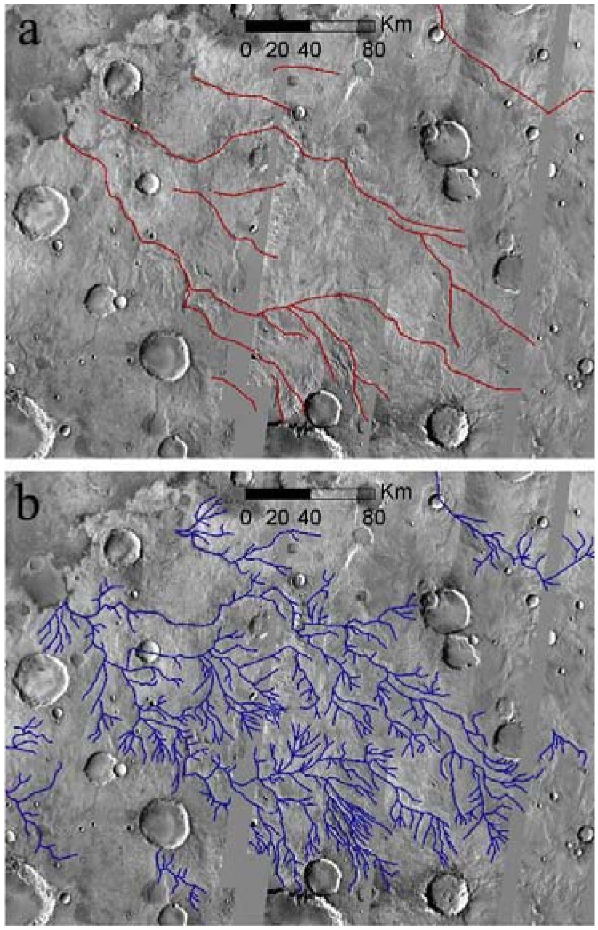

Figure 1. Comparison of valleys mapped by Carr [1] from Viking data (a) to those identifiable in THEMIS data (b) near 3°S, 5°E; both on a THEMIS basemap. Much greater maturity is evident in the new data.

Age Distribution: In terms of age, roughly 91% of newly mapped valley segments lie entirely within Noachian terrains (>3.7 Ga ago), 6% cross into or are entirely contained within Hesperian-aged surfaces (3.7-3.0 Ga) and 3% occur on Amazonian terrain (<3.0 Ga) (Fig. 2). These percentages are similar to those reported from Viking-based mapping [1] and argue for relatively rapid climate change at the end of the Noachian. The valleys on Noachian surfaces occur across most of the Southern Highlands and ages of individual networks can be discerned [7]. While valleys are now identified in terrains thought to be undissected from previous work (e.g. south of Hellas, Fig. 2), substantial areas of ancient crust with no discernible valleys still exist. Several of these sparsely channeled regions appear to have thick mantles that subdue topography and we hypothesize that existing valleys have been buried (e.g., east of Hellas). Hesperian-aged valleys are peppered throughout the cratered highlands with concentrations on the south and east margins of Hellas Basin (Fig. 2). Many of these are on the gentle flanks of the volcano Amphitrites Patera. The Amazonian-aged valleys also occur predominantly on the flanks of volcanoes, including the Early Amazonian-aged Tyrrhena, Hadriaca, and Alba Paterae. Valley incision was isolated to these constructs in the Amazonian with most activity occurring early [8]. The youngest valleys identified on Mars occur in the Tharsis region and most of these likely had a hydrothermal origin [8].

Conclusions: An updated global map of valleys on Mars is nearing completion. The higher resolution THEMIS day IR data allow an unprecedented look at these features related to surface and near-surface water. Many more valleys are seen globally and drainage density measurements are correspondingly higher. These new results are consistent with a warm and wet climate early on that incised the crust with later activity isolated to volcanic constructs.

References: [1] Carr, M.H. (1995) *JGR*, *100*, 7479–7507. [2] Carr, M. H. and F. C. Chuang. (1997) *JGR*, *102*, 9145-9152. [3] Hynek, B. M. and R. J. Phillips. (2001) *Geology 29*, 407-410. [4] Christensen, P.R., et al. THEMIS Public Data Releases, PDS node, ASU, http://themis.asu.edu. [5] Smith D.E. et al. (2001) *JGR*, *106*, 23689-23722. [6] Strahler, A. N., (1958) *Geol. Soc. Am. Bull.*, *69*, 279-300. [7] Hoke M.R.T. and Hynek B.M. (2008) *LPSC XXXVIII (this conf.).* [8] Bowen T.A. and Hynek B.M. (2008) *LPSC XXXVIII (this conf.).* [9] Scott D.H. and Tanaka K.L. (1986) *U.S.G.S Misc. Inv. Ser. Map 1-1802A*. [10] Greeley R. and Guest J.E. (1987) *U.S.G.S Misc. Inv. Ser. Map 1-1802B.*

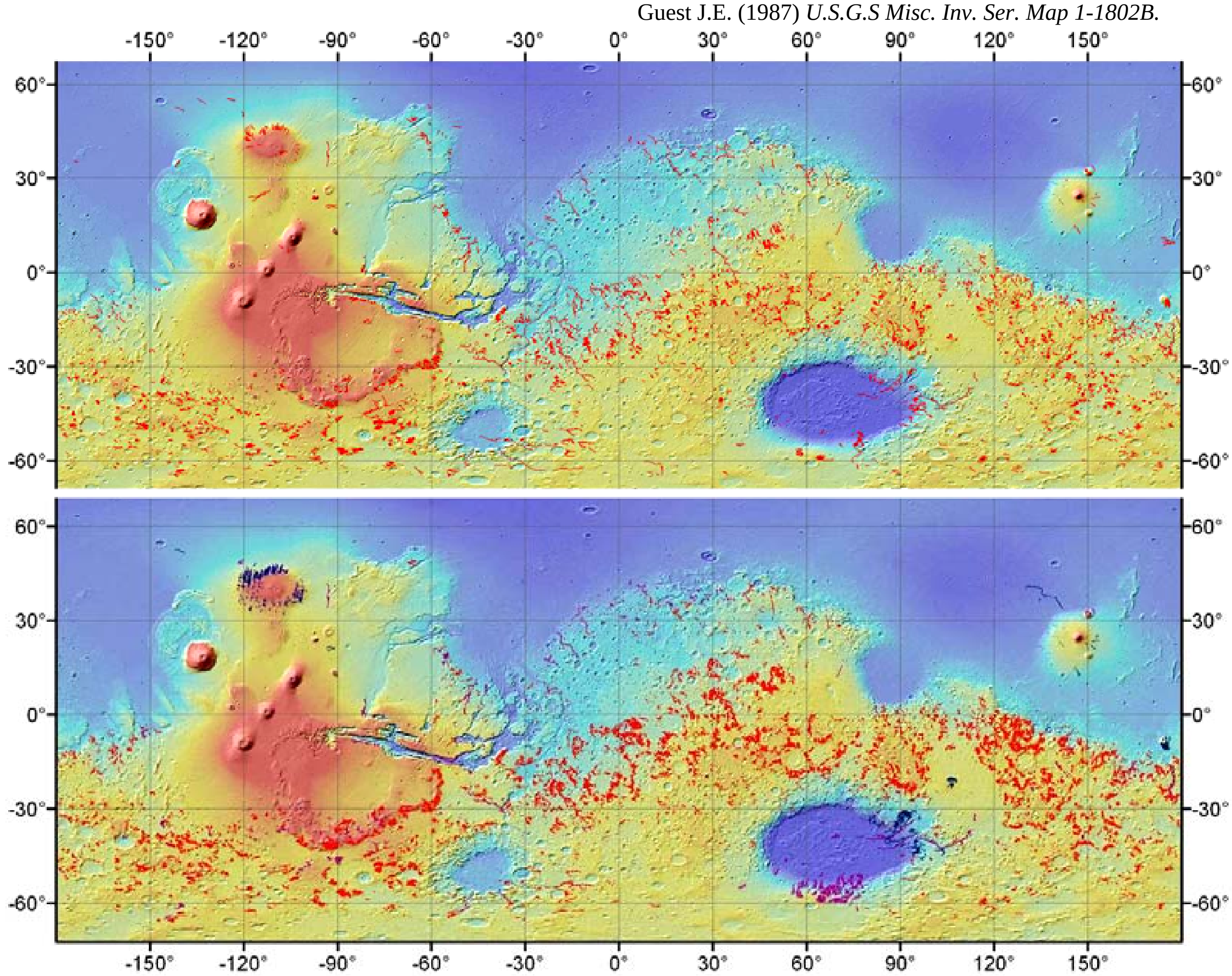

Figure 2. Global comparison of valleys identified by Carr [1] from Viking data (top) and our preliminary updated map using THEMIS data (bottom). In the new map, denser concentrations of valleys are seen almost everywhere and some areas with few identified valleys from Viking data show significant dissection (e.g., south of Hellas Basin; 55°S, 70°E). Colors on the bottom map represent inferred valley ages determined by the youngest terrain unit they incise (red = Noachian, purple = Hesperian, blue = Amazonian) (unit ages from [9-10]). Figure 1 is a higher resolution example comparing the two maps.