COMPARISON OF SMALL VALLEY NETWORKS ON EARTH AND MARS THROUGH SCALING LAWS. J. C. Penido[1] and C. I. Fassett[1], [1]Department of Astronomy, Mount Holyoke College, South Hadley, MA (penid20j@mtholyoke.edu).

Introduction: On Earth, there are empirical relationships between morphometric parameters common for most valley networks carved by rivers, typically relating channel properties to discharge or basin drainage area [e.g., 1-3]. One such relationship is Hack's law, which relates the channel length *L* and the drainage area *A* of the rivers as: $L \sim A^n$ [4]. The exponent *n* in Hack's law has been reported to usually fall between about 0.5 and 0.6 on Earth [3]; theoretical considerations imply that in mature turbulent river systems, a value of ~0.57 should be expected [5].

On Mars, valley networks are the preserved erosional record of early rivers that flowed across the surface [6-8] (Fig. 1). A variety of past studies have investigated the morphometric parameters associated with these valleys to determine whether or not they conformed to the same relationships as their terrestrial analogues [e.g., 3,9-11]. This work has suggested that martian basins are morphometrically distinct from those on Earth [9-11], and that valleys on Mars do not obey Hack's law and other scaling laws [3].

However, the measurements in [3] were made on large valley systems (kilometers in width; hundreds of kilometers in length). Some of these systems appear likely to have formed as outflow channels via catastrophic floods (Hrad Vallis), basin-overflow events (Scamander Vallis [12]), or as volcanic channels (Tinto Vallis [13, 14]).

To test whether Hack's law holds for valley networks at smaller scales than have been measured previously, we used 50-75 m/px digital elevation models (DEMs) derived from the High Resolution Stereo Camera (HRSC) [15, 16]. We measured a variety of valley networks and basins on these DEMs as well as using image data from HRSC, the Mars Reconnaissance Orbiter Context Camera (CTX) [17], and the Thermal Infrared Imaging System (THEMIS) [18] global mosaic.

Observations and Results: Using ArcMap, valleys and watersheds were mapped in three separate areas of Mars (Table 1). Individual valley networks ranged from 14 to 67 km long. A semi-automated ArcMap model was applied to derive watershed areas along the channel profile at fixed length intervals (1 km) (e.g., Fig. 2).

Our data support the interpretation [3] that martian *n* values are dissimilar to those expected based on terrestrial experience and theoretical considerations. The martian valleys had *n* values ranging between 0.5 and 5, with most measurements falling well above what is expected from theory and terrestrial measurements (Table 1, see also Fig. 2).

Along with Hack's law, we compared the valleys' width versus their contributing drainage area. Similar to the length/area scaling, a width-area scaling relationship is expected, $W \sim A^b$, with width *W* and area *A* [3]. A positive exponent *b* is expected since width should increase with area, which is often taken as a proxy for discharge. On Earth, the exponent *b* in this relationship values between 0.3 and 0.5 [3]. In our data, *b* values fall between -0.5 and 1.7 (Table 1; Fig. 3). The median value of *b*~0.2 shows that valley width appear to be increasing more slowly in the small valleys we measure on Mars as a function of contributing area than is typical for rivers on Earth.

Discussion: Our findings on small martian valleys supports and extends the conclusion of Som et al. [3] that typical terrestrial scaling laws do not seem to describe valleys on Mars very well. The reasons for this are not clear, since these scaling laws should be a natural consequence of valleys incising and draining rough topography [5]. However, this result might be a consequence of the immaturity of valley systems on Mars compared to Earth [6, 11, 12]. This immaturity in turn may result from the transience of valley network for-

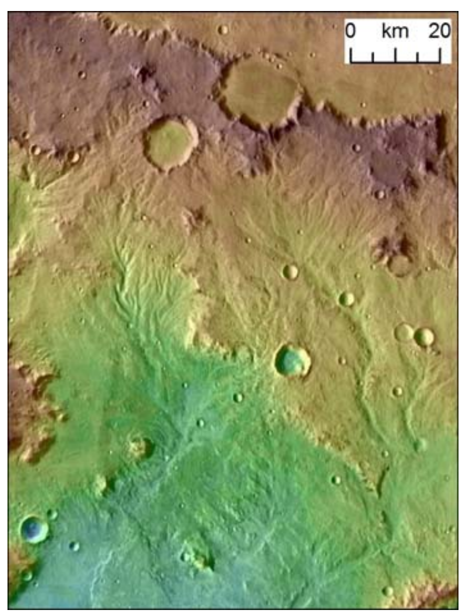

Figure 1. An example of the small valley networks that were measured (HRSC orbit 521 DEM on THEMIS global mosaic).

mation, more limited tectonic forcing on Mars (lack of uplift), despite its contribution to drainage basin evolution on Earth, and/or competition of valley formation with impact cratering [e.g., 6]. More measurements, modeling, and analysis are necessary to understand the relative importance of these considerations to the characteristics that we observe.

Future Work: Along with the results presented here, we plan to (1) continue to analyze valley systems on Mars, (2) examine other scaling relationships on the valley systems we measure, and (3) apply our procedure to a variety of terrestrial DEMs of comparable resolution to HRSC to re-examine empirical relationships such as Hack's law in a variety of terrestrial drainage basins.

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HRSC Orbit #	*Location*	*n* (*Hack's Law*)	*b* (*W/A Scaling*)
521	93.2˚E, 32.6˚S	1.2–5.0 (n=6) median: 1.6	0–1.7 (n=5) median: 0.2
528	62.9˚E 19.7˚S	0.8–3.4 (n=5) median: 1.2	0–1.5 (n=3) median: 0.2
2530	-68.4˚E 34.1˚S	0.5–3.5 (n=5) median: 1.2	-0.5–0.5 (n=6) median: 0.2

Table 1. Scaling relationships derived for small valley networks at three locations on Mars; *n* is the exponent in Hack's law describing how valley length scales with contributing area, $L \sim A^n$, and *b* is the exponent in the width-area scaling relationship that is expected to exist ($W \sim A^b$). Clearly the exponents we derive differ from terrestrial expectations (*n*~0.5–0.6; *b*~0.3-0.5) [3].

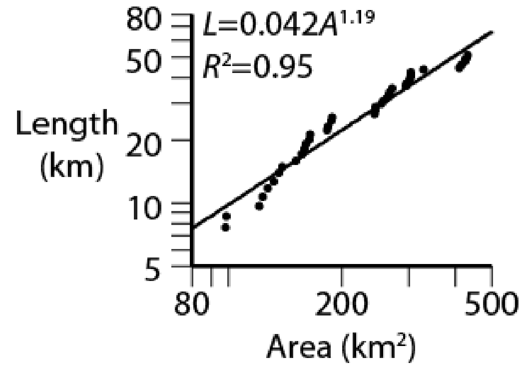

Figure 2. Example length versus area plot for a valley on the stereo DEM from HRSC orbit 528. Note that here, *n*~1.2 rather than the *n*~0.5-0.6 typical for Earth.

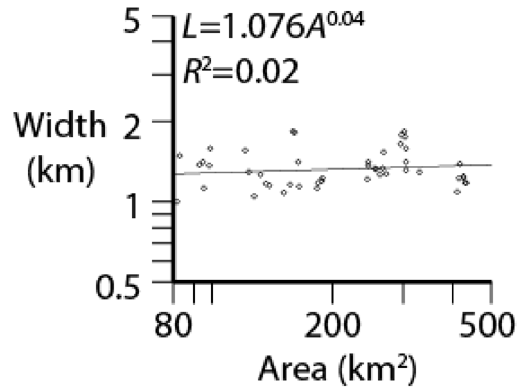

Figure 3. Example width versus area plot for a valley on the stereo DEM from HRSC orbit 528. For this example, valley width is essentially constant and independent of contributing area, rather than growing with watershed area as is typical on Earth (*b*~0.3-0.5) [3]. We find median exponent *b*~0.2