Terrestrial Ephemeral-Channels as Analogues for Large Valley Networks on Mars. S. M. Som[1] , D. R. Montgomery[1], H. M. Greenberg[1] , [1]University of Washington, Dept. of Earth and Space Sciences, Astrobiology Program and Quaternary Research Center, Box 351310, Seattle, WA 98105 (sanjoy@u.washington.edu, dave@ess.washington.edu, hgreen@u.washington.edu)

Introduction: Martian geomorphology preserves evidence of important aqueous activity, as seen in substantial incised valley networks and outflow channels. However, the formation mechanism and evolution of the valley networks remain controversial. It is generally agreed upon by the scientific community that the major outflow channels were formed by a catastrophic release from a liquid water aquifer [1]. Indeed, outflow channels, among other characteristics, initiate from a chaotic region with an initial width similar to the channel mean width, suggesting sudden release. Is this "catastrophic" nature prevalent for the smaller channels as well?

Small channels have been observed to be dendritic, suggesting rainfall, by direct Earth analogy [2]. However, most large channels are not dendritic, and are localized features appearing independently from similar features. This makes it difficult to attribute them with a global warm-wet past [3]. Different theories regarding the origin of the channel-forming fluid have been proposed, such as i) atmospherically fed surface runoff [4], ii) surface runoff caused by higher surface heat flux [5], iii) surface flow caused by hydrothermal systems originating from magmatic intrusions [6], and iv) sapping [7]. Whether the water sources were discrete (point source) or not (meteoritic precipitation across a large drainage area) is highly debated, and has tremendous implications for inferences about the environment in which valley networks formed. A warm-wet past would favor the meteoritic precipitation scenario in a dense atmosphere, while a cold-dry past would more likely support just discrete sources, possibly in a tenuous atmosphere, similar to today.

In this work, we compare the downstream trend in width and slope of large valley networks on Mars, with the downstream trend of perennial and ephemeral water carved channels on Earth, in addition to ancient flood channels preserved in the terrestrial geological record.

Perennial Channels: In perennial terrestrial channels, the variation in width with increasing drainage area is generally characterized by a power law fit of the form $w \sim A^b$. Terrestrial channels generally exhibit an exponent b ranging in the interval of 0.3 to 0.5 [8, 9], related to sustained perennial flow. Since there is no flowing water to help define a channel widths on Mars, and wind erosion may have erased some, particularly smaller, channels, there is substantial ambiguity as to whether the physiographic expression of incised terrain reflects channel or valley widths. However, the assumption of similar, cohesive, erodable material along the complete length of the channels bypasses this ambiguity, since it is the downstream trends, not the absolute widths, that are of interest here.

It has been postulated that erosion rate is a power function of shear stress [10], from which a relationship between slope and drainage area can be derived for equilibrium river profiles: $S \sim A^{\theta}$, where θ, the concavity, is shown theoretically to be ~0.5. However, θ also has been observed to vary between 0.22 and 0.63 for non-equilibrium channels [11]. As such, the value of the concavity cannot constrain whether the channel is at equilibrium. But positive values of θ, translating into concave-up channels, are expected for sustained duration flows typical of humid temperate terrestrial environments

Ephemeral channels: In contrast to perennial channels, arid environments display little downstream variation in channel width, since substrate absorption, water infiltration and evaporation become important variables affecting at-a-station discharges [12]. This asymptotic behavior in downstream width is just a trend, whereas actual widths display substantial local downstream variability [13].

In addition, the longitudinal profiles of arid-environment ephemeral channels typically exhibit a more linear morphology, with minimal concavity.

Catastrophic flooding: Catastrophic flooding in Earth's geological past can guide interpretations of formation mechanisms for fluvial-like channels on Mars. During the Pleistocene, catastrophic outbursts did happen on the planet (the largest known being the well documented lake Missoula drainage event, analogous to outflow channels on Mars), and have been well documented. Incised channels within spillways are the most diagnostic indicator of outburst flooding [14]. Their uniform size and shape, their lack of downstream width increase, and their more "U-shaped" channels make them inconsistent with an origin by gradual down-cutting by long duration fluvial systems fed by meteoritic water. Instead, such features are consistent with short-duration, outburst-type discharges [14].

Methodology: Widths were measured using 30 MOLA cross-sections taken at regular intervals along the channels. Cross-sections that fell in MOLA data gaps [15] were filtered out. Each cross-section was then overlapped with higher resolution THEMIS images for more accurate width measurements.

Preliminary results: As seen below, results for Scamander Vallis (15.8N, 28.5E, Fig. 1) show that although the absolute magnitude in widths measurements differ (due to the lower resolution of MOLA), the trends are very similar (Fig. 2).

Slope measurements (Fig. 3) were taken by fitting a 3rd degree polynomial to the minimum MOLA elevation of each cross-section (Fig. 4). Scamander Vallis' downstream slope variation is shown to be small.

At the time of writing, 5 other downstream trends in width and slope of channels were also measured.

At this stage, large-scale valley networks do not show the systematic downstream trends apparent in perennial terrestrial channel systems. Rather, they show little downstream width variation, and little concavity, suggesting that they were formed by discrete discharges of water, although this work cannot discriminate between what type of point source discharge did occure.

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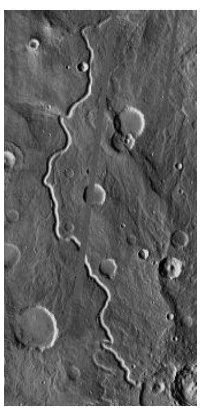

Fig 1: Scamander Vallis (THEMIS mosaic), ~200km long.

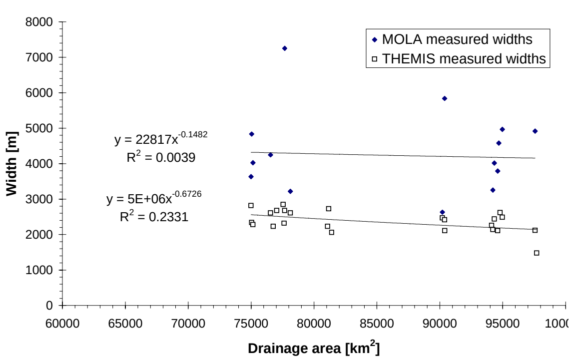

Fig 2: Downstream width vs drainage area for Scamander Vallis (THEMIS and MOLA measurements).

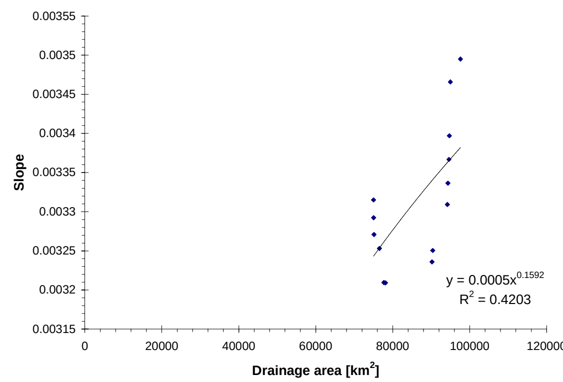

Fig 3: Downstream slope vs drainage area for Scamander Vallis.

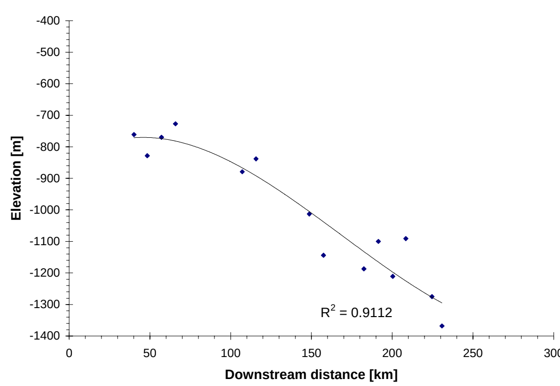

Fig 4: Scamander Vallis: long profile.