DEBRIS FLOW AS A MECHANISM FOR FORMING MARTIAN GULLIES S. J. Conway[1], M. R. Balme[1] J. B. Murray[1] and M. C. Towner[2], [1]Planetary Surfaces Research Team, Dept. of Earth & Environmental Sciences, Open University, Walton Hall, Milton Keynes, United Kingdom, MK7 6AA s.j.conway@open.ac.uk [2]Department of Earth Science and Engineering, Imperial College London United Kingdom SW7 2AZ.

Introduction: The low average temperatures and pressures on Mars are not conducive to the survival of liquid water at the surface, hence the discovery of recently active gullies [1, 2] presents an apparent paradox.

Approach: To approach this problem we have compared the morphometric properties of gullies in various settings on Earth to those on Mars. We have measured debris flows in Westfjords, Iceland [3] and gullies in La Gomera, Canary Islands [4]. The Iceland elevation data were generated from differential GPS and a LiDAR survey and the La Gomera data from differential GPS. In addition we used elevation data from the Shuttle Radar Topography Mission (SRTM) extracted along previously mapped debris flows in the Taurids Mountains, Turkey [5] and the Colorado Front Range, US [6]. We have compared these data to preliminary analyses of stereo HiRISE images of martian gullies in four locations using a method to extract point elevation data developed by Kreslavsky, 2008 [7].

In all cases the elevation along the channel of the debris flow or gully was extracted. For Iceland and La Gomera we also extracted the cross-profiles for comparison with Mars.

Results: Simply comparing the longitudinal profiles of gullies on Mars and the Earth highlights the variability between debris flow sites on Earth (Figures 1 & 2). The martian gully profiles are most similar to debris flows in the Taurids Mountains and in the Colorado Front Range. The overall slope is shallower on Mars compared to the Iceland debris flows and the ephemeral water flow gullies in La Gomera. The runout or total length of gullies is also more variable and greater for Mars than for Iceland and La Gomera. Figure 3 allows comparison of the cross sections from La Gomera (A, B), Iceland (C) and Newton Crater, Mars (D). Note that for La Gomera (A & B) the profiles do not extend beyond the boundary of the gully. Caution should be taken in interpreting the cross profiles for Mars as the error on the elevation is at least 1m and there is low sampling density in comparison to the other datasets. The v-shaped La Gomera cross profile and the Icelandic debris flow compare well to the Mars example in terms of wall-slope.

Discussion: The longitudinal profiles are all concave, showing the influence of water on the slope profile. Hillslope profiles influenced by creep are convex up and hillslope profiles and talus slope [8] profiles (formed by mass wasting and rockfall) are of constant gradient (once equilibrium is reached). Ephemeral gullies tend to follow the shape of the hillslope on which they form [9], as also shown by the La Gomera case. Hence, as hillslope debris flows tend to produce a slightly concave profile [10, 11], as shown in our examples, this seems the best fit for the martian data. Ephemeral gullies are usually v- or square bottomed [12, 13], the La Gomera examples shown here falling into the latter category. However the martian profiles fit better with the examples from Iceland, with a suggestion of levees present in the Mars example given in Figure 3D.

Conclusions and future work: Our results tentatively suggest, based on the morphology alone, that debris flow is a plausible mechanism for forming martian gullies. We plan to collect more examples of the ephemeral gully type on Earth and to produce more profile data for martian gullies. Future work will include analysis of whether there is a slope-area threshold for initiation of incision for martian gullies and analysis of along profile slope-area relationships.

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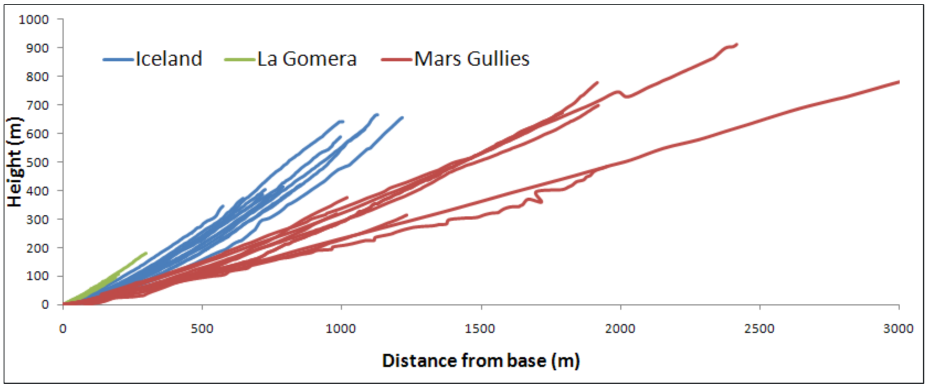

Figure 1: Longitudinal profiles of debris flow gullies in Iceland, gullies in La Gomera and on Mars.

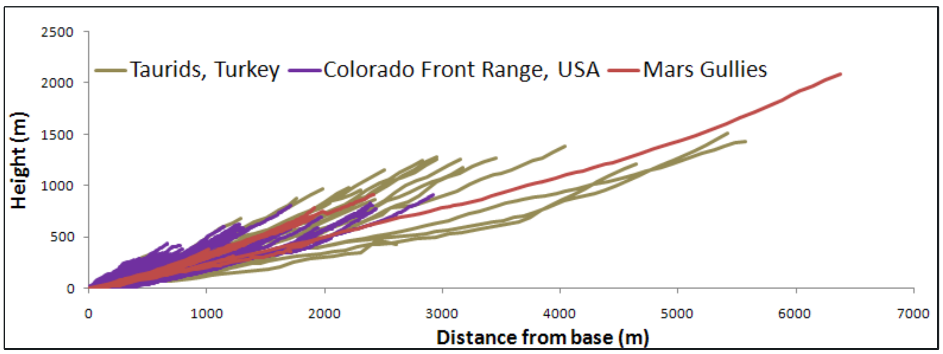

Figure 2: Longitudinal profiles of debris flow gullies in Taurid Mountains, Turkey, the Colorado Front Range, US and of gullies on Mars.

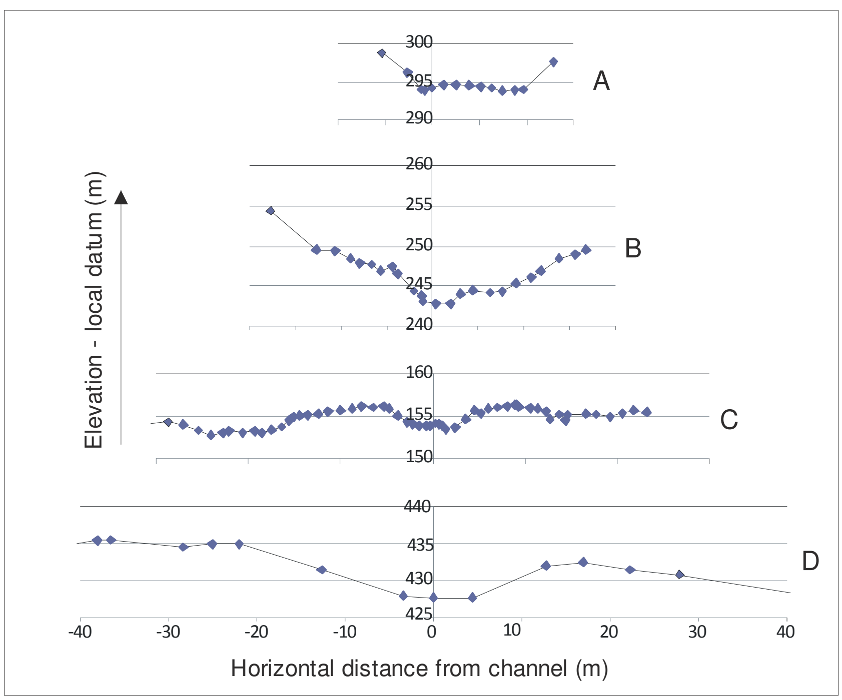

Figure 3: A: La Gomera, square gully cross section. B: La Gomera, v-shaped gully cross section. C: Iceland, debris flow cross section with levees. D: Mars gully cross section, Newton Crater, from HiRISE PSP_003675_1375 and PSP_005877_1375.