MARTIAN GULLY SLOPE MEASUREMENTS MADE USING HIRISE STEREO PAIRS. R.A. Parsons, *(rparsons@pmc.ucsc.edu)*, M. Kreslavsky, F. Nimmo, *Dept. Earth & Planetary Sciences, U.C. Santa Cruz, Santa Cruz CA 95064*.

Introduction The morphology of Martian gullies consist of an eroded alcove, incised channel, and a depositional apron. The distribution of gullies on Mars is limited the mid to high latitudes with the most well-developed occurring between 30 and 45 degrees [1]. Gullies are among the youngest features on Mars based on their superposition on relatively young features such as dunes and polygons, as well as a general scarcity of cratered gullies [2]. The mechanism by which gullies form on Mars remains controversial although numerous models have been put fourth. Christensen [3] proposed gullies form from the melting of an icy mantle deposited at low latitudes during high obliquity periods. Such excursions in the Martian tilt axis have occurred periodically in the recent Martian past about every 100 kyrs [4]. Others suggest that gullies form from groundwater-fed springs [2,5], dry debris flows [6], or perhaps by CO2 out-gassing [7]. Prior studies [8] have measured gully slopes using MOLA topography; here we present higher resolution slope data measured using stereo pairs of HiRISE images. These data place constraints on the plausible formative mechanism(s) of gullies on Mars.

Slope Measurements As of early December 2007 there were about 20 HiRISE stereo pairs of gullies on Mars. Of these we selected nine pairs as the best candidates for slope analysis. Some image pairs were unusable due to dust storms or frost cover, or due to gaps in the data. We selected the highest quality images of fresh-looking gullies in this preliminary study. We measured slopes of a single gully from each of the stereo pairs. In the future we will measure additional gullies contained within these images.

We implement a method developed by Kreslavsky [9] in which spacecraft viewing geometry and an observed parallax between two points in the two stereo images are used to calculate a change in elevation. First, we identify small objects or features (boulders or channel bifurcations, e.g.) common to both images that can be used to accurately determine position within the image at the pixel scale. These points are selected by hand using GIS software. Next, the relative shift in position between the pair of points in the two images gives a parallax vector. The parallax vector orientation is ideally determined by the two camera viewing orientations and its length is proportional to the difference in elevation between the objects. In reality, the observed parallax vector orientation deviates slightly from the predicted orientation - allowing us to determine the error in our slope measurement. Typical errors in slope using this method are between 0.5 to 2 degrees. Typically, we measure slopes between 9 or 10 points along the gully starting above the headwall of the alcove and ending beyond the extent of the debris apron. An example of slope measurements made along a gully at 35^o S latitude is shown in Figure 1.

Results In all but one of the gullies we analyzed, the slope continuously decreases from the alcove to the base of the apron. Longitudinal topographic profiles of the 9 gullies we analyzed are shown in Figure 2. To get characteristic slopes of the gully constituents, we averaged the slopes measured in locations with similar morphology found in the nine profiles. These characteristic slope data are shown in Table 1. We find that all alcoves are steep, often steeper than 28^o. These data are in agreement with previous, less accurate, slope measurements made over a larger dataset [8]. The incised channel slope averages 23^o. Lastly, the deposited material found in the distal apron has an average slope of 17^o. With the exception of the gully at 39.6^o S, the slope is continually decreasing from alcove to apron as one would expect assuming material is eroded from the upland portion and deposited downslope. Compared to terrestrial fluvial alluvial fans, the depositional apron slopes on Mars are significantly steeper, and are more consistent with slopes of terrestrial clast-rich debris flows [10,11]. If Martian gullies are fluvial in origin, the sediment load was high and the flow rate was likely to be low. A more detailed comparison with terrestrial aprons is needed considering differences in gravity in order to distinguish between fluvial and debris flow deposits and to place limits on fluid flow rates and sediment load.

Conclusions The Martian gullies analyzed here have a general concave up topographic profile. The steepest slopes ($\approx 30^o$) occur at the alcove. The incised channels have an average slope of 23^o depositing onto an apron with an average slope of 17^o - based on the nine gullies in this study. Given the relatively low slope of gully fan deposits relative to the angle of repose, it seems likely that a liquid medium is involved in the transport the sediment load. However, compared to terrestrial fans, the steepness of the Martian depositional aprons suggests that flow is matrix (sediment) dominated. In the future, we will explore the effects of slope changes on fluvial and debris-dominated flows on Mars and make comparisons to the observed gully morphology.

References

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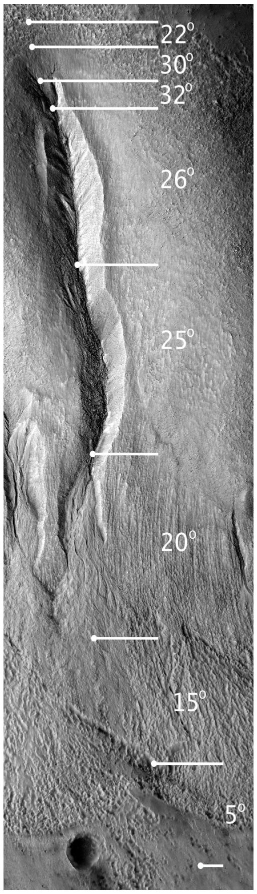

Figure 1: Example of slope measurements made by measuring parallax shifts between stereo pairs. Slope measurements overlaid on HiRISE image PSP_003954_1445 (see Table 1 for location).

Images	Latitude	Alcove slope (^{o})	Channel slope (^{o})	Apron slope (^{o})
PSP_001846_2390	58.72^o N	22	21	13
PSP_001714_2390				
PSP_002888_1400	39.60^o S	24+	21	10
PSP_004167_1400				
PSP_002266_2190	38.61^o N	29	32	22
PSP_002411_2190				
PSP_002659_1420	37.58^o S	29	21	16
PSP_002514_1420				
PSP_001792_1425	37.19^o S	31	22	14
PSP_002425_1425				
PSP_003860_1425	37.10^o S	34	19	14
PSP_003583_1425				
PSP_001578_1425	36.95^o S	34	22	14
PSP_002066_1425				
PSP_003794_1435	36.35^o S	28	21	16
PSP_003649_1435				
PSP_003954_1445	34.99^o S	31	26	18
PSP_004231_1445				
mean		29 ± 4	23 ± 4	17 ± 3

Table 1: Gully slope measurments for nine HiRISE stereo pairs. Alcove measurement at 39.6^o S is likely to be higher due to the large spacing between points used to measure slope.

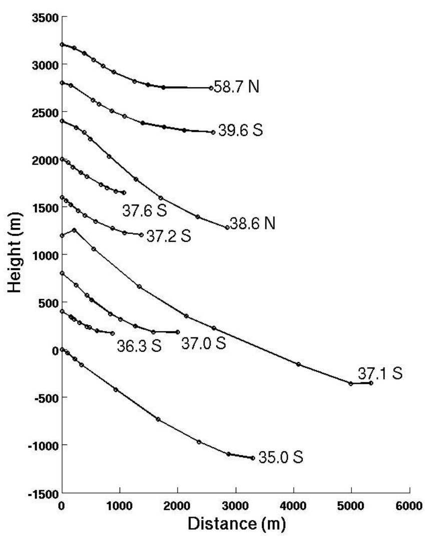

Figure 2: Topographic profiles along the nine gullies analyzed in this study plotted as distance versus arbitrary height. The gullies are located at the latitude indicated on the right.