MORPHOMETRIC ANALYSIS OF A SUBSET OF LANDSLIDES IN VALLES MARINERIS, MARS.

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Introduction: MOLA (Mars Orbiter Laser Altimeter)-derived topographic data and high-resolution MOC (Mars Orbiter Camera), THEMIS (Thermal Emission Imaging System), HiRISE (High Resolution Imaging Science Experiment), and HRSC (High-Resolution Stereo Camera) image data are being used to study the geomorphologic and morphometric character of four landslides in Valles Marineris on Mars. Three landslides are located in Ius, Coprates, and Ganges Chasmata. The fourth (Tuskegee) is located in a chasma adjacent to Tuskegee Crater and near Aurorae Chaos at the eastern edge of Valles Marineris (Table 1). The MOLA-derived DEM (digital elevation model) was utilized to conduct geostatistical terrain analysis for each of these landslides.

Landslide Descriptions: Ius is a large volume catastrophic landslide with a well-defined arcuate main scarp. This scarp has a measured maximum slope angle of 43° and is dissected by numerous rock chutes. Its displaced material—material that has moved away from its original position on the slope [1]—is hummocky and characterized by transverse ridges and furrows. The Coprates landslide is similar to the one in Ius Chasma with the exception that it has a greater number of longitudinal ridges and furrows. The maximum slope angle for the main scarp is 40°. Ius and Coprates represent the larger end members of our data set.

Ganges is a smaller landslide that appears to fail approximately halfway up the canyon wall. Variability in mechanical stratigraphy observed in the canyon wall may be responsible for the failure location (i.e., halfway up canyon wall) and resulting geometry. Additionally, there is a large displaced block at the base of the canyon wall. The displaced material from the Ganges landslide is characterized by a persistent pattern of longitudinal ridges and furrows. Although this landslide has a lobate depositional area, it overlaps an older landslide coming from the opposing (south) canyon wall. The maximum slope angle for the main scarp is 41°. The Tuskegee landslide is the smallest and lacks a prominent arcuate main scarp. Instead, it has two scarps of approximately the same size separated by a narrow topographic bench. The maximum slope angle for the main scarp(s) is only 24°. The Tuskegee landslide also has a lobate depositional area marked by transverse ridges and furrows.

Morphometric Analysis: Morphometry is an important tool for quantitatively describing a landform as well as understanding the range of dynamic geologic processes that shape and modify it during the course of landform evolution. While the Earth's surface can be studied in great detail, morphometric methods are particularly valuable in planetary geology because they provide a means to empirically assess the processes on remote planetary surfaces.

For each landslide, the regions corresponding to the main scarp and displaced material were extracted and their spatial areas calculated. The Ius Chasma landslide has the largest spatial area (424 km^2) for the main scarp and the Coprates Chasma landslide has the largest spatial area (2610 km^2) for the displaced material (Table 1). After extracting slope and elevation values for each landslide, morphometric analysis focused on two key parameters: mean slope and topographic texture (Table 1). Topographic texture is defined as the standard deviation of elevation and serves as a measure of local relief or surface roughness [2].

Results: Mean slope of the main scarp and displaced material were plotted versus area for each landslide (Fig. 1). The Ganges Chasma landslide had both the highest mean slope (31.6°) for the main scarp and the lowest mean slope (4.0°) for displaced material. The hummocky terrain of the Ius landslide had the highest mean slope (9.2°) for displaced material.

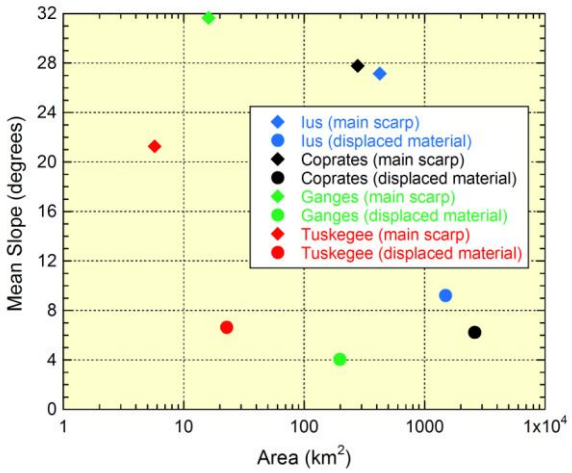

Figure 1. Mean slope of the main scarp and displaced material plotted versus the area of the main scarp and displaced material for each landslide.

The Ius and Coprates landslides are characterized by hummocky, ridged, and furrowed terrain. Topographic texture demonstrates that these landslides are

morphometrically distinct from the Ganges and Tuskegee landslides, which have lower values of topographic texture (Fig. 2). Separate analyses for small, uniform subsets for each landslide verified that this was not a regional topographic effect or related to landslide size.

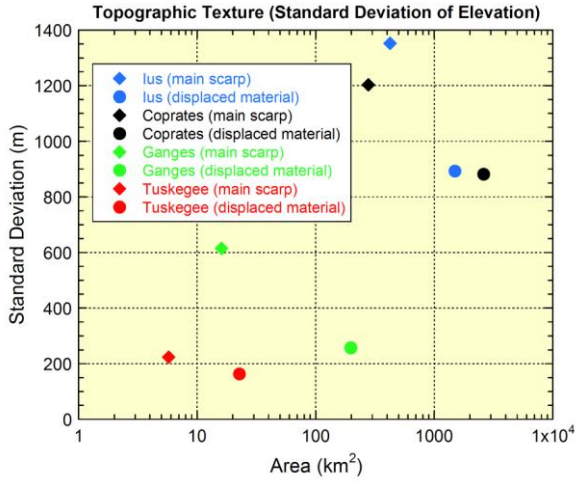

Figure 2. Topographic texture of the main scarp and displaced material plotted versus the area of the main scarp and displaced material for each landslide.

Discussion/Conclusion: The main scarp and displaced material of a landslide provide insight into the geomorphological and mechanical nature of the surface and shallow subsurface of Mars. Detailed morphometric analysis of four landslides in Valles Marineris indicates that they are dissimilar and complex. In part, we assume that this differentiation is related to a difference in fluidization. The Ganges and Tuskegee landslides display characteristics of "wet" mass wasting events that resemble terrestrial debris flows, while the Ius and Coprates landslides—with a more rugged topographic texture or surface morphology—display characteristics of "dry" events that may be analogous to large, dry terrestrial rock avalanches. The state (e.g., stabilized, reactivated), water content, and history of movement of these landslides in Valles Marineris are still poorly known.

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References: [1] Varnes D. J. (1978) Slope Movement 43: Types and Processes, *in* Schuster R. L. and Krizek R. J., eds., Landslides—Analysis and Control: Transportation Research Board Special Report 176, National Research Council, Washington, D.C. [2] Wilson J. P. and Gallant J. C. (2000) Terrain Analysis: Principles and Applications. New York: John Wiley & Sons, Inc.

Table 1. Landslide Morphometry

Parameter		Ius	Coprates	Ganges	Tuskegee
Location	Latitude	6° 29' S	12° 47' S	7° 43' S	2° 56' S
	Longitude	85° 16' W	59° 7' W	41° 25' W	35° 22' W
Area (km^2)	Main Scarp	424	279	16	6
	Displaced Material	1493	2610	198	23
Mean Slope (degrees) [± 1 σ]	Main Scarp	27.2 ± 6.2	27.8 ± 5.4	31.6 ± 6.1	21.3 ± 1.6
	Displaced Material	9.2 ± 5.7	6.2 ± 5.0	4.0 ± 5.2	6.6 ± 7.0
Topographic Texture (m) [Standard Deviation of Elevation]	Main Scarp	1352	1203	615	224
	Displaced Material	893	882	257	164
Elevation (m) [Main Scarp]	Minimum	-1080	-1560	-2796	-3428
	Maximum	4584	3165	-448	-2629
	Mean	1890	968	-1697	-3004
Elevation (m) [Displaced Material]	Minimum	-3240	-5135	-3774	-4031
	Maximum	1390	-739	-2190	-3312
	Mean	-1009	-3931	-3549	-3883

Note: DEM cell size is 463 m