HYPSOMETRIC ANALYSES OF MARTIAN BASINS. J. A. Grant[1] and C. Fortezzo[2], [1]Center for Earth and Planetary Studies, National Air and Space Museum, MRC 315, Smithsonian Institution, Washington, DC 20560, grantj@nasm.si.edu, [2]Colorado State University, Dept. of Earth Resources, Fort Collins, CO 80523.

Introduction: Martian valley networks and their associated drainage basins have been the focus of numerous morphometric studies geared towards understanding the source of water responsible for their evolution. Until recently, the absence of reliable topographic data for Martian basins has limited morphometric analyses of the valley systems primarily to derivation of linear and areal parameters [1-2]. The spectacular Mars Global Surveyor Mars Orbiter Laser Altimeter (MOLA) topographic data now available for Mars, however, enables quantitative assessment of basin area versus elevation characteristics [3-5] that may shed new light on important processes influencing valley formation.

Hypsometric Analyses of Drainage Systems: The degree to which a basin surface has been fluvially eroded into slopes can be evaluated by studying elevation versus area relationships [10, 11]. The resultant distribution of topography can also be an indication of whether the dominant source of water responsible for eroding the basin was precipitation and runoff versus groundwater sapping [3-5]. Integrating the proportion of remaining basin relief relative to area within a basin yields the hypsometric index (HI), which, along with related measure of the skewness and kurtosis of the resultant curve, can help identify properties characteristic of runoff versus sapping dominated systems [3-5]. Typical terrestrial values for HI range from 0.2 to 0.8, with values below ~0.5 being more consistent with runoff dominated drainages [3, 5]. Emphasis here is placed on consideration of HI for a variety of basins on Mars and the Moon, whereas calculations of associated kurtosis and skewness values are ongoing.

Martian Drainage Hypsometry: Previous evaluation of Martian hypsometry [3-5] confirms that the MOLA data possess sufficient fidelity to characterize basin properties. The present study utilizes MOLA data gridded at 1/60th of a degree, nearly a factor of two better than previously employed [3-5], and especially targets hypsometry of basins in Margaritifer Sinus that are associated with Samara and Parana-Loire Valles (Fig. 1). Additional basins in Terra Tyrrhena, Lunae, and Solis Planum (one basin) are also examined. The hypsometry of basins fringing Mare Orientale on the Moon is also derived (using Clementine laser altimeter data) for comparison.

Basin Settings: The Margaritifer Sinus and Terra Tyrrhena regions of Mars preserve some of most extensive and best integrated valley networks on the planet [1, 2, 6-9, 12-14]. In Margaritifer Sinus, two large northwest flowing valley systems, Samara and Parana-Loire Valles, drain an area exceeding 540,000 km^2 before converging on Margaritifer Basin [2], a confluence plain shared with the northward draining Uzboi-Ladon-Margaritifer Valles meso-scale outlflow system [1]. Valleys in Terra Tyrrhena are also well integrated and drain areas exceeding 310,000 km^2 [12, 13]. Geologic and morphometric mapping of valley systems in both regions [1, 2, 12, 14] confirms most preserved valleys were incised from the late Noachian into the early Hesperian and suggests that both precipitation and ground water sapping contributed to their evolution [1, 2, 5]. By contrast, Lunae and Solis Planum are regions on Mars whose preserved history is dominated by volcanic and impact processes with relatively little in the way of preserved valleys [15]. Finally, basin hypsometry in the annulus surrounding the Orientale impact basin on the Moon is derived to include consideration of basins devoid of any possible fluvial influence.

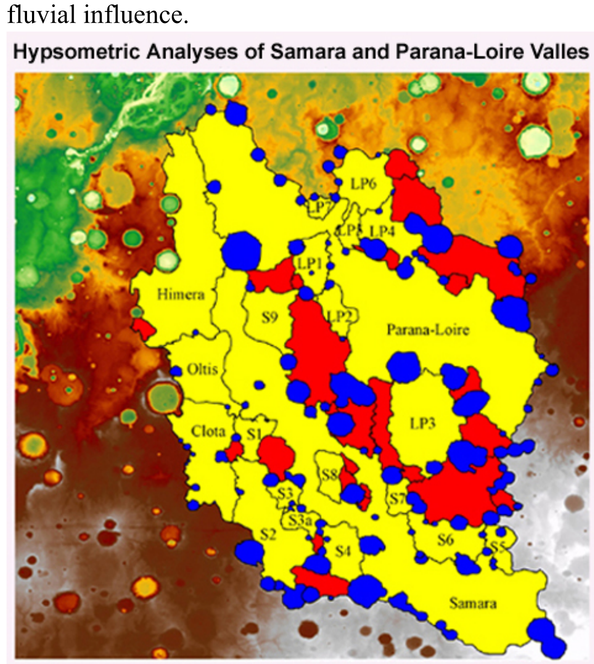

Figure 1. Basins associated with Samara and Parana-Loire valley systems in southeastern Margaritifer Sinus. Similar maps were compiled for other regions investigated and all basins were evaluated using ArcView GIS.

Results: Average hypsometric indices derived for all of the basins studied in each region are presented in Table 1 together with their total range and standard deviation. The average and range of HI for the Martian basins is largely independent of the presence of an incorporated valley system. For example, values of HI for Margaritifer Sinus, Terra Tyrrhena, Lunae Planum, and Solis Planum are broadly similar and range from those typical of terrestrial basins dominated by runoff to those more characteristic of sapping [3, 4] Interestingly, lunar HI's have the lowest average value, range, and standard deviation. The relatively coarse grid of the lunar data, however, requires that these absolute values for HI be viewed with some caution.

In general, the results for Mars are consistent with those derived previously and that were interpreted as supporting the contention that precipitation-recharged groundwater sapping has played an important role in valley evolution [3-5]. The fact that the value, range and standard deviation of HI on Mars appears to be largely independent of setting and that at least some lunar basins are characterized by hypsometric indices expected for drainage basins on the Earth suggests that other processes may have helped to shape the basins.

Table 1. Hypsometric Indices for Mars and Moon

Region	Average Hyps. Index (HI)	Range of HI	Std. Dev. HI
Marg. Sinus	0.54	0.69-0.38	0.087
Terra Tyrrhena	0.66	0.78-0.42	0.103
Lunae Planum	0.56	0.77-0.25	0.163
Solis Planum	0.41	N/A	N/A
Moon (Orientale)	0.50	0.56-0.35	0.084

Discussion: In the terrestrial system, the hypsometric index typically is used to characterize the changing relief relative to area within a drainage basin evolving via fluvial erosion, transport and removal of material. Hence, the resultant distribution of elevation with respect to area can, in some sense, be equated to the amount of erosion a basin has been subjected to via evolution of the incorporated drainage network. Basins experiencing mostly sapping activity undergo more localized, but lesser overall erosion than can be accomplished in basins subjected to runoff [3]. Taken at face value, therefore, the Martian values for HI suggest that both sapping and runoff have played a role in basin evolution. It is more difficult to reconcile, however, why Martian values of HI appear independent of the presence of an incorporated valley system or general geologic setting and why some intra-system basins possess varying HI values.

One possible explanation for the HI values derived for both the Martian and lunar basins relates to the primary activity responsible for shaping the initial catchment: impact processes on Mars and the Moon. By contrast, much of the topography responsible for definition of terrestrial basins is the result of tectonics or activity by alternate processes, with impacts playing an insignificant role. The craters produced by impact possess hypsometry differing from that evolved in a typical tectonic setting. As a result, many cratered surfaces may be "pre-conditioned" for fluvial evolution by possessing initial area-elevation characteristics comparable to those evolved after significant fluvial degradation on the Earth. This statement is supported by HI values derived for the Martian and lunar basins where drainage is absent, but that are in the range expected for terrestrial drainages. Hence, the hypsometry of the Martian valleys may more reflect initial basin configuration and the requirement of minimal erosion to establish an equilibrium drainage profile than the source of water responsible for formation.

Summary: Hypsometric analyses of Martian basins in varying settings and lunar basins in the Orientale Basin annulus confirm HI values in the range expected for fluvially-eroded terrestrial basins. Perhaps indicative of the source of water causing erosion of Mars valleys, the similarity and range of Martian and lunar values also suggests the distribution of relief in basins created by impact vs. tectonics requires minimal fluvial modification for efficient drainage.

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