TOPOGRAPHIC VARIABILITY ON MARS: IMPLICATIONS FOR LAVA FLOW MODELING. L. S. Glaze and S. M. Baloga, Proxemy Research (20528 Farcroft Lane, Laytonsville, MD 20882; lori@proxemy.com).

Introduction: Understanding the scale of lava flow dimensions relative to the surrounding topography may be important for extracting inferences about rheologic changes and interpreting the style of emplacement [1, 2]. The underlying scientific issue is whether flow emplacement is controlled by the large-scale topographic inclination or whether the flow path and emplacement style are substantially influenced by small-scale topography and pre-existing lava flows. The degree of topographic influence has important implications for the validity of theoretical models from which inferences are derived. Specifically, most elementary treatments assume internal streamlines that are parallel, as often seen in the cartoons of flows on an inclined plane. Such an assumption has major ramifications for how models treat internal heat transfer, the character of internal deformation and circulation and perhaps, most importantly, the exposure of the upper crust and radiant heat losses, as well as transient turbulent conditions [3 - 6]. Thus understanding the influence of ambient topographic variability relative to the assumptions of theoretical models is of major significance to their validity.

Topographic Variability: The data presented here are based on statistical analysis of thousands of elevation values in 181 MOLA PEDRs, for ten volcanic areas (Table 1). The resutls are robust because of the large number of data points analyzed and the remarkably well-behaved character of the topographies investigated. The approach employs standard linear regression techniques to fit curves to individual MOLA PEDR profiles over several degrees in each area [7]. The areas were selected because they contain numerous prominent lava flows, although many of the lava flows overlap, intermingle, and cannot be discerned as long solitary, isolated lobate units.

All PEDRs analyzed were well fit by simple polynomial regressions. The standard deviations, *s*, on these regressions are an indicator of the degree of variability in the topography that is superimposed on the regionally sloping trend. The standard deviations for the PEDRs in each of the ten study areas can be averaged together to estimate the overall regional topographic variability (Table 2). When the residuals are normally distributed, as they are in almost all cases, ~68% of the topographic variability should be contained in the range ± 1*s* around the regional trending slope. For example, regressions on the eleven PEDRs analyzed for flow 6 have an average standard deviation (1*s*) of 39.4 m. Flow 6 ranges in thickness from 10 – 40 m. Thus, the flow was emplaced on topography at roughly the same scale as the flow itself, which may have influenced the emplacement process.

Table 2. *Flow Characteristics*

Lava Flow		Mean *s* (m)	Δh/ΔL (m/km)
1	Pavonis	14.4	0.06
2	Pavonis	17.8	0.10
3	Arsia	31.5	0.27
4	Arsia	32.4	0.14
5	Ascraeus	36.9	0.14
6	Elysium	39.4	0.54
7	Elysium	48.0	0.95
8	Elysium	54.5	2.04
9	Alba	57.5	2.2
10	Alba	58.4	1.0

Table 1. *Flow Characteristics*

Lava Flow /location		H range (m)	Slope (°)	Channel?	Δ*L* (km)	# of PEDRs	Latitude Range	Longitude Range
1	Pavonis	13 – 40	0.09	Yes	306	18	6° – 10° N	239° – 245° E
2	Pavonis	30 – 60	0.05	Yes	175	28	8° – 14° N	243.8° – 245.8° E
3	Arsia	12 – 35	0.35	No	76	10	5° S – 2° N	236.5° – 238.5° E
4	Arsia	12 – 31	0.7	Yes	75	10	5° S – 2° N	238.8° – 241.8° E
5	Ascraeus	10 – 45	0.5	Yes	190	33	5° – 10° N	248° – 251° E
6	Elysium	10 – 40	0.6	No	40	11	28º - 31º N	142º – 143º E
7	Elysium	25 – 100	1.0	No	97	22	30º - 35º N	145º – 147º E
8	Elysium	34 – 85	0.8	No	29	16	30º - 35º N	147º – 149º E
9	Alba	16 – 225	0.4	No	77	12	33° – 39° N	257.8° – 258.8° E
10	Alba	5 – 217	0.6	No	107	21	33° – 36° N	255.5° – 257.5° E

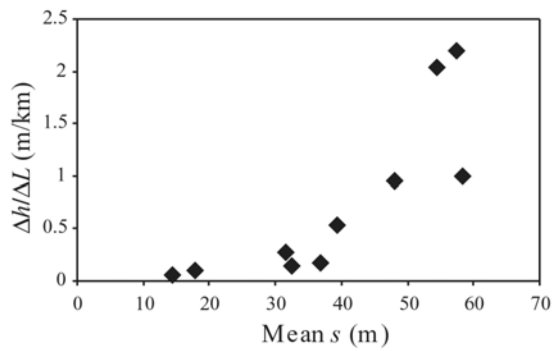
Interpretation: The mean s values in Table 2 are listed in order of increasing magnitude. It is interesting to note that the magnitude is very strongly correlated with volcanic region. While it is not surprising that the topographic variability would be similar for the two areas south of Alba, or north of Arsia, it is remarkable that all the values for the three Tharsis volcanoes fall within a range that is distinct from Elysium and Alba.

Despite this direct correlation with volcanic region, there is only a weak correlation between mean s and emplacement slope. This weak correlation can be seen by looking at the fourth column in Table 1 (arranged from smallest to largest mean s). The apparent correlation can be tested statistically using the Pearson Product Moment (PPM) linear correlation coefficient [8]. In this case, the PPM is $r = 0.677$. While the correlation is relatively weak, r is slightly greater than the critical value of 0.632 (10 points, 5% significance), and therefore, statistically significant.

This weak correlation is interpreted as an indication that volcanoes producing many lava flows have a net effect of increasing the topographic variability and eventually producing a construct with relatively steeper emplacement slopes. Although not quantified in the existing terrestrial literature, this type of correlation is not unheard of on Earth. For example, the slopes of Hualalai, Hawaii (as great as 12 degrees near the summit), are considerably steeper than its neighbor Mauna Loa (typically 7 – 9 degrees near the summit). Likewise, the topography at Hualalai is qualitatively "rougher". On Earth, however, it is difficult to ascertain to what degree these differences are influenced by eruption conditions, as lava composition plays an important role in the extent to which effused flows affect the topographic variability. Unfortunately, the relationship between topographic variability and volcano morphology has not been studied on Earth. It is presently difficult to unravel the effects of eruptive style, topography and composition, relative to the growth of the volcano.

The influence of topographic variability on the emplacement process itself can also be explored. To quantify changes in rheology along the flow path, another statistic has been developed that measures raw thickening (Δh) along the length of a flow (ΔL). The statistic is defined as $\Delta h/\Delta L$ and is, in essence, a rough measure of the viscosity increase along the length of the flow examined, ΔL. Estimated values of this statistic for all 10 flows are given in Table 2.

Figure 1 shows the relationship between flow thickening and topographic variability as described by the mean s. Visually, the thickening statistic appears to show some correlation with s. The PPM for $\Delta h/\Delta L$ and s is $r = 0.828$, which is relatively strong and statistically significant (again, compared to the critical value of 0.632).



The most straightforward interpretation of the apparent correlation between topography and thickening behavior is that an increase in the overall topographic variability tends to increase the disruption of stream lines within the flow, and possibly the upper surface crust. The subsequent cooling of the interior results in an increase in the internal viscosity of the lava, which causes a greater degree of thickening per unit length. The range of topographic variabilities of the pre-existing surface may be the result of variations in eruption conditions, indicating a very different eruptive style at Elysium Mons as compared to, say, the Tharsis shield volcanoes.

Conclusions: Ambient topographic variability and the style, dimensions, and thickening rates of lava flows are clearly interrelated with significant large scale implications for the shapes of volcanic constructs on Mars. The strong correlation between topography and rheology may have a profound impact on how lava flows are modeled. To date, most models have assumed that lava flows are emplaced on a relatively smooth inclined plane, i.e., surface roughness can be ignored. However, this study seems to indicate that the local topographic variability affects the ability of a lava flow crust to retain internal core heat. Thus, the topography may be a stronger influence on rheologic changes than previously assumed.

References: [1] Glaze L. S. et al. (2003) *Icarus*, *165*, 26-33. [2] Baloga S. M. et al. (2003) *JGR, 108* (*E7*). [3] Crisp J. A. and Baloga S. M. (1990) *JGR, 95*, 1255-1270. [4] Crisp J. A. and Baloga S. M. (1994) *JGR, 99*, 11,819-11,832. [5] Rowland S. K. et al. (2004) *JGR, 109* (E10010). [6] Glaze L. S. and Baloga S. M. (2006) *JGR, 111* (E09006). [7] Glaze L. S. and Baloga S. M. (2006) *LPSC XXXVII* #1302. [8] Sheskin (1997) *Handbook of Parametric and Nonparametric Statistical Procedures*, CRC Press.