TOPOGRAPHIC VARIABILITY: IMPLICATIONS FOR LAVA FLOW MODELING. L. S. Glaze[1] and S. M. Baloga[1], [1]Proxemy Research (14300 Gallant Fox Lane, Suite 225, Bowie, MD 20715; lori@proxemy.com, steve@proxemy.com).

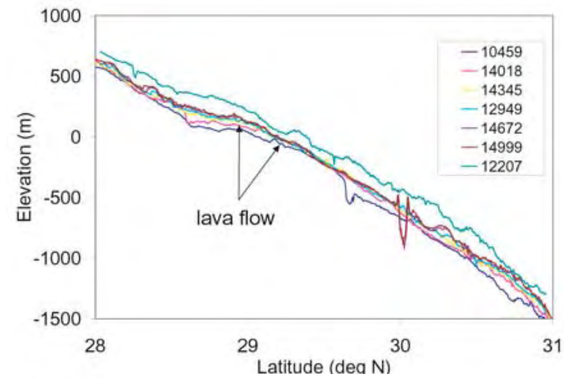
Introduction: *Glaze et al.* [1] and *Baloga et al.* [2] have both recently indicated the importance of understanding the scale of a lava flow relative to the surrounding topography in extracting inferences about rheologic changes and the interpretation of the style of emplacement. The underlying scientific 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.

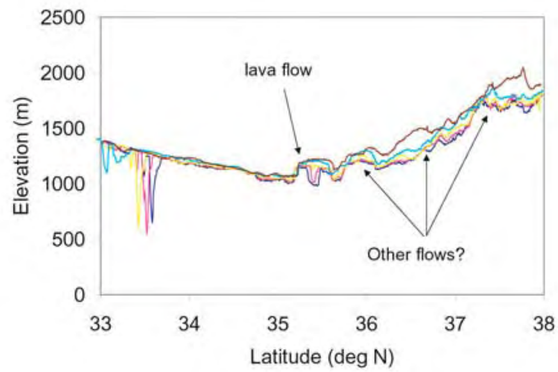
The as yet unanswered question is "What scale of underlying topography is significant for modifying emplacement behavior?" *Baloga et al.* [2] suggested that the flat topography found on the plains of Mars does not disrupt the emplacement of long thick flows sufficiently to expose the core. Thus there is virtually no cooling of the core and we do not see any evidence for a bulk viscosity increase over the length of the flow. Conversely, flows over "rougher" topography are shorter, exhibiting a greater degree of thickening and associated viscosity increase [1].

In addition to the science issues driving our desire to understand the scale of topographic variability, recent efforts have shown that reliable flow thickness profiles can be derived from MOLA Precision Experiment Data Records (PEDRs) [1]. For large flows (significantly thicker than surrounding topographic variation), we can use gridded MOLA data [2] to find flow thicknesses. However, as the flow thickness approaches the same scale as the surrounding topographic variations, the gridded MOLA data become increasingly unreliable.

Intuitively, it seems that the influence of variable topography must be in some way measured relative to the thickness of the flow in question, *i.e*, a 100 m thick flow would be sensitive to topography at a much greater scale than a 10 m flow. Here, we present a method for quantifying topographic variability relative to lava flow thickness that uses MOLA PEDR profiles directly. The basic method is relatively straightforward, but very effective for characterizing topography.

Methodology: Our approach is to analyze the residuals that result from standard statistical regression techniques applied to the MOLA PEDR profiles over several degrees in the region of a lava flow. Figure 1a shows seven MOLA PEDR profiles in the region north of Elysium Mons. The arrows in Figure 1a point to a 10 - 40 m thick lava flow oriented roughly perpendicular to the MOLA PEDR profiles. We can see that the thickness of this lava flow is at a similar scale to the ambient topography and that it is difficult to even identify the flow from the proffles alone [1].





Each PEDR profile in Figure 1a is very well fit by a simple linear regression. Table 1 shows the very high R^2 values for each profile, confirming a significant linear trend in the regional slope. The third column of Table 1 lists the standard error on each regression. The value of the standard error is analogous to the standard deviation of the regression residuals. Averaging, we find that the mean standard error is 78.6 m for the seven PEDR profiles shown in Figure 1a. Thus, ~68% (1 standard deviation) of the topographic variability should be contained in the range ± 78.6 m around the regional trending slope. This confirms our impression that a lava flow between 10 and 40 m thick should be profoundly influenced by the topography. Indeed, the viscosity for this flow exhibits a strong exponentially increasing trend, with an overall increase of ~50 times over 35 km [1].

Alternatively, Figure 1b shows several PEDR profiles across the southeastern flank of Alba Patera. The vertical scales of Figures 1a and 1b are the same. Here we see that the ambient topographic fluctuations appear to be smaller than north of Elysium Mons. In addition, several very large lava flows and other major topographic features are clearly identifiable in the PEDR data.

Table 1. *Topographic Variability: Elysium*

PEDR	R^2 (%)	std. error (m)
10459	97.9	87.6
14999	98.4	75
14672	98.3	73.5
14345	98.1	81.1
14018	97.9	83.8
12949	98.4	72
12207	98	77.7

Table 2 lists the R^2 values and standard errors for polynomial regressions on the PEDR profiles. Because the lava flow of interest is so large, we have excluded it from the regression. The very large fractures to the south have also been excluded. Further, each PEDR profile has been split into two segments, one south and one north of the lava flow, owing to the different slopes in these two regions. Again, the R^2 values in Table 2 are very high, indicating that the regional slopes to the north and south of the large lava flow in Figure 1b are well-described by gently sloping parabolas. The average standard errors south and north of the lava flow are 14.3 m and 61.2 m, respectively, while the lava flow shown in Figure 1b ranges in thickness from 40 - 130 m. Thus, in contrast to the Elysium lava flows in Figure 1a, the Alba flow should exhibit very little influence from the underlying topography. The estimated viscosity increase for this flow is more linear in character. While similar in magnitude to the Elysium flow (~30 – 60 times), the increase takes place over a much longer distance (95 km) [3].

Discussion: An obvious measure for quantifying the infuence of topography on individual lava flows is a simple ratio of flow thickness to the standard error. For the Elysium example, this ratio would range between 0.13 - 0.51. At Alba, the ranges south and north of the lava flow are 2.5 - 8.1 and 0.75 - 2.4. More analysis is required in order to determine what range of values is indicative of 'significant' topography, and at what scale the topographic variations are negligible to the flow dynamics. We are currently in the process of analyzing multiple volcanic flow regions near Elysium Mons, Alba Patera, Pavonis Mons, Ascraeus Mons, and the plains near Tharsis.

Part of this process includes characterizing topographic variability in the presence of other geologic structures, such as craters, ridges, grabens, pre-existing flows and so forth. Determination is made on a case-by-case basis whether there is an advantage to removing all pre-existing structures such that the fitted ambient topography produces normally distributed uncorrelated residuals [4, 5].

Table 2. *Topographic Variability: Alba*

	South		North	
PEDR	R^2 (%)	std. Error (m)	R^2 (%)	std. error (m)
12203	85.5	26.2	96.0	55
18943	97.1	17	96.5	81.9
12618	99.1	9.5	97.0	72.1
16567	98.1	14.1	98.2	54.5
19835	96.7	17.7	96.7	46.9
15083	97.4	14.4	96.1	52.5
12291	97.7	13.6	95.3	56.7
18390	98.9	8.7	95	58.5
20036	98.9	8.4	95.7	54.0
20237	97.3	11.2	92.6	66.1
16655	97.8	13.8	92.3	67.2
18855	97.3	17.1	91.2	69.5

Conclusions: Understanding the influence of ambient topography on the thickness profile of a lava flow is essential for unraveling rheologic changes during emplacement. We have developed a basic topographic variability measure based on the standard error of regression. This method uses the MOLA PEDR data directly. This new statistic can be used along with regional slope and rheologic character (e.g., viscosity change) to better understand the influence of topography on lava flow emplacement. This measure can also be used to help determine when gridded MOLA data can be used to derive thickness profiles.

References: [1] Glaze et al. (2003) *Icarus, 165*, 26-33. [2] Baloga et al. (2003), *JGR, 108,* doi:10.1029/2002JE001981. [3] Glaze et al. (2003) *LPSC XXXIV, Abstract #1315* [4] Draper and Smith (1998) *Applied Regression Analysis, 3rd Edition*, John Wiley. [5] Sheskin (1997) *Parametric and Non-parametric Statistical Procedures*, CRC Press.