Analysis of Alba Patera flows: A comparison of similarities and differences. K.M. Shockey, L.S. Glaze, S.M. Baloga, Proxemy Research (14300 Gallant Fox Lane, Suite 225, Bowie, MD 20715; kmshock@wam.umd.edu)

Introduction: Four Martian lava flows originating from Alba Patera are analyzed in order to compare and contrast characteristics such as relative viscosity increase, degree of degassing, emplacement times, and levee building. Alba Patera's summit is located at 41 °N, 250 °E. Two of the flows, Alba I and Alba III, are located south east of the summit. The other two flows, Alba V and Alba VI, are located west north west of the summit. Our objective is to identify correlations between rheology and emplacement environment, such as sensitivities to local slope and topographic variability. The data sets used in this study include Mars Global Surveyor (MGS) Mars Orbiter Camera (MOC) and Mars Orbiter Laser Altimeter (MOLA), along with recent Mars Odyssey Thermal Emission Imaging System (THEMIS) data and Viking data. The unprecedented volume, quality, and coverage of these data make it now possible to apply mature theoretical models that can help resolve longstanding scientific issues about emplacement of large lava flows on Mars.

Data Collection: As part of this project, we hope to examine a broad range of flow types at Alba. To date, we have examined four flows characterized as sheet flows by Cattermole [1]. A high resolution (128 pixels/degree) MOLA gridded Digital Elevation Model (DEM) was used to determine precise locations of these flows. Maplicity (http://webgis.wr.usgs.gov/) was then used to determine MGS orbit numbers in order to find MOLA Precision Experiment Data Records (PEDR) that cross the flows. When possible, only those orbits perpendicular to the flows were used.

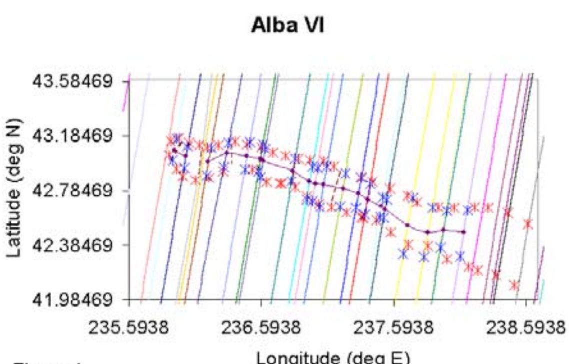

Figure 1

Figure 1 shows an example for the Alba VI flow. The edges of the flow as determined from the shaded relief are indicated by red asterisks, and those determined from individual MOLA PEDR profiles with blue asterisks. The diagonal lines represent individual MOLA orbit ground tracks. The purple line represents the approximate centerline of the flow.

The most important data required by lava rheology models are flow thickness, width and underlying slope, all as functions of distance. The underlying slope for each flow was found from the elevations along the uphill margins of the flows in each PEDR profile. Together, DEM and PEDR data have been compared to determine flow thickness, width, slope, and whether or not the flow contains a channel for a given length of the flow. Although the process sounds straightforward, there are, in fact, a variety of approaches that can be taken to estimate each of these variables. For thickness and width several methods were employed in order to extract more accurate measurements.

Two methods were used in order to determine the width of the flow. The first method directly used the cross flow profile from the PEDR data. As seen in figure 1 the daytime orbits from the MGS that were used are nearly perpendicular to this flow. The edges of the flow are determined from the profile and the distance between these points is calculated.

The second method for determining the width used the shaded relief data created from the DEM as well as the DEM data. Visually analyzing the shaded relief, the margins were determined at various points along the length of flow. Cross flow widths were taken perpendicular to the flow. The distance between the pairs of points were calculated using their latitude and longitudes.

If orbits crossing the flow are not perpendicular to the flow direction then the second method is the most accurate to use. If the orbits are perpendicular then the first method of using the PEDR profiles is the easiest. In the case of Alba VI the first thickness method was used.

Two methods were also used to analyze the thickness of the flows. Because the PEDR profiles are not quite perpendicular to the flow direction, there is some cross flow slope in each profile. The first thickness method directly used the PEDR profile data. In this case the profile was allowed to remain on an incline in order to determine the uphill margin (same approach as used by [2]). The elevation at the edge of this side of the flow and the elevation of the highest peak on this side of the flow were taken. The two were subtracted to find thickness.

The second of the two methods also used the profiles from the PEDR data but the incline was corrected by removing the trend between the flow margins. (same approach as used by [3]). From here the thickness could be pulled off of the profile (shown for Alba VI in Figure 2).

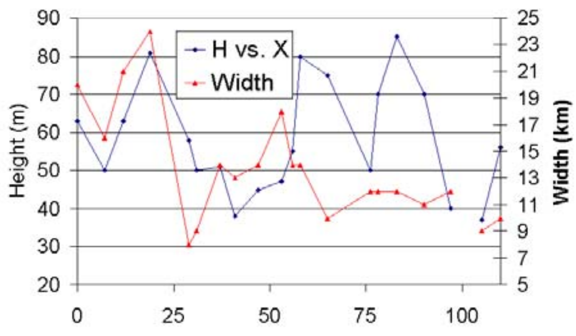

Figure 2

Both of these methods result in very similar estimates for flow thickness, indicating that the amount of cross flow slope introduced by the not-quite perpendicular PEDR profiles is not significant.

A third possible method for determining thickness is to find the regional slope by applying a least squares fit to the PEDR profile and then removing this truly "regional" slope. Based on the fact that both of the previous approaches gave similar results we have concluded that this additional step is not required.

Analysis: As can be seen from Table 1, similar lengths were analyzed for each of the four flows. In general, these flow lengths represent the portion of the flow that can be clearly identified as a single, coherent flow. Beyond the lengths given for Alba I and III, the flows blend in to the surrounding topography. For Alba V and VI, multiple upstream flow lobes appear to converge. In all cases, the portion examined includes the flow front and as much of the upstream flow as can be discerned in image and shaded relief data. It is not possible to identify the sources of these flows, nor to determine how far the portion of each flow examined is from its source. The underlying slopes of all four flows are less than a degree.

The formation (or not) of a channel is important in choosing an appropriate emplacement model due to its effect on volume conservation. Based primarily on the PEDR profiles, we have concluded that none of the four Alba flows discussed here showed any evidence of channel formation. Images from THEMIS, MOC, and Viking are consistent with this conclusion.

The systematic widening of a lava flow with distance is important to understand when trying to constrain flow rheology. When comparing the changing widths of the four flows, Alba V and VI remain at a constant width, or narrow slightly (e.g., Figure 2). In contrast both Alba I and III widen through the length of the flow examined.

Despite the similarity in flow length and underlying slope, a variety of thickening and widening behavior is observed between the four flows. Of the four flows only Alba VI showed a nearly consistent thickness (Figure 2). While there is a great deal of variability in flow thickness at Alba VI, there is no systematic trend in either direction. Similar to Alba VI, Alba V is also a relatively constant width along the length of the flow, and yet Alba V exhibits a significant thickening toward the flow front. Alba I and III thicken 3 - 5 times over the length of the flow. Using a lava flow model that allows for degassing [4], we estimate a viscosity increase of 30-60 times over the Alba I flow. We expect Alba III to show a greater viscosity increase, but not several orders of magnitude as predicted [5]. We expect essentially a constant viscosity for the Alba V and VI flows.

Conclusions: The four flows examined so far are similar in flow type, length, morphology and underlying slope. They exhibit a range of behaviors in flow thickness that do not appear to be correlated to changes in flow width or underlying slope. Thus, we conclude that these changes are a result of differences in lava rheology and/or differences in ambient topography or time-dependence in the effusion rate. The next step in this process is to complete the analysis of viscosity changes for all of the flows in more detail using appropriate models. We then plan to examine other flows on Alba to get a better understanding of the processes that drive Martian lava flows.

References: [1] Cattermole, P et al., (1990), *ICARUS, 83* [2] Glaze, LS et al., (2003), *ICARUS, 165* [3] Baloga, SM et al., (2003), *JGR, 10.1029/2002JE001981* [4] Baloga, SM et al., (2001), *JGR, 106, B7*, 13,395-13,405 [5] Glaze, LS and SM Baloga et al., (1998), *JGR, 103, E6*, 13,659-13,666.

Table 1. Flow numbers refer to an internal identification system.

Lava Flow	Length Studied (km)	Initial Thickness (m)	Front Thickness (m)	Channel	Slope (deg)
Alba I	95	40	130	No	0.4
Alba III	97	20	100	No	0.55
Alba V	143	45	108	No	0.16
Alba VI	110	63	56	No	0.82