COMPARISON OF LAVA FLOWS FROM HAWAII AND ASCRAEUS MONS. E. E. Bjonnes[1] and J. R. Zimbelman[2], [1]Rutgers University, Dept Geological Sciences, 610 Taylor Rd, Piscataway, NJ 08854, (emblue@eden.rutgers.edu); [2]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington DC 20013-7012 (zimbelmanj@si.edu).

Introduction: Extensive lava flows from shield-type volcanoes exist on both Earth and Mars. Hawaii is the prime example for several of these flows on Earth; here we examine a 1907 Mauna Loa flow and an older flow from Mauna Kea (Fig. 1).

Figure 1: Landsat image of Hawaii. Dot shows the Mauna Kea flow; line shows the Mauna Loa flow.

Olympus, Ascreaus, Pavonis, and Arsia Montes are the Martian equivalents of the Hawaiian shield volcanoes. Topography and thermal imaging from MOLA, MOC and THEMIS provide valuable information regarding the morphology of the lava flows surrounding the large Martian volcanoes (Fig. 2).

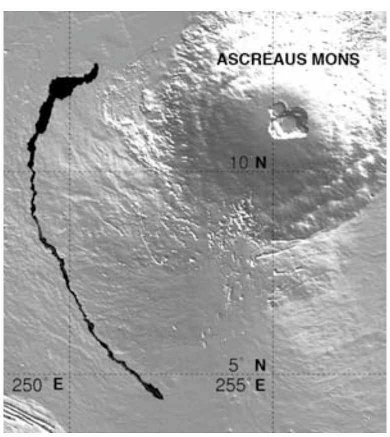

Figure 2: MOLA shaded relief image; black indicates the Martian flow examined here.

Direct comparisons between terrestrial and Martian lava flows provide valuable insight into compositional differences between magmas on both planets, and possibly differences in how the topography varies.

Methods: We georeferenced satellite images [1] and air photos of the Hawaiian lava flows to compare them to MOC and THEMIS data of the Martian lava flow. Field work [2] provided flow thickness data for several points along the Mauna Loa flow, as well as topographic profiles across both the Mauna Loa and Mauna Kea flows. We calculated yield strengths for these data using the following equations [c.f.. 3, 4]:

$$Y_1=\rho gH\sin\theta;$$
$$Y_2=\rho gH^2/W;$$
$$Y_3=\rho g(W-w)\sin^2\theta,$$

where ρ is the lava density (assumed to be 2500 kg/m^3), g is gravitational acceleration, H is the flow thickness, θ is the slope down-flow, W is the flow width, and w is the channel width (if any channels are present in the flow). The effusion rate (F) is given by:

$$F=300\kappa wL/H$$

where κ is the thermal diffusivity (assumed to be 7x10^{-7} m^2/s) and L is the flow length [5, 4]. Finally, we found the viscosity (η) using the equations:

$$\eta_x=w^3Y_x\sin^2\theta/(24F) \text{ (for r<1) and}$$
$$\eta_x=w^{11/4}Y_x^{5/4}\sin^{6/4}\theta/(24Fg^{1/4}\rho^{1/4}) \text{ (for r≥1)}$$

where r=w/(W-w) [5, 4].

Results: The focus of this project was to quantitatively compare Hawaiian and Martian lava flows. Figure 3 (next page) shows a portion of the georeferenced air photo of the Mauna Kea flow with field transects plotted over the image. Topographic profiles were generated using DGPS field data gathered in 2004 and 2005. These data document that the Mauna Loa flow has a much rougher surface than the Mauna Kea flow. Channels that are present in the Mauna Loa flow are much narrower than those found in the Mauna Kea flow. Much of the topography of the flow near Ascreaus Mons is more comparable to that of the Mauna Kea flow than the Mauna Loa flow. The Martian profiles are less irregular than the profiles across the Mauna Loa flow due to MOLA shot spacing. The Martian profiles, however, show a narrow channel similar to those in the Mauna Loa data, and a wide channel like those in the Mauna Loa flow. Channels are not continuous along the Martian flow.

To calculate the yield strength, effusion rate, and viscosity, we used the topographic profiles to determine dimensions of the flows. The total flow length is impossible to determine for the Mauna Kea flow due to erosion along the flow, but the total length of the Mauna Loa flow is between 21 and 22 km from the satellite images. We assumed the Martian lava flow near Ascreaus Mons to be at least 600 km based on THEMIS observations [6]. Using these and other values, the average for each calculation are given below:

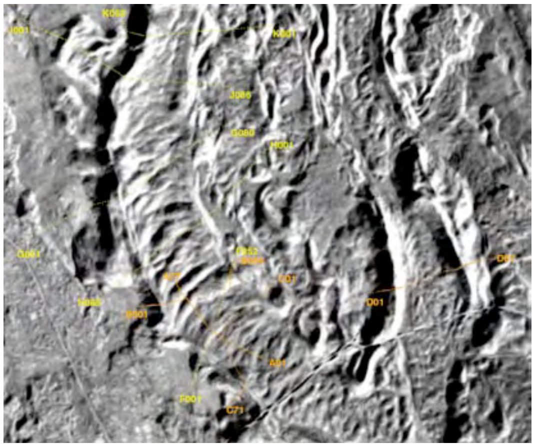

Figure 3: Georeferenced air photo over the Mauna Kea lava flow showing the GPS data points.

Location	Ascreaus Mons	Mauna Loa	Mauna Kea
Y_1	1.52E+03	1.74E+04	2.02E+04
Y_2	1.06E+03	5.83E+03	2.80E+04
Y_3	5.03E+03	5.59E+04	1.25E+04
F	1.51E+04	2.86E+01	
$\square_1$	4.44E+04	7.18E+04	
$\square_2$	1.92E+04	1.70E+04	
$\square_3$	6.56E+04	2.80E+05	

In the Martian calculations, the range of values for each category spanned an order of magnitude, with the average value roughly at the median. In the Hawaiian flows, however, the minimum and maximum values for each category vary only by a factor of 2-3, with the averages centered within the spread.

Discussion: The Mauna Kea flow has much larger channels than the Mauna Loa flow, indicating that whatever process is responsible for channel formation was more successful in the Mauna Kea lava. Channels in the Martian lava flow vary in width from narrow to wide, exhibiting characteristics of both terrestrial examples. The topography across the Ascreaus Mons flow is relatively smooth like the Mauna Kea flow. This could be a factor of the surface actually being smoother or the resolution of the topography artificially smoothing the surface.

The prominent result is the order-of-magnitude difference in yield strengths between the Martian and Hawaiian lavas. This is consistent with conclusions from the THEMIS data sets and compositional data returned by the MER project. Moreover, the Martian flow in question appears to extend to at least 500 km in length, which implies a lower overall yield strength. This discrepancy can be explained with data from the MER rovers, showing the basalts on Mars to be more silicic than those on Earth and not by the differences in gravitational acceleration. Any increased concentration of silica, even in small amounts, will significantly lower the yield strength of the resulting lava, as is seen in the morphological calculations. It is interesting to note that even with differences in yield strengths between the Martian and Hawaiian lava flows, the calculated viscosities are within an order of magnitude.

Conclusions: The Martian and terrestrial lava flows analyzed here show interesting similarities while maintaining their distinct differences. The lower yield strengths of the Martian lava, as determined by topographical features, indicates that there is some feature in Martian lava that prevented it from sustaining as much vertical pressure as terrestrial lava. Even with this, however, the viscosities are similar between the two planets. More examples from both Mars and Earth are needed to assure that such characteristics are indeed similar and are not due to small sample size.

Comparing topography between the Hawaiian and Martian lava flows is more difficult because the resolution of the data are very different. The small-scale features that show up in topographic profiles created by walking across the flow will almost certainly not show up as well from orbit. Consequently, the fact that the surface of the Ascreaus Mons lava flow looks more similar to the smoother Mauna Kea flow may just be an artifact of data resolution. Because the yield strengths, viscosities, and effusion rates are calculated from larger observable features such as flow width, height, and length, the calculations presented here should be valid even with the resolution differences.

References: [1] http://infomart.pdc.org/ikonos. [2] Zimbelman J. R. (2004) *Eos, 85(47),* V33C-1473. [3] Moore H. et al. (1975) *Proc. LPSC 6th*, 101-118. [4] Zimbelman J. R. (1985) *Proc. LPSC 16th, JGR, 90*, D157-D162. [5] Wilson L. and Head J. W. *Nature, 302*, 663-669. [6] Shockey K. M. and Zimbelman J. R. (2005) *LPS XXXVI*, Abs. 1937, LPI, (CD-ROM).

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