MOLA TOPOGRAPHIC CONSTRAINTS ON LAVA TUBE EFFUSION RATES FOR ALBA PATERA, MARS. S.J. Riedel[1], S.E.H. Sakimoto[1], [1]GEST at Code 921, Geodynamics Branch, NASA/Goddard Space Flight Center, Greenbelt, MD 20771 (sj_riedel@hotmail.com), (sakimoto@core2.gsfc.nasa.gov)

Introduction: Alba Patera, Mars (40°N, 250°E) is by area one of the largest known volcanic edifices in the solar system, with a surface area of nearly 5.7 x 10^6 km^2 [1, 2]. It is characterized by several distinct flank slope regions, low average flanks slopes (<1°) and large lava tube and channel flows. Recent high resolution Mars Orbiter Laser Altimeter (MOLA) topography of the edifice reveal innumerable lava tube and channelized lava flows that are particularly well expressed topographically on the relatively shallow western flanks. [Figure 1] The topography clearly shows many more lava tube flows than are visible in prior images, and also suggests that many or even most of the "sheet" flows have topographic central channels.

Alba Patera is on the northern extent of the Tharsis Bulge, and has apparently been present and active throughout a large fraction of Mars' history [3,4]. Alba Patera flow materials are found up to 2500 km from its summit region in the northern plains, and the edifice covers over 5.7 x 10^6 km^2, or about 5% of the surface of Mars [1, 2]. Understanding the eruptive mechanisms and effusive rates is therefore key to the regional thermal history. MOLA topography for Alba Patera shows local to regional scale variations in relative abundance and sizes of lava tube and channelized flows. The upper flanks and summit area are slightly steeper than the lower flanks (slopes ranging from 0.5 to a few degrees, rather than a few tenths of a degree) and tend to have shorter apparent flow distances, and relatively fewer tubes versus channelized flows The topography of the western mid to lower flanks is dominated by the low ridge morphology of lava tube flows. The relative abundance of tube-fed flows per unit area is possibly one of the highest on Mars. Relative abundance of tube fed flows on the lower slopes and lack thereof on the upper slopes of Alba Patera may indicate separate effusive periods, or may be a product of increased slopes and thus less steady flows that are not conducive to channel roofing.

We are using MOLA data as topographic constraints in fluid flow models to estimate effusive rates for flows at Alba Patera. Eventually, we expect to compare channelized and tube flows throughout the Alba Patera edifice, but here, we present preliminary results for lava tube-fed flows on the western flanks of Alba Patera, Mars.

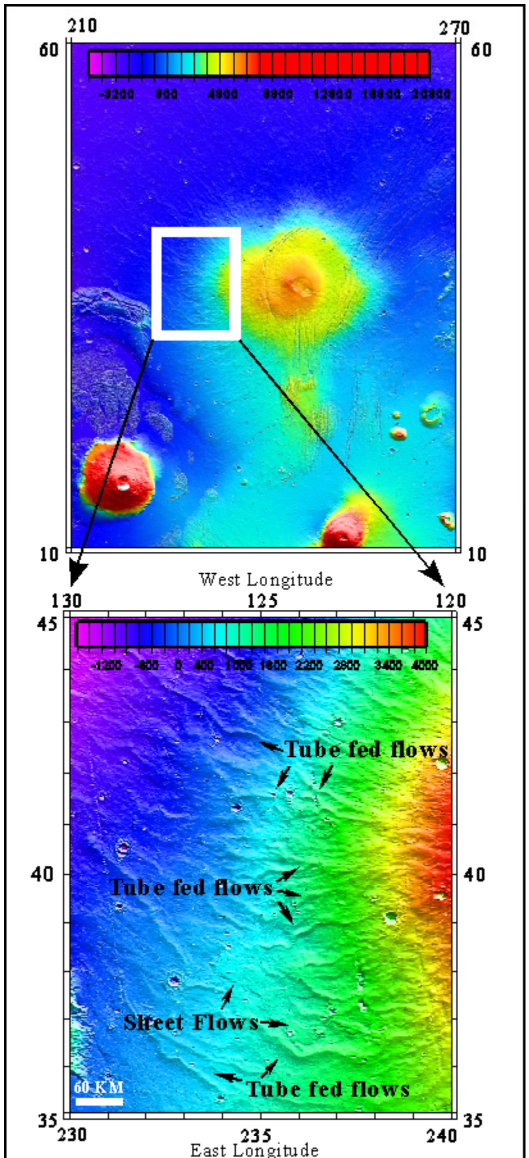


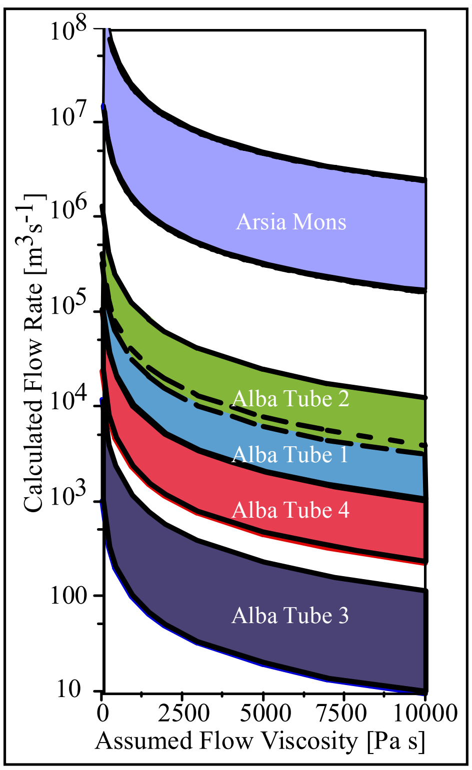
Figure 1. Alba Patera high resolution topography grids at 64 x 256 pixels per degree. Top showing regional area, bottom includes mid to lower western flank region, with 0.1degree slope.

Methods: *Geometric Measurements:* We use MOLA topography profile data regridded with crossover corrections [5] at 64 pixels/per degree in longitude by 256 pixels per degree in latitude—or approximately 900 by 200 meters per pixel. This MOLA gridded data, the MOLA profile data, and Viking imagery are used to locate, identify, and quantitatively characterize lava flow morphology (e.g. lava tube collapse dimensions, flow dimensions, and regional slope). Individual profiles were used for the actual flow measurements, while the gridded topography and images were used for location control and regional (e.g. slope) measurements. MOLA footprints in mapping orbit are approximately 160 meter across and 300 meters apart along track, with absolute vertical accuracy in the submeter level [5, 6, and 7].

Modeling: Using an existing analytic solution of Newtonian rectangular channel flow [8, 9, and 10] along with the above channel topography measurements, we calculate volume flow rates for an assumed range of basaltic magma densities and viscosities. The flow model is an isothermal laminar steady Newtonian flow in a rectangular channel (assuming that the tube is just short of full). The volumetric flow rate is expressed as

$$Q = \frac{4ba^3\rho g \sin(\theta)}{6\mu}\left[1 - \frac{192a}{\pi^5 b}\sum_{i=1,3,5\ldots}^{\infty}\frac{\tanh(i\pi b/2a)}{i^5}\right]$$

where b is the channel depth, 2a is the channel width, μ is the viscosity, ρ is the density, θ is the underlying slope, and g is the acceleration of gravity [8, 9 and 10]. Where channels are very wide relative to their depth, the results approach that of a standard infinite sheet flow model [10].



Results: *Geometric Measurements:* We find that the typical Alba Patera Lava tubes commonly display remarkably consistent tube collapse cross-sections and flow widths along the flows. This consistent flow geometry suggest steady flow rates with consistent underlying slopes, which is consistent with the observed current slopes, which are constant to within less than a tenth of a degree over hundreds of km for many parts of Alba Patera.

Modeling: Our calculations of effusive rates for Alba Patera are thus far within the range shown in Figure 2. Effusive rates for individual flow units vary up to 1.19×10^3. Regionally, flow rates range from 10 Pa s to 1.308×10^6 Pa s. Any volcanic feature shows a characteristic range of calculated eruption rates: Our calculated rates for the western flanks of Alba Patera are commonly several orders of magnitude less than those calculated for other Martian edifices such as Arsia Mons, and Syrtis using the same model. The lower range of eruption rates for Alba Patera is within the range of the highest terrestrial volcanic flows such as the 1984 Mauna Loa, North Queensland, and the Columbia River basalts [11]. The highest range for Alba Patera is several orders of magnitude higher than the effusive rates for any terrestrial analogs.

Conclusion: Alba Patera has long been an edifice of interest due to its immense arial extent and its prominent role in Mars' volcanic history. The new MOLA topographic data confirms its significance, and also reveals a more significant contribution of lava tubes in its construction. Our models use the high resolution topographic data to accurately model flow rates, and we find that Alba Patera tube flows within the mid to lower western flanks [Fig 1] typically could accommodate flow rates between 10 Pa s and 1.308×10^6 Pa s. This is less than prior work [8, 9, 10, 12, and 13] has found for Arsia Mona and Syrtis Major using the same models. We anticipate that comparisons of these results to those in progress for the upper and lower flanks will provide a more accurate assessment of relative tube and channel flow as a proxy for effusion steadiness and rate. This combined with upcoming relative abundance and dating work will help constrain the construction and relative eruptive styles of Alba Patera through time, and in comparison to other martian and terrestrial edifices.

References: [1] Cattermole et al. (1990) *Icarus*, 83, 453-493. [2] McGovern et al. (2001), *JGR planets,* 23,769-23,809. [3] Tanaka et al. (1992) *Mars*, 345-381. [4] Solomon et al. (2001) *EOS Transactions*, 82(20), P31A-06. [5] Neumann et al. (2001) *JGR planets,* 23,753-23,768. [6] Smith et al. (1998) *Science*, 279, 1686-1692. [7] Smith et al. (1999) *Science*, 284, 1495-1503. [8] Gregg and Sakimoto (1998) *LPSC XXI*, # 1499. [9] Gregg and Sakimoto (2000) *LPSC XXI,* #1758. [10] Sakimoto, S.E.H. and T.K.P. Gregg, (2001) *JGR Solid Earth*, 8629-8644. [11] Cattermole et al. (1996). [12] Sakimoto et al. (2000) *EOS Transactions* 81(19) S293. [13] Sakimoto et al. (2000) *EOS Transactions*, 81(48) F782.