EMPLACEMENT CONDITIONS AND VENT LOCATIONS FOR THE CHANNELIZED AND PARTIALLY BURIED LAVA FLOWS SOUTHWEST OF ARSIA MONS. Ian T.W. Flynn[1], David A. Crown[2], Michael S. Ramsey[1]. [1]Department of Geology and Environmental Science, University of Pittsburgh, Pittsburgh, PA 15260, itf2@pitt.edu. [2]Planetary Science Institute, Tucson, AZ 85719.

Introduction: Channelized lava flows are commonly observed in the major volcanic provinces on Mars. The morphology of these flows indicate specific emplacement conditions, which can be modeled to determine flow parameters such as viscosity, emplacement duration, effusion rate, and yield strength [1-4]. However, most channelized flows are only partially exposed due to overlapping younger flows or aeolian mantling. This is observed extensively throughout the lava flow field south of Arsia Mons [5]. Models that rely upon the visible extent of a flow can provide useful insights, but those results could easily misrepresent the true flow conditions at the time of emplacement.

In this study, we present an application of the PyFLOWGO thermorheological model, developed for terrestrial applications and modified for Mars conditions. The goal is to determine the emplacement and flow parameters of a subset of the Arsia Mons channelized flows whose aerial extent is not completely visible (Fig. 1). Applying the model in a novel way to constrain channel width rather than the exposed channel length provides the capability to estimate the actual channel length. We can then project this length upslope to search for potential vent locations.

Methods: The application of PyFLOWGO to Mars channelized lava flows presented here has two steps. For both, the baseline rheological parameters used are from the 2012-13 Tolbachik eruption, which represent a typical basaltic composition [6]. Adaptation of PyFLOWGO to Mars follows methods from [7] but with minor improvements. All modeling was performed over a constant slope of 2° that was calculated in ArcGIS v10.8 and derived from the Mars Orbiter Laser Altimeter (MOLA)/High Resolution Stereo Camera (HRSC) blended digital elvation model (DEM) (~200 m/pixel; ± 3 m vertical resolution).

Measurements of channel width, flow margins, channelized zones, plus channel depth for each flow were performed using the Context Camera (CTX) (~6 m/pixel) and MOLA Precision Experiment Data Point Records (PEDR (~160 m spot size, ~ 300 m along track spacing and 37 cm effective vertical resolution), respectively. The “starting” (first visible evidence) channel width and depth measurements are necessary to initiate the PyFLOWGO model. The central channel width measurements were also taken every 1000 m downflow to corroborate the results as the model propagates the flow downslope.

Step 1. We first vary three of the model inputs (eruption temperature, starting crystal fraction, and crystals grown during cooling) within reasonable ranges to match the exposed channel length to within <5%. This is a higher accuracy requirement than prior terrestrial applications of the model [8].

Step 2. We then use the rheological parameters determined from Step 1 and iteratively narrow the channel width assuming narrowing of the channel closer to the source [9-11]. This step is considered complete where the modeled channel width matches the distal channel width also to within <5%. This modeling step yields the actual channel length of the flow, in addition to the flow’s core temperature, viscosity, mean velocity, crust fraction, spectral radiance, and crust fraction at the time of emplacement. This length is then projected upslope, following the regional aspect and generated slope vectors to a potential vent location. Slope vectors were generated in ArcGIS v10.8 using the MOLA/HRSC blended DEM.

Results: For step 1, the average modeled effusion rate for the five flows studied was 4960 $m^3 s^{-1}$, ranging from 2500 - 6750 $m^3 s^{-1}$. These effusion rates are an order of magnitude higher than recent terrestrial eruptions, yet fall within the ranges from previous investigations of Arsia Mons lava flows [12-14]. The average viscosity for the five flows was 5.5 x 10^4 Pa s, with values ranging from 9.4 x 10^3 - 6.6 x 10^5 Pa s. These values are in the range for both large terrestrial eruptions and those calculated previously for Arisa Mons [14, 15].

For step 2, we found the average channel width for the flows narrowed ~ 600% over the length of the exposed channels. Assuming this narrowing rate further upslope, results for three of the flows (Flows 1, 3, and 5) project to the same feature. We identify this as a long (~48 km) rille with a measured average width of ~873 m (Fig. 2). A lava fan emantes from the southern end of the feature that later develops into a full flow field further south, adding creedance to a flow source location. The rille’s location relative to Arsia Mons is also consistent with terrestrial rift-analogs such as Hawai’i, the Galapagos, and Tolbachik [16, 17].

Conclusions: In this study, we applied a modified version of the PyFLOWGO model to five channelized flows southwest of Arsia Mons. With the flexibility of this model, we were able to first determine the effusion rates, lava viscosities, and then for three of these flows, a possible vent location. Our modeling indicates that these lava flows in the southwest Arsia Mons flow fields were emplaced with effusion rates an order of magnitude higher than those common for larger, modern terrestrial eruptions; but with similar viscosities. This study has shown that PyFLOWGO is an effective model to reproduce the emplacement conditions of planetary channelized flows.

With the ability to identify possible vent locations, we plan to compile a more complete record of flow field evolution as more flows are modeled. Future applications of this approach include modeling the other flows around Arsia Mons, as well as those in Daedalia Planum, Elysium Mons, and the other Tharsis volcanoes.

References: [1] Garry W. B. et al. (2007) *JGR Planets*, 112, 1-21. [2] Glaze L. S. & Baloga S. M. (2006) *JGR Planets*, 111, 1-10. [3] Hiesinger H. et al. (2007) *JGR*, 112, E05011, 24 pp. [4] Hodges C. A. & Moore H. J. (1994) *Atlas of volcanic landforms on Mars,* US Printing Office. [5] Crown D. A. & Ramsey M. S. (2017) *JVGR*, 342, 13-28. [6] Ramsey M. S. et al. (2019) *Ann. Geophys*, 62, 1-44. [7] Rowland S. K. et al. (2004) *JGR Planets*, 109, 1-16. [8] Rowland S. K. et al. (2005) *Bull Volc 67, 634-647.* [9] Cashman K. V. et al. (2013) *Geosphere* 9. [10] Dietterich H. R. & Cashman K. V. (2014) *JGR ES* 119, 1704-1724. [11] Peitersen M. & Crown D. A. (1999) *JGR* 104, 8473-8488. [12] Dvigalo V. N. et al. (2013) *JVS*, 7, 345-361. [13] Kubanek J. et al. (2017) *JGR SE* 122, 7754-7774. [14] Warner N. H. & Gregg T. K. P. (2003) *JGR Planets* 108. [15] Belousov A. & Belousova M. (2018 *Bull Volc* 80. [16] Rowland S. K. et al. (2002) *LPSC XXXIII*, Abstract #1441. [17] Bleacher J. E. et al. (2007) *JGR Planets*, 112, 1-15. [18] Hauber E. et al. (2009) *JVGR* 185, 69-95.

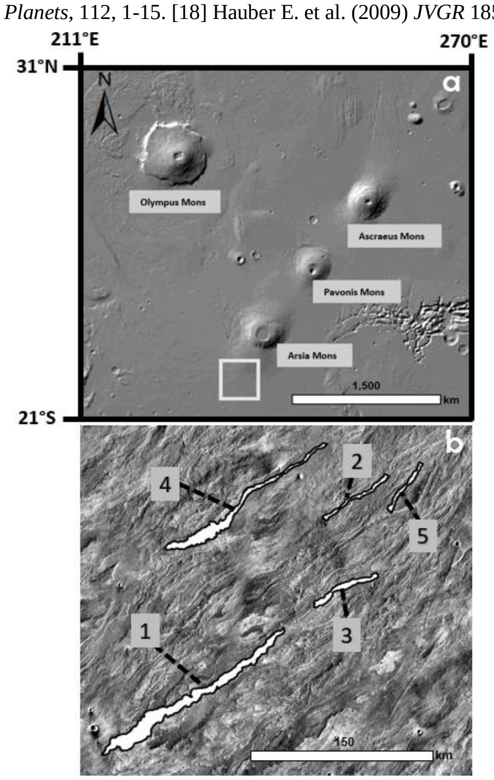

Figure 1 (previous column)*: (a) Shaded relief map derived from the MOLA/ HRSC blended DEM dataset, showing the Tharis volcanic region and the study area, outlined by the white box (14-20.5°S, 122.5-128.4°E). There are ~21 lava flows with well defined central channels in the study area; we chose five of these as representative based on size, areal distribution, and central channel development. (b) Thermal Emission Imaging System (THEMIS) day TIR mosaic of the five flows, outlined and numbered.*

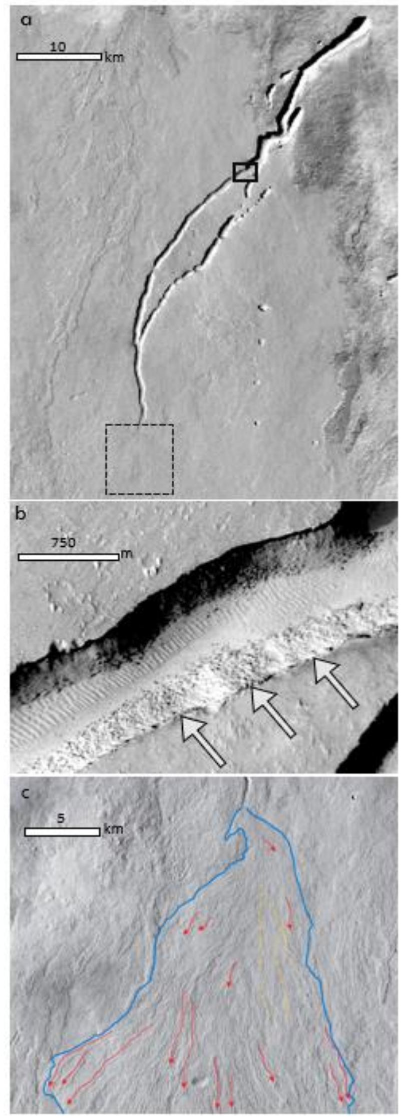

Figure 2. *(a) CTX mosaic showing the potential source/vent for Flows 1, 3, and 5 (feature is centered at 14.5°S, 237.5°E). The black solid and dashed line boxes indicate the regions shown in (b) and (c), respectively. (b) The layering along the rille wall (indicated by white arrows) is similar to that seen in linear vents identified east of Arsia Mons [18]. (c) Lava fan emanating from the end of the rille structure (outlined by the blue line), which develops into a full flow field further south. The orange dashed lines indicate lava channels, and the red arrows denote lava flows.*