MAPPING AND MODELING VENUSIAN LAVA FLOWS: IMPLICATIONS FOR FUTURE MISSIONS.

Ian T. W. Flynn[1], David A. Crown[2], Michael S. Ramsey[1], Magdalena O. Chevrel[3]. [1]Department of Geology and Environmental Science, University of Pittsburgh, Pittsburgh, PA 15260, itf2@pitt.edu. [2]Planetary Science Institute, Tucson, AZ 85719. [3]Laboratoire Magmas et Volcans (LMV), Université Clermont Auvergne, CNRS, IRD, OPGC, 63000 Clermont-Ferrand, France.

Introduction: Volcanism was (and potentially still is) an important process that shapes the Venusian surface. This is evident by the diverse array of volcanic features, surface VNIR emissivity anomalies, and lava flow morphologies observed globally during the Magellan and Venus Express missions [1-4]. A primary objective of the recently selected Venus Emissivity, Radio Science, InSAR, Topography, & Spectroscopy (VERITAS) and EnVISION missions is to determine whether Venus has active volcanism [5-6]. Much remains to be understood regarding Venusian extrusive volcanism, including the petrologic and rheologic properties of individual lava flows.

This research is the first stage of our focus on investigating Venusian channelized lava flows through both detailed flow mapping and thermorheologic modeling. The results from this work can be used to inform upcoming mission planning/operations on potential priority locations for studying volcanic activity, as well as the expected timescales of flow emplacement and cooling.

Channelized Lava Flow Survey: A GIS catalogue of Venusian channelized lava flows is being assembled using Magellan FMAPs and the published literature (i.e., articles, focused geographic studies and geologic quadrangle maps) to create a database of ~100 of the largest channelized flows on Venus. Flow attributes include latitude and longitude of the flow front (or most distal extent), elevations of the proximal and distal parts of the flow, geographic/volcanic associations, and a basic description of the flow (i.e., backscatter, morphology, and morphometry).

Initial Channelized Lava Flow Identifications. A preliminary search of Magellan data and the literature demonstrates that channelized lava flows are a common volcanic flow feature on the surface of Venus. Channelized lava flows have been identified at Atanua Mons, Atla Regio, Beta Regio, Derceto Corona, Uilata Fluctus, Mylitta Fluctus, Turgmam Fluctus, Ovda Fluctus, and Ozza Mons [e.g., 3-4, 7-13]. Channelized lava flows are typically identified by prominent variations in radar brightness between the dark central channel and bright lateral levees (Figure 1). Once completed, our catalogue will provide a fundamental database for studies of Venusian volcanism using current (i.e., Magellan) and future data from VERITAS and EnVISION.

Modeling Lava Flow Emplacement on Venus: The ability to connect lava flow morphology directly to specific eruption conditions is the primary goal of flow modeling, and ultimately reveals important details about the eruptions that produced these flows. For this work, we use rheologic properties from a terrestrial analog and the PyFLOWGO model [14-15] to quantify the effect of the Venusian environment on flow emplacement.

Modeling results. The adaptation of PyFLOWGO to Venus follows a similar approach to the model's investigation of Martian lava flows [16-17]. This includes changing the gravity (Earth, 9.81 to Venus, 8.87 m/s^2), ambient atmospheric temperature (273 to 740 K), atmospheric specific heat capacity (1099 to 1181 J/kg K), wind speed (5 to 1 m/s), and atmospheric density (0.4412 to 67 kg/m^3). The properties of the lava to be modeled are taken from the Great Tolbachik Fissure Eruption (GTFE) along with a constant slope of 1° [18]. The thermorheological properties and length of a Venusian lava flow are most affected by the higher atmospheric density, which reduces the flow length by ~45% due to the higher efficiency of forced atmospheric convective heat loss (Figure 2). Alternatively, processes outside the current ability of PyFLOWGO could be at work (i.e., heat loss based on CO_2-dominated cooling) [19].

The Venusian environment as implemented in PyFLOWGO is used to reproduce a hypothetical 100 km channelized flow, a common length observed [e.g., 1, 3-4, 10]. For this, an effusion rate of 9000 m^3/s is required. Considering the modeled channel width and a constant effusion rate for the 100 km simulated Venus flow, the surface area would be 52.7 km^2. Incorporating the channel depth measurement used for the modeling (8.7 m), a volume of 0.46 km^3 is calculated, which would require an emplacement duration of ~14 hours. The calculated volume and emplacement time are minimum estimates as they only represent the central channel of a single flow and do not account for any volcanic precursory activity, variable effusion rate, flow front dynamics, multiple flow emplacements, or the residual radiant energy released from cooling flows (or other volcanic products) after an eruption has ceased.

Significance: Importantly, both the estimated volume and the emplacement time are within the spatial and temporal resolution anticipated for VERITAS and therefore provide a baseline for future observation planning [6]. Once completed, this study will clarify our understanding of these channelized flows and what to expect should one form during the VERITAS mission.

This is the first attempt to apply an accurately refined thermorheological discharge and flow propagation model to Venus. As such, it has the potential to improve our understanding of the range of eruption durations and flow rates over the planet's volcanic history (as well as inform our understanding of how newly-emplaced flows behave). Because most of the Venusian surface is comprised of effusive (and most likely) basaltic flows, this work also provides important insight into planetary resurfacing processes.

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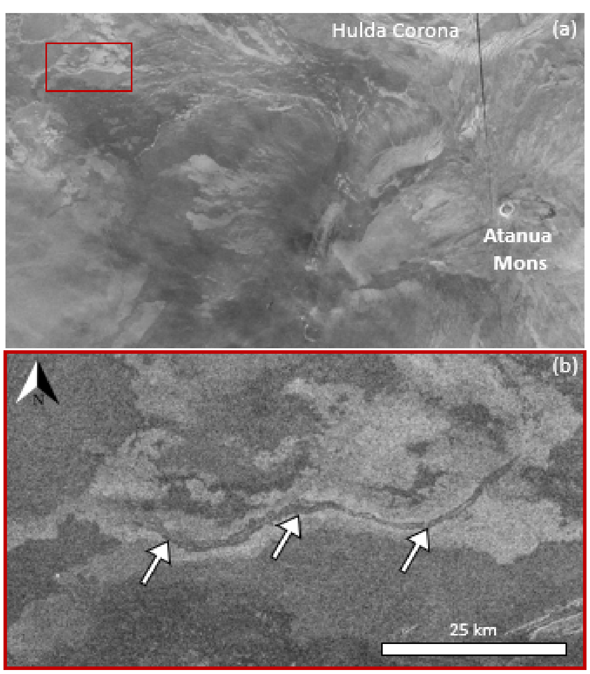

Figure 1. (previous column): (a) Magellan SAR FMAP Global Mosaic (left look) image of Atanua Mons (308.9°E, 9.5°N) region. The red box indicates the region shown in (b). (b) A channelized (white arrows) lava flow example.

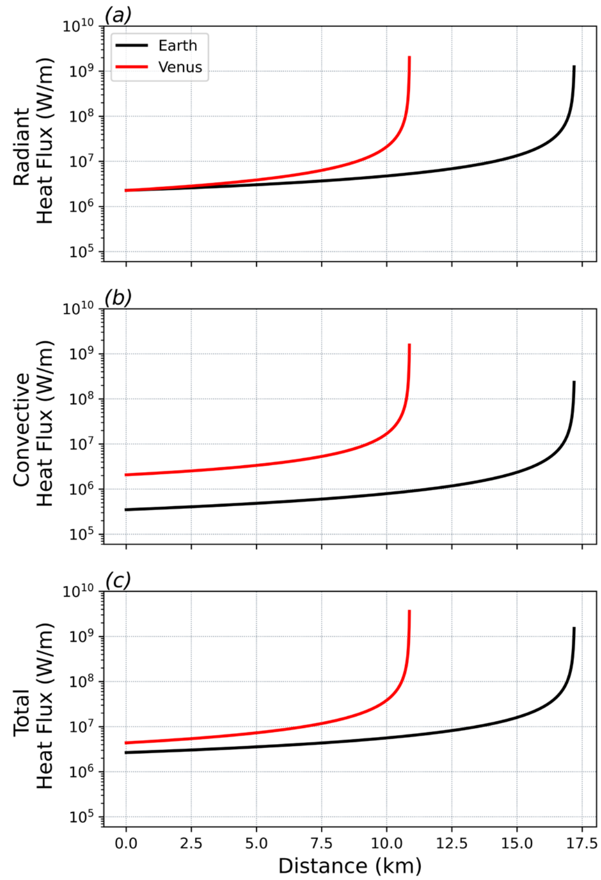

Figure 2. PyFLOWGO heat fluxes for radiant (a), convective (b), and total heat flux (c), results Earth (black line) and Venus (red line) accounting for all currently-available input parameters and tuned to Venus conditions. The atmospheric density is the prime factor for the change in heat flux compared to Earth. The total heat flux accounts for heat loss from radiance, convection, conduction and heat gains from viscous dissipation and the latent heat of crystallization.