FLOOD LAVAS ASSOCIATED WITH THE CERBERUS FOSSAE 2 UNIT IN ELYSIUM PLANITA, MARS. C. W. Hamilton[1,2], [1]Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771 USA (christopher.hamilton@nasa.gov), [2]Department of Astronomy, University of Maryland, College Park, MD.

Introduction: Volcanism has occurred on Mars throughout most of the planet's geologic history, with the majority of erupted material being emplaced during the Noachian and Early Hesperian (>3.6 Ga) [1]. However, eruptions have continued into the geologically recent past (i.e., Late Amazonian) with the youngest and best preserved eruptive products being located in the Elysium Volcanic Province [2]. Understanding the characteristics of eruption products in the Elysium Volcanic Province is therefore important for constraining the frequency, magnitude, and emplacement style of recent volcanic events on Mars as well as for inferring the planet's long-term thermal evolution.

The Elysium Volcanic Province includes two dominant components: the Elysium rise unit and Cerberus Palus [2]. The Elysium rise unit includes the volcanoes Elysium Mons, Hecates Tholi, and Albor Tholi and model ages for their associated lava flows range from 3.4 Ga to 60 Ma, with a peak in activity at ~2.2 Ga [1]. In contrast, Cerberus Palus, located on the southeastern flank of the Elysium rise, is generally much younger and divides into two principal units: Cerberus Fossae 2 and Cerberus Fossae 3. The age and location of these units suggests that during the Amazonian there was a gradual transition in location of peak volcanic activity away from the central portions of the Elysium rise.

The Cerberus Fossae 2 unit, which is the primary focus of this study, includes regionally extensive flows that appear to originate from the Cerberus Fossae fracture system in Grjótá and Rathway Valles. These flows are lightly cratered, suggesting Middle to Late Amazonian age [2] and are thought to consist of lava and fluvial sediments [3]. The Cerberus Fossae 3 unit overlies the southeastern end of the Cerberus Fossae 2 unit and is similarly associated with a combination of lava and water discharge events [2–8]. The structure of the Cerberus Fossae 2 unit is complex, but recent studies (e.g., [8]) suggest that the unit may include lava flows from at least eleven discrete periods of activity ranging from ~2–234 Ma.

Approach: The Cerberus Fossae 2 unit is re-examined using 453 Mars Reconnaissance Orbiter (MRO) Context Camera (CTX) images (6 m/pixel), 217 MRO High Resolution Science Imaging Experiment (HiRISE) images (0.26 m/pixel), as well as the Mars Odyssey Thermal Emission Imaging System (THEMIS) Daytime Infrared (IR) global mosaic (100 m/pixel; Version 11), and Mars Global Surveyor (MGS) Mars Orbiter Laser Altimeter (MOLA) data. These data were projected using the United States Geologic Survey (USGS) Integrated Software for Imager and Spectrometers (ISIS). To better constrain flow morphology, high-resolution (1 m/pixel) digital terrain models (DTMs) were generated from four HiRISE stereo-pairs using BAE Systems Socet Set [9]. These data were combined in ArcGIS with previous regional maps by [2] and [8] as a basis for the geological mapping presented in Figure 1.

Results: Previous studies (e.g., [2–4,10]) inferred a contact between the northeastern margin of the Cerberus Fossae 2 unit and Elysium rise unit. However, based on newly acquired MRO imagery, the Cerberus Fossae 2 unit appears to continue toward the northwest through the Tartarus Colles (i.e., high-standing remnants of the Noachian Nepenthes Mensae unit) and onto Vastitas Borealis (Fig. 1). Previous studies may have overlooked this association for reasons: (1) the passageway toward the Tartarus Colles is largely obscured by an unnamed multi-layer impact crater (40 km rim-to-rim diameter) centered at 169.85°E 19.24°N, (2) secondary craters in the vicinity of this impact crater locally modify the crater population on flow surfaces, (3) the flow passes through a series of narrow (~1 km-wide) topographic constrictions that are difficult to observe in THEMIS-scale imagery, and (4) the unit exhibits roughness and albedo variations that appear as unit boundaries in low-resolution imagery, whereas at higher resolutions they are resolved as facies transitions within a series of flows that constitute a single unit (i.e., flow field). Although there are significantly fewer craters on the this unit than on the Late Hesperian Elysium rise unit, variations in crater density within the Cerberus Fossae 2 unit suggests that it may include flows from multiple eruptions with model ages ranging from 10–40 Ma [10] to ~62–250 Ma (i.e., 125 Ma with a factor of ±2 uncertainty [11].

Previous studies have argued that the youngest of the surficial flows associated with Cerberus Fossae 2 unit were associated with aqueous floods erupted from an extensive subsurface aquifer [3,5,10]. Although streamlined islands and ancient erosional landforms are common in Grjótá Valles, we find no evidence that the surfical flows consist of aqueous flood deposits. Instead high-resolution MRO imagery reveals surface features that are consistent with lava flow emplacement. These flow characteristics include: (1) unconfined lobate flow margins with peripheral fractures

analogous to inflated pāhoehoe flows with monoclinal clefts and lava-rise pits (Fig. 2), (2) transitional surface textures from smooth surface flows to rough flows and slabby flows analogous to pāhoehoe and rubbly-pāhoehoe, (3) disrupted flow surfaces composed of jigsaw-fit plates that are analogous to platy-ridged lava flows (4) evidence of constructional, rather than erosional, channels, (5) competent deposits accreted to the margins of high-standing topography, which indicates the passage of a viscous flow followed by partial drainage, and (6) numerous cratered cone groups that resemble the products of terrestrial explosive lava-water interactions.

Discussion and Conclusion: New geological mapping of the Cerberus Fossae 2 unit reveals a previously undocumented branch of the flow moved northeast and debouched onto Vastitas Borealis. The morphology and facies associations of surficial flows within this unit are consistent with one or more flood lava flows that inundated an older valley system. The youngest flows within the Cerberus Fossae 2 unit are therefore analogous to the lava-draped channel system identified in the Cerberus Fossae 3 unit within Athabasca Valles [7,8]. Although the Cerberus Fossae 2 unit is distinctly younger than the Elysium rise unit, it may be a composite structure formed during multiple episodes of volcanic activity. This suggests both massive and frequent volcanic eruptions from the Cerberus Fossae in Grjótá Valles during the Middle to Late Amazonian. Model ages of flow surfaces within the Cerberus Fossae 2 and 3 units suggest that there may have been overlapping periods of volcanic activity in these regions. This implies an extended and complex eruption history within Cerberus Palus.

References: [1] T. Platz and G. Michael (2011) *EPSL*, 312 140–151. [2] K. Tanaka et al. (2005) *USGS Map* 2888 [3] J. Plescia (2003) *Icarus*, 164, 79–95. [4] D. Burr et al. (2002) *Icarus*, 159, 53–73. [5] D. Burr et al. (2009) *In:* Megaflooding on Earth and Mars, *Cambridge Univ. Press*, 194–208. [6] W. Jaeger et al. (2007), *Science*, 317, 1709–1711. [7] W. Jaeger et al. (2010) *Icarus*, 205, 230–243. [8] J. Vaucher et al. (2009) *Icarus*, 200, 39–51. [9] R. Kirk et al. (2008) *JGR*, 113, E00A24. [10] D. Burr and A. Parker (2006) *GRL*, 33, L22201. [11] C. Hamilton et al. (2010) *JGR*, 115, E09006.

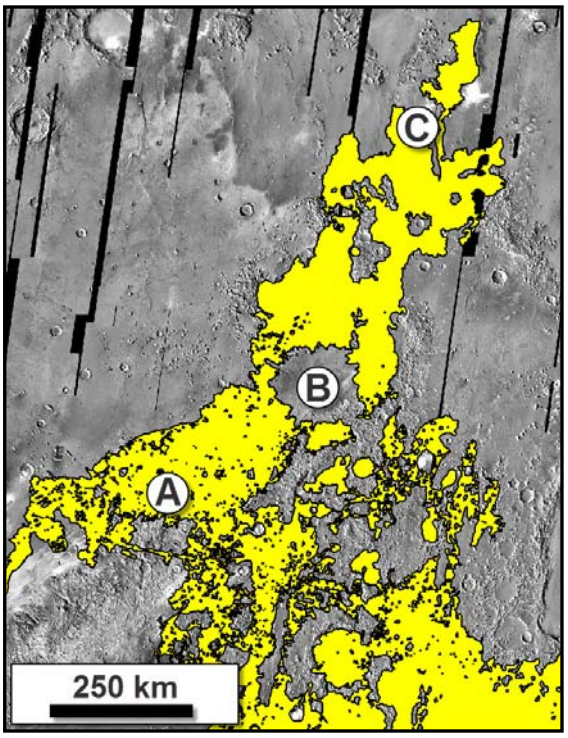

Figure 1. Northern portion of the Cerberus Fossae 2 unit (yellow) extending from 180°E 8°N (lower right) to 160°E 30°N (upper left). (A) Source region in Grjótá *Valles. (B) Unnamed multi-layer impact crater. (C) Location of Figure 2a. The basemap is the THEMIS IR Daytime mosaic (Version 11). North is up.*

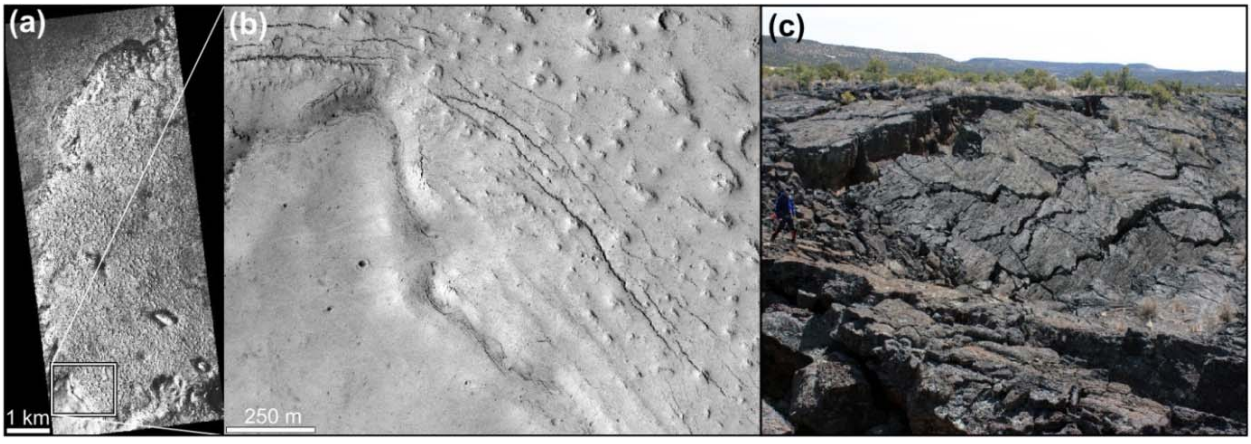

Figure 2. Diagnostics of lava emplacement and inflation. (a) HiRISE ESP_018035_2080 shows part of the Cerberus Fossae 2 unit northeastern Elysium Planita, Mars. The flow surface exhibits depressions that are interpreted to be lava-rise pits. (b) Magnified view of cracks along the margin that are interpreted to be inflation clefts in a pahoehoe-like lava flow. (c) Analogous inflation clefts near the ~15 m-high margins of the McCartys lava flow, New Mexico.