**CRATER COUNT AGES AS CONSTRAINTS ON MAGMA SOURCE(S) OF THE CERBERUS PLAINS FLOOD LAVAS, MARS.** K. B. Golder[1] and D. M. Burr[1], [1]University of Tennessee Knoxville, Department of Earth and Planetary Sciences, 1412 Circle Drive, Knoxville, TN, 37996 (kgolder@vols.utk.edu).

**Introduction:** The three late-Amazonian-aged channels in the Cerberus plains, Athabasca, Grjotá, and Marte Valles, each emanates from separate points along the Cerberus Fossae (Fig. 1) [e.g., 1 and references therein], and each is thought to have developed due to catastrophic aqueous flood events, followed by lava infilling [e.g., 2-4]. Crater-count-derived age estimates (Table 1) indicate lava emplacement occurred in a westward progressing sequence, retreating toward Elysium Mons. These ages are the youngest on Mars associated with regional-scale aqueous floods and volcanic activity.

Uncertainty lingers regarding the eruptive history of the infilling lavas and the timing of these events. Due to overlap in the published crater-count derived lava ages (Table 1), we hypothesize that *a single, extensive lava emplacement event occurred across the three channel systems within the same moment in geologic time.* Such a finding would imply that the lavas within the three channels were sourced from the same regional magma chamber. We have also developed two alternative hypotheses supposing that the lava eruptions were discrete events; **(1)** *the lava emplacement within the three channels occurred in sequence, from east (oldest) to west (youngest),* and **(2)** *the lava emplacement within the three channels occurred in sequence, from west (oldest) to east (youngest).* Results supporting the alternative hypotheses would suggest the lava flows developed during the westward retreat of the magma chamber, or that the eruptions occurred during eastward migration of the magma chamber and dike propagation, respectively.

This region of Mars is ideal for performing crater counts due to the extensive surface features retaining well preserved morphologies, affording the best opportunity for accurate analysis and interpretation of the flood and volcanological events that formed them.

| Channel | Age estimate |
|---|---|
| Athabasca | 2-8 Ma [2] |
| | 1.5-200 Ma [5] |
| Grjotá | 10-40 Ma [2] |
| Marte | 35-140 Ma [2] |
| | ~10-200 Ma [6] |

**Table 1: Crater-count-derived ages for the lava surfaces.**

**Data:** Topographic data will be derived from Mars Orbiter Laser Altimeter (MOLA) 463 m/pixel gridded topography and 168 m-diameter Precision Experiment Data Records (PEDRs) shots [7]. High Resolution Stereo Camera (HRSC), Context Camera (CTX), and High Resolution Imaging Science Experiment (HiRISE) digital elevation models (DEMs) will supplement the MOLA DEM. Morphological characteristics will be obtained through Thermal Emission Imaging System (THEMIS) 100 m/pixel infrared day- and nighttime images [8]; HRSC ~15 m/pixel images [9]; CTX 6 m/pixel images [10] and; HiRISE ~0.25 cm/pixel images [11].

**Methodology:** In order to determine the development and age of the Cerberus plains channel system and associated lavas, the hypotheses described above will be tested by two distinct approaches.

*Morphological Mapping:* Mapping will be performed in the ArcGIS environment and build upon previous global [e.g., 12] and regional [e.g., 13] geological maps. Primary mapping will use a CTX basemap, supplemented by THEMIS, HRSC, and HiRISE images where gaps exist in CTX data coverage. Current progress of unit identification, contact mapping, and channel delineation is presented in Figure 1. The full extent of the water carved channels and associated lavas are of primary importance to facilitate later analyses, described in the following sections. Initial stratigraphy will be determined based on unit contacts and indications of superposition, embayment, onlapping, and cross-cutting relationships. Local topographic relationships will also be used to refine stratigraphic relationships. This approach will use PEDR-shots along individual flows and surrounding terrain, and HRSC, CTX, and HiRISE DEMs to characterize the topography across the entire flow.

*Crater Counts:* Estimation of planetary surface ages relies on crater-size frequency distributions, a statistical approach in which craters of various diameters within a given area are counted. Those features which contain higher densities of impact craters are inferred to be older than surfaces with a lower density of craters [e.g., 14, 15]. Targets for crater counting require sufficient CTX coverage and will be distributed along the channels and their adjacent terrains (Fig. 1), and will require an ~1000 $km^2$ or greater area coverage [16].

Secondary crater populations that originate as ejecta from a primary impact may skew the crater counting results by overestimating small crater populations. Within the Cerberus plains exists the young (~5 Ma) Zunil impact site and its resultant secondary crater populations [5]. However, for this work, locations for crater counting will be chosen outside of Zunil secondaries, which are obvious in visible-wavelength and thermal data [5].

In the ArcGIS environment, the CraterTools plug-in will be used to count craters and perform initial bestfit age estimates based on isochrons and crater production functions [e.g., 17 and references therein] for the chosen sites (Fig. 1). For comparison, crater-count ages will also be derived using the independent Craterstats2 program.

**Expected Results:** Lava flows at a consistent stratigraphic level, and crater count constrained age with narrow ranges and overlapping error bars would support the *null hypothesis*. This result would indicate that the lavas found within the channels originated from the same large, regional-scale subsurface magma source, which was likely tapped during geologically instantaneous dike propagation along the Cerberus Fossae. The alternate hypotheses would be supported by inconsistent stratigraphy, and ages derived from crater counts that exhibit either an increasing or decreasing age progression eastward from Elysium. These results would suggest either that previous age estimates with broad age ranges identified temporally overlapping discrete flows in the region, and the oldest lavas are located near the distal extent of the Cerberus Fossae fractures, or conversely that the previous age estimates were incorrect, and the oldest lavas are located proximal to Elysium Mons. These two alternative outcomes would implicate either a single magma source propagating along the fracture network, or that isolated magma chambers were breached in sequence.

**Conclusions:** This work will test whether lavas in the three major outflow channels in the Cerberus plains formed as the result of a single large flow or smaller discrete flows, while also resulting in inferences for the behavior of the subsurface magma reservoir(s). Refined age constraints through crater counts builds on and further develops previous work indicating the surface of Mars has been volcanically active in the very recent geologic past. Corroboration and extension of this previous evidence would add to the number of volcanically active terrestrial bodies within the Solar System, such as Io, the Earth, and most recently the Moon [18].

**References:** [1] Burr et al. (2009) *Megaflooding on Earth and Mars*, pp. 194-208. [2] Burr et al. (2002a) *GRL, 33(22)*. [3] Burr et al. (2002b) *Icarus, 159*, 53-73. [4] Plescia (2003), *Icarus*, *164*, 79-95. [5] McEwen et al. (2005) *Icarus*, *176*, 351-381. [6] Berman and Hartmann (2002) *Icarus*, *159*, 1-17. [7] Smith et al. (2001) *JGR*, *106*, E10. [8] Christensen et al. (2004) *SSR*, *110*, 85-130. [9] Neukem et al. (2004). *ESA-SP*, *1240*, 17-35. [10] Malin et al. (2007) *JGR*, *112*, E05S04. [11] McEwen et al. (2007) *JGR*, *112*, E05S02. [12] Tanaka et al. (2014) *USGS-SI Map 3292*. [13] Tanaka et al. (2005) *USGS-SI Map 2888*. [14] Hartmann and Neukem (2001) *SSR*, *96*, 165-194. [15] Hartmann (2005) *Icarus*, *174*, 294-320. [16] Warner et al. (2015) *Icarus*, *245*, 198-240. [17] Michael (2013) *Icarus*, *226*, 885-890. [18] Braden et al (2014) *Nature Geosci.*, *7*, 787-791.

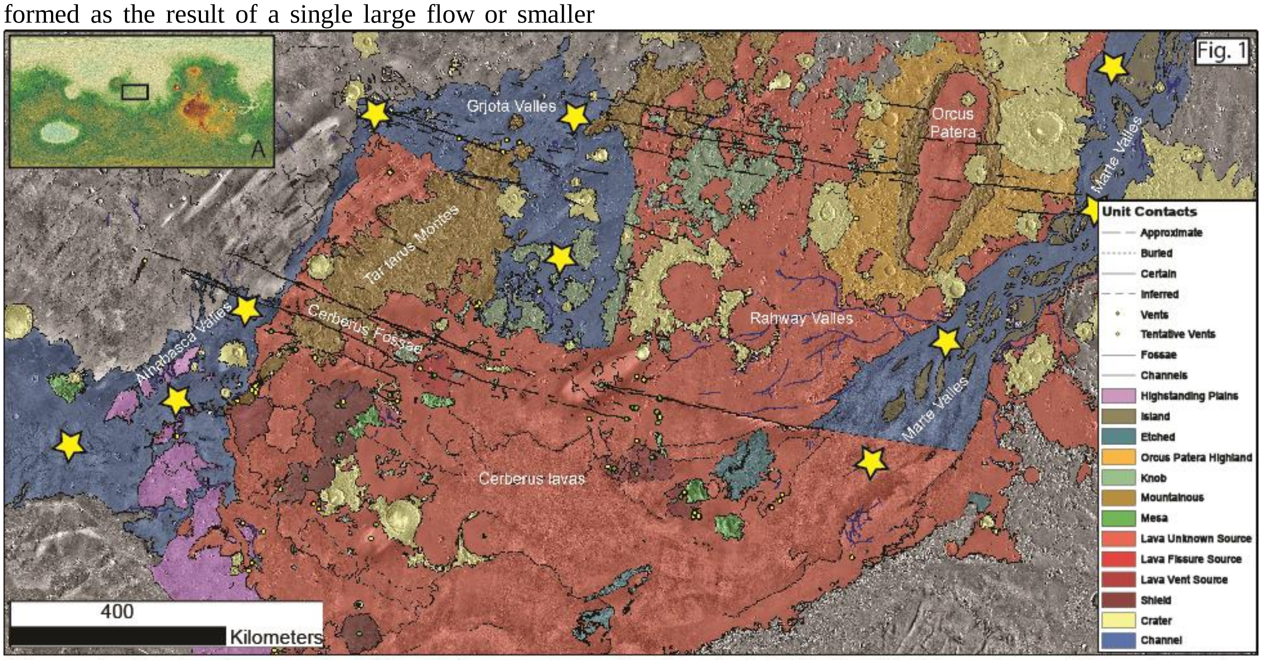


Figure 1: Regional context of the Cerberus plains (centered at 170˚ E, 10˚ N), major outflow channels; Athabasca, Grjotá, and Marte, current geologic units, and extent of geologic mapping. Selection of locations for in-channel crater counts are denoted by yellow stars. (Inset A): Global location of Cerberus plains.