47th Lunar and Planetary Science Conference (2016) 1543.pdf

IMPLICATIONS FOR LATE AMAZONIAN MAGMA MIGRATION DERIVED FROM NEW CRATER-COUNT AGE ESTIMATES OF THE CERBERUS CHANNEL FLOOD LAVAS, MARS.

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Introduction: Volcanic activity has been a dominant surface process on Mars throughout its history and can be used to infer subsurface activity. Young regional volcanism on Mars is epitomized within the Cerberus plains (CP) as distinct lava flows in three circum-Cerberus aqueous flood channels, Athabasca (AV), Grjótá (GV), and Marte (MV) Valles [e.g., 1-4; Fig. 1]. Each channel and corresponding infilling lavas emanate from separate points along the regional Cerberus Fossae (CF) fissure network [e.g., 5-8]. The CF have been modeled as radial to the Olympus/Tharsis volcanic complex (OTVC) [9], though the fissures also appear radial to the Elysium volcanic province [3,6,10]. The bulk of formation activity for both edifices is old, but limited volcanism at both sites continued into the very recent past and may be coincident with the volcanotectonic activity in the CP [10,11]. Previous work has dated the emplacement of the lava flows within AV at 1.5-200 Ma [6,8], the GV lavas at 10-40 Ma [6], and the MV lavas at 10-200 Ma [2,6]. However, these age estimates, excluding [8], did not take into account the presence of significant secondary crater populations nor consider their implications for magmatic processes. Refined model ages for these lavas will lead to a more robust determination of emplacement timing. The relative timing of emplacment can be used to infer the migration pattern of the magma source(s).

Hypotheses: Based on the previous age estimates, our null hypothesis is *lava emplacement within the three channels occurred in sequence, from east (oldest) to west (youngest).* Such a finding would suggest the lava flows developed as a consequence of late stage volcanism related to the OTVC and subsequent westward migration of magma along the fissure network. Alternate hypotheses include a) *lava emplacement occurred from west to east*, suggesting Elysium Mons as the source of the lavas; and, b) *lava emplacement occurred with no discernable directional trend,* and is not related to either bordering volcanic province.

Methods and Data: We are testing these hypotheses using two complementary approaches. **(1)** Geomorphological mapping was used to define the spatial distributions of the lavas in the three channels within the study area, and select locations for crater counts on the lava surfaces: and **(2)** crater counting techniques were used to refine the emplacement ages of the lavas through absolute age estimates based on crater production rate models. This work was performed using Thermal Emission Imaging System (THEMIS) 100 mpp infrared day- and nighttime mosaics [12]; High Resolution Stereo Camera (HRSC) ~15 mpp [13], and Context Camera (CTX) 6 mpp images [14].

Geomorphological Mapping: Building on previous work [15-18], we mapped the channels and associated lavas in ArcMap using a CTX basemap at a scale of

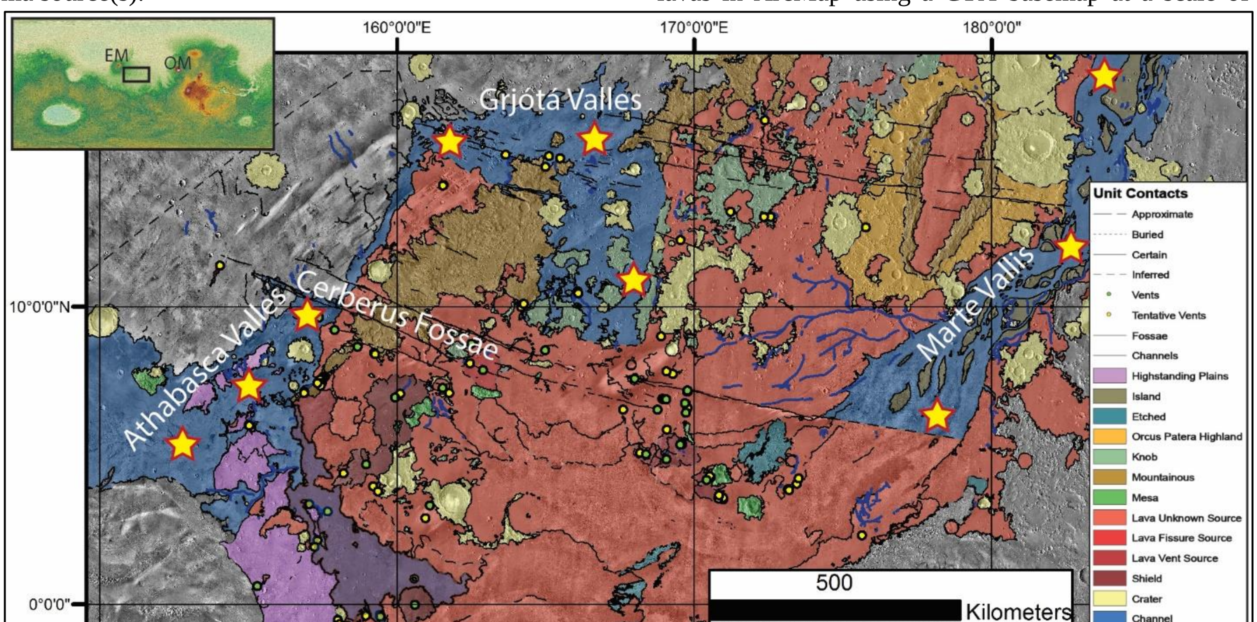

Figure 1: Cerberus plains (centered at 170° E, 10° N), major outflow channels; Athabasca, Grjótá, and Marte, geologic units, and extent of geologic mapping. Selection of locations for in-channel crater counts denoted by yellow stars. (Inset): Location of Cerberus plains, Elysium Mons (EM) and Olympus Mons (OM).

1:100 K, with THEMIS and HRSC images filling CTX coverage gaps. Our mapping of the lava flow extents set the geospatial boundaries for crater counting. AV extends west [15], GV extends north [16], and MV extends northeast [17] beyond the chosen study area.

Crater Counts: Crater count sites proximal, medial, and distal to the lava flow sources were chosen for crater size frequency distribution analyses [Fig. 1, yellow stars]. A minimum area of 1000 km^2 was used, as recommended to provide a statistically representative sampling of crater sizes [19]. All craters within the chosen sites were counted, excluding obvious secondary clusters or preexisting lava-embayed craters. The observed rollover at small crater diameters is a result of observation loss due to resolution limits and/or resurfacing processes [20]. The best isochron fits were achieved when excluding craters <40 m in diameter [Fig. 2, red line]. The CraterTools plug-in [21] was used to count craters in ArcGIS. Crater-count model ages were derived using best-fits to isochrons based on crater production functions in Craterstats2 [22, 23].

Secondary Craters: Secondary craters, which originate as ejecta from primary impacts, may skew crater counting results through contamination and subsequent overestimation of small crater populations [24]. Within the CP, secondaries from the young Zunil (~1 Ma) [8,25] and Corinto impacts (~3 Ma) [26] overlap AV, as is discernable in visible and thermal data [8,25,26]. Thus, locations for crater counting were chosen to exclude secondaries from Zunil and Corinto.

Results: The extent of the lavas within the channels are presented in blue in Fig. 1. The dashed line at the head of MV denotes the location of the now-buried segment of the CF from which the initial channel scouring event was sourced [6, 27].

Crater-count-derived model ages range from 3.4 Ma (proximal) to 2.9 Ma (distal) for AV [Fig. 2]. Crater counts for GV and MV for the proximal-to-source regions give model ages of 58 Ma and 79 Ma, respectively [Fig. 2].

Implications: Model ages of the AV lavas decrease with distance from the source, although the error bars of the distal and proximal locations both overlap with those of the medial location [Fig. 2]. Regional age trends for all lavas are consistent with previously published ages, though more precise due to counts having been performed over a wider area and using higher-resolution imagery. The derived ages for channel-infilling lavas support the null hypothesis, where emplacement of the lavas occurred in a westward-progressing sequence, and thus suggest a concurrent westward migration of magma away from the OTVC.

Future work: Medial and distal crater counts of the lavaswill be performed within GV and MV to further constrain the lava ages. Buffered crater counts [28] will also be performed on the CF to infer the timing and directionality of the opening of this fissure network, in support of the age estimates of the lavas. Ultimately, this work will further our understanding of surface and subsurface volcanic activity during the very late-Amazonian period on Mars.

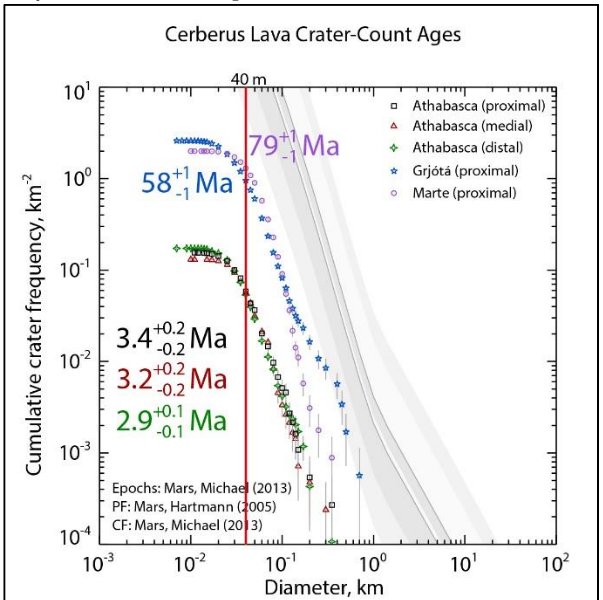

Figure 2: Model ages for the circum-Cerberus channel lavas. The ages decrease westward from the OTVC.

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