A UNIQUE YOUNG FLOW SOUTHWEST OF CERBERUS FOSSAE, MARS

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Introduction: Analysis of CTX and HiRISE images has revealed a fresh lobate flow with unique morphologic characteristics (Fig. 1). The flow is ~34 km long, 0.5 - 2.0 km wide, falls ~50 m along its length, and has a broad distal fan ~6 x 9 km in size. The flow originates from within the ejecta blanket (at 0° 35'N, 155° 17'E) of a 10 km diameter impact crater, but appears to closely linked to a partially buried remnant of a large yardang formed within the lower unit of the Medusae Fossae Formation [1].

The source area of the flow (Fig. 2) is a 1.2 x 1.5 km depression that is eroded into the yardang material. A CTX-derived digital elevation model reveals that this depression is ~20 m deep (implying a volume of ~0.3 km^3 for the removed material). Multiple phases of upwelling can be identified in the source area, where overlapping concentric ridges can be seen. Absent from the source is any landform comparable to the vent structures typically seen at Martian volcanic calderas or volcanic vents [2, 3]. There is a single elevated block ~20 m high within the source area that is interpreted to be an erosional remnant from the pre-existing terrain. This block shows no signs of fluid flow around it to indicate how the surrounding material was eroded. Numerous pitted domes (red dots in Fig. 2) can also be identified.

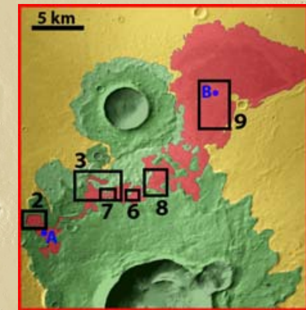


Fig. 1: The new flow (red) identified here. Direction of flow from left to right. MOLA data show the change in elevation between points "A" and "B" is 46 m. Locations of other figures are numbered. Part of CTX image P20_008700_1787.

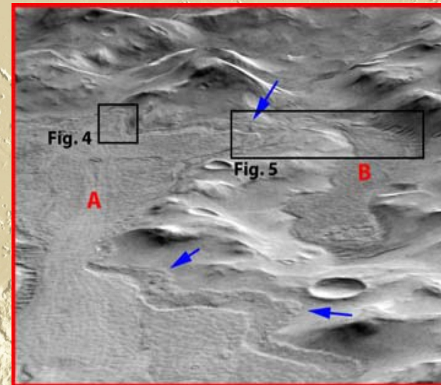


Fig. 3: Oblique view of middle portion of flow, looking west. "A" is the main flow, "B" marks a spill-over lobe in a local depression, and the blue arrows identify high-stands and subsequent drain-back from topographic highs. Direction of flow was from top to bottom of image. Peak at top center of image is ~50 m high. CTX image draped over DEM derived from CTX frames G19_025486_1805 and P20_008700_1787. North is to the right.

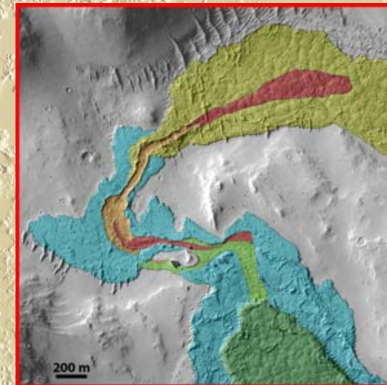
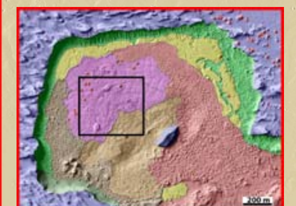


Fig. 5: Along the path of the flow, there are several examples of over-spill channels (in red) that crested local topographic highs. These over-spills then fed new flow lobes that are trapped within local depressions. Different segments of the flow are identified in green, light blue and tan. Note channelized portion of flow (orange). Direction of flow was from bottom to top of image. Part of HiRISE image ESP_027464_1805.



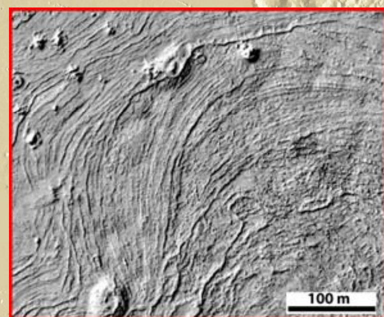


Fig. 2: Above: Source area of flow. Purple, tan and red units are successive phases of the flow. Blue denotes pre-flow yardang surface, and green denotes recently emplaced eolian materials. Note remnant block of basement material preserved near the center of source area. HiRISE frame ESP_025697_1805. At right is detail of the outflow unit (denoted by box in the image above).

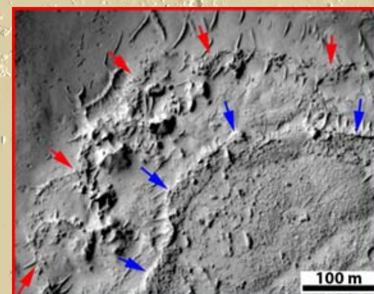


Fig. 4: The super-elevated portions of the flow display signs of post-emplacement drain-back towards the main portion of the flow. Here we see the pre-existing surface at top of image, the deformed surface of the flow that has drained away from high points (red arrows) and the segmented perimeter of the main flow (blue arrows). Run-up height of the flow is ~8 – 10 m. Part of HiRISE image ESP_027464_1805.

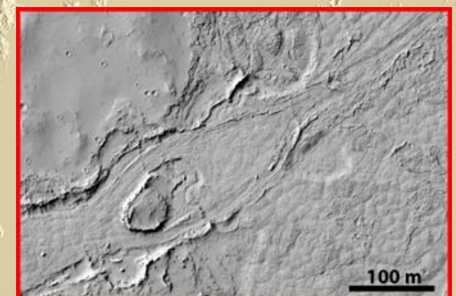
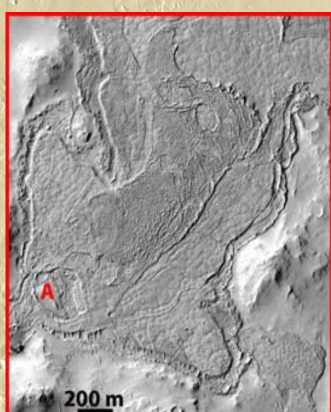


Fig. 6: Where the flow encountered pre-existing topographic highs, there are instances where a stream-lined island developed that disrupted the downstream flow. Direction of flow was from left to right. Part of HiRISE scene ESP_026264_1805.

Flow Morphology: There is a remarkable diversity of morphologies on the flow surface but, with the exception of the distal end, there is no correlation between the down-flow distance and these morphologies. Many of the textures identified here can be seen within a few kilometers of the sources as well as close to the distal end of the flow. MOLA data indicate that the flow is very thin along its length, and it is typically between 2 – 4 m thick.

As can be seen in Figs. 3 and 4, some of the edges of the flow appear to be "super-elevated", where the flow has ridden-up over local topographic obstacles and then slumped back to the base-level of the flow, sometimes trapping segments of the lobe in local depressions (Fig. 5). In several places, the flow bifurcated and then re-coalesced around pre-existing obstacles (Figs. 6 and 7). This bifurcation caused down-stream disruptions to the flow surface that consequently have a much more crenulated surface that has separated as sheets of material, very similar in morphology to the lava flows discussed by Murray *et al*. [4].

The flow also displays several types of lineation that are both parallel and transverse to the direction of flow (Fig. 7). These lineations display similarities in size, defining rectangles on the surface with widths of 45 – 60 m along almost all of the flow length. The lineations also cross textural boundaries within the flow, suggestive of cooling or dessication cracks of different scales.



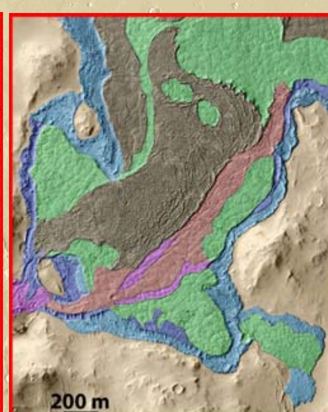


Fig. 8: Example of the complex morphology of the flow as a pre-existing obstacle ("A") was encountered. This pre-existing obstacle produced a shear zone with rougher textured on the down-slope side. In the interpretive sketch at right, the flow surface can be seen to have formed plates of material (brown unit) that could be reassembled into a single unit. Direction of flow was from lower left to top right. HiRISE frame ESP_026264_1805.

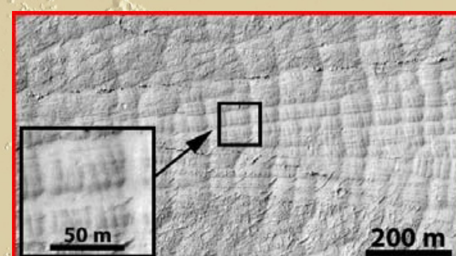


Fig. 7: The surface of flow is characterized by both large (main image) and small (insert) transverse and longitudinal ridges, interpreted to be products of flow transport. Direction of flow was from left to right. Similar structures have been identified on other flows by [7]. Part of HiRISE image ESP_026264_1805.

Possible Mode of Formation: While the flow may be comprised of lava that had a very low viscosity during its emplacement, a more likely origin appears to be as a large mud flow. It is proposed here that this flow may have been produced by water reaching the surface within the yardang materials and the subsequent mobilization of the unconsolidated material that comprised the yardang. Based upon the uniform morphology and apparent constant thickness of the flow along its length, the viscosity of the flow does not appear to have changed from the earliest phase of its eruption until the distal portion of the flow (Fig. 6) was reached. This distal portion of the flow bears a close similarity to the fresh flows in Cerberus Fossae that have previously been interpreted as potentially ice-raft flows [4] or once highly fluid lava flows [5 - 7].

Broader Implications: The morphology of this flow raises the intriguing possibility that some of the other very young flows within the Cerberus Fossae region [7, 8] may also be something other than lava flows. The smooth transition of surface texture from the "cubic-texture" seen in Fig. 7 to the crenulated distal portion of the flow (Fig. 9) indicates that this flow was emplaced as a single flow. Future studies of the young flows within Cerberus Fossae should, therefore, consider alternative modes of formation for these flows and the implications that a different origin might have for the recent geologic history of Mars, particularly the inference that young fluvial channels were subsequently buried by lava flows [8].

Fig. 9: Left: The distal portions of the flow show a remarkable similarity to textures interpreted to be lava flows [6, 7]. Direction of flow is towards top of image. HiRISE image ESP_028097_1805. Right: Another flow in Cerberus Fossae, part of Unit *Aav* of Jaeger *et al*. [6], that has similar surface textures but has previously been interpreted as a lava flow. Part of HiRSE image ESP_011680_1825.

References: [1] Zimbelman J.R. and L.J. Griffin (2010) *Icarus 205*, 198 - 210. [2] Mouginis-Mark P.J. and S.K. Rowland (2001), *Geomorphology 37*, 201 - 223. [3] Mouginis-Mark P.J. and P.R. Christensen (2005), *JGR 110 (E10)* doi: 10.1029/2005JE002421. [4] Murray, J.B. *et al*. (2005), *Nature 434* (7021), 352 – 356. [5] Vaucher J. *et al*. (2010), *Icarus 200*, 39 – 51. [6] Jaeger W. L. *et al*. (2010), *Icarus 205*, 230 – 243. [7] Ryan, A.J. and P.R. Christensen (2012), *Science* 336, 449, doi: 10.1126/science.1219437. [8] Jaeger, W.L. *et al*. (2007), *Science* 317, 1709, doi: 10.1126/Science.1143315.