HIRISE PERSPECTIVES ON THE FLOWS OF HRAD VALLIS, MARS. P. J. Mouginis-Mark, Hawaii Institute Geophysics and Planetology, SOEST, Univ. Hawaii, Honolulu, HI 96822. (pmm@hawaii.edu).

Introduction:

The lobate material that flowed from Hrad Vallis has been studied for almost 30 years [1 - 3], and yet aspects of the flow remain unresolved. Possible modes of formation include it being a lahar deposit [4, 5] or a flow generated by the intrusion of a sill into a water-rich substrate [6]. As part of a new 1:100K and 1:200K-scale mapping project for the USGS, a reappraisal is under way of the properties of this material and the enigmatic craters on the flow, aided by the significantly improved spatial coverage from CTX images and an order of magnitude improvement in spatial resolution provided by HiRISE images over earlier data.

Two discrete flows are identified (Fig. 1), with a lower flow unit originating from the eastern section of fractures and an upper flow from the western segment of the Hrad Vallis fracture. Superposition relationships show that the upper flow formed second, and emerged from the same (western) fissure segment from which water originated. In contrast, the source of the lower flow lacked associated water discharge.

Key questions addressed with HiRISE data:

1. Physical properties of the flow? Sections of the source fracture (Fig. 2) show a large number of boulders >8 m in dia. in the exposed walls. These wall units are different from the layers interpreted to be lava flows as there is no discrete pattern to the block distribution. The occurrence of the boulders implies that material within the flow would take a significant time to equilibrate in temperature [6], and the boulders would have remained hot during flow emplacement.

2. What was the origin of the enigmatic craters on the flow? A total of 42 unusual craters (mean dia. = 630 m, SD = 556 m) on the upper flow, and 593 craters (mean = 271 m, SD = 77 m) on the lower flow have been mapped (Fig. 1). The larger (> 1 km dia.) examples of these craters have already been shown to possess thermal anomalies [7]. HiRISE images indicate that these thermal anomalies correlate with outcrops of many rocks 2 – 4 m dia. on surface (Fig. 3). The distribution of these rocks lacks the radial pattern expected for an impact ejecta. Concentric features at larger craters also show greater degree of blockiness.

On the downstream segment of lower flow, a concentration of these craters exists where the slope is low. This area is noteworthy due to the occurrence of three ~20 to 25 meter-high domes with summit craters (Fig. 4). The origin of these domes cannot yet be resolved, but possibilities include pingos or mud volcanoes [8 – 10]. Peripheral fractures are similar to those observed around the craters, raising the possibility that the domes are precursors to the craters. A problem with the pingo model is the requirement to preserve the ice to produce domes that exceed 25 m height. Alternatively, these domes may be the equivalent to lava rises [11]. This would imply post-emplacement inflation of the flow, but no evidence for protracted flow after it came to rest can be found in HiRISE data.

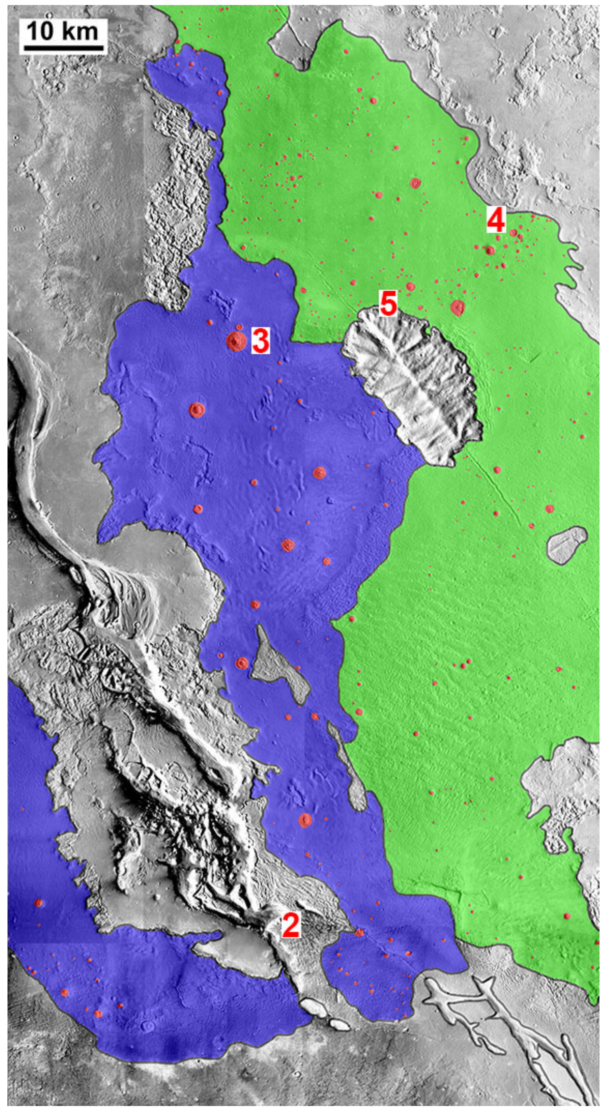

Fig. 1: Geomorphic map of the upper (blue) and lower (green) flows originating from Hrad Vallis. Red dots are the enigmatic craters discussed here. Numbers denote locations of other figures. Base image is a mosaic of CTX images, centered at 34.5°N, 142.0°E.

3. How fast were segments of the flow moving? There is no indication that the lower lobe climbed up or over-rode Galaxius Mons (34.8°N, 142.3°E), which is the ~130 m high mountain embayed by the lower flow. No evidence of drain-off from the mountain can be seen (Fig. 5), although the mountain's surface appears to be mantled and may have contraction cracks.

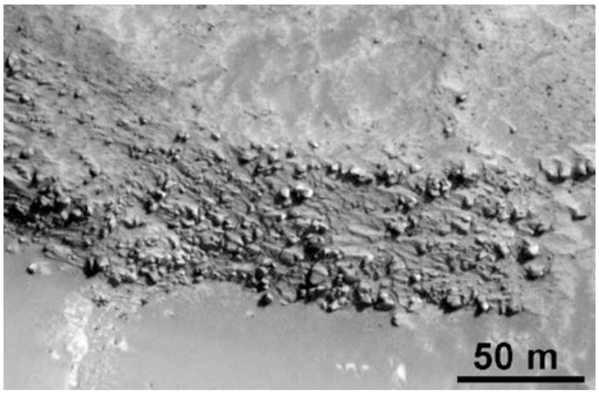

Fig. 2: Numerous individual boulders displaying minimal sorting within the topmost layer of the wall of Hrad Vallis, is consistent with the idea that the flow lobe is a mudflow that originated from Hrad Vallis. Part of HiRISE image PSP_006169_2140. Note that the image has been rotated 180 degrees to aid the visualization of the scene.

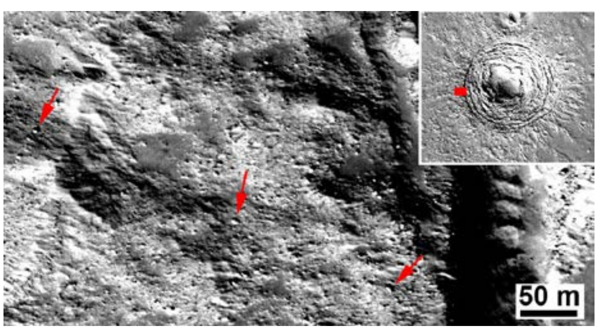

Fig. 3: Material surrounding one of the larger craters on the upper flow, which is one of the previously identified thermally anomalous craters [7]. Numerous boulders up to 4 m in diameter (red arrows) are visible on the western rim of the crater. Inset at the top right shows image location with respect to crater rim (red box). Part of HiRISE frame PSP_005879_2150.

4. Any signs of dewatering on the surface of the flow? No small channels or other signs of "dewatering" have been observed on the surface of either flow, suggesting a lack of free water during flow formation.

References: [1] Mouginis-Mark, P. J. (1985). *Icarus* 64, 265 – 284. [2] De Hon, R. A. (1992). *Proc. Lunar Planet. Sci. Conf.* 22, 45 – 51. [3] De Hon, R. *et al*. (1999). *USGS Misc. Map* I-2579. [4] Christiansen, E. H. (1989). *Geology* 17: 203 – 206. [5] Pedersen, G. B. M. and J. W. Head (2013). 44th *LPSC*, abstract #1514. [6] Wilson, L. and P. J. Mouginis-Mark (2003). *J. Geophys. Res*. 108, doi: 10.1029/2002JE001927. [7] Morris, A. R. and P. J. Mouginis-Mark (2006). *Icarus* 180, 335 – 347. [8] Dundas, C.M. *et al*. (2008). *Geophys. Res. Lttrs.* 35, LO4201, doi: 10.1029/2007GL031798. [9] Skinner, J. A. and A. Mazzini (2009). *Marine Petrol. Geol*. 25, 1866 – 1878. [10] Dundas, C. M. and A. S. McEwen (2010). *Icarus* 205: 244 – 258. [11] Walker, G. P. L. (1991). *Bull. Volcanol*. 53: 546 – 558.

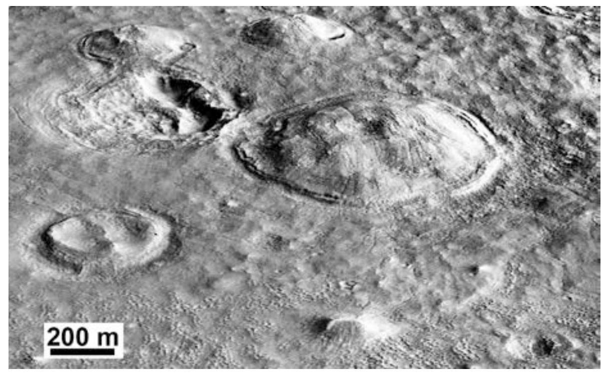

Fig. 4: Oblique view looking east of unusual pits and mounds on the distal portion of the lower flow unit. Height of the dome just right of center is ~25 m. DEM derived from segments of HiRISE images ESP_016256_2155 and ESP_016322_2155.

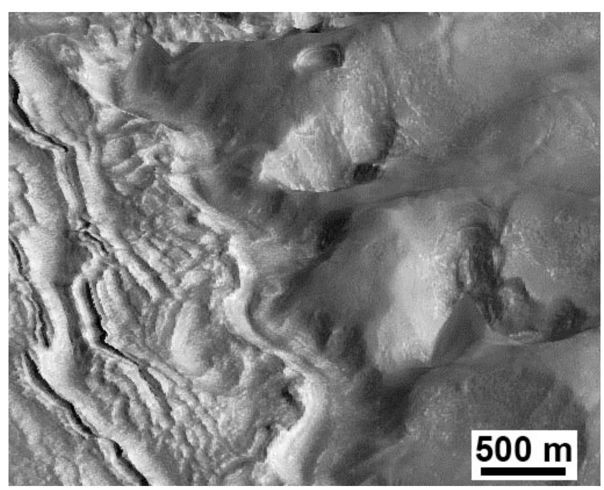

Fig. 5: Northern boundary between lower flow (at left) and the mountain Galaxius Mons (at right). Note the lack of "drain-off" from the mountain to the surface of the flow and the relief of the fractures (~45 m deep) around the base of the mountain. DEM derived from segments of HiRISE images PSP_007672_2155 and PSP_007883_2155.