Supporting Online Material for

Athabasca Valles, Mars: A Lava-Draped Channel System


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**HiRISE Imaging**

The HiRISE camera acquires images at scales of 0.25 to 1.3 m/pixel. Most of these images include a central strip of color data (blue-green, red, near infra-red) that covers 20% of the field of view. Fourteen separate charge-coupled device (CCD) detectors are used together in a pushbroom mode to build up images up to 20,000 pixels wide and typically about 80,000 pixels long. HiRISE will collect data over ~1% of the surface of Mars during the 2-year Primary Science Phase of the MRO mission, which began in November 2006. Further design, performance and operations details for the HiRISE camera are provided in (S1) and (S2). NASA’s MRO science mission is described in (S3).

**Image Processing**

Radiometric and geometric calibration, mosaicing of data from the separate detectors, orthorectified map projection, and anaglyph production are all accomplished with the U.S. Geological Survey’s Integrated Software for Imagers and Spectrometers, Version 3 (ISIS3) (S4, S5). Further processing of stereo image pairs enable the construction of digital elevation models with a 1 m posting and better than 25 cm vertical precision (S6). Anaglyphs presented here are should be viewed with a red filter over the left eye and a cyan (blue+green) filter over the right.
Fig. S1. Cross-sectional schematic diagram illustrating an interpretation of the tributary source region shown in HiRISE image PSP_001408_1900 (cf. Fig. S3). The fronts are inferred to be surficial features emplaced by surges in a waning fissure eruption. The arcuate fronts terminate at a terraced wrinkle ridge (tectonic ridge formed by compressive deformation) to the northwest. However, flows visibly drape some of the higher terraces on the ridge. These uppermost flows may record a high-stand, but that is not demonstrable since wind-swept bright material obscures the lower terraces. Alternatively they may have been emplaced at an earlier time.
Fig. S2. Proximal distributary channel of Athabasca Valles. (A) HiRISE image PSP_002371_1890. (B) Higher resolution sub-region showing a left-lateral shear zone at the boundary between medial platy-ridged terrain and marginal polygonal terrain. *En-echelon* gashes intersect the boundary at angles of $\sim 10^\circ$-$25^\circ$. The gashes show bilateral symmetry in paired, opposite-sensed shear zones. They are principal ($R_1$) Riedel shears, which are common secondary structures in brittle shear zones.
Fig. S3. Subsection of HiRISE image PSP_001408_1900. A flow with lobate margins embays a wrinkle ridge (i.e., a ridge formed by compressive tectonic deformation), draping erosional terraces on its flank. Wind-swept, bright material is superposed on the lower terraces obscuring the stratigraphic relationship between the upper and lower flow exposures. An interpretation of this image is shown in Fig. S1.
Fig. S4. Anaglyph showing a subsection of HiRISE stereo image pair PSP_002661_1895 and PSP_003294_1895. (A) Transverse dunes beside a streamlined “island” in Athabasca Valles. Previous studies interpreted these dunes as bedforms shaped by catastrophic flooding (e.g., S7). Consequently, high-resolution images were expected to reveal rounded, flood-transported boulders within the dunes. (B) However, it is apparent in HiRISE data that the dunes are draped by lava. They exhibit the same rough, ridged texture as lavas elsewhere in the channel system, and they are riddled with RMLs.
Fig. S5. Anaglyph showing a subsection of HiRISE stereo image pair PSP_001606_1900 and PSP_002226_1900. RMLs are a continuum of landforms between mounds and rings. A progressive increase in diameter (a-h) accompanies the transition from mound-shaped to ring-shaped RMLs. In this anaglyph, the RML walls have a dappled appearance that hints at a rough surface with knobs near the limit of resolution, which is consistent with ~30-cm-scale clasts. The walls also support substantial overhangs, so they must be coherent and mechanically strong. An indurated fragmental lithology, such as cemented course-grained sediments or welded lava spatter, is the best fit to these observations.
**Fig. S6.** Cross-sectional schematic diagram illustrating hydrovolcanism in a deflating lava flow emplaced over wet ground. The expansion of steam is limited by confining pressure from the lava overburden. Therefore, the hydrovolcanic model predicts that RMLs will be concentrated atop buried ridges and along the channel margins, where the flow is thinnest. Additionally, the RMLs should be aligned over buried terraces in the channel walls, since the supply of groundwater (and, therefore, the steam budget) is locally enhanced. The distribution of RMLs in Athabasca Valles is somewhat different from the observed distributions of terrestrial hydrovolcanic cones (*S8, S9*). This is because the lava flow in Athabasca Valles once ran deep and subsequently deflated. The observed RML distribution matches these predictions very well.
Fig. S7. (A) Anaglyph from a subsection of HiRISE stereo pair PSP_001606_1900 and PSP_002226_1900 showing diverse RMLs in proximal Athabasca Valles. The yellow box for (A) magnifies a bright-rayed Zunil secondary superimposed on the rim of a moat encircling an RML. The crater exposes rocky material. (B) Anaglyph from a subsection of HiRISE stereo pair PSP_002147_1875 and PSP_002292_1875 showing a sinuous field of RMLs in distal Athabasca Valles. The yellow box for (B) magnifies a dusty secondary crater. The non-circularity of this crater was previously cited as evidence for post-impact modification by the RML to its south (S10). However, HiRISE shows that the boulder-strewn crater ejecta is superimposed on the RML.
Table S1. Ancillary data for HiRISE images.

<table>
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<tr>
<th>Image ID</th>
<th>Latitude° †</th>
<th>Longitude° †</th>
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<th>Length (km)</th>
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†Planetocentric
†Value at center of image

Note: Image width is 20 000 times the pixel scale.
References

S4. The ISIS software, along with documentation and tutorials, is available at no cost from http://isis.astrogeology.usgs.gov/