EARLY HiRISE OBSERVATIONS OF RING/MOUND LANDFORMS IN ATHABASCA VALLES, MARS.

W. L. Jaeger[1], L. P. Keszthelyi[1], A. S. McEwen[2], C. M. Dundas[2], P. S. Russell[3], and the HiRISE team. [1]U.S. Geological Survey, Astrogeology Team, 2255 N. Gemini Dr. Flagstaff, AZ 86001 (email: wjaeger@usgs.gov); [2]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721; [3]Div. Planetary Sciences, Physikalisches Institut, Univ. Bern, Sidlerstrasse 5, 3012 Bern, Switzerland.

Introduction: Thousands of enigmatic 10-100-m-scale ring/mound landforms (RMLs) dot the floor of Athabasca Valles, which is believed to be the youngest flood-carved channel system on Mars [1-3]. These features are key differentiators between competing hypotheses for the recent geological history of the region. Several RML formation models have been proposed, each tied to a different inferred lithology for the channel floor. Studies that invoke a lithology of icy sediments interpret the RMLs as pingos (ice-cored mounds) in various stages of collapse [4-6], those that favor an explosively devolatilized debris flow interpret the RMLs as cryovolcanic cones [7], those that call upon a glaciofluvial origin for Athabasca Valles interpret the RMLs as kettles where calved blocks of ice came to rest [8], and those that hypothesize an igneous lithology interpret the RMLs as rootless cones formed via steam explosions through a lava flow emplaced over a wet/icy substrate [9, 10].

HiRISE Data: As of early January 2007, four HiRISE images showed RMLs in Athabasca Valles. These images sampled both the main channel and its distributary network at a scale of 27-55 cm/pixel.

RML Morphology. The RMLs imaged by HiRISE exhibit a morphological continuum from simple mounds to pitted cones to raised rings (Fig. 1). This transition is accompanied by a progressive increase in RML diameter from ~20 m for a typical mound-shaped feature to ~60 m for a typical ring-shaped feature. Larger, amoeboid RMLs are also observed. They appear to be compound structures formed from coalesced rings. Nested RMLs, with pitted cones situated inside raised rings, are common as well (Fig. 2).

The RMLs are texturally distinct from their surroundings. Dappled shading on their walls hints at a rough surface with knobs near the limit of resolution. Several of the walls are either overhung or undercut, which suggests that they are composed of relatively strong material, and where impact craters cut RMLs, the ejecta tends to be boulder rich. In contrast to earlier findings based on lower resolution images [6], bright-rayed Zunil secondary craters are superimposed on RMLs, indicating that the latter are older (Fig. 2).

Annular Moats. Many RMLs are surrounded by moats. Some moats are topographically subtle (Fig. 1), whereas others have sharp outer rims (Fig. 2). The range of moat morphologies shown in HiRISE images offers a clue to their formation. Incipient moats are manifest as ring fractures, and evolved moats are characterized by tilted plates that overrode their surroundings in minature thrust faults. Thus, the moats appear to have formed by the loading and, in some cases, brittle failure of a thin, rigid crust over a deformable layer.

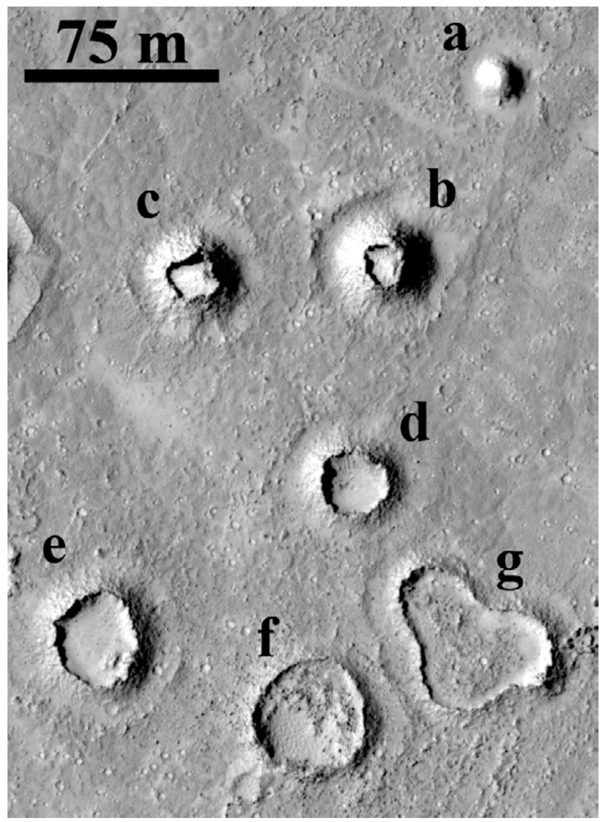

Figure 1. Subsection of HiRISE image PSP_001606_1900 showing the continuum of RML morphologies from mounds (a), to pitted cones (b, c), to rings (d-f), to amoeboid features with raised perimeters (g).

Wakes. Relict wakes trail from the downslope sides of numerous RMLs. The wakes are bounded by paired sets of parallel ridges, and the regions between them are generally rough, with angular blocks jutting out of the surface. Many wakes are severed where rafted plates broke apart (Fig. 3). This observation indicates that the wakes formed in the brittle crust of a mobile fluid flow. However, they are not gouges where the translating flowtop crumpled against fixed obstacles. Instead, they appear to have formed as successive or continuous explosions from a stationary source ripped through the brittle crust on the flow, in a process loosely analogous to the formation of the Hawaiian Island chain. By this model, the material within the wakes is a mixture of explosive products, older disrupted crust and upwelling fluid from inside the flow, and the paired ridges are chains of deposited spatter. This hypothesis is consistent with the observation that some wakes grade from paired ridges to overlapping rings in the upstream direction, which is a geometry hinted at in Figure 3 and shown clearly in MOC image R05-01465.

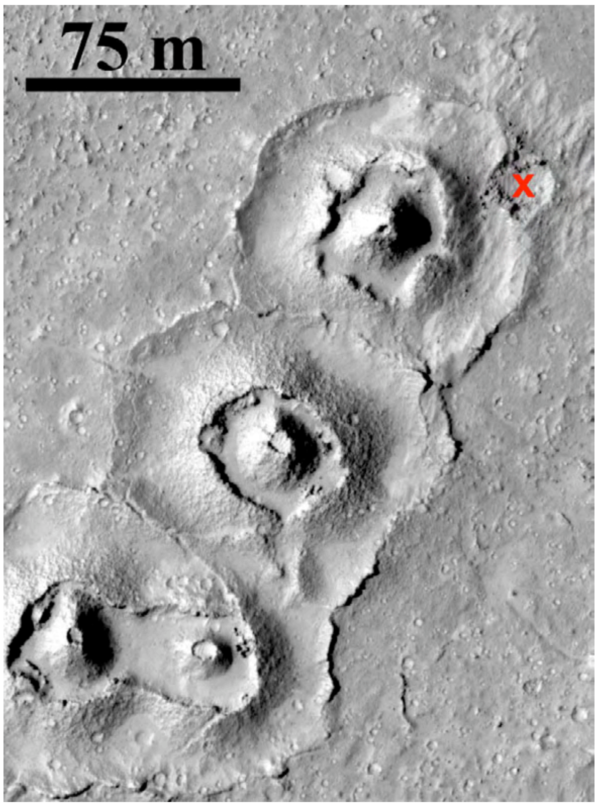

Figure 2. Portion of HiRISE image PSP_001606_1900 showing sub-linearly aligned RMLs with nested structures and prominent moats. The red "x" indicates a bright-rayed Zunil secondary impact crater superimposed on an RML.

Conclusions: HiRISE observations of Athabasca Valles show that the RMLs formed on the thin, brittle crust of an active fluid flow. Therefore, they are neither kettles nor pingos. The remaining hypotheses, cryovolcanic cones and hydrovolcanic (rootless) cones, both invoke an explosive origin for the RMLs. Wake morphologies suggest that the gas driving the explosions was housed in the substrate, rather than the flow itself, which counter-indicates cones built via the explosive degassing of a debris flow. Moreover, the strength of the RML walls and of the tilted plates at moat perimeters is difficult to reconcile with a lithology of clastic sediments but consistent with welded spatter and solid lava. Ice-cemented sediments are also strong, but they are not a viable alternative since near-surface ice is not stable at such low latitudes [e.g., 11].

Collectively, these observations are most consistent with the hydrovolcanic (rootless cone) model. The RMLs are inferred to have formed as late-stage structures in a very fluid and voluminous lava sheet flow that deflated and draped the pre-existing flood-carved landscape in Athabasca Valles [12]. This interpretation is consistent both with new HiRISE images and with earlier geophysical datasets that show the region to be rough, rocky and hydrogen-poor.

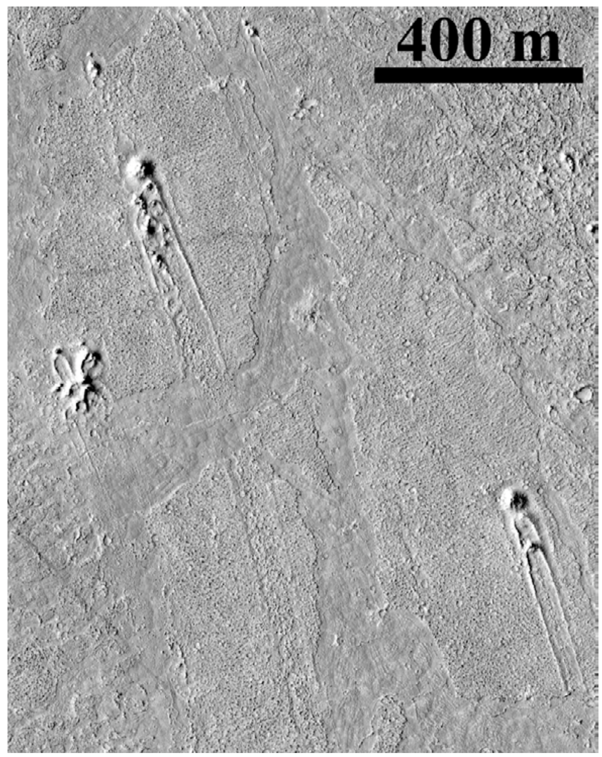

Figure 3. Wakes trail from small clusters of RMLs in HiRISE image PSP_001540_1890. The wakes are severed where mobile plates rafted apart.

References: [1] Tanaka K. L. and Scott D. H. (1986) *LPS XVII*, 865-866. [2] Burr D. M. et al. (2002) *Icarus 159*, 53-73. [3] McEwen A. S. et al. (2005) *Icarus 176*, 351-381. [4] Rice J. W., Jr. et al. (2002) *LPS XXXIII*, Abstract #2026. [5] Burr D. M. et al. (2006) *Icarus 178*, 56-73. [6] Page D. P. and Murray J. B. (2006) *Icarus 183*, 46-54. [7] Hoffman N. and Tanaka K. (2002) *LPS XXXIII*, Abstract #1505. [8] Gaidos E. and Marion G. (2003) *JGR 106*, 2002JE002000. [9] Keszthelyi L. et al. (2000) *JGR 105*, 15,027-15,050. [10] Lanagan P. D. (2004) thesis, University of Arizona. [11] Mellon M. T. et al. (1997) *JGR 102*, 19,357-19,369. [12] Jaeger W. L. et al. (2007) *LPS XXXVIII*, Abstract, this issue.