EVIDENCE FOR BASINWIDE MUD VOLCANISM IN ACIDALIA PLANITIA, MARS.

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Introduction: High-albedo mounds in Acidalia Planitia occur in enormous numbers. They have been variously interpreted as pseudocraters, cinder cones, tuff cones, pingos, ice disintegration features, or mud volcanoes [1-4]. Our work [5] uses regional mapping, basin analysis, and new data from the Context Camera (CTX), High Resolution Imaging Science Experiment (HiRISE), and Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) to re-assess the origin and significance of these structures.

Results: *Geologic Setting.* Chryse and Acidalia Planitiae (Fig. 1) have been proposed to be remnants of impact basins, formed ~4 Ga ago [6]. Together, they comprise an embayment [7] that was the focal point for sediment deposition from Hesperian outflow channels. Chryse is the proximal, shallower portion of the embayment and Acidalia is the distal, deeper portion.

Mound Characteristics and Age. The mounds (Fig. 2) are circular to sub-circular, domal, hundreds of meters to several km in diameter. Most have high albedo relative to surrounding plains. The mound surfaces are typically smooth, and pitted or unpitted. Rims are well defined, and some mounds have encircling moats or apron-like extensions. In THEMIS Nighttime IR data, the mounds are considerably darker than the plains (Fig. 3), suggesting low thermal inertia commonly associated with fine-grained or poorly consolidated sediments [4, 8].

The mounds occur singly, in pairs, in irregular clusters and in chains that may be aligned with troughs of the giant polygons (Fig. 2) of Acidalia or with arcuate ridges in the "thumbprint terrain."

Most of the mounds are younger than Early Amazonian, as the majority overlie Vastitas Borealis Units mapped as Early Amazonian [3].

Abundance. The mounds were mapped using their dark response in Nighttime IR (Fig. 3). They were documented in an area ~2.5 (10^6) km^2 (red outline, Fig. 1). 18,000+ mounds (> 300 m diam.) were counted in ~ 45% of that area [9]. Extrapolating to the 2.5 (10^6) km^2 results in an estimate of 40,000 mounds. The number would be greater if smaller mounds had been included.

Indications of Flow. Flow-like features associated with the mounds include i) high-albedo material extending from mound surfaces into polygon troughs (Fig. 4A), ii) lobate forms emanating from individual mounds (Figs. 4B-E), iii) linear features extending from mounds into the plains (Fig. 4F), iv) coalescing mounds (top of Fig. 2C), and (not shown) v) conical internal mound structure [5].

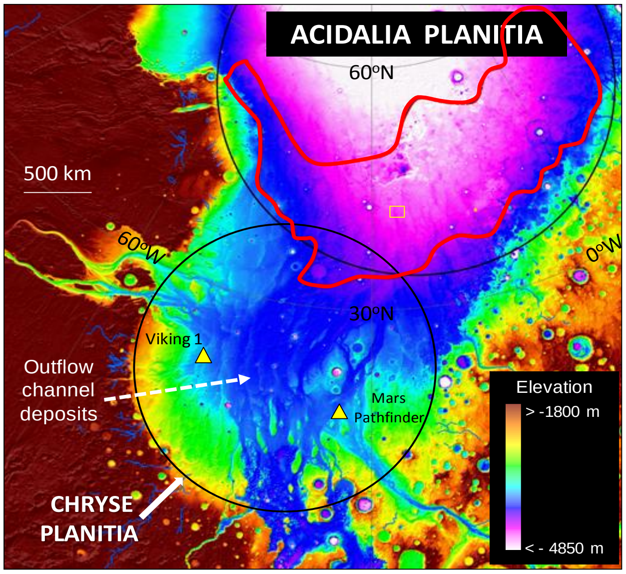

Fig. 1. Chryse-Acidalia embayment on stretched MOLA topography (polar projection). Black circles show proposed impact basins [6]. Red outline is area in which mounds can be demonstrated. Small yellow rectangle is area of Fig. 3C.

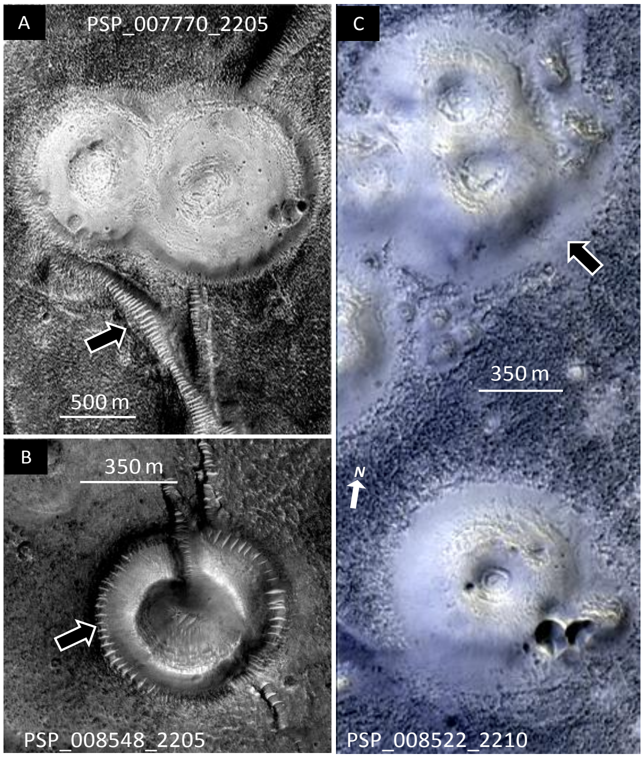

Fig. 2. HiRISE images of Acidalia mounds. Arrows in (A) show dunes in polygon troughs, in (B) dunes in moat around mound, and in (C) apron from mound onto the plains (C).

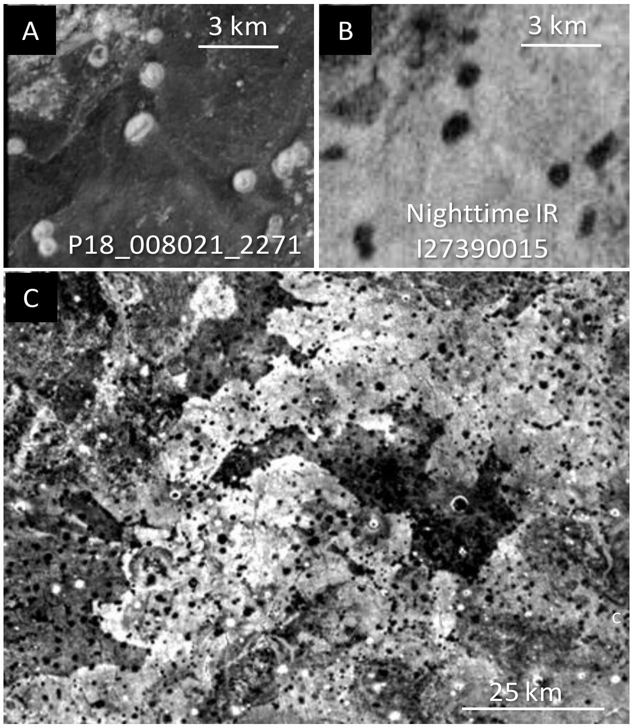

Fig. 3. Abundance of Acidalia mounds. (A-B) show correlation of dark Nighttime IR response (B) with high-albedo mounds in CTX image (A). (C), Nighttime IR mosaic illustrating regional abundance; area of (C) is small yellow rectangle in Fig. 1.

Mineralogy. CRISM data suggest that the mounds and plains have generally similar composition. Both show the muted mafic responses common in Acidalia [10-12]. However, subtle differences are suggested by VNIR-FEM products and ratio analyses indicating enhanced coatings or ferric oxides in the mounds compared to the plains [5, 13].

Analogs. Of the potential analogs, pingos, tuff cones, and mud volcanoes seem most viable. However, pingos are difficult to reconcile with the unfractured surfaces, distinct mound texture and albedo, associated flow-like features, and the fact that several mounds have their internal cores exposed but lack collapse features, as might be expected if they were pingos cored by ice. Tuff cones seem inconsistent with the morphological variability and alignment of the Acidalia mounds, and by the lack of evidence for widespread Amazonian magmatism. Only the mud volcano alternative is consistent with all the data [5], though the process in Acidalia would have had distinctly martian attributes. Moreover, extensive mud volcanism would be predicted in Acidalia from its geologic setting, as its distal position would have fostered rapid accumulation of fine-grained, muddy sediments - a critical ingredient for the development of mud volcanism.

Conclusions and Implications: 40,000+ high-albedo mounds occur in southern Acidalia. These structures have geologic, physical, mineralogic, and morphologic attributes most consistent with an analog similar to terrestrial mud volcanism.

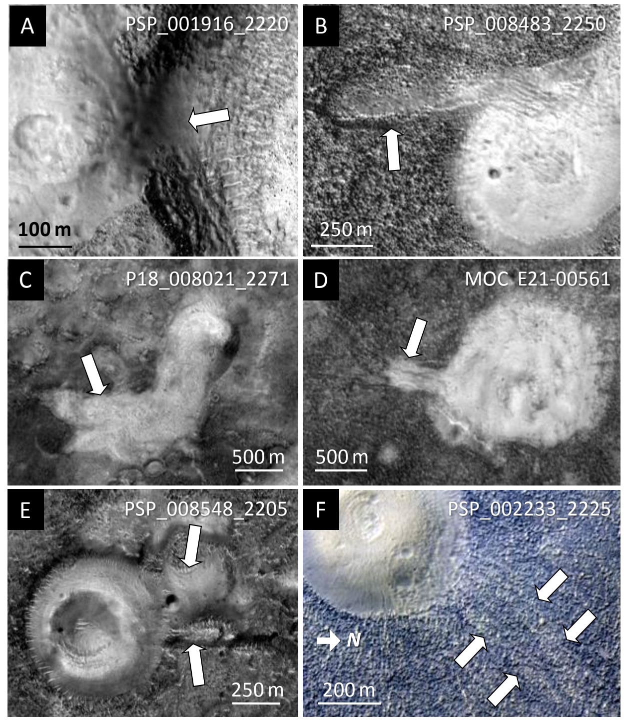

Fig. 4. Flow-like structures (arrows) associated with Acidalia mounds. HiRISE images (A-C, E-F); MOC image (D).

We propose [5] that the profusion of mounds in Acidalia is a consequence its unique setting, being the depocenter for the fine fraction of sediments delivered by the outflow channels. The large number of mounds, coupled with their widespread distribution, may reflect a major episode in the history of the lowlands, possibly even a basinwide event of mud eruption. Such an event might include loss of overburden through sublimation of an ocean, dissociation of gas hydrates, or hydrothermal/tectonic pulses. Significant release of gas may have been involved.

Mud volcanoes transport minimally-altered materials from depth to the surface and are often associated with organic-rich sediments. Accordingly, mud volcanoes on Mars might contain biosignatures of life that may have existed in Acidalia's large watershed or in fluid-rich microhabitats in Acidalia's subsurface.

Thus, the mounds in Acidalia not only may reflect a major event in the history of the lowlands but also may offer a means of tapping samples from deep zones of potential astrobiological significance.

References: [1] Tanaka K. (1997) JGR 102, 4131-4150. [2] Tanaka K. *et al.* (2003) JGR 108, E4, GDS24-1-GDS 24-32. [3] Tanaka K. *et al.* (2005) Nature 437, 991-994. [4] Farrand W. *et al*. (2005) JGR 110 doi: 10.1029/ 2004JE002297. [5] Oehler D., Allen C. (submitted). Icarus. [6] Frey H. (2008) Geophy. Res. Let. 35, L13203. [7] Oehler D., Allen C. (2009) LPS XL, # 1034. [8] Putzig N., Mellon M. (2007) Icarus 191, 68-94. [9] Amador E., Allen C., Oehler D. 2010. LPS XLI. [10] Salvatore M. (2009) LPS XL, # 2050. [11] Wyatt M., McSween Jr. H. (2002) Nature 417, 263-266. [12] Wyatt M. (2008) GSA Abs.Prog. #268-3. [13] Allen C. *et al.*, (2009) LPS XXXX, #1749.