CONTINUING STUDY OF ANOMALOUS PIT CRATERS IN THE THARSIS REGION OF MARS: New Observations From HiRISE and THEMIS.

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Introduction: The Mars Odyssey Thermal Emission Imaging System (THEMIS) [1] observed seven deep pit craters around Arsia Mons [2]. These features are roughly circular with typical diameters of ~100-250 m. From a nadir perspective, sunlight did not illuminate the floors or walls in THEMIS observations, indicating either steep or overhanging interior walls. Diurnally observed thermal characteristics indicate that floor temperatures are controlled by materials deep beneath the surface. Each of the seven pits originally discussed in [2], was cooler than surrounding surfaces (including shadowed regions) during the afternoon and was much warmer than all nearby surfaces in predawn observations.

The work presented here is from an ongoing investigation of these features using new data returned by the HiRISE camera [3]. To date, pits with characteristics like those discussed here have only been found in the Tharsis region, mostly on or near Arsia Mons. Accordingly, this may be a region on Mars with an upper-surface layer that is competent enough to support vertical walls ~100 m tall and possibly overhanging ledges.

Observations: *Annie*: (Figure 1) This pit crater is located on Arsia Mons' northern flank, and lies at the center of a 'typical' pit-crater chain [4]. Though relative sizes and positions of the adjacent pits could suggest an intact overhanging ceiling with void space extending laterally beneath the surface, there is no observational evidence that such void space exists and such is probably unlikely. The diameter of this pit crater is ~260 m at the widest point, and calculations from shadow measurements show the center of the floor to be ~112 m below the surface.

Jeanne: A HiRISE observation of this pit (Figure 2-A) shows the interior to be in shadow with emitted radiance no greater than that of atmospheric haze. Observed from the west at an off-nadir angle, this pit is a deep shaft with near-vertical, rocky walls. We can see a portion of illuminated wall in this image, but still cannot see the floor with a solar incidence angle of 41°. We can therefore update the estimated the minimum depth to be at least 172 m (previous minimum estimate from THEMIS observations was 75 m [2]), which is greater than the pit's diameter. Figure 2-B shows the first observation to resolve floor features (large boulders), but only by stretching the data to the limit of HiRISE detection capabilities. Without a distinct shadow across the floor, however, we still do not have a firm estimate of depth.

Listed below are recent HiRISE observations of six of the seven pits described in [2] (names are informal):

- Jeanne: PSP_003647_1745, PSP_004847_1745 and PSP_005770_1745
- Dena: PSP_004913_1735 and PSP_005836_1735
- Wendy: PSP_005058_1720
- Annie: PSP_005414_1735
- Abbey and Nikki: PSP_005203_1730 and PSP_005625_1730

Additional features: HiRISE has observed two additional features similar to the seven pits discussed in [2]. This pair of pit craters with sheer walls is located to the north of Arsia Mons (Figure 3). These are the only such features we have identified, to date, that are not directly related to Arsia Mons. These pits have similar size, appearance, and thermal characteristics as those discussed in [2], but are different because they contain material that is darker than the material observed in the pits around Arsia Mons. Aeolian processes have exhumed some of this material to form a dark, fan-shaped albedo feature that is not present around the other pits. Diurnal thermal observations from THEMIS indicate that this albedo feature is composed of larger grain sizes (and therefore, higher thermal inertia [e.g., 5]) than covers the surrounding surface. This pair of pit craters is located near the end of a much older chain of pit craters, which may signify a more recent episode of collapse along the same zone of extension. Thus, pit-crater formation may be an ongoing process that continues into the present day.

Discussion: Previous discussions suggested that these collapse features may be skylights that open into subsurface cavernous voids. While this possibility cannot be completely ruled out, the recent HiRISE observations indicate that these pits are more likely to be deep vertical shafts that may have a small amount of overhang at the edges. Further observations that focus upon interior walls of these pits will provide more conclusive information. The mechanisms that cause these pit craters to be different from those typically found across Mars [4] are not yet well understood. The surface material may be too strong to have allowed collapse to continue, or these may represent an intermediate stage in the evolution of pit-crater formation. Mass wasting/slope retreat acts to widen and degrade pit craters over time, decreasing their depth/width ratios.

The high aspect ratios of the features discussed here may point to more recent collapse. This would suggest that extensional deformation on the north flank of Arsia Mons, where the anomalous pits are seen, was active relatively recently.

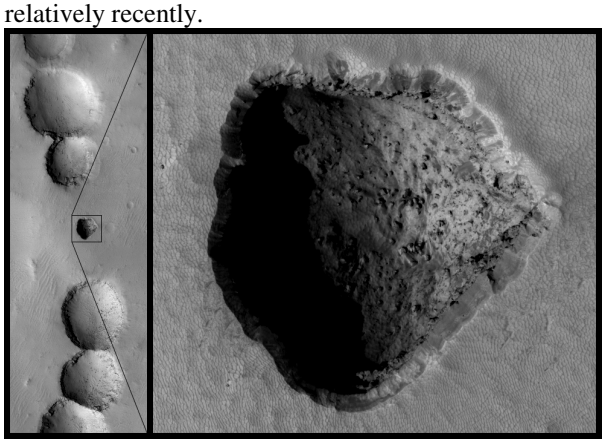

Figure 1: HiRISE observation (PSP_005414_1735) of 'Annie' where both the floor and near-vertical walls are visible.

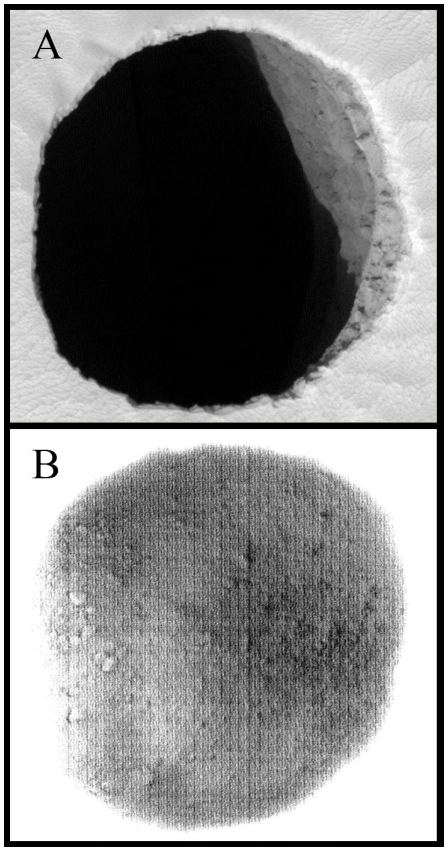

Figure 2: HiRISE observations of 'Jeanne.' [A] (PSP_004847_1745) the solar incidence angle is ~41°, but sunlight does not illuminate the interior of this feature. HiRISE detects no features in this darkness, where measured radiance values are equivalent to hose of atmospheric haze. [B] (PSP_005770_1745) is another HiRISE image that shows floor features in the shadow. This image was taken with no 14 →8-bit compression applied, thus utilizing the full dynamic range of HiRISE.

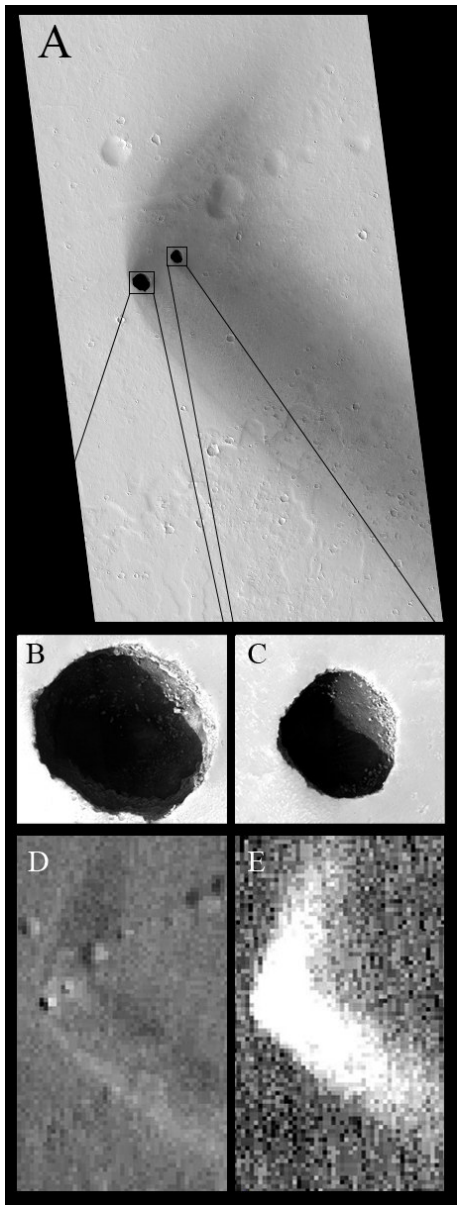

Figure 3: HiRISE [A,B,C] and THEMIS IR [D,E] observations of a pair of pit craters located to the north of Arsia Mons (247.55° E, 17.27° N). Shadow measurements indicate that [B] is ~125 m deep and [C] has a depth of 68 m at the edge of the shadow. Unlike the pits adjacent to Arsia Mons, these show a subsurface material that is distinctly darker than the surface layer. THEMIS afternoon [D] and predawn [E] thermal observations indicate that the fan-shaped albedo feature surrounding these pits has higher thermal inertia (probably from larger grain sizes) than the surrounding terrain.

References: [1] Christensen, P.R. et al. (2004) *Space Sci. Rev.*, *110*(1), 3985-4015. [2] Cushing et al. (2007) *GRL*, *34*, L17201. [3] McEwan et al. (2007) *JGR*, *112*(E5), E05S02. [4] Wyrick et al. (2004) *JGR*, *109*, E06005. [5] Presley, M.A. and P.R. Christensen (1997) *JGR*, *102*(E3), 6551-6566. [6] Malin et al. (1992) *JGR*, *97*(E5), 7699-7718.