THE ASYMMETRIC EJECTA PATTERN OF ZUNIL CRATER, MARS. P. J. Mouginis-Mark[1] and V. L. Sharpton[2]. [1]HIGP/SOEST, Univ. Hawaii, Honolulu, HI 96822 (pmm@higp.hawaii.edu) and [2]Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058 (Sharpton@lpi.usra.edu).

Introduction: Previous studies [1, 2] have drawn attention to the large number of secondary craters and rays from the Martian impact crater Zunil (Fig. 1). This crater is ~10.1 km in diameter and is located within the Cerberus Plains at 7.8°N 166.7°E. Preblich et al. [2] proposed that Zunil was formed by a moderately oblique impact from the east. However, this analysis failed to take into consideration both the near-range ejecta deposits as well as the topography and morphology of the rim, both of which illustrate pronounced azimuthal variations that are rarely seen on other fresh impact craters on Mars identified by [3]. Here we utilize a new digital elevation model (DEM) of Zunil, derived from stereo CTX images, as well as HiRISE scenes, to investigate these other attributes of the crater.

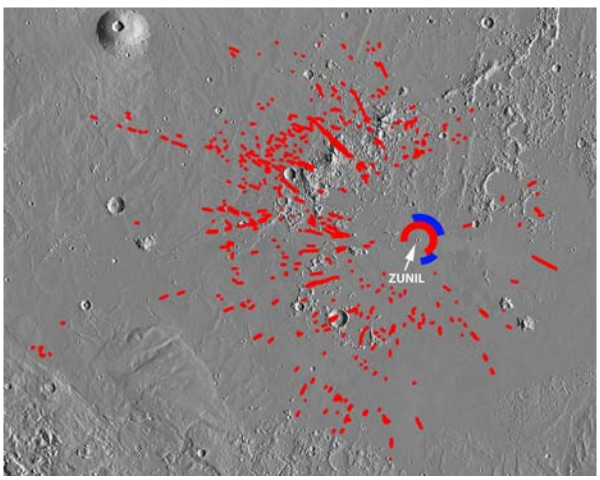

Fig. 1: Distribution of Zunil's rays, compared to the azimuths of the crater's rim that display pits (broken blue circle) and fluidized ejecta blanket (broken red circle). Map of rays modified from [2]. Base map is a MOLA shaded relief image.

Ejecta and Rim Morphology: Fig. 2 illustrates that Zunil is highly unusual in that the northern segment of the ejecta blanket is composed of ejecta layers that are typically interpreted to be fluidized ejecta [4]. In contrast, the SW part of the ejecta blanket lacks fluidized features (e.g., distal ramparts and longitudinal grooves) and instead has a morphology typically associated with ballistic ejecta. However, a comparison between the pattern of crater rays and the azimuthal variations in near-rim ejecta shows few correlations (Fig. 1).

There is also a marked variation in the morphology of the rim crest of Zunil (Fig. 3). In particular, the topmost layers of the SW rim displays layering all the way to the rim crest that are interpreted to be uplifted lava flows from the pre-impact surface. In contrast, the northern rim illustrates the same pitted and degraded morphology that was attributed to unconsolidated ejecta at Tooting Crater [4].

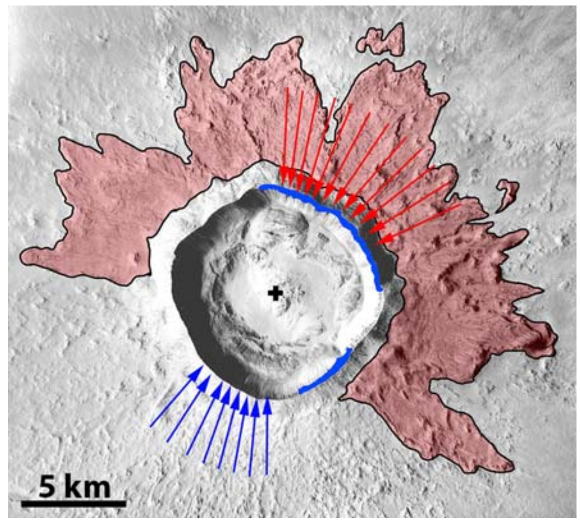

Fig. 2: Distribution of fluidized ejecta layers (light red) and pits on the rim crest (blue) of Zunil crater. Blue arrows indicate location of 8 profiles across ballistic crater rim; red arrows denote locations of 12 profiles across the eroded crater rim (Fig. 4). Center of Zunil denoted by "+". Part of CTX image G05_020211_1877.

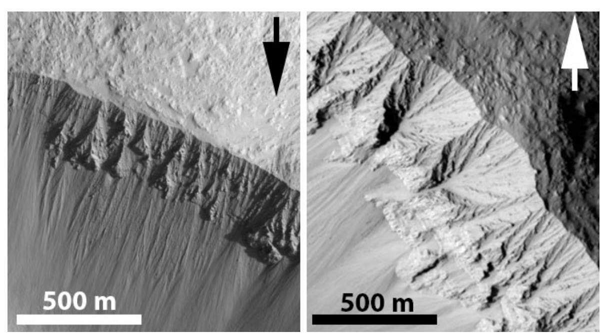

Fig. 3: Contrasting rim morphologies for Zunil. Arrows point north. Left: On southern rim, layered lava flows extend to rim crest with almost no erosion. HiRISE image PSP_002397_1880. Right: On the NE and SE rim, there has been extensive erosion of unconsolidated material (blue rim segments in Fig. 1). HiRISE image PSP_002252_1880.

Rim Topography: To further investigate the morphology of the interior and rim topography of Zunil, we have produced a DEM from a stereo pair of CTX images (Fig. 5). This DEM has allowed us to compare the average topography of the crater cavity (Fig. 4) and construct a profile around the perimeter of the rim crest (Fig. 6). Two attributes are apparent from the interior profiles: the segments of the cavity that are radial to the layered rim (i.e., SW rim) have (1) steeper upper slopes and (2) are deeper (by ~200 m) than the profiles across the pitted portions of the rim (i.e., N to E rim). A profile around the perimeter of the rim crest (Fig. 6) also reveals some differences. The southern rim has lower variability (SD = 40.1 m) than the NE rim (SD = 62.8 m) and is generally higher than the NE rim (by ~30 m). Zunil has an average rim height of 440 m NS a depth/diameter ration of 0.1175. The deepest part of the crater floor is 735 m below the surrounding, pre-impact, terrain.

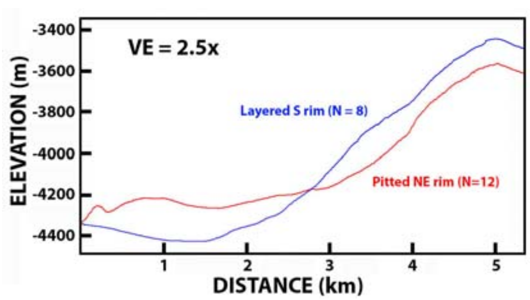

Fig. 4: Average (N= number used) profiles for crater interior with eroded rim (red line) and layered rim (blue). See Fig. 2 for locations of individual profiles.

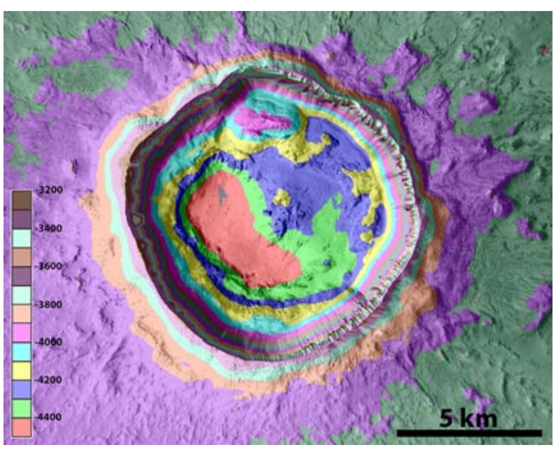

Fig. 5: Topographic map of Zunil crater. Contour interval is 100 m (scale bar at left gives range). Note that the deepest part of the floor is in the SW portion of the crater, which matches the azimuths of the layered rim material. In contrast, the outer rim is narrowest in the NE, which correlates with the eroded and pitted rim crest. Base image is part of CTX frame G05_02011_1877.

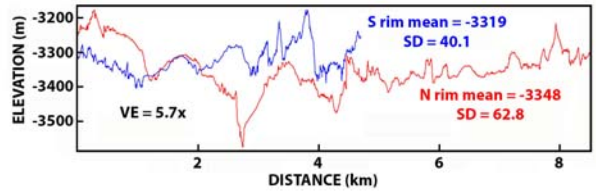

Fig. 6: Rim crest topography for Zunil. Blue line is rim segment with layered units (i.e., S rim) and red line is eroded rim (NE rim). Note the greater amount of relief (~375 m) for eroded rim compared to ~200 m for layered rim.

Conclusions: The striking azimuthal variations in the ejecta deposits and rim morphology of Zunil do not correlate with previously identified crater rays and secondary craters. This is enigmatic, because our interpretation of the eroded NE and SE rim segments is that they are indicators of unconsolidated material that formed the late-stage ejecta at these azimuths. A possible explanation could be that Zunil formed on a structural boundary between relatively competent rock (lavas) toward the SW and less indurated material (pyroclastics, sediments, etc.) toward the N and NE. If this interpretation is correct, it seems reasonable to expect that this unconsolidated material would be less likely to produce chains of secondary craters. Alternatively, as lobate ejecta layers are typically interpreted to be indicative of volatiles within the target at the time of crater formation [4 – 6], there may have been an asymmetric distribution of volatiles within the target materials within which Zunil formed. However, this volatile asymmetry does not influence the distribution of secondary craters.

The new CTX DEM provides useful information on the post-impact modification of the crater cavity. Large slump blocks on the northern floor are no doubt responsible for the shallow segments of the floor, but it is interesting that the deepest part of the crater floor correlates with the azimuths where the layered rim units occur. The pits that are characteristic of the NE and SE rims contribute the greater topographic variability of the rim, and correlate with the narrowest segment of the outer crater rim.

References: [1] McEwen A. S. *et al.* (2005) *Icarus* 176, 351 - 381. [2] Preblich, B. S. *et al*. (2007) *JGR* 112 (E05), doi: 10.1029/2006JE002817. [3] Tornabene L. L. *et al.* (2006) *JGR* 111, doi: 10.1029/2005JE002600. [4] Mouginis-Mark, P. J. and J. M. Boyce (2012) *Chimie der Erde Geochim* 72, 1 – 23. [5] Carr, M. H. *et al*. (1977) *JGR* 82, 4055 - 4065. [6] Barlow, N. G. and C. B. Perez (2003). *JGR* 108 (E8) doi: 10.1029/2002JE002036.