Geologic and topographic mapping of Tooting crater, Mars, from HiRISE and CTX data: Rim slumping controls the distribution of impact melt, pitted terrain, mudflows and cavity dewatering. P. J. Mouginis-Mark[1] and H. Garbeil[2], [1]Hawaii Institute Geophysics & Planetology (HIGP), SOEST, University Hawaii, Honolulu, HI 96822 <pmm@hawaii.edu>, [2]HIGP, SOEST, University Hawaii, Honolulu, HI 96822.

Introduction: The martian crater Tooting (23.4ºN, 207.5ºE) is ~29 km in diameter and classified as a multi-layered ejecta crater [1]. We are conducting detailed topographic and geologic mapping of the crater in order to produce a 1:200K geologic map of the crater. Because of its very young age [2] and the fact that Tooting crater formed on virtually flat, young, layered basalt lava flows within Amazonis Planitia [3], it provides valuable insight into cratering mechanics and the post-impact modification of the crater cavity. Using recently released stereo data from the Context Imager (CTX), along with multiple HiRISE images that provide almost complete coverage of the crater cavity, we are investigating the relationship between the crater topography and the previously recognized asymmetry in ejecta distribution [2], the occurrence of terrace formation, the distribution of possible impact melt, and pitted terrain.

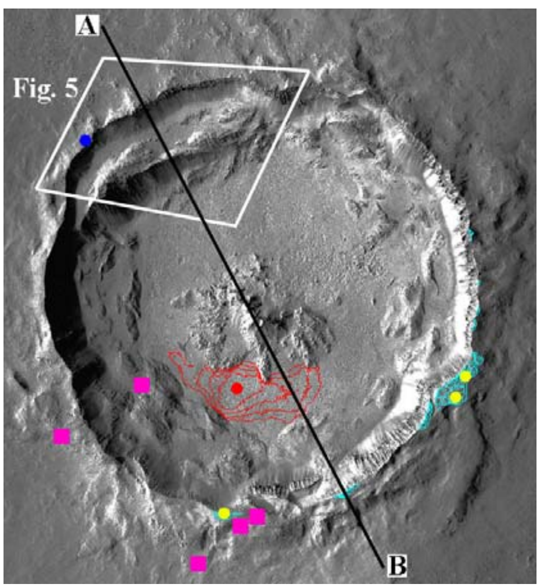

Fig. 1: Distribution of low and high points within Tooting crater. Yellow dots mark highest points on rim (-2,913 m), blue dot the lowest (-3,493). Blue contours are at 25 m intervals, and show elevations above 3,000 m. Red dot is low point on floor (-5,146 m), and red contours, at 25 m intervals, denote points on floor below -5,075 m. The profile A-B in Fig. 6 is shown, as is the field of view of Fig. 5. Pink squares mark locations of flows identified by Morris et al. [4] as flows of impact melt and/or mudflows. Base CTX image P03_002158_2034.

We have generated a digital elevation model (DEM) for the whole crater using CTX data, and selected higher-resolution DEMs from the HiRISE data. To produce these DEMs, we rely on a series of frequency domain cross correlation kernel operations to refine the auto-matching with the finest kernel at 8 x 8 pixels. This means that the spatial resolution of the derived DEMs is of the order of 2 m for HiRISE and 50 m for CTX.

Rim height and crater depth: The new CTX DEM allows a more complete analysis of the topographic variability of the rim and floor than we were previously able to conduct [2]. The total elevation change from the lowest point on the floor to highest point on the rim is 2,233 m. The total variation in relief around the crest of the crater rim is 580 m. Tooting crater is ~29 km in diameter, so that the depth/diameter ratio would be between 0.077 to 0.057. We also note that Morris et al. [4] proposed that, prior to rim slumping, Tooting crater may have had a diameter of ~26.4 km. This means that the depth/diameter ratio would have been between 0.0846 and 0.063. These ratios are ~1.7x predicted [5] for the highest part of the rim, and ~1.3x the value for the lowest point. The implication is that any future cratering model that predicts the initial geometry of craters on Mars should include significantly deeper craters than previously expected.

Distribution of key geologic units: Two geologic units on the floor are particularly illuminating for the evolution of Tooting crater. Tornabene et al. [6] have identified a new geomorphic unit within young impact craters. Pitted material (Fig. 2) is very extensive at Tooting crater, and occurs not only on the floor, on terrace blocks and on the rim where the material appears to have ponded in depressions (Fig. 3). Fractured terrain (Fig. 4) is exclusively found at the topographically lowest portions of the crater floor (Fig. 1), ~100 m below the mean elevation of the crater floor.

Large terrace blocks have played an important role in the evolution of Tooting crater. The most prominent of these blocks (Fig. 5) appears to have reduced the elevation of the rim crest by several hundred meters (Fig. 6). The edge of this block is upturned, with ~300 m of relief compared to the ponded material trapped against the crater wall.

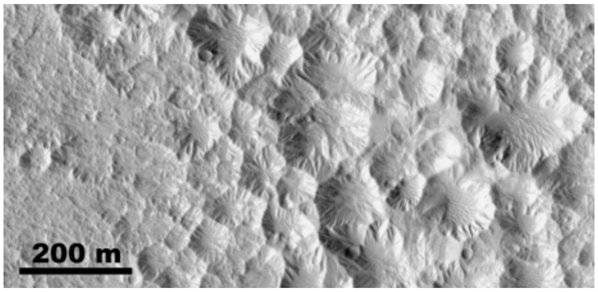

Fig. 2: Typical pitted terrain on northern floor of Tooting crater. HiRISE frame PSP_001538_2035.

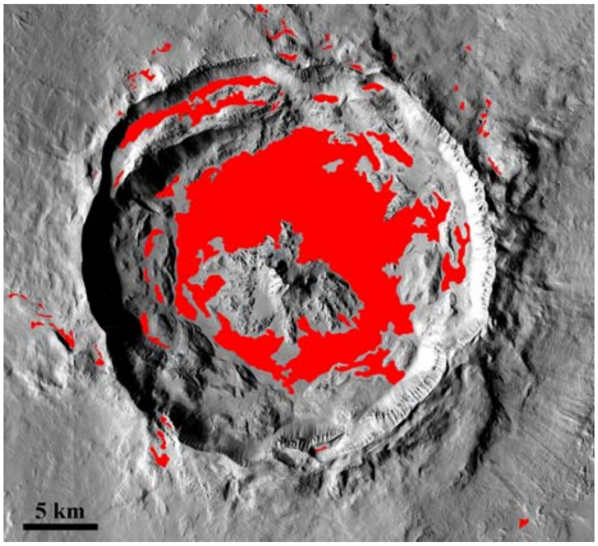

Fig. 3: Distribution of pitted terrain (shown in red) within the cavity of Tooting crater. Base image is CTX frame P01_001538_2035.

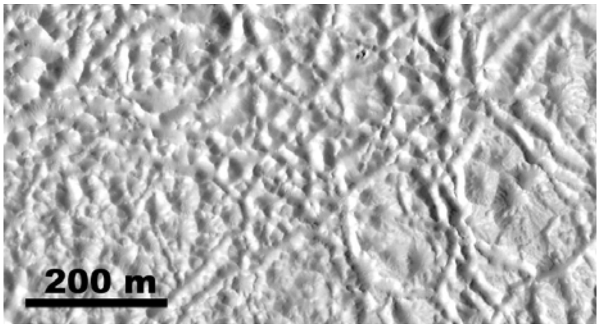

Fig. 4: Typical fracturing material in crater cavity. HiRISE frame PSP_001538_2035.

Synthesis: Our mapping has revealed a close relationship between the distribution of ejecta and rim slumping, which in turn may have controlled the formation (and distribution) of pitted terrain, and the preservation of exposed impact melt of the crater floor. We have shown [2] that the distribution of the ejecta volume reveals that, for a given radial distance from the cavity rim, the ejecta blanket is ~100 m thicker on the northeastern portion of the ejecta blanket than on the southwestern portion. Paradoxically, where the ejecta is thickest out to ~1 crater radius from the rim crest, the rim is lowest (Fig.1); we interpret this to be due to the extra loading that has produced slumping of the rim. Where slumping took place, impact melt on the rim was destroyed, and redistributed as hot volatile-rich material on the floor. We postulate that this material then degassed to produce the pitted terrain. Only where slumping did not occur are the flows identified by [4] preserved on the rim and the wall subsequently "dewatered" to produce mudflows and valley networks. The lack of slumping precluded much material from being emplaced on the floor, and this is where the floor is now deepest. The absence of in-fill meant that fractured impact melt on the floor is still exposed in these areas. Other anomalously deep craters on Mars should therefore be studied to see if they too retain exposures of impact melt.

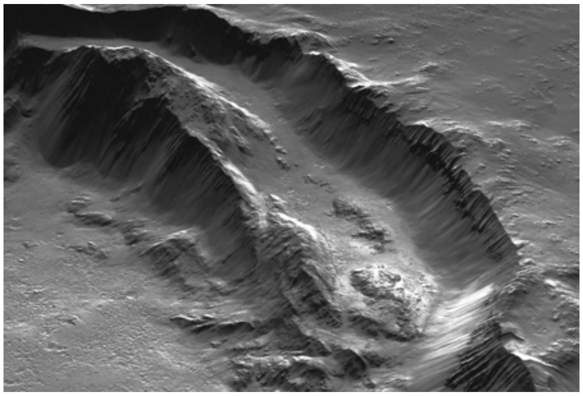

Fig. 5: Oblique view of the prominent bench on the NW rim of Tooting crater. View is looking west.

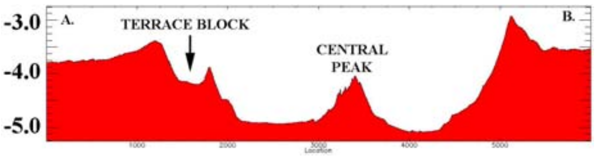

Fig. 6: Topographic profile A to B (Fig. 1) across Tooting crater, showing the greater elevation of the southern rim, the greater depth of the southern floor, and the large height of the central peak. Elevation in km relative to Mars datum.

References: [1] Barlow, N.G. et al. (2000). *JGR-Planets* 105: 26733 - 26738. [2] Mouginis-Mark, P.J. and H. Garbeil. (2007). *MAPS* 42: 1615 – 1625. [3] Tanaka, K.L. et al. (2005) USGS Map I-2888. [4] Morris, A. et al. (2009). Possible impact melt and debris flows at Tooting crater, Mars. Submitted to *Icarus*. [5] Garvin, J.B. and J.J. Frawley (1998). *GRL* 25: 4405 – 4408. [6] Tornabene, L.L. et al. (2007). *7th Int. Conf. Mars* abs.#3288.