SELF SECONDARY CRATERING ON THE RIM OF THE MARTIAN IMPACT CRATER TOOTING: OR SOMETHING ELSE. Joseph M. Boyce and Peter J. Mouginis-Mark, Hawaii Institute Geophysics Planetology, University of Hawaii, Honolulu, HI 96822 (jboyce@higp.hawaii.edu).

Introduction: Small areas containing anomalously high numbers of small (i.e., ~ 20 - 70 m dia.) nearly circular craters located on the rim of Tooting crater (23^{o}N, 152^{o}E), Mars, were reported by [1, 2] and attributed to fallback of very high-ejection angle debris from the excavation of that crater [2]. This interpretation has important implications for crater density-based age estimates of individual large impact craters [3], as well as for impact cratering mechanics [4].

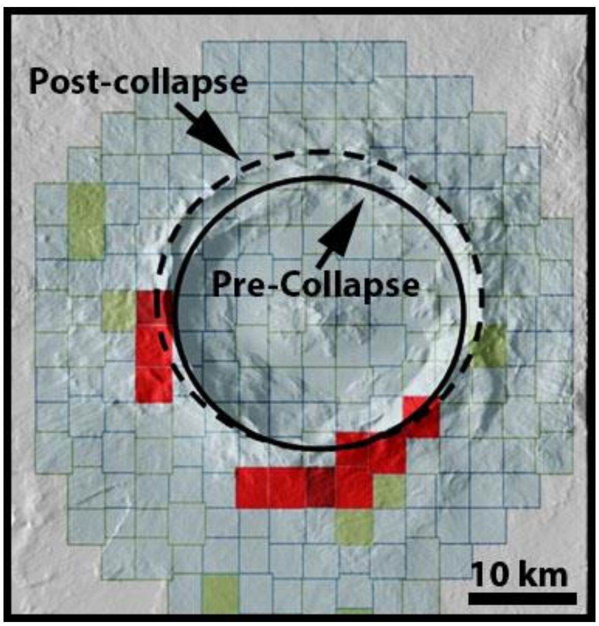

Fig. 1: Density of craters >50 m dia. on Tooting crater out to ~0.5 R from the rim of the crater. Each cell is 2.95 km x 2.95 km, with the color of each cell a function of the number of craters in that cell. Light blue cells contain 2 ± 2 craters/cell, light green from 6 ± 1 crater/cell, burgundy from 9 ± 1 craters/cell, and red >11 craters/cell. The solid black circle is the approximate location of the rim before wall collapse and the formation of terraces, and the dashed circle is the approximate location of the current rim.

Data: In an effort to better understand these implications, we have produced a crater density map of Tooting (Fig. 1) covering an area out to ~0.5 crater radii from the rim. This map is a grid of 2.95 km x 2.95 km sample cells in which all craters > 50 m dia. in each cell were counted. It shows two relatively high crater density areas, one on the east rim, and the second on the south-southwest rim. The small craters in these two areas are generally circular, and appear to be randomly distributed (Fig. 2), which is very different from secondary craters formed by low-incidence angle debris [5]. In the southern area, [1] observed that impact melt flows have breached some craters suggesting that those craters formed after the surface had stabilized, but before the melt had solidified.

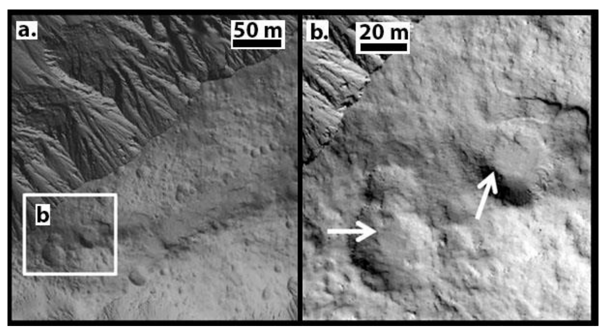

Fig. 2: Relatively high density area on the southern rim of Tooting crater. "b" is an enlargement of the area shown in "a". Note the lobate material that appears to have flowed down into and ponded in the two largest crater, see arrows.

Figure 3 is a plot of the cumulative size frequency distribution (CSFD) of craters in the high crater density area on the south east rim of the crater (i.e., fallback craters), the ejecta of Tooting [1], and the Amazonis Planitia surrounding Tooting [1] that show that the densely cratered areas are significantly more cratered than either Tooting ejecta or Amazonis Planitia. These data show that the heavily cratered areas are 1) significantly more densely cratered than other crater materials or the surrounding terrain, 2) restricted to near-rim locations (rim outward to ~ 3-5 km) where major collapse has not occurred [1, 6], and on the up-range side of the crater [1]. In addition, a prelimianary survey of fresh Martian craters (>~5 km dia.) shows no such densily craters areas on their rims.

Discussion: The location of the densely areas on Tooting may provide insight into the origin of their craters and their effects on crater density age measurements of the crater [2]. For example, if these densely cratered areas are the result of fallback, as has been suggested by [1, 7, 8], then such areas should occur around the entire crater rim, but they do not. The occurrence of these areas in only places along the rim of Tooting where major rim collapse has not occurred may indicate that other such heavily cratered areas formed but were destroyed by later rim collapsed. Alternately, this distribution could be, in some way, the result of the oblique impact that formed Tooting [1]. If these areas were produced by fall-back, then this debris must have been ejected on narrowly confined, nearly vertical trajectories causing this debris to land in a zone restricted to near the rim. The flight time of the ejecta must be relatively short in order for the rotational speed of Mars to not displace them, and so that impact melt on the surface was still molten after the ejecta landed.

Conclusions: If these anomalous areas of high crater density on the rim of Tooting are the result of ejecta fallback and their confinement to near the rim is characterisitic of such fallback, then this fallback 1) would not affect most crater density age measurements because of its restriction to the rim, and 2) this restriction does not fit strictly into any model of ejecta, but may be consistent with material tossed upward by central peak formation [3].

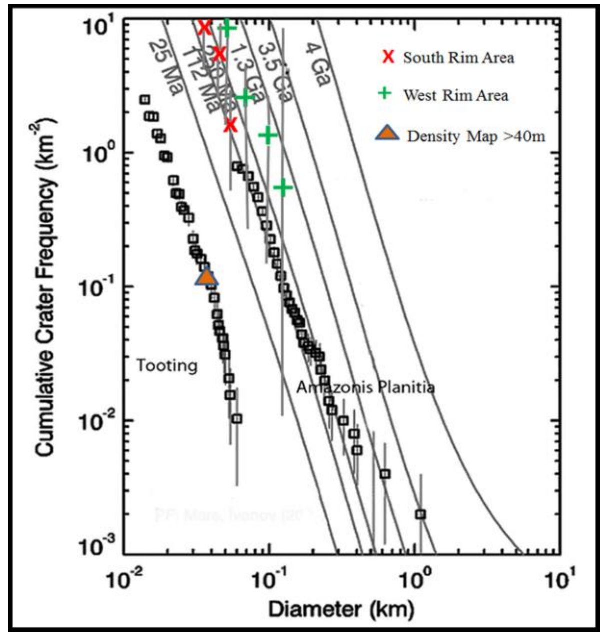

Fig. 3: Cummulative size frequency distribution (CSFD) diagram of the craters on Tooting ejecta [1], the Amazonian plains surrounding Tooting [1], and the densely cratered areas on the south (red Xs) and west (green crosses) rim of Tooting. The cummulative number of craters > 40 m dia. (normalized to 1 km^2) in the light blue and green cells in Fig. 1 (orange triangle) is consistent with the density of craters on Tooting ejecta, while the cummulative number of craters in the burgundy and red cells is consistent with the density of the fall-back craters in this figure.

References: [1] Mouginis-Mark, P., Boyce J., (2012). *Chemie der Erde – Geochemistry*, 72 (1), 1-23; [2] Boyce J., Mouginis-Mark, (2015). Workshop Crater Studies and Dating of Planet. Surface, Abst. # 9005; [3] Hartmann, W. K. *et al*. (2010). *Icarus* 208, 621 – 635. [4] Melosh, H. J. (1989). *Impact Cratering*, Oxford Univ. Press, 245 p.; [5] Preblich, B.S. *et al*. (2007). *JGR* 112, E05006. [6] Senft, L., and S. Stewart (2011). *Icarus*, 214, 67-81; [7] Zanetti et al., 2017, Icarus, 298, p. 64-77; [8] Plescia J., Robinson, M., 2019, Icarus, 321, p. 974-993.