THE INFLUENCE OF PRE-EXISTING TOPOGRAPHY ON THE DISTRIBUTION OF IMPACT MELT ON MERCURY.
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Introduction and Background: The objective of this study is to contribute to the global analysis of the origin, distribution, and modes of occurrence of impact melt deposits and the factors responsible for their emplacement enabled by the high-resolution images obtained during the MESSENGER primary orbital mission [1]. Characterizing the nature and distribution of impact melt in craters on planetary surfaces is an important goal in understanding the nature of the cratering process and differences among planetary bodies [1-9].

The basic characteristics of the distribution of impact melt in fresh craters is derived from Apollo-era analyses that interpreted lava-like material on lunar crater rims as impact melt on the basis of deposit distribution, lack of volcanic sources, morphology of the material, and time of emplacement [e.g., 3,4]. Recent radar and visible high-resolution images of impact melt deposits surrounding lunar craters [5-8] confirm details of the three major modes of occurrence of melt deposits exterior to crater interiors [3,4]: (1) thin veneers, (2) flows, and (3) ponds. An analysis of exterior melt ponds and flows around 55 lunar craters [4] showed that hard-rock veneers and very small ponds were the dominant mode of occurrence around the smallest craters, but that at diameters >10 km, ponds near the rim and flow lobes become prominent, with flows more conspicuous than ponds up to ~50 km. Modes of occurrence of rim melt deposit were found to be positively correlated with size-dependent morphologic differences within crater interiors: rim deposits become prominent at the same crater size that wall terraces and central peaks become abundant, and proportionally larger amounts of melt appear to have been emplaced on the rims of larger craters. Evidence for the timing of melt emplacement [4] suggested that collapse of the cavity (formation of central peaks and wall terraces) caused ejection of impact melt onto the crater rim, followed by drainage back down into the crater interior and drainage of expelled melt outward and down the crater rim. Two additional factors were documented as important in the distribution of impact melt on lunar crater rims: (1) the angle of incidence and approach direction in an oblique impact (lower-angle impacts emplaced melt preferentially downrange), and (2) the pre-impact topography of the target site (melt was emplaced preferentially on the rim adjacent to the lowest parts of rim, and opposite the highest part of the rim, commonly marked by the most prominent slumping) [4]. Later analyses, combining a number of perspectives [9], led to proposals that proportionally more melt was formed in larger craters.

For craters on Mercury, the proportion of melt in a cratering event is predicted to be higher than for the Moon be-

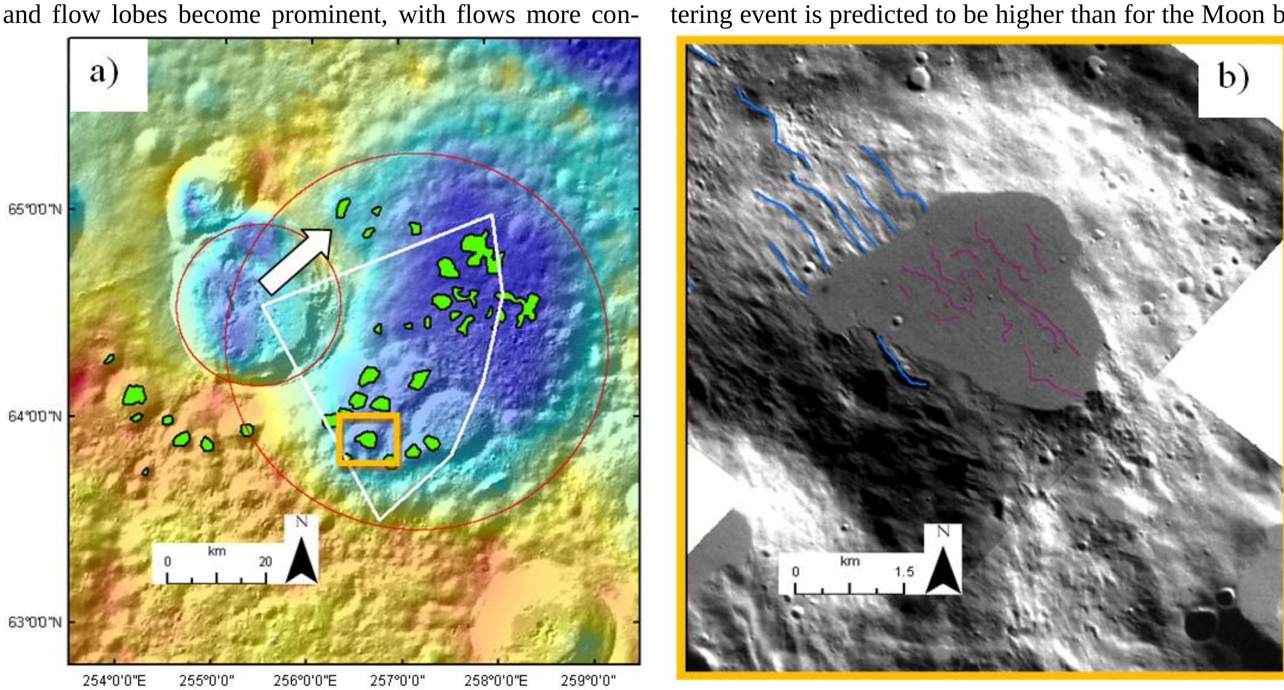

Figure 1. (a) Crater centered at 64.5°N, 255.5°E. Large red circle is pre-existing crater, and small red circle is the fresh impact. The green patches are melt ponds, and the white outline is the predicted melt ejection zone, which corresponds with the low section of the rim crest. The white arrow indicates the downrange direction of the impact. The orange square is enlarged in (b), where the purple lines indicate surface cracks on the melt pond and blue lines highlight the flow scours leading into the pond from the direction of the crater.

cause of higher mean impact velocities [9]. Furthermore, the higher surface gravitational acceleration on Mercury may act to enhance wall slumping [10] and thus to influence melt expulsion. In this analysis, we document two craters (Figs. 1,2) with similar morphology to assess the distribution and characteristics of impact melt on the rims of large craters on Mercury in situations where the impact target point coincides with prominent variations in pre-existing topography (crater walls and rims).

Analysis: To date, we have mapped the distribution of impact melt on the rims of two fresh impact craters, centered at 64.5°N, 255.5°E (Fig 1), and 5.8°S, 259.2°E (Fig 2). For each, we analyzed the role of pre-existing topography in the distribution of impact melt ponds. Figure 1a show a fresh 33-km-diameter crater that formed on the rim of an older 77.5-km-diameter crater. Note that the height of the rim crest inside the older crater is substantially lower than that of the rim crest on the older crater rim**.** For this crater the downrange direction of the impact, deduced from ejecta deposits (white arrow), and the locations of the majority of the melt pools do not coincide. Melt ponds dominate along a pie-shaped segment to the east-southeast of the crater rim crest, a direction different from the downrange direction and nearly coincident with the low point in the rim crest (Fig. 1a). Approximately 66 percent of the area mapped as melt ponds lies within 2.5 crater radii in the direction of the lowest rim height. MLA data indicate that the low portion of the rim is ~500 m lower than the rim on the opposite side of the crater. For the Moon, melt ponds for craters of this diameter typically lie within 0.65 crater radii [4]. Melt ponds for the craters studied on Mercury range from approximately 0.5 to 2.5 crater radii. Although higher surface gravitational acceleration on Mercury than the Moon may inhibit the ejection distance of the melt outside the parent crater, it could favor flow for greater distances once the melt lands, particularly if on steep slopes. Scour-like marks around the melt pond are evident in Fig. 1b and may indicate flow of the melt. More data are needed on the distance of the ponds from the rim crest on the Moon and Mercury (e.g., see [11]).

High-resolution images of the melt ponds (Fig. 1b) show smooth, fresh-appearing surfaces with few craters and modifications. Melt ponds such as these (Fig. 1a) inhabit topographic low areas, and features interpreted to be scour structures formed on the surrounding terrain as the impact melt flowed across the surface and ponded. Linear and polygonally arrayed surface cracks are interpreted as melt cooling cracks. Stratigraphic relationships show that the melt ponds postdate the surrounding terrain comprised of ejecta deposits, consistent with the idea that the melt was expelled from the crater and then flowed into its current position immediately following ejecta emplacement.

For the 28-km-diameter crater centered at 5.8°S, 259.2°E (Fig. 2) a substantial amount of the melt apparently flowed into one large pond at the lowest topographic point near the center of the 55.5-km-diameter pre-existing crater. Numerous small ponds are observed in an almost stair-step manner from the apparent low in the rim crest (southeastern quadrant of the crater) opposite a large imbricate set of slump terraces on the high part of the crater interior and extending down to the central peak. This distribution provides further evidence that the pre-existing topography influenced both preferential wall collapse and melt ejection and the maximum distance of melt from the rim crest (~1.6 radii).

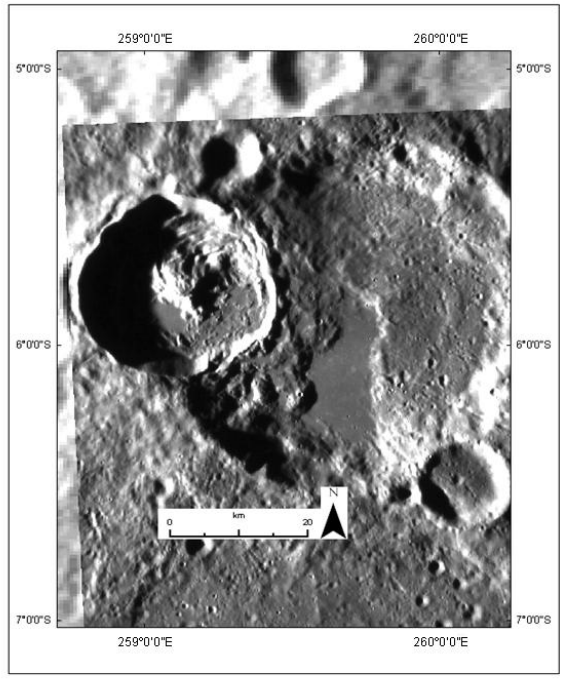

Figure 2. Crater centered at 5.8°S, 259.2°E. A large quantity of melt has accumulated in the lowest area of a pre-existing crater. This pond is adjacent to the rim crest low of the fresh parent crater.

Conclusions: These two craters provide clear examples of the influence of pre-existing topography (mostly older crater rims and floors) on the areal distribution and radial distance of impact melt ponds on crater rims on Mercury. Where the rim crest is low, melt ponds form and often preferential slumping occurs on the opposite wall in areas of higher rim topography. For both examples melt ponds occur at greater radial distances, up to 2.5 crater radii from the rim crest, than on the Moon where typical values are 0.65 radii. Additional high-resolution images of these and other craters with exterior melt ponds will reveal more details about the distribution of melt in and around craters on Mercury [1,11] and enable improved comparison with the Moon [3,4,6,12].

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