IMPACT MELT EMPLACEMENT ON MERCURY. J. W. Daniels[1] and C. D. Neish[1], [1]The University of Western Ontario, London, ON, Canada (jdanie4@uwo.ca).

Introduction: Impact cratering is a geologic process that takes place, in one form or another, on virtually every celestial body. In this work, we focus on the emplacement of impact-generated melt deposits about fresh impact craters. Understanding this process is important in comprehending the physics of impact crater formation as well as the crustal properties of the host body. Is there a pattern to how this melt is emplaced? If so, what are the key factors contributing to this pattern of emplacement? This work looks to build on prior work completed for Venus and the Moon [1, 2], applying the methods used towards understanding melt emplacement around complex impact craters on the planet Mercury. In many ways, it represents an intermediate case between the Moon and Venus; its surface resembles more the Moon, yet possesses a higher gravity field than the Moon does. Preliminary results so far suggest that melt emplacement on Mercury exhibits a pattern closer to what is observed on Venus than on the Moon; this suggests that gravity plays a dominant role in how impact melt is emplaced on any given rocky body.

Background: *The Moon.* From [1], it was found that a large number of lunar complex craters exhibit ejected melt ponds and flows near to their respective rim crest low. The fairly high topographic variation present on the Moon may be responsible for impact-generated melts being preferentially ejected from the shallowest part of the crater rim (referred to in [1] and [2] as the “rim crest low” or “RCL”). Melts are thought to be ejected during the modification stage of crater formation. Gravity plays a role determining the depth of the resultant crater as well as amount of melt produced by the impact [3, 4, and sources therein]. On the Moon, the craters are deeper, and contain less melt, with respect to crater size than craters on Venus [5, 6]. This means the forces involved in ejecting melt from lunar craters must expel that melt over comparatively higher rim elevations [see 6].

Venus. From [2], comparing complex craters on Venus and on the Moon, it was suggested that the shallower crater depths on Venus compared to the Moon might explain why the distribution of ejected melt material on Venus was more evenly distributed about the crater rim. Due to its higher gravity, craters on Venus tend to be shallower than those on the Moon and contain proportionally more melt [5]. While on the Moon topographic lows may provide an energy-saving conduit for melts to be ejected, on Venus the comparatively shallower topography and large melt volumes mean the momentum left over from the initial impact event is sufficient to eject the melt in the direction of impact. The observation that Venusian impact melts tend to be emplaced downrange was first made by [6].

Mercury, a potential “missing link”: *Methods.* In this work, we analyzed a number of complex, fresh, mercurian craters bearing exterior melt deposits to determine how those deposits were emplaced. We wish to determine whether melt deposits on Mercury are emplaced more like the Moon, subject primarily to higher overall topographic variation, or like Venus, subject primarily to higher surface gravity. The third possibility is that Mercury’s melt-bearing craters might plot as a hybrid between these two “extremes.”

The catalog of rayed mercurian craters provided in [7], and the more extensive catalog of Kuiperian craters found in [8] provided the starting point for the catalog that was compiled for use in this project. These craters were first viewed with the Mercury QuickMap to search for exterior impact melt deposits. A total of 26 potentially melt-bearing complex craters were identified for further study. Due to the nature of MESSENGER’s elliptical orbit around Mercury, the resolution of the Mercury Laser Altimeter (MLA) data for Mercury’s southern hemisphere was too low to be useful; therefore, only craters in the northern hemisphere possessed MLA of high enough resolution to be acceptable. Craters that lay north of 45ºN latitude were optimal; for those craters south of 45ºN where MLA data was poor, we used the Mercury MESSENGER Globabl DEM 665m map created by [9, 10]. MDIS (Mercury Dual-Imaging System) WAC and NAC data for each crater was superimposed under the elevation data in QGIS. Melt ponds were identified and outlined in the MDIS data. The greatest concentration of melt ponds is assigned a dominant direction using a 16-part pie-shaped grid and compared to the dominant RCL direction via that same grid. If both directions are within the same grid slice, we categorize the crater as “coinciding”; if both are within 45º of each other, then it is categorized as “within 45º”; if both reside between 45º and 90º of each other, then it is categorized as “within 90º”; the remainder of the possibilities are collectively categorized as “90º or greater.”

Kuiperian craters are known to be the freshest craters on Mercury, with a subset of these craters also identifiable as “rayed.” For the rayed craters, the rays themselves are thought to erode, due primarily to space weathering on Mercury, rather quickly geologically-speaking [3, 7]; as for the Kuiperian craters, specific features are noted such as a smooth crater floor and terraced crater walls [3, 4, 8]. Because impact-generated melts tend also to be erased relatively quickly [1, 2], these types of craters therefore are optimal for this project. Figure 1 illustrates the manner of ejected melt deposits that were analyzed in this work; pond-like deposits represent just one of a number of modes by which melt may be emplaced. Other forms include flows and veneers [see 3].

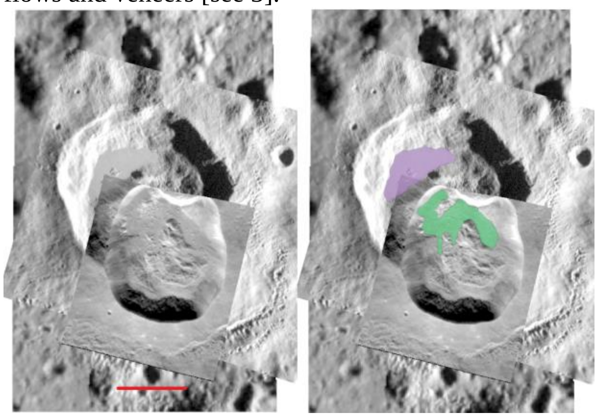

Figure 1: Left. MDIS mosaic of Ailey crater on Mercury, with MDIS-NAC overlays highlighting a ponded melt deposit in an adjacent crater just north of Ailey; red bar ~ 10 km. Right. The same MDIS imagery of Ailey, with exterior melt highlighted in violet and melt-filled crater floor in green.

In addition to mapping out exterior melt deposits, we also mapped the rim topography, the crater floor, and crater rays. Crater rim topography is important in locating the RCL of the crater. Comparing the average rim elevation with the average floor elevation, crater depth can be determined which can then be compared to [2] to determine if difference in rim-floor elevation of mercurian craters is a key factor in melt emplacement. Any of the cataloged craters that possess an asymmetric ray pattern about them can be inspected to imply direction of impact (see [3], and sources therein); for sufficiently oblique impacts, a small "forbidden zone" lacking in ray material can form, located prior to the crater itself and in the direction of impact. That third aspect may determine how much influence impact direction has on melt ejection on Mercury [3].

Results. Four of the craters in the initial catalog had to be removed from the analysis; for three of the craters the elevation data available was too poor to use effectively, while the final crater suffered from insufficiently high-resolution MDIS imagery to make out the melt ponds (in other words, this crater may be a false positive). The remaining 22 craters have sufficient data to allow for immediate further analyses. Of these craters, five were noted as "coinciding," four were noted as "within 45º," seven were noted as "within 90º," and the remaining six fell under "90º or greater." This distribution, given in Figure 2, is similar to the distribution noted by [2] for Venus, implying gravity plays a greater role on Mercury than topographic variation does. There appears to be a threshold wherein a celestial body with a gravity field below this threshold will show an exterior melt deposit emplacement distribution similar to the Moon, whereas bodies lying above this threshold will show a distribution similar to Venus. We suggest this threshold lies somewhere between the surface gravity of the Moon and that of Mercury.

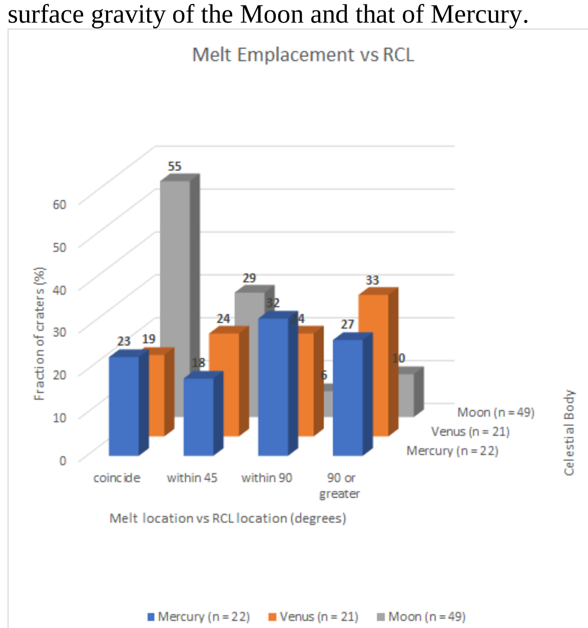

Figure 2: The relationship between melt emplacement direction and RCL, for Mercury (this work), Venus (from [2]), and the Moon (from [1, 2]). Mercury patterns closer to Venus than to the Moon.

References:

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