THE UNUSUAL CRATERING AND RESURFACING HISTORY OF MERCURY AS REVEALED BY THE SPATIAL DENSITY OF CRATERS. R. R. Herrick[1], E. M. Wheeler[1], W. G. Crumpacker[1], D. Bates[1], [1]Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320 (rherrick@gi.alaska.edu).

Introduction: Using MDIS images, we have compiled a database of all impact craters on Mercury with D > 5 km (43K total craters), excluding obvious secondaries (those in chains and clusters). For craters with D > 10 km (17K craters), we have characterized interior and exterior morphology, degradation state, and the presence of post-impact filling. The database represents a unique resource for understanding the resurfacing history of Mercury, examining regional variations in near-surface rheology, and studying the effects of target and impactor properties on final crater forms. Here we highlight two of the more interesting results regarding the spatial density of craters: Confirmation of large (diameter D > 5 km) distal secondaries around impact basins (D > ~150 km), and the number of filled versus unflilled craters.

Large distal secondares: Using a moving circular window of a fixed radius, we count the number of craters in the window and calculate a spatial density per million sq km. We then compared compared the spatial density of different crater populations to look for interesting trend. In comparing craters with 5 < D < 10 km to the population with D > 10 km, we found that some of the fresh peak-ring craters have an annulus with a high spatial density of 5-10 km craters that does not exist at larger diameters, indicating a population of large distal secondaries. In Figure 1 we show the results for the area surrounding Derain impact crater (D = 175 km). Previous works demonstrated the existence of large secondaries based on R-plots of specific regions [e.g., 1,2], but those works also counted obvious secondaries in chains and clusters and did not fully explore the spatial distribution of these secondaries. In the example with Derain we see these isolated secondaries concentrated in an area 1.5 to 5 radii beyond the crater that generated the secondaries. There are a handful of fresh craters with D > 150 km, and we hope to evaluate different diameter-range pairings to determine whether larger basins show an annulus of even larger secondaries.

Unfilled versus filled craters: For craters with D > 10 km, one of our morphological criteria was to evaluate whether the crater experienced significant post-impact filling by volcanism or the ejecta of other craters. The importance of considering filled versus unfilled craters is an aspect of planetary surface dating that has not been fully appreciated for Mercury: strictly speaking, any time a partially filled crater is used in dating a planetary surface, the interpreted age must involve a nonunique model (perhaps unstated) of resurfacing for the region. Whether we classified a crater as filled or not was based on morphological criteria, primarily whether the rim is elevated and the extent to which the interior looks flooded and interior features can be described. For larger craters the absence of a central structure (peak or ring) is a strong indicator of a partially filled crater, although at the largest diameters partially filled craters and other observables make it clear that some flooding occurred even though the central structure is preserved. The ambiguity is greater at smaller diameters: crater interiors are harder to resolve, and fresh craters in the simple-complex transition zone can have a flat floor but not a central structure. Global topography is not yet available for Mercury, and assessments of fill based on rim height or crater depth would have their own set of problems. As almost all

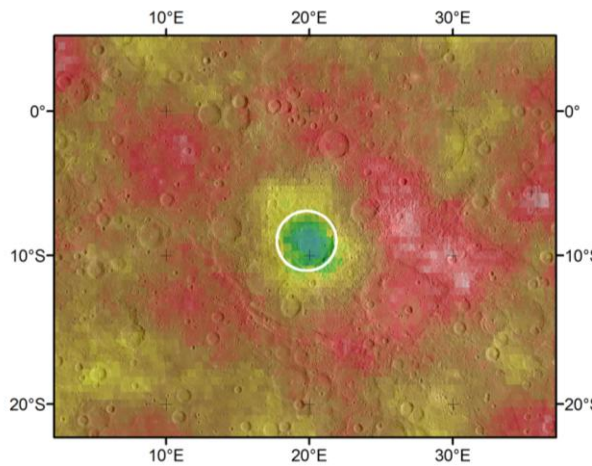

Figure 1. Spatial density of 5-10 km craters (does not include craters in chains or clusters) on Mercury in the vicinity of Derain peak ring crater (D = 175 km).

fresh craters above 20 km form with a central structures [3,4], here we show spatial densities for filled and unfilled craters with D > 20 km. We use a counting circle of D = 700 km. In Figure 2 we show the spatial density of only unfilled craters. In Figure 3 we show the ratio of unfilled to all craters (range 0 to 1, with 1 indicating no filled craters in the counting circle).

Several notable observations arise from our results. We classified roughly two-thirds of the craters with D > 20 as being significantly filled; this is a much higher percentage than either the lunar highlands or mare, and suggests a far different resurfacing history involving lots of thin lavas occurring during the time when the cratering record was being emplaced. When only unfilled craters are considered, there are several areas on Mercury that have surfaces approaching the youth of the Smooth Plains / Caloris [5], and the maximum density of craters in the highlands decreases by a factor of two. For one estimate of the crater production function [6], the latter would place the oldest surface, not volcanically modified, at ~3.9 Ga, about 100 My younger than if flooded craters are counted. What jumps out of Figure 3 is that Caloris is the only place where all of the craters are unfilled. It has been noticed that there are no partially buried craters in Caloris [7], but it has not been observed that the area is unique globally.

Conclusions: In terms of dating the last surface formed, contamination from distal secondaries and partially flooded craters are significant issues [2]. If we consider only unfilled craters, then the range of crater densities on the Mercury decreases by a factor of two, and there are some surface that are likely as young as the Smooth Plains. We suggest that the uniqueness of Caloris may be that the impact may have perturbed the core-mantle boundary to the extent that subsequent volcanism was both voluminous and rapid.

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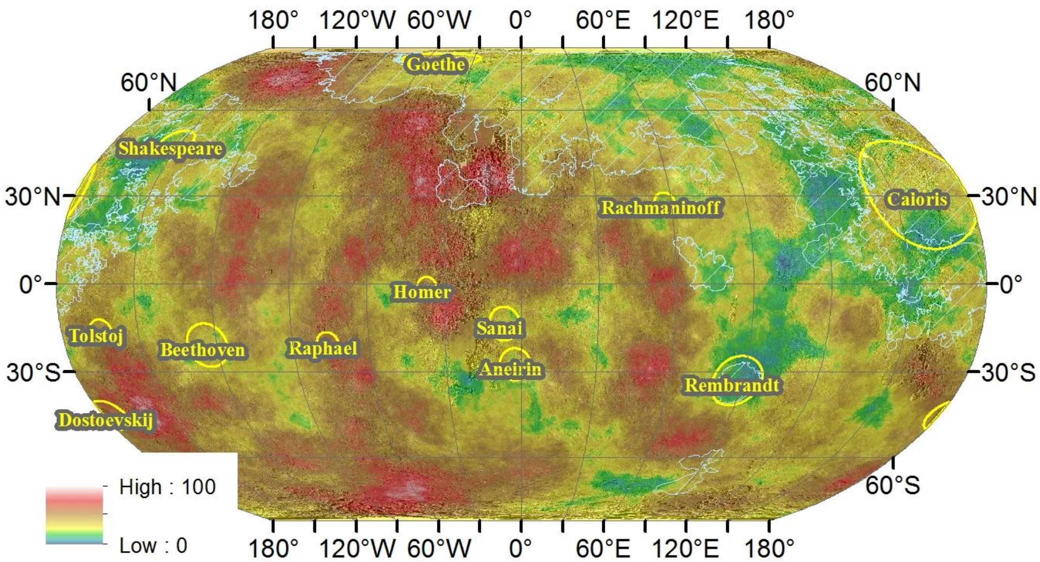

Figure 2. Craters per million sq. km of unfilled craters with $D > 20$ km, using a counting circle with $D = 700$ km. Named basins over 300 km are outlined in yellow and light blue hatched areas are the five largest contiguous areas of smooth plains [5].

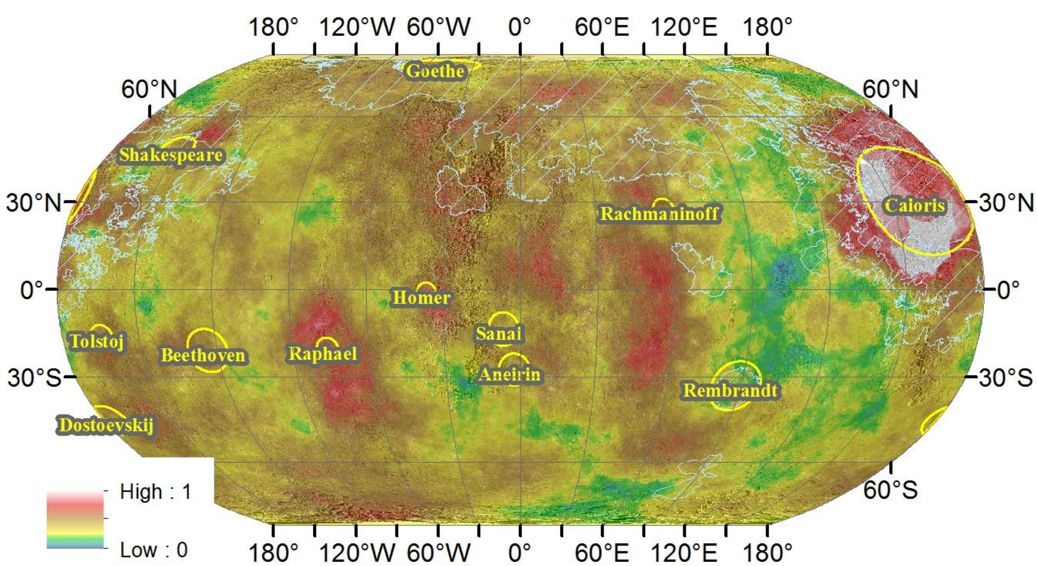

Figure 3. Ratio of unfilled craters to all (unfilled plus filled) craters, using same parameters as Figure 2.