DETAILED ANALYSIS OF THE INTRA-EJECTA DARK PLAINS OF CALORIS BASIN, MERCURY.

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Introduction: The Caloris basin on Mercury (Fig. 1) is floored by light-toned plains and surrounded by an annulus of dark-toned material interpreted to be ejecta blocks and smooth, dark, ridged plains. Strangely, preliminary crater-counts indicate that these intra-ejecta dark plains are younger than the light-toned plains within the Caloris basin. This would imply a second, younger plains emplacement event, possibly involving lower albedo material volcanics, which resurfaced the original ejecta deposit. On the other hand, the dark plains may be pre-Caloris light plains covered by a thin layer of dark ejecta. Another alternative to the hypothesis of young, dark volcanism is the possibility that previous crater-counts have not thoroughly distinguished between superposed craters (fresh) and partly-buried craters (old) and therefore have not accurately determined the ages of the Caloris units.

This abstract outlines the tasks associated with a new mapping project of the Caloris basin, intended to improve our knowledge of the geology and geologic history of the basin, and thus facilitate an understanding of the thermal evolution of this region of Mercury.

Task 1: Classify craters based on geomorphology and infilling: The established crater classification scheme – used in the Tolstoj and Shakespeare quadrangles [1,2] and formalized in 1981 [3] – was based on degree of crater degradation, in which fresh craters were labeled C_5 and the most degraded craters were identified as C_1. We will design a classification scheme for Mercurian craters that includes both degradation state and level and type of infilling. We will incorporate a classifier that notes the level of infilling in a crater, from mostly buried (we presumably would not be able to observe a completely buried crater in visible imagery) to completely unfilled, after the observations by [4]. We will also distinguish between craters infilled with 1) lava, 2) impact melt and 3) ejecta, based on our interpretation of the MDIS images.

The difference between craters filled with lava and craters filled with impact melt may not always be easy to determine. The amount of impact melt associated with a crater is proportional to the impact velocity squared. Since the impact velocity on Mercury is ~40 km/s there should be far more impact melt associated with craters on Mercury than on the Moon or Mars, where impact velocities are ~20 km/s and ~15 km/s respectively [5]. Also, the greater gravity of Mercury could tend to accentuate the amount of melt present. A flat-floored crater with melt in the rim is most likely a crater filled with impact melt. A crater with a breached rim, or flow lobes stretching over the rim, is more likely to be a crater filled with lava. We expect that the identification between the two types of fill will not always be obvious and opinions from all team members will be debated for the more ambiguous craters.

We will identify all primary craters on the Caloris floor and within the dark annulus surrounding the basin in the MESSENGER MDIS data. We will identify craters in either a previously released mosaic or a mosaic that we have created ourselves using ENVI, and then use the individual MDIS images to measure and analyze the geomorphic features. Each crater will be assigned a classification, following the scheme developed in the first part of the task.

Secondary craters usually have morphologies distinct from primary craters and they tend to occur in either clusters or chains. Observed Caloris secondaries will be classified as Van Eyck formation, after the geomorphic mapping in the Tolstoj [1] and Shakespeare [2] quadrangles.

No crater classification scheme can be rigorously or consistently applied until all of Mercury is imaged at a variety of lighting angles [6]. This will not be truly possible until MESSENGER goes into orbit on March 18, 2011. Right now we only have access to images of Mercurian craters at multiple lighting angles in quadrant A. To account for the non-ideal range of solar incidence angles in the released MDIS images we will utilize image processing techniques, such as high-pass filtering, to enhance edge detection and thus encourage crater identification. However, we will also revisit our crater classifications as new data are released.

Task 2: Create a high-resolution map of the intra-ejecta dark plains: We will use the new high resolution (200-300 m/p) imaging data from the MDIS instrument to create a new geomorphic map of the dark annulus around the Caloris basin. We will start in the region where MESSENGER data overlaps Mariner 10 images (quadrant A in Figure 1). By comparing the Caloris group formations mapped in the Tolstoj [1] and Shakespeare [2] quadrangles to the overlapping MDIS images, we will determine the distinctive geomorphology of each of these units and use this as diagnostic criteria for identifying these units in regions never before mapped. We will then utilize the developed diagnostic criteria to map quadrants B, C and D. Caloris group formations will be mapped where identified and any new units will be defined and mapped as necessary. Specifically, we will delineate hummocks and smooth plains within the Odin formation and map them separately. We will look for unequivocal evidence of volcanic activity within the dark annulus and the Odin Formation, such as vents and flow lobes. The location of any filled craters observed in Task 1 will be especially noted.

Task 3: Perform crater counts of the intra-ejecta dark plains, the ejecta, and the Caloris floor light plains: Craters identified in Task 1 will be compared to the geomorphic units mapped in Task 2. The diameters of craters superposed on each individual surface unit will be measured and counted separately. The area covered by each geomorphic unit will then be determined.

Crater counts will be normalized to a common area of one million square kilometers. We will determine the crater size-frequency distribution (SFD) of each geomorphic unit by plotting crater diameter against the normalized cumulative crater count on a log-log graph. Younger surfaces have SFDs that plot to the left and below older surfaces and so the relative ages of multiple units can be determined. Statistical uncertainties and plotting techniques will follow the form outlined by the Crater Analysis Techniques Working Group [7]. Given the resolution of the images, we expect to be able to compile reliable statistics down to crater diameters of 1-2 km.

We will analyze the crater density of the Caloris floor plains unit, the Odin Formation ejecta and the Odin Formation intra-ejecta dark plains. We will do a second count of craters on the Caloris floor that includes all observed craters, including those that are filled, to attempt to get a minimum age for the underlying dark basement. Crater counting on any additional geologic units will depend upon results of the geomorphic mapping.

Task 4: Refine the stratigraphy of Caloris basin units: Presently, mapping relationships indicate that the stratigraphy of the Caloris basin is as illustrated in Figure 1b. However, this stratigraphic cross-section does not take into account the nature of the Odin Formation intra-ejecta dark plains. If these plains are in fact a lava flow younger than the Odin ejecta and distinct from the smooth plains (ps), then this needs to be reflected in both the cross-section and a stratigraphic column. Similarly, the cross-section should more clearly reflect the stratigraphy of the Caloris units if the Odin Formation is comprised of multiple facies (hummocks and plains) of excavated dark basement material. If the intra-ejecta dark plains are ps material embaying the ejecta, this too should be somehow reflected in any stratigraphic analysis of the basin.

The new crater counts in Task 3 will help determine the timing relations between the units identified in Task 2. We can then refine the stratigraphy of the Caloris basin units.

References: [1] Schaber and McCauley (1980) USGS Map I-1199. [2] Guest and Greeley (1983) USGS Map I-1408. [3] McCauley et al. (1981) *Icarus 47*, 184-202. [4] Murchie et al. (2008) *Science 321*, 73-76. [5] Cintala and Grieve (1998) *Meteorit. Planet. Sci. 33*, 889–912. [6] Spudis and Guest (1988) in *Mercury*, eds. Vilas, Chapman and Matthews, 118-164. [7] Crater Analysis Techniques Working Group (1979) *Icarus 37*, 467-474.

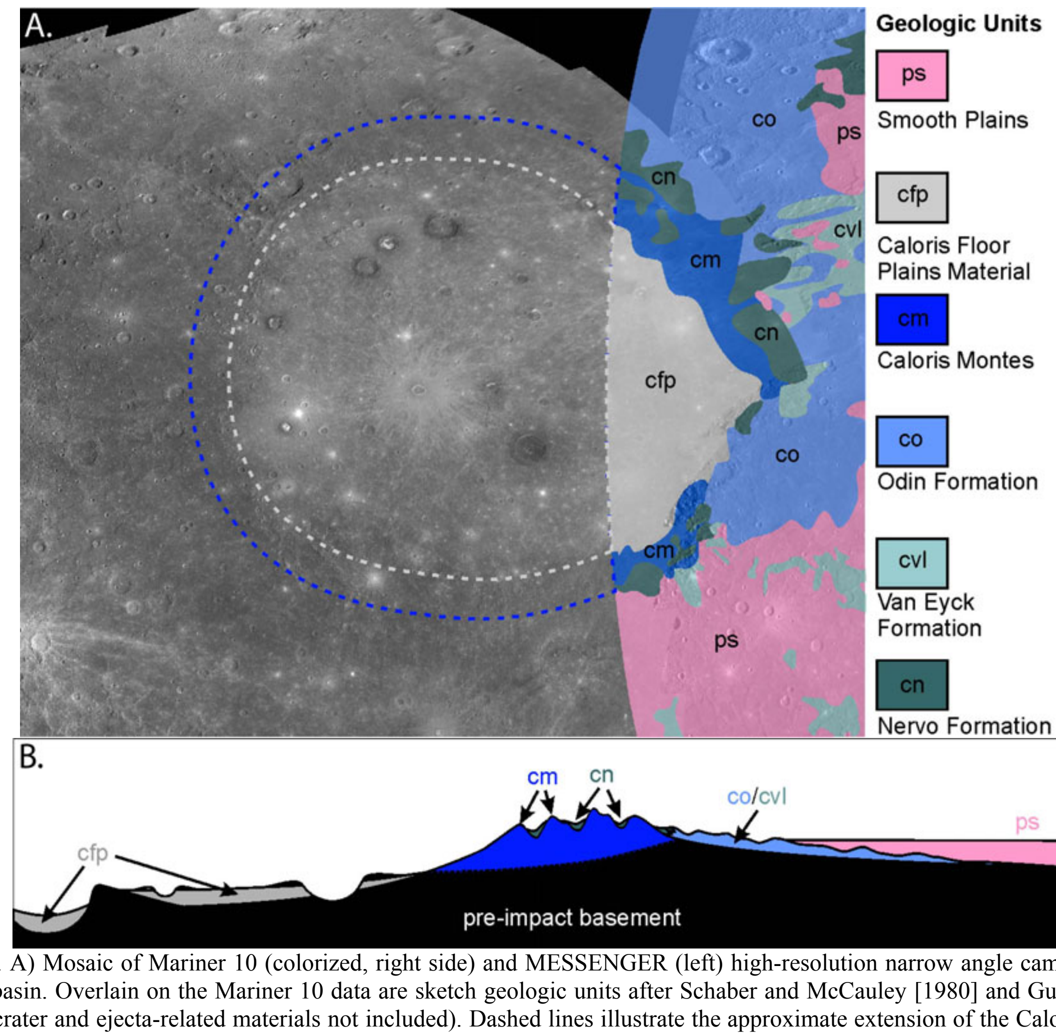

Figure 1. A) Mosaic of Mariner 10 (colorized, right side) and MESSENGER (left) high-resolution narrow angle camera data for the Caloris basin. Overlain on the Mariner 10 data are sketch geologic units after Schaber and McCauley [1980] and Guest and Greeley [1983] (crater and ejecta-related materials not included). Dashed lines illustrate the approximate extension of the Caloris Floor Plains Material unit (grey) and the Caloris Montes basin rim unit (blue). B) Schematic geologic cross-section from the Caloris basin center (left edge) and outward. Odin (co) and Van Eyck (cvl) Formations are combined for simplicity.