DEPTH TO DIAMETER STUDIES OF MERCURIAN MATURE COMPLEX CRATERS USING MARINER 10 STEREO TOPOGRAPHY.

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Introduction and Background: Morphologic characteristics of 316 mercurian impact craters were identified by Pike [1], such as crater depth (d) and diameter (D). This study [1] also classified the craters into seven morphologic groups (based on lunar classes), and better quantified the diameters of crater morphologic transitions (i.e. the transition between simple and complex craters). In particular, the Pike study [1] resolved ambiguity in previous measurements [2-5] of the depth to diameter ratio (d/D).

We present crater depth and diameter measurements from newly-derived topographic data that were not available when Pike and others performed their crater studies with the Mariner 10 images. Previous crater studies [1-5] relied primarily on shadow measurements; these measurements yield accurate relative heights, but are limited to craters that have shadows that reach the crater center. The utilization of stereo topography in our study allows us to make measurements on many more craters because the technique is not limited to craters with shadows.

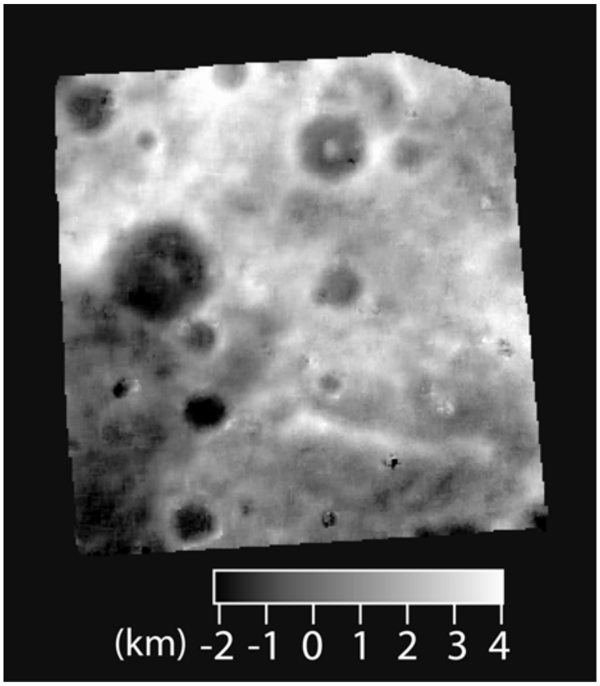

Figure 1: An example of a Mariner 10 stereo-derived DEM used in this study. Pictured is a small area 455 km across (146°W to 161°W, 29.8°S to 15.2°S) of the Tolstoj Quadrangle.

Data and Methods: Digital elevation models (DEMs) were constructed using Mariner 10 stereo pairs and the stereo-matching software, SMTK [6,7,8]. The topographic data typically has 1-2 km spatial resolution and vertical resolution better than 1 km. Although absolute elevations cannot be determined, accurate relative heights can be measured from the stereo-derived topographic products.

As discussed in the study by André et al. [9], individual stereo-derived DEMs (Figure 1) were mosaicked to create regional topographic products, and then regional DEMs were combined to create quadrangle products. Once regional or quad-level products were constructed, crater depth and diameter measurements were extracted. To determine the mean crater depth we used a first-order fit to the rim surface and determined the maximum depth under the rim.

Results: The data reported by André and Watters [10,11] are updated in this study. We measured the depths and diameters of 189 mature complex craters within the Tolstoj, Discovery, and Michaelangelo quadrangles of Mercury. The least squares regression to the d/D data is:

$$d = 0.267D^{0.519}.$$

A total of 58 mature complex craters were measured by Pike [1], and the least squares regression to the Pike d/D data is:

$$d = 0.353D^{0.496}.$$

Discussion: The updated d/D data also shows agreement in overall slope with that of Pike's [1] measurements. As noted in the original study [11], comparison of the linear fits (Figure 2) reveal that some of our measurements are slightly lower than those reported by Pike [1]. This indicates that our measurements include craters that have shallower depths compared to similarly-sized craters [see 11]. To better understand our measurements, we attempted to determine if there are any correlations between the d/D ratios and terrain type or latitude.

Terrain type. We examined the d/D ratio of craters superposed on specific terrains to investigate whether terrain types demonstrate significant d/D ratio differences. The terrain types of craters were classified according to the system described by Spudis and Guest [12] and Spudis and Prosser [13] into four general categories: intercrater plains, basins materials, crater materials, and plains materials. Intercrater plains are the oldest terrains located between and around the ancient cratered terrain [12]. Basin materials are classified as being deposited from basins younger than the intercrater plains, such as Dostoevskij, Tolstoj, Beethoven, and Caloris [12]. Crater materials are impact crater materials of various degrees of degradation and infilling [12, 15]. Finally, plains materials are thought to be volcanic plains that tend to fill depressions, similar (in some ways) to the lunar maria [12]. Each crater was classified into one of those four categories based on the descriptions of the geologic maps [13,14,15], and the d/D ratio between each classification was examined. Even though it has been suggested that terrain type may influence the d/D ratio [i.e. 1,16,17], we found no statistically significant correlation between terrain type and the d/D ratio of mature complex craters.

Latitude. We also examined whether the d/D ratio varied with latitude. Previous analysis of the d/D ratio of polar and equatorial simple and complex craters found no statistically significant difference with latitude [16,17]. We compared the d/D ratios of the craters located in mid-latitude and equatorial regions; no polar craters were measured in this study. We found no statistically significant correlation between latitude and the d/D ratio.

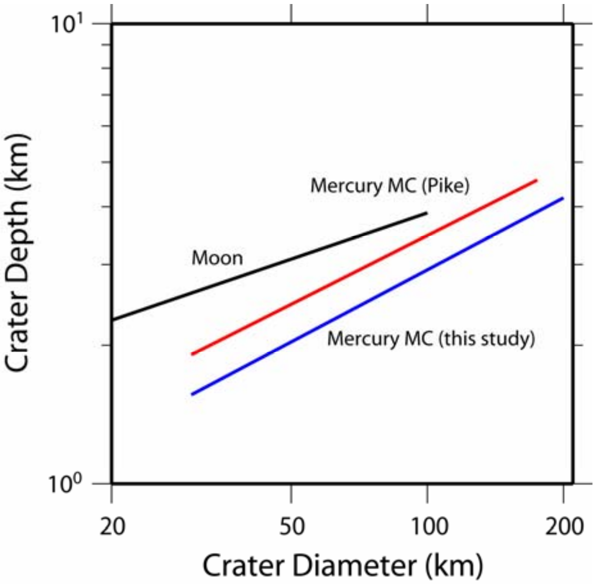

Figure 2: The least-squares fit to the datasets (this study and [1]). MC refers to the term “mature complex”. The lunar fit for complex craters [18] is also shown for comparison.

Conclusions: The new measurements reported here add to and improve the fundamental dataset [1] of the characteristics of impact craters on Mercury. The increased number of measured craters also allows us to examine possible trends in the d/D ratio that Pike [1] was unable to investigate fully due to small sample sizes. We did not detect a correlation between the d/D ratios with either terrain type or with latitude. We look forward to the many unanswered questions about impact craters that will be investigated by the MESSENGER mission to Mercury, which will provide better image resolution and thus allow for much more detailed analyses of crater morphology and statistics [19].

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