PILOT STUDY OF DOUBLET CRATERS ON MERCURY R. A. Fevig[1] and P. F. Wren[2], [1]Department of Space Studies, University of North Dakota, Clifford Hall Room 512, 4149 University Ave Stop 9008, Grand Forks, ND, 58202 [2]Mars Space Flight Facility, School of Earth and Space Exploration, Arizona State University, 201 Orange Mall, Tempe, AZ 85287 ronald.fevig@und.edu

Introduction: Doublet craters are formed by the virtually simultaneous impact of two bodies that are following a close, parallel trajectory [1]. These types of craters have been previously observed on Mercury, Venus, the Earth and Moon, Mars, Ceres, and Vesta [24,2,3,4,5,6,7,8,21,22]. It was originally thought that such crater pairs were formed by a single impactor through atmospheric [9] or tidal [1,10] disruption processes that separated the original body in to multiple impactors. Subsequent studies have shown that sufficient separation to create the observed doublets [11,12] can not occur though such processes.

Doublet craters and binary asteroids. It is now estimated that binary asteroids constitute approximately 15% of the near-Earth asteroid population [2,18]. This provides a potential source for doublet craters, so long as the separation between binary asteroid components is sufficiently large [12]. A systematic study of doublet craters on Mercury could provide insight into the percentage of the terrestrial planet crossing asteroids that were binary systems.

Purpose for a doublet crater search on Mercury. We previously investigated the preponderance of doublet craters on Solar System bodies spanning the vicinity of the Earth to the Asteroid Main Belt. This is our first foray in to a systematic survey of doublet craters on Mercury. Others have begun to investigate this cratering phenomenon on this planet [24]. Ultimately, we seek to better understand the distribution of binary asteroids from the Asteroid Main Belt inward by next determining the relative abundance of doublet craters on Mercury. Our hope is that we can partially reconcile the perplexing dilemma regarding the lack of widely separated binary asteroids which would be necessary to produce our observations of doublet craters.

Data and Methods: This pilot study was undertaken to 1) assess the feasibility of using the global crater database developed by Herrick et al. [27], 2) determine the likelihood of locating doublet craters on the surface of Mercury, and 3) estimate the time required to expand this research to a global scale.

Applicability of the existing crater database. Based on MESSENGER imagery from the MDIS instrument and topography from the laser altimeter, Herrick et al. (2018) created a global Mercury database of approximately 31,600 impact craters ≥ 5 km. After an informal examination of the craters identified in what we will heretofore refer to as the "Herrick database", we concluded that not all craters at or above 5 km in diameter were identified. We made the decision to augment this existing crater database by further identifying craters down to 3 km, so that we could be confident we had found all impact crater ≥ 4 km.

Mercury Data. Employing JMARS as our GIS, we used the MDIS 166m Mercury Global Basemap [25] along with the Herrick crater database. For the detailed examination of individual craters, we referred to individual MDIS images [26].

Study areas. We defined three search areas bounded by lines of longitude and latitude, each 10°x10° in extent (ref. Figure 1).

Enhancing the crater database. While displaying the outlines of the craters from the Herrick database, we scanned the search areas and recorded (using the Crater Counting Layer in JMARS) any additional craters between 3 km and 6 km not already outlined. The crater data from the Herrick database and our new counts were merged into an enhanced impact crater database for the three study areas.

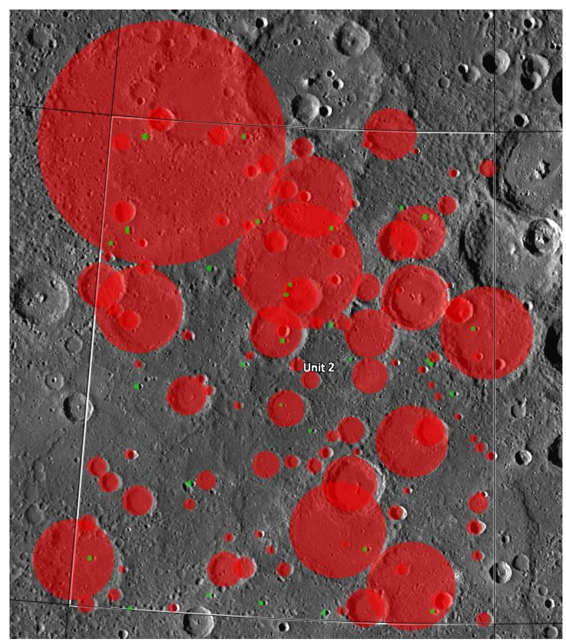

Figure 1: Study area showing craters from the enhanced crater database. Red are from Herrick et al. (2018), green are newly added.

Searching for doublet craters. Proximal crater pairs will be considered potential doublets. A Python script processes the enhanced craters within a study area, and identifies crater pairs whose separation is equal to or less than their combined radii, or in other words, their rims touch or overlap. Following the same process as our previous work [19,21,22], these crater pairs will be examined in MDIS NAC images and evaluated using our scoring system.

Results: Within our three test areas, we identified additional impact craters in the 3 km to 5 km range, nearly doubling the total number of craters identified when combined with the Herrick database craters.

Our analysis of the three regions of our systematic survey for doublet craters shown in Figure 1 yielded 21 crater pairs in total. Scoring of these pairs showed there is just one possible doublet crater above the lower bound for our crater size range. Figure 2 shows the one possible doublet crater in our survey sample.

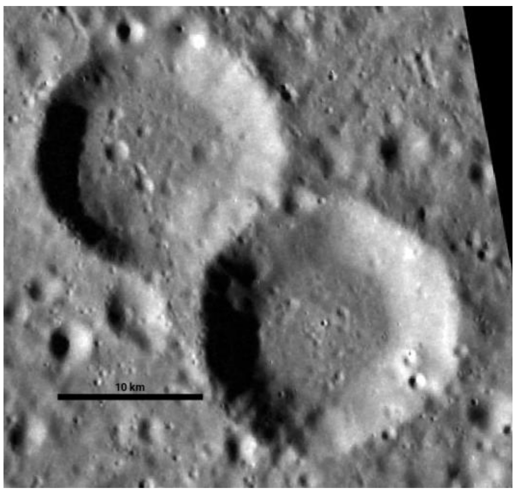

Figure 2: Though not entirely conclusive, there is evidence of a septum for the possible doublet shown.

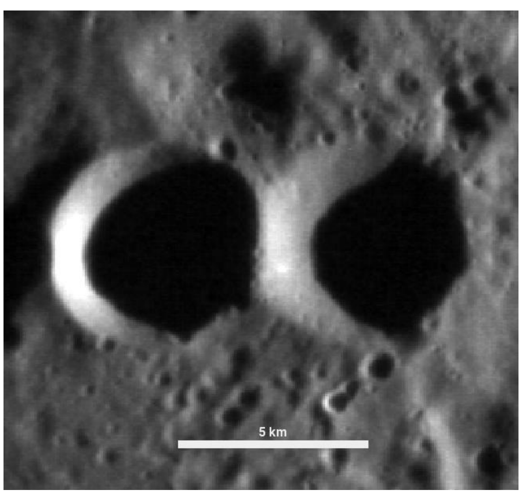

Figure 3: We found other potential doublet craters during a cursory search beyond the three designated areas of our systematic survey. The best of these doublets is shown here.

During our analysis of crater pairs in the three selected regions we ventured into other areas of Mercury to spot check for doublet craters. While not a systematic search, we quickly found evidence for other doublets, one of which is shown in Figure 3.

Continuing Work: We will expand our systematic data collection and analysis to include regions beyond the three we have already covered. We are noting that secondary craters likely adulterate the crater pair tabulations, and will attempt to account for these interlopers that can mimic doublet craters. We are currently working to apply morphologically-based techniques that would examine

- Crater rim shape regularity
- Crater depth/diameter ratio
- Asymmetric crater excavation

to help us remove crater pairs from consideration that contains secondaries, or that are coincidental. We will complete our analysis of the candidate pairs prior to the 52ND LPSC and report our findings at that time.

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