THE DISTRIBUTION OF SURFACE ROUGHNESS IN AND AROUND COMPLEX CRATERS ON MERCURY.

Hannah C. M. Susorney[1], Olivier S. Barnouin[1,2], and Carolyn M. Ernst[2], [1]Department of Earth and Planetary Sciences, The Johns Hopkins University, Baltimore, MD 21218, USA (hsusorn1@jhu.edu); [2]The Johns Hopkins University Applied Physics Laboratory, Laurel, MD 20723, USA.

Introduction: The roughness of a planetary surface at different scales can provide information on how geologic processes have created and modified topography. On bodies where the geology is dominated by impact cratering, e.g., Mercury [1] and the Moon [2], surface roughness may be a useful proxy for surface age [2, 3, 4]. If surface roughness can be correlated with the density of primary craters on a surface and thus age, it can provide a means of estimating surface age that can complement the measurement of crater size-frequency distributions [5]. Previous studies have focused on how kilometer-scale surface roughness changes with crater density [3], but no study has focused on how surface roughness is distributed around individual craters. Here, we look at the distribution of surface roughness in and around complex craters on Mercury to gain insight into how the impact cratering process has contributed to surface roughness. Our ultimate goal is to understand if a correlation between surface roughness and surface age (crater size-frequency distribution) exists on Mercury.

Method: We use topography measurements from the Mercury Laser Altimeter (MLA) on the MErcury Surface, Space Environment, GEochemistry, and Ranging (MESSENGER) spacecraft [6] to assess the surface roughness generated at individual craters on Mercury.

Previous studies have used median differential slope [6, 7] and the interquartile range of profile curvature [1] to measure surface roughness on Mercury. In this investigation, we calculate surface roughness as the root mean square (RMS) deviation of the difference in height over a given baseline, a method commonly used in terrestrial landscape evolution studies [8]. The RMS deviation on Mercury is computed directly from individual MLA tracks for baseline lengths between 500 m and 250 km, and here we focus primarily on surface roughness at the 1-km baseline. To understand how surface roughness is distributed around a given impact crater, we plot a radial profile of surface roughness calculated in 1-km-wide annular bins radiating outward from the crater center.

Surface Roughness Distribution around Complex Craters: The radial distribution of surface roughness was determined around 26 complex impact craters on Mercury. An example of the radial distribution in surface roughness is shown in Fig. 1 for the crater Abedin, a relatively fresh complex crater. The topography (Fig. 1B) of Abedin shows a classic complex impact crater structure with an elevated central peak and crater rim, surrounded by ejecta and secondary fields, which are also visible in the Mercury Dual Imaging System (MDIS) mosaic (Fig. 1A). The 1-km-baseline surface roughness of Abedin (Fig. 1C,D) shows elevated values at the central peak and rim and lower values on the crater floor. The ejecta of Abedin have lower surface roughness values adjacent to the rim of the crater, and surface roughness increases outward to form a local maximum ~2 crater radii from the center, where the secondary field is prominent. Although the elevated surface roughness values at the local maximum are lower than those of the rim and central peak, the areal extent of the region corresponding to the local maximum is much larger (Fig. 1C).

Variations in Surface Roughness Distribution with Crater Diameter: The elevated surface roughness associated with ejecta at the 1-km baseline is not found for all of the measured complex craters. It is observed only for some craters more than 100 km in diameter (Fig. 2). For smaller craters (less than 100 km in diameter), ejecta surface roughness values at the 1-km baseline approximate background values. Craters larger than 100 km in diameter that do not posses the local maximum in roughness over the ejecta and secondary crater fields display generally reduced surface roughness around the crater (e.g., Hokusai, which is known to exhibit abnormal ejecta [9]) or have portions of their ejecta and/or secondary fields embayed by smooth plains. From comparisons of MDIS images with the areas of elevated surface roughness outside of the craters, the local maximum where observed appears to be related to the presence of secondaries that are ~1 km in diameter and influence the surface roughness at 1-km baselines. We expect that the local maximum in surface roughness may also be detected at smaller baselines for smaller primary impact craters that generate smaller secondaries that cannot be detected at the longer baseline. A preliminary assessment of surface roughness of ejecta deposits at the 500-m baseline confirms this suggestion.

Discussion: In order for surface roughness to be used to estimate the age of a surface, a correlation with the density of primary impact craters is required. Our study has shown that for surface roughness at the 1-km baseline, the ejecta and secondary fields comprise the

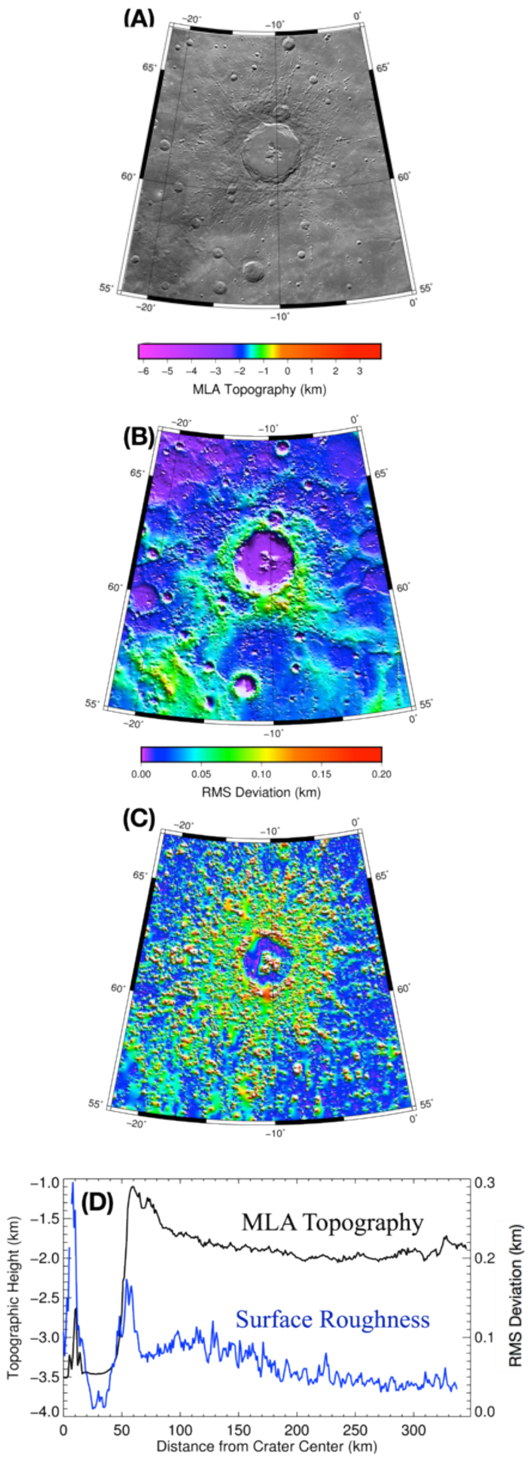

Figure 1. Abedin crater (diameter 116.23 km) and its surrounding ejecta and secondary crater fields. (A) MDIS mosaic; (B) MLA topography; (C) surface roughness at a 1-km baseline; (D) radial profiles of topography and surface roughness (RMS deviation) of Abedin versus distance from the crater center. (A), (B), and (C) are polar stereographic projection centered at 61.73°N 349.34°E.

largest aerial extent of enhanced surface roughness for many craters more than 100 km in diameter. The roughness values of these ejecta and secondary fields are similar to those measured in heavily cratered terrain on Mercury. Studies of intercrater plains (heavily cratered terrain) on Mercury have drawn attention to the dominance of secondary craters in modifying the landscape [10]. If the ejecta and secondary fields of these large impact craters were the primary source of the elevated surface roughness in heavily cratered terrain, this effect would preclude the straightforward use of surface roughness for estimating surface age since a region could have elevated surface roughness because of the presence of a few large complex craters. Future efforts to correlate surface roughness with surface age on Mercury must take into account the role of ejecta and secondary craters.

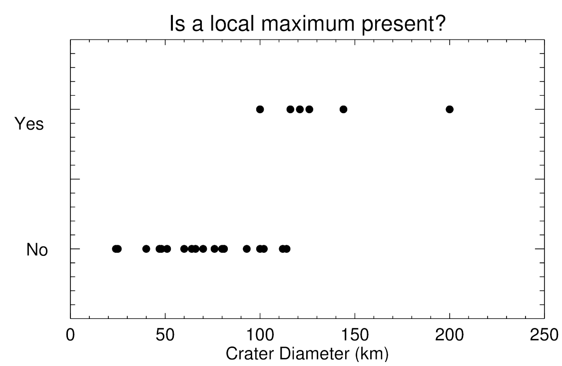

Figure 2. The diameters of impact craters that have a local maximum near the ejecta and secondary fields in radial profiles of surface roughness at the 1-km baseline approximately 2 crater radii outward of the crater center. The few craters larger than 100 km in diameter that do not posses a local maximum in radial profiles of surface roughness have ejecta that were embayed by smooth plains or display generally lower surface roughness values than typical for Mercury.

References: [1] Kreslavsky M. A. et al. (2014) *GRL*, 41, 8245–8251. [2] Rosenburg M. A. et al. (2011) *JGR*, 116, E02001. [3] Rosenburg M. A. et al. (2015) *JGR*, 120, 177–194. [4] Yokota Y. et al. (2014) *GRL, 41*, 1444-1451. [5] Crater Analysis Techniques Working Group (1979) *Icarus*, 37, 467-474. [6] Zuber M. T. et al. (2012) *Science*, 336, 217–220. [7] Yang, D. et al. (2013) *LPS, 44*, Abstract 2347. [8] Shepard M. K. et al. (2001) *JGR*, *106*, 32777–32795. [9] Barnouin O. S. et al. (2015) *LPS, 46*, Abstract 2672. [10] Whitten J. L. et al. (2014) Icarus, 241, 97-113.