Crater Morphometry and Crater Degradation on Mercury: Mercury Laser Altimeter (MLA) Measurement and Comparison to Stereo-DTM Derived Results

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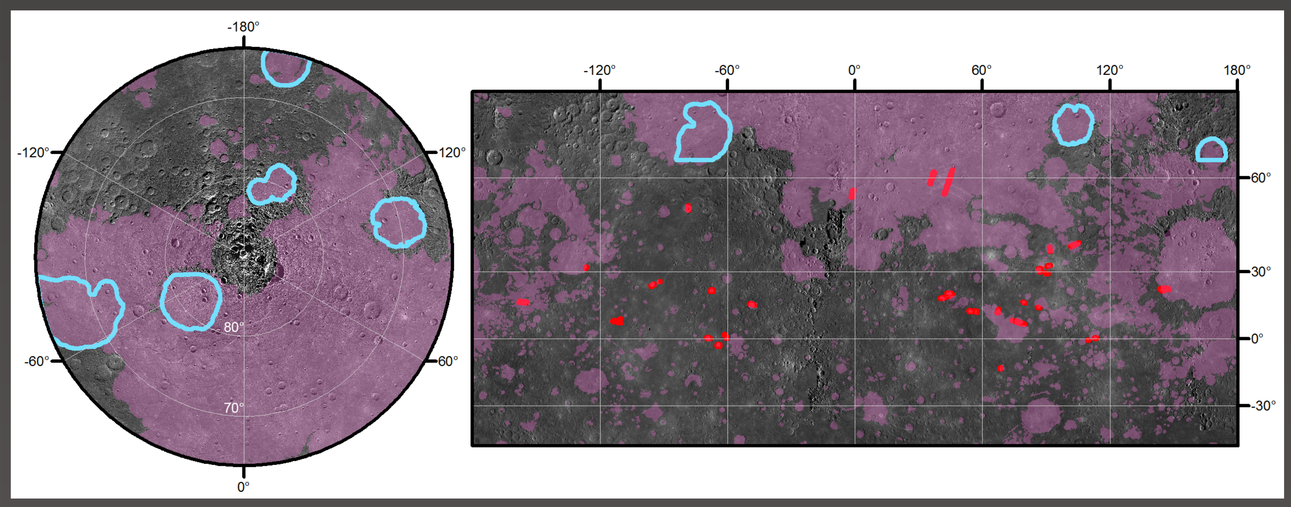
1. Overview and Summary

Examining the topography of impact craters and its evolution with time is useful for assessing how fast planetary surfaces evolve. New measurements of depth/diameter (*d/D*) ratios for 204 craters of 2.5 – 5 km diameter superposed on Mercury's smooth plains are reported. The median *d/D* was 0.13, much lower than is expected for newly formed simple craters (~0.21). On the Moon, the craters that post-date the maria are much less modified and the median crater in this size range has a *d/D* indistinguishable from the fresh value. This difference in crater degradation is remarkable given that the smooth plains and maria likely have ages that are comparable, if not identical. Applying a model for topographic diffusion, the results presented here imply crater degradation is at least ~2–3× faster on Mercury than the Moon, likely symptomatic of faster landform evolution on Mercury at all scales.



3. Study Areas

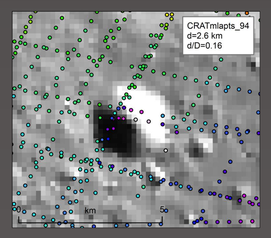
Polar (cyan) and non-polar (red) measurement areas within smooth plains. Polar study area craters measured with MLA profiles; non-polar regions examined with MDIS stereo DTMs. Purple area outlines mapped extent of the smooth plains.

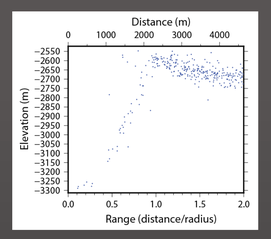
2. Methods

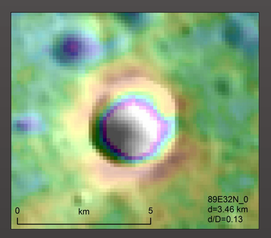
Depth/Diameter ration of 2.5 to 5 km craters on Mercury was measured with two different topography data sets:

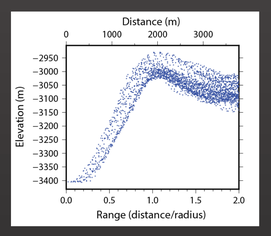
(1) MLA profiles
- Five northern smooth plain areas
- MDIS North Polar Mosaic as basemap
- Each crater mapped in CraterTools [1] in ArcMap; used only craters with MLA shot data from the final PDS release within 30% of the crater center retained in final count
- Crater depth determined using evolution difference between maximum and minimum MLA shot

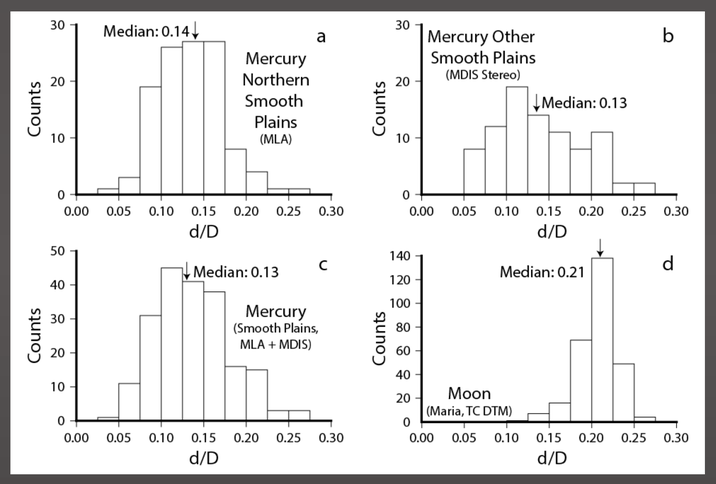
(2) MDIS-derived stereo DTMs
- Lower altitude smooth plains
- Crater rims mapped on orthoimages associated with each DTM
- From mapped crater, elevation data were extracted and converted to radial profiles from co-aligned DTMS.
- Minimum and maximum elevations used to compute the depth





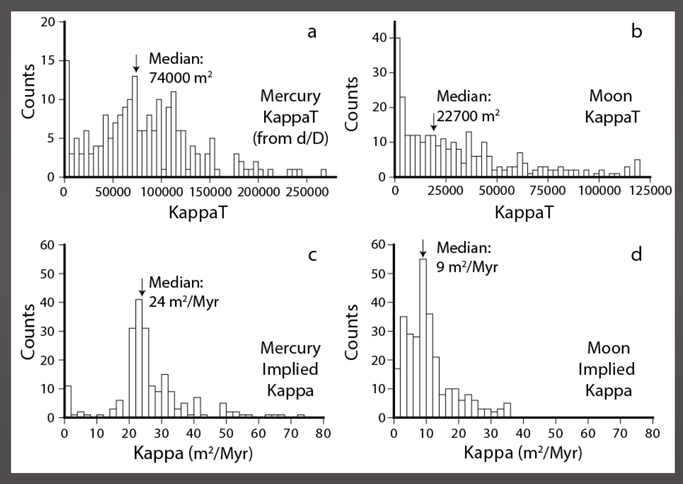






4. d/D on the Smooth Plains and Lunar Maria

Frequency distribution of depth/Diameter (*d/D*) values superposed on:
(a) northern smooth plains of Mercury using MLA profiles,
(b) other smooth plains on Mercury from MDIS data,
(c) combination of all smooth plains measurements,
(d) for craters that post-date the lunar maria from *Fassett and Thomson,* 2014 [*4*] measured using the Terrain Camera DTM [*5*].



5. Inferred Diffusion Rates

Frequency distributions of inferred degradation state (κt) for craters on:
(a) Mercury, derived from d/D
(b) the Moon, inferred by fitting diffusion profiles [*4*] .
(c) Mercury, assuming these craters formed over an age of 3.7 Ga for Mercury's smooth plains and a chronology model for porous crust [*7*],
(d) the Moon, assuming an average age of 3.44 Gyr for the maria region measured by [*4*].

6. Implications / Discussion

Comparing the diffusivities inferred above for 2.5 to 5 km craters on the Moon (~9 m^2/Myr) and Mercury (~24 m^2/Myr) suggests a factor of two-to-three enhancement in the topographic evolution of Mercury compared to the Moon. This may be scale-dependent [*8*], but represents our best current estimate for the relative rate of landform evolution between the two bodies.

The more rapid degradation of craters and faster topographic evolution on Mercury inferred here are consistent with several independent observations of the surface of Mercury:
- Evidence suggests regolith thicknesses enhanced by a factor of 3 over the Moon [*9,10*].
- Optical maturation of rays is enhanced by a factor of up to four on Mercury compared to the Moon [*11*].

One enduring mystery about Mercury is that no part of its surface is as densely covered by craters of ~20 to 100 km in diameter as the lunar highlands. One common explanation is that Mercury resurfaced by volcanism at essentially global scales [*12, 13, 14*]. One alternative is that Mercury's inter-crater plains experienced faster topographic evolution than the lunar highlands.

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