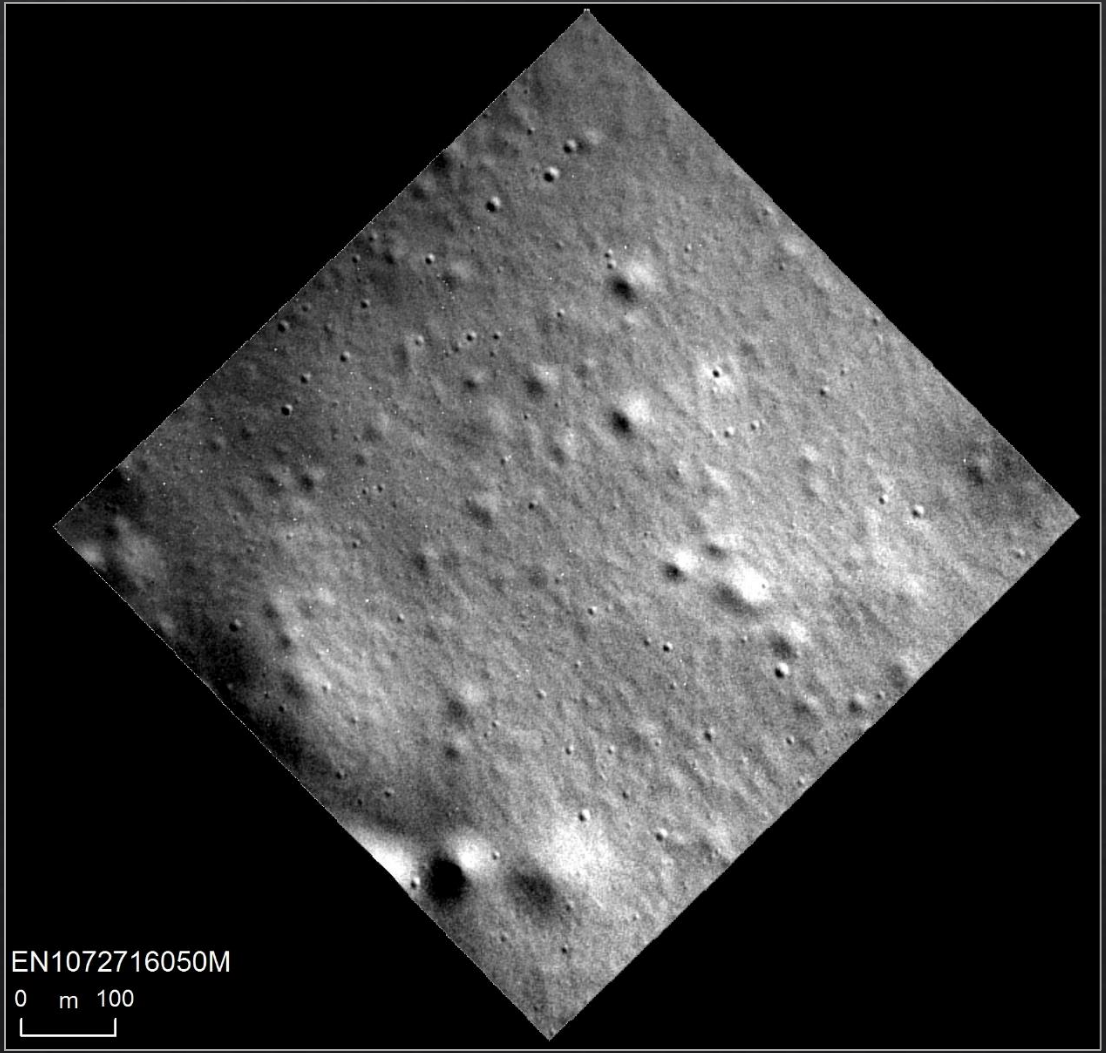
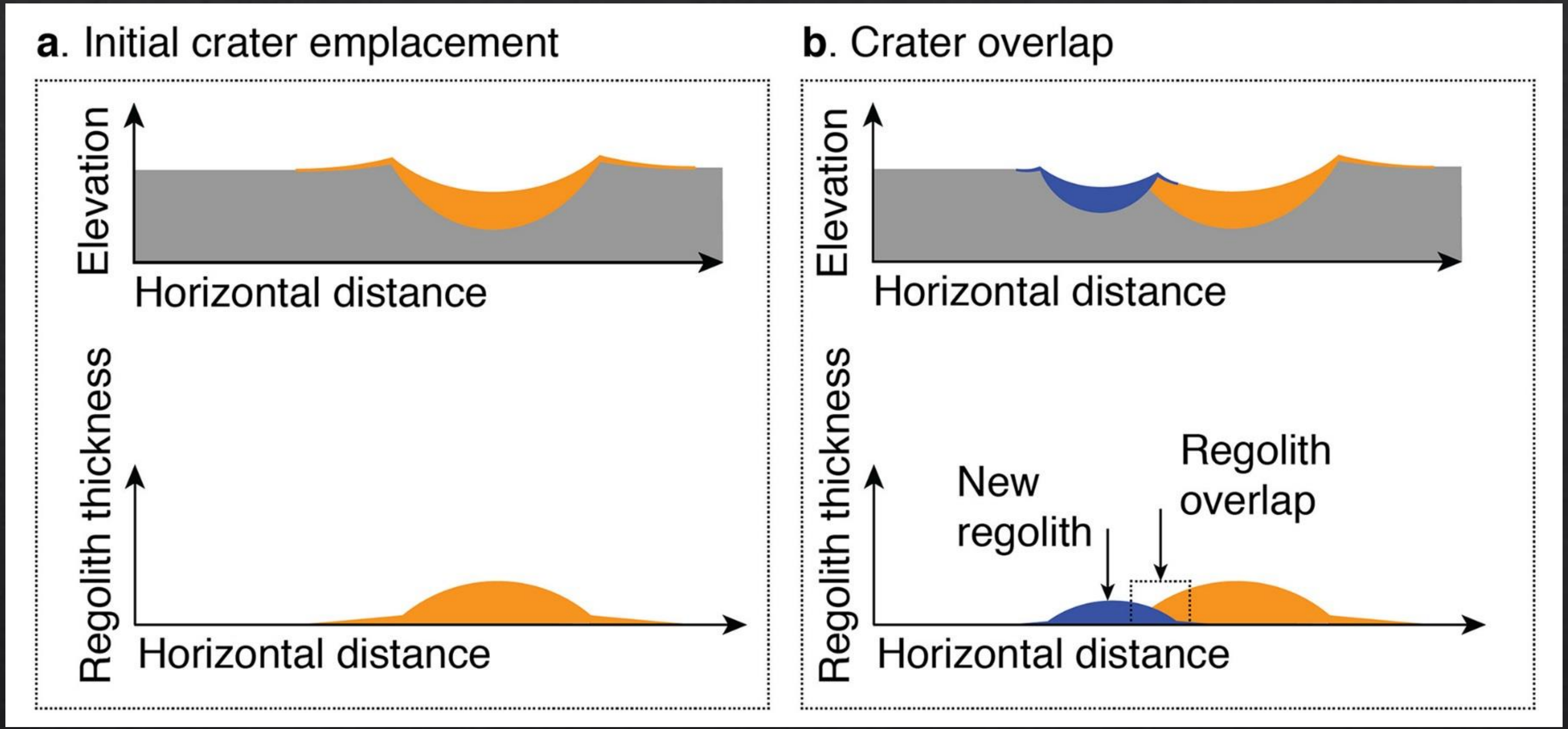


The Nature and Mobility of Regolith on Mercury's Smooth Plains

(A) Observations of Crater Degradation
(B) Equilibrium Size-Frequency Distributions

Caleb Fassett, Toshi Hirabayashi, Lillian Ostrach, Wes Watters, Jenny Whitten, and others

Cratering ➔ Mercury's Regolith



Hirabayashi et al., 2018

Impacts are a dominant mechanism for growing the regolith on the Moon and Mercury.

- Controlled by rate that craters fragment bedrock.
- As regolith grows, larger craters are needed (regolith growth is self-buffering).

Regolith Mobility and Topographic Diffusion

- Operating hypothesis is that regolith growth is fast, so regolith can be treated as a continuum.
- Classical diffusion, topography *h*: $\frac{\partial h}{\partial t} = \kappa \nabla^2 h$
  - Downslope transport q ∝ slope.
  - A classic model for hillslope evolution on Earth.
  - Leads to smoothed, rounded, topography.

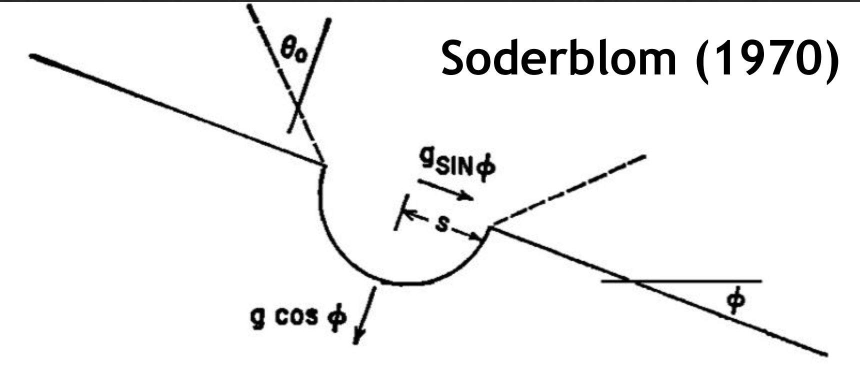
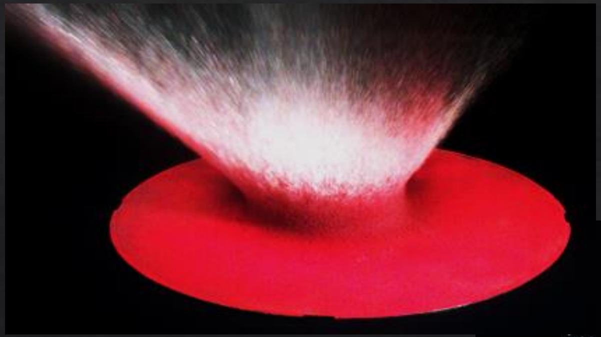
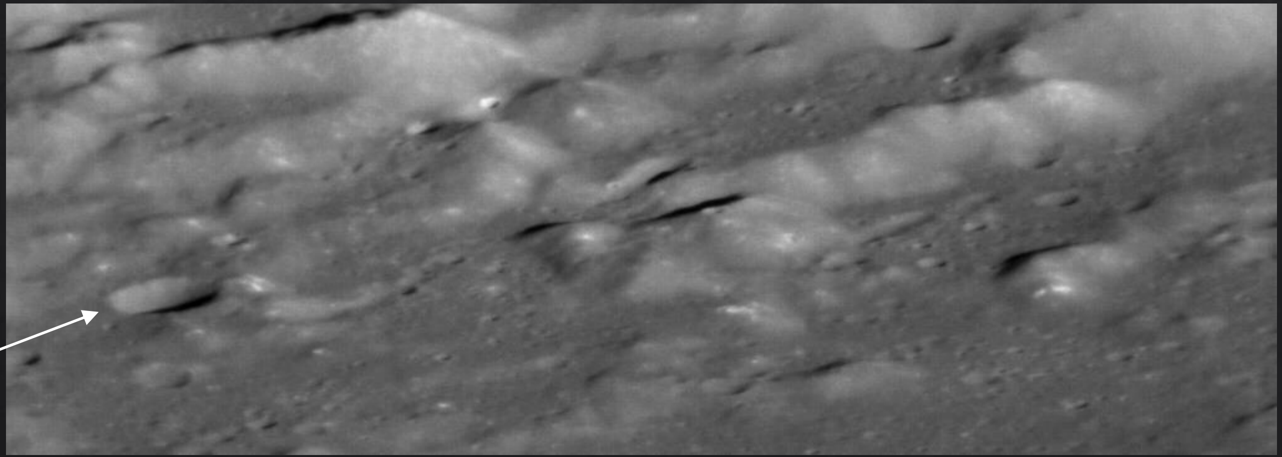


Fig. 2. The geometry of the ejecta trajectories of a crater eroding a surface with slope Φ.



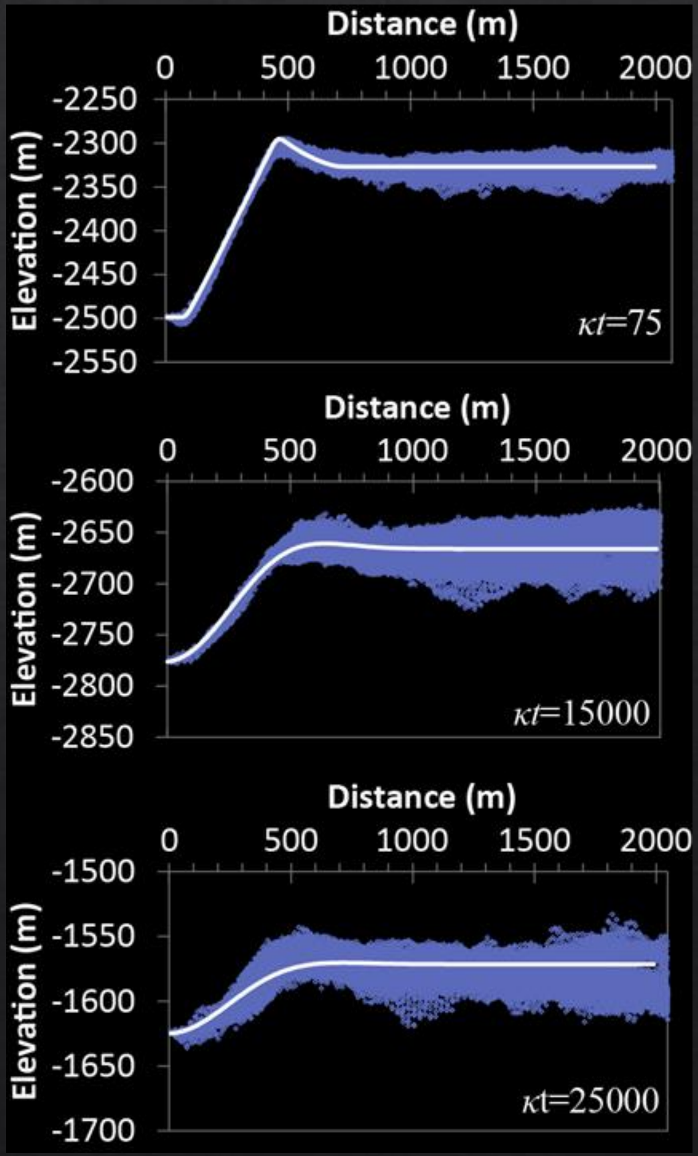

D~3 km

EN1059413078M

Observations of Crater Degradation: κt

- With high-quality radial profiles, can directly fit topography to estimate "diffusion age" or "degradation state": κt.

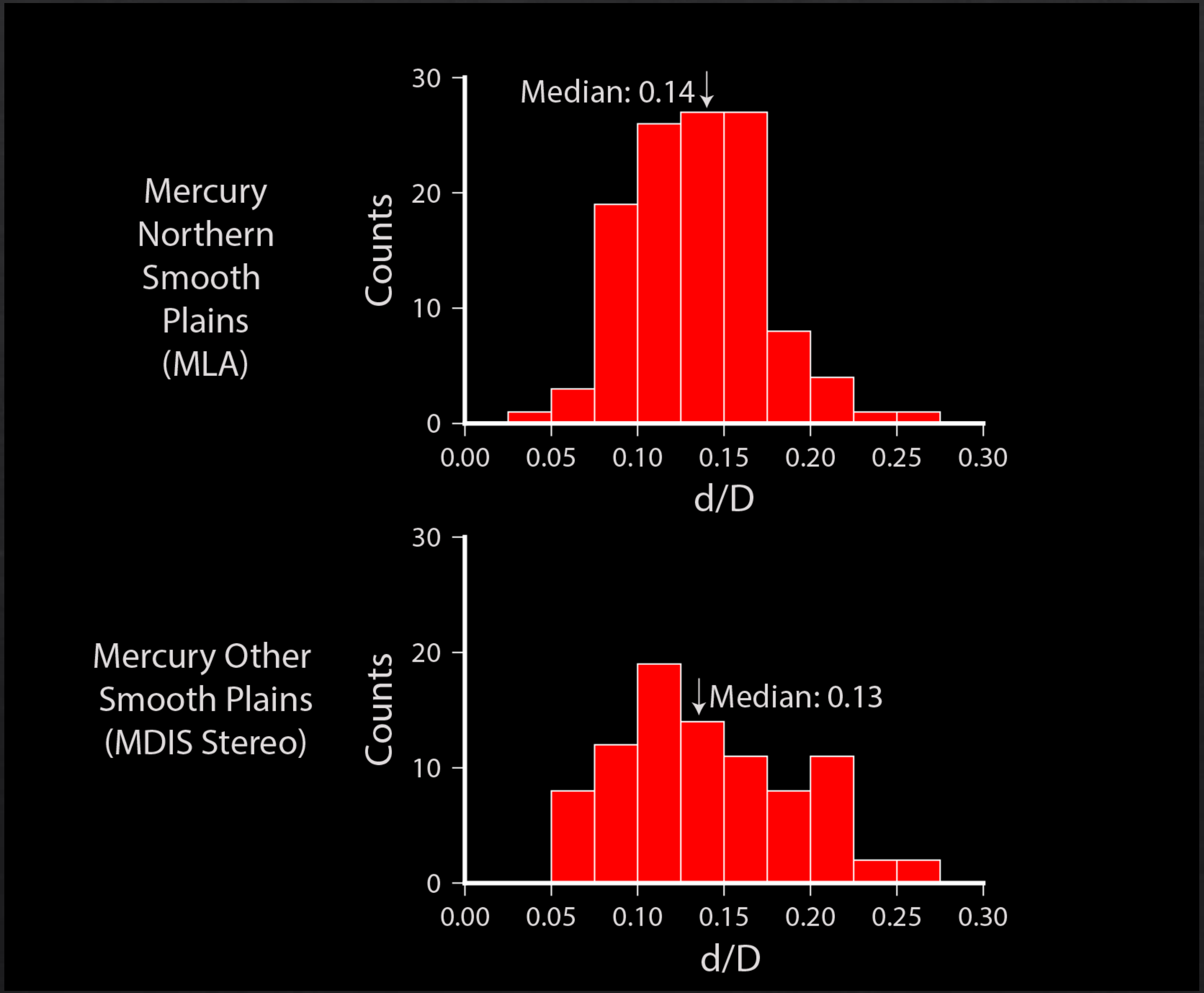
- 13000+ craters on the maria (D=800 m to 5 km) in Fassett and Thomson (2014). Provides:
  - Estimates for diffusivity / degradation history κ.
  - Estimates for the age of individual features.
  - Estimates for a unit's age based on median degradation state of its craters.



Observations of Crater Degradation: d/D

- Craters: *D*=2.5 to 5 km
- Superposed on smooth plains only.
- Attempted to exclude secondaries (clusters, rays, obvious primary source, etc.)
- Measured two ways, each with own challenges.

Fassett et al., 2017



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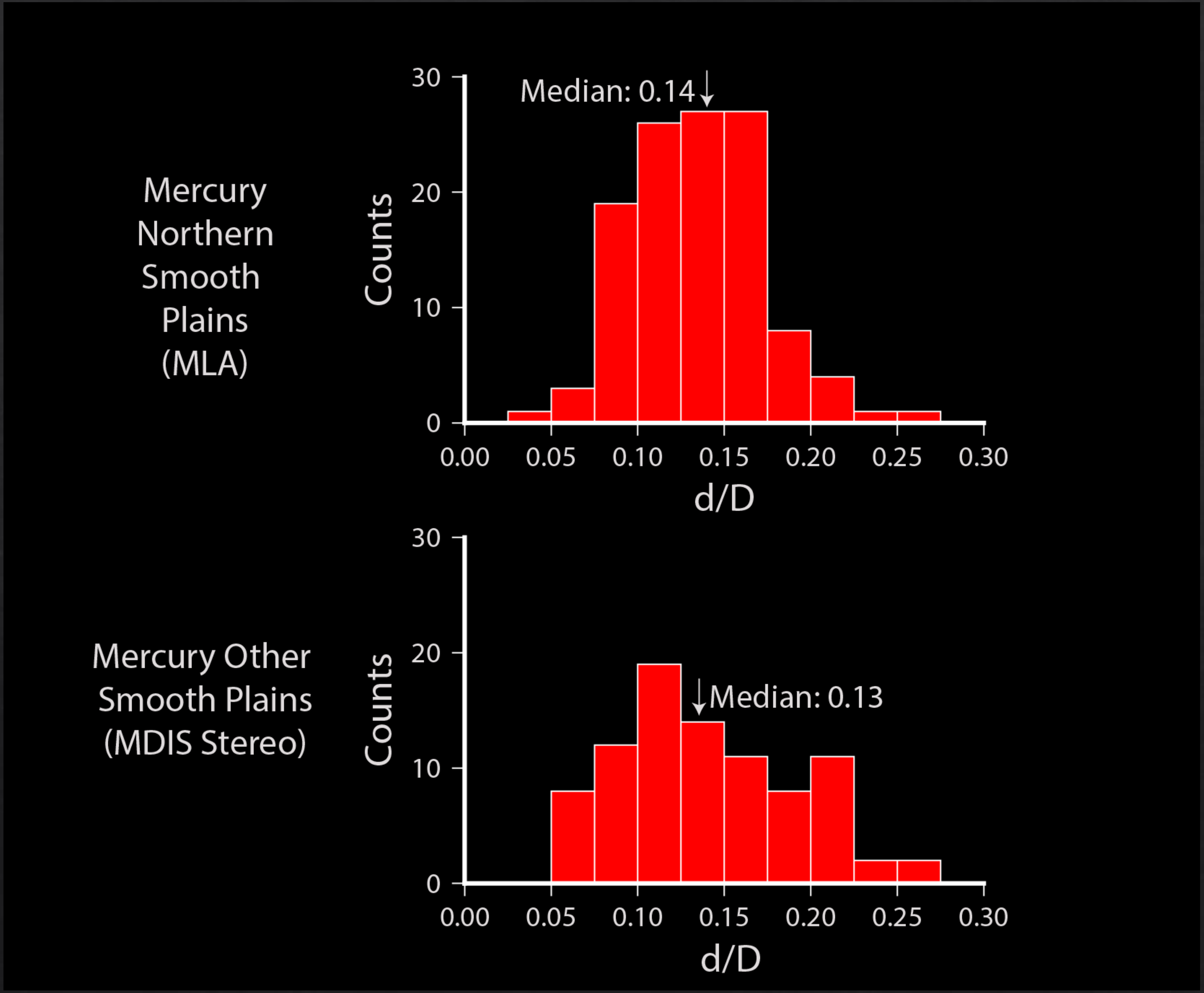
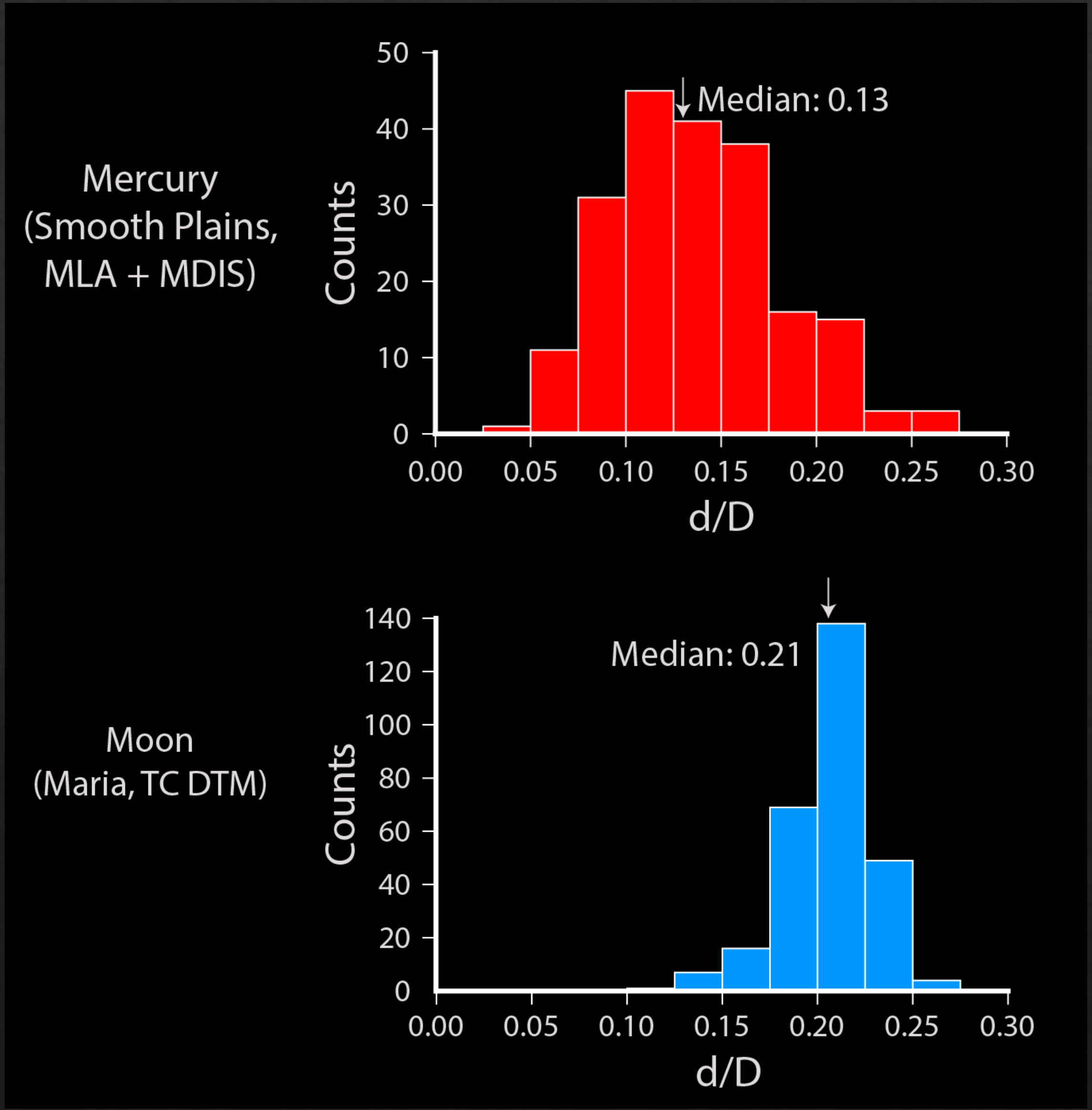


Observations of Crater Degradation: d/D

- Craters: *D*=2.5 to 5 km

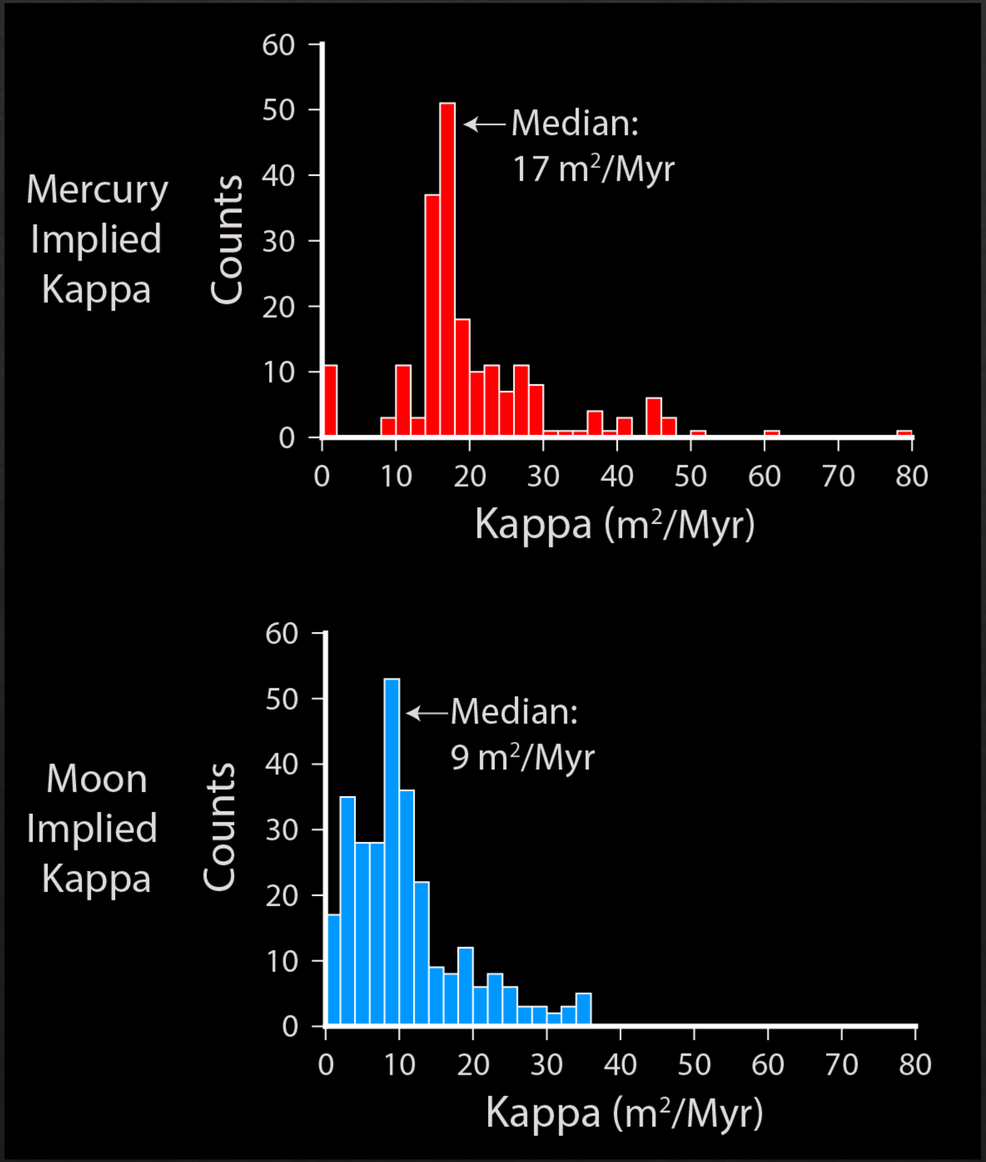
- Big difference between Moon and Mercury!
- Most likely explanation is different degradation rate.



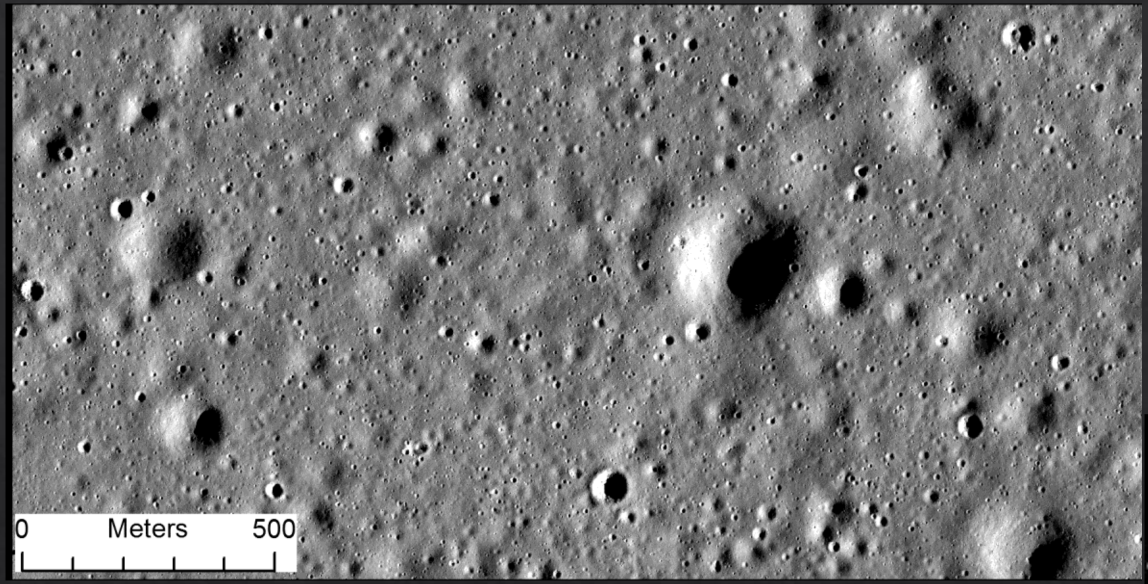
Fassett et al., 2017

Mercury / Moon Rate Comparison

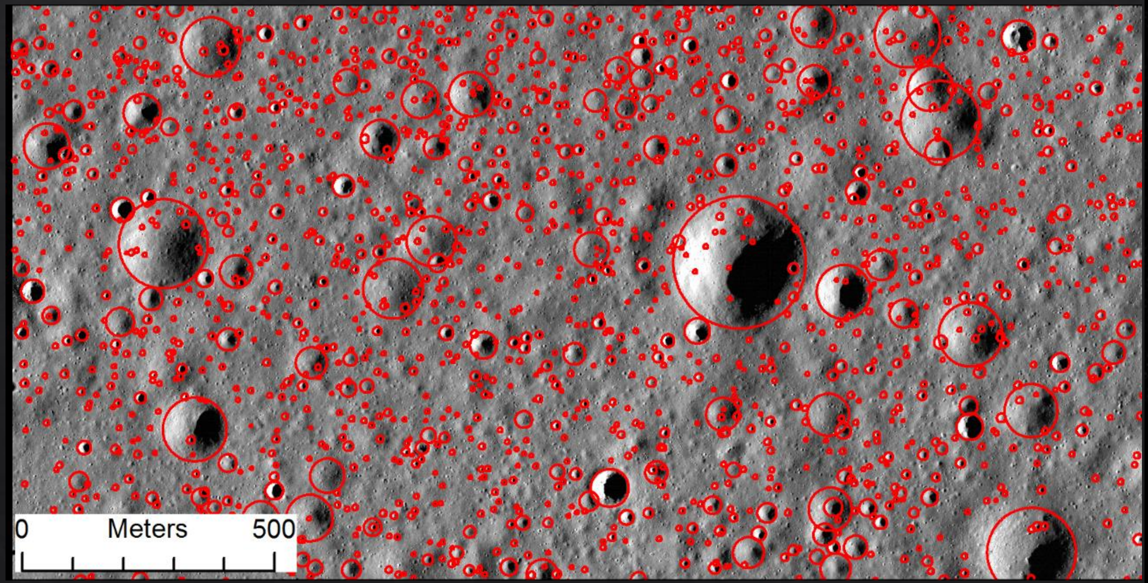
- Need to make assumptions about relative age of smooth plains and maria to understand implications for rate.
  - From crater SFD of smooth plains and *Le Feuvre and Wieczorek* (2011) porous model: 3.5 Ga average age for smooth plains.
  - Average lunar maria age = 3.33 Ga with NPF.
- Mercury has >~2× faster degradation than Moon.



Topographic Diffusion / Equilibrium Link

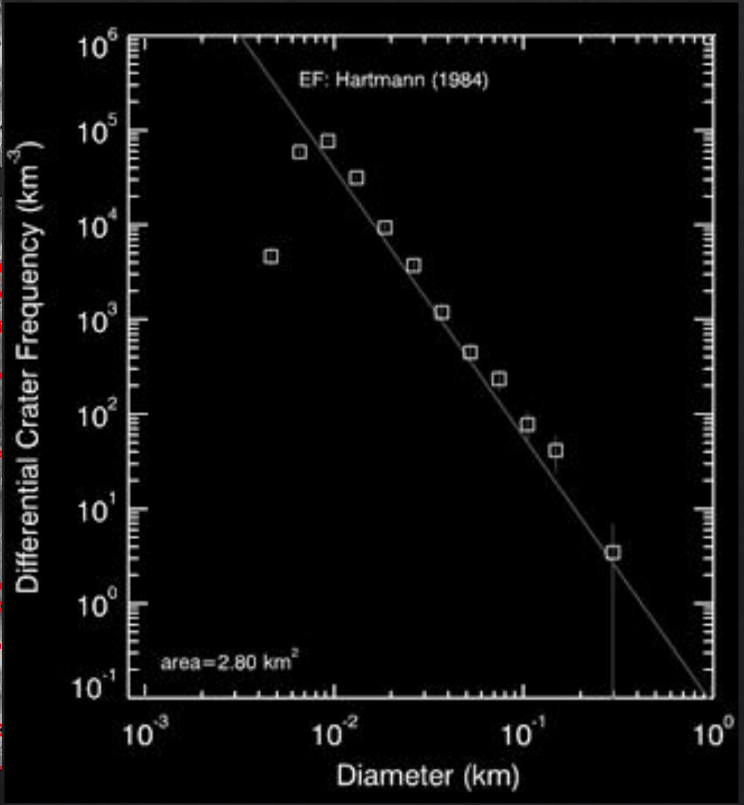


Fassett count from Robbins et al., 2014, near Apollo 15.

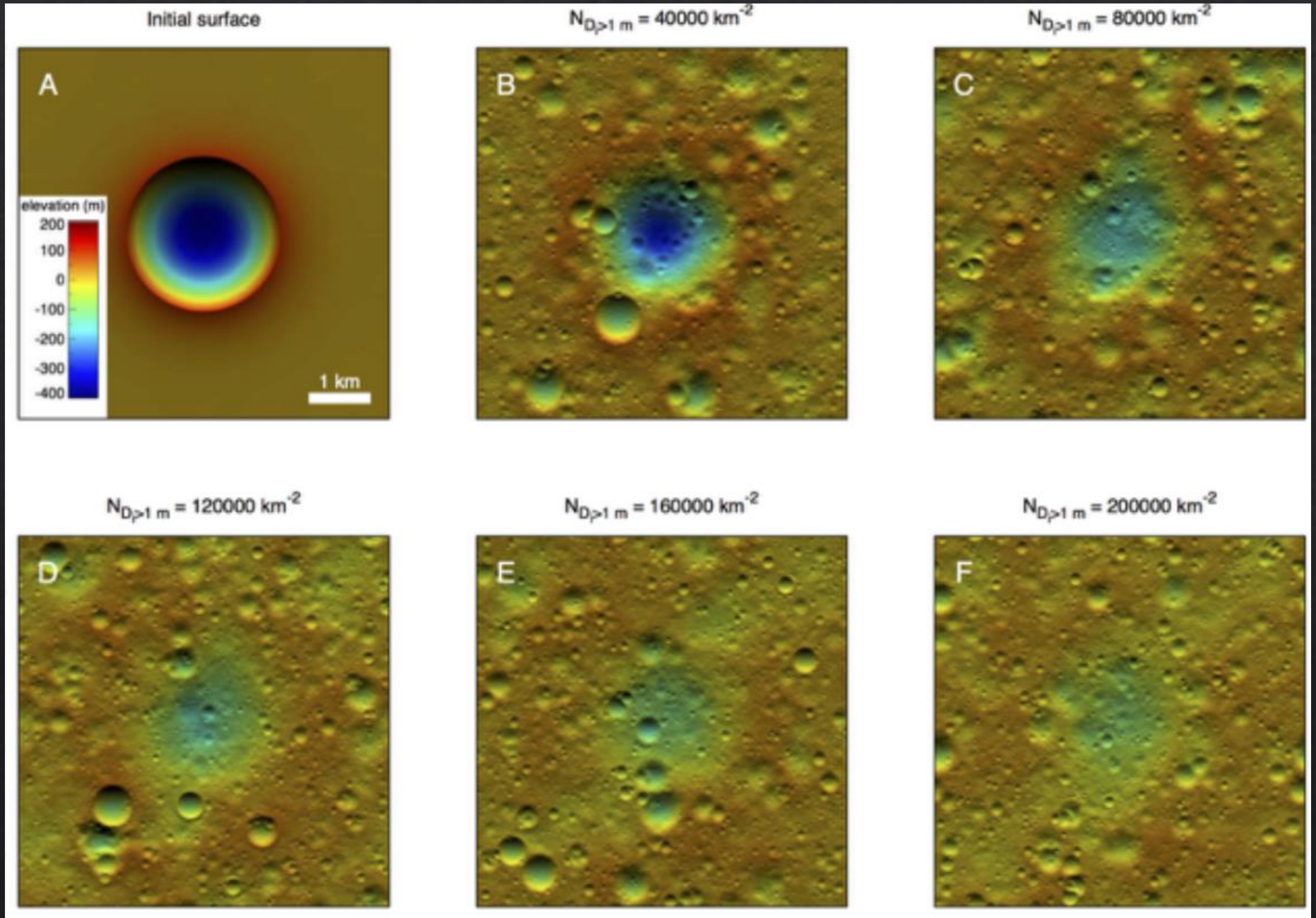


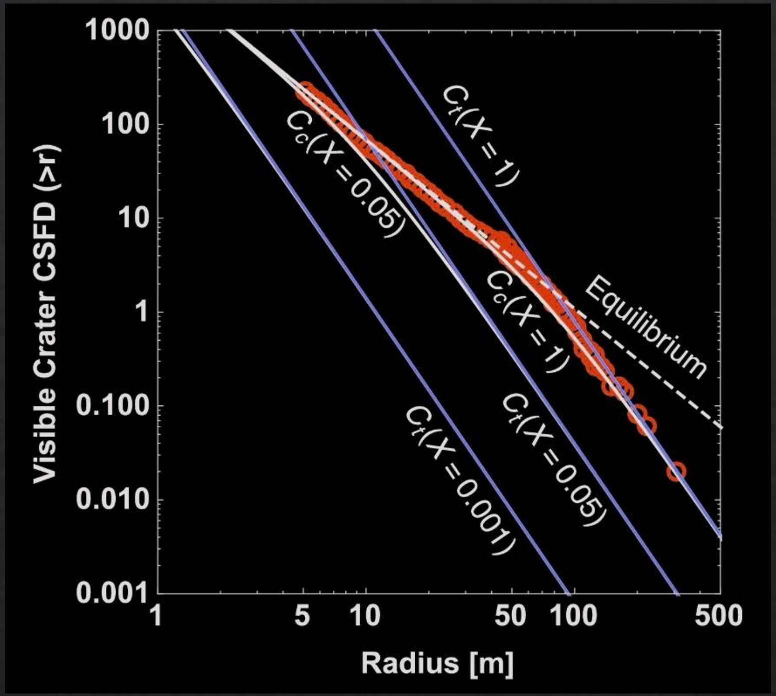
On the Moon, all maria are in equilibrium in D~100 to ~300 m size range.

A symptom of equilibrium is that counts become more subjective.



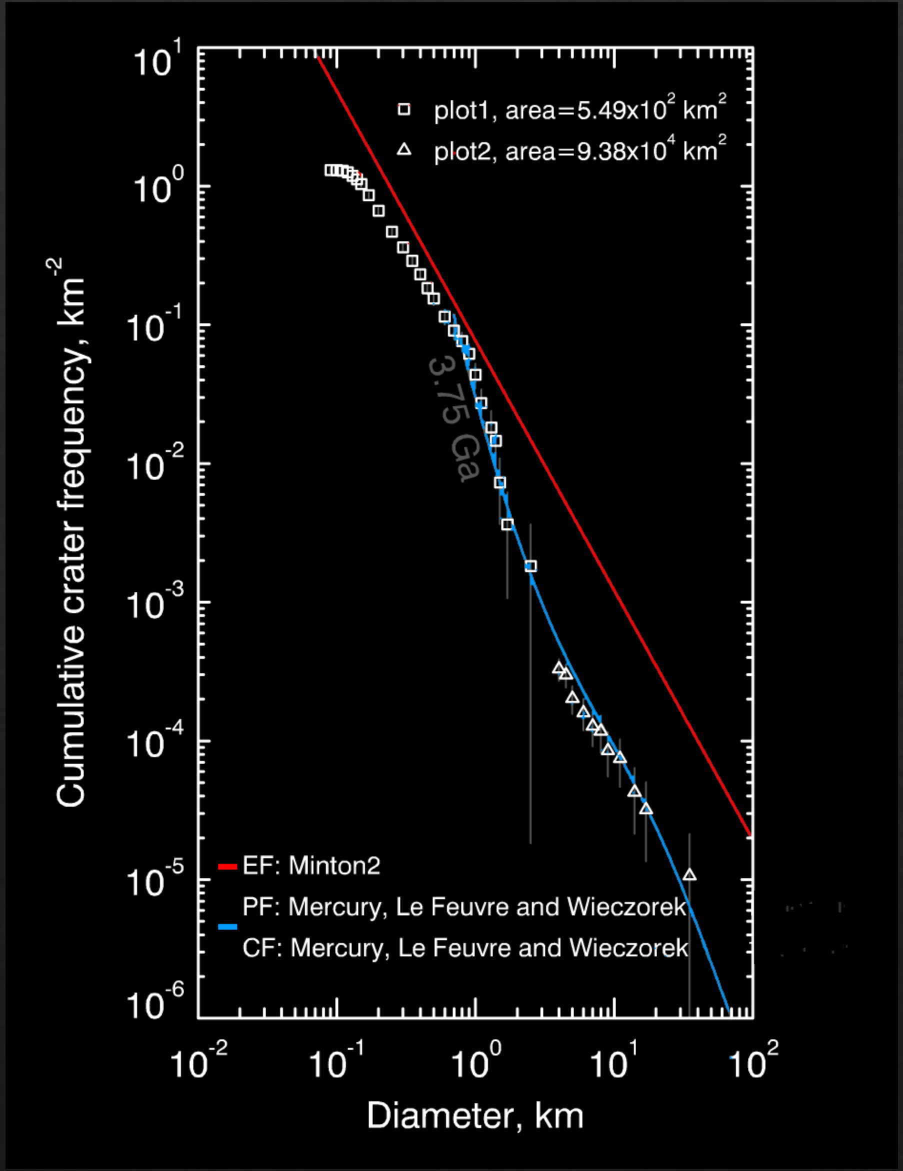
Topographic Diffusion / Equilibrium Link

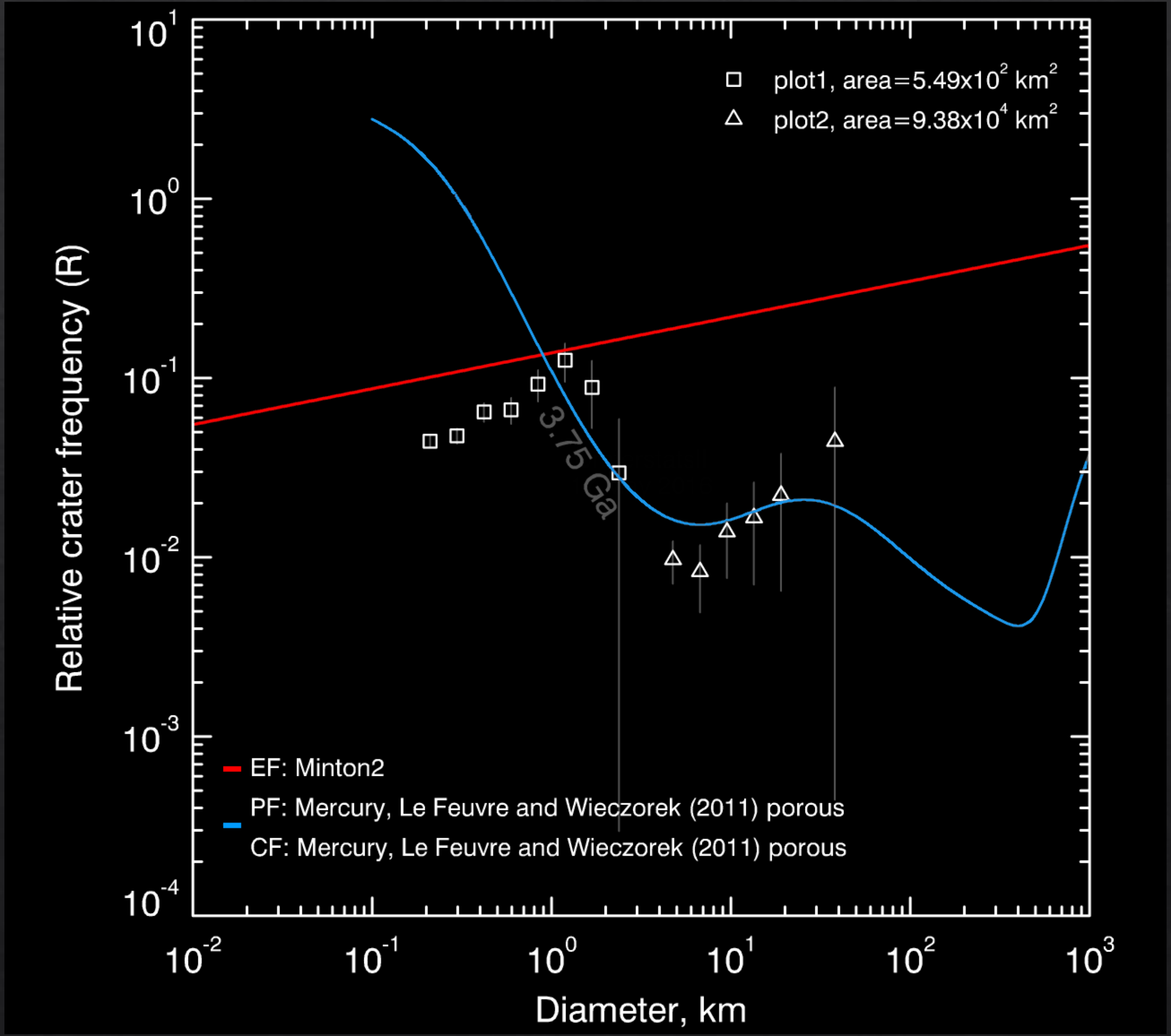




Both analytical calculations (Hirabayashi et al., 2017, top) and numerical experiments (e.g., Minton et al., 2018, left) demonstrate that diffusive degradation controls equilibrium.

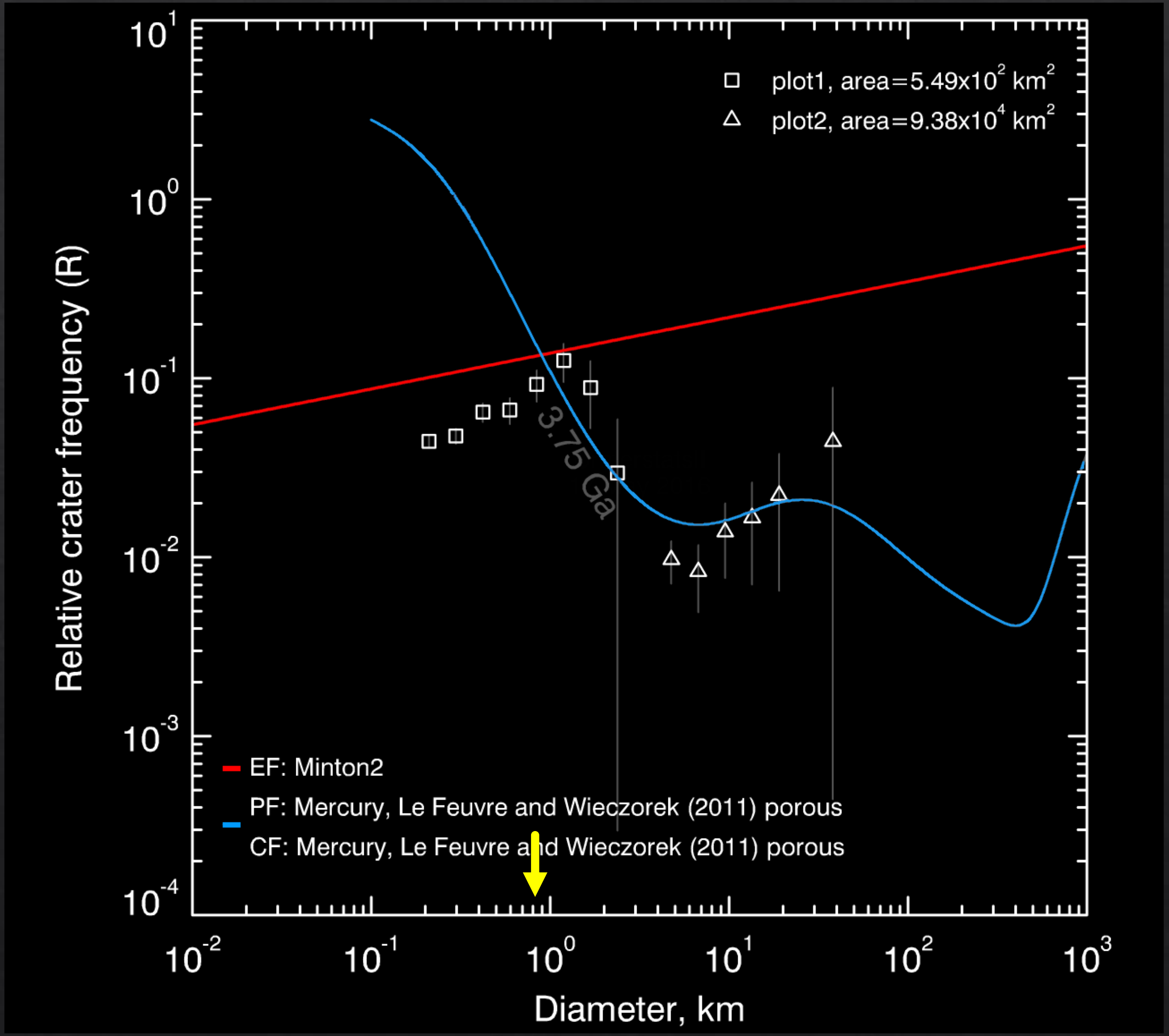
Measurements of Equilibrium SFD on Mercury





Measurements of Equilibrium SFD on Mercury

- On this smooth plains, ~800 m equilibrium diameter, ~2× as large as typical maria
- Consistent with regolith developed to many tens of meters depth; thickest areas up to 100+ m.
- Equilibrium density is lower than on Moon. Equilibrium SFD slope might be lower too.



Conclusions

- Two different lines of evidence:
  - Crater degradation rates at ~2.5 to 5 km sizes;
  - Equilibrium SFD characteristics;
- Both observations point to:
  - Thicker regolith on Mercury;
  - Transport of regolith with greater efficiency.