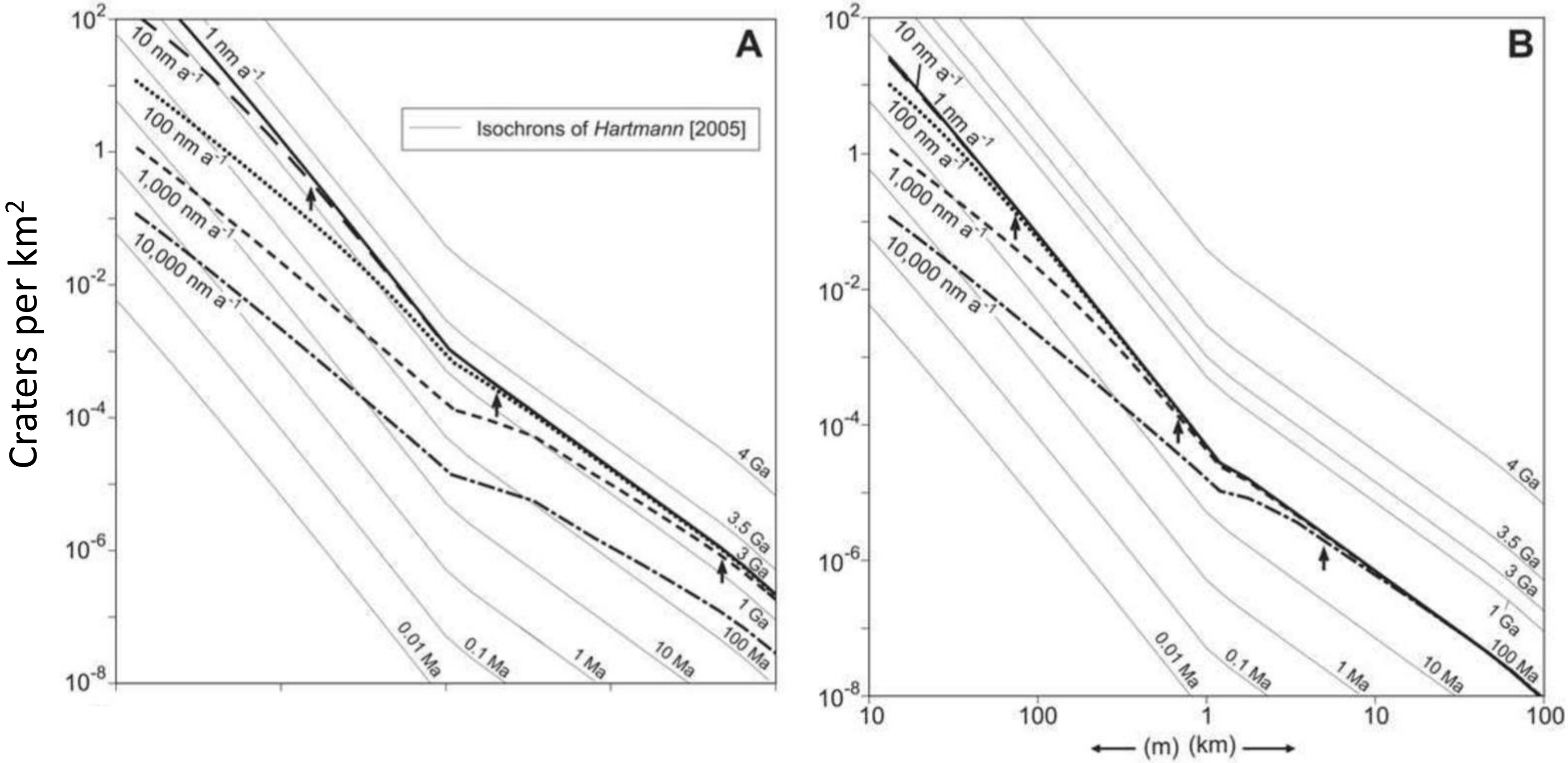
CRATER DENSITIES ON LOWER MOUNT SHARP AS A PROXY FOR MODERN GEOLOGIC EROSION

CALEF III, Fred John, Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109, DAY, Mackenzie D., Department of Earth and Space Sciences, University of Washington, Seattle, WA 98105 and NEWSOM, Horton E., Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131, fcalef@jpl.nasa.gov

Overview

Estimating crater retention age from crater counts is an established technique for dating crater surfaces. However, such methods work best on areas greater than 10000 km^2 and with crater diameters greater than 250-500 m due to undersampling of large crater on small geologic units and erosion/burial of small craters over billion year timescales. Geologic units at tens of meters scale (i.e. HiRISE) are difficult if not impossible to date accurately via crater counting at this time. We want to examine crater retention as a proxy to understand the current erosion rate of lower Mount Sharp morphologic units. We assume higher crater retention reflects more indurated sediments that in-turn are more difficult to erode, reflecting unique geologic units.

"A reanalysis of prior studies indicates that low to moderate long-term rates of erosion and crater infilling can mask an ancient age and result in small-crater populations similar to those offered as evidence for young and geologically significant surface activity."



Effect of obliteration on crater-count chronologies for Martian surfaces

Smith, Gillespie, and Montgomery, GRL, 2008.

- Impact Rates
- Atmospheric Filtering
- Crater Formation Heterogeneity
    - Secondary Cratering
    - Self-secondary cratering
    - Target Properties
    - Crater Modification
- Statistical/Observational bias

"Establishing confidence in a model age ultimately requires an understanding of the geologic context of the surface being dated as reliability can vary considerably and limitations of the dating technique should be considered in applying ages to any geologic interpretation."

"One challenge associated with dating young surfaces is that recent geological activity tends to be very spatially limited. As a result, the numbers and sizes of craters available for statistics are also limited."

"Smaller craters form in a strength-scaling regime, where the final crater is affected by the projectile parameters, as well as the target properties." Williams et al., 2014, Van der Bogert et al., 2017.

Dating very young planetary surfaces from crater statistics: A review of issues and challenges

Jean-Pierre Williams, Carolyn H. van der Bogert, Asmin V. Pathare, Gregory G. Michael, Michelle R. Kirchoff, Harald Hiesinger, MAPS, 2017.

We assume higher crater retention reflects more indurated sediments that in-turn are more difficult to erode, reflecting unique geologic units.

"Work on young platy-ridged Martian lava flows exhibiting two different surface textures (rough ridged areas and smooth polygonally patterned areas) shows that this effect can be quite significant, leading to differences in crater diameters, for example, on the order of 50% for craters less than 100 m in diameter (Dundas et al., 2010)" Williams et al. 2017.

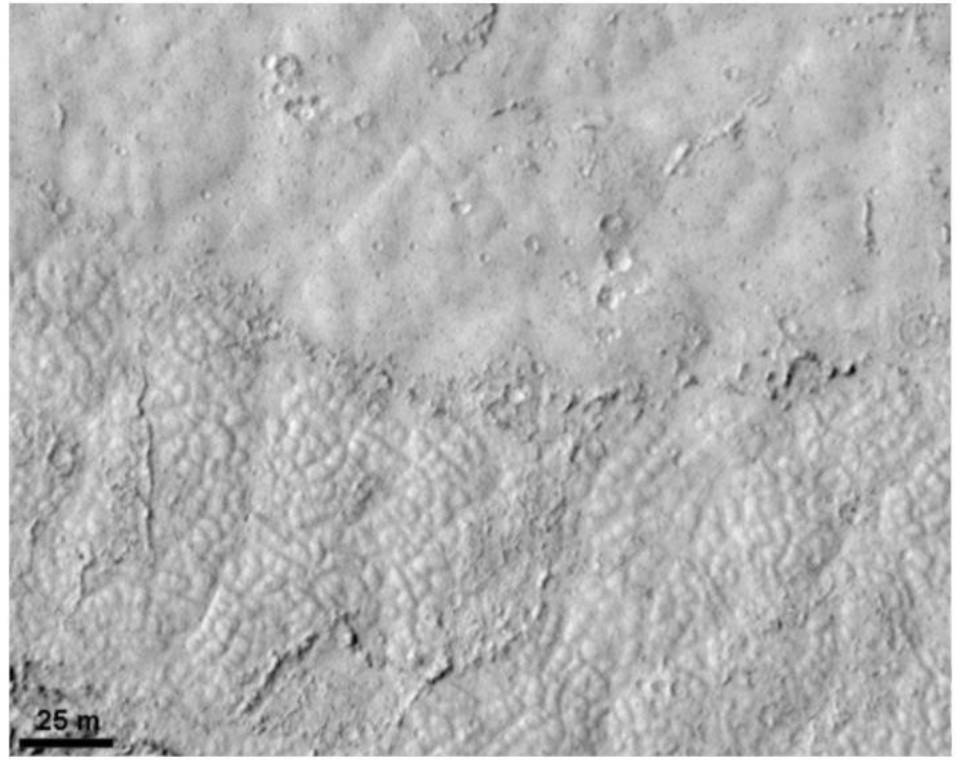
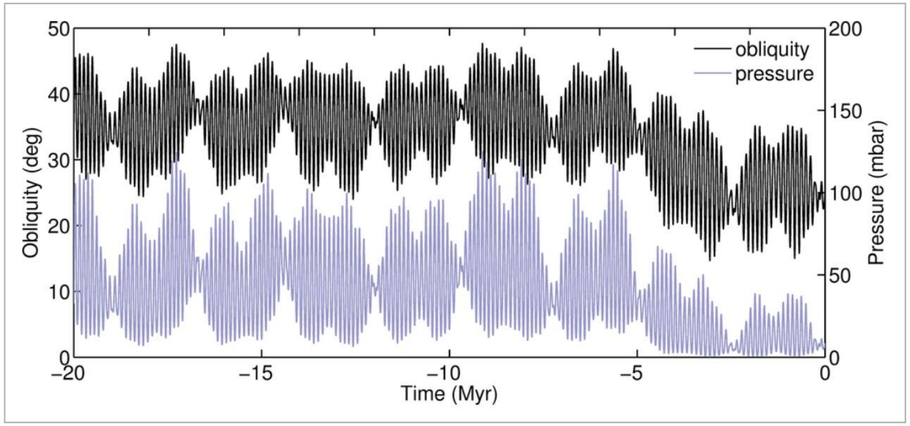


Figure 3. Cutout of HiRISE image TRA_000854_1855, showing a region between plates in a platy-ridged surface in Elysium. An area of well-defined polygons and few craters transitions to a smoother, potentially dust-mantled surface with many more craters. Such sites may have undergone a complex history of burial and exhumation. (Image credit NASA/JPL/University of Arizona).

(Dundas et al., 2010

Assumptions/Parameters

- craters with D <=250
- retained on small geologic units (<10000 km^2)
- eroding craters this size takes less than one billion years (ish).
- Erosion raters over this time period are, on average, constant.



Laskar et al., 2004

Assumptions/Parameters (Part 2)

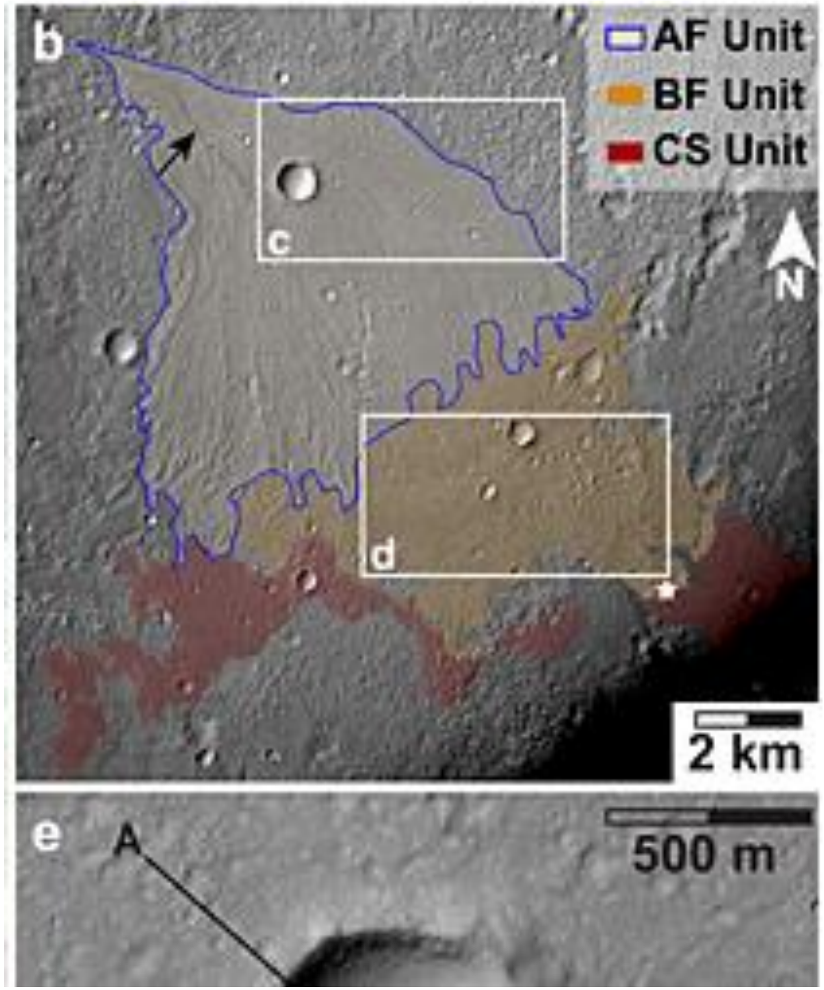
- Impact Rates (generically constant last 2ish Gyr)
- Atmospheric Filtering (stable over last 1 Gyr)
- Crater Formation Heterogeneity
  - Secondary Cratering (some, but should be obvious)
  - Self-secondary cratering (not at this crater D)
  - Target Properties ***YES!!!
  - Crater Modification (not to the extent in small D)
- Statistical/Observational bias (ALWAYS)

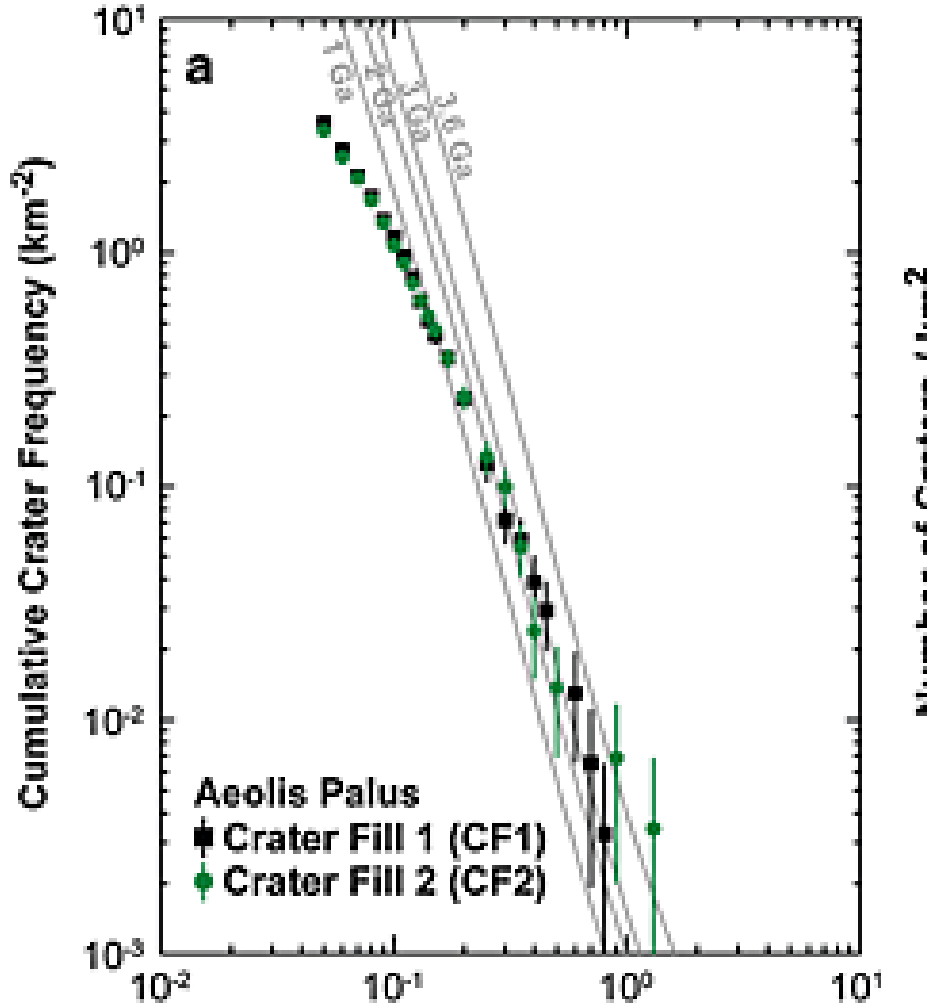
Erosion Rates from Small Crater Degradation

- 3-30 nm/yr in Meridianni Planum (Golombek et al. 2006, 107 2010, 2014; Fenton et al. 2015).
- ~103 nm/yr for a light- 101 toned layered deposit at Arabia Terra (Smith et al., 2008)
- ~100 nm/yr for Gale Crater and VM (Kite and Mayer, 2016)
  – 0.5 Ga to erode a 250 m D crater (d = 50 m, if d/D = 0.2)

Small Crater Removal

From Grant et al., “The timing of alluvial activity in Gale crater, Mars”



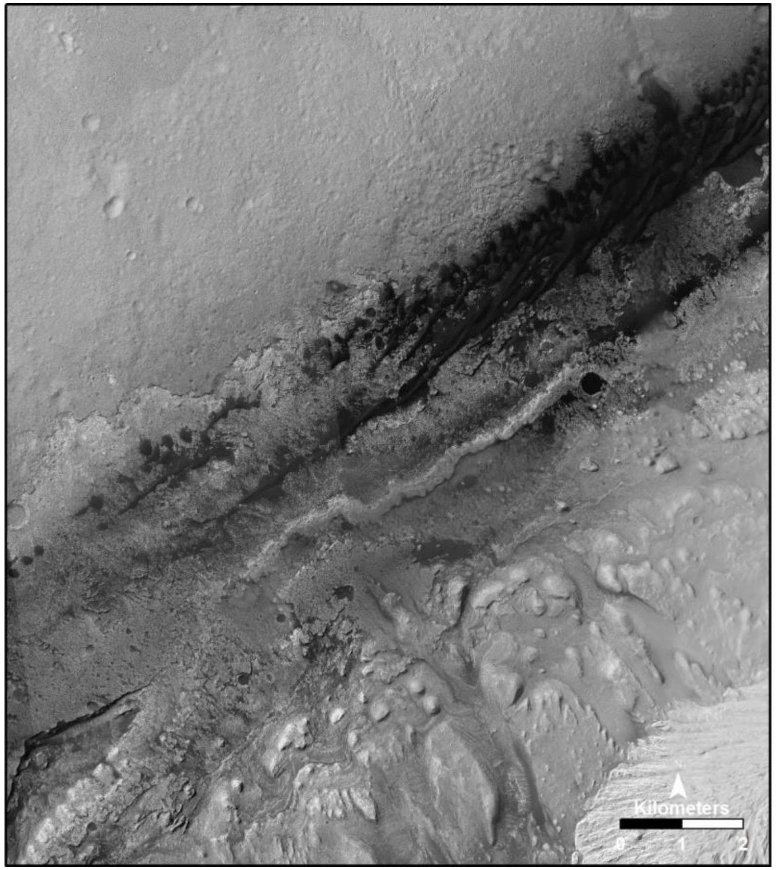


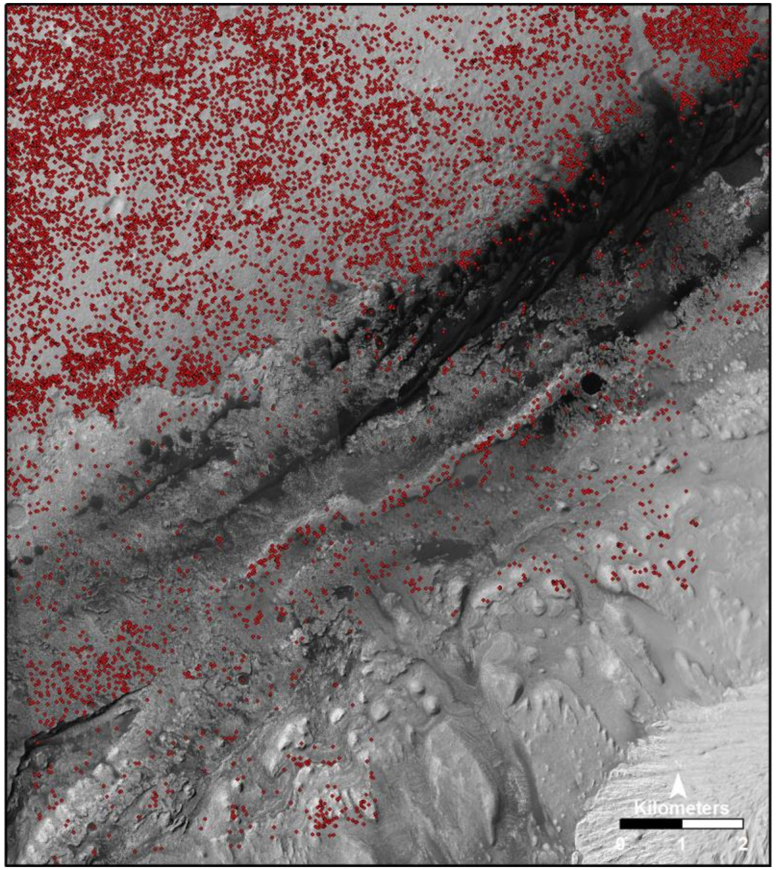
Crater Diameter (km)

Geophysical Research Letters
Volume 41, Issue 4, pages 1142-1149, 18 FEB 2014 DOI: 10.1002/2013GL058909
http://onlinelibrary.wiley.com/doi/10.1002/2013GL058909/full#grl51383-fig-0001

Crater Densities

~75000 craters D <=250 m overall.
~1200 craters for this study

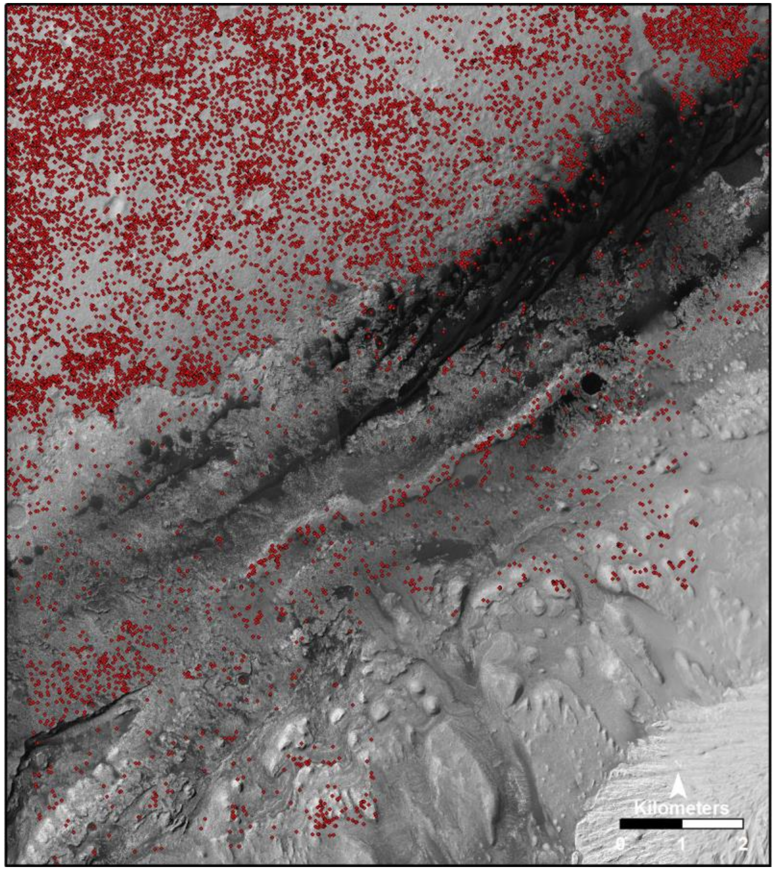




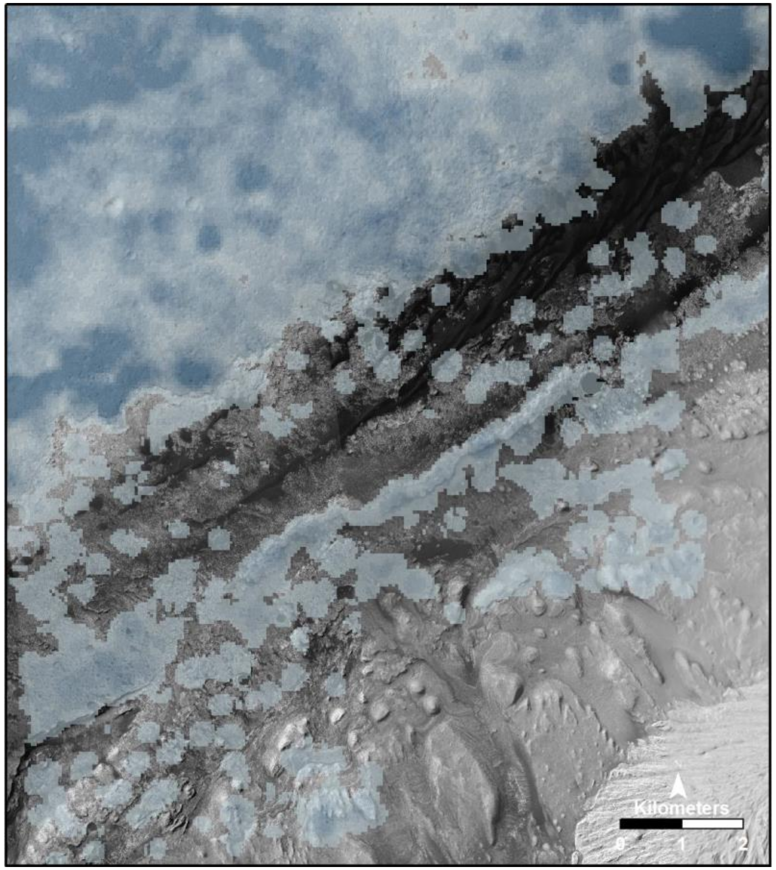
Original crater dataset from Day et al. 2012

Crater Densities

~75000 craters D <=250 m overall.
~1200 craters for this study



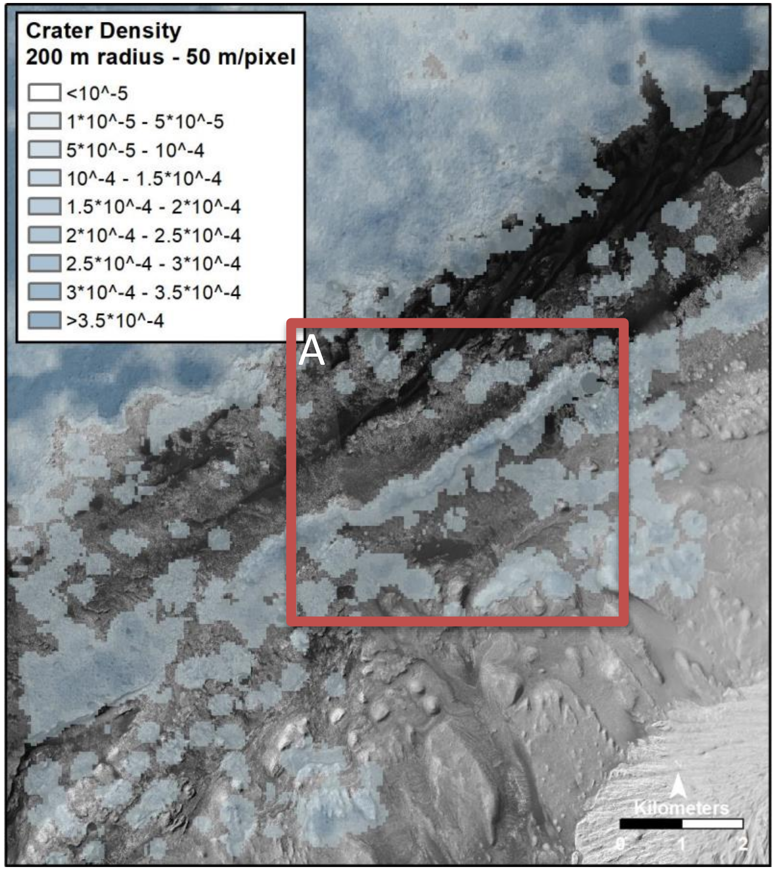
Original crater dataset from Day et al. 2010

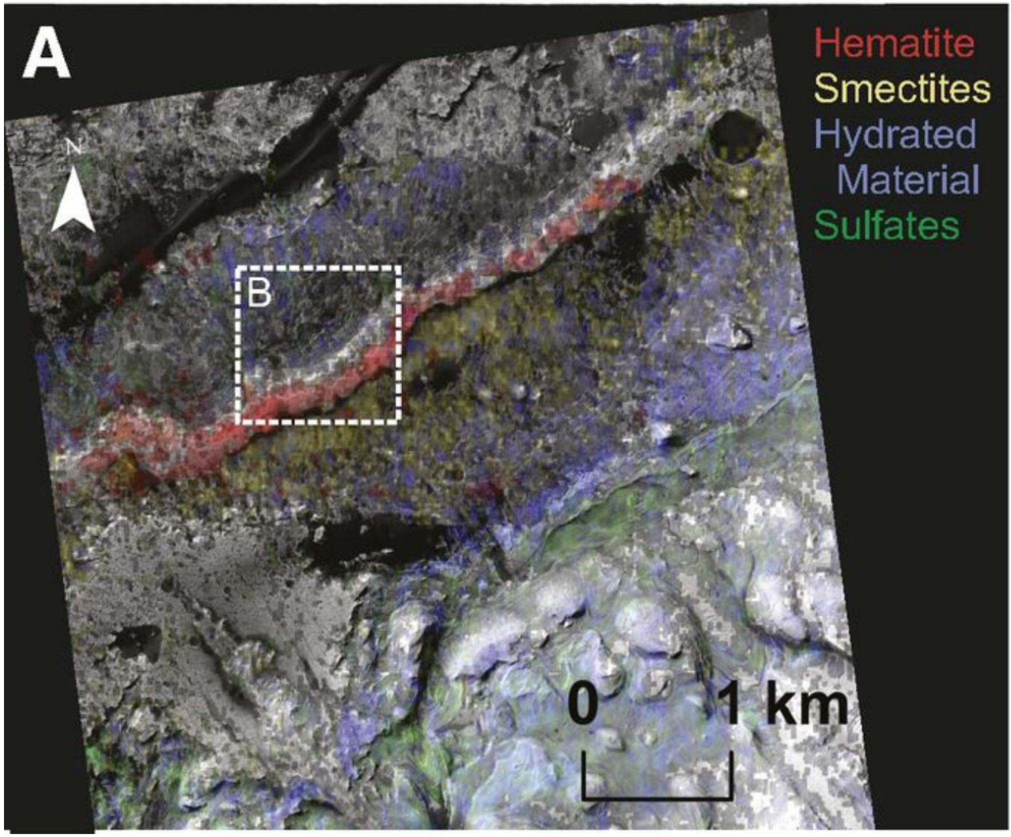


Point Density Kernel
200 m circle radius every 50 m.

Mapping Comparisons

Spectral Units from Fraeman et al., 2013



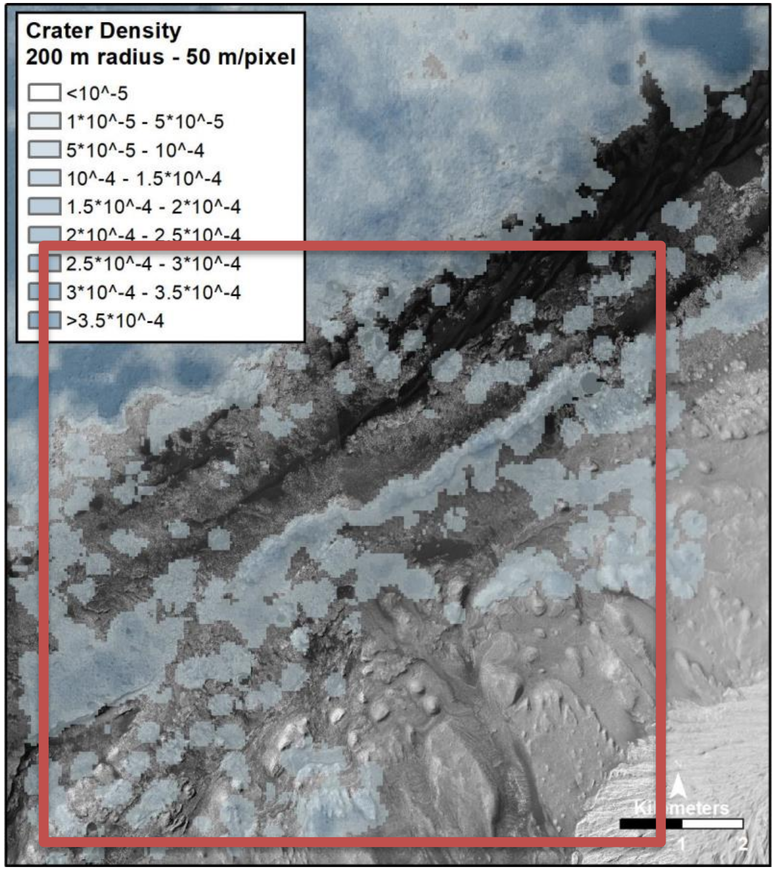


~1200 craters for this study

Original crater dataset from Day et al. 2010

A hematite-bearing layer in Gale Crater, Mars: Mapping and implications for past aqueous conditions
Geology. 2013;41(10):1103-1106. doi:10.1130/G34613.1

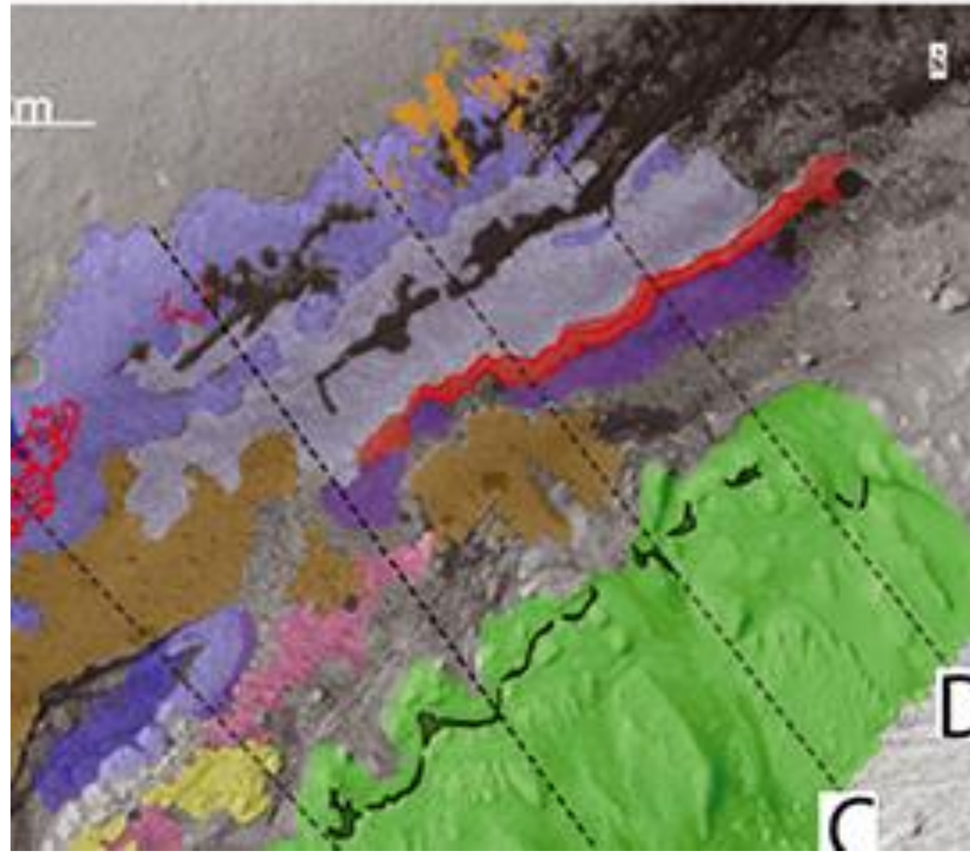
Mapping Comparisons



~1200 craters for this study

Original crater dataset from Day et al. 2012

Spectral, morphologic, and thermophysical units from Fraeman et al., 2016



Journal of Geophysical Research: Planets
Volume 121, Issue 9, pages 1713-1736, DOI: 10.1002/2016JE005095
http://onlinelibrary.wiley.com/doi/10.1002/2016JE005095/full#jgre20565-fig-0013

Conclusion

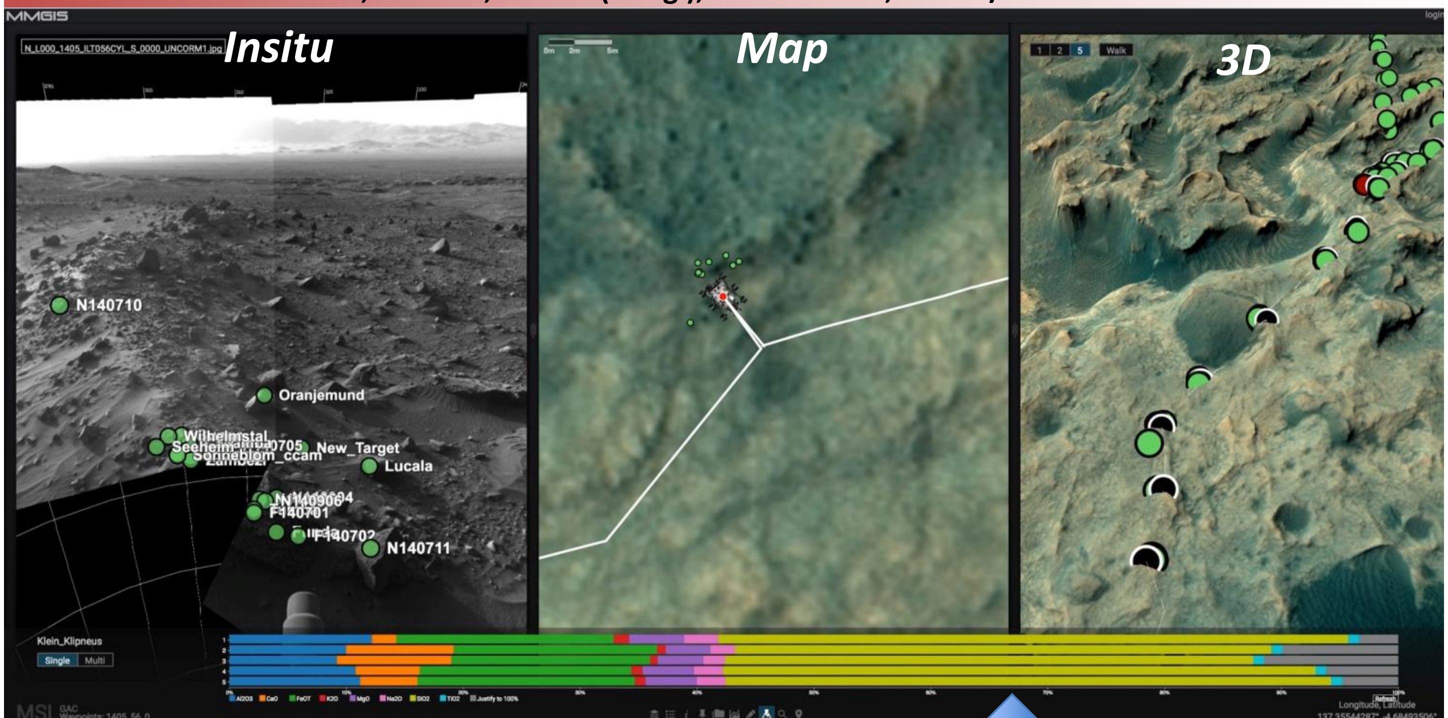
- Densities for small D<=250 m craters somewhat mirror orbital units determined from spectra and morphologic/thermophysical properties on lower Mt. Sharp.
- Crater densities are non-uniform = erosion rate is as well.
- Higher erosion rates on less cratered units for lower Mt. Sharp
  - Unit age not necessarily a factor
  - Composition or Induration (or exposure to water)
  - Less cratered units have ‘fresher’ material at the surface.
    - “[for light-toned, layered deposits] erosion is swift enough that radiolysis cannot destroy complex organic matter at some locations…” Kite and Mayer, Icarus, 2016

Back up slides

355-5 *Spatial Data Infrastructure for Mars Rovers*

Halls 4EF **Wednesday, 25 October 2017 9a-6:30p**

Calef, Soliman, Abarca (Gengl), Abercrombie, Powell/JPL-Caltech



Targets display on "undistorted" NAVCAM Mosaic

HiIRISE Orthophoto Color Basemap at 25 cm/pixel

HiRISE 1 m/pixel Elevation Model

Science Product Data Visualization