Assessing the roughness properties of circumpolar lunar craters: Implications for the timing of water-ice delivery to the Moon

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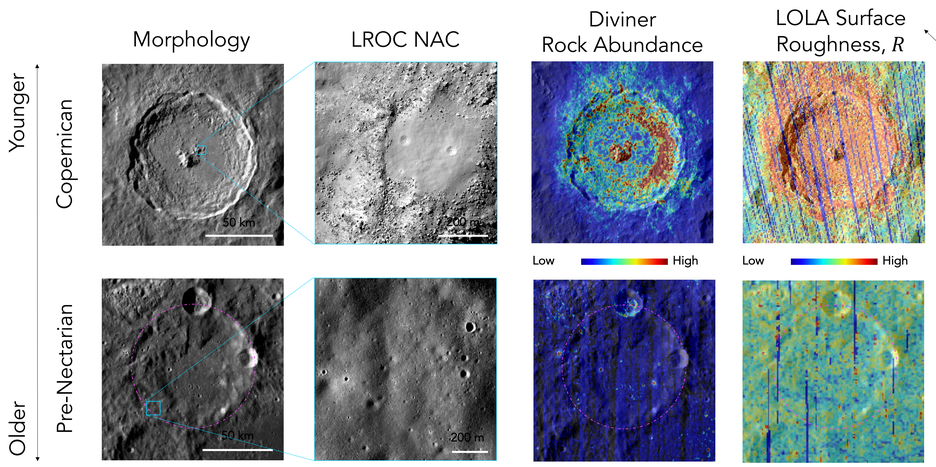
Young craters are distinct from old craters in various properties.



$$R = \sqrt{\frac{1}{n-v}\sum_{i=1}^{n} z_i^2}$$

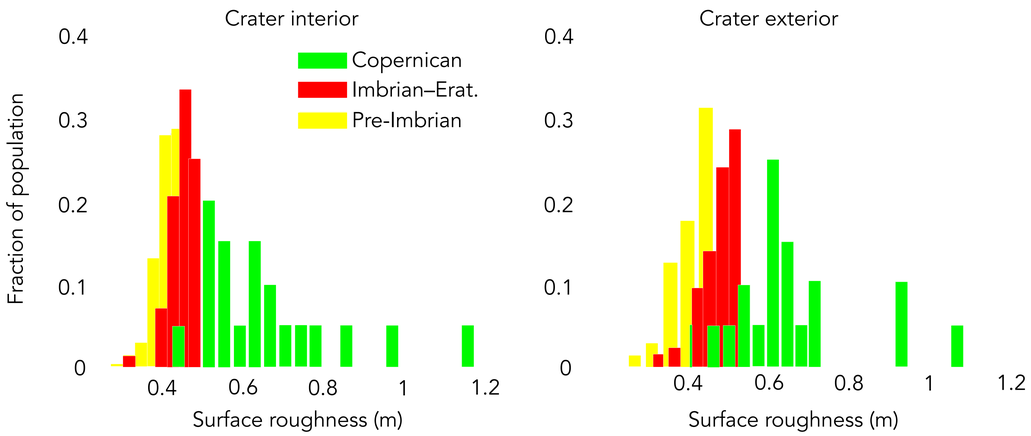
height residual for a given spot

# of LOLA spots

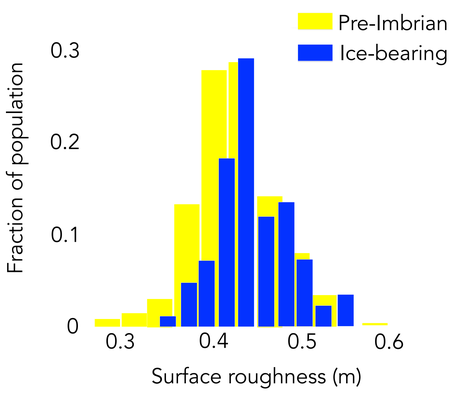
# of degrees of freedom

Surface roughness is a valuable indicator of crater degradation[1–5].

Pre-Imbrian (least rough) < Imbrian–Eratosthenian < Copernican (most rough)



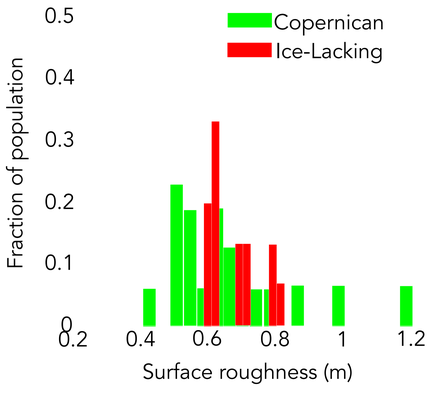
Some ice-bearing[6] craters (N=92) are rougher than Pre-Imbrian craters (α= 0.001).



We consider the ice-bearing roughness to be a minimum due to the smoothing effects of:

1. Mass wasting[7,8]
2. The presence of frozen volatiles[1,9,10]
3. Crater walls[5,7]
4. Small crater degradation[11–13]

There are no ice-bearing[6] craters within the Copernican-only domain in roughness space.

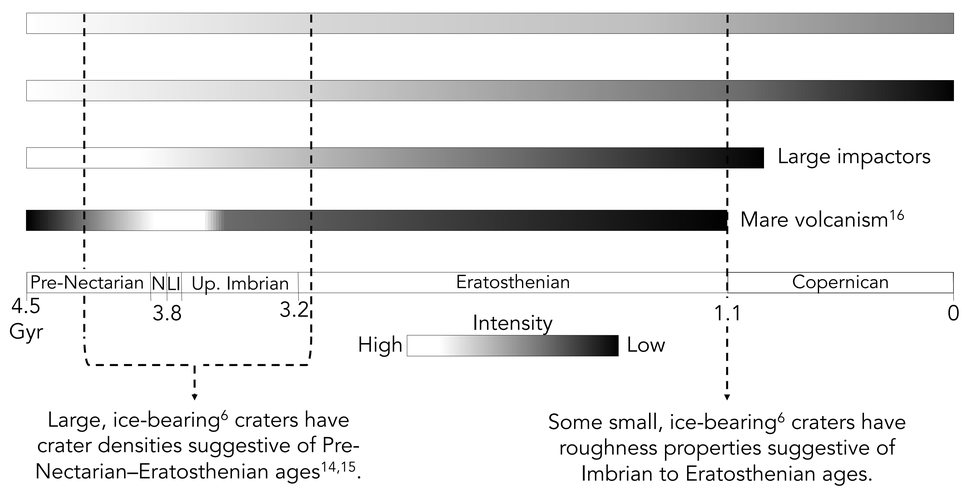


All of the 15 rough polar craters that are found within the Copernican-only domain lack water-ice detections[5].

If surface ice is stable in these permanently shadowed craters, then

- either ice has not been delivered to these young craters since their formation,
- or it has since been destroyed.

Micrometeoroid and solar wind bombardment are active processes that may contribute to younger surface volatiles.



The presence of ice in craters younger than 3.5 Gyr suggests that mare volcanism[16] cannot be responsible for all of the surface ice because this volcanism peaked in intensity before the younger cold traps were formed.

On-ground investigations (e.g., VIPER) are essential in understanding the ages and origins of the ice.

For more details about this study, visit our paper: https://doi.org/10.1029/2020GL087782

References

[1]Kreslavsky and Head (2000) https://doi.org/10.1029/2000JE001259
[2]Rosenburg et al. (2011) https://doi.org/10.1029/2010JE003716
[3]Kreslavsky et al. (2013) https://doi.org/10.1016/j.icarus.2013.04.027
[4]Neumann et al. (2015) https://www.hou.usra.edu/meetings/lpsc2015/pdf/2218.pdf
[5]Wang et al. (2019) https://www.hou.usra.edu/meetings/lpsc2019/pdf/1262.pdf
[6]Li et al. (2018) https://doi.org/10.1073/pnas.1802345115
[7]Zuber et al. (2012) https://doi.org/10.1038/nature11216
[8]Fassett & Thomson (2014) https://doi.org/10.1002/2014JE004698
[9]Putzig et al. (2014) https://doi.org/10.1002/2014JE004646
[10]Moon et al. (2019) https://ui.adsabs.harvard.edu/abs/2019AGUFM.P51D3402M/abstract
[11]Bart & Melosh (2010) https://doi.org/10.1016/j.icarus.2010.05.023
[12]Basilevsky et al. (2018) https://doi.org/10.1016/j.pss.2017.06.001
[13]Mahanti et al. (2018) https://doi.org/10.1016/j.icarus.2017.08.018
[14]Deutsch et al. (2020) https://doi.org/10.1016/j.icarus.2019.113455
[15]Cannon et al. (in rev.) https://www.hou.usra.edu/meetings/lpsc2020/pdf/1488.pdf
[16]Needham and Kring (2017) https://doi.org/10.1016/j.epsl.2017.09.002