Latitude Distribution of Martian Craters with Morphologies Caused by Aeolian Erosion

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Introduction

- The current Martian climate is monitored yearly and well documented (Giuranna et al., 2021).
- While the ancient climate is not as well understood, craters provide a controlled source of land of a predictable age to allow observation as to how geology has been impacted since formation (Day et al., 2016).
- Wind is one of the most prominent causes of erosion on Mars. It can carry and collect small particles; it can also cause small particle to collide with larger geological structures and induce breakage (Greeley et al. 2001).
- Studies have confirmed wind as a major cause of dunes in Martian craters; a significant correlation has been found between dune thickness and wind strength (Gunn et al., 2022).
- There is disagreement over whether peaks in Martian craters are caused by wind erosion. Models using wind tunnels have experimentally determined that wind could be a cause for the observed peak structure (Day et al., 2016).

Research Questions

- Does the distribution of Martian craters containing dunes (a wind-caused erosion trait) vary with latitude on Mars, controlling for diameter and longitude?
- Do peaks, a trait that could either be caused by wind erosion or impact recoil, share similar latitude distribution with dunes?

Methods

Sample

- Martian Craters with diameter greater than 1 km (n=378,540) were observed telescopically and compiled into a database by Stuart Robbins. Most craters are 4.2-3.8 billion years old, and still exist due to absent Volcanism.

Measures

- Telescopic data includes crater **latitude**, **longitude**, and **diameter**, measured from the center of the craters least square circle fit.
- Observations are included about craters morphology: both ejecta and interior.
- Interior morphology is split into 3 categories. The first describes the topography (including **peaks**), while the other two reference features of interest on the craters wall or floor (including **dunes**, channels, or gullies).

Results

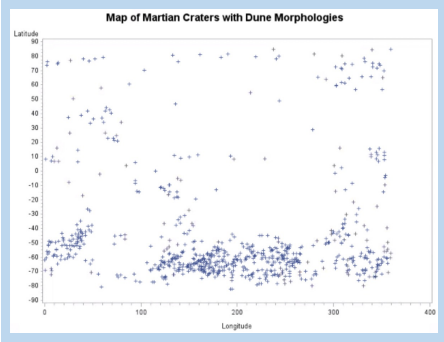
Univariate

- 0.2% of craters have dunes; 0.78% of of craters have peaks.

Bivariate

- A chi-square test showed a significant correlation between **proportion of craters with dunes** and **latitude range** (X^2=2228.31, p<0.0001).
- A post HOC test showed that southern latitudes (80 to 40 degrees south) had a significantly higher proportion of craters with dunes (.94%) than all other latitudes. This is clearly shown by figure 1.
- Northern latitudes (40 to 80 degrees north) had a significantly higher proportion of craters (.12%) than middle latitudes.
- Southern-middle (40 degrees south to the equator) and northern-middle (the equator to 40 degrees north) had a significantly smaller proportion of craters with dunes (.04%) than other latitude ranges, but do not differ significantly from each other (X^2=.6047, p<0.4366).

Figure 1. Latitude vs. longitude for craters with dunes.

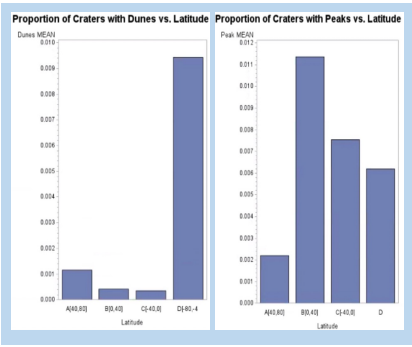


- A chi square test also showed a significant correlation between the **proportion of craters with peaks** and **latitude ranges** (X^2=389.87, p<0.0001) though the distribution is not the same as for dunes (figure 2).
- A post HOC test showed the proportion of craters with peaks was significantly greater at southern latitudes than northern latitudes (X^2=91.36, p=0.0006), southern-middle latitudes than southern latitudes (X^2=11.82, p<0.0001), and northern-middle latitudes than southern-middle (X^2=111.01, p<0.0001).

Multivariate

- After controlling for longitude and crater diameter, middle latitudes are still predicted to have a significantly lower proportion of craters with dunes than northern and southern latitudes (p<0.0001).
- There is no longer a significant difference between the proportion of craters with dunes at northern latitudes and at southern latitudes (p=.053).
- Diameter is significantly associated with the proportion of craters with dunes (p<0.0001) but longitude is not (p=0.0857).

Figure 2. Latitudinal distribution of Martian craters with dune morphologies and peak morphologies.



Discussion

- Dunes within Martian craters do have a latitude-based distribution around the planet and appear significantly less frequently near the equator than at northern or southern latitudes.
- Dunes may appear more frequently at southern latitudes than northern latitudes, though this may be on account of differences in crater diameter.
- Peaks within Martian craters also have latitude-based distribution around the planet, though the distribution is not similar to that of dunes. Peaks are found the most frequently at latitudes near the equator.
- The fact that peaks do not share a latitude distribution with dunes could potentially be used as evidence that peaks within Martian craters were caused by impact recoil as opposed to wind erosion, though more research is required to confirm such a causal relationship.

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Giuranna, M., Wolkenberg, P., Grassi, D., Aronica, A., Aoki, S., Scaccabarozzi, D., Saggin, B., & Formisano, V. (2021). The current weather and climate of Mars: 12 years of atmospheric monitoring by the Planetary Fourier Spectrometer on Mars Express. *Icarus (New York, N.Y. 1962)*, *353*, 113406. https://doi.org/10.1016/j.icarus.2019.113406

Greeley, R., Kuzmin, R. O., & Haberle, R. M. (2001). Aeolian Processes and their Effects on Understanding the Chronology of Mars. *Space science reviews*, *96*(1-4), 393-404. https://doi.org/10.1023/A:1011917910624

Gunn, A., Rubanenko, L., & Lapotre, M. G. A. (2022). Accumulation of windblown sand in impact craters on Mars. *Geology (Boulder)*, *50*(9), 981-985. https://doi.org/10.1130/G49936.1