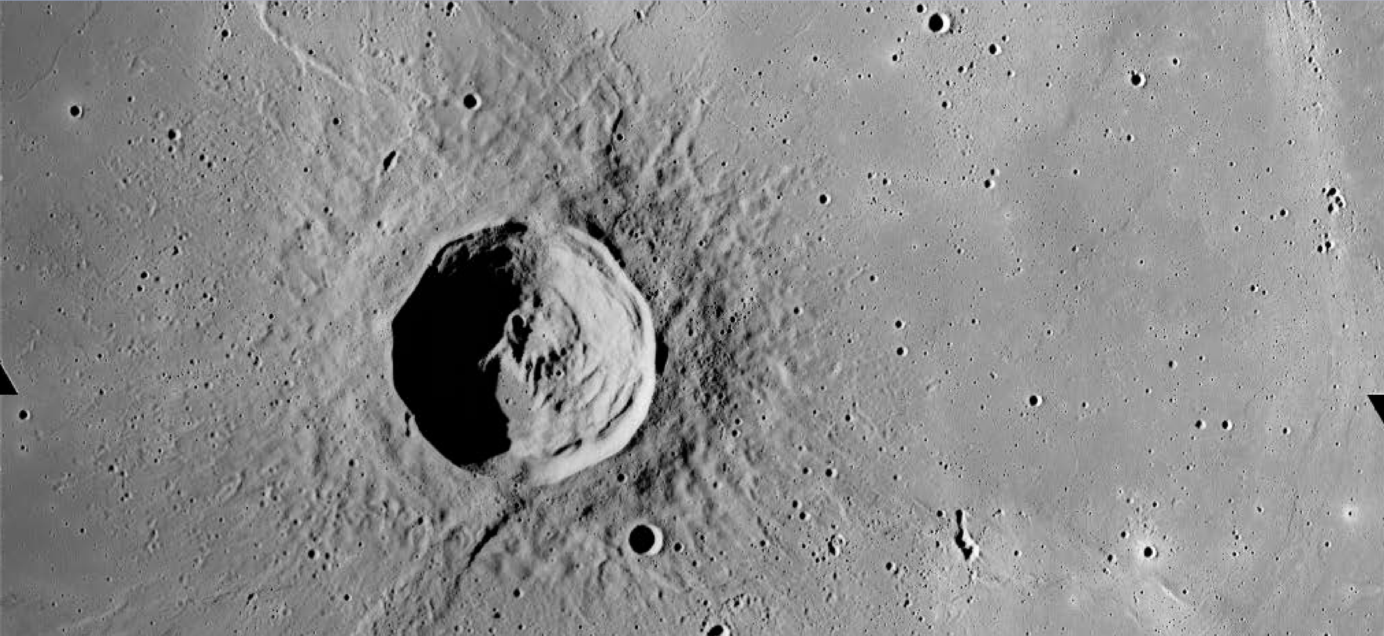

OPTICAL MATURITY of INNER WALLS in LUNAR CRATERS

#1859

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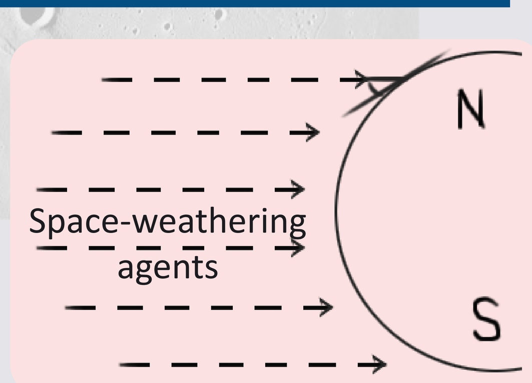
• Motivation: Latitude-dependent Maturity



It has recently been found that the **maturity indices** of the lunar regolith such as the **optical maturity (OMAT)** or **mean grain size <d>** are **latitude dependent** (Hemingway et al. 2015, Jeong et al. 2015). This dependence is thought to be a result of **reduced space weathering effects at high latitudes**, where the flux of weathering agents such as micrometeoroids and solar wind particles is smaller.

Here we extend our previous work (Jeong et al. 2015) to the inner walls of lunar impact craters. We analyze the OMAT profile in craters as a function of distance from the crater center. We also analyze OMAT differences between the northern and southern inner walls as well as those between the eastern and western inner walls.

• Data Preparations

– Optical Maturity (OMAT)

OMAT is a parameter based on the Euclidean distance to a hyper-mature point in the near-IR ratio-reflectance plot, developed by Lucey et al. (2000).

High OMAT :	Fresh regolith
Low OMAT :	Mature regolith

$$\mathrm{OMAT} = \left[(R_{750} - x_0)^2 + \left(\left(\frac{R_{950}}{R_{750}}\right) - y_0\right)^2\right]^{\frac{1}{2}}$$

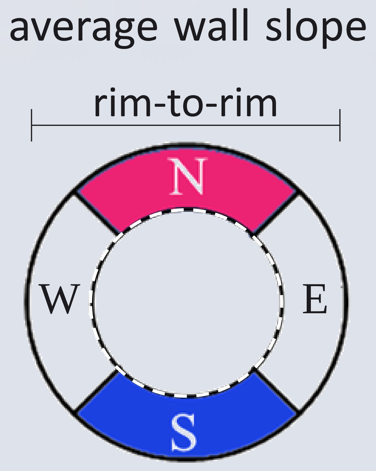
Since the reflectance is a function of both incidence and reflectance angles, it is critical to correct the effect of local topography on OMAT, particularly when the craters are the subjects of analyses. We use the **topography-corrected, 1-km resolution OMAT data** from the SELENE Multiband Imager data (Lemelin, personal communication) for our analyses.

– Impact Crater Database

The craters we considered in our analyses are from **the Lunar Impact Crater Database 2015** from the **Lunar and Planetary Institute**. We consider the craters whose latitude is between -58° and +58° and whose diameter is between 5 km and 120 km. We exclude the craters whose OMAT image has too many bad pixels. The total number of craters considered here is 4775, and 994 of them have age information.

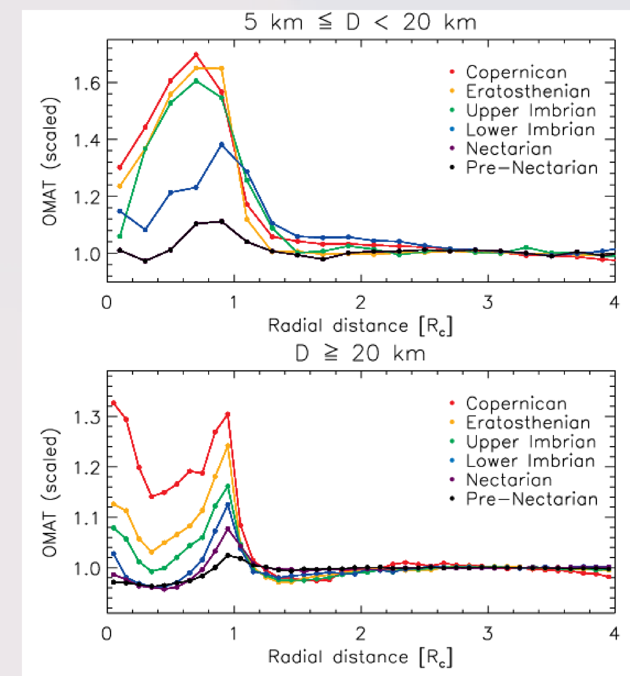
– Crater Walls

We divide the inner wall of a crater into four quadrants: North, East, South, and West. When comparing the OMAT values between these walls, we only consider the craters whose average wall slope is greater than 10°. The average wall slope of a crater is determined from the LRO Digital Elevation Model.



The wall is defined as a annulus area between the maximum elevation circle around the crater rim and the 10%-depth circle from the flat floor inside.

• Radial Profile of Optical Maturity (OMAT)

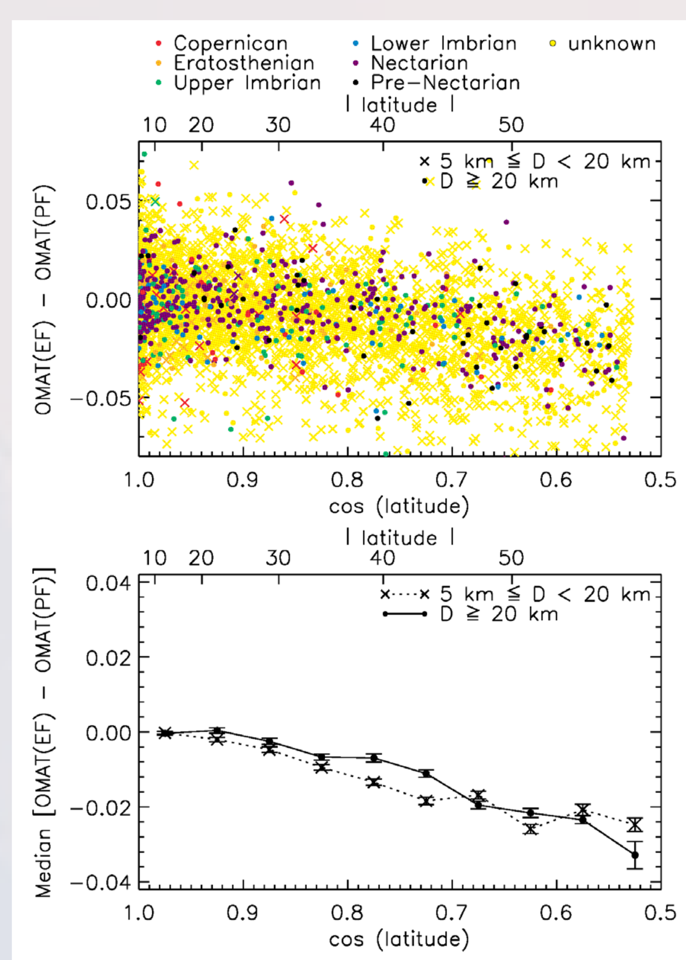


▶ We investigated the radial OMAT profiles of craters for six different age groups as a function of distance from the crater center for two diameter ranges: 5 km < D < 20 km and 20 km < D < 120 km.

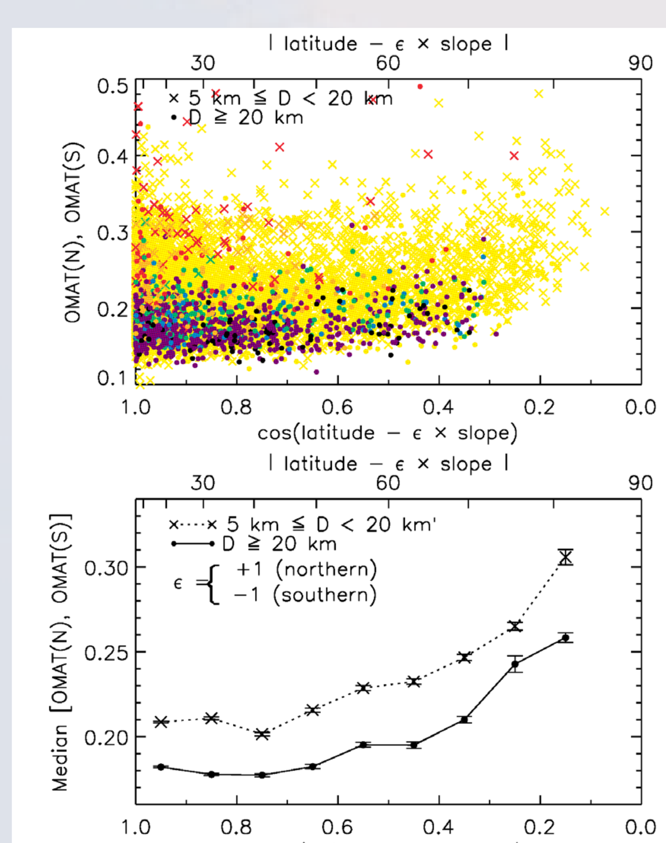
The OMAT values are scaled to the mean OMAT values between 2.5 R_c and 3.0 R_c, where R_c is the crater radius.

Interestingly, the **OMAT profile of the crater resembles the topography of the crater**–The OMAT value is larger where the topography is steep (walls and peaks) and OMAT profiles fluctuate much less for older craters, where the topography is generally flatter due to various diffusion mechanisms. This implies that **as craters age, the OMAT values of the craters gradually decrease to neighboring values**, but this takes place more quickly at flatter areas in the craters.

• N-S OMAT Asymmetry: Incidence Angle of weathering Agents

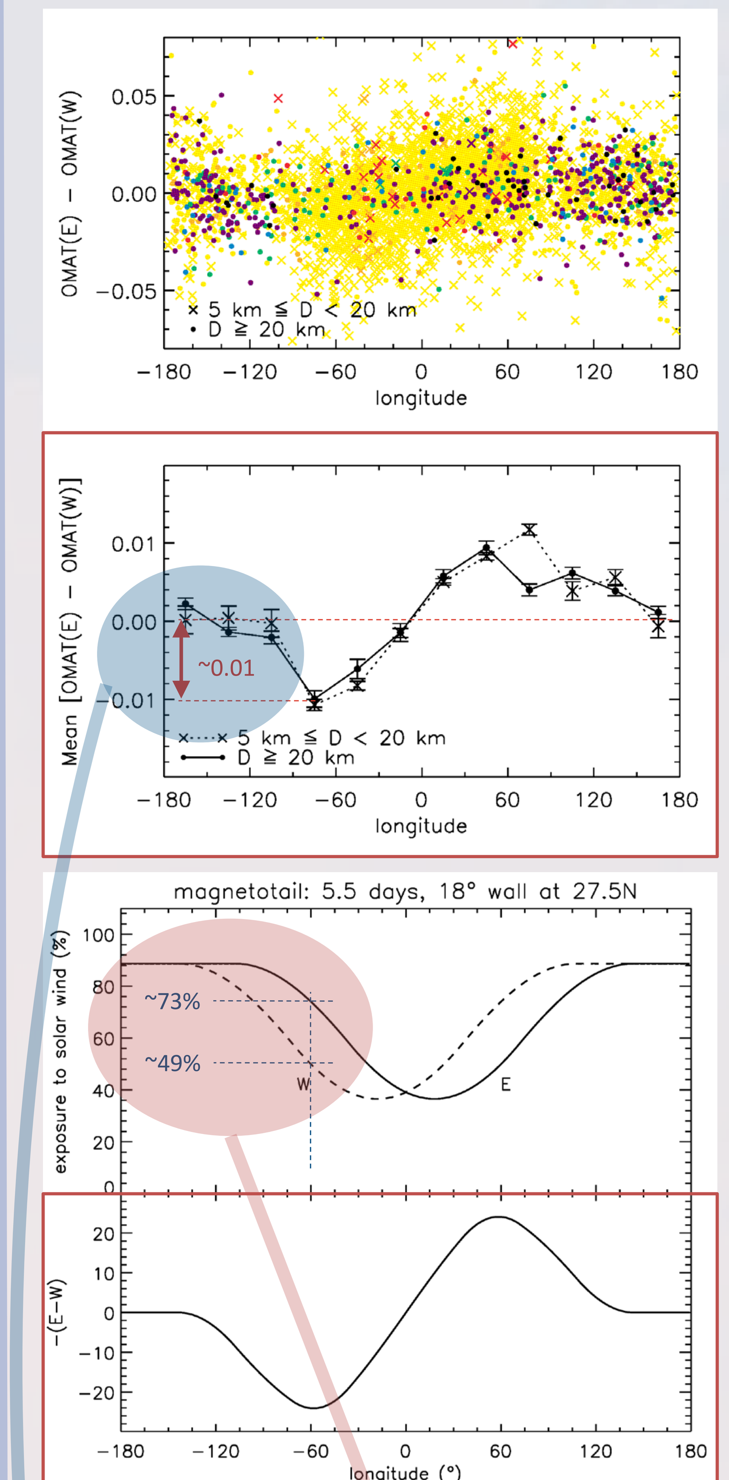


◀ We studied the **OMAT differences between the equator-facing (EF) and pole-facing (PF) walls as a function of latitudes**. There is no significant OMAT difference at the equator, but **as the latitude increases, the EF walls have gradually smaller (more mature) OMAT values**. This is thought to be because the EF walls generally have a **higher flux of space weathering agents**. Smaller craters show larger OMAT differences because they generally have steeper topographies.

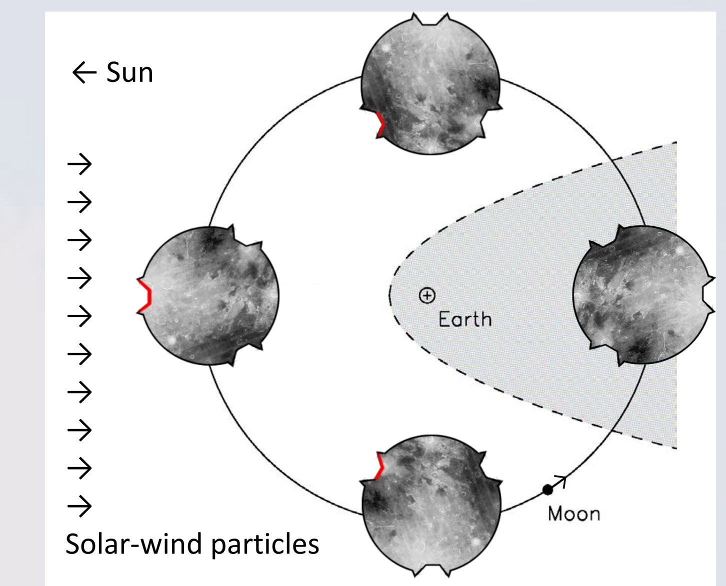


◀ We show the **OMAT values of the northern and southern walls as functions of "latitude + ε x slope"**, which the angle between the northern or southern wall's normal vector and the equatorial plane. (ε is -1 for N walls, +1 for S walls). This angle can be regarded as the **"angle of attack" of the crater wall against the space-weathering agents**. The figure shows that the crater walls continue to be fresher at angles of attack larger than 58°, which is the latitudinal upper limit of the craters considered here.

• E-W OMAT Asymmetry: Geomagnetotail Shielding on the Near-side



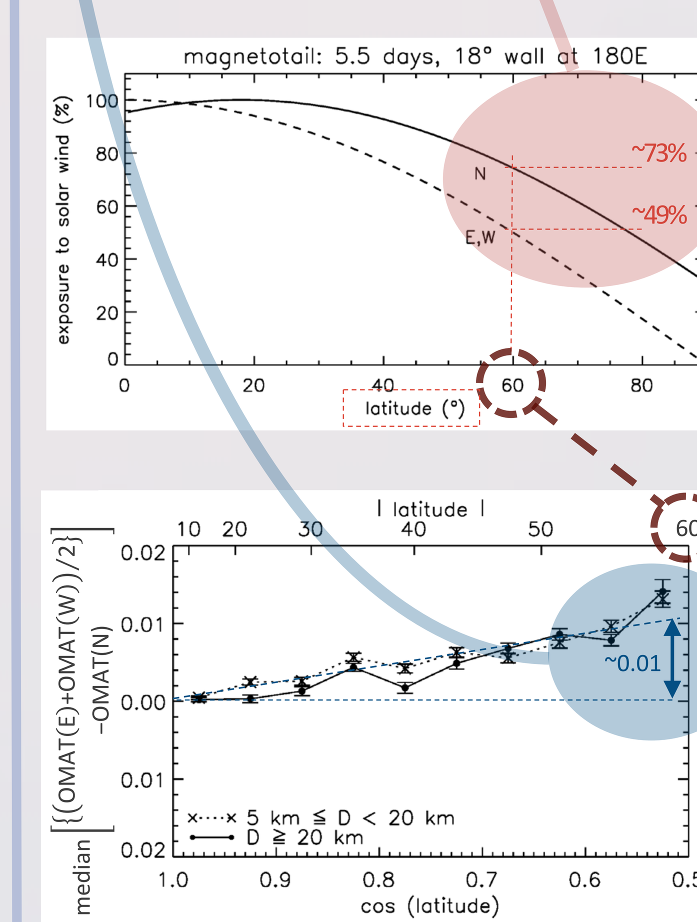
◀ We also studied **the OMAT differences between the eastern and western walls as a function of longitude**. The overall mean value curve (bottom panel) has a minimum near longitude -60° and a maximum near +60°. This is thought to be due to the **shielding of solar wind particles on the near-side while the Moon passes through the terrestrial magnetotail for 5-6 days in every 27.3-day orbit.**



◀ **We calculated the amount of the exposure to the solar wind on the eastern and western walls as a function of longitudes.** The craters are assumed to be at 27.5° latitudes, and to have a 18° wall, which is the mean absolute latitudes and the mean slope of the craters analyzed here.

Due to the magnetotail, there is a reduction of exposure on the near-side craters with exposure minima shifted just as much as the wall slope. The maximum exposure amount is ~90% of that at the equator because the incidence angle of solar wind particles increases.

The exposure difference between E and W walls has minimum and maximum around +/- 60 longitudes and well reproduces the mean value curve of OMAT(E) – OMAT(W) above. It is indicated that **the E-W asymmetry of crater walls can be explained by the preferential shielding of solar wind particles on the lunar near-side by the Earth's magnetotail.**



◀ In addition to with the minimum/maximum longitudes, we also evaluated how well the calculated values reproduce the OMAT differences analyzed here.

We calculated the latitudinal exposure variation on 18° wall craters along the anti-Earth meridian that have little to do with the magnetotail shielding. It is **at 60° latitudes** that **the exposure amount on N and E/W walls equals to that of E/W wall at minimum/ maximum longitudes**.

◀ As predicted by the exposure calculation, the OMAT change at the exposure minimum/maximum longitudes (↕), ~0.01, equals to the OMAT difference between N and E/W walls at 60° latitudes (↕).

This indicates that **the N-S and/or E-W OMAT asymmetry on crater walls can be described by the differential exposure to the solar wind particles on the regolith**.

• References

[1] Hemingway D. et al. (2015) Icarus, 261, 66-79.
[2] Jeong M. et al. (2015) ApJS, 221, 16.
[3] Lucey P. G. et al. (2000) JGR, 105, 20297.