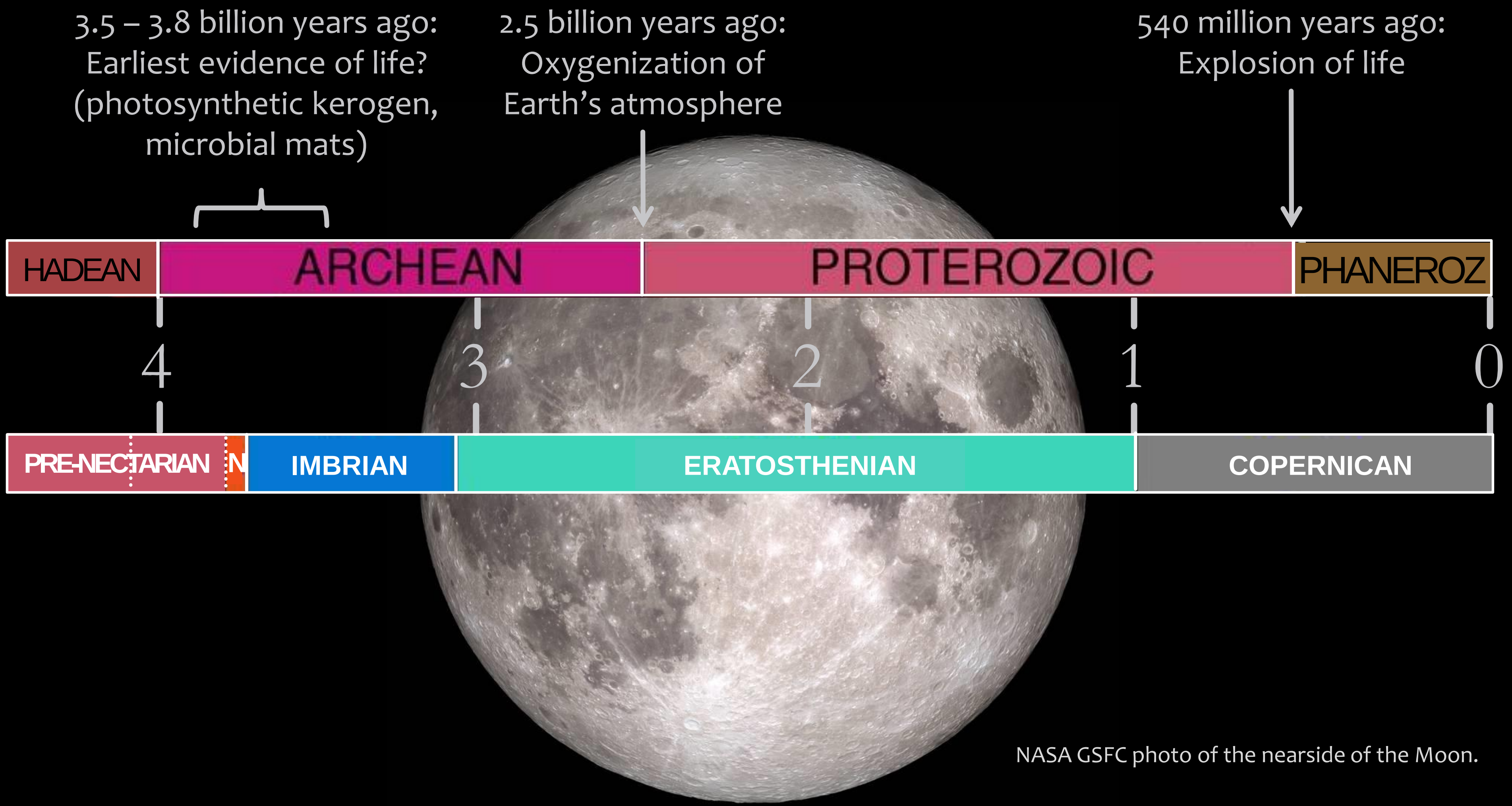
Lunar Geology Session Overview

Dr. Debra Needham
Marshall Space Flight Center

NASA SSERVI Exploration Science Forum

June 28, 2018

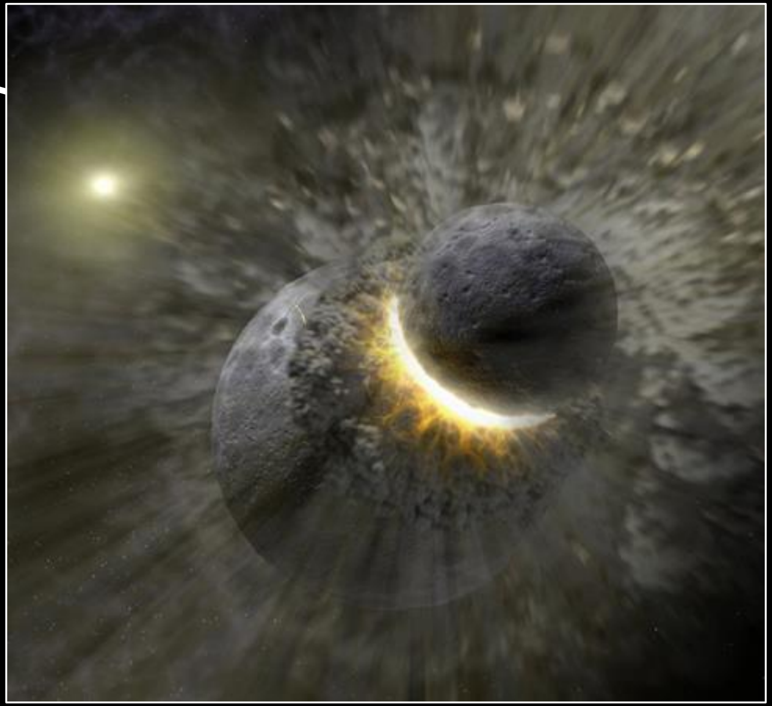
Lunar Geologic History



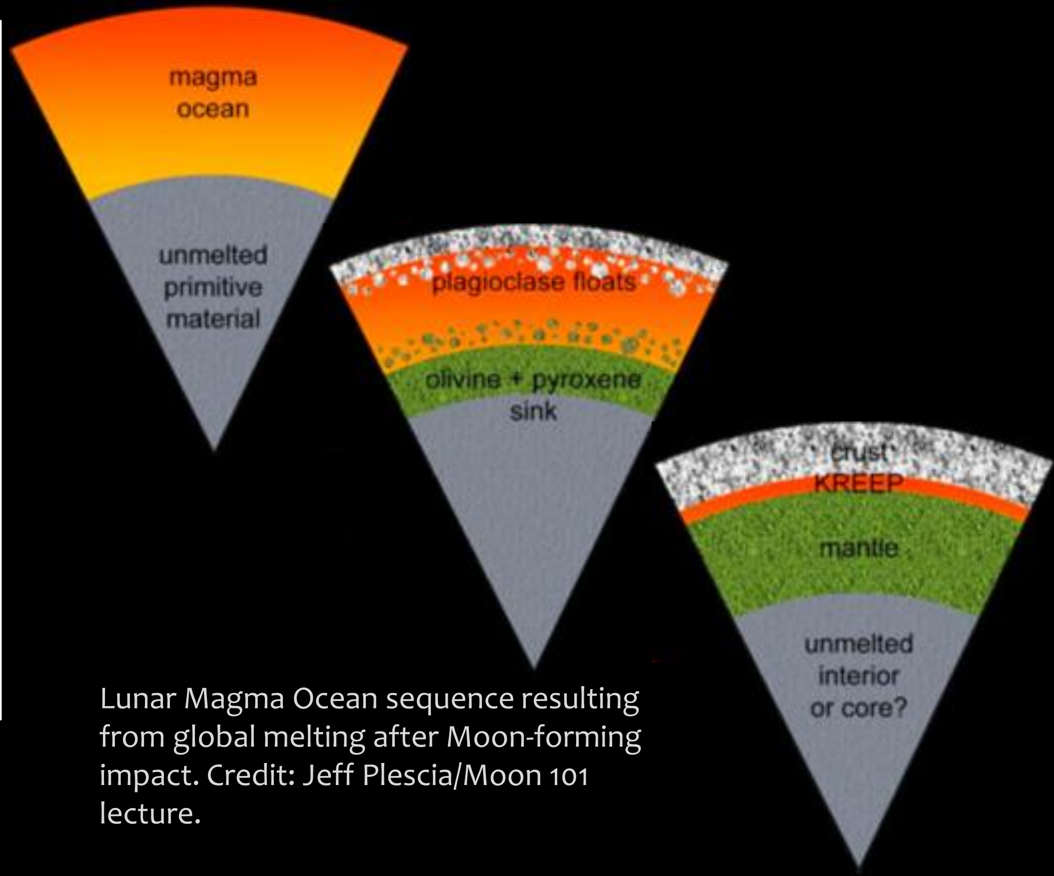
NASA GSFC photo of the nearside of the Moon.

Lunar Geologic History

Moon Formation and Magma Ocean

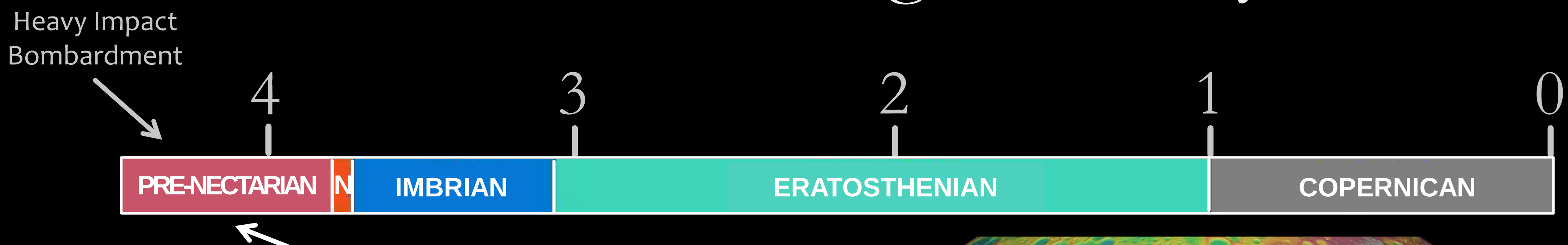


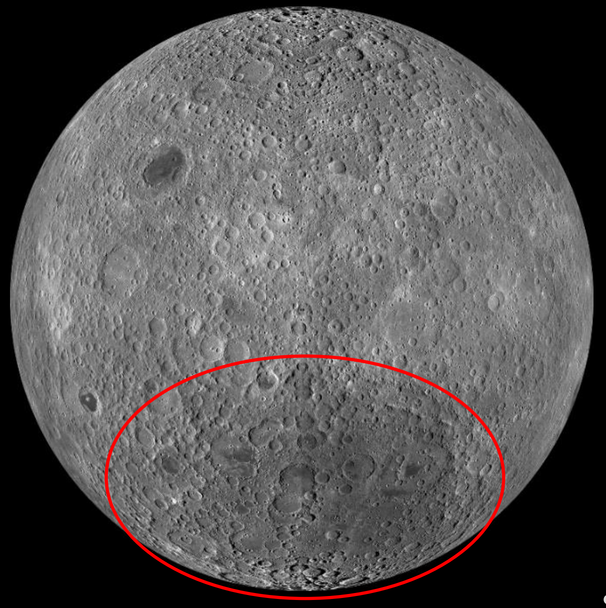
Giant impact between Mars-sized object and proto-Earth, from NASA/SSERVI.

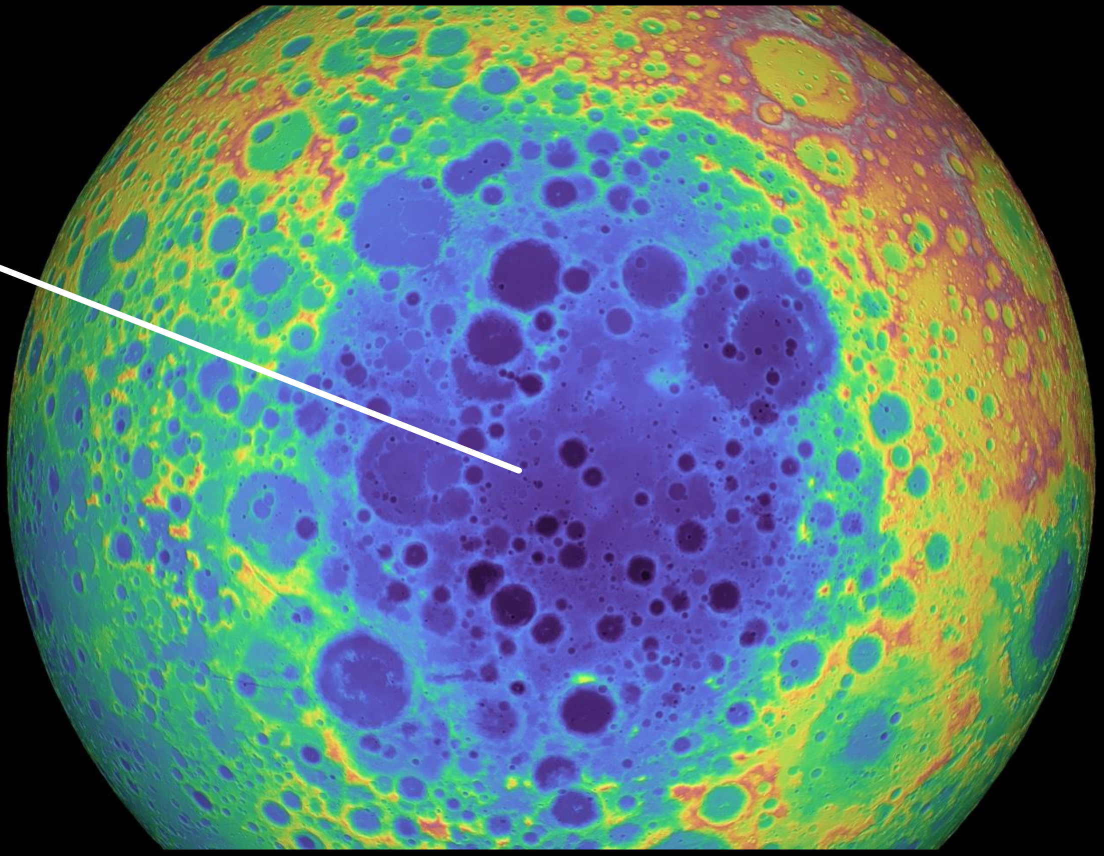


Lunar Magma Ocean sequence resulting from global melting after Moon-forming impact. Credit: Jeff Plescia/Moon 101 lecture.

Lunar Geologic History

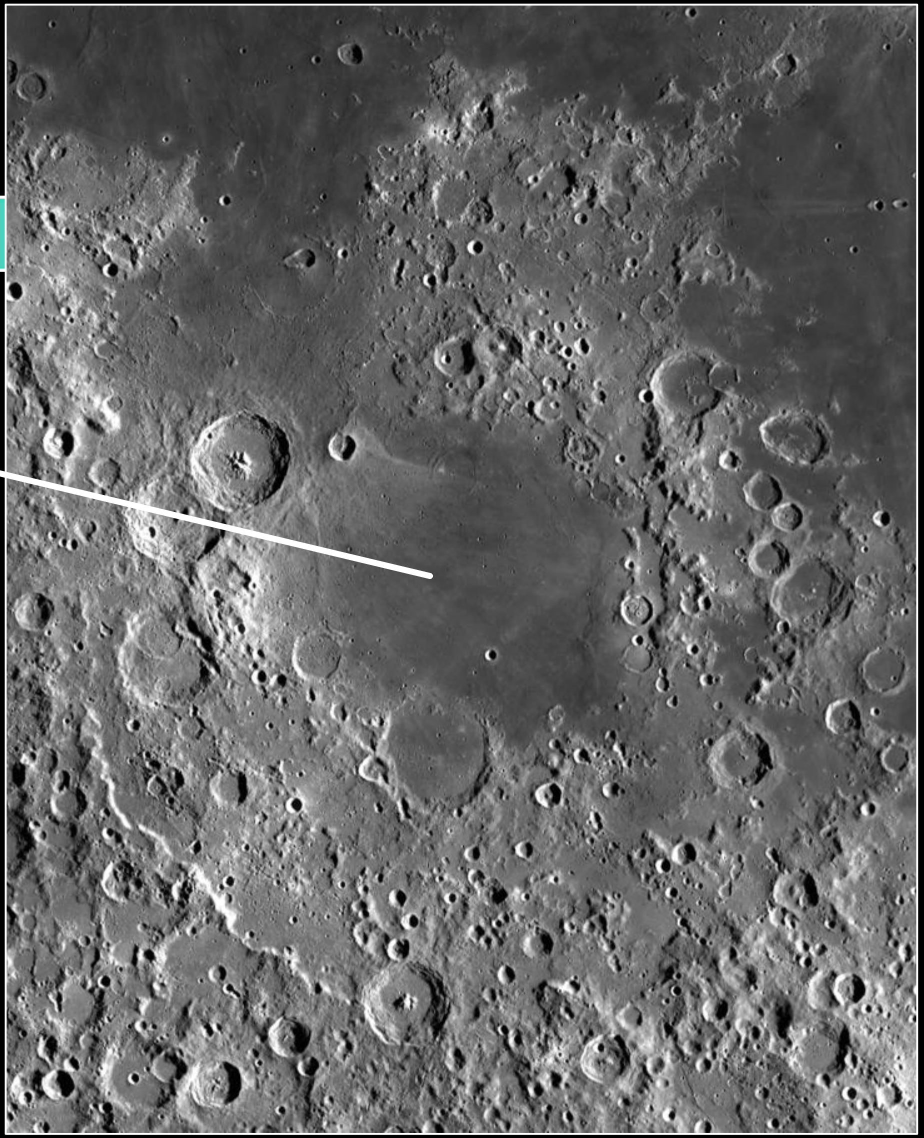






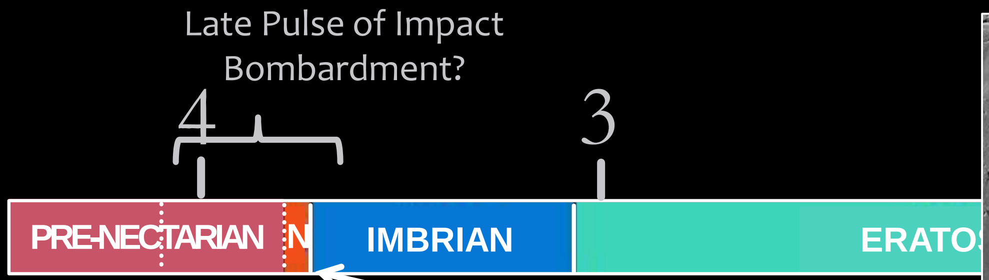
South Pole – Aitken basin on the lunar farside in LRO LOLA topography data.

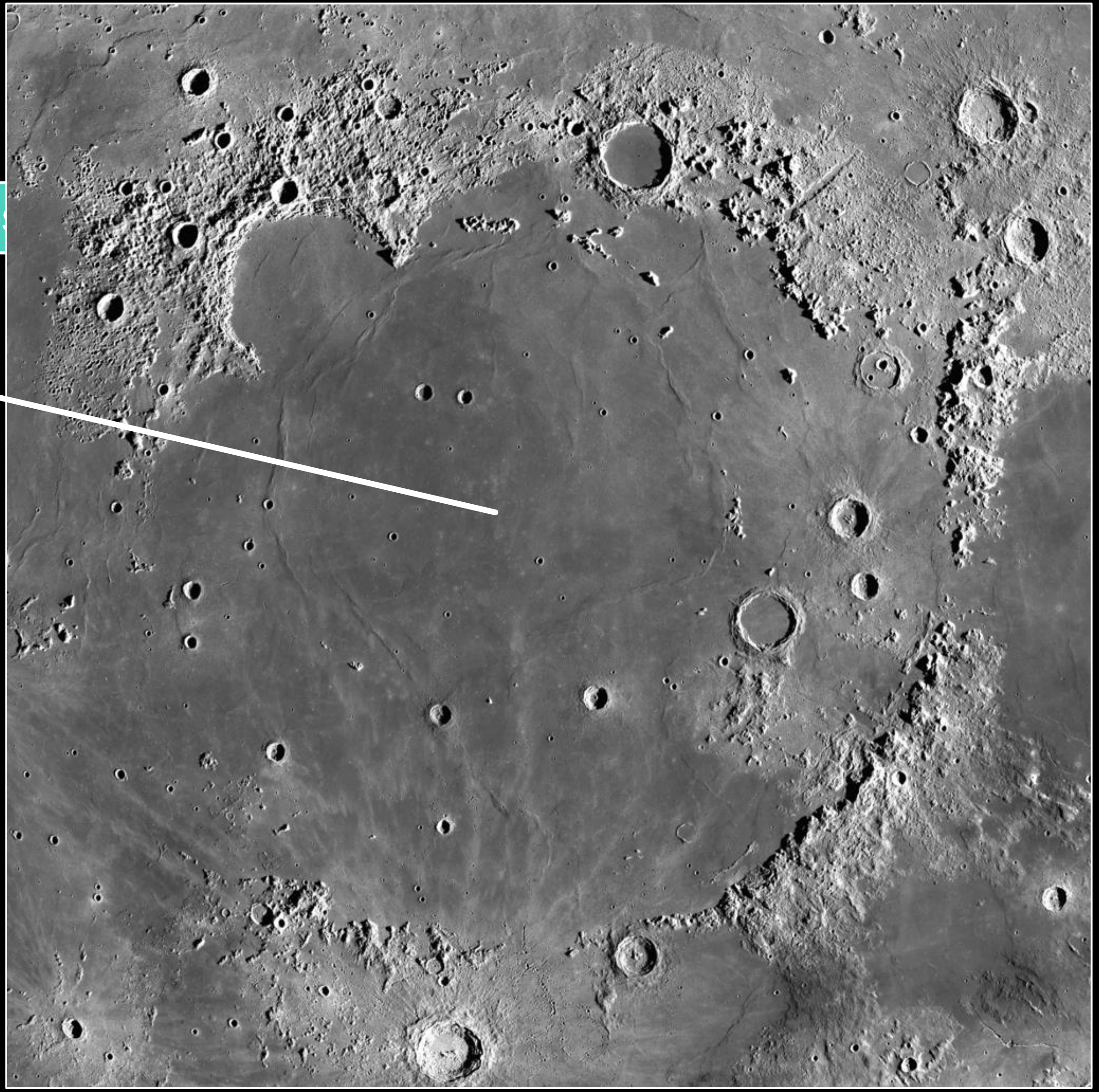
Lunar Geologic History



NASA Lunar Reconnaissance Orbiter Camera image of Nectaris basin, 885 km diameter.

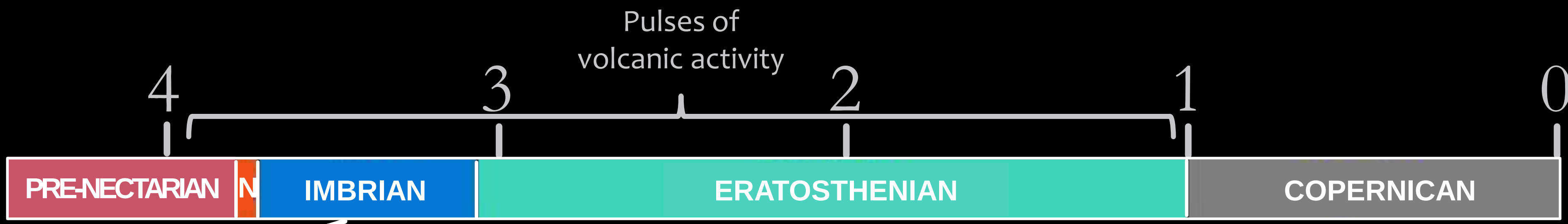
Lunar Geologic History



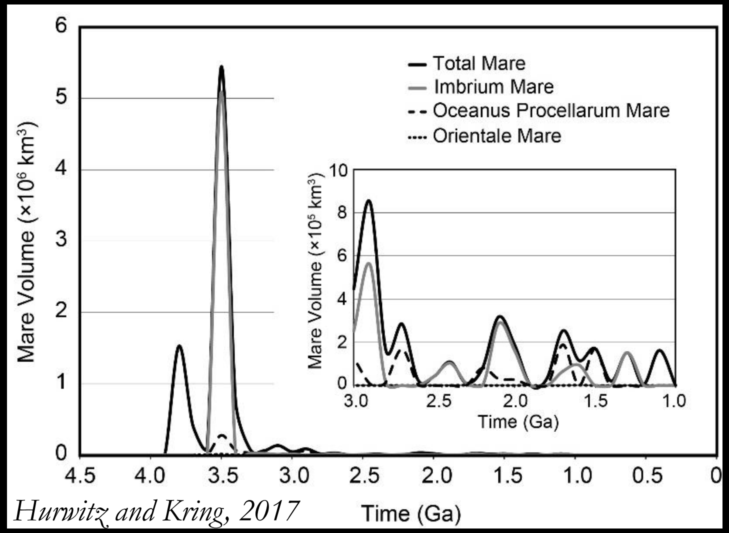


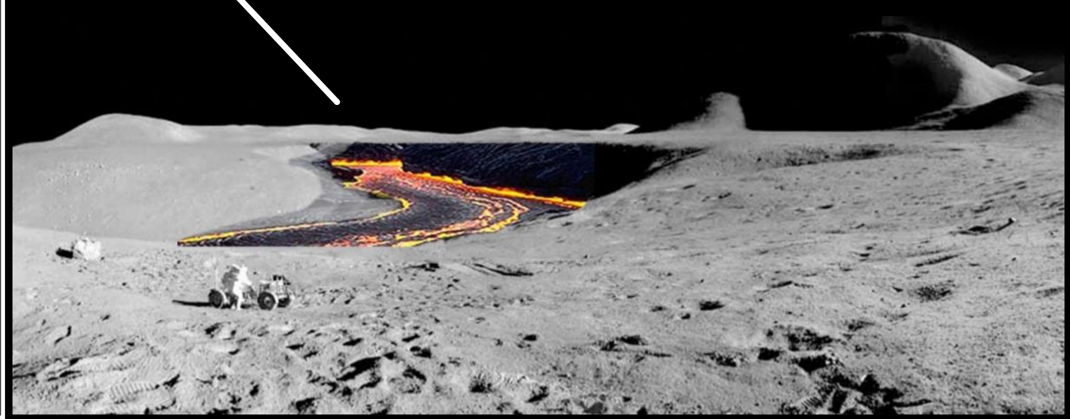
NASA LRO Camera
Image of Imbrium
basin, 1321 km
diameter.

Lunar Geologic History

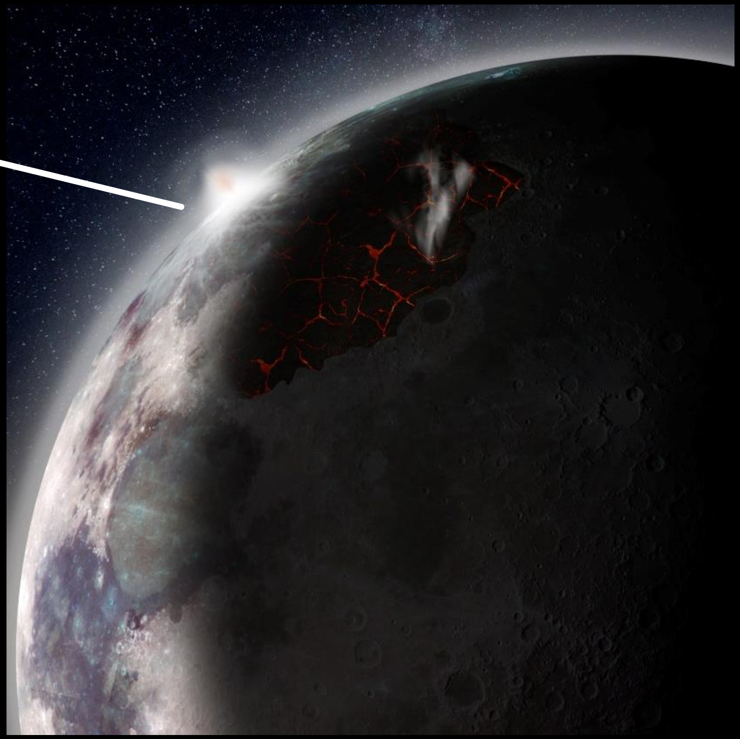


Volume of erupted lunar basalts



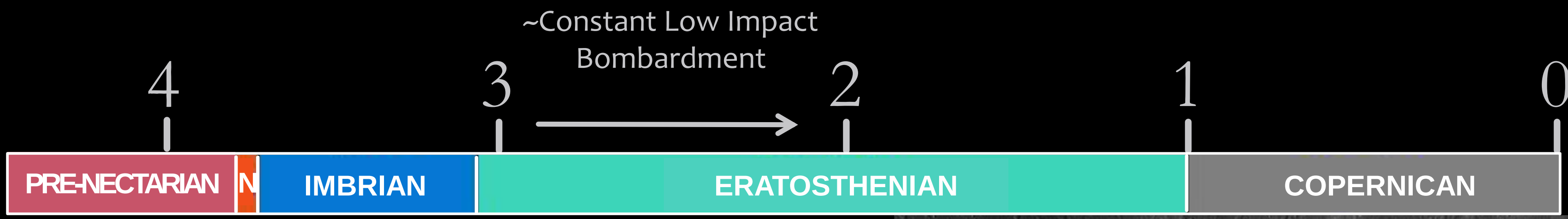


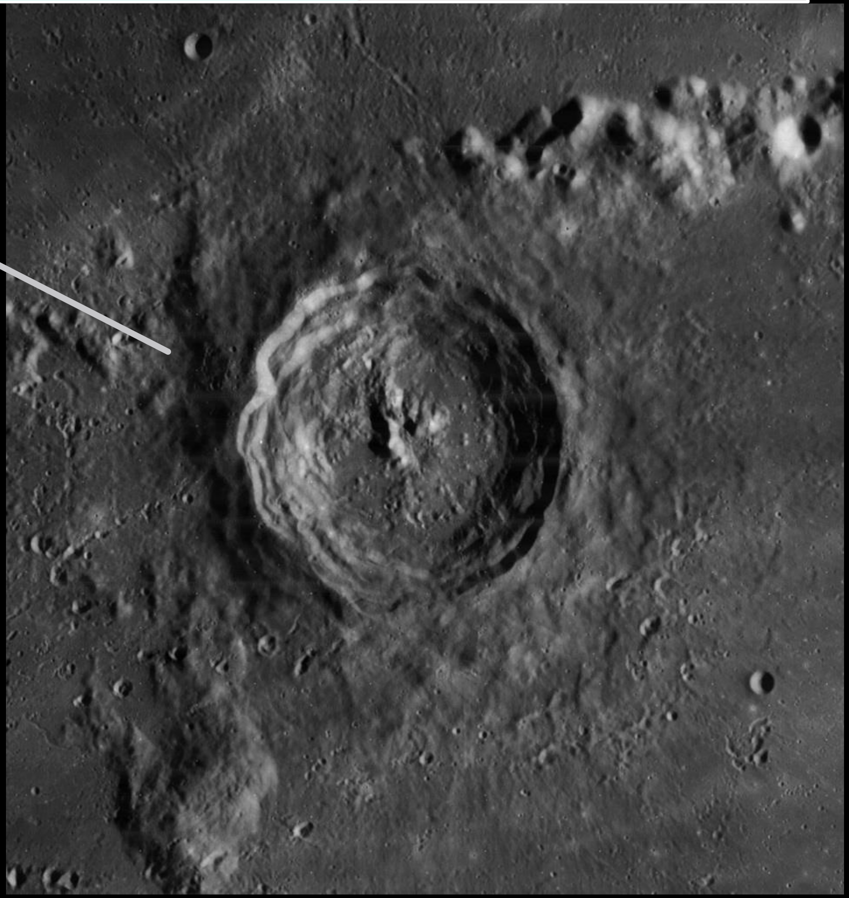
Modified from Apollo 15, Station 2 Panorama, frames A15-85-11446 – 11455.



NASA\MSFC; *Hurwitz and Kring, 2017*

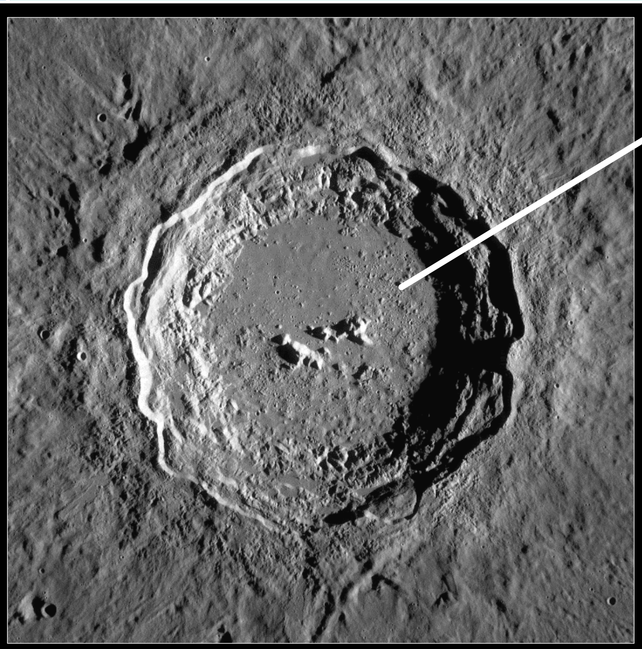
Lunar Geologic History





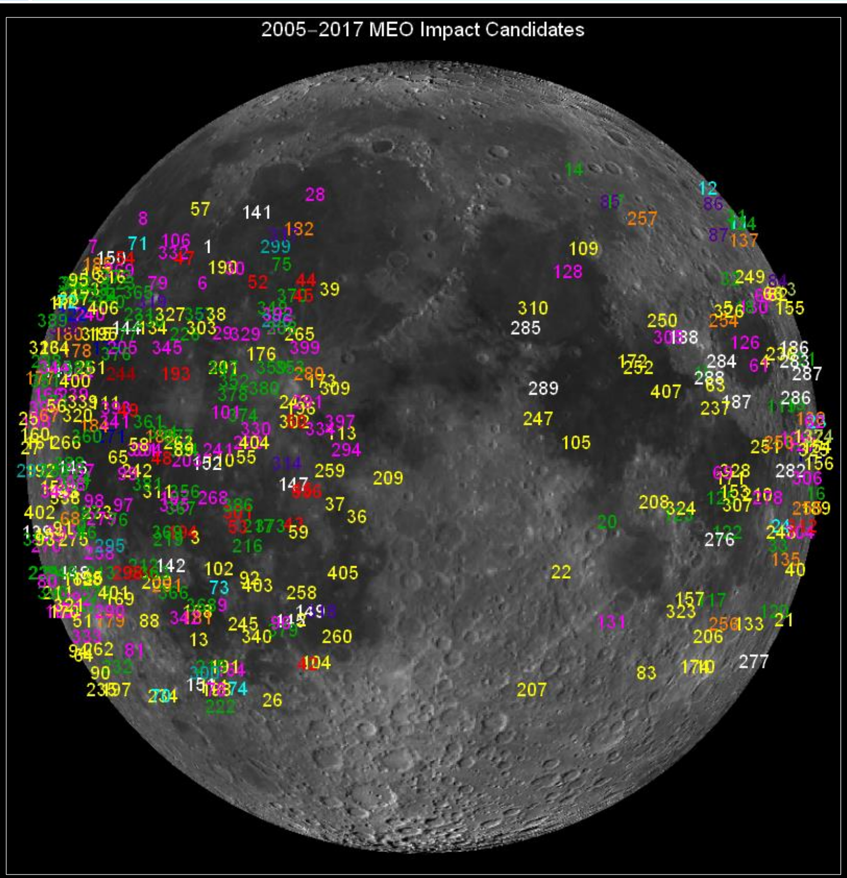
Lunar Orbiter IV image: Eratosthenes, 58 km diameter; Well-defined rims and ejecta.

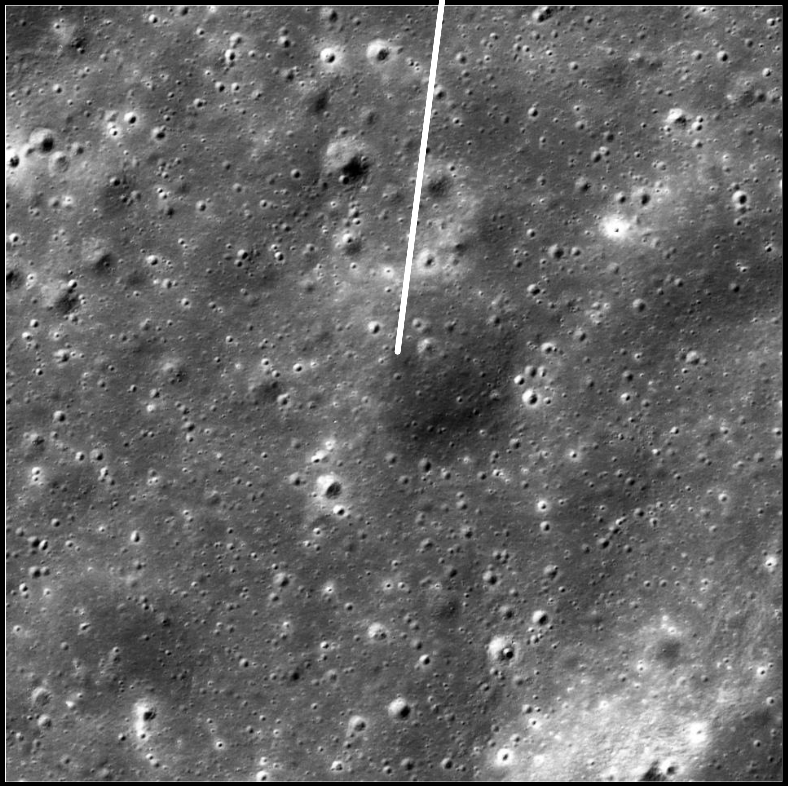
Lunar Geologic History



Copernicus crater (93 km diameter) and crater rays from NASA LRO images and an Apollo 17 orbital photo. Young craters preserve bright rays.

Lunar Geologic History





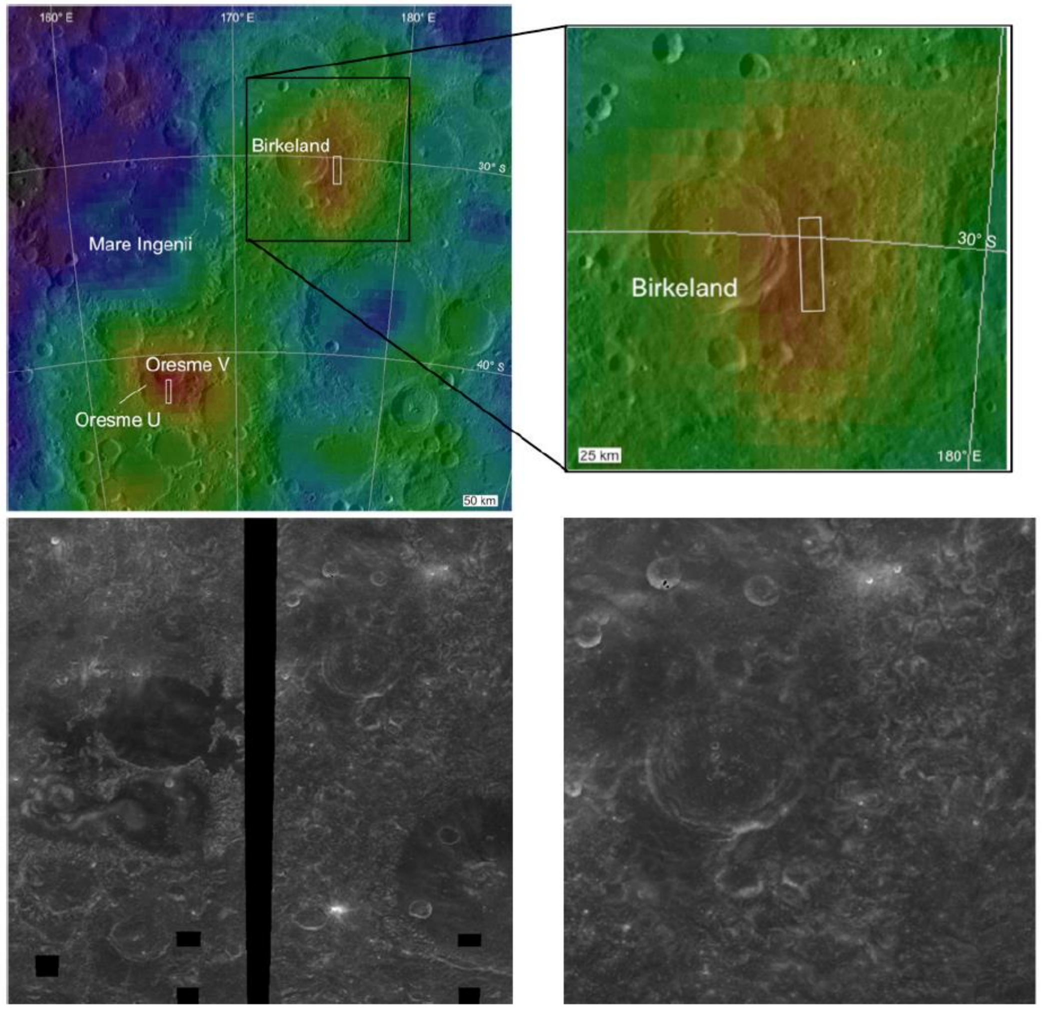
New craters observed via flashes from MSFC ground-based telescopes and via NASA's Lunar Reconnaissance Orbiter's Camera.

Drs. Bill Cooke and Rob Suggs, MSFC.

Characterizing Thorium-rich Features

Ryan Watkins and Colleagues

- Use photometry, mineralogy, and optical maturity (OMAT) to characterize Th anomalies and implications regarding heterogeneities in the lunar crust.
- Photometric and spectral properties reveal compositional information that can be compared to areas of similar Th and FeO contents at Apollo sites.
- Provide insight into relationships between soil maturity and particle size, roughness, and composition.

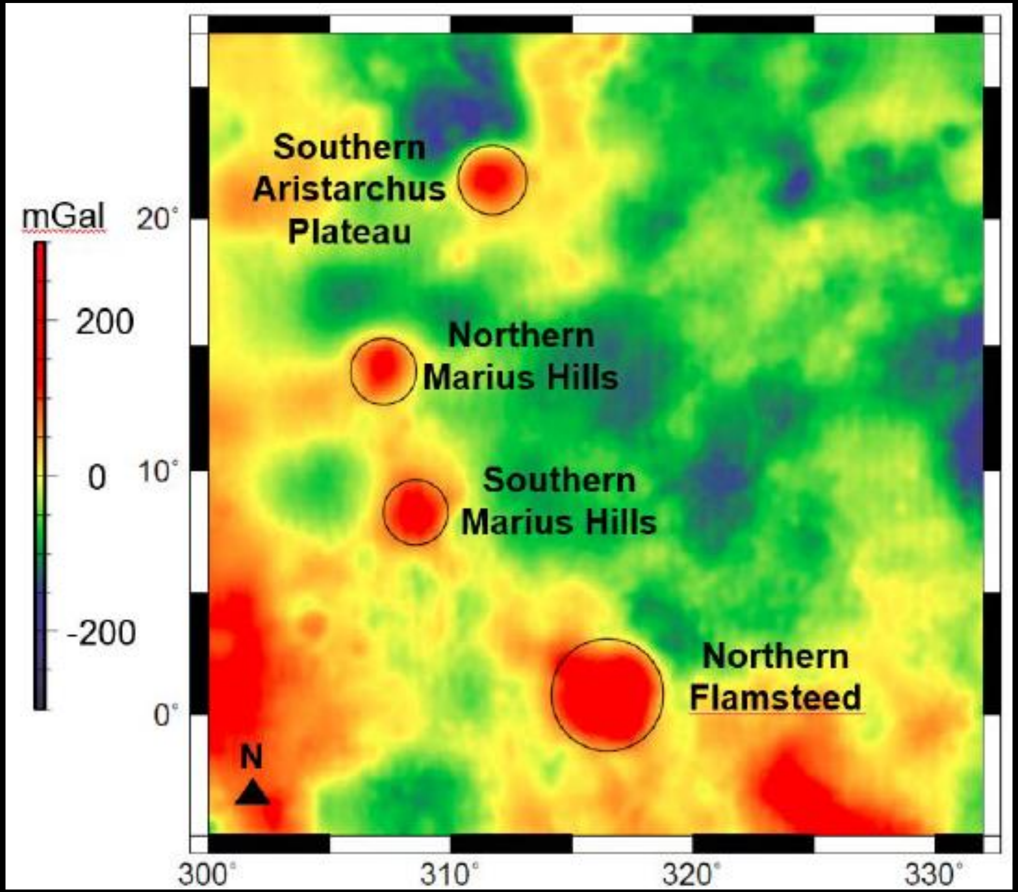


SPA Th hotspots in Lunar Prospector (top) and OMAT (bottom) images superposed on LRO WAC images.

Insight into Subsurface Impact and Volcanic/ Magmatic Structures

Ariel Deutsch and Colleagues

- Constrain the subsurface structures that contribute to four positive Bouguer gravity anomalies observed in Oceanus Procellarum.
- GRAIL gravity data and geologic analyses are used to distinguish between several origin hypotheses: Filled Craters, Dike Swarms, Magma Reservoirs, Mantle Upwelling, and Deep Mantle Reservoirs.

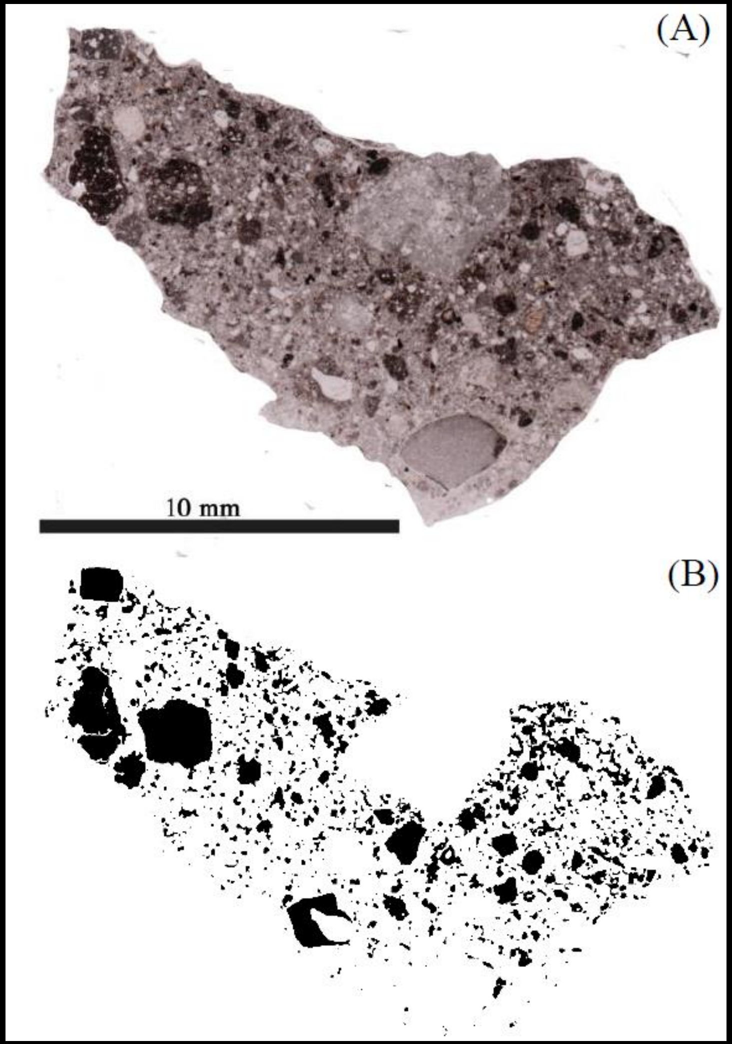


Four positive Bouguer gravity anomalies in Oceanus Procellarum, in GRAIL-derived GRGM900c Bouguer spherical harmonic solution from degrees 6 to 660.

“Suevite” Formation in Terrestrial and Lunar Impact Breccias

Patrick Hill and Colleague

- Better understand the formation of polymict impact breccias with particulate matrices: Is volatile content important? Are all suevites formed under conditions similar to that of Ries crater?
- Investigate thin sections of Apollo 14 and 16 impact melt-bearing breccias to analyze particle morphology, shape complexity, and particle sorting to gain an understanding of the melt-rock phase.

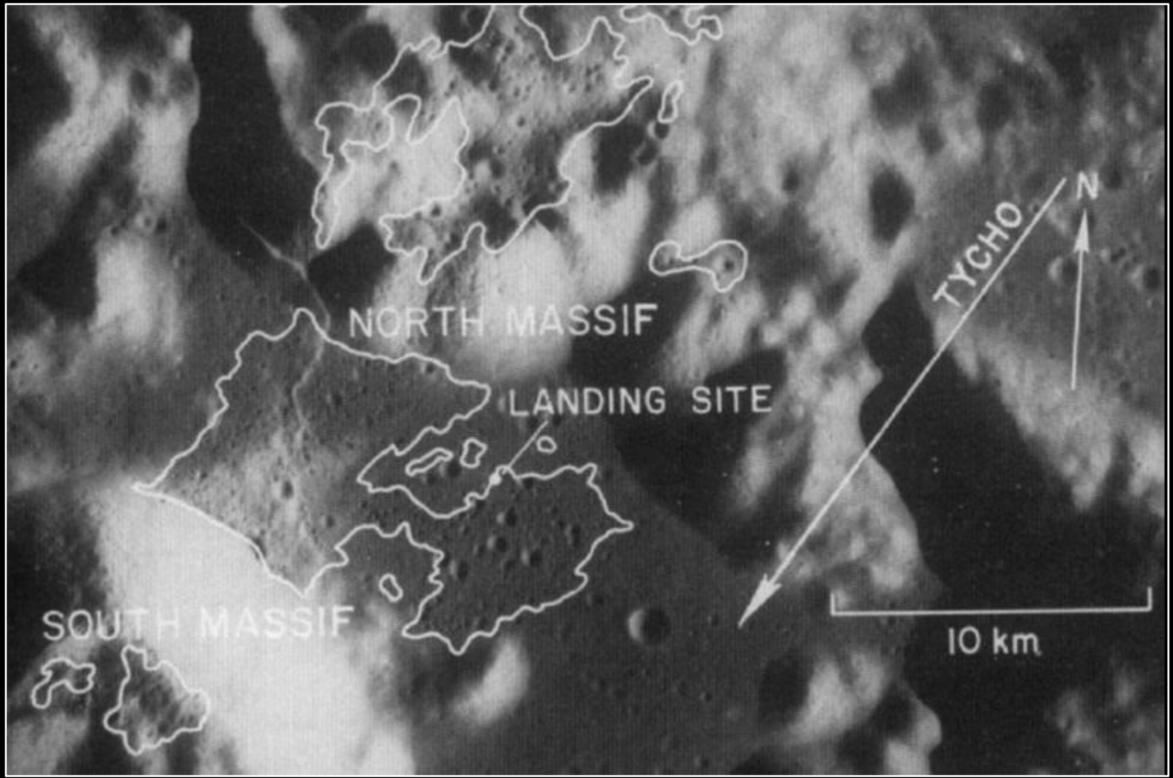


Apollo 16 sample 67016 (A) in plain polarized light, and 67016 (B) converted to an 8-bit greyscale of only impact melt-rock clasts present.

Identification of Secondary Craters at the Apollo 17 Landing Site

Jordan Kendall and Colleagues

- Develop new approaches from modeling and observations to distinguish between primary and secondary craters in the Taurus-Littrow Valley.
- Use iSALE-3D impact shock physics hydrocode software to infer depth to diameter ratios for highly oblique secondary craters as suspected for LTV.



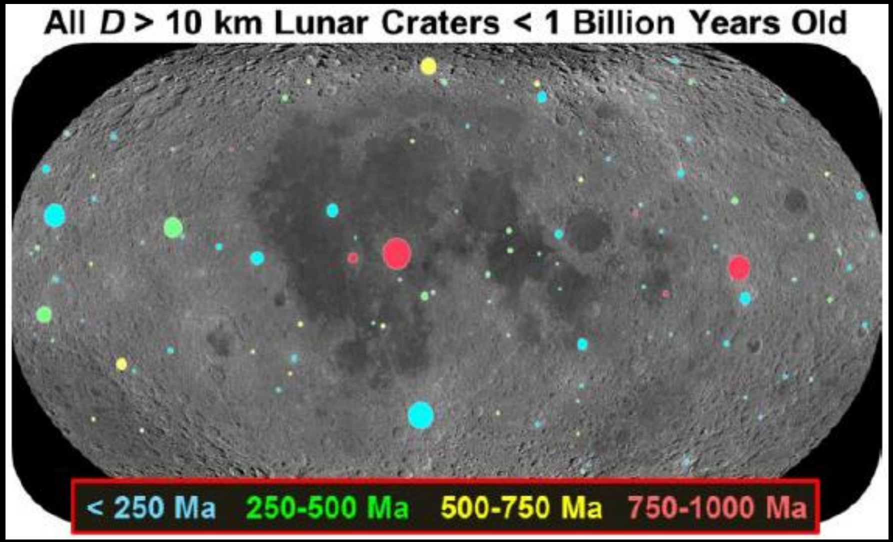
Map of crater clusters across the Taurus-Littrow area, from Lucchitta, 1977.

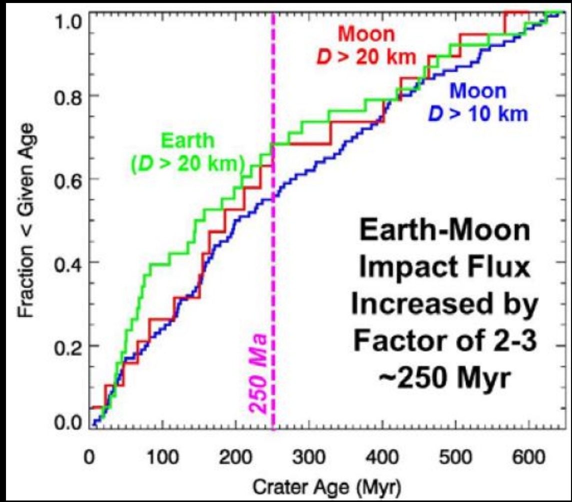
What Really Happened to Earth's Older Craters?

Bill Bottke and Colleagues

- Most assume that Earth's crater record is heavily biased, with erosion/tectonics preferentially destroying older craters. Is this true??

- Comparisons between Earth's crater record, where nearly all D $\geq$ 20 km craters formed < 650 Myr ago, and the Moon's crater record of craters with D $\geq$ 10 km and ages < 1 Ga are used to test this idea.





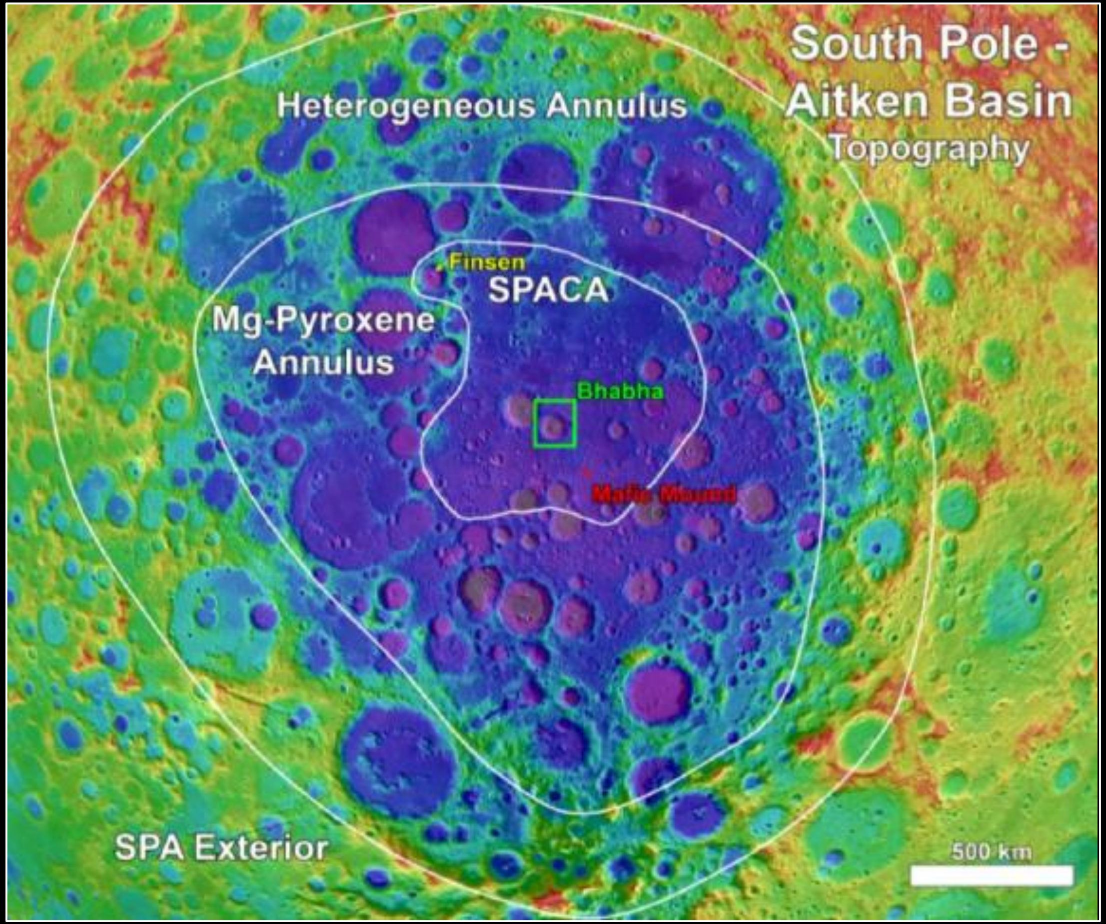
The distribution of 111 rocky craters D$\geq$ 10 km on the Moon, and age-frequency distributions of lunar and terrestrial craters.

The Compositional Anomaly within South Pole – Aitken Basin

Daniel Moriarty and Colleague

- Modern spectroscopic data from Kaguya and Moon Mineralogy Mapper (M^3) reveal an SPA Compositional Anomaly: an extensive, thick unit in central SPA that exhibits distinctive pyroxene compositions with intermediate Ca/Fe.

- Using spectral and observational analyses, this work aims to identify a source for this anomalous terrain.



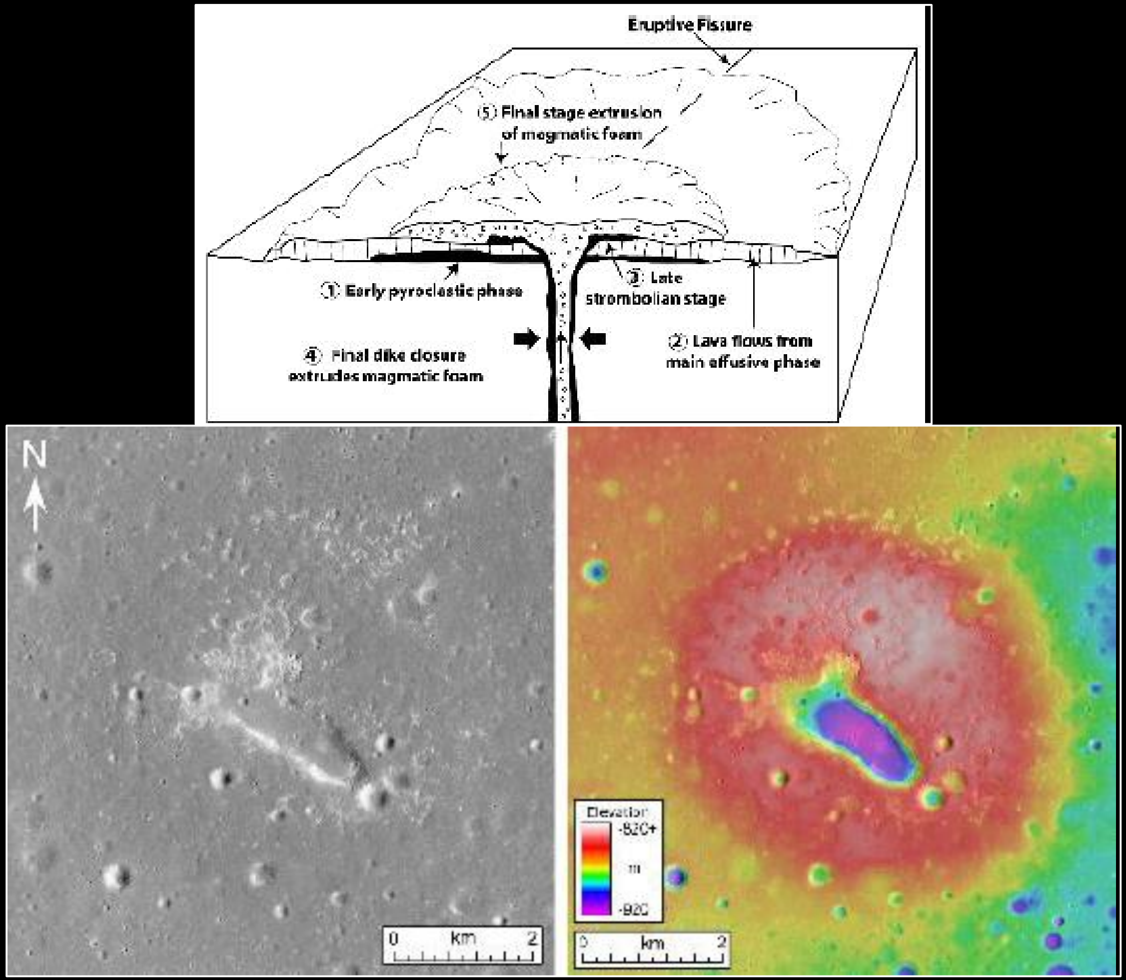
The four compositional zones of South Pole – Aitken basin revealed by M^3 spectral data, overlaid on LOLA topography.

Linking the Origin of Irregular Mare Patch Sub-Types at Cauchy 5

Le Qiao and Colleagues

- Whether two IMP sub-types, large features associated with vents/pit craters and smaller features with no associated vent, have similar origins is not known because their morphologies are not distinctive and the smaller features are too small to date confidently.

- The Cauchy 5 small shield volcano provides a hybrid example that links the small and large IMP types and, thus, can be used to decipher the origin of IMPs.



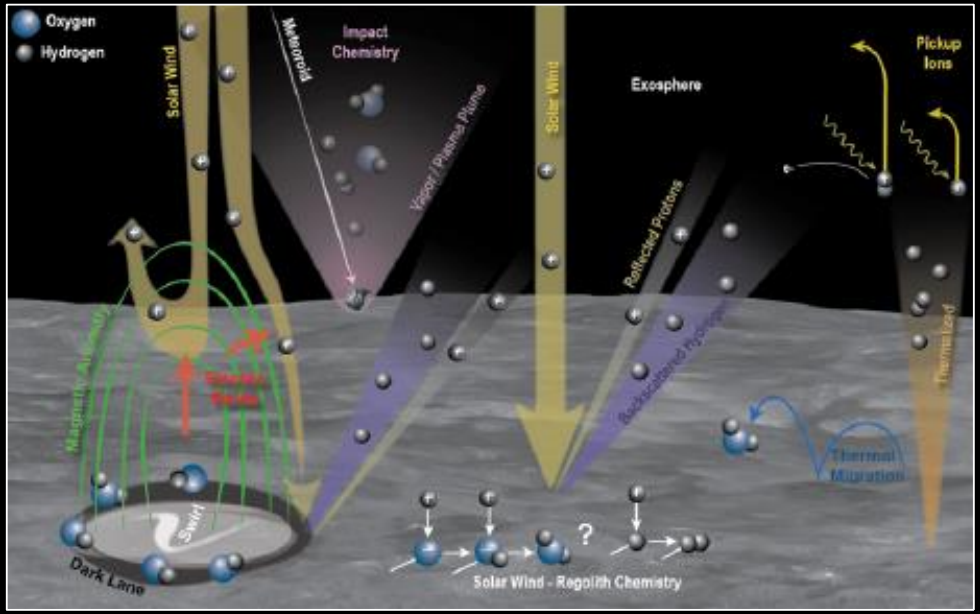
Model for formation (top), and an image and topography data (bottom) of Cauchy 5 small shield volcano.

Tethered MicroSat Investigation of Space Weathering and the Water Cycle at the Moon

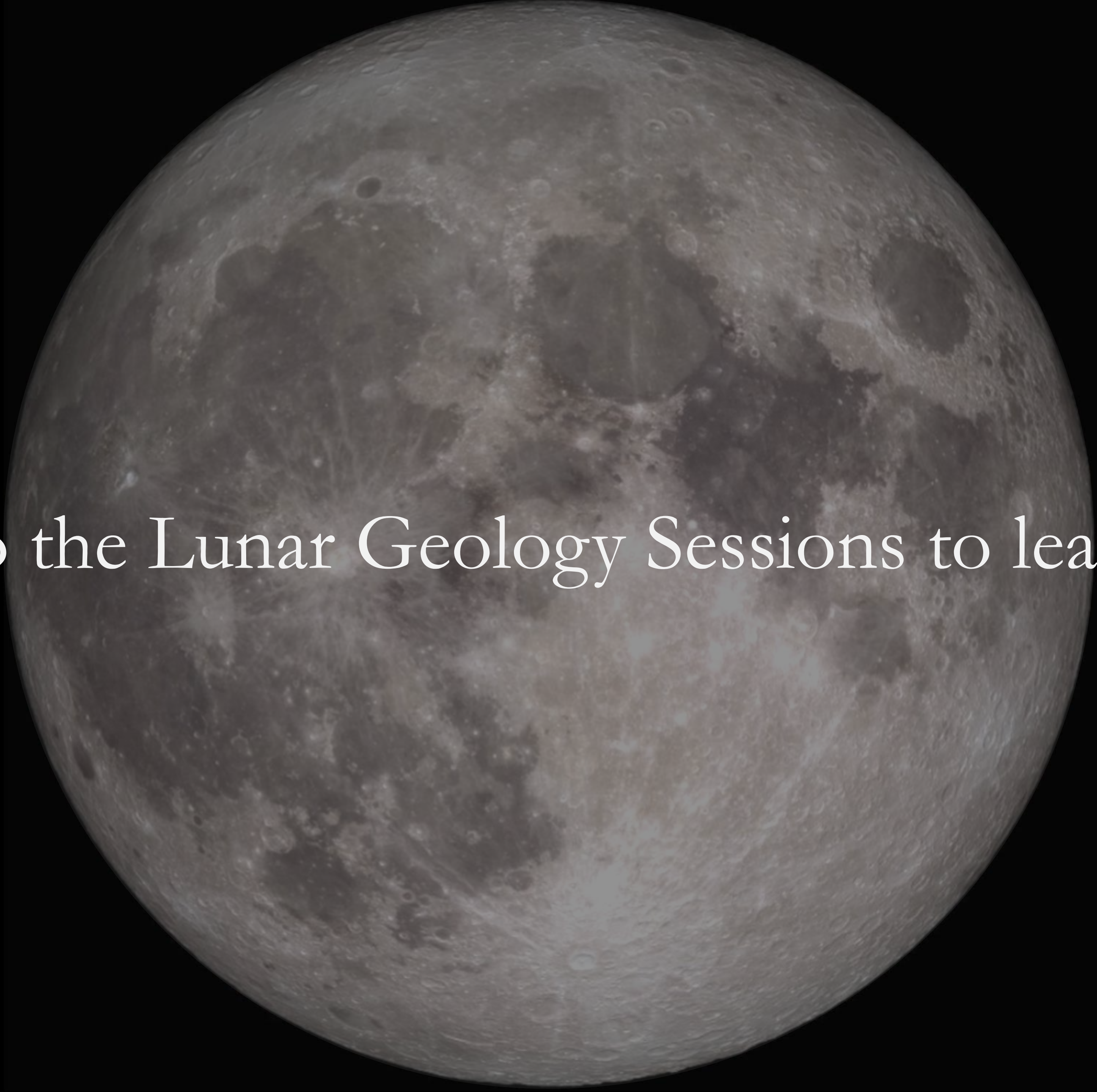
Timothy Stubbs and Colleagues

- The science goal of the BOLAS mission is to determine the role of solar wind in space weathering and creation of water products on the surface of the Moon, as well as investigating local crustal magnetic anomalies.

- This mission concept uses two tethered MicroSats to achieve the repeated, low-altitude, dual-point measurements required to understand fundamental processes involved in the interactions between the lunar surface and space environment.



Lunar processes investigated by the Bi-Sat Observations of the Lunar Environment Above Lunar Swirls (BOLAS) mission.



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