

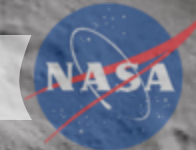


Artemis II Science Observations and Objectives mapped to Big Picture Science

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Bottom Line Up Front: Artemis II and the Big Picture



Crew observations during Artemis II will **directly contribute to science**.

Focused observations will inform open science questions of interest to the scientific community and relate to fundamental lunar and planetary questions.

Fundamental science observations will inform

Recent History and Evolution of the Moon

Composition and how recently the Moon was volcanically active

Clues to geologic processes and formation

Fundamental questions about lunar environment (e.g. dust, meteorite activity)

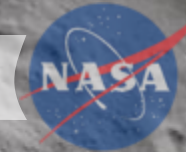
Exploration questions observations will inform

Future science and exploration landing site selection

Implications for mission planning and safety



Crew Observation Science Tracker



Observations of...

Color and Albedo



Are clues to...

Composition



From YOUR observations we get...

Where to look for subtle differences in what the crust is made of (landing site selection or targeted data collection)

Photometric Changes



Physical & Compositional Properties



Differences in the regolith that are not easily observed with static orbiters

Swirl Locations



Buried Magnetized Sources



Are the swirls as obvious and distinct to the eye as they are in images and if not, why and how should we explore them

Geologic Features



Geologic History



Observations of key Solar System processes that may be too nuanced for orbiters

Impact Flashes



Meteorite Activity



Constrain the impact rate in the Earth-Moon system at a scale we can't measure on or from Earth (science & exploration impacts)

Lunar Sunset & Sunrise



Dust above the Lunar Surface



Is dust levitated above the surface due to static electricity or other processes

Terminator & Limb



Subtle Morphology



How have processes changed the surface in recent history



Artemis Enables Focused Research

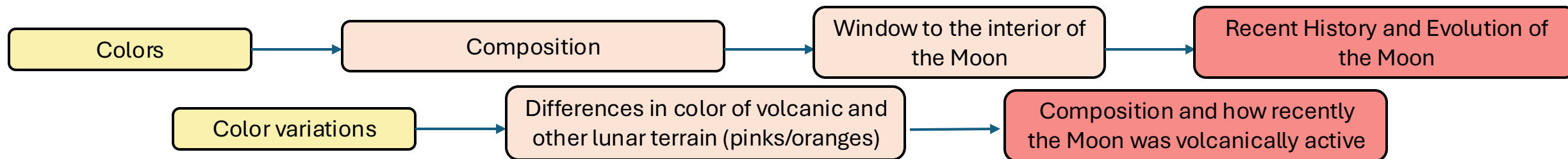
What crew describes

What the description tells the science team

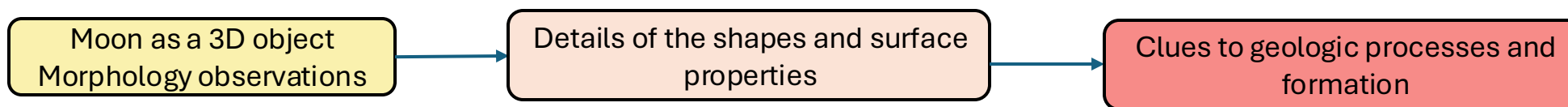
Fundamental science/explorations question the observation helps answer

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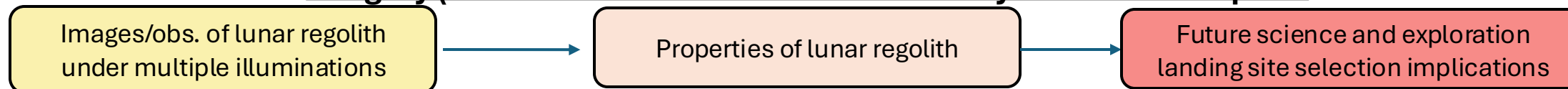
Human eye's ability to see subtle color variations contribute to science



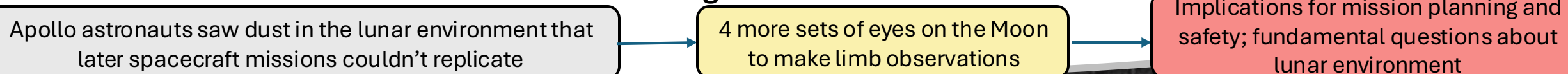
Seeing the 3-dimensional features of the Moon this perspective cannot be achieved by remote sensing satellites



Photometric observations of the lunar regolith - provide detail and context that complement LRO imagery (and that would take LRO months to years to accomplish)

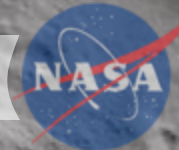


Looking for lofted dust





Future Mission Sites and Instruments



Artemis II data and observations can influence the selection and preparation for future mission types and sites.

Apollo 15 images and observations heavily influenced the selection of the Apollo 17 landing site at Taurus-Littrow by:

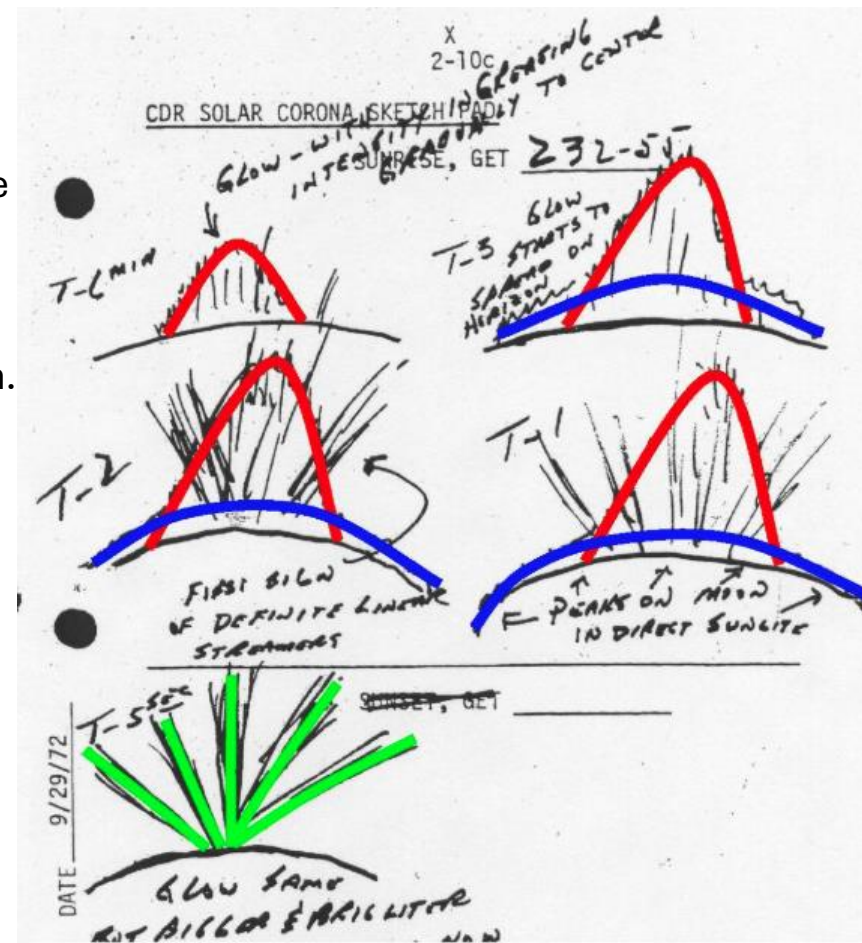
1. Inspiring science investigations to sample older highland materials and younger volcanic deposits.
2. Demonstrating feasibility of landing in Hadley Rille, between surrounding mountains.



Apennine Mountains running southwest to northeast and the Apollo 17 landing site at Taurus Littrow. Credit: AS15-0854M.jpg

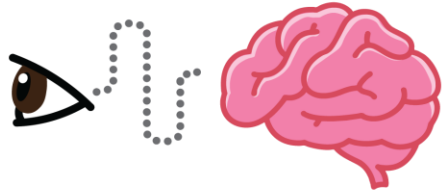
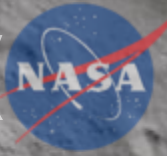
Gene Cernan's observations of lunar dust during Apollo 17 played a pivotal role in shaping the objectives of NASA's Lunar Atmosphere and Dust Environment Explorer (LADEE) mission.

Cernan's sketches of sunrise with "horizon glow" and "streamers" were studied by LADEE, interpreted to be coronal and zodiac light, lunar horizon glow due to exospheric dust, and crepuscular rays formed by shadowing and scattered light. Credit: NASA





Observing the Unexpected



**Cameras and instruments can't do some things that human eyes can do.
Therefore, it is very likely you will observe things we do not expect.**

Eyeballs connected to a Brain

~52MP with 20/20 vision

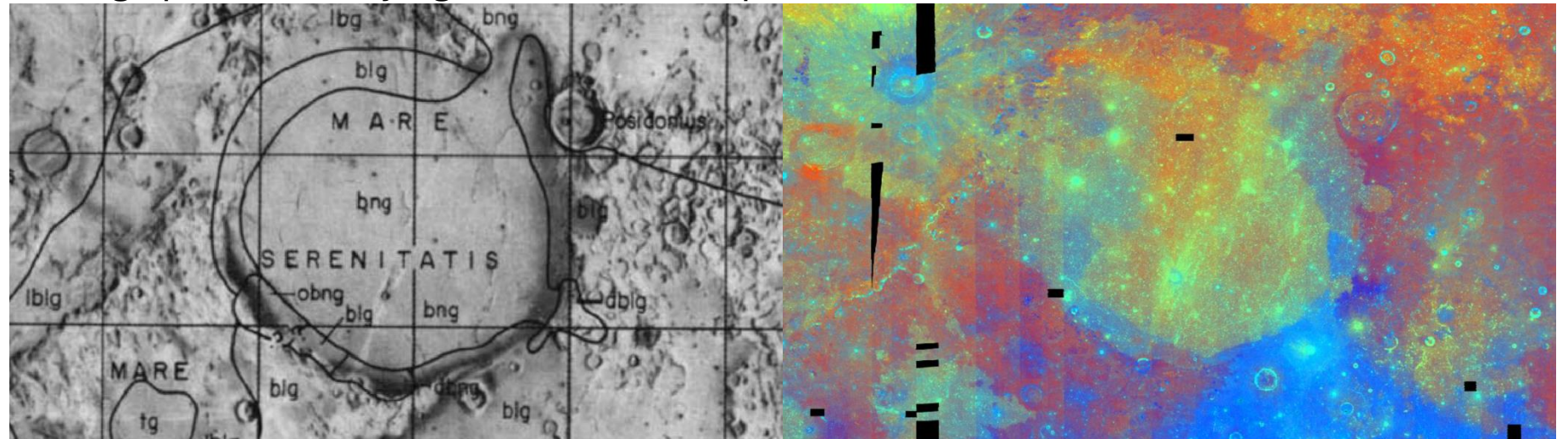
The instant exposure bracketing, depth compositing, 3D imaging, and panorama stitching that goes on in the brain is incredible.



Nikon D5 ~20.8MP

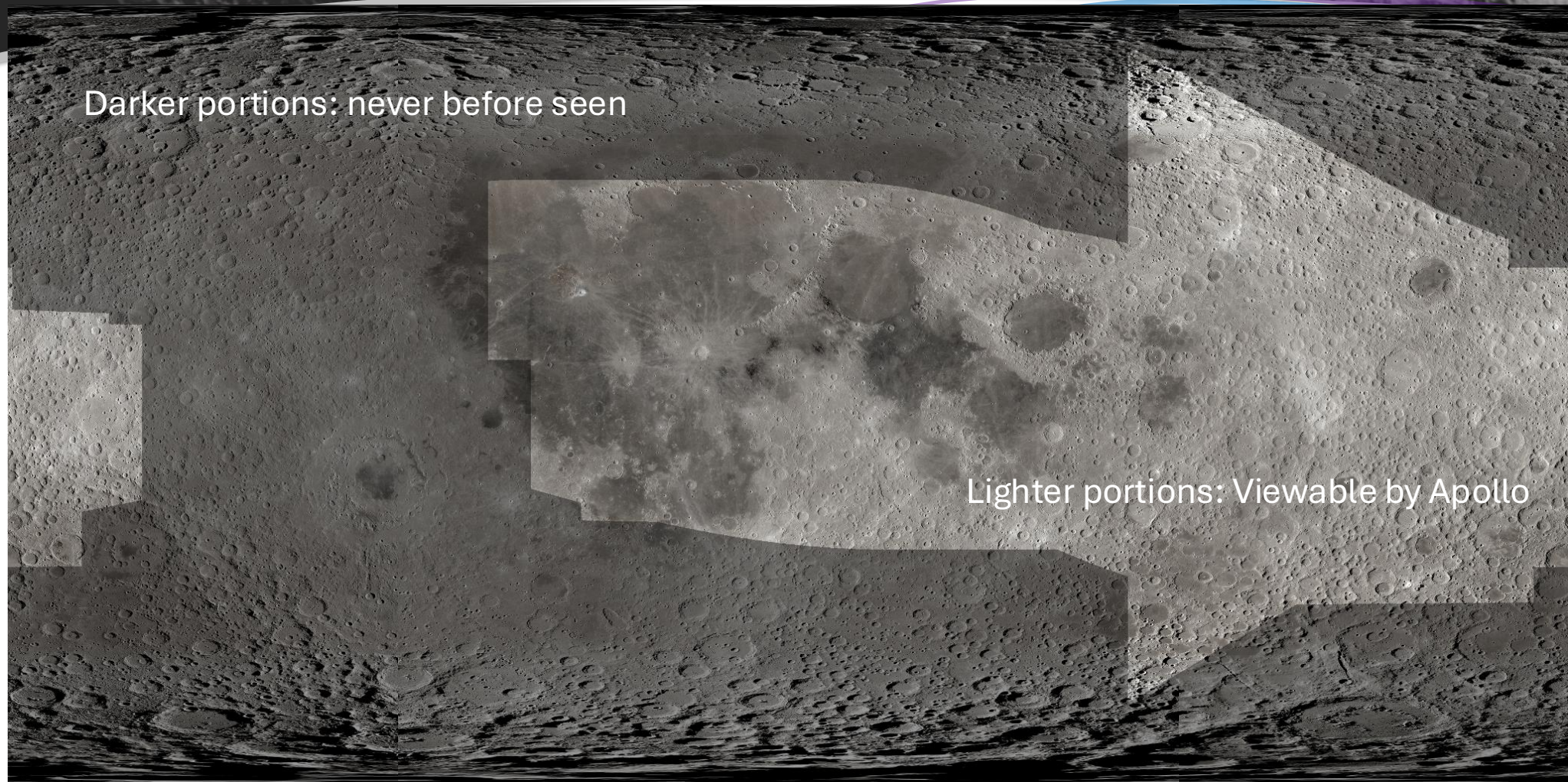
3 photos to capture exposure range
Multiple images to take mosaic

During Apollo, identifying colors was unexpected and confirmed with future mission data





Never Seen by Human Eyeballs



Darker portions: never before seen

Lighter portions: Viewable by Apollo

"This map shows the sunlit parts of the lunar surface that the Apollo astronauts could see from orbit. The darkened parts of the map were either never in sunlight (the large gap that includes Orientale) or were beyond the horizon of the spacecraft. The large cone shape represents part of Apollo 13's flyby." (Credit: Ernie Wright)



Scientific Observations of Earth



Apollo 8 Earthrise Image

AS08-14-2383, Dec 24, 1968.

Bill Anders, Hasselblad, 250mm lens.

- First image of Earth-Moon taken by human
- Highlighted Earth as a singular life supporting system
- Influential environmental photograph



Apollo 17 Blue Marble

AS17-148-22727, Dec 7, 1972, approximately 29,000 kilometers away from Earth.

- First photograph taken of the **whole** Earth,
- First Apollo image of the south polar ice cap
- Believed to be most reproduced image of all time.
- Challenged traditional mapping conventions by showing the Earth without meridians and parallels. Today's equivalent would be wide-angle universe images from Hubble and Webb.

- **Artemis II Observation Inspiration:** First human view of Earth rising (or setting) over the lunar horizon in more than 50 years
 - **Impact:** The Earth has changed since 1972.
 - We know from human spaceflight imagery global satellite systems that human footprints (city lights, linear agricultural patterns, changes in forest cover) have changed over time – human footprints are both bigger and global. How far away from Earth can your eye see them?
 - When does the shadowed part of the Earth start twinkling with city lights?
- **Color Observations:**
 - The colorful Earth can be used as a color palette to calibrate more subtle hues you see on the Moon.
 - If you see Antarctica or polar icecaps, they can be used to "white balance" your lunar photography.
 - Observing the Earth: How far away from Earth do colors change, allowing you to see changes in the different greens of vegetation or different blues in the oceans?
- **Global systems:** You will be able to see global-scale systems like tropical storms, dust storms, ice cover, maybe aurora.
- **Joint Artemis-ISS observations – a first!** Your global perspective complements the more detailed perspective seen by your colleagues on the ISS.



Orientele



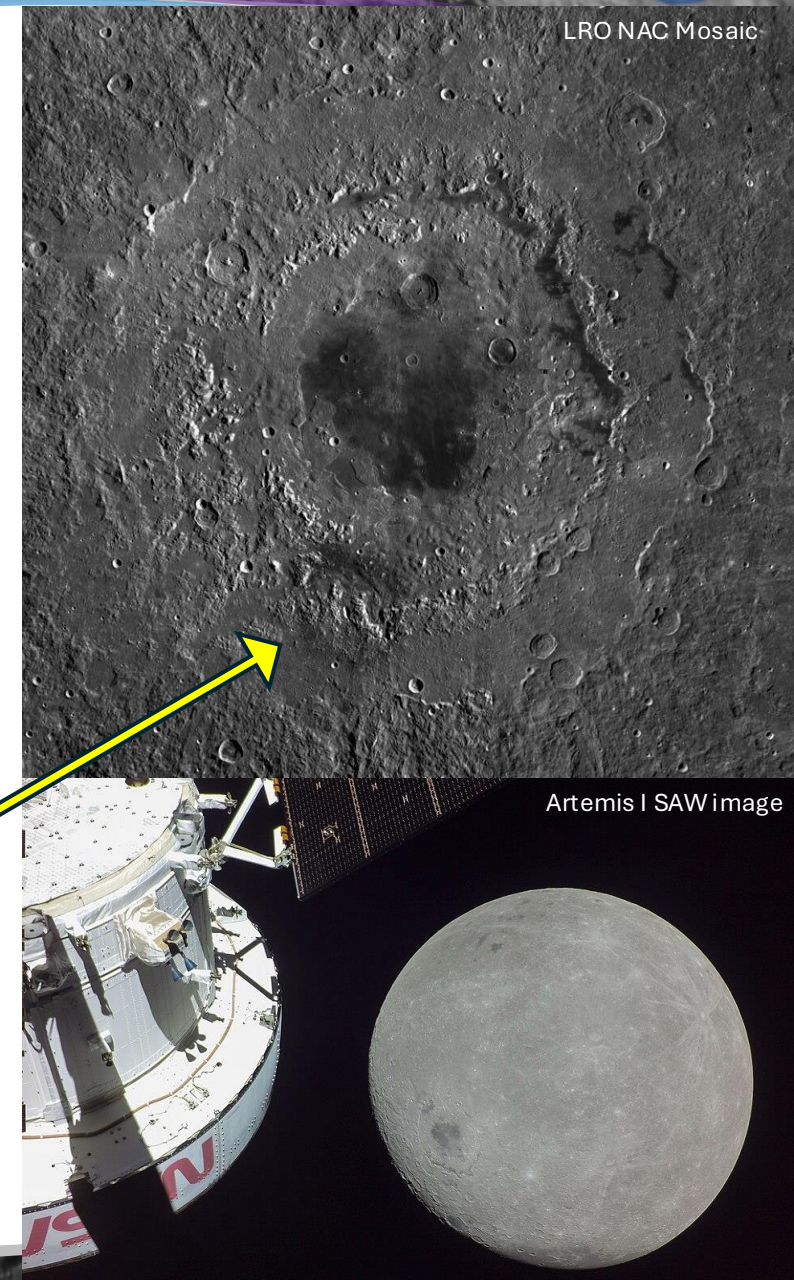
LRO NAC Mosaic

Solar System Impact History

- Orientele is the poster child of impact craters. Understanding Orientele can inform our knowledge of large-scale impact basins formation across the solar system from Mercury to Pluto.
- The Orientele Basin has never been directly observed by humans. The Artemis II crew observations may be the first. Ways the observations can support scientific research include
 - Photometric observations taken at various points of the flyby can reveal topographic details of the impact features;
 - Color and albedo variations in the volcanic terrains can inform current hypotheses about formation

Orientele Dark Ring

- The Orientele dark ring is of research interest as it is the only potential ring-shaped or annular volcanic deposit on the Moon.
- The formation mechanism for the dark annular ring is not resolved. Morphologic and spectral studies have hypothesized that it could be high energy eruption that spewed through a partially blocked vent, a thin draping pyroclastic deposit, or a later surface modification.
- Direct observations can inform this research





South Pole Aitken Basin

AS08-13-2320 (NASA/ASU)

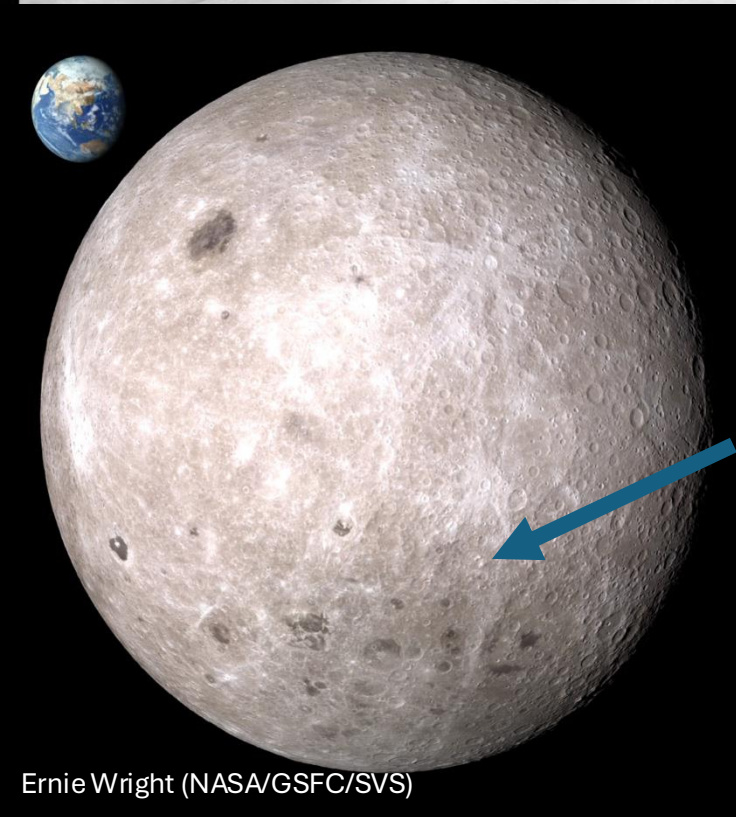
Apollo 8 photographed a large mountain range on the lunar horizon, they didn't know at the time, but this was **the first photograph of a portion of the South Pole-Aitken Basin (SPA) taken by humans**. Their photo of these mountains provided evidence towards the presence of a large impact structure on the lunar farside. A feature we are still trying to interpret!

Orbital data from robotic missions show that the interior of SPA is compositionally distinct, but the interior of the basin has never been observed by humans. Are colors apparent? If so, where are they and how do they relate to measured compositional anomalies? Your observations will provide important information into how the formation of the basin, and the 4+ billion years of history after its formation, influence what is observed and measured.

Impact to the South Pole: The size of SPA (2,500 km in diameter, the distance from Houston, TX to Toronto, ON) stretches from mid-latitudes to the lunar South Pole, the target for landed Artemis missions.

Understanding how, when, and the influence of the formation of this basin is critical to interpreting samples from Artemis missions. Observations of the interior of SPA will help us better interpret what was exposed and ejected by the largest impact basin on the Moon, and perhaps in the entire Solar System.

<https://svs.gsfc.nasa.gov/11747/>



Mountain imaged by Apollo 8

Ernie Wright (NASA/GSFC/SVS)



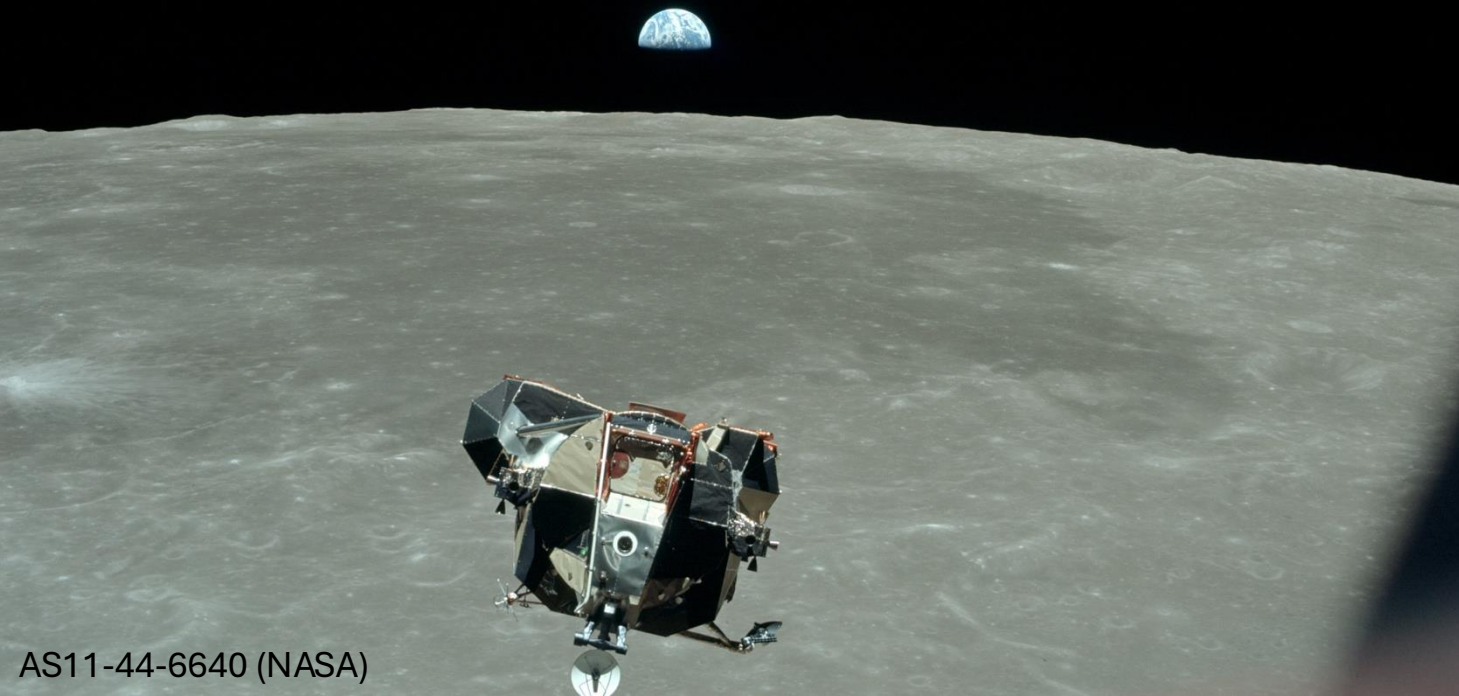
Inspiration

Apollo 17 Moon

AS17-152-23312 – As the Apollo 17 crew departed the Moon, the most recent visit by humans, this image the eastern limb of the Moon, covering portions of the nearside (top left) and farside (bottom right) remind us that the farside of the Moon is the realm of the explorer. For as long as humans have gazed at the Moon, we have all shared the nearside. **Only 27 humans, soon to be 31, have laid eyes on the farside.**

Apollo 11: Coming Home

Photos taken by humans of the Moon (and the Earth) remind us that of our place in the Solar System. Human eyes and voices, with a first-person vantage, transports humanity off planet. Not only are all humans (minus Michael Collins in the FOV of this image), note the bright crater ejecta at left!



AS11-44-6640 (NASA)



AS17-152-23312 (NASA)

Why The Moon?

President Kennedy said “... because it is there.” That we have a Moon is why we have tides, we have a stable rotational axis, and likely why life has flourished on this planet. The link between the Earth and Moon over 4.5 billion years has created a system that not only allows life to flourish, but also to inspire humans to go further into our solar system.

The insights we get from the Moon tell us how planets form, evolve, and how special our home really is.