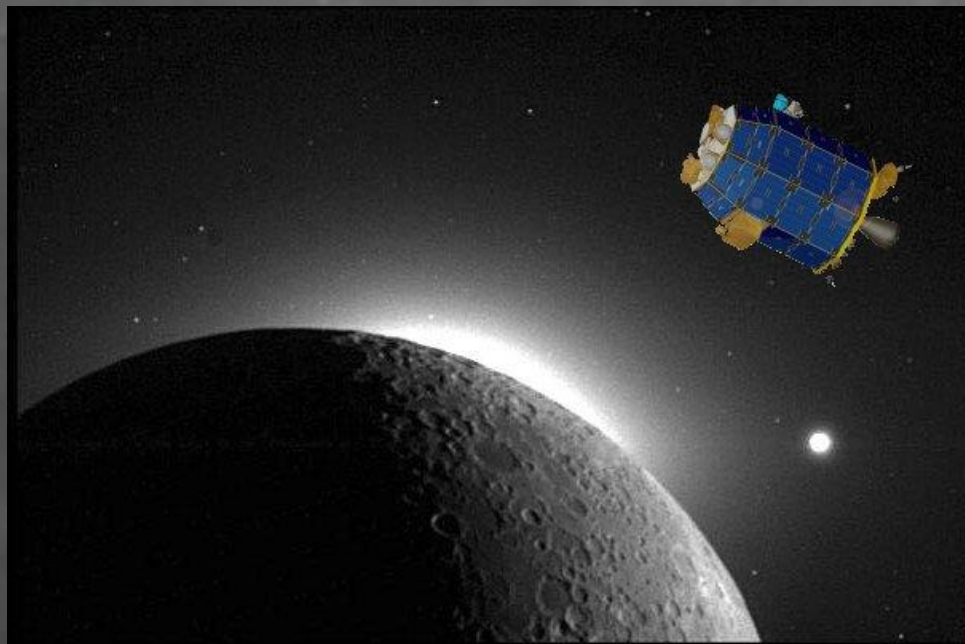




Exploring the Moon with NASA

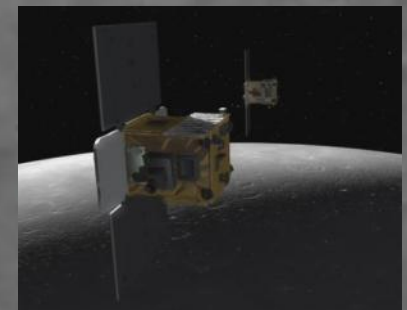
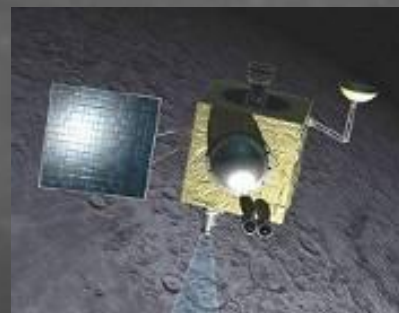
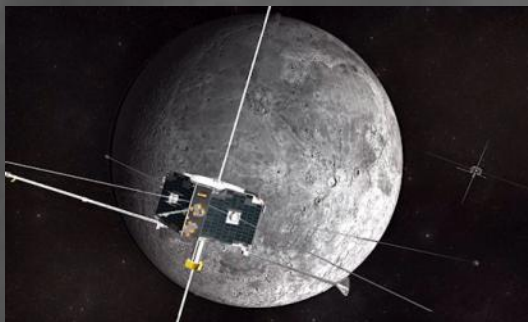
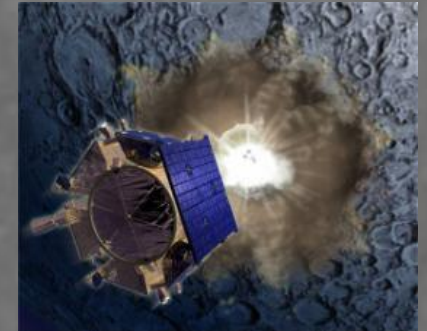
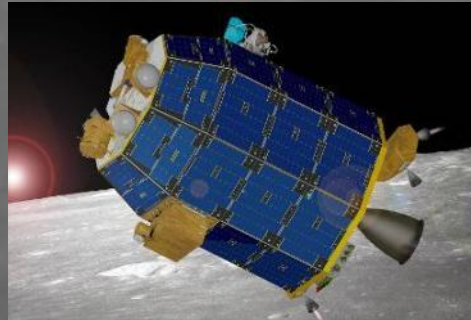
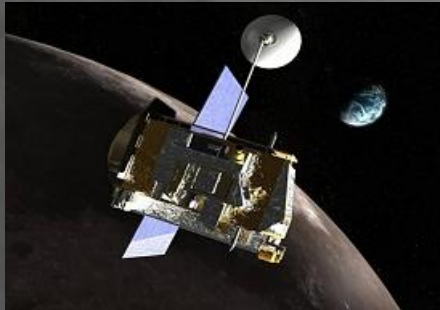
Journey through the Universe 2012

Brian Day
LADEE Mission E/PO Lead
NASA Lunar Science Institute Citizen Science Lead
Brian.H.Day@nasa.gov





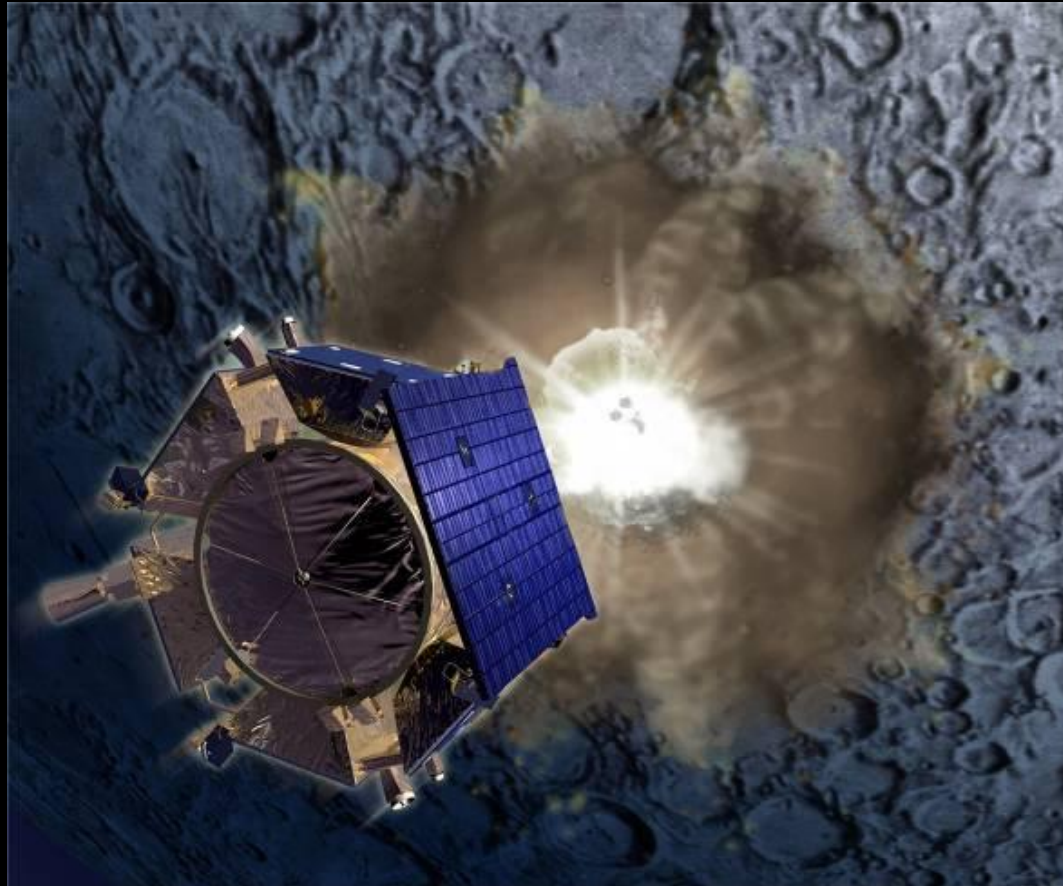
A new generation of robotic lunar explorers is revolutionizing our understanding of the Moon.



After the Apollo missions, many people viewed the Moon as a completely dry, airless, unchanging world. We now recognize the Moon as a fascinating place with amazing surface features, ongoing geology, and a thin but active atmosphere.



LCROSS Mission Concept



- Impact the Moon at 2.5 km/sec with a Centaur upper stage and create an ejecta cloud that may reach over 10 km about the surface
- Observe the impact and ejecta with instruments that can detect water



Lunar Reconnaissance Orbiter (LRO)

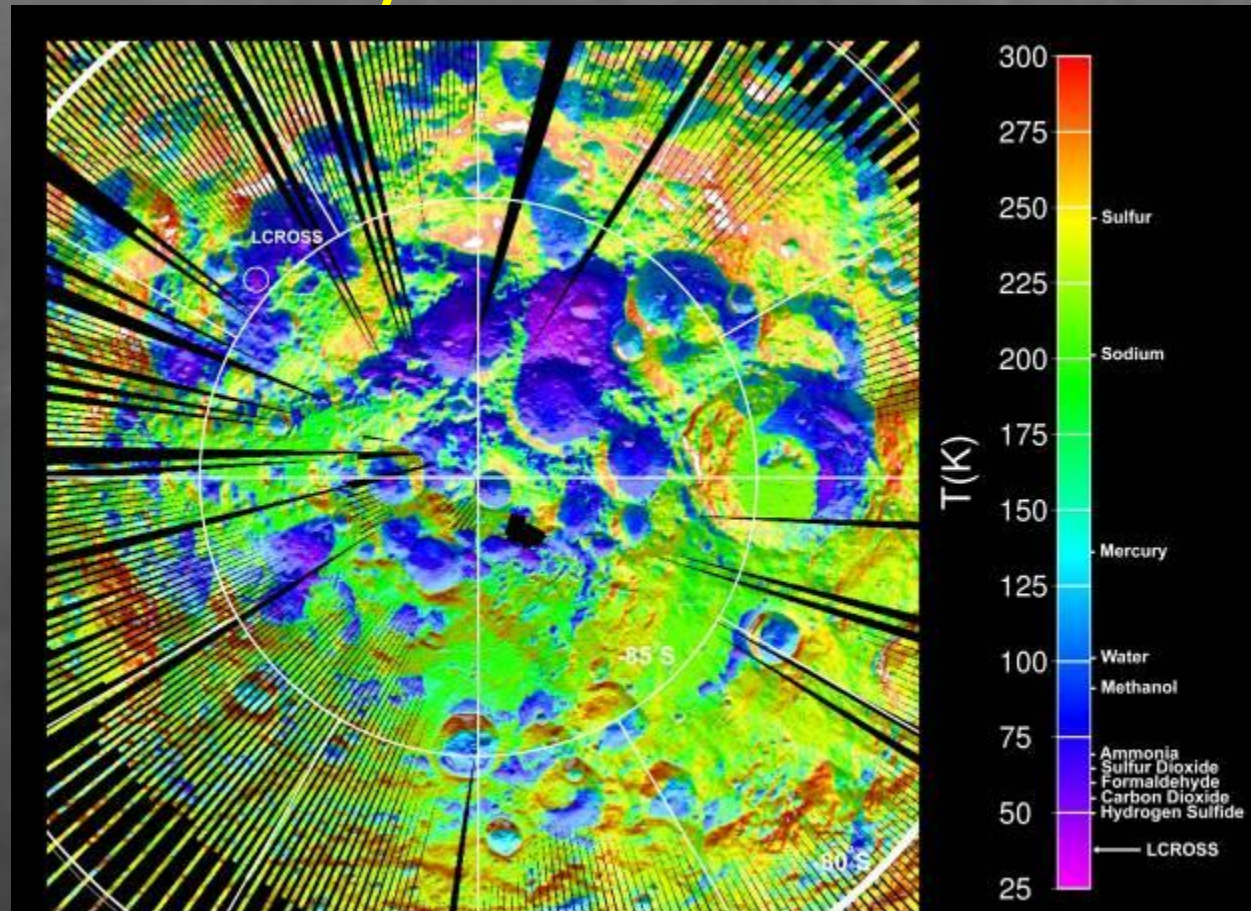
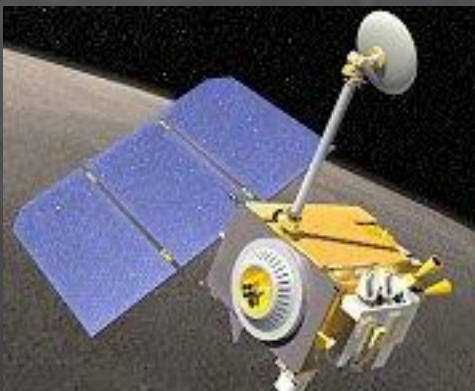
- LROC – image and map the lunar surface in unprecedented detail
- LOLA – precisely measure the ups and downs on the lunar surface with a laser altimeter
- LAMP – see into the Moon's permanently shadowed regions
- CRaTER - measure the global lunar radiation environment
- DIVINER – measure lunar surface temperatures & map compositional variations
- LEND – study hydrogen concentrations in lunar soil: a clue for finding water





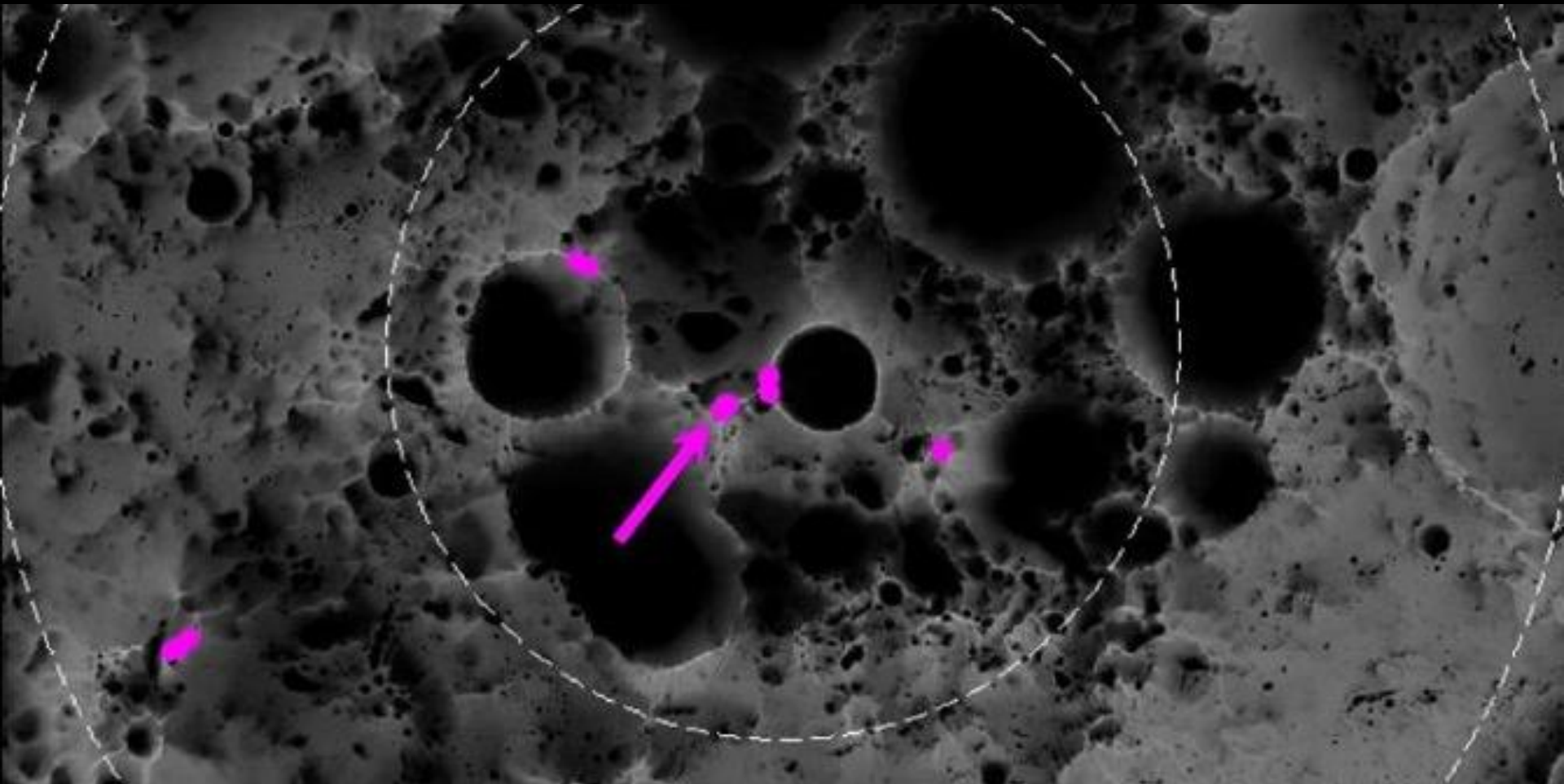
The Moon's Permanently Shadowed Craters are the Coldest Places We have Found in the Solar System

- LRO has measured temperatures as low as -248 degrees Celsius, or -415 degrees Fahrenheit
- This is colder than the daytime surface of Pluto! (-230 Celsius)





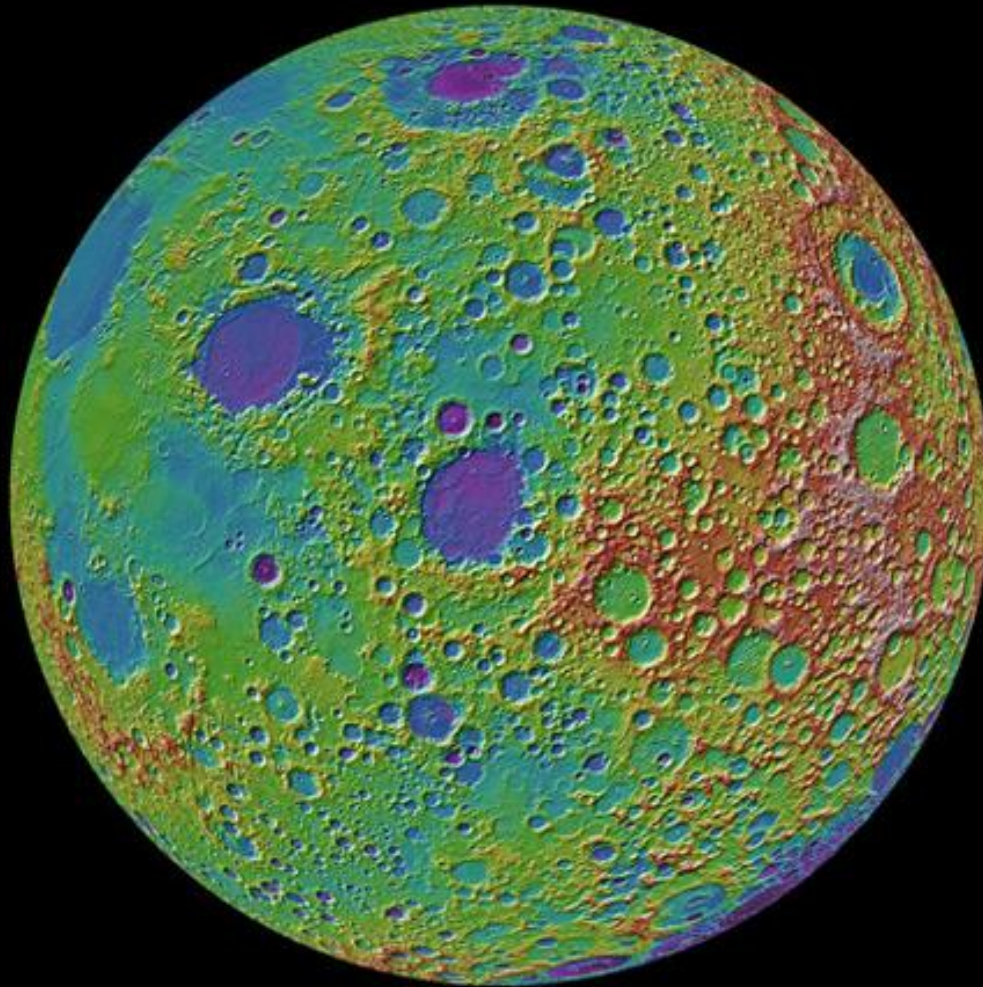
Areas of Near Constant Sunlight at the South Pole



Areas with approximately 96% illumination



LRO studies the ages of craters and the history of impacts

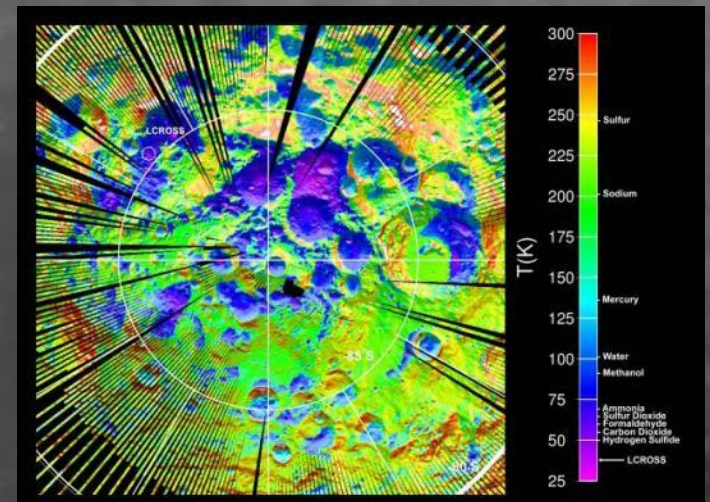


Unlike on the Earth, because there is so little erosion on the Moon, lunar craters can last for billions of years. This provides a history of rates of meteoroid impacts in the inner solar system and gives us valuable clues about the early history of the Earth.



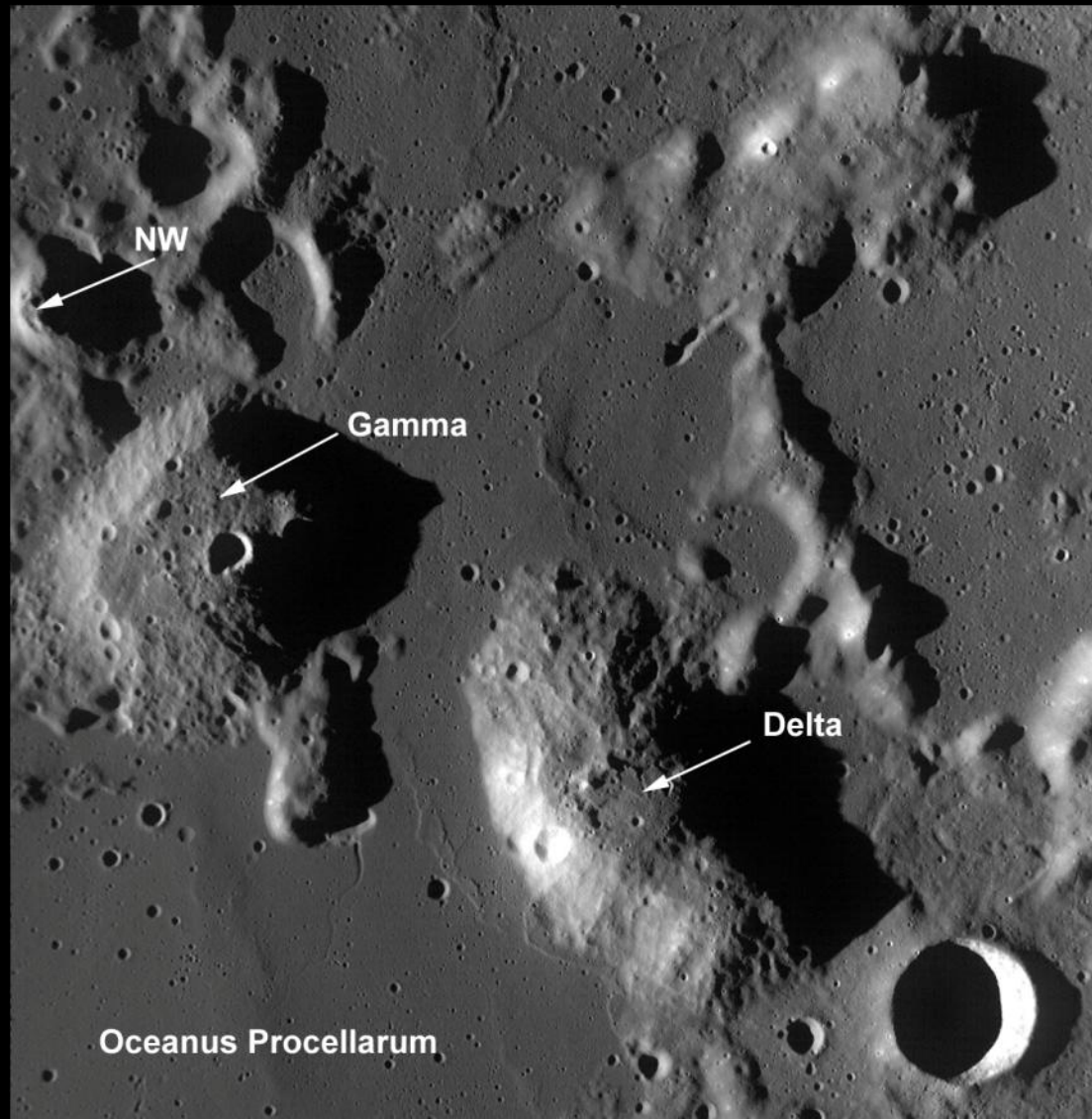
LRO's DIVINER Indicates Widespread Ice at Lunar Poles

- In permanently-shadowed craters at the Moon's poles, surface deposits of water ice have been found.
- These areas are surrounded by much larger permafrost regions where ice exists just beneath the surface.



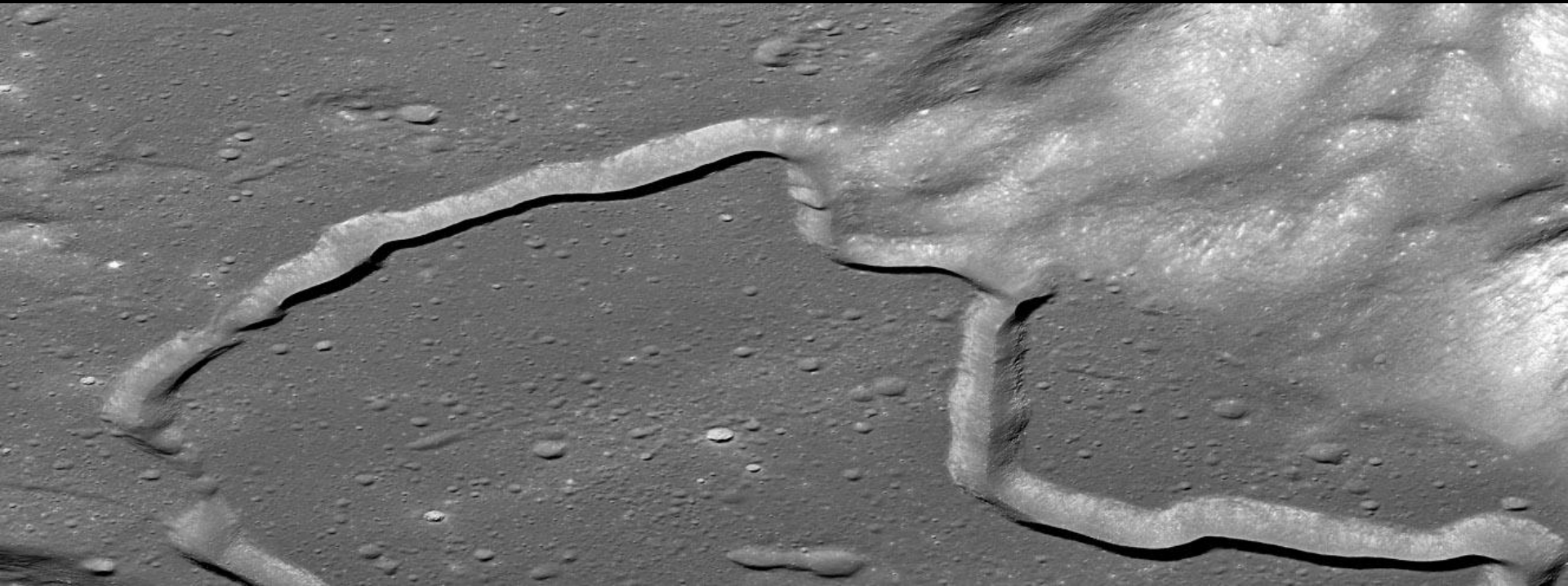


Gruithuisen Domes – Large Volcanoes





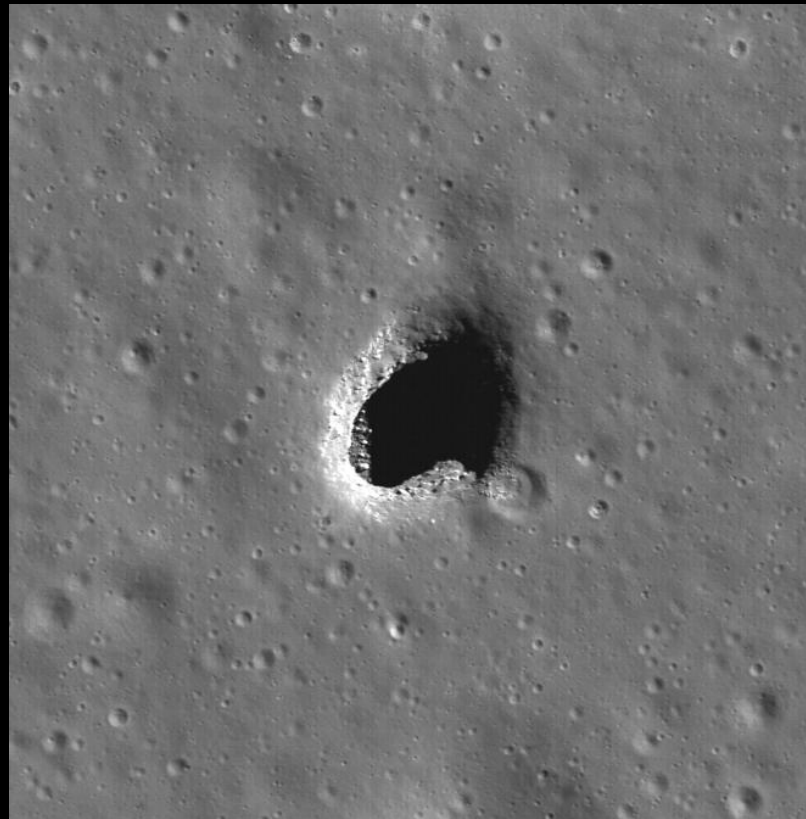
Sinuuous Rilles – Ancient Lava Channels



While this looks like a dry river bed, no water flowed here. Long ago, a river of molten lava carved this path on the lunar landscape. Later, it was visited by the Apollo XV astronauts.



Lunar Pits

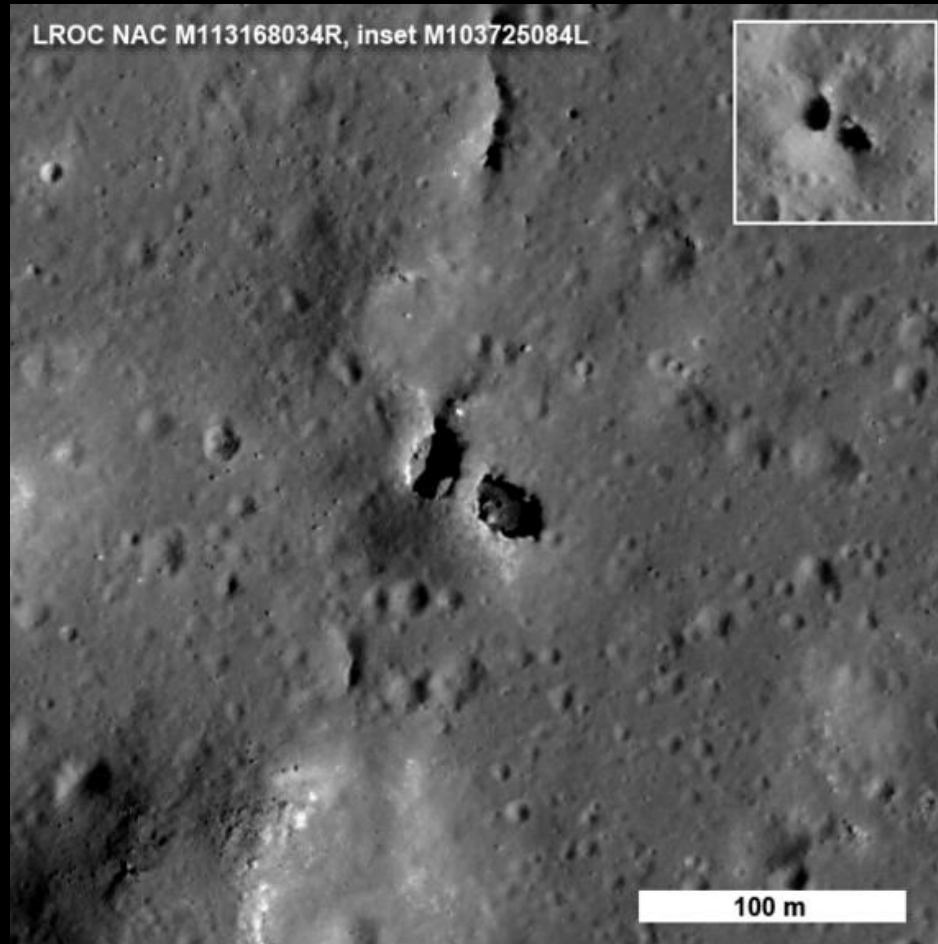


Pit in Mare Ingenii – Diameter ~ 130m

Unlike craters, lunar pits seem to be openings into large voids beneath the Moon's surface. Some researchers think these pits are natural skylights opening into vast caverns that were formed long ago by flowing lava



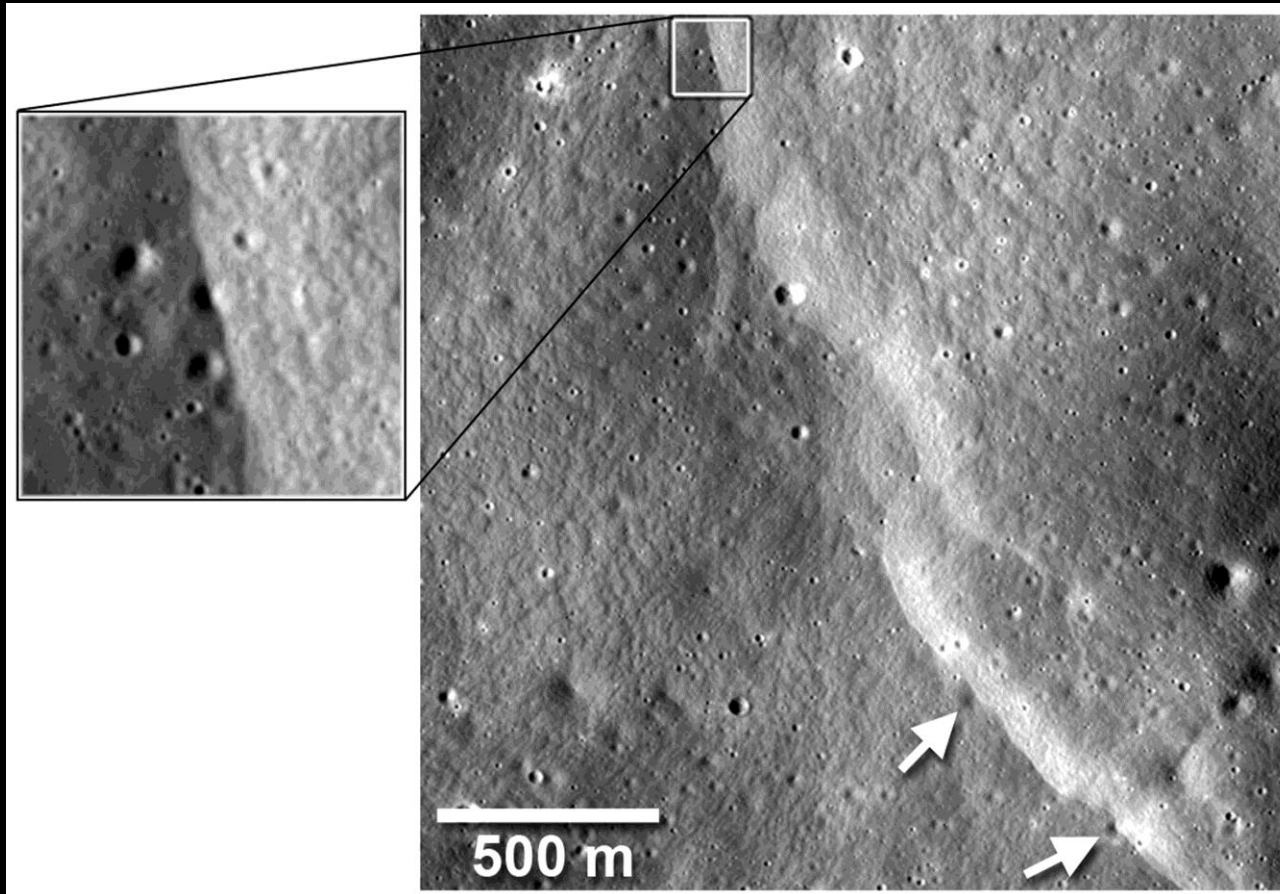
Natural Bridge in King Crater



An especially interesting looking pit!



Lobate Scarps – The Shrinking Moon



These cliffs occur across the Moon. They tell a story of the Moon shrinking as it cools. As the Moon shrinks, its surface buckles, forming these scarps. In some cases, the scarps lie on top of craters, showing the scarps are younger than the craters.

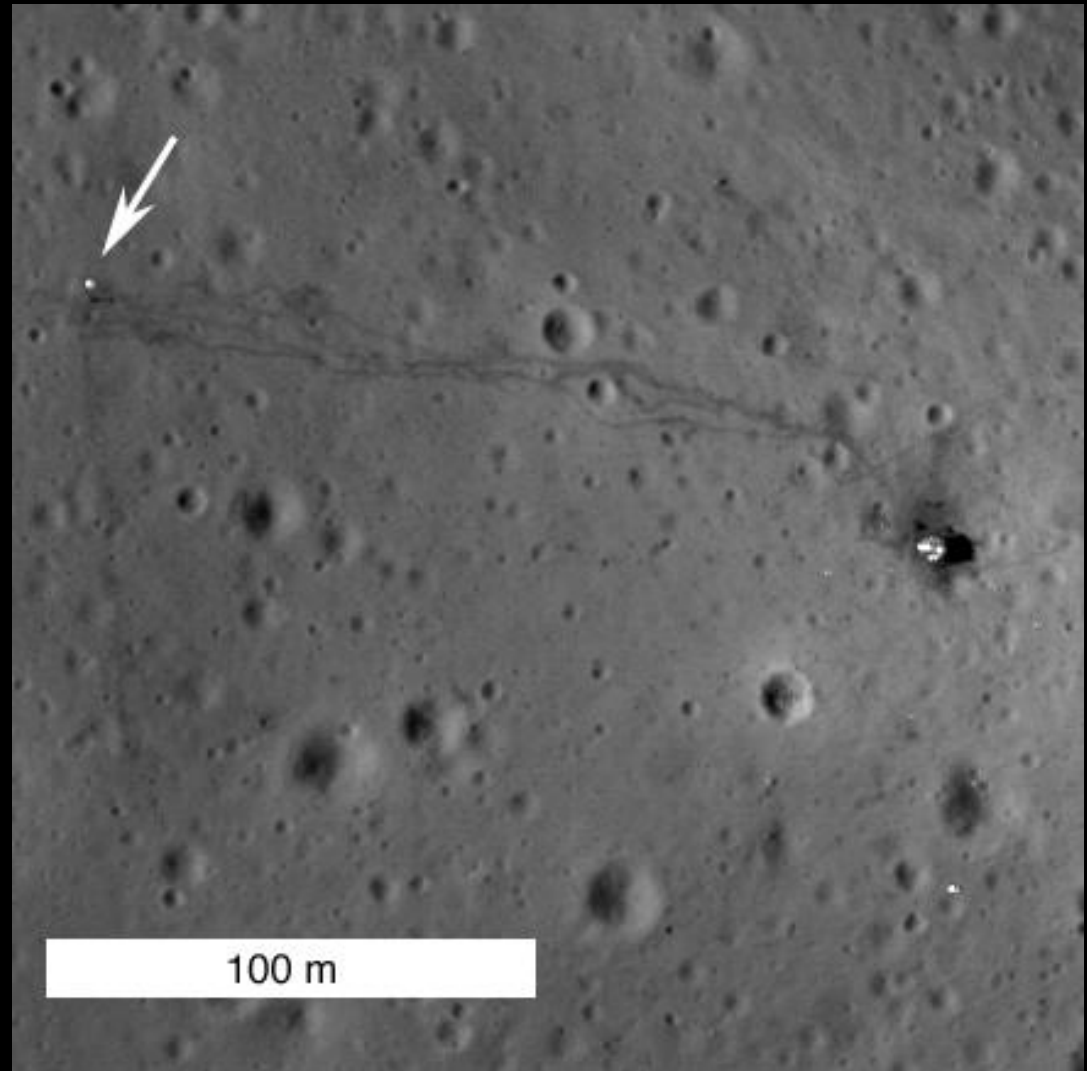


Apollo 14 Landing Site Imaged by LRO

On the right, you can see the descent stage of the lunar module which carried the astronauts down to the surface of the Moon.

On the left, the arrow points to an instrument package with experiments left on the Moon by the astronauts.

In between you can see some dark squiggly lines – the footprints of the astronauts.





You Can Help Explore the Moon!

Visit <http://www.moonzoo.org/> to see how you can help explore the images from LRO.

MOON ZOO

YOUR CHANCE TO EXPLORE THE MOON

LOG IN

Home

How To Take Part

About

FAQ

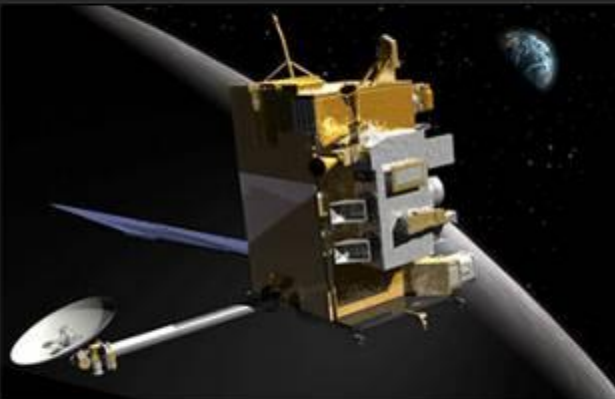
Moonometer™

Forum

Blog

Moon Zoo Live!

Explore the Moon



See the Moon like never before

MOON ZOO

Launch

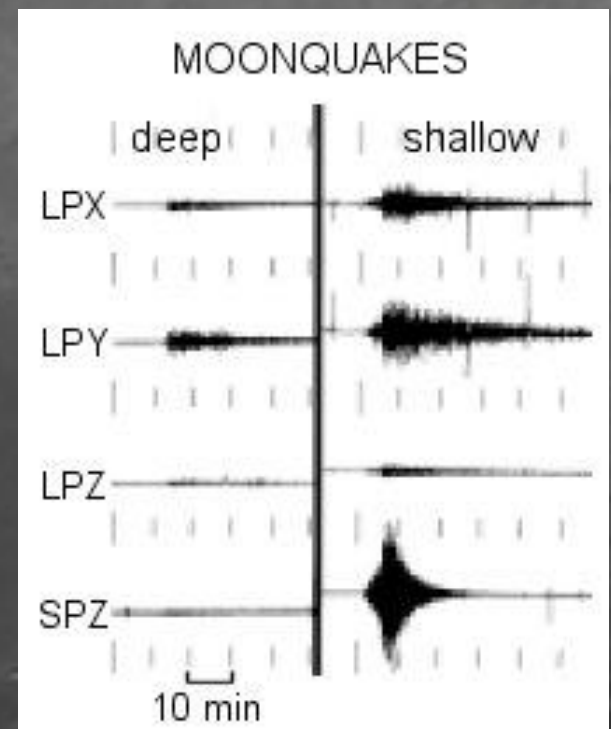
Welcome to Moon Zoo

Welcome to Moon Zoo — with your help, we hope to study the lunar surface in unprecedented detail. Thanks to the help of the Moon Zoo community we have already visually classified 1,637,191 images from NASA's Lunar Reconnaissance Orbiter (LRO). Read more [about the LRO and Moon Zoo](#) or learn [how to take part](#).



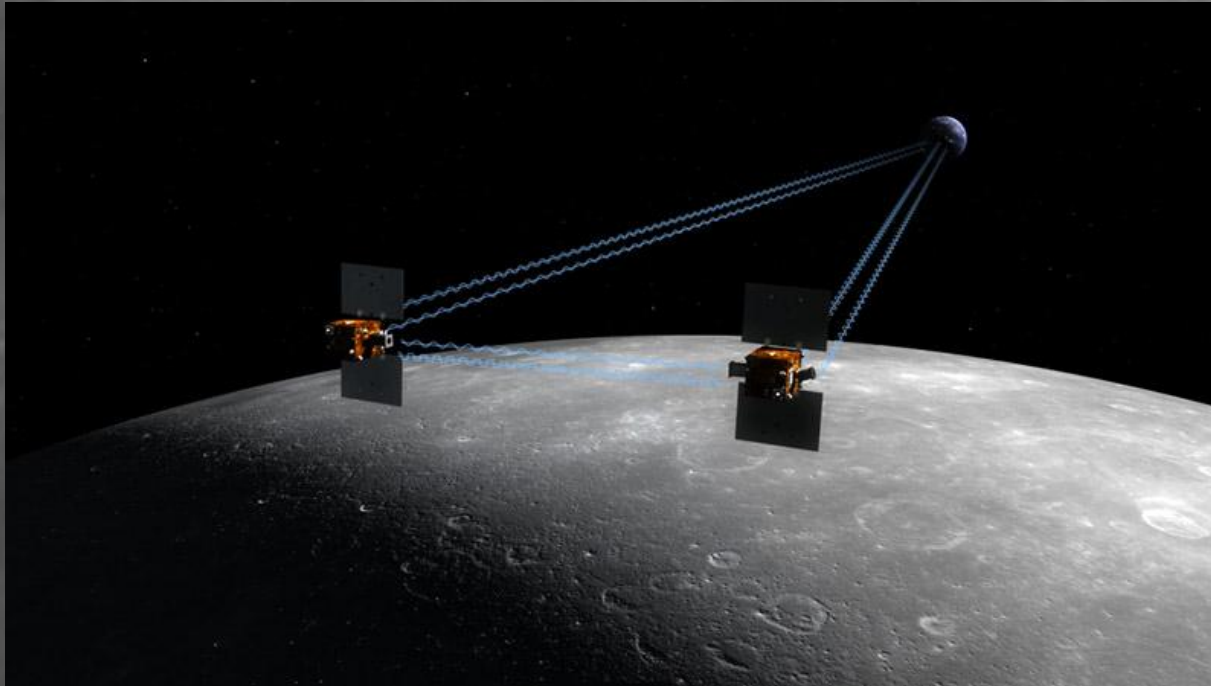
Moonquakes – A Whole Lot of Shaking Going On

- Deep moonquakes about 700 km below the surface, probably caused by tides.
- Vibrations from the impact of meteorites.
- Thermal quakes caused by the expansion of the frigid crust when first illuminated by the Sun at dawn.
- Shallow moonquakes 20 or 30 kilometers below the surface. Up to magnitude 5.5 and over 10 minutes duration! We don't know their cause.





Gravity Recovery and Interior Laboratory GRAIL

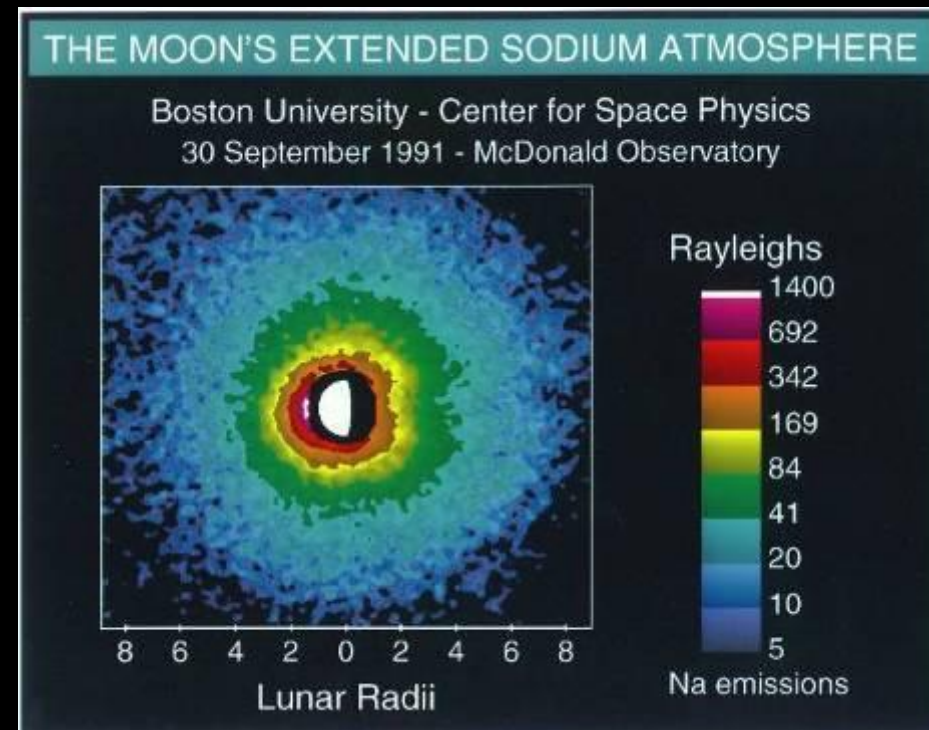


- Launched Sept 10, 2011.
- Two spacecraft flying in orbit around the Moon together.
- Mapping the interior of the Moon from core to crust.
- Middle school classes are directing the cameras aboard these spacecraft! Visit <https://moonkam.ucsd.edu/>



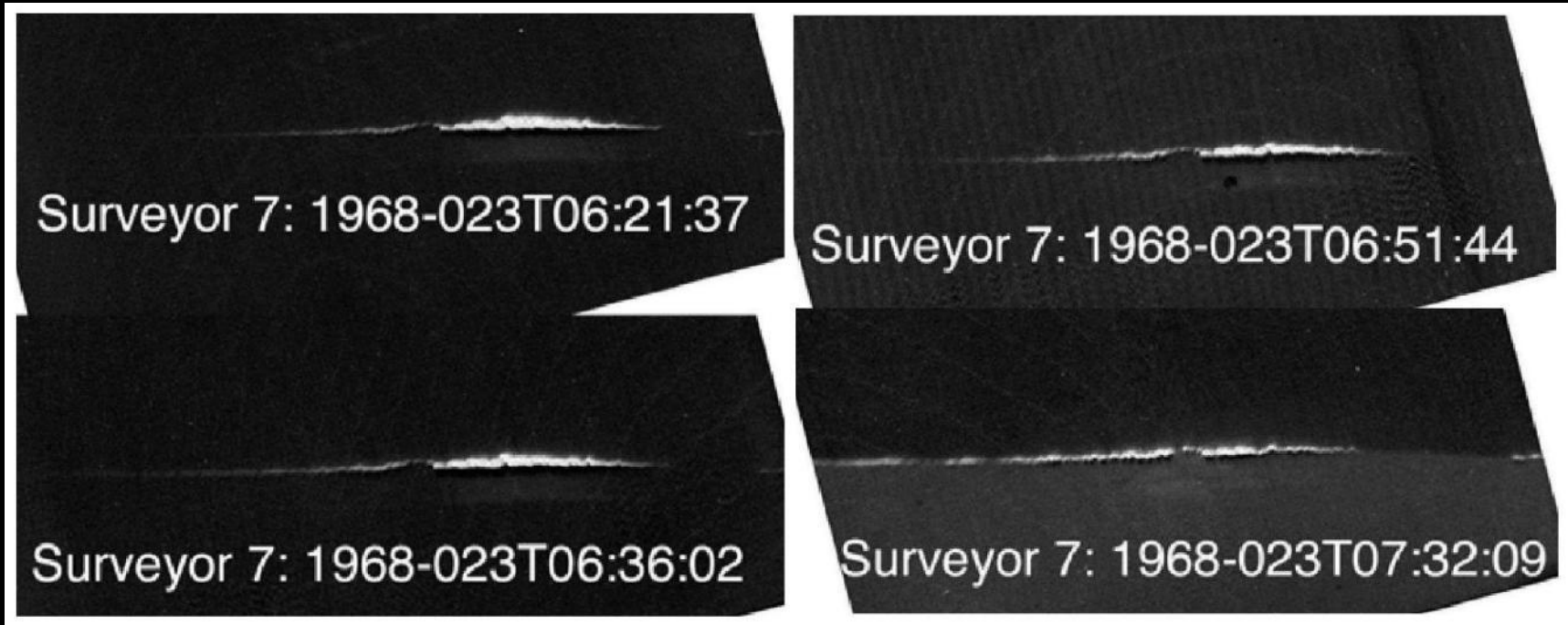
Lunar Atmosphere

- Does the Moon really have one? Yes, but very thin! A cubic centimeter of Earth's atmosphere at sea level contains about 10^{19} molecules. That same volume just above the Moon's surface contains only about 100,000 to a few million molecules.
- The atmosphere at the Moon's surface is about as thin as the outermost fringes of Earth's atmosphere where the International Space Station orbits.





A Dusty Lunar Sky?



In 1968, NASA's Surveyor 7 moon lander photographed a strange "horizon glow" looking toward the daylight terminator. Scientists think this may be caused by sunlight scattered from electrically-charged moon dust floating just above the lunar surface.



A Dusty Lunar Sky?

More possible evidence for dust came from the Apollo missions.



Apollo Astronaut sketch (G. Cernan)

While orbiting the Moon, some Apollo astronauts saw glowing streamers stretching up high into the sky when the Sun was just below the horizon. Again, many scientists think this may be sunlight reflecting of dust that has been lifted high into the Moon's atmosphere.



The Lunar Atmosphere

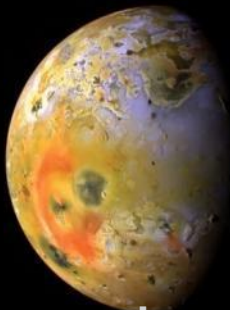
The type of thin atmosphere the Moon has may be the most common type of atmosphere in the solar system...



Mercury



Europa &
other Icy
satellites



Io



Moon



Large
Asteroids &
KBOs

We know very little about this most common type of atmosphere, but we are lucky enough to have one in our own back yard! How will we study it?



LADEE

The Lunar Atmosphere and Dust Environment Explorer

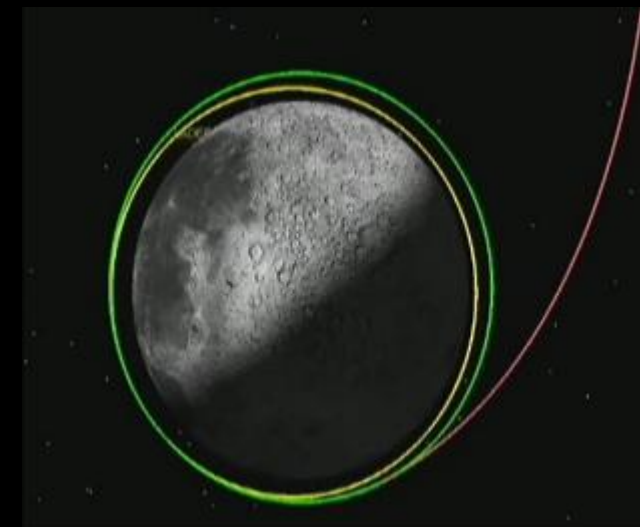
- A robotic spacecraft that will orbit the Moon and then dip down low to fly through the lunar atmosphere.
- It will sample the atmosphere to see what it is made of, what its structure is and how it changes over time.
- It will study dust that has been lifted up into the lunar atmosphere.
- The time to make these observations is now, before continued exploration alters the thin and fragile lunar atmosphere.





LADEE Mission Profile

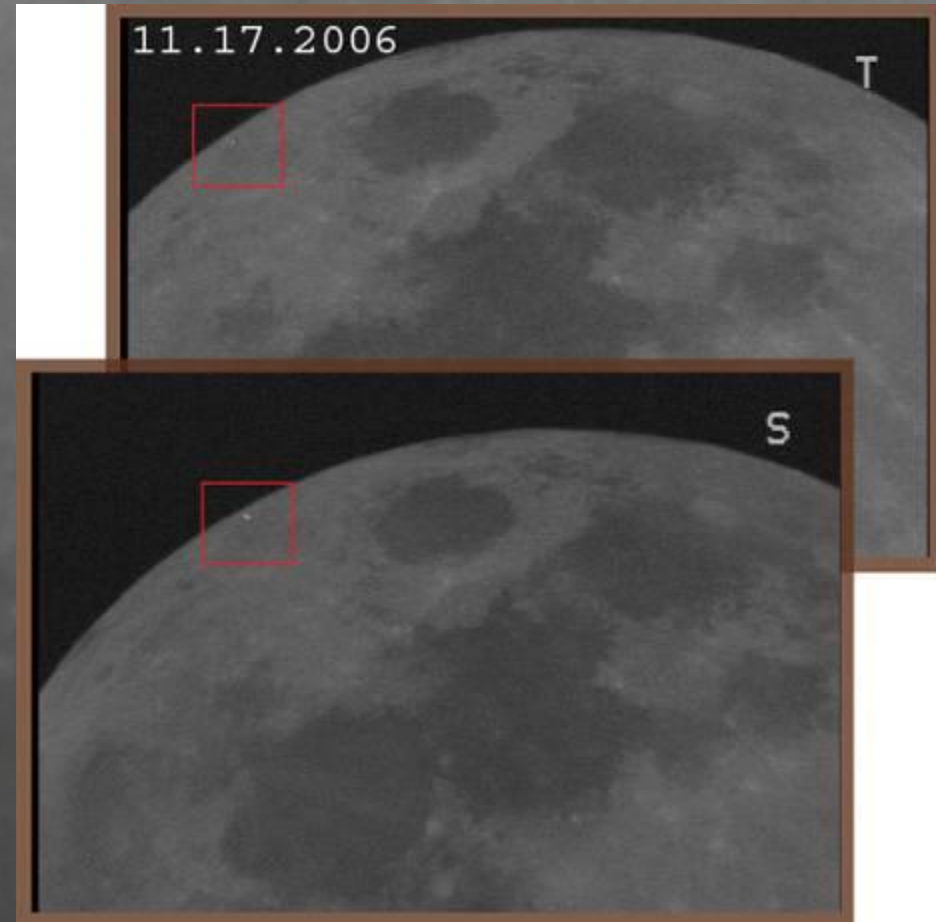
- Launch in 2013 from Wallops Flight Facility in Virginia.
- LADEE will be the first mission to fly on the new Minotaur V rocket.
- Once it gets to the Moon and settles into its working orbit, it will conduct a 100-day science mission at ~20-75km.





LADEE and Lunar Impacts

We think meteoroid impacts may be one of the major sources of the lunar atmosphere and dust. Observations of the flashes of meteoroid impacts on the Moon can be made using 8 to 14 inch diameter telescopes, the kind of telescopes that some schools and many amateur telescopes have. These observations could be very valuable to the LADEE mission.





Meteor Counting

- Even if you don't have a telescope, you can still participate in the science of the LADEE mission!
- The vast majority of meteoroids impacting the Moon are too small to be observable from Earth.
- Small meteoroids encountering the Earth's atmosphere can result in easily-observable meteors.
- Conducting counts of meteors during the LADEE mission will allow us to estimate what is happening on the Moon at that time.



Image credit: NASA/ISAS/Shinsuke Abe and Hajime Yano



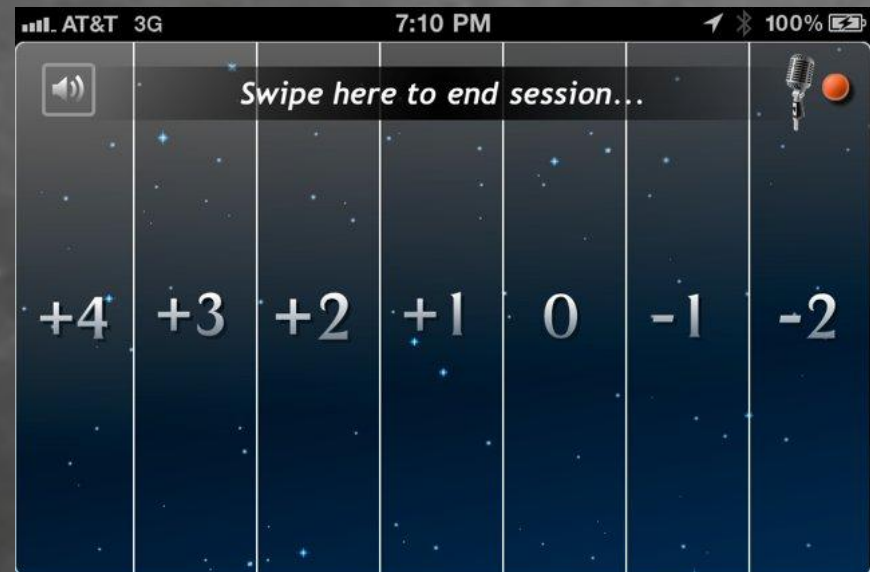
Meteor Counter

Available on the
App Store

For iPhone, iPad & iPod Touch



<http://meteorcounter.com/>







Lunar Sample Educational Disk Program

Six samples of lunar material (three soils and three rocks) encapsulated in a six-inch diameter clear lucite disk are available for you to borrow and bring into your classroom. The disk is accompanied by written and graphic descriptions of each sample in the disk.

Mr. Louis Parker

JSC Exhibits Manager

National Aeronautics and Space Administration

Lyndon B. Johnson Space Center

Mail Code AP

2101 NASA Parkway

Houston, Texas 77058-3696

Telephone: 281-483-8622

FAX: 281-483-4876

E-Mail: louis.a.parker@nasa.gov



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

+ Visit the NASA Portal
+ S.O.N. Home

TaSS HOME

SUN-EARTH VIEWER

TRACKING THE PERFECT STORM

◆ SPACE WEATHER RESOURCES



Student Observation Network:
Tracking a Solar Storm

SUNSPOT REGIONS



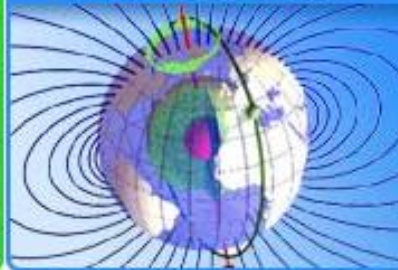
Do sunspot regions exist today that could be a source of solar storms?

STORM SIGNALS



Have storm signals been recorded today due to a solar storm that could affect Earth?

MAGNETOSPHERE



Has there been a measurable disturbance in the Earth's magnetic field?

AURORAS



Have auroras been seen within the last 24 hours due to a solar storm?

- Solar radiation and particles play key roles in the production of the lunar atmosphere.
- Your students can track the development of solar storms using data from student observations, observatories, and spacecraft.
- <http://son.nasa.gov/tass/>



THE ROYAL OBSERVATORY GREENWICH PRESENTS

SOLAR STORMWATCH

HOME

WHY SCIENTISTS NEED YOU

MISSION BRIEFING

SPOT & TRACK STORMS

TALK ABOUT IT

Solar scientists need you!

Help them spot explosions on the Sun and track them across space to Earth. Your work will give astronauts an early warning if dangerous solar radiation is headed their way. And you could make a new scientific discovery.

GET STARTED

Photo by NASA

- Your students can help interpret data from NASA's STEREO (Solar TERrestrial RELations Observatory) spacecraft.
- <http://www.solarstormwatch.com/>



Impact Cratering: A major force in shaping the surface of the Moon and a potentially important source for the lunar atmosphere.

Cratering the Moon

NASA Quest Challenge Educator Guide



<http://quest/challenges/lcross/>





Cratering the Moon

NASA can simulate cratering impacts at the Ames Vertical Gun Range. Allows study of:

- Different impactor shapes, masses and compositions
- Different impact velocities and angles
- Different target compositions and structures





In the Cratering the Moon activity, students design their own lunar impact simulator. They conduct a study to determine what role the angle of incidence of an impact plays in determining how effective an impactor is in excavating material from beneath the Moon's surface.





Fresno Co. Juvenile Justice Campus



Student-designed lunar impact simulator

- 3 teams totaling 60 students creating designs around LCROSS Impact the Moon Challenge.
- Demonstrates continued utilization of resources.
- Successfully engaging a particularly challenging student audience.



International Observe the Moon Night (InOMN)

- World-wide celebration of the Moon and lunar science.
- Events held at NASA centers, museums, and schools.
- InOMN 2010 and 2011 each featured over 500 events in more than 50 countries.
- InOMN 2012 will occur on Saturday, September 22.
- NASA programming streamed to local events.
- Visit <http://www.observe-themoonnight.org/> to find an event near you or to learn how to conduct your own event.





Additional Reading from NASA Science News

NASA Mission to Study the Moon's Fragile Atmosphere: Overview of the lunar atmosphere and the LADEE mission.

http://science.nasa.gov/science-news/science-at-nasa/2009/23oct_ladee/

Moon Storms: How results from from the Apollo missions provides evidence of levitated lunar dust.

http://science.nasa.gov/science-news/science-at-nasa/2005/07dec_moonstorms/

Moon Fountains: Describes the "fountain model" of levitating moondust.

http://science.nasa.gov/science-news/science-at-nasa/2005/30mar_moonfountains/

Don't Breathe the Moondust: Examines the potential toxicity of lunar dust.

http://science.nasa.gov/science-news/science-at-nasa/2005/22apr_dontinhale/

Crackling Planets: The electrostatic hazards of lunar and Martian dust.

http://science.nasa.gov/science-news/science-at-nasa/2005/10aug_crackling/

En Route to Mars, the Moon: How learning to cope with lunar dust may help us in future explorations of Mars.

http://science.nasa.gov/science-news/science-at-nasa/2005/18mar_moonfirst/



Selected Online Resources

LADEE – <http://www.nasa.gov/ladee>

NASA Lunar Science Institute - <http://lunarscience.arc.nasa.gov/>

Exploring the Moon - http://www.nasa.gov/pdf/58199main_Exploring.The.Moon.pdf

Lunar and Planetary Institute - <http://www.lpi.usra.edu>

My Moon - <http://www.lpi.usra.edu/mymoon/>

Explore! - <http://www.lpi.usra.edu/education/explore/>

LRO - <http://www.nasa.gov/lro>

Solar System Exploration at JPL - <http://sse.jpl.nasa.gov>

Year of the Solar System - <http://solarsystem.nasa.gov/yss/>

Lunar Samples Program - <http://curator.jsc.nasa.gov/lunar/index.cfm>

Moon Zoo - <http://www.moonzoo.org/>

Tracking a Solar Storm - <http://son.nasa.gov/tass/>

Solar Stormwatch - <http://www.solarstormwatch.com/>

LCROSS Cratering the Moon - <http://quest/challenges/lcross/>

Lunar Impact Monitoring –

http://www.nasa.gov/offices/meo/outreach/lunar_impact_monitoring_detail.html

International Observe the Moon Night - <http://www.observethemoonnight.org/>

Meteor Counter - <http://meteorcounter.com/>

GRAIL MoonKAM - <https://moonkam.ucsd.edu/>



Questions