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Recent Lunar Science Discoveries and an Opportunity to Celebrate Them

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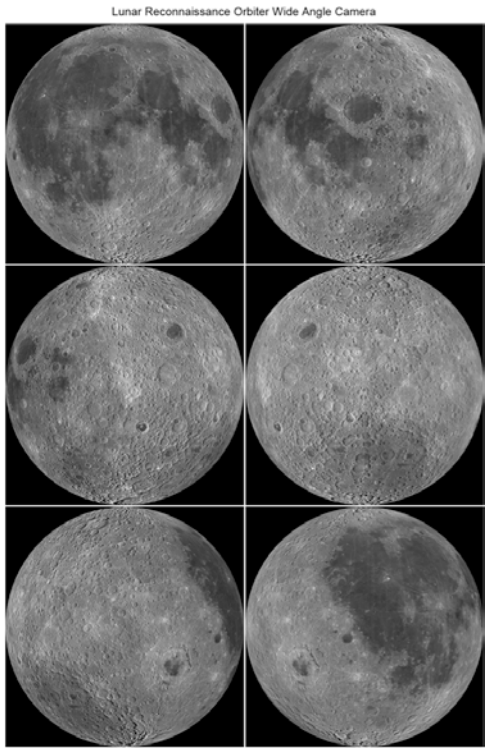
NASA's Lunar Reconnaissance Orbiter

Much of the Moon's surface is ancient. Many Moon rocks record ages over 4 billion years old [e.g. see Reference 1]. Yet NASA's Lunar Reconnaissance Orbiter (LRO) spacecraft is revealing a world that is not as static or dry as we once thought. Global high-resolution data and images from LRO have enabled us to make new discoveries about the Moon, overturning paradigms and revolutionizing our understanding of Earth's nearest neighbor.

With the LRO Camera and the Lunar Orbiter Laser Altimeter, we now know the shape of the Moon's solid surface better than any other object in the Solar System — including the Earth [e.g. see Reference 2]. (Our sea floor topography data is lower resolution than topography data of the lunar surface.) The Moon boasts the coldest place ever measured in the Solar System, with a temperature of -248°C (about 24 Kelvin) [3]. (Yes, that is even colder than Pluto!) We have discovered over 230 lunar pits [4], which may one day provide radiation protection for astronauts on the Moon, and generated maps of the unusual illumination conditions at the lunar poles, with areas in near-constant shadow beside areas with near-constant sunlight [5]. Images and data from LRO continually improve our understanding of impact crater science. This data also provides enhanced context for lunar samples returned from the Apollo astronauts.



Our new, global, high-resolution view of the Moon with NASA's Lunar Reconnaissance Orbiter Camera. Shown here are six orthographic views of the Moon created from the LRO Wide Angle Camera's global mosaic. From upper left to lower right the central longitude is 0°, 60°, 120°, 180°, 240°, 300°. Credit: NASA/Goddard/Arizona State University.

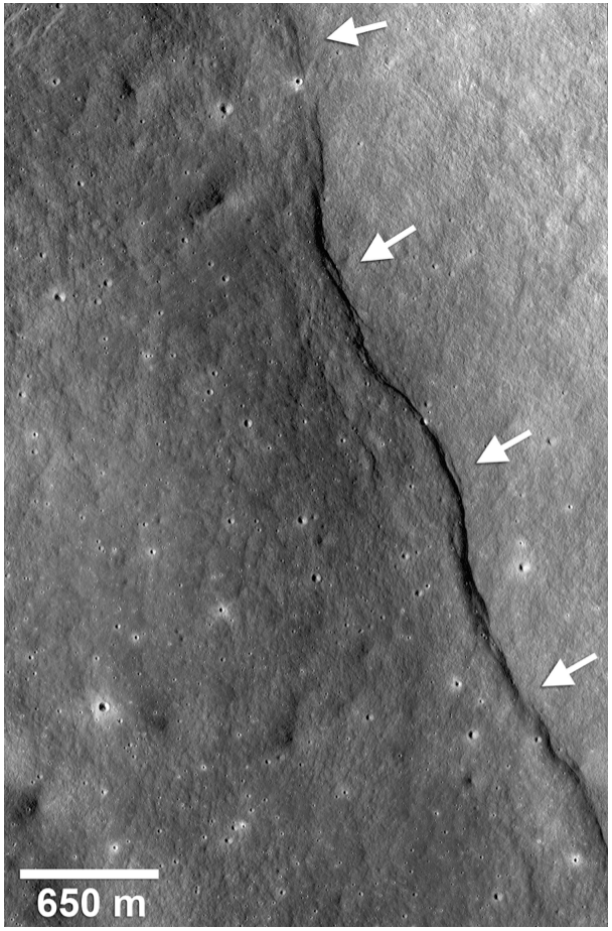
Recent Activity on the Moon

Some of the most exciting results from LRO reveal recent activity on the Moon. Data from LRO provide evidence that the Moon has been geologically active in the shockingly recent past. Cliffs in the lunar crust created by thrust faults indicate the Moon shrank globally in the geologically recent past, and may still be shrinking today [6]. Prior to LRO, the commonly accepted end of lunar volcanism was 1 to 1.5 billion years ago. Now there is evidence of lunar volcanism within the past 100 million years — perhaps within 50 million years [7].

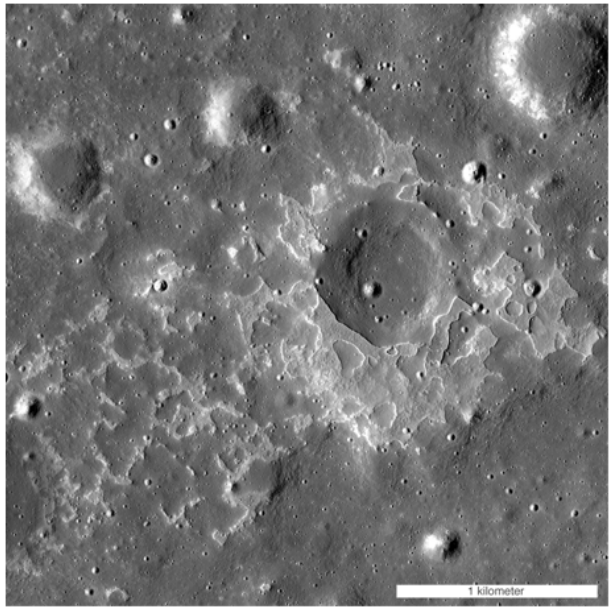
LRO provides increased evidence of water on the Moon–at the poles, on pole-facing slopes, and around the globe–with models indicating movement of water across the lunar surface [e.g. see References 8, 9, 10, 11].

With LRO's cameras, we are watching new

impact craters form on the Moon [12]. Finding and analyzing new impact craters helps us better understand the objects available to form new impact craters and the current impact cratering rate in the inner Solar System, which we use to date planetary surfaces. Generally, the more craters found on a planetary surface and the larger the craters are, the older the surface is considered to be.



In recent geologic time, as the Moon's interior cooled and contracted, the Moon's radius shrank by about 100 m. The contraction caused thrust faulting, which formed cliffs around the Moon. This example of a thrust fault scarp is in the farside impact crater Gregory (2.1°N, 128.1°E). Mapping the distribution and determining the size of all of these scarps will help scientists reconstruct the tectonic and thermal history of the Moon. Image credit: NASA/Goddard/Arizona State University/Smithsonian.

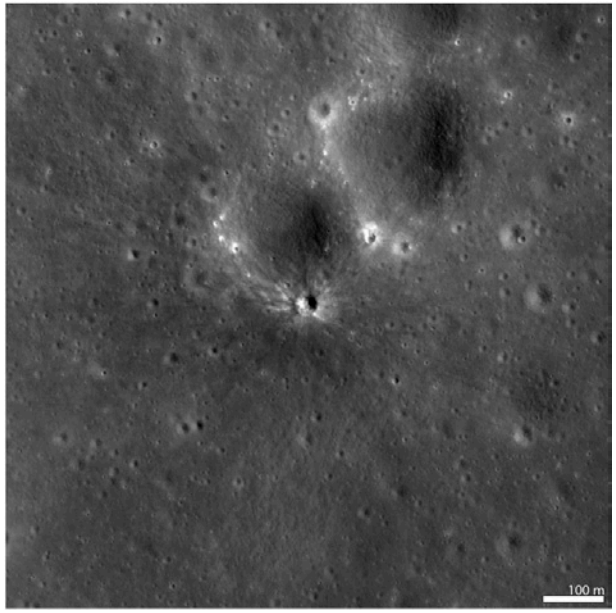


The high-resolution images from the Lunar Reconnaissance Orbiter's Narrow Angle Cameras are revealing young volcanic deposits around the Moon. The sharp details seen in their surfaces and their general lack of large (>20 meter-diameter) superimposed impact craters indicate that these deposits likely formed in the past 100 million years – or even more recently. This young volcanic deposit is found near the crater Maskelyne (4.330°N, 33.750°E). Image credit: NASA/Goddard/Arizona State University.

These lunar science discoveries — and more — can be highlighted and celebrated in a global public observing event: International Observe the Moon Night.

International Observe the Moon Night

International Observe the Moon Night (InOMN) is a worldwide, public celebration of lunar science and exploration held annually since 2010. One day each year, everyone on Earth is invited to observe and learn about the Moon together, and to celebrate the cultural and personal connections we all have with Earth's nearest neighbor. Everyone, everywhere is invited to participate, and anyone, anywhere can host an InOMN event. Each year, thousands of people participate in InOMN at institutions, parks, and backyards around the world. Events range from small family gatherings to community events drawing hundreds of visitors. InOMN events



The Lunar Reconnaissance Orbiter has been capturing images of the Moon since 2009. Each image is a narrow strip of the lunar surface, but over time, coverage builds. Repeat imaging of the same spot sometimes reveals changes – such as the formation of a new impact crater. A bright flash seen through an Earth-based telescope on 11 September 2013 sent the LRO Camera team on a search for a new impact crater believed to have caused the flash. They found it. In images acquired in March and April of 2014, the team discovered the approximately 34-meter-diameter impact crater that caused the brightest flash yet captured by the "Moon Impacts Detection and Analysis System" (MIDAS). Crater location: (17.167°S, 339.599°E). Image credit: NASA/Goddard/Arizona State University.

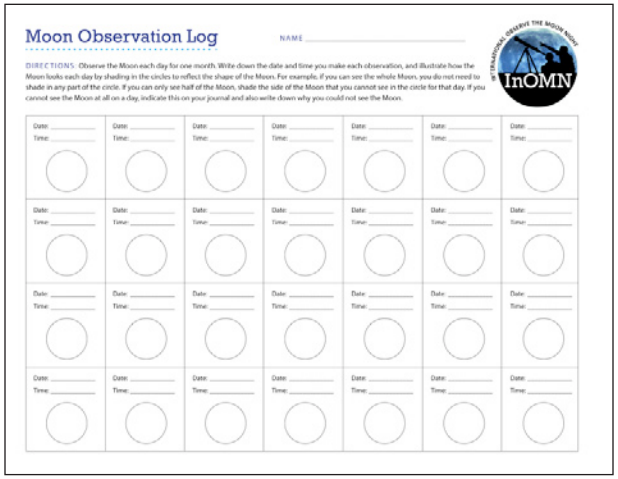
2015 International Observe the Moon Night event map. 545 InOMN events were registered in 54 countries around the world. Since 2010, 98 countries and 49 US states (and Washington D.C.) have hosted 3,284 registered InOMN events, reaching approximately 450,000 people.

do not need to follow a set agenda: hosts can tailor their events to match their available resources and expertise, and the needs and interests of their audience. The seventh annual International Observe the Moon Night is October 8, 2016. Go look at the Moon! And invite your students and their families to join you.

InOMN is an excellent opportunity to share lunar science and exploration with your students and your community, and enhance the exposure to space science topics students receive in the classroom.

The InOMN website (*observethemoonnight.org*) has resources to help event hosts, including step-by-step suggestions for hosting an InOMN event, customizable flyers, presentation materials, certificates of participation, evaluation materials, and links to information about lunar science and exploration and to connect with lunar enthusiasts around the world through social media. The InOMN team offers professional development for hosts, highlighting NASA lunar and planetary science research that hosts can share with their visitors. The InOMN website also includes activity suggestions, which can be done at InOMN events or in classrooms before or after InOMN. A permanent resource is a printable Moon observation journal that can be distributed at InOMN events, or by teachers in support of InOMN. Students can track the Moon through its phases and changing position in the sky for a month (a full lunar cycle), and then reflect on their observations.

InOMN is usually held in the fall, when the Moon is around first quarter. Fall in the Northern Hemisphere is generally a good time for a lunar observing event, because of the weather and school scheduling, and a first quarter Moon is visible in the afternoon and evening, a convenient time for most hosts and participants. Furthermore, the best observing is typically along the dusk/dawn terminator, where shadows are the longest, not at full Moon. The InOMN team creates a new Moon map each year showing the exact phase it will be on InOMN, and highlighting a few features of interest with high-resolution images and captions. While hosts are encouraged to hold InOMN events on the announced date, we understand that this isn't always possible — InOMN materials are editable so that hosts can change the date and add the location of their events.


Moon Observation Log

NAME

DIRECTIONS: Observe the Moon each day for one month. Write down the date and time you make each observation, and illustrate how the Moon looks each day by shading in the circles to reflect the shape of the Moon. For example, if you can see the whole Moon, you do not need to shade in any part of the circle. If you can only see half of the Moon, shade the side of the Moon that you cannot see in the circle for that day. If you cannot see the Moon at all on a day, indicate this on your journal and also write down why you could not see the Moon.

Resource available on the International Observe the Moon Night website. This printable Moon observation journal that can be distributed at InOMN events, or by teachers in support of InOMN. This side of the journal provides a space for students to record their observations of the Moon's phases and the time they see the Moon in the sky over the course of a month: a full lunar cycle. Questions for reflection are provided on second page of the journal.

Schools, and all hosts, are welcome to host either public or private events. Public events are listed on the InOMN website with an address, so that anyone interested in participating in an InOMN event may find them. Private events are still listed as part of the global celebration, but without information that would allow non-members to join.

Telescopes and binoculars are not required to view the Moon, but they add to the observing experience. If your school does not have a telescope, or if you would like additional observing support, try contacting your local astronomy club. Many clubs are eager to partner with other institutions to host InOMN events. The Find Partners link (under Get Involved) on the InOMN website will help you connect to your local astronomy club. Here you can also find links to the NASA Speakers Bureau and the NASA Solar System Ambassadors, other groups who might be willing to give presentations or provide other support for your event.

The Moon is a gateway to the Solar System and beyond, so hosts are encouraged to also observe

Telescopes and binoculars are not required to view the Moon, but they add to the observing experience. If you would like additional equipment and expertise to assist in astronomical observing at your event, try enlisting support of a local astronomy club. Image credit: NASA/Goddard.

and discuss planets and other celestial objects and events. InOMN provides a perfect opportunity to highlight another Moon-related event not to be missed in North America the following summer: the total solar eclipse of August 21, 2017.

Prepare for the August 2017 Total Solar Eclipse

The seventh annual International Observe the Moon Night is October 8, 2016. The following year, InOMN will be held on July 15, 2017 — about five weeks before the total solar eclipse that will cross North America on August 21. Check the InOMN website for resources that highlight lunar science that will influence the eclipse, such as the topography of the Moon, which affects the edges of the eclipse path and the location and duration of Baily's beads. You can also participate in public webinars hosted by the InOMN team, discussing the Moon, lunar science, and lunar and solar eclipses — and how to safely view a solar eclipse — in the weeks between InOMN and the August eclipse. The 2017 Moon observation journal will extend until August 21, such that observers in North America will be able to complete their journals with a solar eclipse.

To learn more about International Observe the Moon Night, register your InOMN event, and access InOMN resources, visit *observethemoonnight.org*.

Find recommendations of activities for your InOMN event, or to use in your classroom before or after InOMN, see the InOMN website and the InOMN list on NASA Wavelength: *nasawavelength.org/list/602*.

Featured Resource: Toad in the Moon

The pattern of lighter and darker features on the face of the Moon has been interpreted in many ways by different cultures. In this activity, students are introduced to some of the patterns various cultures saw in the Moon and then can create their own.

Download the activity (pdf).

Resources

NASA's Lunar Reconnaissance Orbiter:
lro.gsfc.nasa.gov
nasa.gov/lro

NASA's Lunar Reconnaissance Orbiter Camera:
lroc.sese.asu.edu

International Observe the Moon Night website:
observethemoonnight.org

Hands-on Activities Recommended for InOMN on NASA Wavelength:
nasawavelength.org/list/602

Information about and images of the Moon from NASA:
Moon.nasa.gov
nasa.gov/moon
solarsystem.nasa.gov/planets/moon

NASA's Lunar Mapping and Modeling Portal (view and analyze a wide variety of lunar image and data products from NASA missions):
lmmp.nasa.gov

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[8] Hayne et al., 2015. Evidence for exposed water ice in the Moon's south polar regions from the Lunar Reconnaissance Orbiter ultraviolet albedo and temperature measurements. Icarus, 255, 58–69.

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[12] Robinson, 2014. Another new crater! LROC featured image, 15 September 2014. lroc.sese.asu.edu/posts/810