# Exploring the lunar south pole: Lessons from Chandrayaan-3

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On August 23 the Indian Space Research Organisation (ISRO) successfully landed a spacecraft on the moon's south pole, a location that has always been of particular interest to scientists due to the unique

conditions created by the planet's extremities.

The moon rover, Chandrayaan-3, which recently completed its 14-day mission, made history by landing on the lunar south pole. Dr. Laura McKemmish, an astrochemist from UNSW Sydney, explains the significance of the mission and what the future holds for lunar exploration.

"This is the first landing of India on the moon, and it will make India the fourth country ever to land on the moon," says Dr. McKemmish. "The ability of our global civilization to go into space exploration is really, really crucial to enable humankind as a global community to explore elsewhere in the universe."

Interest in the southern pole of the moon stems primarily from the fact that scientists have been aware of the presence of frozen water there, and locating water is a large part of Chandrayaan-3's mission. "Identifying frozen bodies of water on the moon is a really important gateway for further space discovery in our solar system."

## Navigating craters, darkness and extreme temperatures

Following a failed mission to land on the moon in 2019, India joined the US, China and the Soviet Union as only the fourth country to reach this milestone.

Chandrayaan means "moon vehicle" in Hindi and Sanskrit. The vehicle took off from a launch pad in southern India on July 14 and completed a 'soft landing' on the moon nine days later. A soft landing is when the space shuttle is kept intact.

Attempts by various space agencies have been made to land on the south pole of the moon, but it's notoriously difficult to do, thanks to rugged terrain, extreme temperatures, lack of light and communication difficulties.

"Humans have been landing on the equator of the moon for more than half a century," says Dr. McKemmish. "And while a soft landing is always more technical, when the landscape is more cratered, such as it is at the south pole, that landing becomes even harder. There's also increased complexities with communication at the poles, compared to the equator."

Chandrayaan–3 will be running a series of experiments including a spectrometer analysis of the mineral composition of the lunar surface.

"Generally a moon rover will be digging up samples, taking lots of photos, and taking various spectral readings investigating how the material interacts with light," says Dr. McKemmish.

"For this mission, the spectroscopic technique used is basically focusing a laser on the surface, causing the moon rocks to become a plasma. This plasma emits colors of light depending on its composition and thus this measurement tells us a lot about the geology and history of the rock."

Already, this technique has been used to measure the presence of aluminum, silicon, calcium, iron and sulfur on the surface of the moon, as confirmed by ISRO.

Since the moon rover has completed its walk, scientists will be analyzing data looking for signs of frozen water.

## Using water to make rocket fuel

Water ice has already been definitively confirmed at the poles of the moon.

"If you think of most of the surface of the moon, it goes in and out of sunlight, making the temperature range quite large," says Dr. McKemmish. But the water at the poles has been detected in the shadows of craters, where the temperatures never reach above -250 degrees Fahrenheit, and due to the minimal tilt of the moon's rotation axis, sunlight never reaches these regions.

Initially, scientists from the University of Hawaii, Brown University and NASA used data from an instrument that was on board the Chandrayaan-1 spacecraft, launched in 2008 by the ISRO, that was uniquely equipped to confirm the presence of solid ice on the moon, without landing on it.

"Scientists first looked for water by studying the surface, as it reflects light in a different way to other geology. This was corroborated when they shone infrared light down. That's light that emits at a lower energy than our visible light, and water absorbs it at a characteristic frequency."

Water not only supports life, and could be used by astronauts stationed permanently on the moon—but it also has other important uses.

"Water can be broken down into hydrogen and oxygen," says Dr. McKemmish. "As well as allowing us to breathe, oxygen has some other essential ways in which it can support humans. In particular, oxygen and hydrogen together are a fuel that can power spacecraft built from material on the moon to missions to other parts of the solar system."

Use of moon-based material and fuel is significant because getting anything from Earth's gravitational pull up into space is really expensive, as it requires a huge amount of energy.

"Anything that you can create or find on somewhere like the moon, which has much lower gravity, means it's much cheaper and this could make it far easier to pursue a human mission to Mars.

"This work is building towards a permanent base on the moon, like how there is permanent human presence on the International Space Station. It's about moving towards constructing spacecraft in orbit, because it's a lot cheaper if we can do things in space."

## Lessons from Chandrayaan-3

While this mission has been a historic moment in itself, it has also acted as a gateway to further discovery.

As Dr. McKemmish explains, exploring the south pole of the moon is exploring a new region of the planetary surface. "If you think about Earth, Antarctica is completely different than the middle of the Australian desert, which is completely different from the Amazon rainforest.

"And obviously, life creates some of this variation. But even without life, there's a lot of variability on earth, and that tells us a lot of interesting things about the history."

Dr. McKemmish emphasizes that the surface of the moon is not all homogenous. "It is fascinating scientifically to understand the diversity of the moon's different environments, but it is also important economically. Beyond the crucial presence of water in the south pole regions, we are really interested in knowing if there are regions near these water deposits that are particularly metal rich. This would be a perfect location for a future moon base."

Importantly, it's also telling a story where space isn't dominated by a few

countries, but invites a more global community into exploring space. Since the Chandrayaan–3 spacecraft mission, the ISRO has already launched a rocket to study weather patterns from the sun.

"Australia is a reasonably small country worldwide, and we thought it was important enough to create a space agency," says Dr. McKemmish. "In fact, the Australian Space Agency is launching a moon rover on the Artemis mission as soon as 2026. And you can even take a crack at naming the spaceship."

Provided by University of New South Wales

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