

Chandrayaan-3: scientists say water ice easier to find on moon than believed

Researchers from the Physical Research Laboratory, Ahmedabad, have used data from the ChaSTE instrument to report a larger area of the moon where water ice can be easily accessed

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SHREEJAYA KARANTHA



This image captured by the Chandrayaan-2 orbiter shows the location of Shiv Shakti point, where the Vikram lander of the Chandrayaan-3 mission descended, and the surrounding terrain. The position of the sun is revealed by the orientation of the shadows. | Photo Credit: ISRO

As countries like the US, China, Russia, and India develop plans for long-term stations on the moon, water available on the moon itself is emerging as a vital resource. Aside from meeting the drinking and sanitary needs of astronauts, scientists are also working on using moon water as fuel for rockets launched from the natural satellite.

In a new study, researchers from the Physical Research Laboratory (PRL) in Ahmedabad have found that the area of the moon where water ice can be easily accessed is greater than expected.

Their study aims to provide a more detailed understanding of the moon's thermal environment and ice distribution, laying the groundwork for future exploration and habitation strategies.

Data from Vikram

The first step to understand how much water there could be on the moon is to know the temperature on the surface.

Scientists also need this detail if astronauts are to withstand the moon's natural environs: moon-days are intensely hot while nights are frigidly cold, it lacks an atmosphere, and it is more threatened by deadly solar flares from the sun than the earth.

The new study marks a significant advance on this front. It is based on ground-level observations made by Chandrayaan-3, the Indian Space Research Organisation (ISRO) mission whose Vikram lander touched down on the moon in August 2023.

A team of researchers led by PRL scientist K. Durga Prasad has uncovered insights of temperature variations on the moon's surface and at depths of up to 10 cm.

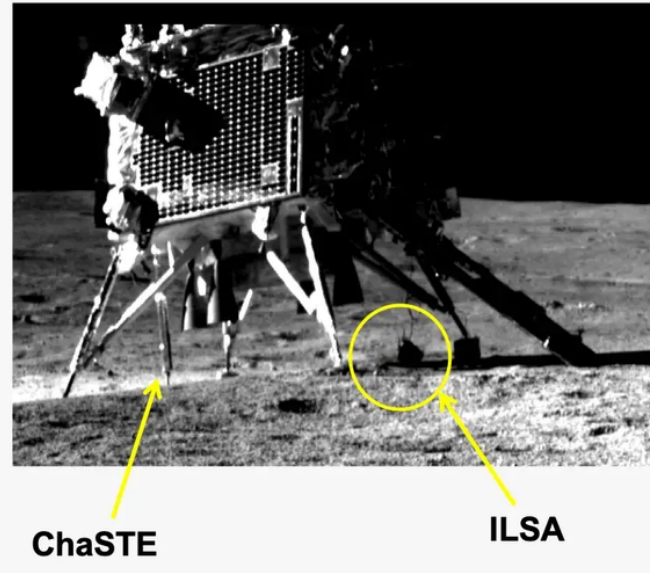
The findings were published in a **March 6 paper** in the journal *Communications Earth & Environment*.

Use of RTD sensors

Using the Chandra's Surface Thermophysical Experiment (ChaSTE) onboard the Vikram lander, the researchers conducted an *in-situ* (directly at the site) experiment to measure the temperature of the top 10 cm of lunar regolith at 69.373° south and 32.319° east. This spot is Shiv Shakti point, where Vikram landed. It is located in the moon's south pole region.

Vikram as seen by Pragyan

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This image collage shows the location of the ChaSTE instrument onboard the Vikram lander. The lander was photographed by the Pragyan rover. | Photo Credit: ISRO

The ChaSTE instrument is equipped with a thermal probe, which the lander deployed and penetrated into the lunar soil. According to Prasad, 10 “custom-designed platinum resistance temperature detector (RTD) sensors with very high accuracy in the entire range of measurement” are mounted on the ChaSTE probe. RTDs are a type of temperature sensor that measure temperature by detecting changes in electrical resistance.

The team used ChaSTE to acquire RTD signals and convert them into digital data.

The team collected temperature data from ChaSTE for approximately 10 earth days, from August 24 to September 2, 2023, which is about eight hours of a lunar day. The diurnal lunar temperature values, i.e. the range between day and night, were obtained using an established 3D thermophysical model developed by PRL, Prasad added.

The ground truth

The team found the peak surface temperature at the site to be 82° C. Prasad said, “The *in-situ* temperature profile itself was surprising” because it recorded higher temperatures than those predicted by the Diviner instrument onboard NASA’s Lunar Reconnaissance Orbiter (LRO).

The temperature was also found to drop drastically to roughly -181°C at night. “It was exciting to know that actual surface temperature at high latitude locations can go to both high and low extremes,” Prasad said.

Higher latitude regions are those located farther from the equator.

He added that a large temperature difference observed between day and night means the lunar surface could harbour unique thermophysical properties.

Significant change

The team attributed the higher-than-expected daytime temperature to the sun-facing slope of the location. But it was still intrigued enough to investigate the temperature at points that were sloped in other directions.

Due to their higher exposure to the sun, water is not likely to be found in the sun-facing slopes.

To investigate lunar temperatures at different locations with different orientations, the team built a model based on the ChaSTE measurements. They found that the surface temperature at a flat site around a metre away from the ChaSTE instrument’s position was 58.85°C . This value agreed with orbiter-based remote-sensing observations.

That the temperature at Shiv Shakti point was 82°C and just a metre away dipped to 58°C implied lunar surface temperatures vary significantly at metre scales. Further investigations by the team showed that larger slopes that faced away from the sun and had a tilt of more than 14° could maintain lower temperatures, creating conditions suitable for water ice to migrate and stabilise beneath the surface.

In other words, since water ice can exist within the shallow subsurface at certain high latitudes as well, the team’s findings indicate the resource can be accessed from more places on the moon than previously believed.

First of its kind

The study presents the first *in-situ* measurements of temperature at a high latitude region on the moon, offering accurate data on surface and near-surface temperatures close to the polar regions, according to Prasad.

Scientists previously thought water ice existed in stable quantities only at the moon's poles. The study has shown that certain higher latitude locations may provide a similar environment as near the poles for water ice to accumulate at shallow depths.

“This becomes an interesting finding as exploration of high latitude regions is less technically challenging than that of lunar poles, an important aspect for future *in-situ* exploration and human activities on the moon,” Prasad said.

Based on the temperature profiles obtained from ChaSTE measurements, the team is currently studying the thermophysical properties of the lunar surface, including how it affects lunar temperatures. Through this, Prasad said, they can “model the migration and stability of the water-ice for other different representative locations on the moon”.

This can lead to a comprehensive understanding of the moon's thermophysics and its near-surface and sub-surface water-ice distribution.

Shreejaya Karantha is a freelance science writer and a content writer and research specialist at The Secrets of The Universe.

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