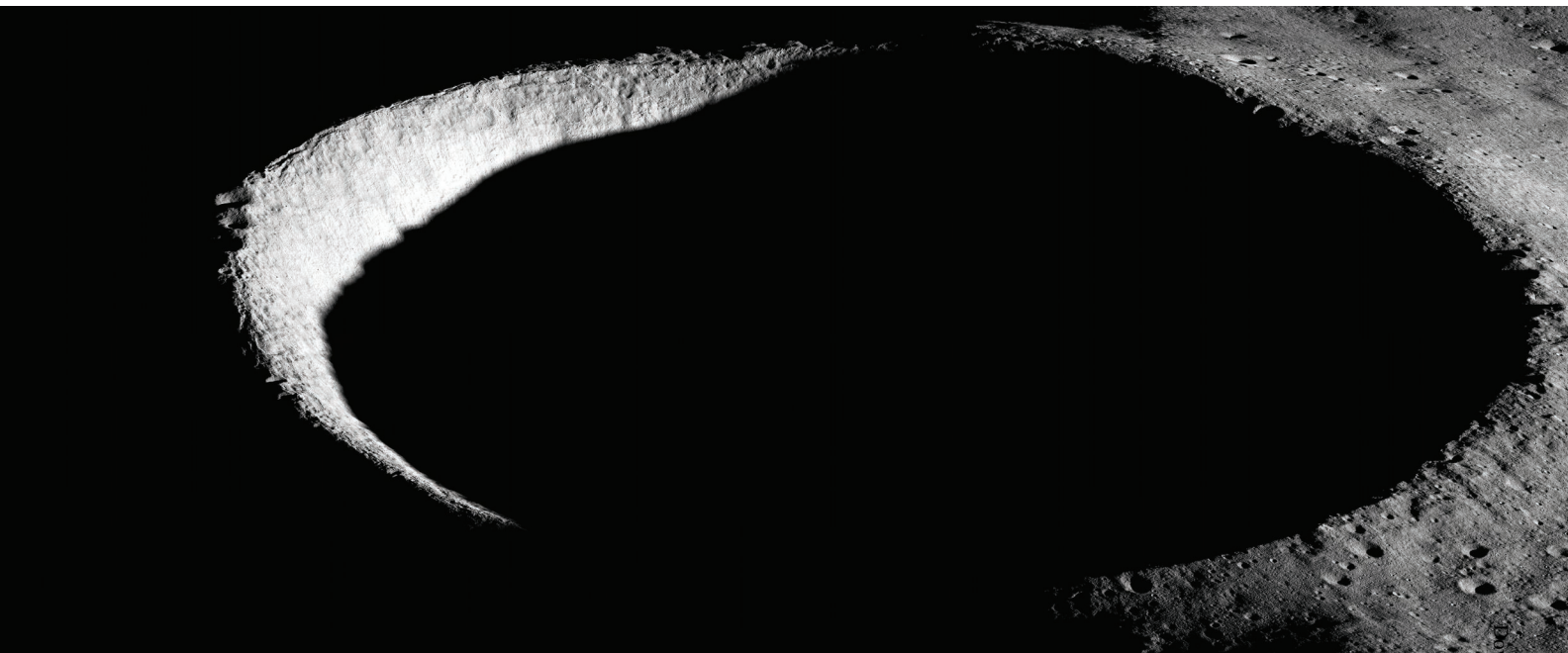




PLANETARY SCIENCE

China mission aims to probe the Moon's hidden water

Chang'e-7 will send a hopping craft into a polar crater to directly sample lunar ice **DENNIS NORMILE**

Shackleton crater, in permanent shadow near the Moon's south pole, may be Chang'e-7's target in its hunt for ice.

Over decades, lunar orbiters have amassed evidence that the Moon's polar craters hold stores of water, locked up as ice. But no mission has directly sampled these frozen deposits to determine how much ice is there, how it is distributed, or how it got there in the first place. As early as next week, China will launch Chang'e-7, a robotic mission designed to address those questions by sending a thruster-powered "hopping" probe into a crater near the lunar south pole, among the coldest, darkest places in the Solar System.

The practical stakes of the hunt for ice are high. China and NASA are racing to build the first crewed lunar outposts early next decade. Ice deposits could provide drinking water, breathable oxygen, and hydrogen for rocket fuel. The craters may contain other valuable volatiles, such as helium-3, a rare isotope used in cryogenics and proposed as a fusion fuel. Lunar base planners are eyeing "the strategic use of these potential resources," says Carolyn van der Bogert, a planetary geologist at the University of Münster.

Chang'e-7 would also extend China's remarkable run of lunar

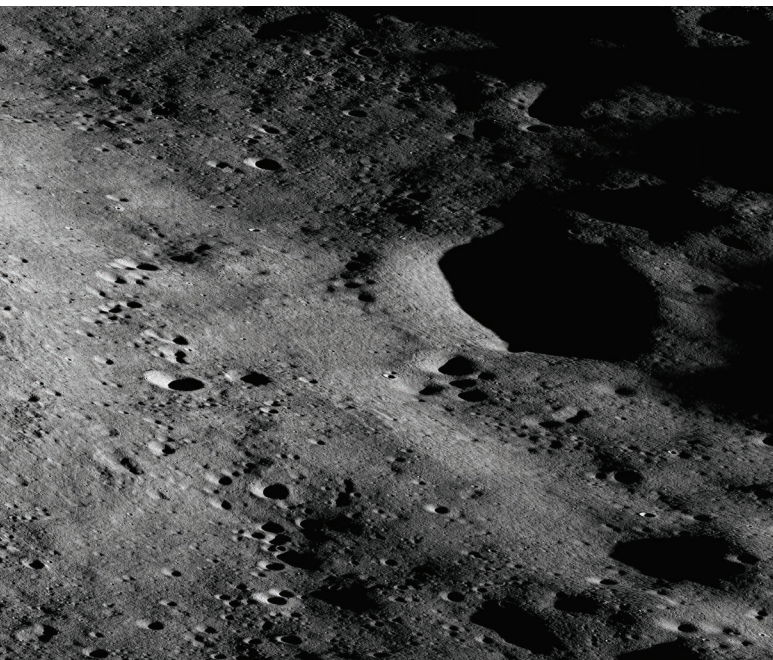
successes. "Chinese scientists didn't know what we could achieve" in lunar science, says Yuqi Qian, a planetary geologist at the University of Hong Kong. But with the Chang'e missions, named after a Chinese Moon goddess, China "grew its capabilities step by step," he says, progressing from orbiters to landers, rovers, and, most recently, the first sample return from the Moon's far side.

Rocks returned by the Apollo missions of the 1960s and '70s have long suggested sunlit regions of the Moon are nearly bone dry. But in the 1990s, NASA's Clementine and Lunar Prospector orbiters found the first compelling evidence of ice in permanently shadowed polar craters, which could trap water and keep it frozen for billions of years. Because these craters never receive sunlight, the spacecraft relied on indirect measurements. Clementine detected bright radar reflections consistent with ice, and Lunar Prospector found unusually high concentrations of hydrogen—a likely sign of buried ice. However, later studies raised questions about the claims.

A more direct line of evidence came in 2009, when NASA's Lunar Crater Observation and Sensing

Satellite mission sent a spent rocket stage crashing into a shadowed crater. A trailing spacecraft flew through the impact plume and confirmed the presence of water vapor and other volatiles. "However, it didn't provide many details about the geological setting of the water ice," van der Bogert says. Major questions remained: How much ice is there? Is it pure or mixed with soil? And how deep is it? "How water ice is distributed with depth is the major unknown," says Shuai Li, a planetary geologist at the University of Hawaii at Manoa.

That's where Chang'e-7 comes in. The mission includes an orbiter, lander, rover, and the hopping probe, all supported by a previously launched communications satellite. The preferred landing site is on the rim of Shackleton crater, where nearly continuous sunlight can power the mission's components while permanently shadowed terrain lies only a short distance away. Using small thrusters, the hopping probe will explore cratered terrain too steep for the rover. It will drill as deep as 1 meter into the frozen soil, heat the samples, and analyze the gases they release.



RESEARCH INTEGRITY

Hundreds of paper-mill papers peddled in ads were later published

More than one-fifth of papers at some IEEE conferences appear linked to authorship for sale **JEFFREY BRAINARD**

One Facebook ad touted authorship spots on a conference paper about using online technology to manage soil fertility. For the equivalent of about \$64, a buyer could be the paper's fifth author; for \$87, first author. The same ad offered similar terms for spots on other papers, on topics such as traffic management and industrial automation, all to be published at conferences run by the nonprofit computer science and engineering society IEEE. And that ad was just one of hundreds.

In recent years, research integrity sleuths have become familiar with these types of ads, for IEEE conference proceedings and other publishers' journal articles. But it has been difficult to track down whether scientists have actually bought the author slots, and whether these suspect papers have ultimately made it into print.

Now, a study reports that such ads appear to have plenty of takers among IEEE conference participants: Out of 4407 unique paper titles listed in ads from 2021 to '25, nearly half, or 2062, matched papers later published. (In computer science, full papers are often published in conference proceedings.) These are just a small fraction of the 300,000 conference papers IEEE publishes each year, but some meetings may be particularly vulnerable. At IEEE conferences that published at least 25 papers linked to ads, they made up more than 10% of all the meeting's articles, and at three of those conferences, more than 20%, according to the study, posted on 11 August on the arXiv preprint server by social scientist Anna Abalkina of the Free University of Berlin and colleagues.

The study does not prove any IEEE authors paid for their authorship slots. Still, it represents "very important and meticulous work" extending what's known about paper mills, shadowy businesses that sell fake authorships or manuscripts, says Guillaume Cabanac, a computer scientist at the University of Toulouse who has studied publication misconduct.

IEEE's director of publishing ethics and conduct, Luigi Longobardi, says, "We are really grateful for the work" by Abalkina's team. "These are issues that we are aware of and that we are working on."

The researchers focused on ads mentioning IEEE because of the publisher's history of retracting conference papers with research integrity problems. These retractions, which Cabanac and colleagues have calculated total more than 17,000 since 2002, exceed those of any other publisher.

The ads identified as part of the new study appeared on more than 200 social media accounts, some of which appear to specialize only in authorship offers for IEEE papers.

The measurements will do more than confirm the presence and abundance of water. Instruments on the hopper will gauge the ratio of ordinary hydrogen to its heavier isotope, deuterium—a chemical fingerprint that can help distinguish among competing ideas for the ice's origin. Some scientists think the polar ice was delivered by ancient comet and asteroid impacts, whose water tends to be relatively rich in deuterium. Others argue that a substantial fraction formed on the Moon itself, as hydrogen ions from the solar wind reacted with oxygen in lunar minerals. Because solar wind hydrogen is strongly depleted in deuterium, that process would leave a much weaker deuterium signal. Water released from the Moon's interior by ancient volcanic eruptions would be expected to carry an intermediate isotopic signature.

Although the ice deposits may contain water from all three sources, the isotope measurements could reveal which contributed the most to the polar craters. Knowing where the water came from would provide important clues to the Moon's formation and evolution, says Qian, who is not a member of the Chang'e-7 team but studies Chang'e data and samples.

Like Lunar Prospector, the Chang'e-7 orbiter will map hydrogen from above, by detecting neutrons generated when cosmic rays strike the lunar surface. Hydrogen slows those neutrons before they escape to space, so regions that emit fewer are inferred to contain more hydrogen—and more water. Comparing orbital and surface measurements will provide what Qian calls "very precious ground truth," and could also enable reinterpretation of decades of previous orbital observations.

Chang'e-7 won't have the lunar south pole to itself for long. NASA's VIPER rover, the European Space Agency's PROSPECT drilling package, and the Japan-India LUPEX rover all aim to investigate ice there over the next several years, drilling up to 1.5 meters beneath the polar surface for samples. Each spacecraft has unique capabilities, "but the science that will come out of [these missions] is certainly complementary," says PROSPECT project scientist David Heather.

Collectively, they promise to probe the Moon's least explored but most intriguing landscape, revealing how the lunar poles acquired their water—and whether it could sustain humanity's return. □



China mission aims to probe the Moon's hidden water

Dennis Normile

Science **393** (6813), . DOI: 10.1126/science.ael6248

View the article online

<https://www.science.org/doi/10.1126/science.ael6248>

Permissions

<https://www.science.org/help/reprints-and-permissions>

Use of this article is subject to the [Terms of service](#)

Science (ISSN 1095-9203) is published by the American Association for the Advancement of Science. 1200 New York Avenue NW, Washington, DC 20005. The title *Science* is a registered trademark of AAAS.

Copyright © 2026 The Authors, some rights reserved; exclusive licensee American Association for the Advancement of Science. No claim to original U.S. Government Works