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Space exploration

To the moon and back

China's most advanced lunar mission yet will fill gaps in the moon's history and could be a dry run for sending humans, reports **Donna Lu**

CHINA has launched its Chang'e 5 spacecraft, the first mission designed to bring moon rocks back to Earth in more than four decades.

The uncrewed Chang'e 5 probe will attempt to collect at least 2 kilograms of lunar dust and debris from the northern region of Oceanus Procellarum, a previously unvisited area on the near side of the moon.

If successful, the Chang'e 5 return mission will make China only the third country, after the US and the Soviet Union, to have retrieved samples from the moon. The last sample return mission was carried out in 1976 by the Soviet Union's Luna 24 robotic probe, which brought back around 170 grams of rocks to Earth.

Chang'e 5 launched early on 24 November, Beijing time, from a Long March 5 rocket at a site in Wenchang on Hainan Island in the South China Sea. The spacecraft consists of an orbiter, re-entry capsule, lander and ascent stage (see diagram, right). It is set to reach lunar orbit later this month, at which point the lander and ascent stage will separate from the main spacecraft in order to touch down on the moon.

Given that many factors can affect the probe's actual landing point, the China National Space Administration selected a large potential landing area near Mons Rümker, a 1300-metre-high volcanic formation, says Long Xiao at the China University of Geosciences in Wuhan, who helped propose candidate sites for the mission.

"The landing site covers two different geological units," says Xiao. To the west, the basalts – rock formed from the rapid cooling of lava – resemble those sampled in the Apollo missions. Chang'e 5 is aiming to land east of Mons Rümker in an area that contains

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China's Chang'e 5 lunar probe blasted off on 24 November local time from Hainan Island in the South China Sea

what appears to be much younger rock, around 1.2 billion to 2 billion years old.

"These would be the youngest volcanic samples to ever be returned from the moon," says Catherine Neish at Western University in Canada. "This is an extremely exciting mission."

In the Apollo missions, which consisted of six lunar landings between 1969 and 1972, astronauts brought back 382 kilograms of lunar rocks to Earth. The samples returned from the Apollo missions are between 3.1 and 4.4 billion years old.

Once Chang'e 5 lands, it will use two sampling methods, a major improvement on Luna 24, says James Head at Brown University in Providence, Rhode Island. First, the lander will drill and collect a core of regolith – loose soil and broken rocks – around 2 metres deep. A robotic arm will also scoop up shallow soils on the surface.

2 kg

Amount of lunar rock that the Chang'e 5 mission aims to collect

While the aim is to collect at least 2 kilograms of samples, Chang'e 5 has a maximum sample capacity of around 4 kilograms.

The lander is also equipped with a visible near-infrared spectrometer, as well as ground-penetrating radar to help it assess the make-up of the soil beneath it. "Lunar ground-penetrating radar is critical in correlating the structure and layers of the lunar soil and understanding its origin," says Head.

All in a day's work

Unlike the previous Chang'e spacecraft, Chang'e 5 isn't equipped with heating units to help it weather the extreme cold of the lunar night, so sampling will need to take place during a single lunar day – roughly 14 Earth days.

Once Chang'e 5 completes its surface operations, the samples will be stored in its ascent stage, which will lift off from the moon and make contact with the orbiter again. The samples will then be transferred to the re-entry capsule and the spacecraft will depart lunar orbit. It is expected to land in Inner Mongolia in mid-December.

"Any time you are landing on another planet's surface, it is challenging, but this mission is more complex in nature because a sample will be collected, stowed and then lifted off the lunar surface for its return to Earth," says Kerri Donaldson Hanna at the University of Central Florida. "This is something that has not been done in the modern era of space exploration."

If the Chang'e 5 mission is successful, the return of new samples will fill a major gap in our understanding of how the moon developed.

"This will be a really key piece of information to understanding the

NASA

Oceanus Procellarum (the central dark region) is an unexplored lunar plain

thermal evolution of the moon's interior," says Marc Norman at the Australian National University in Canberra.

If analysis shows that the samples are as young as we think they are – 2 billion years or younger – it would shed light on what happened on the moon at a time when it was cooling down and also shutting down its magnetic field, says Neish.

The samples will also help researchers better calibrate the age of surfaces on the moon based on the density of impact craters. Older surfaces tend to have more and larger craters than younger surfaces.

"If we can tie an absolute age to crater densities in that vicinity on the moon, that will give us a really useful data point for doing geological mapping on other planets in the solar system," says Norman.

Once the samples are returned to Earth, they will be stored at the National Astronomical Observatories of China in Beijing.

"As part of the safekeeping strategy, some samples will be stored permanently at Hunan University to avoid any potential loss due to natural disasters," says Head.

Because of the limited amount of lunar material, research laboratories that are successfully granted samples may be restricted to certain kinds of analysis, such as minerology or isotope studies, with non-destructive research methods to be used first, says Xiao.

Chang'e 5 is part of the four-phase Chinese Lunar Exploration Program run by the Chinese government, and is probably a preparatory step towards sending taikonauts to the moon in future, perhaps around 2030. "The Chinese are thinking very long term about this and very strategically about what they want to accomplish by going to the moon and going to Mars," says Norman.

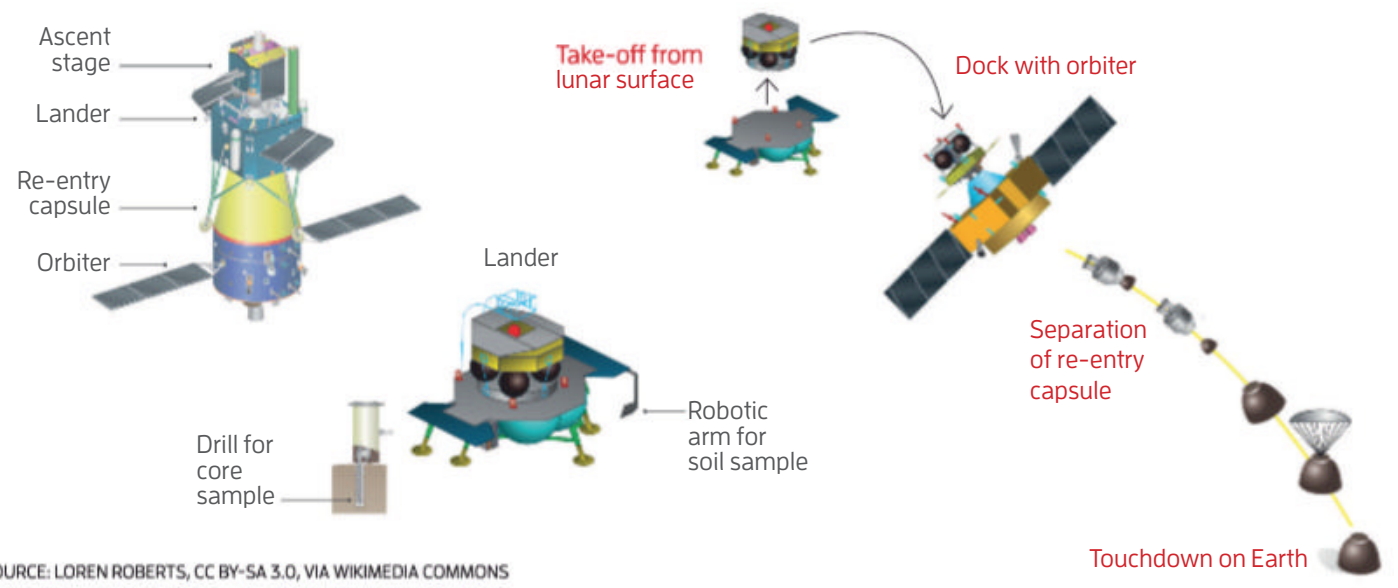
Phase one – Chang'e 1 and Chang'e 2 – involved orbital missions, while the Chang'e 3 and Chang'e 4 missions in phase two used soft landers and rovers. Phase three, sample return, is comprised of Chang'e 5 and Chang'e 6, which is planned for launch in 2023 or 2024. Phase four will involve exploration at the moon's south pole.

"The Chinese have had a good success rate for their Chang'e missions so far," says Lionel Wilson at Lancaster University in the UK.

"This is something that has not been done in the modern era of space exploration"

"The Chang'e 4 landing was on the lunar far side where there was absolutely no possibility of any realistic last-minute corrections to the landing process from Earth, thus confirming that they have a robust landing system, so I expect they will land successfully." ▮

How Chang'e 5 will bring moon rocks back to Earth



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Astronomy

Earth's minimoon has drifted away beyond our reach

Leah Crane

CHINA might have its sights set on the moon (see left), but astronomers are on the look out for alternatives. Earlier this year, they spotted a minimoon orbiting Earth. It has now drifted away, but we should soon be able to detect more of these miniature companions.

When astronomers at the Catalina Sky Survey in Arizona spotted a dim object they called 2020 CD3 hurtling across the sky in February, they couldn't be sure whether it was a minimoon or an artificial object like a rocket booster. Over the following few months, Grigori Fedorets at Queen's University Belfast in the UK and his colleagues used a series of telescopes around the world to take more measurements of the object and figure out what it was.

They found that it had a diameter of about 1.2 metres. Based on its colour and brightness, it was probably made of silicate rock, like many rocks in the asteroid belt. The researchers also traced back its orbit in an effort to find out where it might have come from before it was caught in Earth's orbit about 2.7 years earlier (*The Astronomical Journal*, doi.org/fj42).

"Based on simulations, the average capture time for minimoons is only nine months, so this was captured for a longer time than is expected," says Fedorets. "But this object flew very close to the [regular] moon, and that put it into a more stable orbit."

2020 CD3 drifted out of Earth's orbit in March, but the researchers predict that once the Vera C. Rubin Observatory – under construction in Chile – is finished, we should be able to find many more objects like it.

"We could detect a minimoon once every two or three months in the best-case scenario," says Fedorets. "In the worst-case scenario, maybe once a year." ▮