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Lunar probe has transferred samples for return trip to Earth

Complicated maneuvers come next, with Inner Mongolia landing set for late June

By **ZHAO LEI**
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Lunar samples collected from the moon's far side by China's Chang'e 6 mission have been delivered to their final carrier, which will later bring them to Earth, according to the China National Space Administration.

After flying in a lunar orbit for about 56 hours, the sample-loaded ascender of the Chang'e 6 probe docked with the orbiter-reentry capsule combination at 2:48 pm on Thursday and then transferred a sealed container holding the precious lunar samples to the reentry capsule, the administration said.

The operation was the second automated rendezvous and docking of any spacecraft in lunar orbit. The first was made during the Chang'e 5 mission in December 2020.

The administration said that before the docking, the ascender carried out four orbital adjustment maneuvers.

Next, the ascender will depart from the orbiter-reentry capsule combination, which will then continue orbiting the moon until ground control gives it the order to leave lunar orbit and head back to Earth.

After arriving in Earth orbit, the orbiter and reentry capsule will eventually separate, and the reentry capsule will conduct a series of complicated maneuvers to return to a preset landing site in North China's Inner Mongolia autonomous region in late June.

As one of the world's most notable space missions this year, the Chang'e 6 is an unprecedented endeavor aimed at retrieving samples from the lunar far side for scientific studies.

So far, all of the lunar substances on Earth were collected from the near side of the moon through the United States' six Apollo manned landings, the former Soviet Union's three Luna robotic missions and China's Chang'e 5 unmanned mission.

The landscapes and physical characteristics of the far side, which permanently faces away from Earth, are very different from those of the near side, which is visible from Earth, according to scientists.

Analyzing the samples will help to better understand the origins of the moon and the solar system, they said.

The 8.35-metric-ton Chang'e 6 spacecraft, consisting of an orbiter, a lander, an ascender and a reentry capsule, was launched by a Long March 5 heavy-lift carrier rocket on May 3 from the Wenchang Space Launch Center in Hainan province. It entered lunar orbit on May 8.

After a host of sophisticated steps, the lander touched down at the South Pole-Aitken Basin, one of the largest known impact craters in the solar system, on Sunday morning.

During the 49-hour surface operation, which lasted from Sunday morning to Tuesday morning, a mechanical arm and a drill operated to collect surface and underground materials, which were then placed in a special container on the ascender. Meanwhile, several scientific apparatus were activated to conduct survey and analysis assignments.

After the tasks were completed, the ascender lifted off from the lunar surface and reached lunar orbit on Tuesday morning.

Wang Yanan, chief editor of Aerospace Knowledge magazine, said the successful docking and sample transfer marked another step closer to the full success of the Chang'e 6 adventure.

"Robotic rendezvous and docking between spacecraft require cutting-edge technologies, excellent planning and exceptionally high precision," he said. "Before Chang'e 5, all rendezvous and docking operations between two spacecraft components in lunar orbit took place during the Apollo missions, and those were monitored and controlled by astronauts with support from ground controllers."

A screen at the Beijing Aerospace Control Center shows the ascender of the Chang'e 6 probe, carrying samples collected from the moon's far side, successfully docking with the probe's orbiter-reentry capsule combination in lunar orbit at 2:48 pm on Thursday. JIN LIWANG / XINHUA

Details of national flag unfurled on moon revealed

By **LIU KUN** in Wuhan
and **ZHENG CAIXIONG**

Chinese scientists overcame a number of challenges to develop the special national flag, made of basalt fibers, that was unfurled earlier this week by the lander of the Chang'e 6 lunar probe.

The flag, made to withstand extreme environments such as medium, high and low temperature fluctuations, high vacuum conditions and strong ultraviolet radiation, caught the eye of people around the world when it became the first flag of any country to fly on the far side of the moon.

The basalt fiber was jointly developed by Wuhan Textile University and China Space Sanjiang Group Co.

Xu Weilin, an academician at the Chinese Academy of Engineering, said his team successfully developed the high-quality "stone version" fabric national flag after overcoming major hurdles over the past four years, including difficulty weaving the fibers and ensuring that the colors won't fade.

Basalt fiber has excellent thermal insulation and radiation resistance, so it can withstand the harsh lunar environment, according to Xu, who is also president of Wuhan Textile University in Hubei province.

The features of basalt fiber, an inorganic fiber, include a smooth surface, brittleness and fragility, which makes it difficult to spin and weave, Xu said.

The flag that Chang'e 6 unfurled on the moon is the same size as the one planted during the Chang'e 5 mission on the near side of the moon — 30 centimeters by 20 cm, which is about the same size as a sheet of A4 paper.

But the density of the basalt fibers used in the Chang'e 6 flag is nearly twice that of the Chang'e 5 flag, which makes it reasonable to assume that the basalt fiber flag is heavier, he said.

However, Xu's team developed ultrafine basalt fibers with a diameter about one-third that of human hair, so the Chang'e 6 flag weighs just 11.3 grams, which is 0.5 gram lighter than the Chang'e 5 flag, said Xu.

As a lightweight and flexible protective material, basalt fiber will be used increasingly in the aerospace sector, such as for spacesuits, spacecraft and lunar bases, he said.

Xu said his team has begun research on the application of basalt fibers in areas such as heat resistance and flame retardance, including for protective clothing and bags, fully leveraging the ability of ultrafine basalt to withstand special environmental conditions such as high temperatures.

Cao Genyang, a professor on Xu's team who also participated in the development of the Chang'e 5 flag, said a fireproof suit made of basalt fibers is not only fire-resistant and insulative against heat, but also cost-effective.

"Basalt fiber costs 25,000 yuan ($3,450) per metric ton, which is much lower than quartz fiber and carbon fiber ... and thus the market prospects are very promising," he said.

According to Cao, typical firefighting suits and lifesaving rope are usually made of organic materials, and they will burn when exposed to high temperatures of 550 C.

However, he said, "The melting point of the basalt fiber garment is 1,600 C, so it can be used for a short time at a high temperature of 1,200 C, and for a long time at 800 C."

Firefighting suits, fire blankets and related products made from basalt fibers will be gradually produced in the years ahead, he added.

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A Chinese flag is unfurled on Tuesday by the lander of the Chang'e 6 probe on the far side of the moon. PROVIDED TO CHINA DAILY