

News & Highlights

China's Latest Moon Mission Returns New Lunar Rocks

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After a quick visit to the Moon in December 2020, China's Chang'e 5 mission has delivered back to Earth the first new specimens of lunar rock and soil since 1976 [1]. Scooped from a volcanic location not sampled before, the material may provide insights into the Moon's evolution and the history of the solar system. The mission also demonstrates a new level of technical sophistication for the Chinese space program and provides a blueprint for future expeditions to return samples from other bodies in the solar system, said Jim Head, a professor of geological sciences at Brown University in Providence, RI, USA.

In multiple missions in the 1960s and 1970s, the US Apollo astronauts carried 382 kg of lunar rocks and soil back to Earth [2]. And between 1970 and 1976, three Soviet robotic Luna spacecraft came home with around 0.3 kg [2]. In the years since, scientists have studied this material to investigate questions such as how the Moon formed, how its surface has weathered in response to radiation from space, and even whether lunar soil contains lethal microbes (it apparently does not) [3,4]. The US National Aeronautics and Space Administration (NASA) has more than 300 kg of its collection left that scientists can apply to study, and in 2019 the agency opened up access to a stash of rocks that had been sealed since the early 1970s [5,6].

Still, the additional Chinese samples could furnish a wealth of new data and enable study of a different area of the Moon. The Apollo missions picked up specimens at six sites [7], and the Soviet probes visited another three [8]. "We have explored such a small portion of the Moon that our impression is highly biased by the few samples we have," said Richard Carlson, a geochemist and director of the Earth and Planets Laboratory at the Carnegie Institution for Science in Washington, DC, USA. Moreover, rapid advances in analytical technology, such as more powerful synchrotron beams for probing chemical composition [9], allow extraction of much more information from smaller amounts of lunar material, as little as a few micrograms, said Darby Dyar, a professor of astronomy at Mount Holyoke College in South Hadley, MA, USA. Researchers can now perform measurements "we could only dream about 20 years ago," she said.

China has sent four previous missions to the Moon, most recently the Chang'e 4 lander and its accompanying rover that are still exploring the previously uncharted far side [10,11]. But Chang'e 5 performed more complicated maneuvers and required

more precise control than did its predecessors. The four components of the craft (Fig. 1) blasted off on 23 November 2020 and entered the Moon's orbit on 28 November 2020 [12]. After separating from the other two sections of the craft, Chang'e 5's ascent vehicle and lander (Fig. 2) touched down on the surface on 1 December 2020 (Fig. 3) and spent the next two days excavating and drilling 1.7 kg of rock and soil. The ascent vehicle then took off with the samples and passed them to the return capsule, which left the Moon's orbit and returned to Earth by parachute on 16 December 2020 [1].

"Chang'e 5's ability to land and return samples is much different than what the Soviets did," said Head. The Soviet craft blasted directly back to Earth, so they were limited to sites on the near side of the Moon. In contrast, Chang'e 5's ascent vehicle rendezvoused with the return capsule in orbit, meaning that future collection missions using this strategy could land anywhere on the Moon, including the far side, which has never been sampled. "That's a big deal," Head said.

Chang'e 5's orbital handoff also offers lessons for upcoming attempts to bring back material from elsewhere in the Solar



Fig. 1. This artist's conception shows the four components of Chang'e 5 (right) separating from the Long March 5 rocket that lifted them into space. Chang'e 5 went on to the Moon, landing on 1 December 2020. Credit: China News Service (CC BY 3.0).

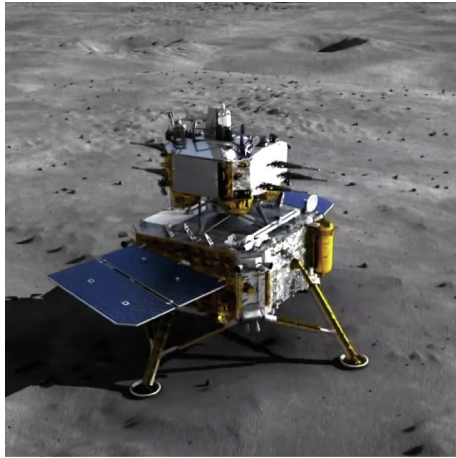


Fig. 2. In an artist's rendition, Chang'e 5's lander and ascent vehicle sit on the lunar surface at their landing site near Mons Rümker. The ascent vehicle carried 1.7 kg of lunar material into orbit and transferred it to Chang'e 5's return capsule for the trip back to Earth. Credit: China News Agency (CC BY 3.0).

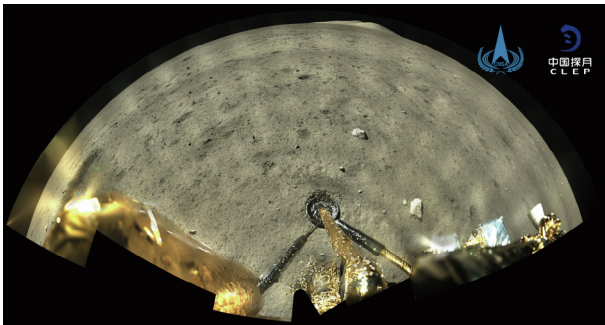


Fig. 3. This photo taken by Chang'e 5's lander shows the lunar surface in the foreground. The 1300 m high Mons Rümker is barely visible as the bump at the center-right top of the image. Credit: China National Space Administration (public domain).

System, Head said. Over the last two decades, a handful of robotic missions has collected samples from comets and asteroids. For example, NASA's OSIRIS-REx spacecraft grabbed material from the asteroid Bennu in 2020 and will arrive back at Earth in 2023 [13]. The next destination for a sample return mission is Mars. NASA's Perseverance rover put down on the planet in February 2021 [14], joining the InSight lander that has been there since 2018 [15]. Perseverance will cache samples on the surface that future spacecraft from NASA and the European Space Agency will pick up and bring back to Earth, again through an orbital transfer [16]. Chang'e 5 "is a dress rehearsal for the international Mars return mission," said Head.

China plans to keep most of the lunar samples but will share some with scientists outside the country [17]. Although part of the material will go toward outreach and education, including a portion that will be displayed at the National Museum of China in Beijing, China [18], the amount left for scientific analysis "is a goldmine," said Dyar. For instance, the new samples could help researchers refine their understanding of lunar history. Scientists can estimate the age of a location on the Moon from the number of craters it contains—the more craters, the older it is—and the material from the Apollo and Luna missions helps calibrate their dating [19]. Chang'e 5's sampling site, near a mountain known as Mons Rümker, could be as little as one billion years old, more than two billion years younger than the locations explored by the Apollo

and Soviet missions [20]. "It gives us another time point to check the crater chronology," said Dyar.

Change' 5's specimens could also reveal new information about volcanic activity on the Moon. Researchers think that most eruptions ceased around three billion years ago, but the volcanic plain where the craft touched down formed much more recently [21]. The samples may indicate whether high levels of radioactivity or other factors allowed volcanic activity to continue in this region, Head said. The spacecraft's cargo could also help test a hypothesis about the early solar system, Carlson said. Because many Apollo rocks are about the same age, some scientists have proposed that the inner solar system was battered by space rubble around 3.9 billion years ago, an event called the late heavy bombardment [22]. But some recent studies have challenged the idea, and the Chang'e 5 samples could provide relevant data on this point.

The Chang'e 5 mission continues, with the fourth component of the craft, the orbiter that continued to circle the Moon during sample collection, moving to a position in space from which it may observe the Sun or perform other studies [23]. Along with the potential scientific payoffs, maneuvering the craft to this point and keeping it there gives the spacecraft's operators more experience with command and control and telemetry, said Head. "China is using this mission to its full advantage," he said.

Additional planned missions should give scientists access to even more moon rocks in the near future. Chang'e 6, scheduled to lift off in 2023 or 2024, will bring back samples from the Moon's South Pole, which is intriguing because it contains large amounts of water [24,25]. NASA has contracted with four private companies to collect samples on the Moon [26], although how the material will get back to Earth remains unclear [27]. The astronauts NASA plans to land on the Moon in 2024 will also bring back more material for scientific study [28]. In the meantime, researchers will be busy analyzing the new samples delivered by Chang'e 5. "I'm looking forward to seeing what they brought back," said Carlson.

References

- [1] Voosen P. China lands its Moon rocks in Inner Mongolia [Internet]. Washington, DC: Science; 2020 Dec 16 [cited 2021 Feb 10]. Available from: <https://www.sciencemag.org/news/2020/12/china-lands-its-moon-rocks-inner-mongolia>.
- [2] Bartels M. The Moon on Earth: where are NASA's Apollo lunar rocks now? [Internet]. New York: Space; 2019 Jul 14 [cited 2021 Feb 10]. Available from: <https://www.space.com/where-are-nasa-apollo-moon-rocks.html>.
- [3] Resnick B. How Apollo Moon rocks reveal the epic history of the cosmos [Internet]. New York City: Vox; 2019 Nov 19 [cited 2021 Feb 10]. Available from: <https://www.vox.com/the-highlight/2019/6/21/18677691/apollo-anniversary-moon-rock-lunar-sample-geology>.
- [4] Bartels M. NASA fed Apollo 11 Moon rocks to cockroaches (and then things got even weirder) [Internet]. New York: Space; 2019 Jul 26 [cited 2021 Feb 10]. Available from: <https://www.space.com/apollo-lunar-samples-safety-animal-testing.html>.
- [5] Grossman L. How NASA has kept Apollo Moon rocks safe from contamination for 50 years [Internet]. Washington, DC: Science News; 2019 Jul 15 [cited 2021 Feb 10]. Available from: <https://www.sciencenews.org/article/nasa-apollo-anniversary-moon-rocks-preservation>.
- [6] Greenfieldboyce N. Moon rocks still awe, and scientists hope to get their hands on more [Internet]. Washington, DC: National Public Radio; 2019 Jul 8 [cited 2021 Feb 10]. Available from: <https://www.npr.org/2019/07/08/736212760/moon-rocks-still-awe-and-scientist-hope-to-get-more>.
- [7] Eicher DJ. What the Apollo Moon rocks told us [Internet]. Waukesha: Astronomy; 2019 Jun 21 [cited 2021 Feb 10]. Available from: <https://astronomy.com/news/2019/06/what-the-moon-rocks-told-us>.
- [8] Lewis C. Revisiting the Soviet lunar sample return missions [Internet]. Washington, DC: Smithsonian National Air and Space Museum; 2020 Dec 16 [cited 2021 Feb 10]. Available from: <https://airandspace.si.edu/stories/editorial/revisiting-soviet-lunar-sample-return-missions>.
- [9] Jacoby M. Revealing materials' secrets with synchrotron light [Internet]. Washington, DC: Chemical and Engineering News; 2016 Aug 8 [cited 2021 Feb 10]. Available from: <https://cen.acs.org/articles/94/i32/Revealing-materials-secrets-synchrotron-light.html>.
- [10] Leslie M. A Chinese lander explores the far side of the Moon. *Engineering* 2019;5(4):598–9.

- [11] Jones A. NASA spacecraft reveals travels of China's Yutu 2 rover on far side of the Moon [Internet]. New York: Space; 2021 Jan 6 [cited 2021 Feb 10]. Available from: <https://www.space.com/china-chang-e-4-moon-rover-2-years-old>.
- [12] Lyons K. China's Chang'e 5 completes docking mission on its way back to Earth [Internet]. New York City: The Verge; 2020 Dec 5 [cited 2021 Feb 10]. Available from: <https://www.theverge.com/2020/12/5/22156311/china-change-5-docking-mission-moon-lunar-samples>.
- [13] Palmer C. Asteroid missions begin to pay off. *Engineering* 2021;7(4):418–20.
- [14] Achenbach J, Kaplan S, Guarino B. NASA rover Perseverance lands on Mars in mission to search for past life [Internet]. Washington, DC: Washington Post; 2021 Feb 18 [cited 2021 Feb 19]. Available from: <https://www.washingtonpost.com/science/2021/02/18/mars-landing-nasa/>.
- [15] Woo M. A new lander on Mars. *Engineering* 2019;5(3):355–6.
- [16] Leslie M. Three new missions head for Mars. *Engineering* 2020;6(12):1336–8.
- [17] Jones A. China says it's open to sharing Moon rocks as Chang'e 5's samples head to the lab [Internet]. New York City: Space; 2020 Dec 23 [cited 2021 Feb 10]. Available from: <https://www.space.com/china-sharing-chang-e-5-moon-samples>.
- [18] Clark S. Chinese mission returned nearly 4 pounds of lunar samples [Internet]. Cape Canaveral: Spaceflight Now; 2021 Jan 1 [cited 2021 Feb 10]. Available from: <https://spaceflightnow.com/2021/01/01/chinese-mission-returned-nearly-4-pounds-of-lunar-samples/>.
- [19] Normille D. China set to bring back first rocks from the Moon in more than 40 years [Internet]. Washington, DC: Science; 2020 Nov 19 [cited 2021 Feb 10]. Available from: <https://www.sciencemag.org/news/2020/11/china-set-bring-back-first-rocks-moon-more-40-years>.
- [20] Qian Y, Xiao L, Head JW, van der Bogert CH, Hiesinger H, Wilson L. Young lunar mare basalts in the Chang'e-5 sample return region, northern Oceanus Procellerum. *Earth Planet Sci Let* 2021;555:116702.
- [21] Wall M. China's Chang'e 5 lands on the Moon to collect the 1st fresh lunar samples in decades [Internet]. New York City: Space; 2020 Dec 1 [cited 2021 Feb 10]. Available from: <https://www.space.com/china-chang-e-5-lands-on-moon-to-collect-lunar-samples>.
- [22] Mann A. Bashing holes in the tale of Earth's troubled youth [Internet]. London: Nature; 2018 Jan 24 [cited 2021 Feb 10]. Available from: <https://www.nature.com/articles/d41586-018-01074-6>.
- [23] Jones A. Chang'e-5 orbiter embarks on extended mission to Sun–Earth lagrange point [Internet]. Tysons Corner: Space News; 2020 Dec 21 [cited 2021 Feb 10]. Available from: <https://spacenews.com/change-5-orbiter-embarks-on-extended-mission-to-sun-earth-lagrange-point/>.
- [24] Jones A. China unveils ambitious moon mission plans for 2024 and beyond [Internet]. New York City: Space; 2020 Oct 19 [cited 2021 Feb 10]. Available from: <https://www.space.com/china-planning-future-moon-missions-change-7>.
- [25] Jones A. China's new moon mission returns the first lunar samples since 1976 [Internet]. Washington, DC: National Geographic; 2020 Dec 17 [cited 2021 Feb 10]. Available from: <https://www.nationalgeographic.com/science/2020/11/china-launches-first-moon-sample-return-mission-in-over-40-years/>.
- [26] Harper J. NASA to pay company \$1 to collect rocks from Moon [Internet]. London: BBC News; 2020 Dec 4 [cited 2021 Feb 10]. Available from: <https://www.bbc.com/news/business-55170788>.
- [27] Brinkmann P. NASA chooses 4 firms for first private lunar sample collection [Internet]. Washington, DC: United Press International; 2020 Dec 3 [cited 2021 Feb 10]. Available from: https://www.upi.com/Science_News/2020/12/03/NASA-chooses-4-firms-for-first-private-lunar-sample-collection/1751607010919/.
- [28] Howell E. NASA's Artemis moon science goals will use 'opposable thumbs' and astronaut geology training [Internet]. New York City: Space; 2020 Dec 8 [cited 2021 Feb 10]. Available from: <https://www.space.com/nasa-artemis-moon-landing-astronaut-science-goals>.