Scientists eager for Chang'e-6 lunar farside samples to bring new discoveries

Wei Yang,[1,*] Yuyang He,[1] Yuqi Qian,[2] and Zongyu Yue[1]

[1]Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

[2]Department of Earth Sciences & Laboratory for Space Research, The University of Hong Kong, Hong Kong 999077, China

*Correspondence: yangw@mail.iggcas.ac.cn

Received: June 8, 2024; Accepted: June 18, 2024; Published Online: June 19, 2024; https://doi.org/10.1016/j.xinn.2024.100660

Citation: Yang W., He Y., Qian Y., et al., (2024). Scientists eager for Chang'e-6 lunar farside samples to bring new discoveries. The Innovation **5(5)**, 100660.

The tidal locking effect keeps the Moon consistently presents its one side—the near side—to Earth, rendering the other side—the far side—inaccessible for people standing on Earth. Consequently, the far side of the Moon remained shrouded in mystery for human observers until the onset of space exploration.

In 1959, the Soviet Union's Luna 3 spacecraft returned the first views ever of the far side of the Moon. Despite the blurriness of the photo by contemporary standards, the stark contrast between the near side and far side of the Moon was striking. Since then, a growing number of orbital probes have revealed significant differences between the two sides of the Moon, including lunar crust thickness, magma activities, and compositions. However, the origins of these differences remain unexplained.

On January 3rd, 2019, China's Chang'e-4 mission successfully achieved landing on the far side of the Moon for the first time in human history. The landing site was situated within the Von Kármán crater (177.577°E, 45.457°S) in the South Pole-Aitken basin. Following the landing, the Yutu-2 rover executed surface exploration missions. The rover identified materials potentially derived from the lunar mantle and was operational for a continuous period of 67 lunar days.

On May 3rd, 2024, China's Chang'e-6 probe was launched from the Wenchang satellite launch site in Hainan with the aim of retrieving 2-kg samples from the far side of the Moon. The landing took place on June 2nd on a basalt unit (153.9856°W, 41.6383°S) in the southern Apollo basin.[1] Similar to the Chang'e-5 mission,[2] the Chang'e-6 lander-ascender collected samples using core drilling and surface scooping techniques. On June 4th, the ascender separated from the lander, took off with samples, and later docked with an orbiter-returner in orbit and then transferred samples to the orbiter-returner on June 6th. The Chang'e-6 returner is expected to deliver the samples to Earth on June 25th.

The Chang'e-6 mission represents a significant milestone in the history of human lunar exploration, marking the first sample return from the far side of the Moon (Figure 1A). To date, ten successful lunar sample-return missions were all conducted on the near side of the Moon. These nearside samples have significantly advanced our understanding of the Moon, including its chemical characteristics, physical processes, and geological evolution. This knowledge has led to the proposal of hypotheses regarding the giant impact origin of the Moon and the lunar magma ocean model.

The lunar surface is categorized into three distinct geological terranes: the Procellarum KREEP (an acronym for the incompatible K, rare-earth elements, and P) Terrane, the Feldspathic Highland Terrane, and the South Pole-Aiken Terrane (Figure 1A). The Chang'e-6 sample is expected to be the first sample from the South Pole-Aiken Terrane. Consequently, it is therefore expected that these samples will contribute to a more comprehensive understanding of lunar evolution.

To identify the most concerned scientific problems that could be addressed by the Chang'e-6 lunar samples, the Chang'e-6 Landing Site Geological Background Workshop was convened at the Institute of Geology and Geophysics, Chinese

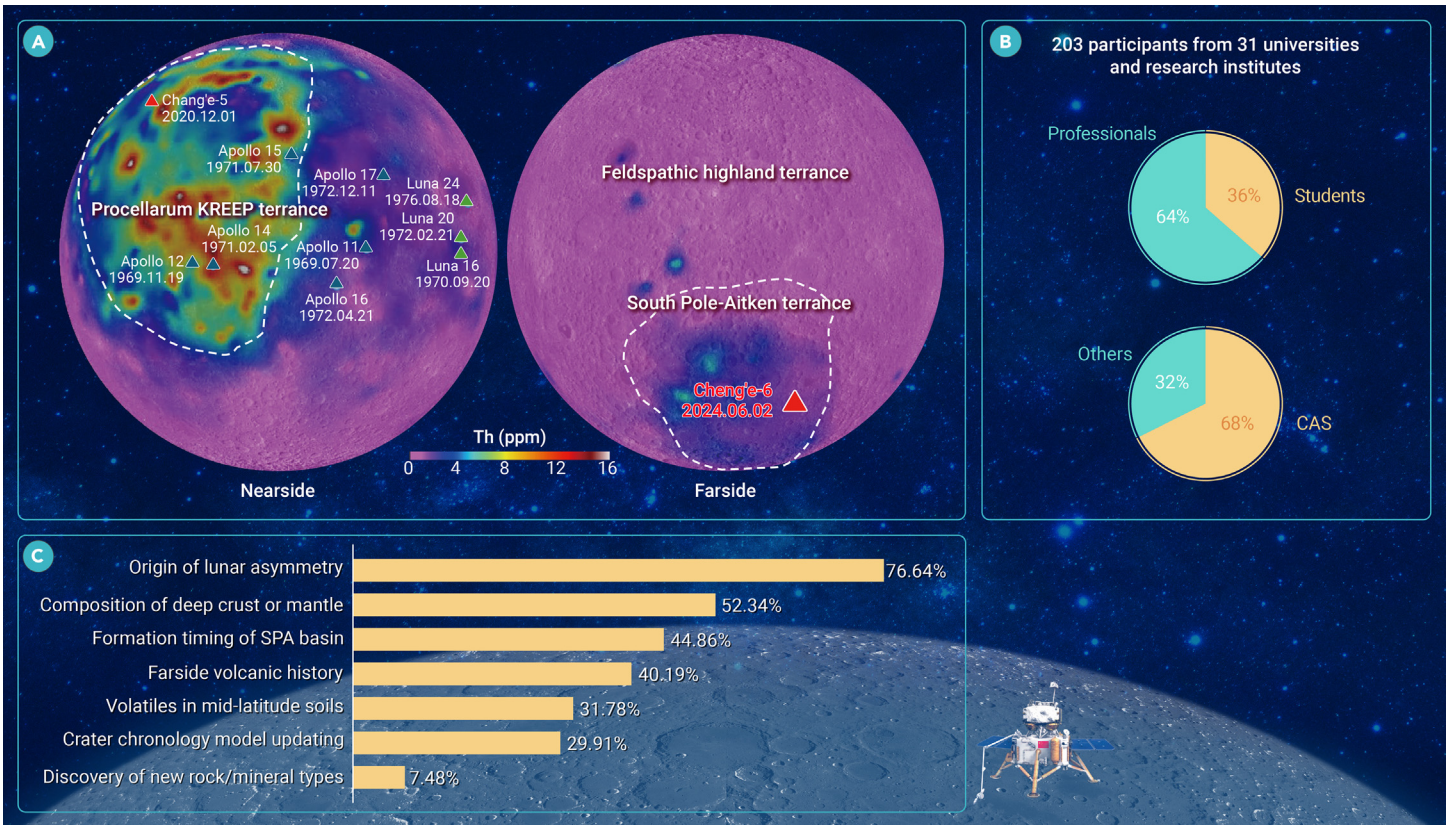

Figure 1. Chang'e-6 sampling site and scientific issues that the samples can address (A) Th distribution map of the Moon with the three geological terranes and landing sites of the sample return missions marked. (B) Overview of participants and their institutions of the Chang'e-6 Landing Site Geological Background Workshop. CAS, Chinese Academy of Sciences. (C) The results of the participants' votes on their most concerned scientific problems regarding the Chang'e-6 lunar samples. Each participant can cast 3 votes.

Academy of Sciences, on June 7th, 2024. A total of 203 participants from 31 domestic universities and research institutes attended (Figure 1B).

During the workshop, representatives of research teams, which have conducted independent studies on the geological context of the Chang'e-6 landing area recently,[1,3-5] presented comprehensive details on the geological characteristics of the landing area. This was followed by a panel discussion on potential scientific problems related to the samples. The participants then voted on three scientific problems that they deemed most important. The top seven scientific problems, as voted upon, are (Figure 1C) as follows:

(1) The origin of lunar asymmetry: questions regarding the crustal and mantle rock similarities and differences between the two sides of the Moon.
(2) The composition of the deep crust or mantle: questions regarding the petrological and geochemical characteristics of deep lunar crust or mantle if there are impact-excavated materials present in the Chang'e-6 lunar regolith.
(3) The formation timing of South Pole-Aitken Basin: questions regarding the geological history of the South Pole-Aitken Basin and the Apollo Basin, as well as the depth and extent of the melt pools caused by the impacts that formed these basins.
(4) The farside volcanic history: questions regarding the number of volcanic episodes, the secular evolution of the mantle, and the thermal history of the Moon that can be revealed by volcanic and potentially intrusive igneous rocks.
(5) The volatiles in mid-latitude soils: questions regarding the water content within the major types of materials in the Chang'e-6 lunar regolith, the water content of the farside lunar mantle as indicated by igneous rocks, and the implantation and retention mechanisms of solar-wind-derived water.
(6) Crater chronology model updates: questions regarding the agreement between the new calibration point of the Chang'e-6 landing site and the existing crater chronology model and if the late heavy bombardment hypothesis at 3.9 Ga could be supported by impact crater statistics and isotopic dating results.
(7) The discovery of new minerals and/or rocks: questions regarding the existence of undocumented rocks and/or minerals, as well as their formation mechanisms and conditions.

New samples will inevitably lead to new discoveries. Fascination with the Moon is rooted in Chinese culture down the ages, as evidenced by the mythological narrative of Chang'e, a lady who journeyed to and resided on the Moon. Now, Chinese scientists are eagerly anticipating the opportunity to contribute to lunar science. The Chang'e-5 mission has already begun accepting applications from international scholars. The Chang'e-6 lunar probe carried four international payloads that are developed jointly by Chinese and foreign scientists. It is conceivable that the openness of Chinese lunar exploration activities will be mirrored in the study of Chang'e-6 lunar samples. The lunar scientific community and all of humankind are anticipated to reap the rewards of collaborative efforts undertaken by international scientists from a wide range of geographical and disciplinary backgrounds.

REFERENCES

1. Yue, Z., Gou, S., Sun, S., et al. (2024). Geological context of Chang'e-6 landing area and implications for sample analysis. Innovation ***5***: 100663. https://doi.org/10.1016/j.xinn.2024.100663.
2. Yang, W., and Lin, Y. (2021). New Lunar Samples Returned by Chang'e-5: Opportunities for New Discoveries and International Collaboration. Innovation ***2***: 100070. https://doi.org/10.1016/j.xinn.2020.100070.
3. Zeng, X., Liu, D., Chen, Y., et al. (2023). Landing site of the Chang'e-6 lunar farside sample return mission from the Apollo basin. Nat. Astron. ***7***: 1188–1197. https://doi.org/10.1038/s41550-023-02038-1.
4. Qian, Y., Head, J., Michalski, J., et al. (2024). Long-lasting farside volcanism in the Apollo basin: Chang'e-6 landing site. Earth Planet Sci. Lett. ***637***: 118737. https://doi.org/10.1016/j.epsl.2024.118737.
5. Jia, Z., Chen, J., Kong, J., et al. (2024). Geologic context of Chang'e-6 candidate landing regions and potential non-mare materials in the returned samples. Icarus ***416***: 116107. https://doi.org/10.1016/j.icarus.2024.116107.

ACKNOWLEDGMENTS

We thank Zongcheng Ling, Jian Chen, Yang Liu, Sheng Gou, Yi Chen, Sen Hu, Yangting Lin, Xian-Hua Li, and Fu-Yuan Wu for advice on scientific issues. This study was funded by the National Natural Science Foundation of China (62227901, 42241103) and the Key Research Program of the Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS-202401).

DECLARATION OF INTERESTS

The authors declare no competing interests.