

New Lunar Samples Returned by Chang'e-5: Opportunities for New Discoveries and International Collaboration

Wei Yang^{1,2} and Yangting Lin^{1,2,*}

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

²Innovation Academy for Earth Science, Chinese Academy of Sciences, Beijing 100029, China

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

Received: December 7, 2020; Accepted: December 11, 2020; Published Online: December 16, 2020; <https://doi.org/10.1016/j.xinn.2020.100070>

© 2020 The Author(s). This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

On December 16th, 2020 at 17:59 UTC, the sample capsule of Chang'e-5 successfully landed at Dorbod Banner, Inner Mongolia, China. It is a milestone for the Chinese Lunar Exploration Program (CLEP), which has achieved the goals of its first three phases: orbiting, landing, and sample return. China becomes the third country to return samples from the Moon after the United States and the Soviet Union. Forty-four years since the Luna 24 mission in 1976, new lunar samples have been returned to Earth.

Chang'e-5 was launched from Wenchang Satellite Launch Center, Hainan Island, on November 23rd, 2020 at 20:30 UTC and landed on the Moon in a region known as Oceanus Procellarum (Figure 1) on December 1st, 2020. After 19 hours of lunar surface activities, sample collection and packaging were completed on December 2nd. Then, the ascent vehicle took off with the sam-

ples from atop the lander on December 3rd to rendezvous with the orbiting spacecraft (returner vehicle). The sample capsule reentered the Earth's atmosphere on December 16th, 2020.

Chang'e-5 collected the lunar samples in two ways: soil core drilling, and soil and rock fragment scooping (Figure 1). The lander was equipped with a panoramic camera, a landing camera, a visible and near-infrared imaging spectrometer, and a ground-penetrating radar. These payloads obtained *in situ* reflection spectra of the surface materials, and the topography and shallow structure of the landing site, providing vital geological context for the returned samples.

The samples returned from the Moon are invaluable for planetary sciences. For example, the discovery of pure anorthosite fragments in the

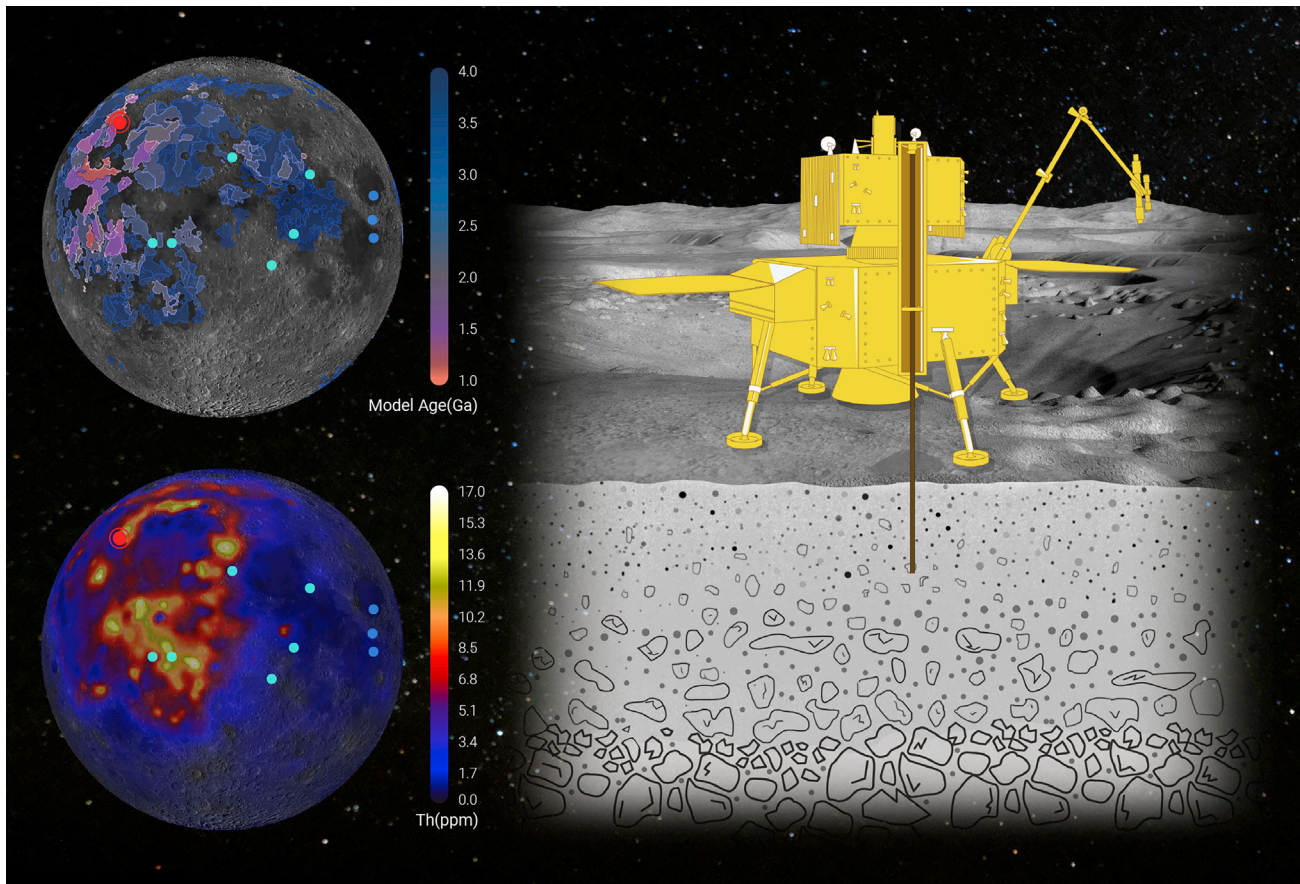


Figure 1. The Chang'e-5 landing site and collecting samples on the Moon (Left) Distribution of model ages of mare basalts and Th abundances of the nearside of the Moon, with landing sites of the Chang'e-5 (red), Apollo (cyan), and Luna (blue) sample return missions (modified from QuickMap, <https://quickmap.lroc.asu.edu/>). Age and Th data are from Hiesinger et al.¹ and Lawrence et al.² (Right) Cartoon showing Chang'e-5 on the Moon, drilling a soil core and scooping surface materials from the lunar regolith.

Apollo samples revealed a global magma ocean in the Moon's early history.³ When calibrated using the absolute ages of the returned samples, the impact craters on the Moon provide an approximate relative chronology for other planetary surfaces in the inner solar system.⁴ The compositional relationship between the Earth and the Moon offers constraints on various lunar formation hypotheses.⁵

The landing site of Chang'e-5 is located far from the six Apollo and three Luna sampling sites. The crater counting method indicates that the lava flows at the Chang'e-5 landing site are much younger than the basalts collected by the Apollo and Luna missions. Furthermore, the remote sensing data show that these younger lavas are enriched in K, REE (rare earth elements), and P components (so-called KREEP, the proposed last dregs of the Lunar Magma Ocean) with high abundances of radiogenic elements, such as K, U, and Th (Figure 1). Therefore, these new lunar samples will allow a better understanding of the formation and evolution of the Moon. For example, calibration with the isotope chronological data can make the crater counting method more accurate for younger geological events at the Moon and the rest of the inner solar system. These young basalt rocks can reveal the late history of lunar volcanism and the geochemical features of the lunar mantle reservoir. The drill core of lunar soil will benefit the understanding of the effects and mechanisms of space weathering on airless bodies and the secular evolution of the solar wind.

The CLEP consists of five subsystems: the spacecraft system, the rocket system, the launch site system, the tracking and control system, and the ground application system. The ground application system is responsible for curating the lunar samples. The China National Space Administration (CNSA) established a lunar sample management committee to evaluate the requests for the samples.

To promote collaboration and interaction between Chinese and European scientists in the area of lunar science, CNSA and the European Space Agency (ESA) co-organized four workshops, in-person in Beijing (2017), Amsterdam (2018), and Zhuhai (2019), and an online one (2020) due to the COVID-19 pandemic. Both sides have established the CNSA-ESA joint research team to analyze lunar samples and participate in lunar exploration.

Chang'e-5 is the first sample return mission of the long-planned sequence of space exploration by China. Its technology and experience will be utilized for future sample return missions. Chang'e-6 will attempt to return samples from the Moon's south pole region. Sample return missions to Mars and an asteroid as the quasi-satellite of the Earth are also planned for this decade. As the world's second-largest economy, China looks forward to contributing to human deep space exploration. Chinese scientists look forward to collaborating with scientists worldwide to contribute to planetary sciences.

REFERENCES

1. Hiesinger, H., Head, J.W., Wolf, U., et al. (2011). Ages and stratigraphy of lunar mare basalts: a synthesis. In *Recent Advances and Current Research Issues in Lunar Stratigraphy* (Geological Society of America), 1–51.
2. Lawrence, D.J., Puetter, R.C., Elphic, R.C., et al. (2007). Global spatial deconvolution of Lunar Prospector Th abundances. *Geophys. Res. Lett.* **34**, L03201.
3. Wood, J.A., Dickey, J.S., Jr., Marvin, U.B., and Powell, B.N. (1970). Lunar anorthosites. *Science* **167**, 602–604.
4. Stöffler, D., Ryder, G., Ivanov, B.A., et al. (2006). Cratering history and lunar chronology. *Rev. Mineral. Geochem.* **60**, 519–596.
5. Canup, R.M. (2004). Dynamics of lunar formation. *Annu. Rev. Astron. Astrophys.* **42**, 441–475.