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1th Initial Evidence of Lunar Mantle Composition Detected by *Chang'e*-4

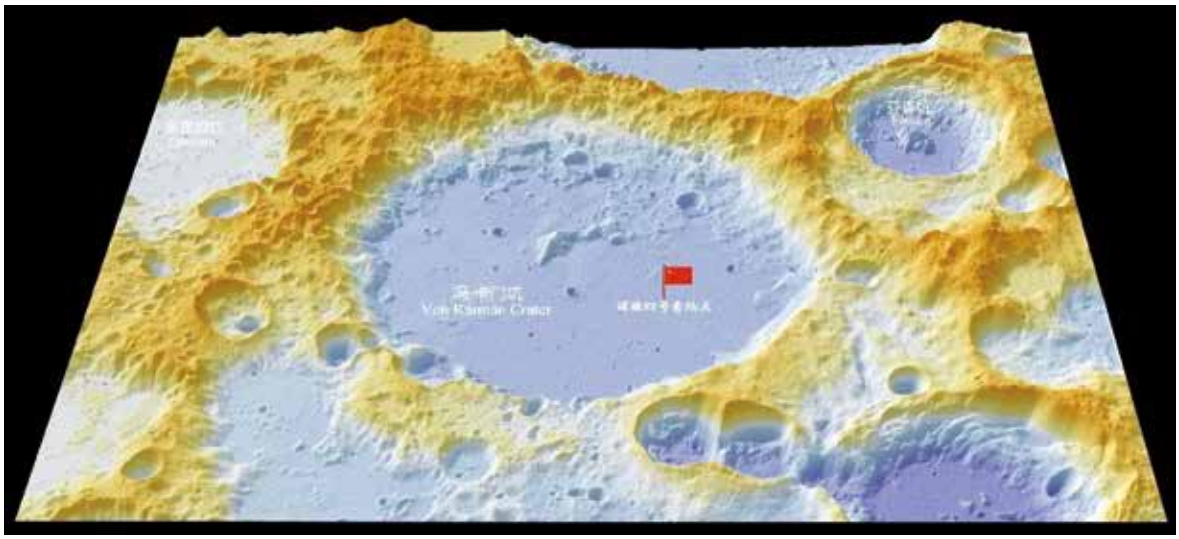
By SONG Jianlan (Staff Reporter)

It marks the first step on the far side of the Moon; it would never be resigned to playing second fiddle.

Previous research suggested that the lunar crust as well as the mantle could both have formed at the infantile stage of the Moon's evolution. At this stage, major crashes and the accretion process generated a great amount of energy that melted down the minerals and gave birth to a magma ocean. When this ocean cooled down, lighter substances, represented by the calcium-rich plagioclase, crystallized and rose to shape the crust, while the heavier ones, like the femic minerals including olivine and low-calcium pyroxene, sank down to form the mantle.

Curiously, the lunar samples returned by the Apollo and Luna missions did not give any direct information about the substantial composition of the mantle, leaving the above-mentioned inference unsupported for a long time. Still, the detection of such evidence is not impossible – under certain conditions the mantle substance could emerge to the surface and be picked up and recorded by man-made devices. Large craters left by big clashes on the Moon, scientists conceive, might provide some clues, as the great impact from the clashes could have penetrated and ripped open the crust, exposing the mantle partially to the surface.

The mission *Chang'e*-4 under China's Lunar



On January 9, 2019, *Chang'e*-4, a mission under China's Lunar Exploration Program, touched down on the eastern floor of the Von Kármán crater of the Moon's far side, and sent hours later the rover *Yutu*-2 to carry out an *in-situ* exploration of the local environment, the first ever made by a man-made spacecraft. It successfully detected initial evidence for the composition of the lunar mantle. Shown here is the landing site with possible mantle materials built up. (Credit: CLEP/GRAS/NAOC)

Exploration Program (CLEP), helped to fill this gap with its *in-situ* investigation – the first ever by human beings – in the South Pole-Aitken basin (SPA) on the far side of the Moon, unveiling the first clips of this immersed world. This work, published in May 2019 in *Nature*, ranks first in the annual science advances of China for 2019.

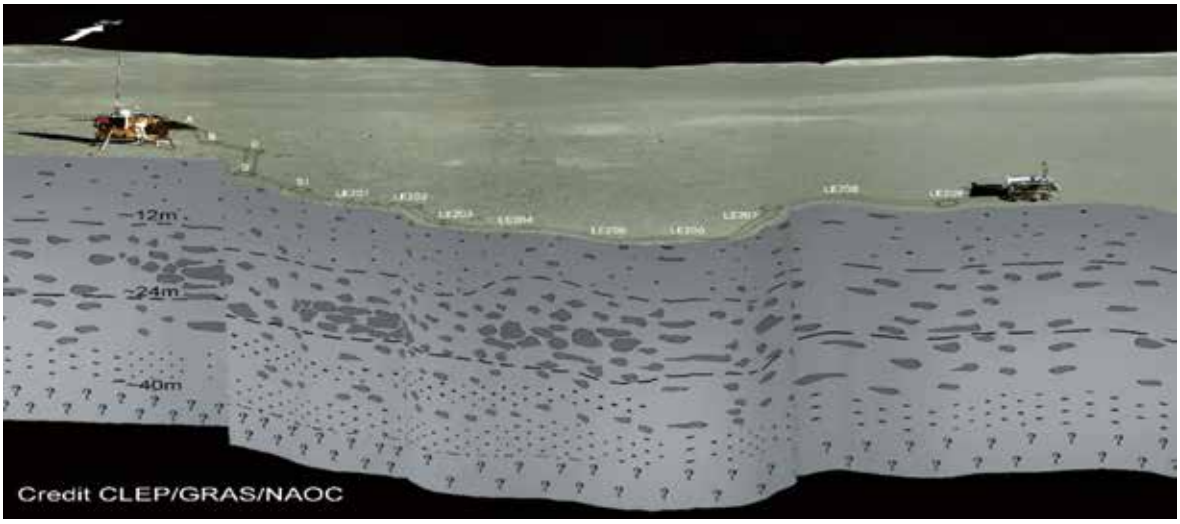
Measuring 2,500 km in diameter, SPA ranks the oldest and the largest impact basin on the far side of the Moon. Very likely, the great impact that has shaped it has also penetrated the lunar crust and caused some buildup of materials from the mantle. However, existing remote sensing data from lunar orbiters gives no sign of widespread olivine, despite the signals indicating abundant femic minerals. Therefore, whether or not such substance has originated from the mantle was left open.

On January 9, 2019, *Chang'e*-4 successfully landed at the Von Kármán crater of this area, and sent the rover *Yutu*-2 to probe this area. Based on the data obtained by the visible and near-infrared imaging spectrometer (VNIS) aboard *Yutu*-2, a team led by Prof. LI Chunlai from the National Astronomical Observatories (NAOC), CAS reported, together with their collaborators, the initial evidence for the existence of orthopyroxene and olivine in this area, indicating possible mantle origin of the accumulative materials near the landing site. According to their further background analysis, these mantle materials could have been projected from the 72 km-diameter Finsen crater near to the landing site of *Chang'e*-4.

Aside from revealing the possible composition of lunar mantle substance, this work has also improved the understanding of the formation and evolution of the lunar interior, and offered new constraints for the research into the early magma ocean.

Yutu-2, which is still roving on the Moon, will continue fact-finding mission at the bottom of the Von Kármán crater, aimed at understanding their geological background, origin and composition, laying a foundation for future sample-return missions of the CLEP. The beginning of 2020 has seen another discovery published concerning the lunar subsurface structure, based on *Yutu*-2's first two lunar days' investigation. The results reveal the shallow subsurface structure of the lunar strata of this area, presenting the first high-resolution image of a lunar ejecta sequence ever produced and the first direct measurement of its thickness and internal architecture.

For more about CLEP, please turn to page 27 in this issue.



A joint team led by NAOC published February 27 in *Science Advances* the ensuing discovery by *Yutu*-2, revealing the shallow subsurface structure of the lunar strata near the landing site. (Credit: CLEP/GRAS/NAOC)

Reference

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