CNSA Deep Space Scientific Data

Ruihong YANG, Yongliao ZOU

CNSA Lunar Exploration and Space Engineering Center

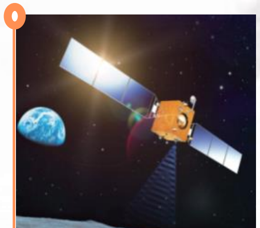
Nov. 20, 2017, Vienna, Austria

youngeeer@163.com

Table of Contents

Three Steps of CLEP Before 2020

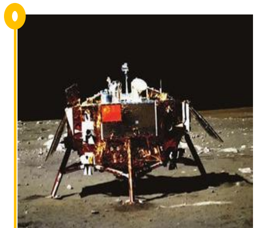
Orbiting



Chang'E-1
2007.10

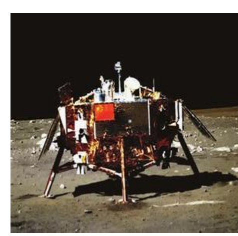
Chang'E-2
2010.10

Landing

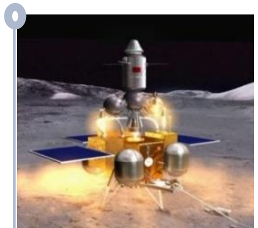


Chang'E-3
2013.12

Chang'E-4
2018

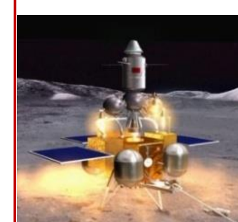


Return



Chang'E-5
2019

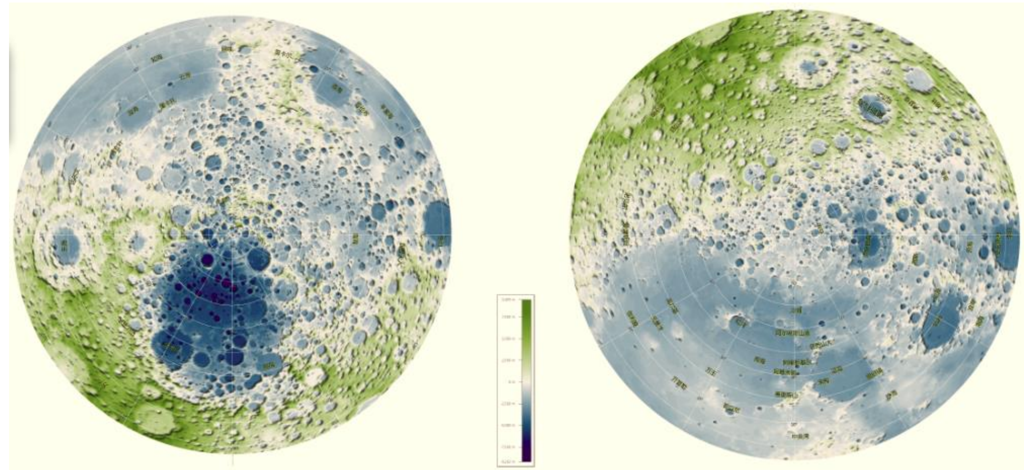
Chang'E-6

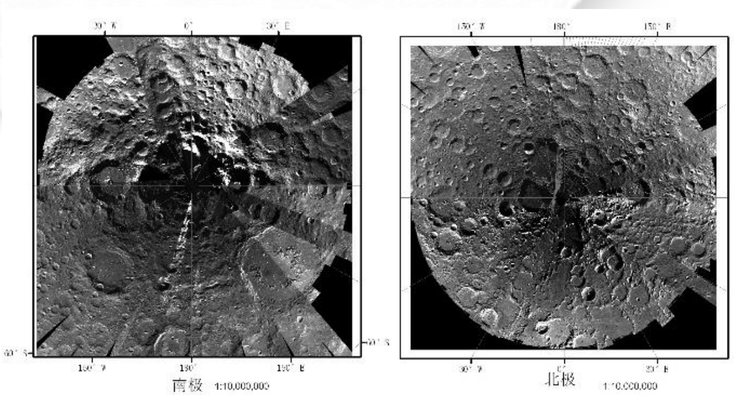


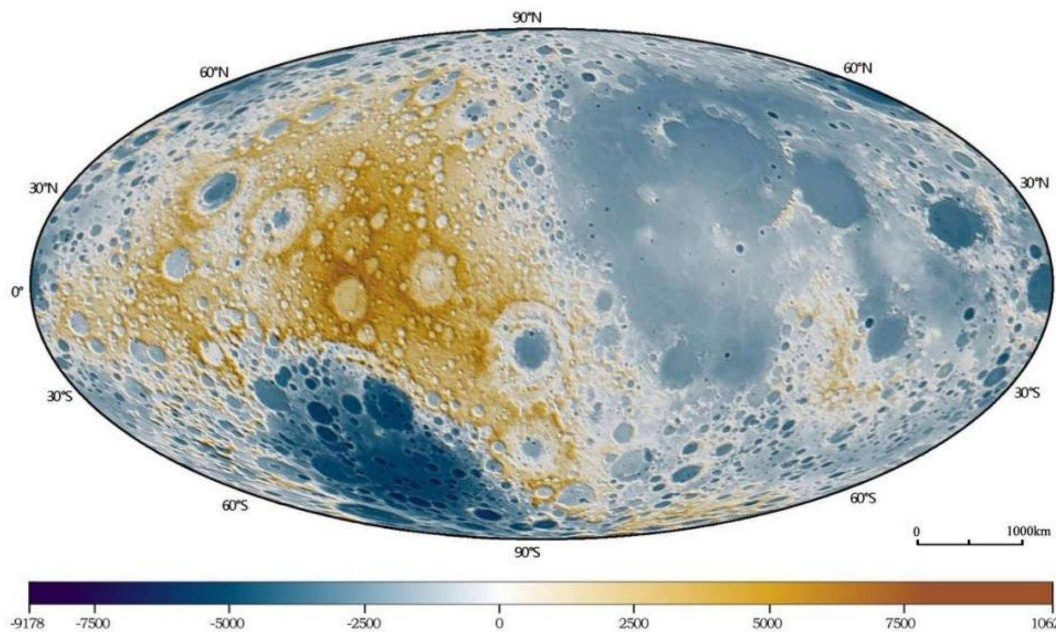
CLEP SCIENTIFIC DATA

CHANG'E-1

- Launched in Oct. 24th, 2007
- Operation in-orbit for 494 days
- Controlled to impact the moon on March, 2009







CLEP SCIENTIFIC DATA

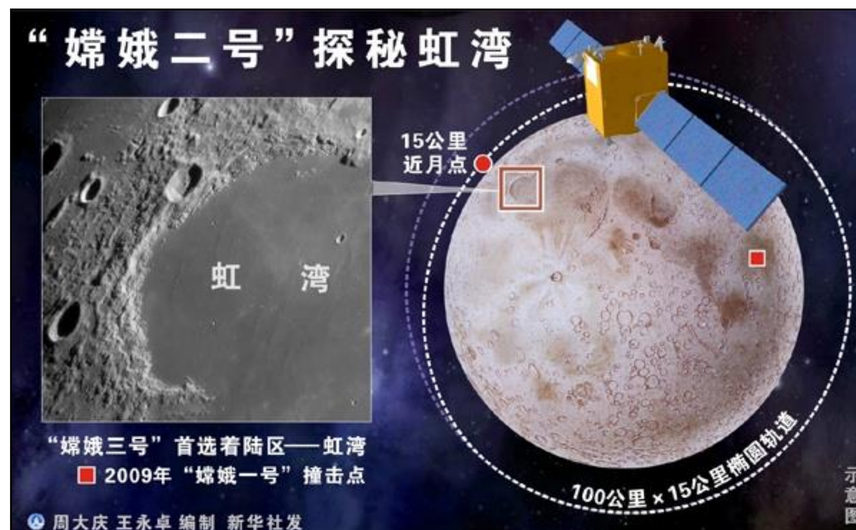
Chang'E-1 carried 8 payloads, including CCD, LAM, XRS, GRS, IIM, MRM, HPD, SWID. 58,157 data files were released with a total amount of 1010 GB.

Playload	Data level and number of files					Amount of released data (GB)
	01	2A	2B	2C	03	
CCD	30	4233	4233	3302	188	162.41
GRS	2748	----	----	1241	4	37.84
HPD	1846	----	----	1846	1546	5.49
IIM	10	711	711	711	----	625.19
LAM	10	1801	1801	----	2	1.12
MRM	10140	----	----	1690	16	17.60
SWID	3678	----	3678	----	7791	121.23
XRS	3572	----	----	888	----	38.75

CLEP SCIENTIFIC DATA

CHANG’E-2

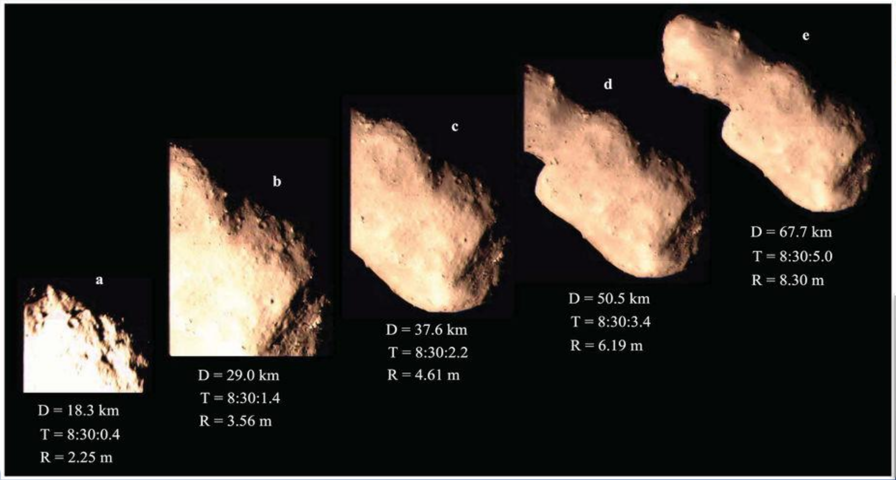
- Launched in Oct, 2010
- Validated some key technologies for landing
- Obtained high resolution image of Sinus Iridium
- Explored the landing region for Chang’E-3
- Carried extended test at Sun-earth L2

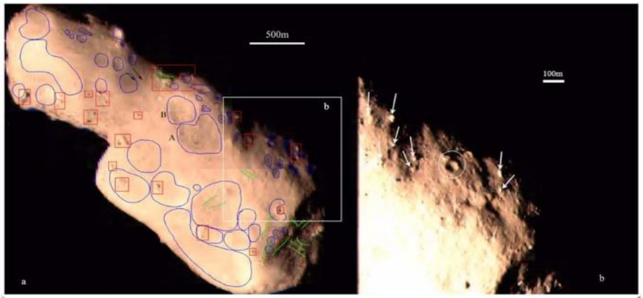


CLEP SCIENTIFIC DATA

Carried 7 payloads, CCD, LAM、XRS、GRS and so on. 38843 data files were released with a total amount of 3005 GB.

Playload	Data level and number of files				Amount of released data (GB)
	2B	2C	03	Senior	
CCD	----	18946	203	406	2853.85
GRS	----	2403	----	----	29.91
HPD	----	2419	----	----	5.25
LAM	56	----	----	----	0.017
MRM	----	2401	----	----	0.97
SWID	4749	----	----	----	88.85
XRS	----	7260	----	----	26



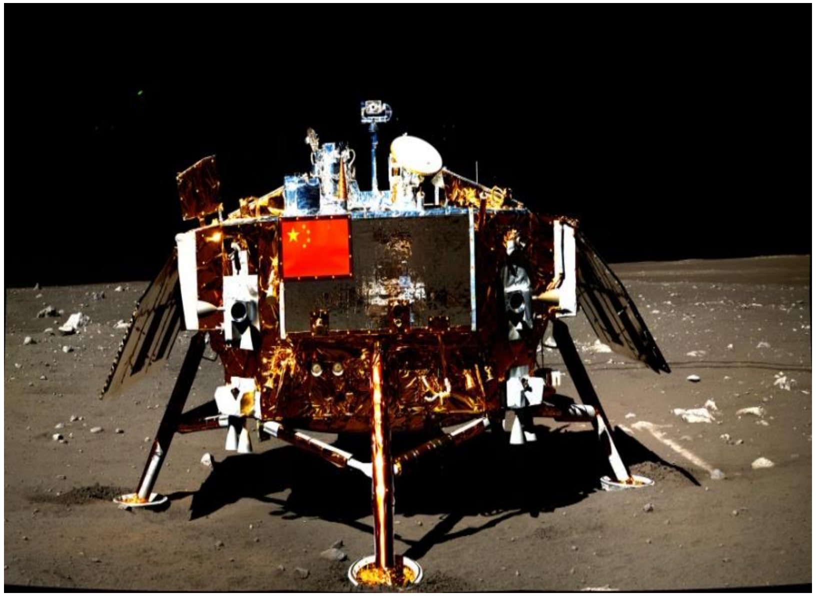


Toutatis images taken by CE-2
Scientific Reports,**3**, 3411, 2013,
www.nature.com

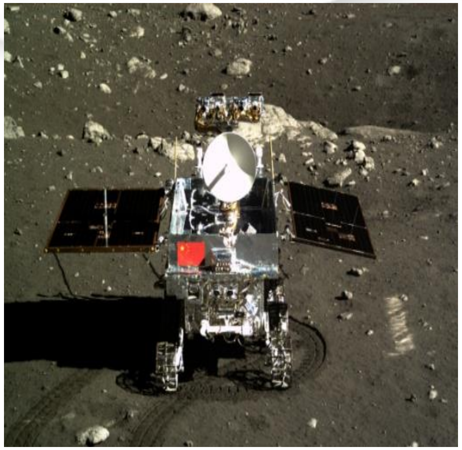
CLEP SCIENTIFIC DATA

CHANG'E-3

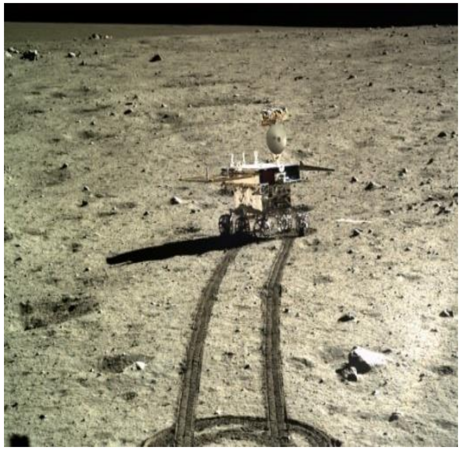
- Chang'E-3 soft landed on the designated area of Sinus Iridium, Dec. 14, 2013
- Separation of Lander and Rover, Dec. 15
- Realizing Chinese spacecraft's first soft landing on extraterrestrial bodies.



CE-3 Lunar Lander



welcome



Yutu's footprint

Earth, Merry Christmas!

CLEP SCIENTIFIC DATA

The lander carried MUVT、EUVC、TCAM、LCAM

The rover carried PCAM、APXS、LPR, and VNIS.

254120 data files with a total amount of 2004 GB were released.

Playload	Data level and number of files			Amount of released data (GB)
	2A	2B	2C	
PCAM	578	578	336	10.03
PIXS	8	4	----	0.09
VNIS	14	14	----	0.34
LPR	21	21	21	1.81
LCAM	4672	4672	----	9.57
TCAM	797	677	677	13.28
EUVC	388	388	----	0.036
MUVT	120127	120127	----	1968.96

CHANG’E-4

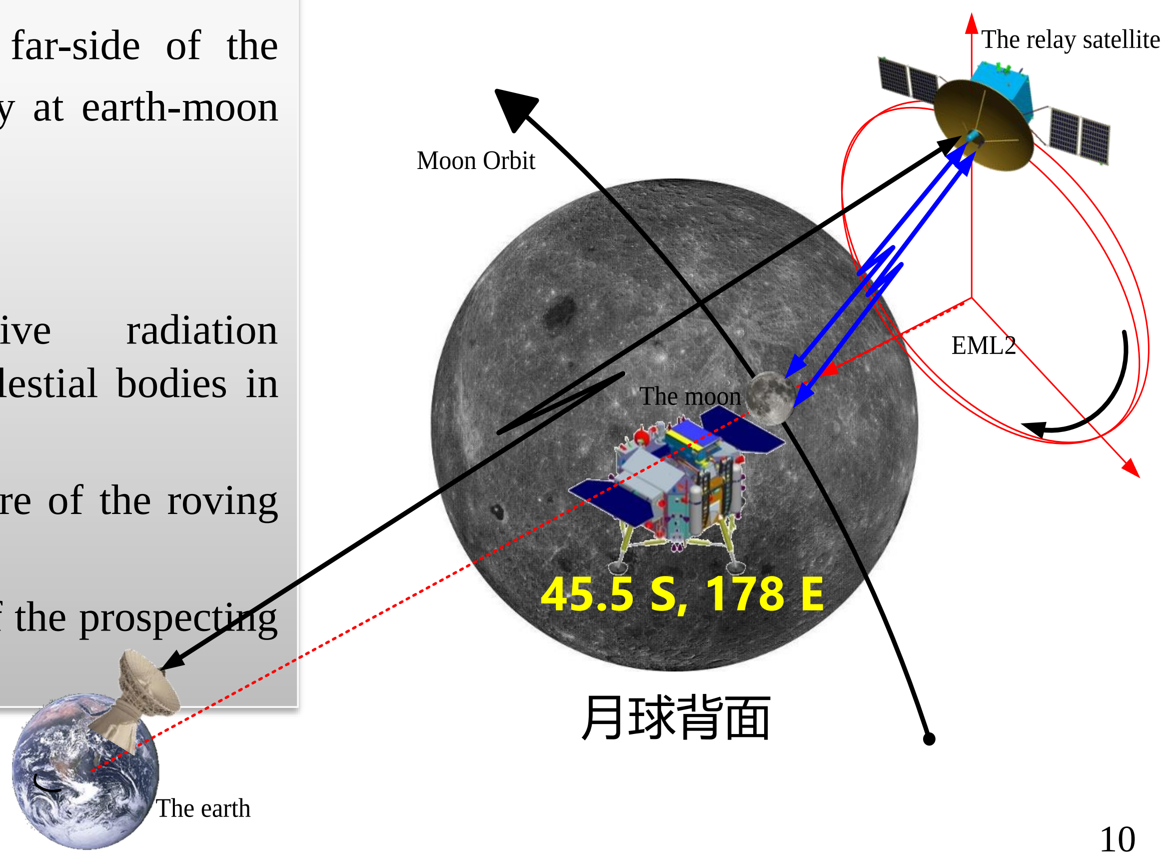
Farside moon misson. Composed of two launching in 2018. The relay satellite will be launched around May, 2018.

Engineering Objective

- Realizing soft landing on the far-side of the moon and communication relay at earth-moon L2 point.

Scientific Objective

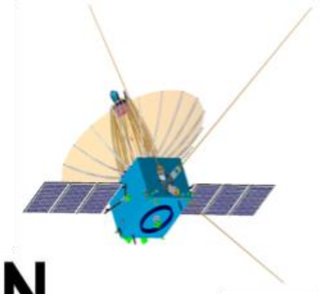
- To obtain the radioactive radiation characteristics of the natural celestial bodies in the low frequency band.
- To obtain the superficial structure of the roving area.
- Exploration of the topography of the prospecting area.



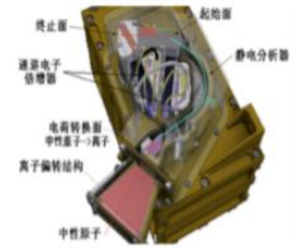
CLEP SCIENTIFIC DATA

Payloads

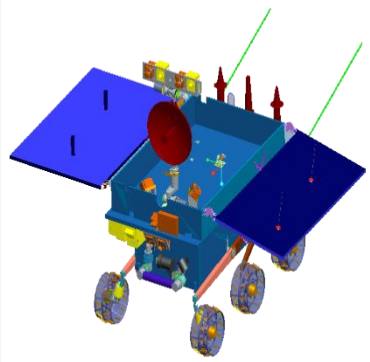
- Landing camera (Lander)
- Panoramic camera (Lander)
- Lunar neutrons & dosimetry detectors (Lander, Germany)
- Low frequency radio detectors (lander/relay sat., Netherlands)
- Retro reflector (relay sat.)
- Ground penetrating radar (Rover)
- Infrared imaging spectrometer (Rover)
- Topography and geology camera (Rover)
- Advanced Small Analyzer for Neutrals (Rover, Sweden)
- Mirco-imager (Saudi Arabia)



NCLE(Relay sat.)



ASAN (Rover)

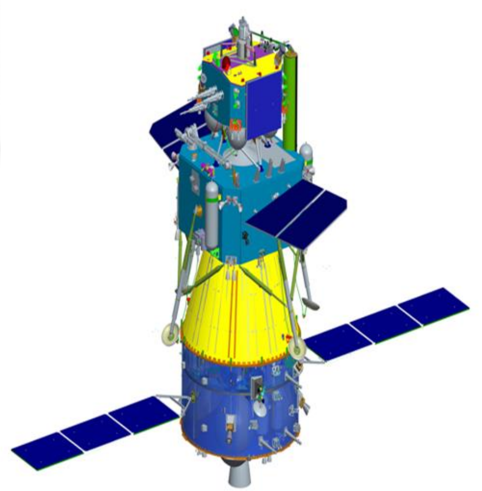


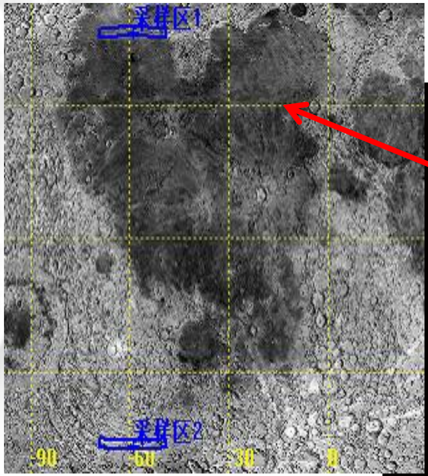
LND (Lander)

KACST

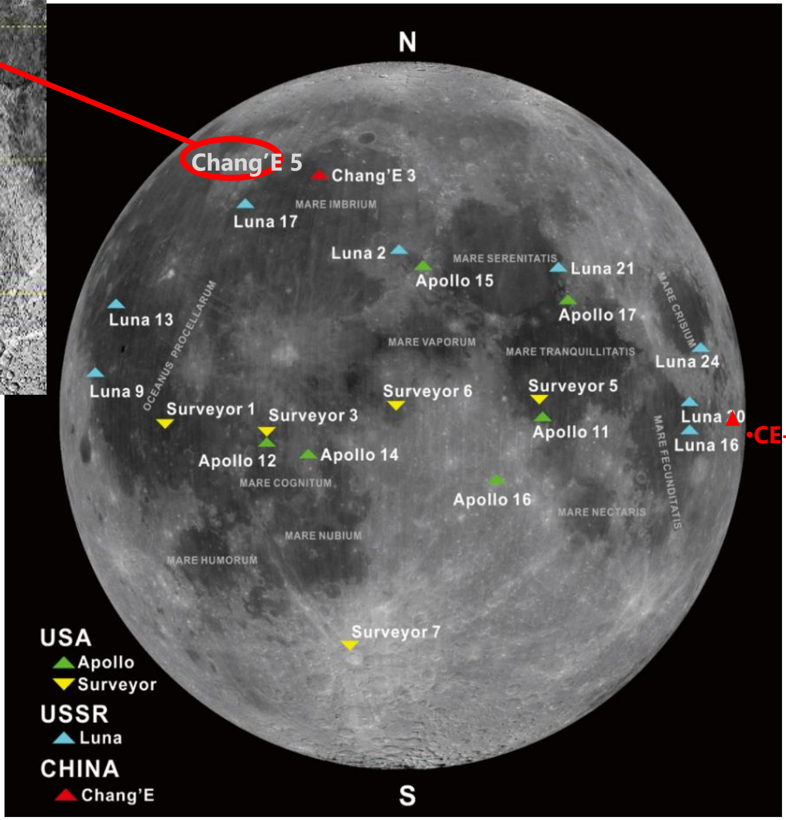
CHANG'E-5

- A lunar sample return mission.
- Launched in 2019.





Lunar sample study. Further the understanding of the moon formation and the evolution.



Landing site

Engineering Objective

Lunar sample return

Payloads

- **landing camera**

  analysis of topography and geological conditions

- **Panoramic camera**

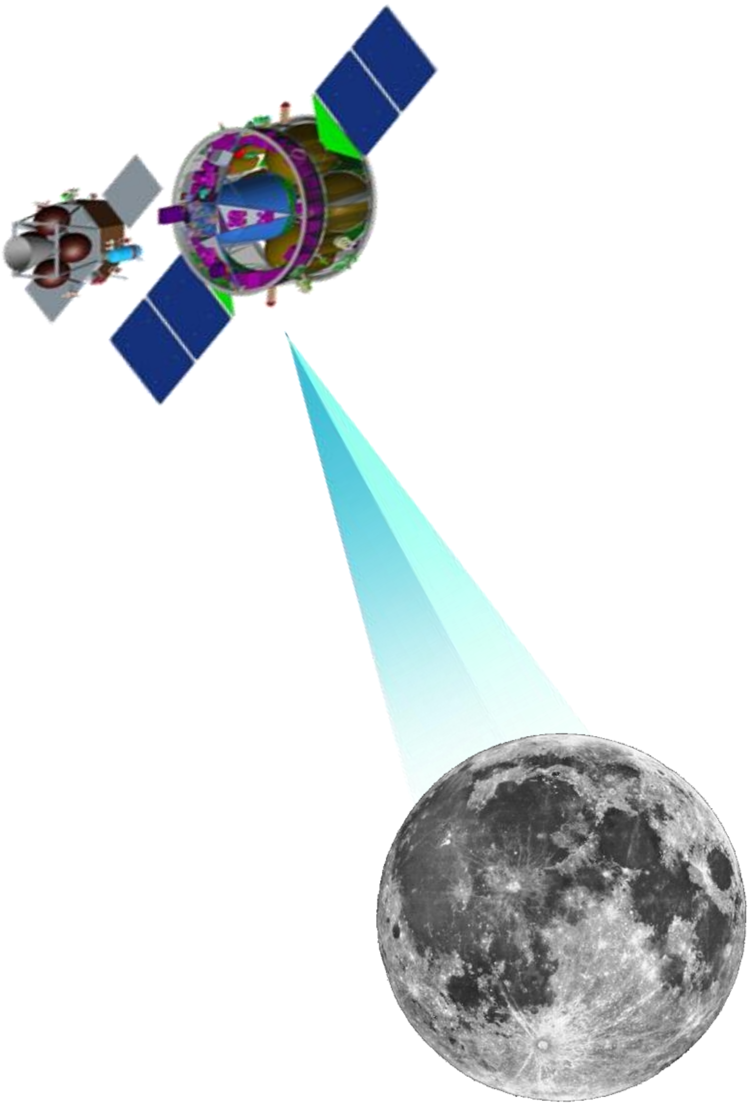
  obtain high resolution images of the landing area and sampling area. Study the lunar topography and geological structure and analyze the comprehensive research on the moon

- **Mineral spectrum analyzer**

  Obtain the visible and infrared reflectance spectra of the sampling area, mineral composition analysis, and the results of laboratory measurements

- **Soil structure detector**

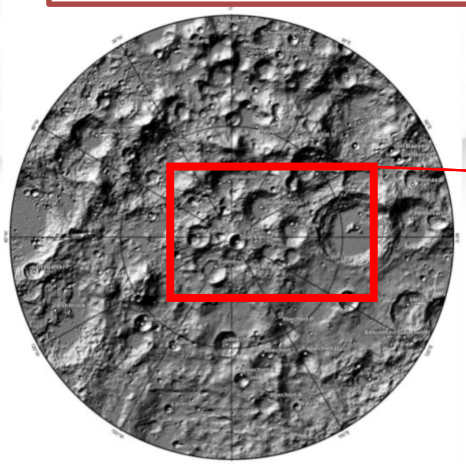
  subsurface structure detection, analysis of lunar regolith thickness and structure, to provide information support for the drilling process

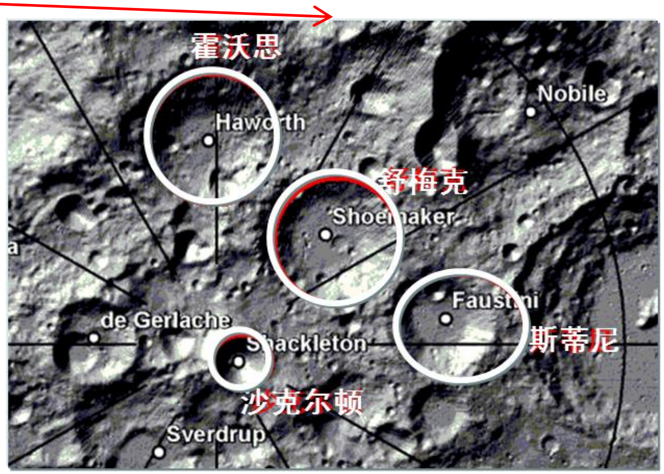


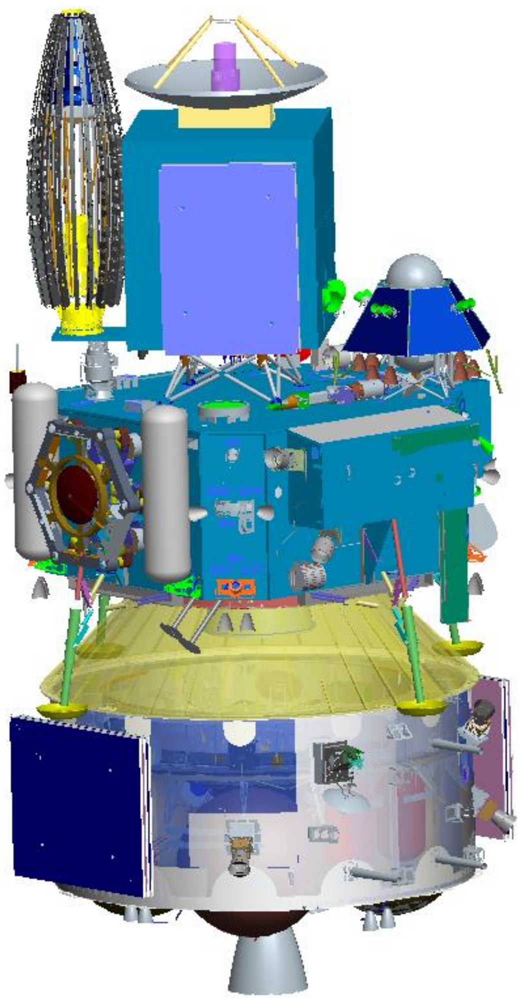
PROGRESS ON CLEP

Lunar Polar Region Missions

- Planning 3 missions.
- Investigate south polar regions geology features, mineral composition, volatile.
- Conduct observation of the earth, micro ecosystem research.
- One mission will be sample return.



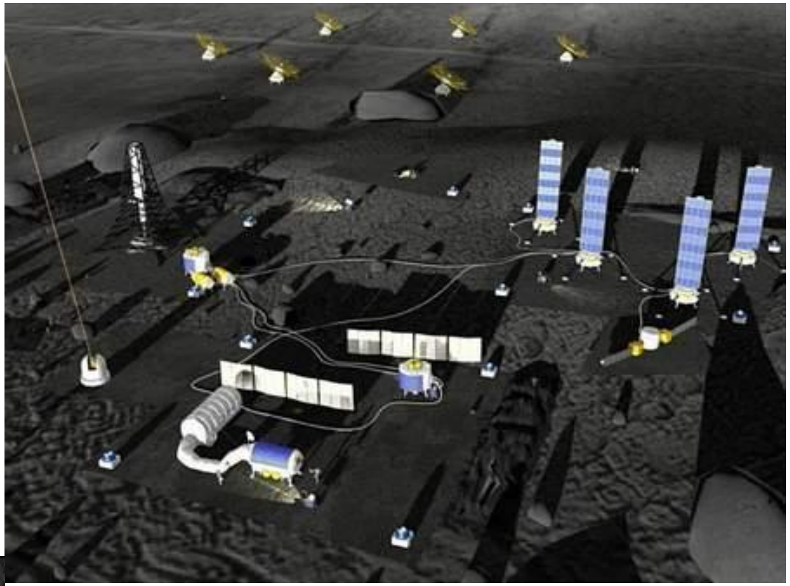


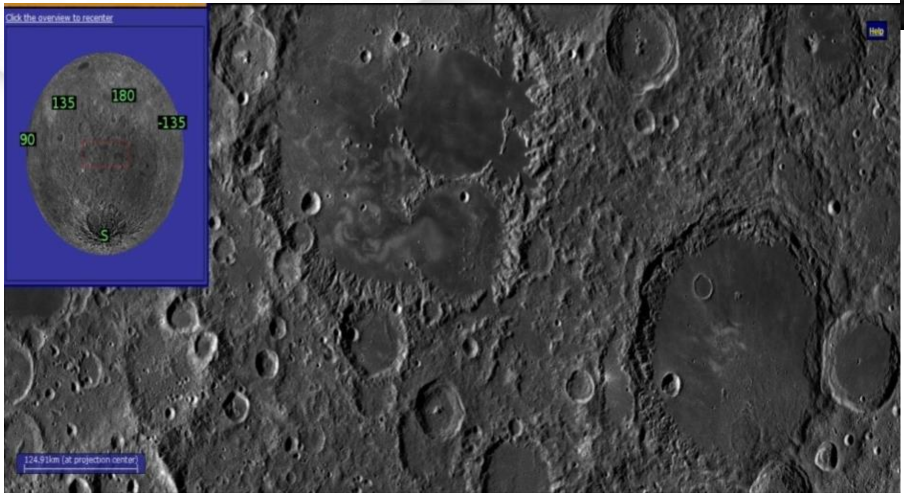


International Lunar Research Station

Missions

- Establish long-term energy supply, autonomous infrastructures.
- Conduct robotic scientific research and technology tests.





- Lunar environment and resource prospecting.
- Lunar-based observation.
- In-situ resource utilization.

Table of Contents

Scientific Data Policy

Basic Principle : Openness and Sharing

Management Organization

- On behalf of CNSA, Lunar Exploration and Space Engineering Center (LESEC) is responsible for the management of scientific data from lunar and deep space missions.
- The National Astronomical Observatory is responsible for receiving, processing and storing scientific data.

Data Level

- 0 Level
- 1 Level
- 2 Level

Scientific Data Policy

Processing Period

- *1-year data processing period*
- **CNSA identifies the types of scientific data that are publicly available**

Data Users

- **Payloads development units can use all levels of scientific data for its payload.**
- **Other users may apply for use of Level 1 and 2 scientific data and indicate whether subsequent data for that type are required.**

Data Application

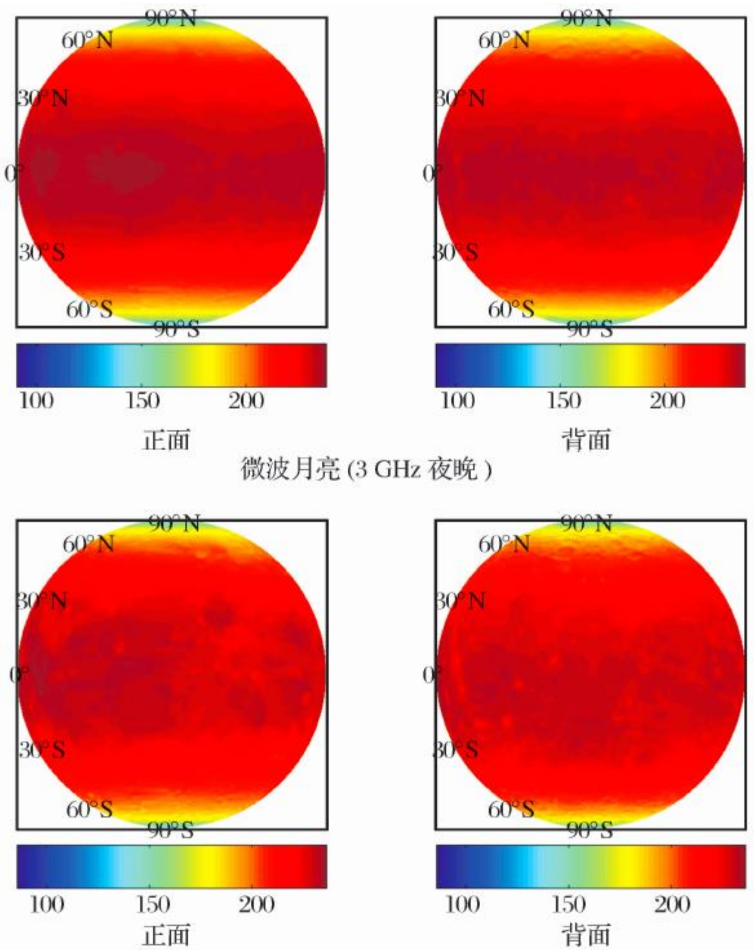
- **The new data application system is under construction, scheduled in 2018**
- **Data on Chang'E 1, 2 and 3, as well as future Chang'E-4, 5, Mars mission, and lunar samples can be applied.**

Table of Contents

Scientific Outcomes

CHANG'E-1

- The CELMS performs microwave sounding of the entire moon from lunar orbit.
- Microwave moon was created.
- Microwave sounding data were obtained covering 4 frequency channel (3, 7.8, 19.5, and 37 GHz) and 8 times orbits of the entire lunar for the first time at 200 km orbital altitude

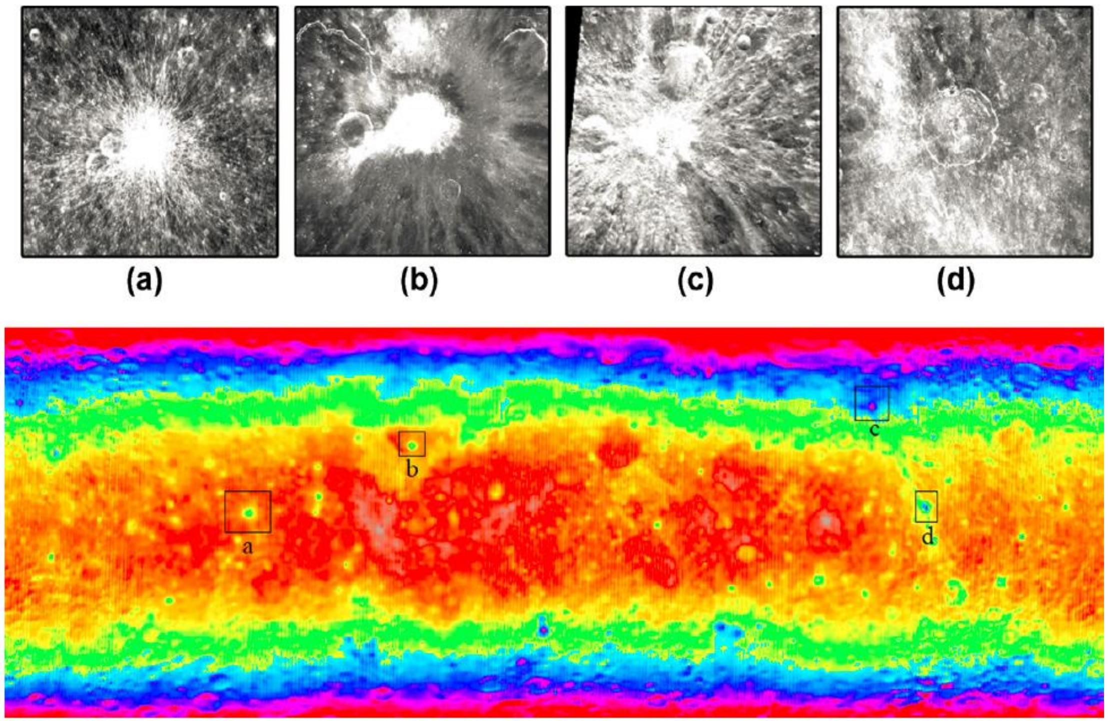


Bright temperature at different frequencies（MicM Ortho）

Scientific Outcomes

CHANG’E-1

- Hundreds of lunar cold spots were found in dark moon’s entire lunar microwave image
- Most of these cold spots are young craters with radial patterns indicating that thermal anomalies in these areas are related to the stone content

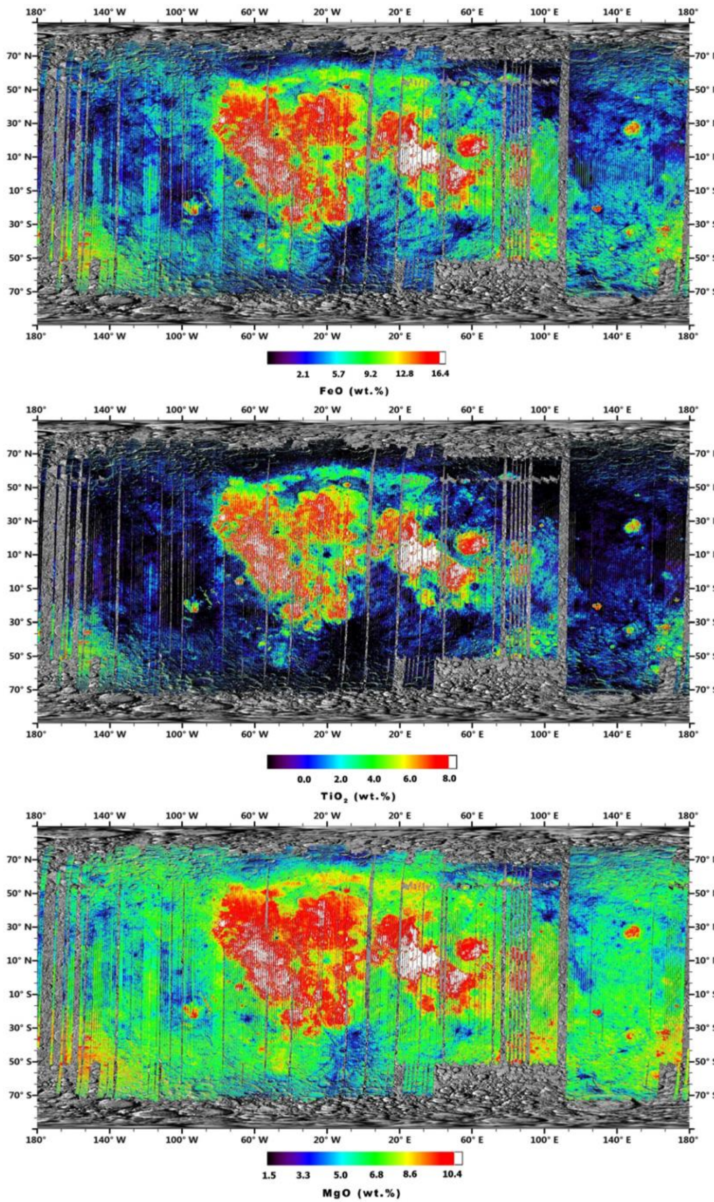


Zheng, et al., 2012. First microwave map of the Moon with Chang’E-1 data: The role of local time in global imaging. Icarus 219, 194-210

Scientific Outcomes

CHANG'E-2

The amount and distribution characteristics of Fe, Ti, Mg, Al, Ca, and Si in lunar surface were retrieved by using the data of Chang'E-1 interferometric imaging spectrometer (IIM) further obtained the global Mg#

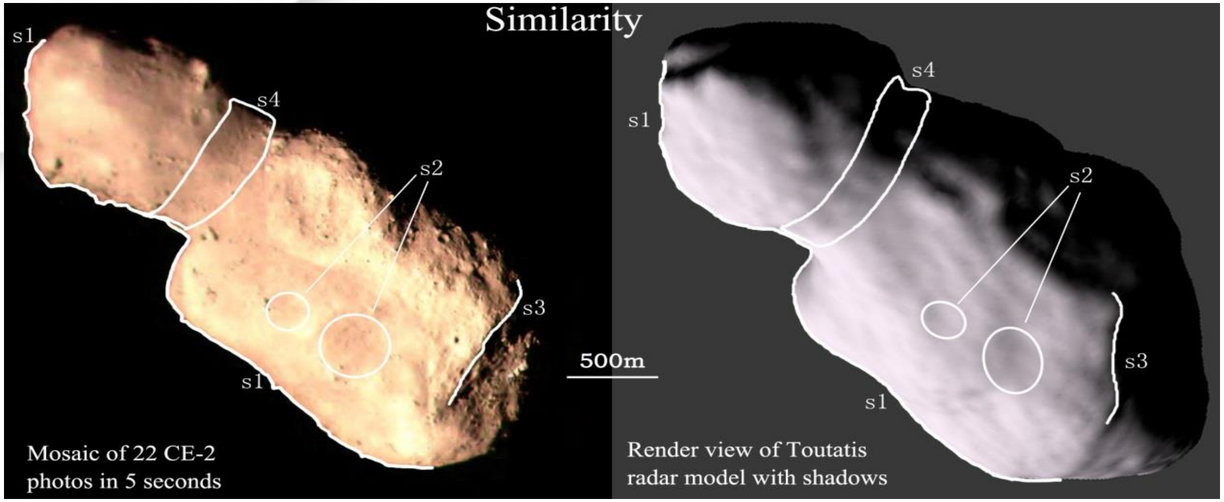


Wu, Y. Z. (2012). "Major elements and Mg# of the Moon: Results from Chang'E-1 Interference Imaging Spectrometer (IIM) data." Geochimica Et Cosmochimica Acta ***93****: 214-234.*

Scientific Outcomes

CHANG'E-2

- Compared with the results of ground-based radar imaging acquired in the past by multiple flyovers, the flying distance and image resolution are calculated, and the correctness of the radar model is discussed.
- There was a difference in the distribution of impact craters between its large and small lobes.

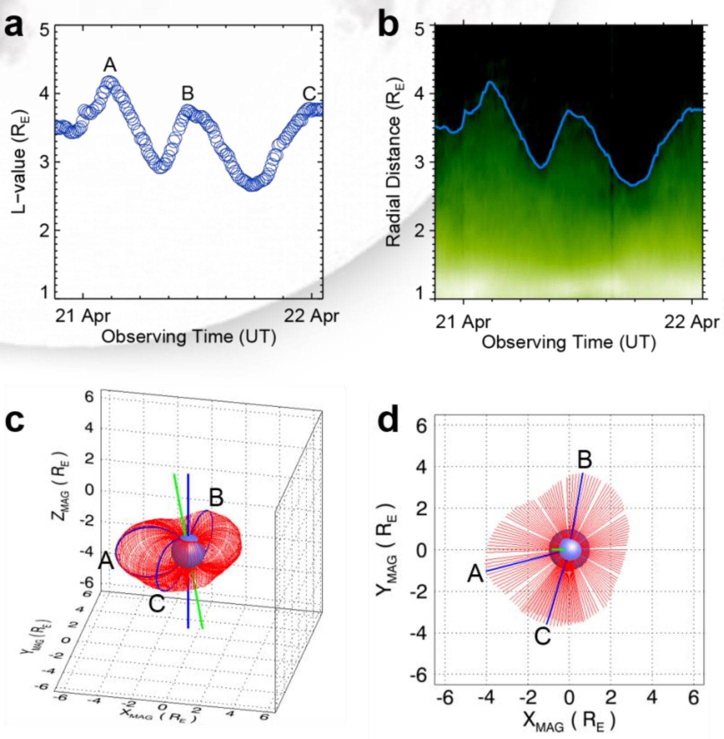


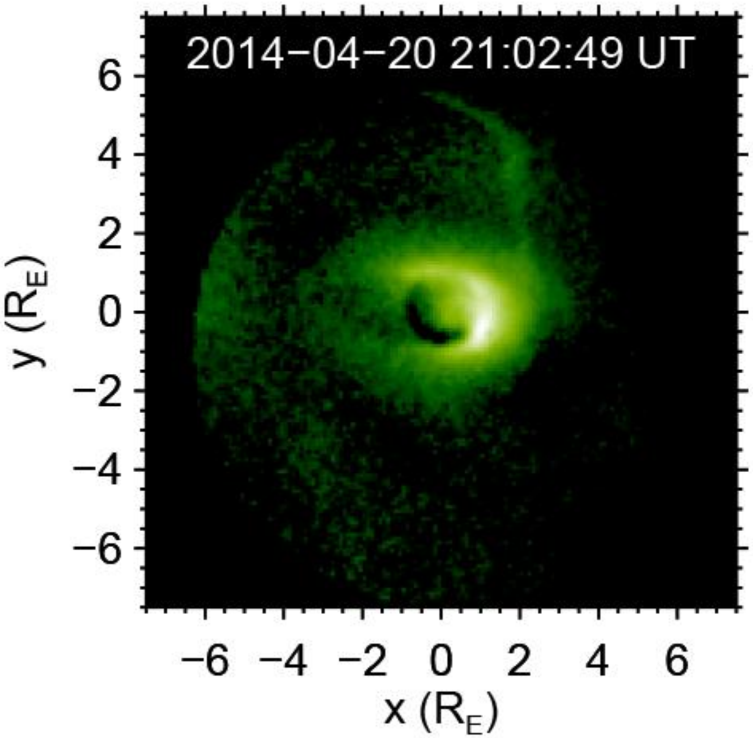
Zou, X. D., C. L. Li, J. J. Liu, W. R. Wang, H. Li and J. S. Ping (2014). "The preliminary analysis of the 4179 Toutatis snapshots of the Chang'E-2 flyby." *Icarus* ***229****: 348-354.*

Scientific Outcomes

CHANG'E-3

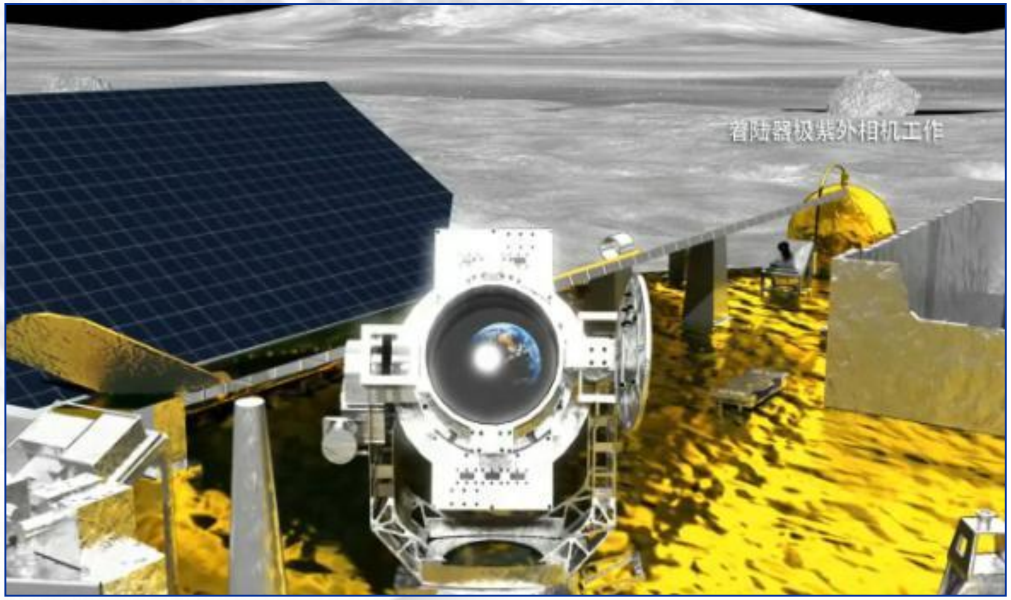
- Earth's plasma layer detection
- Observation of the extreme ultraviolet of Earth's plasma by great field from fix points on the moon

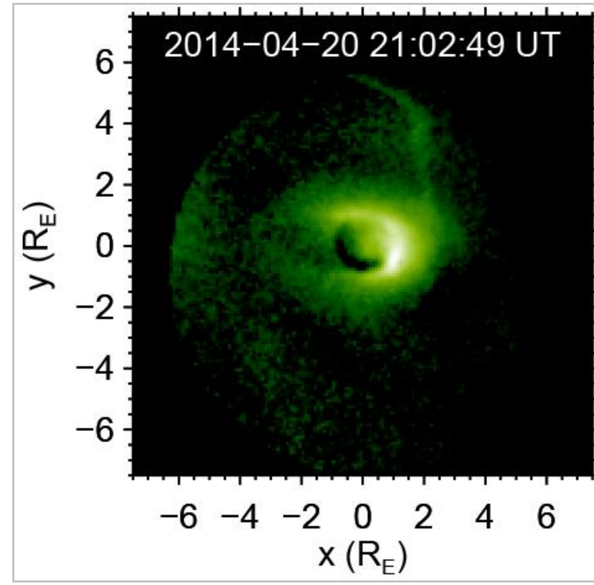


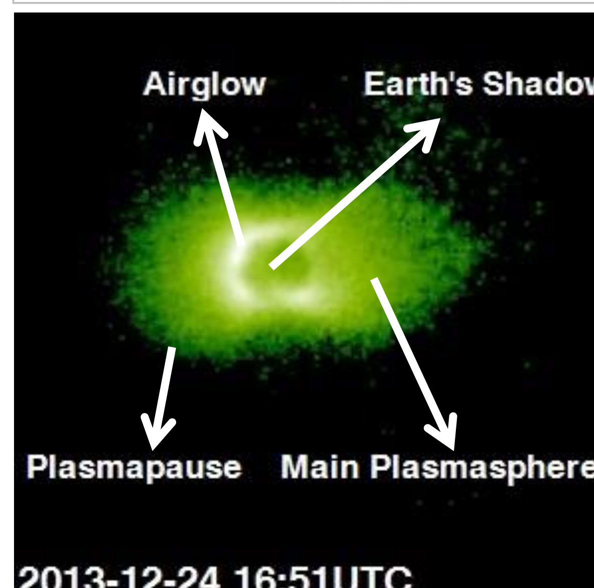


Scientific Outcomes

CHANG'E-3



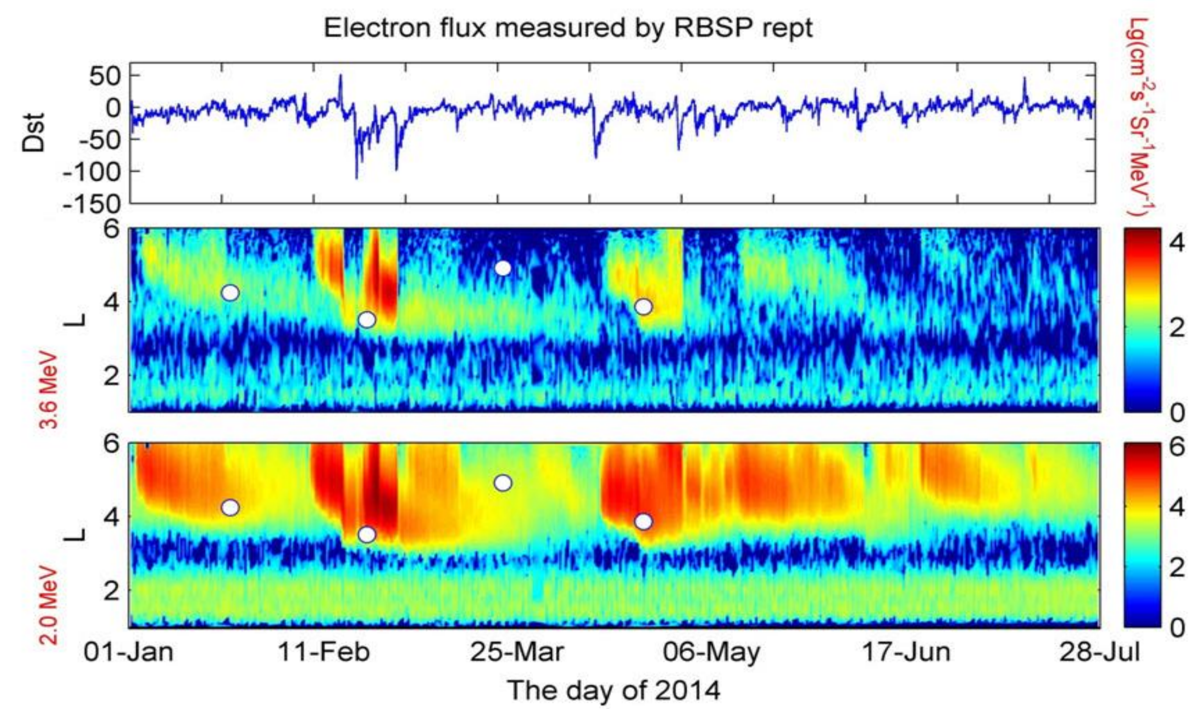




Boundary layer of the Earth's plasma layer occurred convex under influence of magnetosphere sub-storms , discovered by EUV camera, confirming that the scale of the earth's plasma layer is inversely related to the intensity of geomagnetic activity.

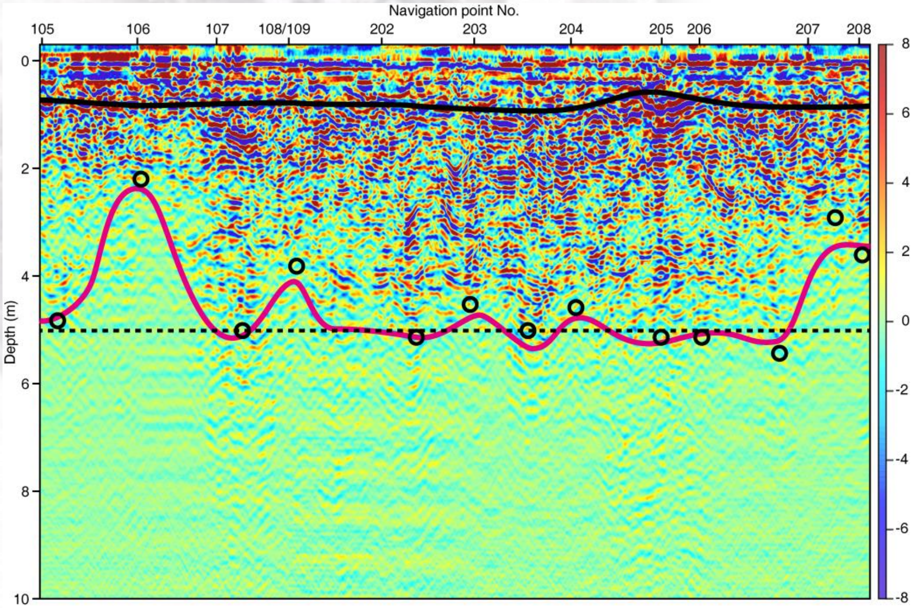
CHANG'E-3

- Confirm the scale of the Earth's plasma layer is inversely related to the intensity of geomagnetic activity (published in JGR, 2016).
- Propose that the spatial structure of the plasma layer is constrained and controlled by the Earth's magnetic and electric fields.



Scientific Outcomes

CHANG'E-3



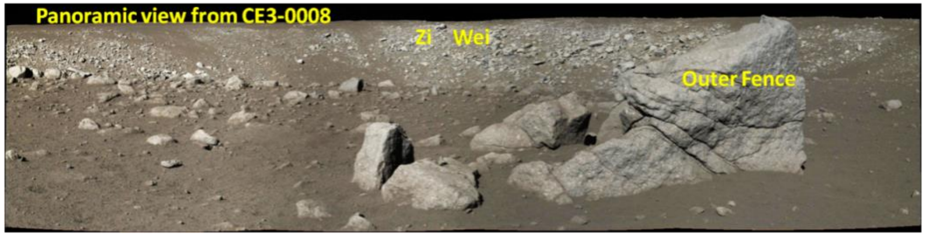
Reveal the history of the volcano evolution in the Mare Imbrium area.

Zhang, J., et. al., (2015). "Volcanic History of the Imbrium Basin: A Close-up View from the Lunar Rover Yutu." *Proceedings of the National Academy of the Sciences of the United States of America*: doi: 10.1073.

Scientific Outcomes

CHANG'E-3

- A new type of rock was discovered. (Published in Nat Commun, 2015)
- Rock ejected from the "ZIWEI" crater in Chang'E-3 landing area was a brand new moon basalt



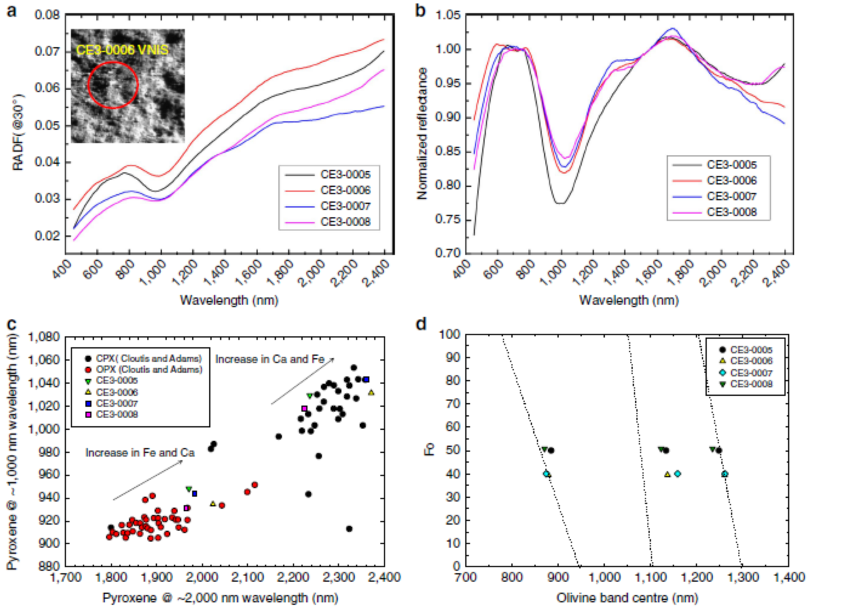


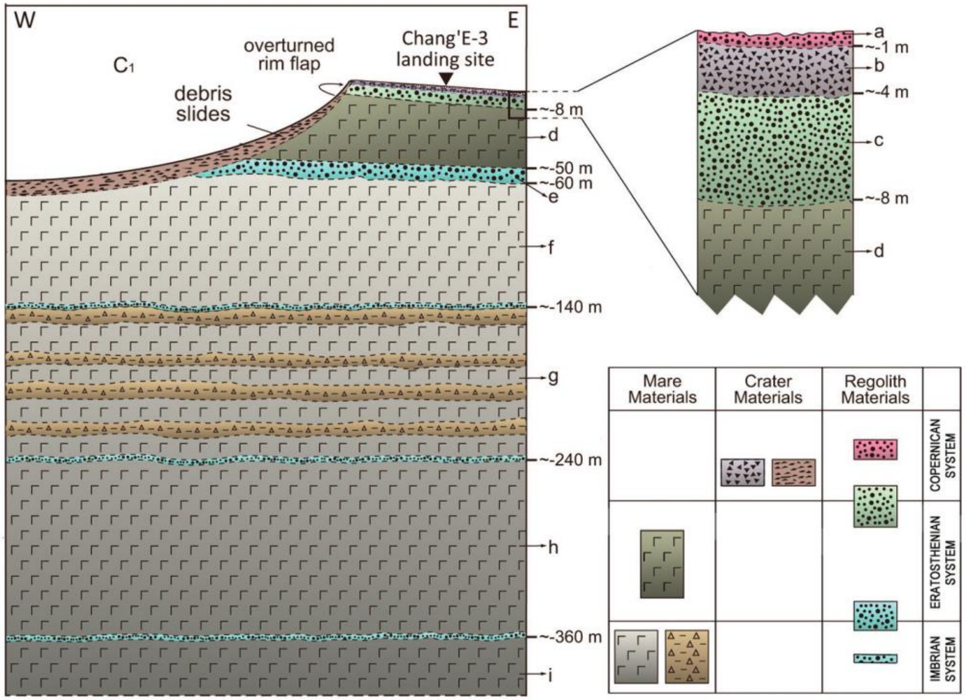
Figure 3 | Visible-NIR spectral properties and mineral chemistry of Chang'e-3 soils from VNIS. (**a**) Combined VNIS spectra (450–2,400 nm) from sites 0005, 0006, 0007 and 0008. The inset image is from site CE3-0006 of the VNIS (450–950 nm) image mode at 750 nm. The dashed circle indicates the region measured by the VNIS-point spectral mode (900–2,400 nm). (**b**) VNIS spectra after continuum removal. (**c**) Pyroxene VNIS peak positions of the CE-3 soils overlain on experimental results from Adams[27] and Cloutis and Gaffey[28]. (**d**) Fo values of olivine in four CE-3 soils derived from VNIS spectra, overlain on calibration lines (Sunshine and Pieters[20]).

Zongcheng Ling, et al., Correlated compositional and mineralogical investigations at the Chang'e-3 landing site, 2015, Nature Comunications. DOI: 10.1038/ncomms9880.

Scientific Outcomes

CHANG'E-3

Reveal the geological features of the patrolling area: The characteristics of the shallow structure in the geological evolution history was analyzed for the first time.



Geological and Geophysical Interpretation of

Chang'E-3 Landing Site profile

Long Xiao et. al., A Young Multilayered Terrane of the Northern Mare Imbrium Revealed by Chang'E-3 Mission, ***Science****, 2015, 347（6227）1226-1229.*

Scientific Outcomes

CHANG'E-3

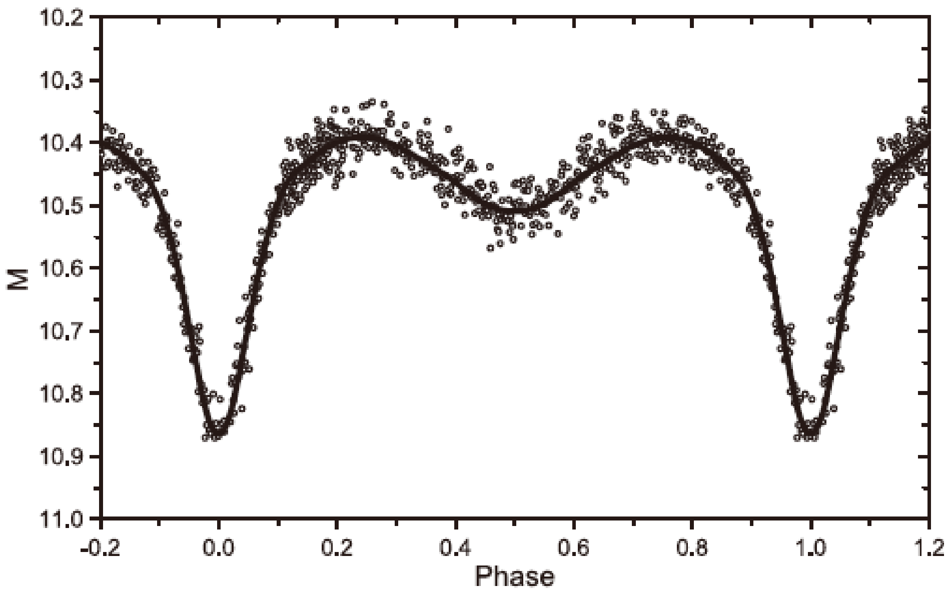
New record of the content of outer layer of water in the Moon. (Published in Earth and Planetary Astrophysics, 2015)

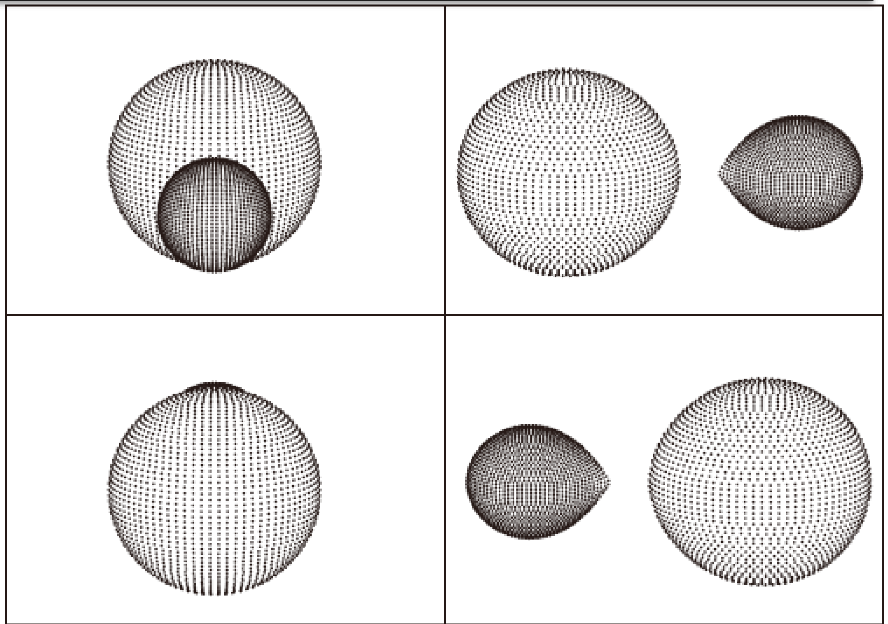
Device	Detection Principle	Surface Density (cm^{-3})
HST Limb Spectrum	3087 Å resonance fluorescence	$<10^6$ (5σ)
Apollo12/14/15 CCGEs	Particle Counting	$<10^7$
Chandrayaan/CHACE	Particle Counting	$\sim 2\times10^9$
Lunar-based Optical Telescope	Particle Counting	$<10^4$

Scientific Outcomes

CHANG'E-3

- A rare celestial body found in process of rapid material exchange in binary stars
- A number of samples found in process of chronic material evolution in binary substance
- Short time scale changes in detached binaries and contact binary, indicating new spots are producing from these binary stars
- Semi-contact close binary in six-star system
- Contact binary stars found in two six-star systems





Thank You !