Chinese Lunar Exploration Program

China National Space Administration

June, 2014

Planning of
Chinese Lunar Exploration Program

Chinese lunar exploration program is an unmanned mission before 2020, and it has three phases which achieve the following objectives separately: lunar orbiting exploration; soft landing on the moon's surface, patrolling and probing; and sampling and returning to the Earth.

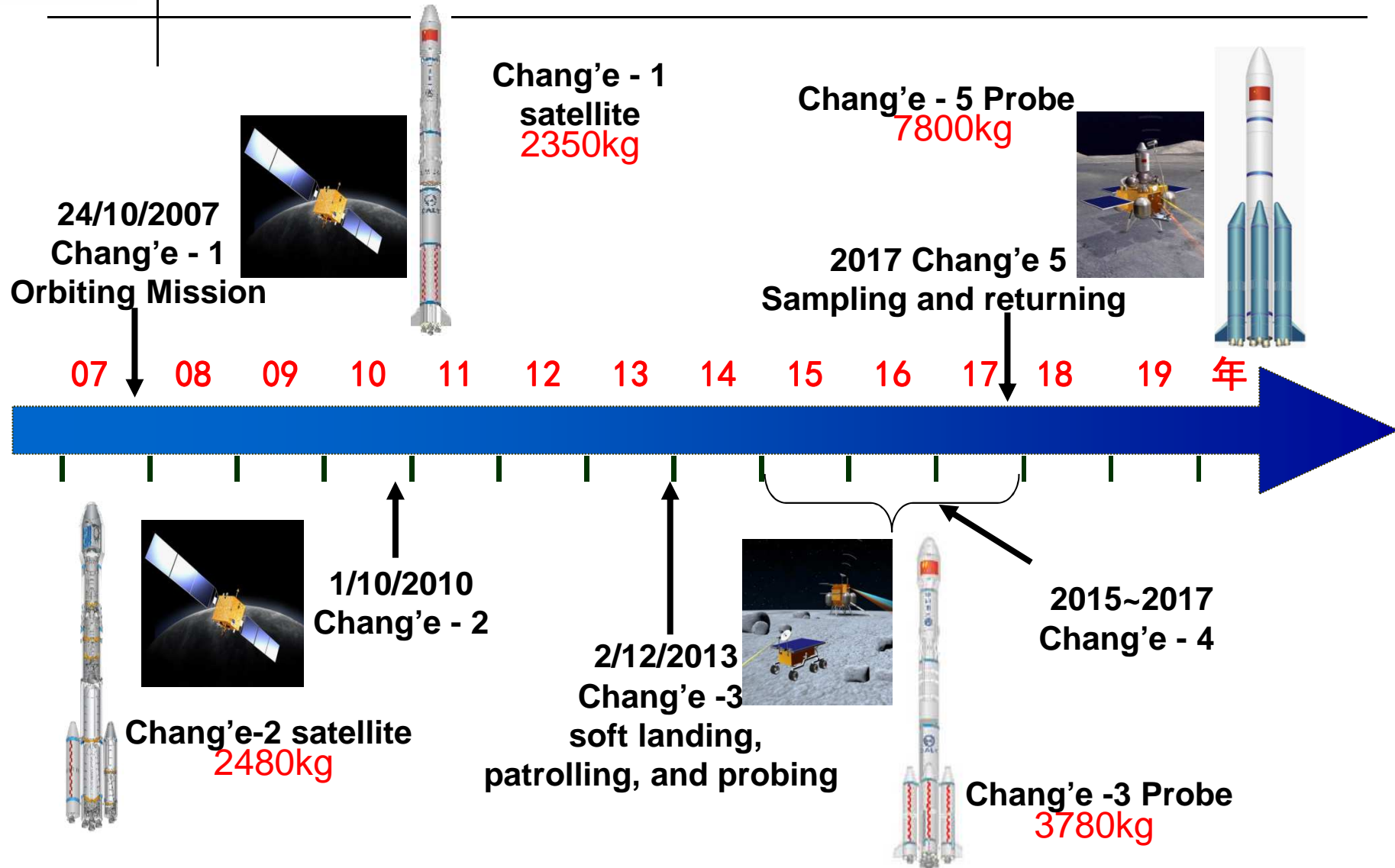**Oribiting**

2004 ~ 2007

Landing

2008 ~ 2014

Returning

2011 ~ 2020

Roadmap of Chinese Lunar Exploration Program

Chang'e - 1 satellite 2350kg

Chang'e - 5 Probe 7800kg

24/10/2007 Chang'e - 1 Orbiting Mission

2017 Chang'e 5 Sampling and returning

07 08 09 10 11 12 13 14 15 16 17 18 19 年

1/10/2010 Chang'e - 2

2/12/2013 Chang'e -3 soft landing, patrolling, and probing

2015~2017 Chang'e - 4

Chang'e-2 satellite 2480kg

**Chang'e -3 Probe** 3780kg

Chang'e -1

- Chang'e 1 was successfully launched on Oct. 24th, 2007, which made the Chinese dream of flying to the moon come true.

- Carried out a comprehensive remote sensing survey and obtained the 120 m resolution full moon image map, elevation map and element content distribution, etc.

- on Mar. 1st, 2009, made a controlled crash into the moon, successfully completed its mission. The totally time of in-orbit operation is 494 days.
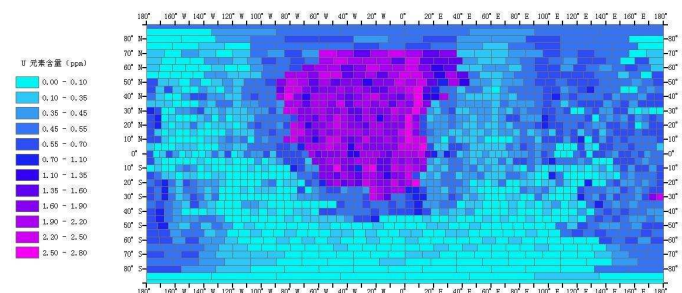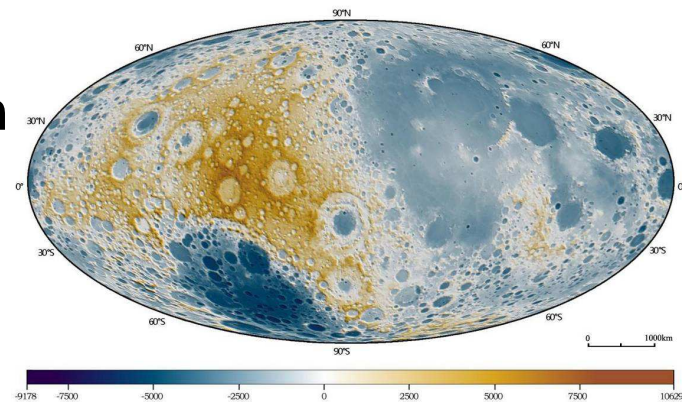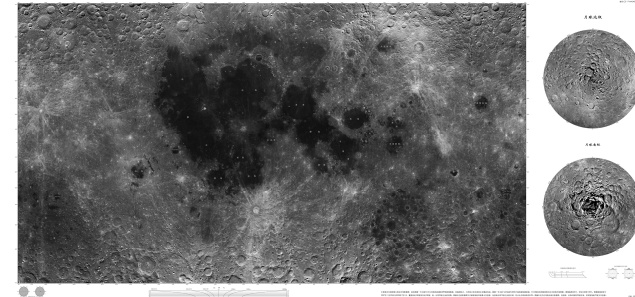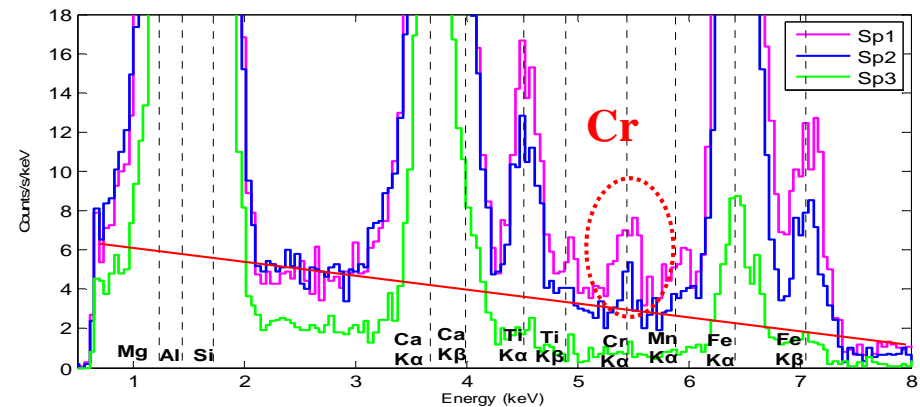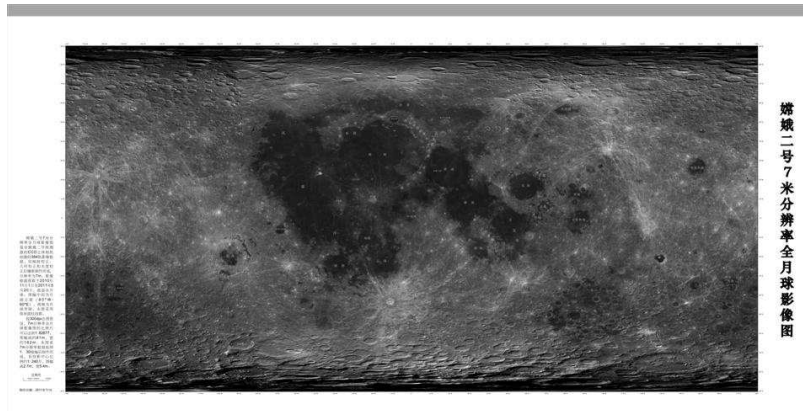
Chang'e -2

- Chang'e 2 was launched successfully On Oct.1, 2010.

- As the first satellite of Phase II, validated some of the key technologies of landing as well as searching landing eara for the subsequent Chang'e 3 mission.

- Obtained the full moon image maps with 7m resolution and local image maps with 1.5m resolution.

- Discovered chromium elements, micro magnetosphere, and solar wind acceleration and deceleration on the moon.
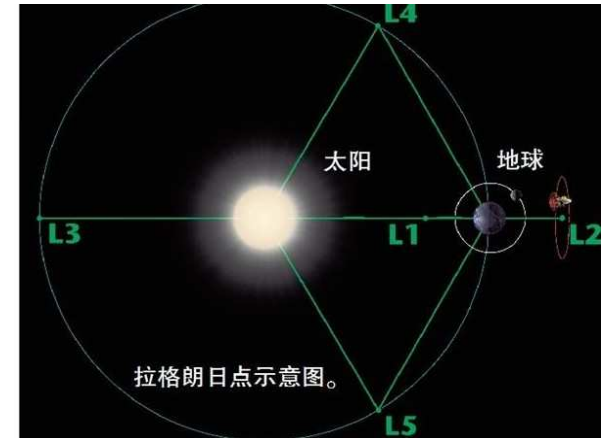
Chang'e -2

■ **Starting from lunar orbit, Chang E II flew around the L2 Sun-Earth Lagrange point, to carry out X / γ-ray astronomical exploration, plasma detection on the distant magnetotail region, etc.**

■ **On Dec.13th,2012, 7 million km far from earth, it carried out close exploration of the Toutatis (4179) asteroid at a distance as short as 3.2 km.**

■ **It is currently more than 90 million km away from the Earth, and is expected to fly back to a position 7 million km from the Earth in 2029.**
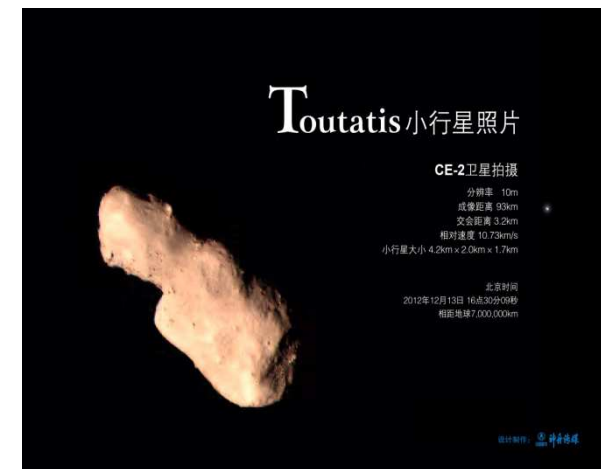
Chang'e -3

Mission Target：

- The first Chinese spacecraft soft landing on moon, as well as patrolling and probing.

Scientific objectives：

- Conduct survey of moon surface morphology and geological structure
- Conduct survey of constituent of the moon surface and available resources
- Implement Earth plasma layer probing and Lunar-based optical astronomical observations

Lander

The Lander completed the earth-moon orbit transfer, moon orbiting, and powered descent after launched and injected to the orbit with the patroller, and carried out the probing after soft landed on the preselected landing area in Rainbow Bay of the moon.

Main Performance Index

Launch mass：	**Less than 3640kg**
The envelope size：	**Dia.3650mm，height3450mm**
landing speed：	**Lengthways＜3.8m/s Crosswise＜1m/s**
Landing attitude control error：	**3 axis attitude control error ≤5°**
Landing angular speed control error:	**All 3 axis ≤2°/s**
Working hours on	**>12 months**
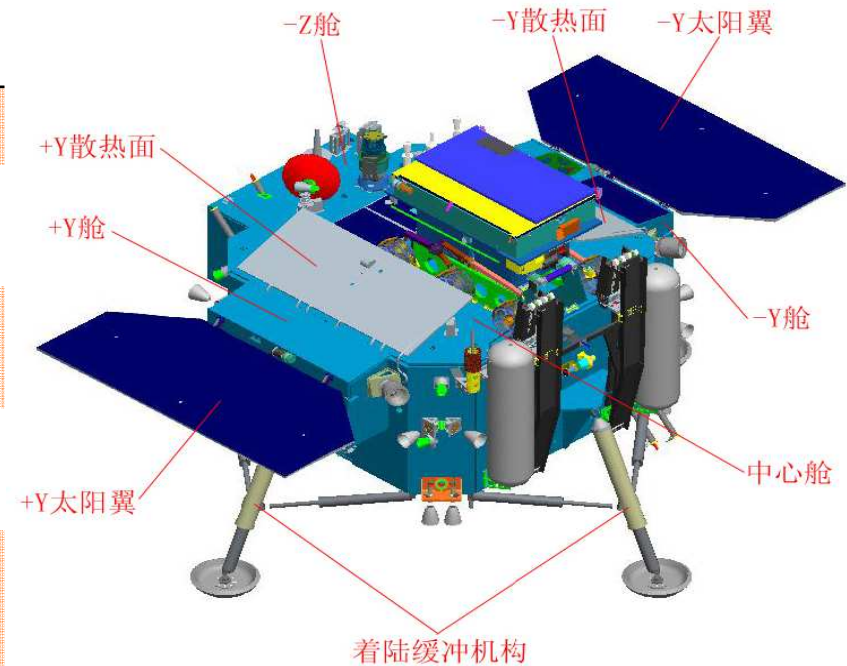
The Yutu Patroller(Lunar Rover)

After it arrived the moon surface，Yutu Lunar Rover started patrolling and probing.

红外成像光谱仪　巡视器器表国旗　激光点阵器　X频段接收天线　UHF频段发射天线

X频段发射天线

压紧释放机构b

-Y 太阳翼

右避障相机
左避障相机

粒子激发X射线谱仪定标装置　机械臂　粒子激发X射线谱仪探头　粒子激发X射线谱仪生存装置
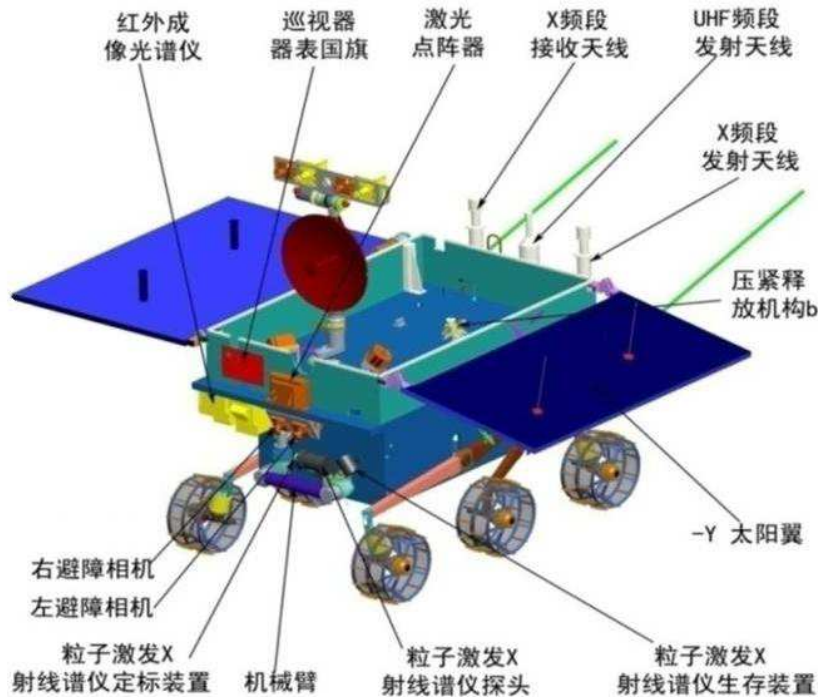
Main Performance Index

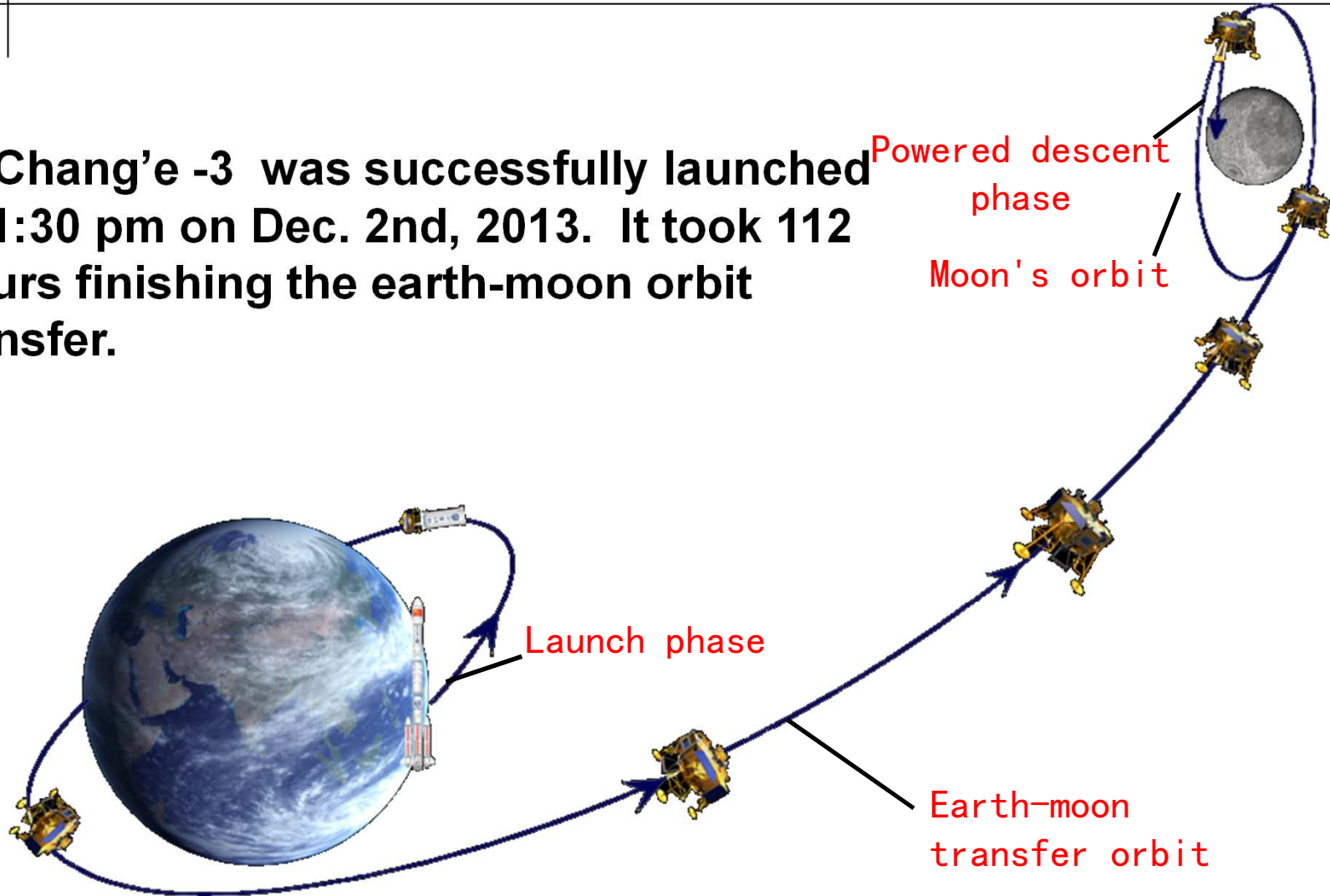| Mass：	140kg
The envelope size：	1500mm(L)×1020mm(W) ×1110mm(H)
Maximum travelling speed：	≥200m/h
Obstacle crossing ability：	≥ 200mm High
Gradeability：	≥ 20° slope
Working hours	

The earth-moon orbit transfer

- **Chang'e -3 was successfully launched at 1:30 pm on Dec. 2nd, 2013. It took 112 hours finishing the earth-moon orbit transfer.**
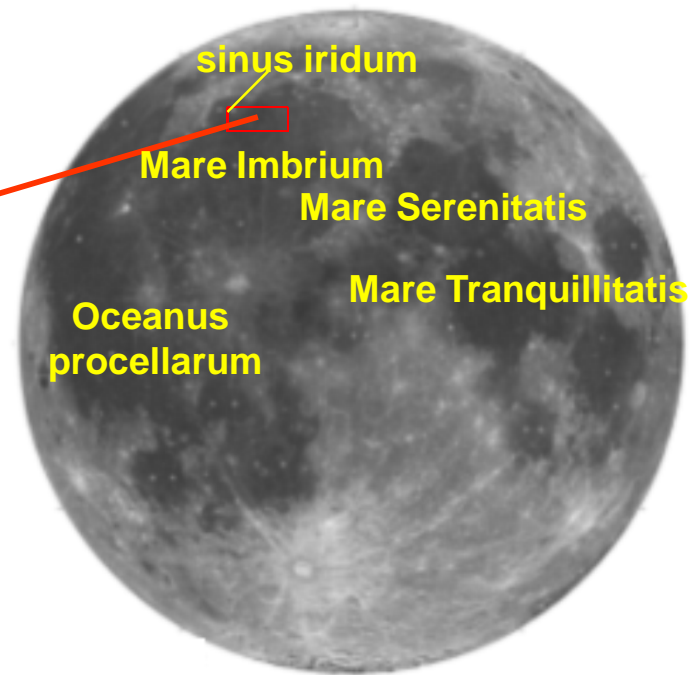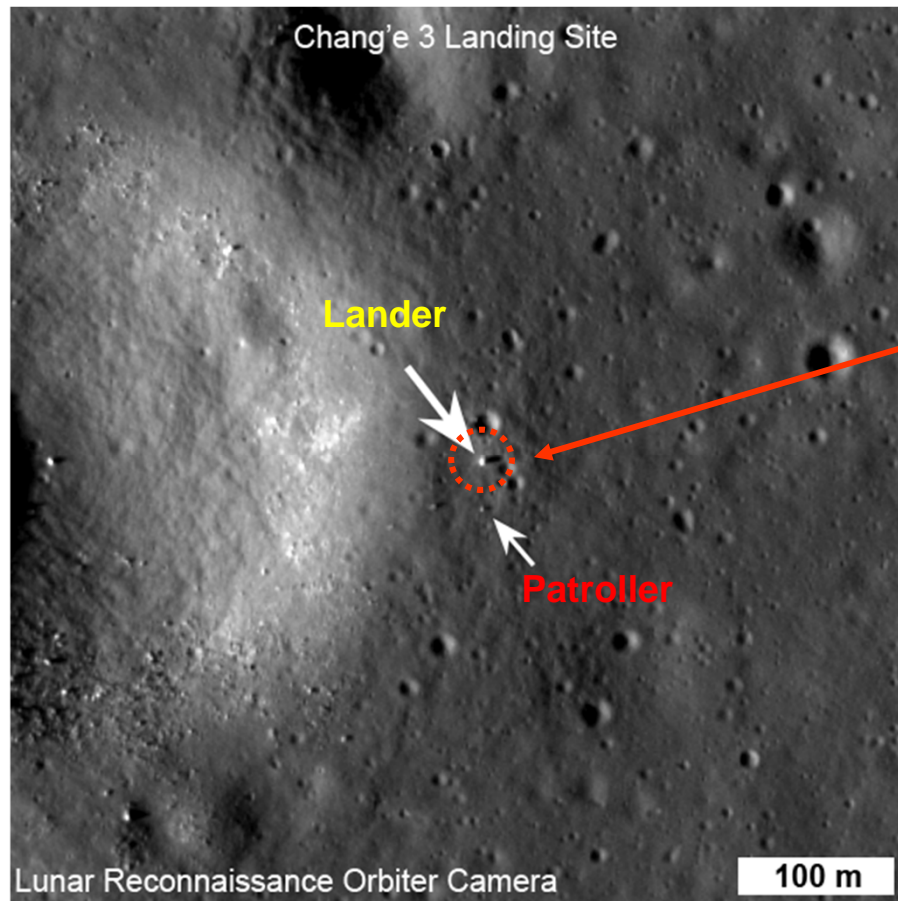
Powered descent phase

Moon's orbit

Launch phase

Earth-moon transfer orbit

9:11 pm, Dec.14, 2013, landed at the northwest area of Mare Imbrium (44.12° N，19,51° W)

Chang'e 3 Landing Site

Lander

Patroller

Lunar Reconnaissance Orbiter Camera

100 m

sinus iridum

Mare Imbrium

Mare Serenitatis

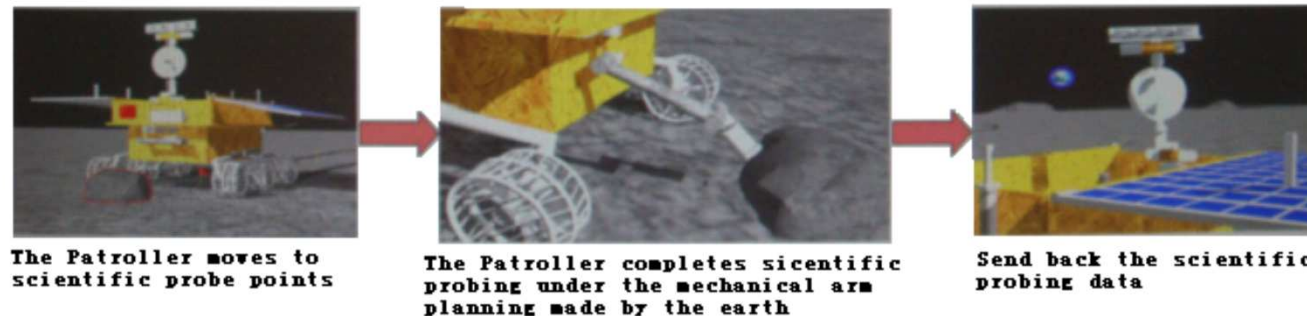Mare Tranquillitatis

Oceanus procellarum

Selenographic Patrolling

The patroller used teleoperation to implement lunar surface exploration. Each exploration would go through two steps: perception and planning, and scientific exploration.

The Process of Perception

| The Patroller get perception of the lunar surface | Make integrated planning according to scientific probe points | Implement period programme and confirm the steerpoints | Make route planning and confirm the exercise path |

The Scientific Probing Process of Patroller

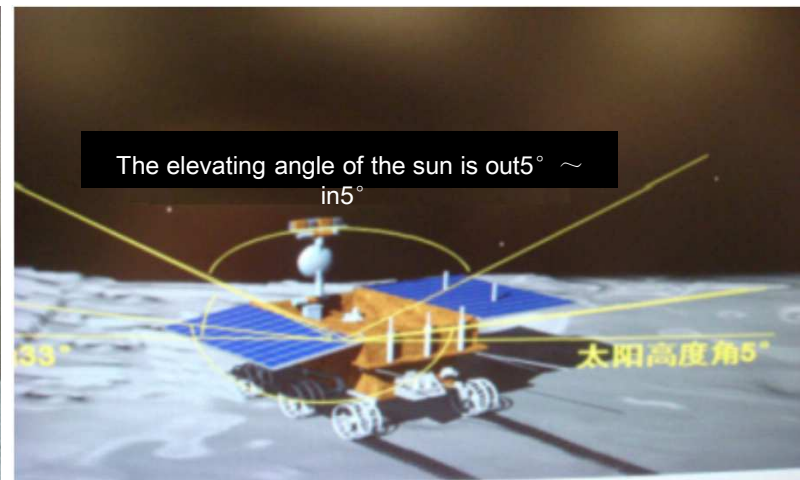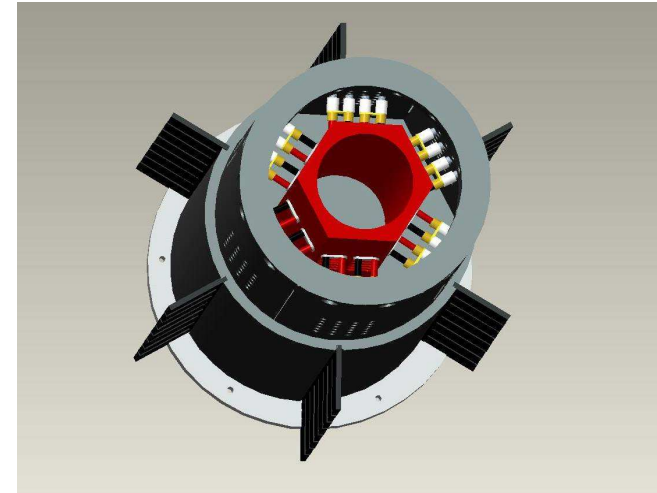| The Patroller moves to scientific probe points | The Patroller completes sicentific probing under the mechanical arm planning made by the earth | Send back the scientific probing data |

Get through the moon night

■ **Independent dormancy and awaken during the night and the day.**

■ **Used plutonium-238 isotope heat source and two-phase fluid loop to get through the night.**
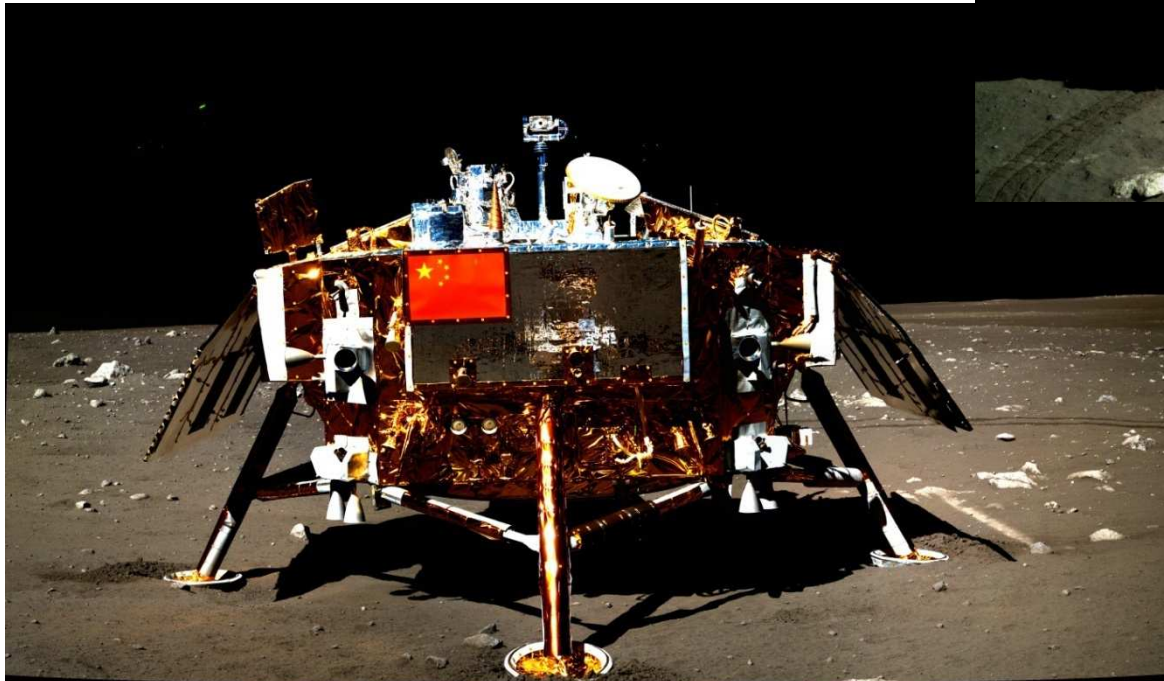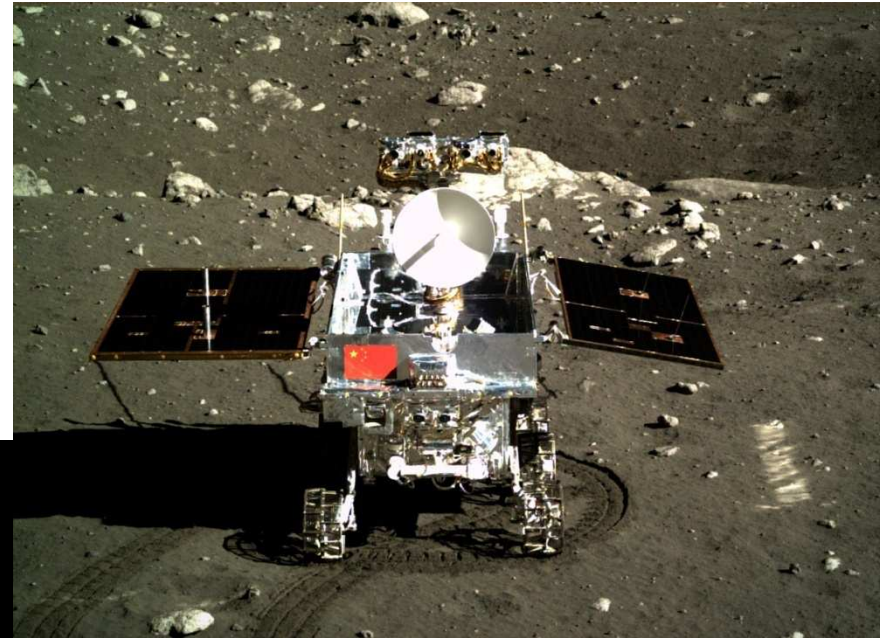
■ **Endured 6 day and night alternates.**

The Lander awakes and gets ready to work

着陆器唤醒
并建立工作状态

太阳高度角为15°～20°

太阳高度角为10°～15°

The elevating angle of the sun is out5°～in5°

太阳高度角5°

The elevating angle of the sun is 15°～

The elevating angle of the sun is 10°～

Exploration Achievements

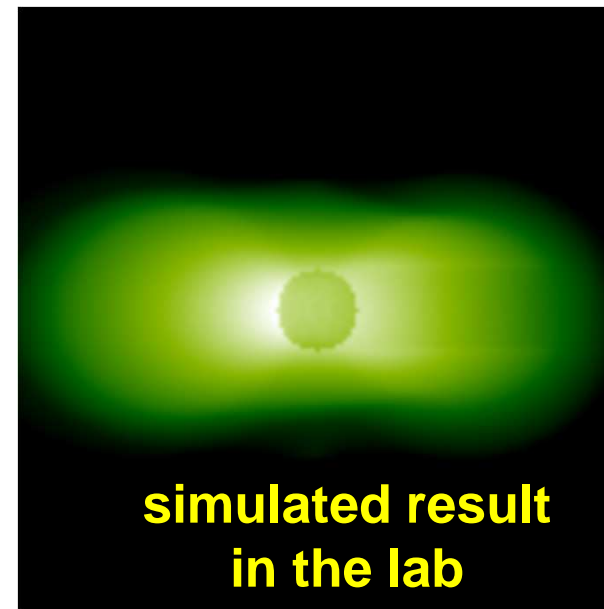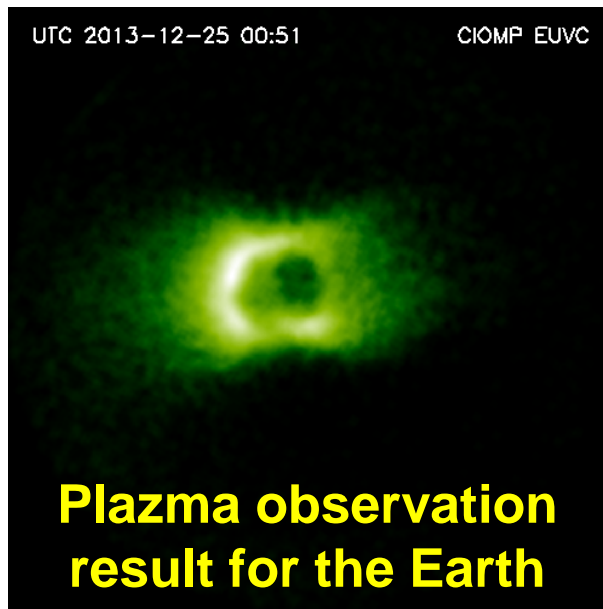During the day time of the first 4 months, the Lander got **118.5GB** original detecting data.

The Patroller got **32GB** original detecting data.

Exploration Achievements

Extreme ultraviolet camera （30.4nm wave band）

UTC 2013-12-25 00:51   CIOMP EUVC

Plazma observation result for the Earth

simulated result in the lab

For the first time in the world, Chang E III obtained the Earth's wide field image of 15E-R plasma layer from the surface of the moon. The image accurately shows the outline of the Earth, the Earth's shadow, the range of Earth plasma layer, the profile of ionospheric airglow, and the apex of the Earth's plasma layer, etc. Obtained more than 600 images in total.

Exploration Achievements

Lunar-based astronomical telescope

The first unmanned automatic moon-based Lunar-based astronomical telescope in the world.

Observe the brightness and variances at near-UV band for various celestial bodies. Up till now, more than 32,000 images have been obtained.

Long time observation(18h per day)

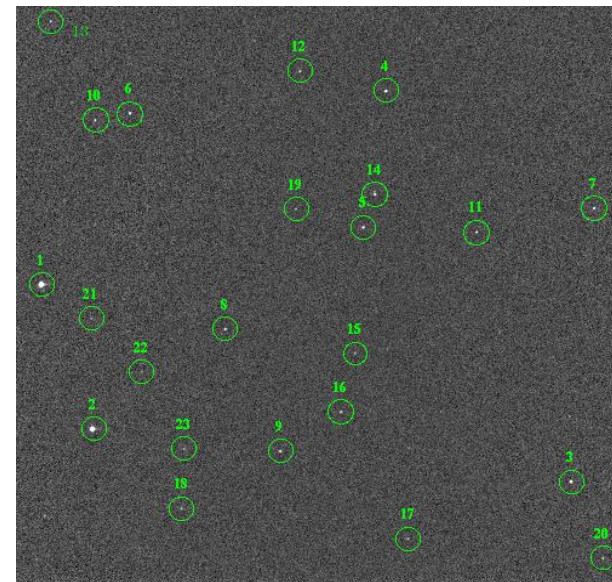**No atmosphere and other disturbance**
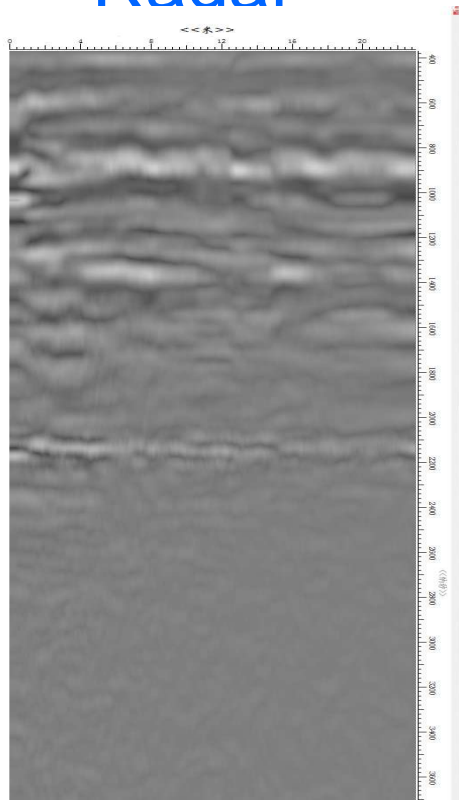
14-magnitude star

Image of the Draco constellation
Identified celestial coordinates of 23 celestial bodies

Exploration Achievements

Lunar Probing Radar

Dual-channel time-domain pulsed radar with no carrier frequency , obtain the thickness and structure of the lunar regolith as well as the structure profiles of the lunar shallow crust.

■ The Primary Test Result of Lunar Regolith （see left-hand chart ） showed obvious stratification within 140 meters into the moon.

■ The Primary Test Result of Geological Structure（see the chart below） showed obvious stratification within the 10 meters under the surface of the moon.

Primary Test Result of Lunar Regolith
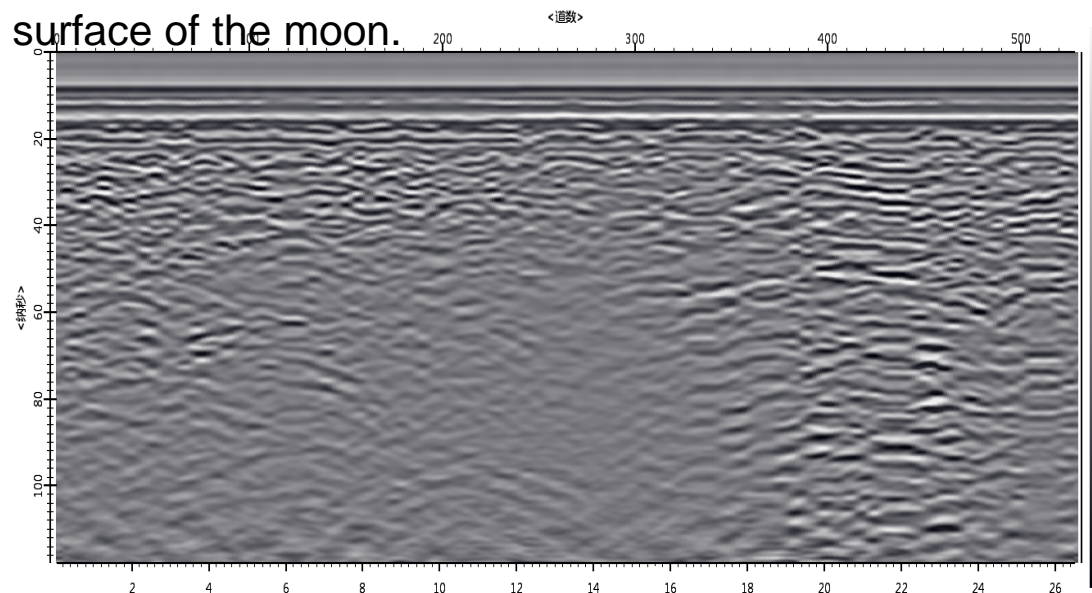
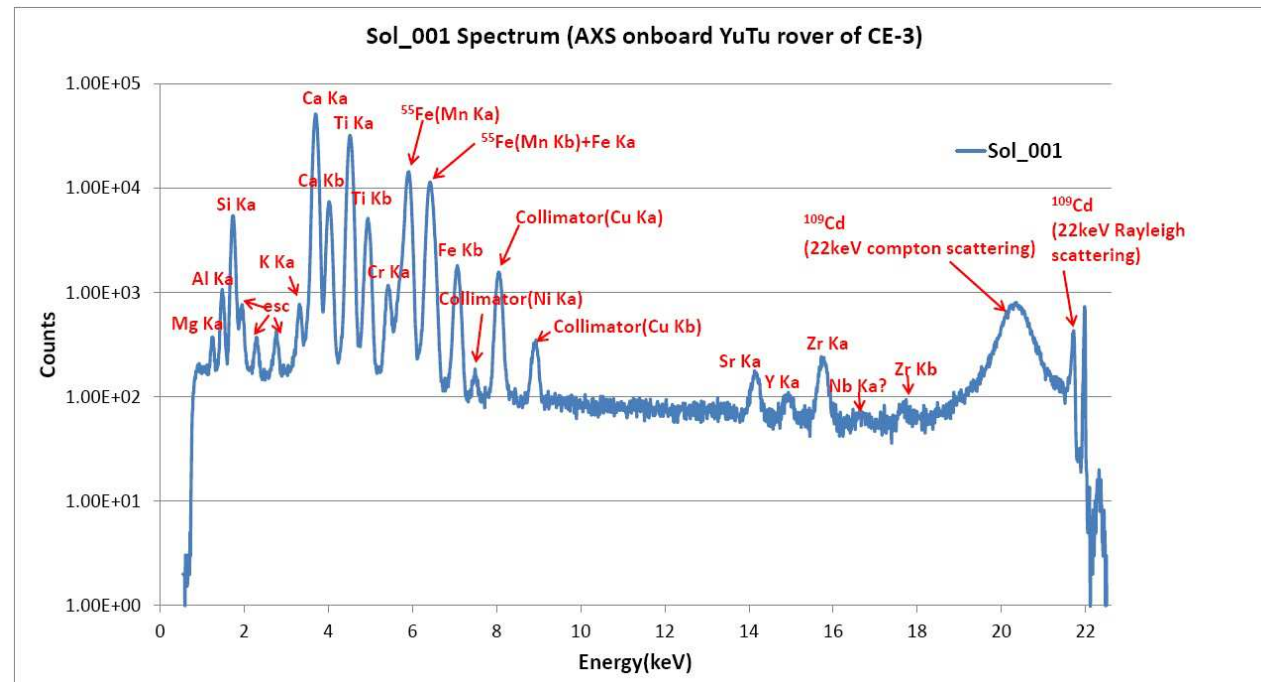Primary Test Result of Geological Structure

Exploration Achievements

The Particle Inducing X-ray Spectrometer

■   Analyzed the chemical element composition of the lunar surface samples

■   Identified the following eleven elements: magnesium, aluminum, silicon, potassium, calcium, titanium, chromium, iron, strontium, yttrium and zirconium.
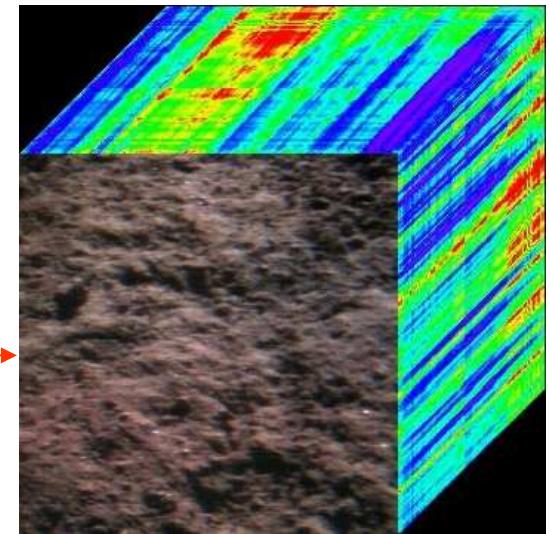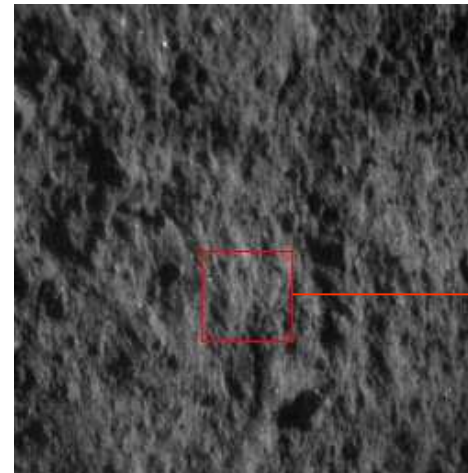
Exploration Achievements

The Infrared Imaging Spectrometer

Spectral imaging function——VNIR (0.45~0.95μm)

Spectrum detection function——SWIR (0.9~2.4μm)

红外成像光谱仪20131223月面探测区全波段反射率

Reflectivity curve of VNIS's premiere lunar surface detection

Single band image and its cube of VNIS's premiere lunar surface detection
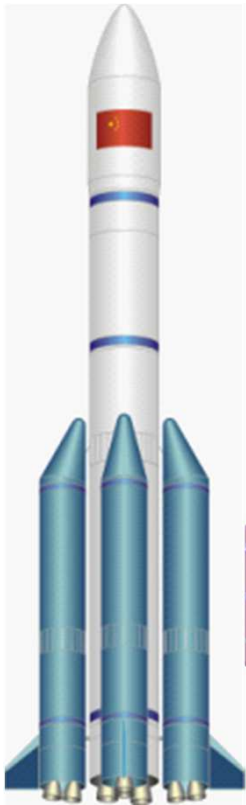
Current Situation of the Probe

- The 6th moon night by May 23
- The Lander is proper functioning
- Patroller encountered control fault, part of the loading works normally
- Under the abnormal condition and the extreme low temperature, the patroller's performances are gradually degenerated.
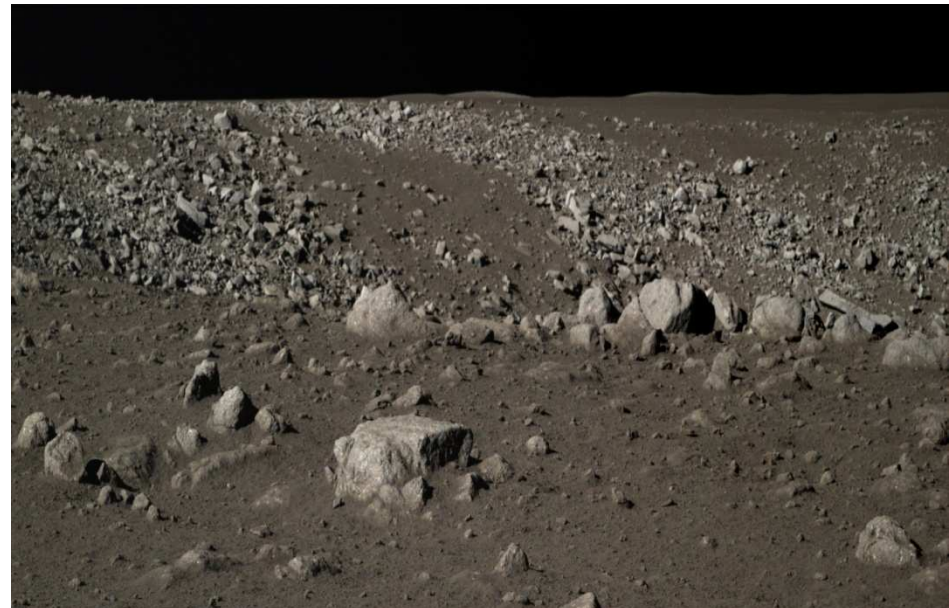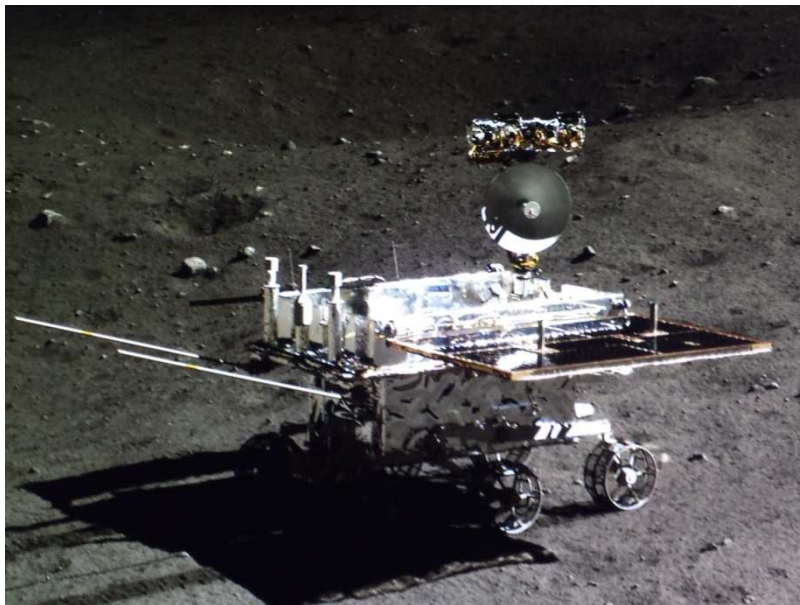
Lunar Exploration Program Phase III

The Chang'e-5, Sampling and Returning Probe, is under developing.

It plans to be launched around 2017 at the newly built launching site at Wenchang, Hainan province, using the newly developed CZ-5 carrier rocket.

New probe, New rocket, New launching site.

Thank you!