Three Steps of CLEP Before 2020

Orbiting:
- Chang'E-1: 2007.10
- Chang'E-2: 2010.10

Landing:
- Chang'E-3: 2013.12

Return:
- Chang'E-4: 2018
- Chang'E-5: 2019
- Chang'E-6
CHANG’E-1

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

<table>
<thead>
<tr>
<th>Payload</th>
<th>Data level and number of files</th>
<th>Amount of released data (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>01</td>
<td>2A</td>
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<tr>
<td>CCD</td>
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<td>4233</td>
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<tr>
<td>GRS</td>
<td>2748</td>
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<td>HPD</td>
<td>1846</td>
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<tr>
<td>IIM</td>
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<td>711</td>
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<tr>
<td>LAM</td>
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<tr>
<td>MRM</td>
<td>10140</td>
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<tr>
<td>SWID</td>
<td>3678</td>
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</tr>
<tr>
<td>XRS</td>
<td>3572</td>
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</table>
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
Carried 7 payloads, CCD, LAM, XRS, GRS and so on. 38843 data files were released with a total amount of 3005 GB.

<table>
<thead>
<tr>
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<th>Amount of released data (GB)</th>
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<tbody>
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<td>2B</td>
<td>2C</td>
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<tr>
<td>CCD</td>
<td>----</td>
<td>18946</td>
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<tr>
<td>GRS</td>
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<td>2403</td>
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<td>HPD</td>
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<td>2419</td>
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<tr>
<td>LAM</td>
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<td>MRM</td>
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<td>2401</td>
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<tr>
<td>SWID</td>
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<td>----</td>
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<tr>
<td>XRS</td>
<td>----</td>
<td>7260</td>
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</tbody>
</table>

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

<table>
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<tr>
<th>Payload</th>
<th>Data level and number of files</th>
<th>Amount of released data (GB)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2A</td>
<td>2B</td>
</tr>
<tr>
<td>PCAM</td>
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<tr>
<td>PIXS</td>
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<td>VNIS</td>
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<td>LPR</td>
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<td>LCAM</td>
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<td>TCAM</td>
<td>797</td>
<td>677</td>
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<td>EUVC</td>
<td>388</td>
<td>388</td>
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<tr>
<td>MUVT</td>
<td>120127</td>
<td>120127</td>
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</tbody>
</table>
Farside moon mission. 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.
**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)
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
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

01 CLEP Scientific Data

02 Scientific Data Policy

03 Scientific Outcomes
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

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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)
Hundred 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.

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#.

**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.

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Scientific Outcomes

CHANG’E-3

- Earth’s plasma layer detection
- Observation of the extreme ultraviolet of Earth’s plasma by great field from fixed points on the moon
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.
**Scientific Outcomes**

**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.

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

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

<table>
<thead>
<tr>
<th>Device</th>
<th>Detection Principle</th>
<th>Surface Density (cm⁻³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST Limb Spectrum</td>
<td>3087 Å resonance fluorescence</td>
<td>&lt;10⁶ (5σ)</td>
</tr>
<tr>
<td>Apollo12/14/15 CCGEs</td>
<td>Particle Counting</td>
<td>&lt;10⁷</td>
</tr>
<tr>
<td>Chandrayaan/CHACE</td>
<td>Particle Counting</td>
<td>~2×10⁹</td>
</tr>
<tr>
<td>Lunar-based Optical Telescope</td>
<td>Particle Counting</td>
<td>&lt;10⁴</td>
</tr>
</tbody>
</table>
**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!