EARTHQUAKE
e-Newsletter about what's movin' and shakin' at the Earth Science Museum

Earth Science Museum, 3215 W. Bethany Home Rd., Phoenix, AZ 85017
www.earthsciencemuseum.org, scote@earthsciencemuseum.org, 602-973-4291

July 2024
Volume 13, Issue 7

ESM OUTREACH UPDATE

Mardy Zimmermann, Outreach Coordinator

May Outreach

With schools closed for the summer, there are no ESM outreach activities to report this month.

Chang'e Lunar Sample-Return Missions

By Harvey Jong

Last October we reported on the OSIRIS-Rex's incredible journey of returning samples from the asteroid Bennu (See October 2023 newsletter). This article continues the focus on space exploration with some other sample-return missions that have been in the news. On June 25, 2024, the return capsule of the Chang'e 6 lunar probe landed on Earth with material collected from the far side of the Moon. In addition, recent analysis of the samples retrieved from the near side of the Moon by the Chang'5 mission revealed two unusual, previously unknown polymorphs of the mineral rutile (TiO_2) (Zeng et al., 2024).

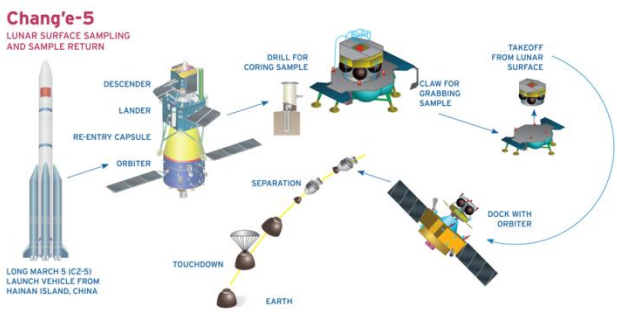
Chinese Lunar Exploration Program (CLEP) and the Chang'e Missions

The Chinese Lunar Exploration Program (CLEP) is the China National Space Administration (CNSA)'s ambitious multi-phase program for investigating the Moon. Since 2007, the space agency has been launching a series of robotic missions which are named Chang'e after the Moon goddess from Chinese mythology. These probes are leading the way towards human lunar landings in 2030. Currently, the program is focused on a phase involving sample return from the lunar surface.

Chinese Lunar Exploration Program Logo
CNSA graphic, - PD?, via Wikimedia Commons
The logo features a stylized crescent Moon with two footprints at its center.

Chang'e 5 Mission

The Chang'e 5 was the CLEP's fifth lunar exploration mission and the first sample-return mission. It retrieved the first lunar samples since the Soviet Union's Luna 24 mission in 1976.



Chang'e 5 Mission Profile
Loren Roberts illustration, - CC_BY_SA-3.0, via Wikimedia Commons

The Chang'e 5 was launched in 2020 using a Long March 5 rocket which is the CNSA's heavy-lift launch vehicle. The 3-stage version of the rocket is 69.35 m (227.5 ft) high and can carry an 8,800-9,400 kg (19,400-20,700 lb) payload into lunar orbit.

It currently represents the world's third most powerful launch vehicle behind SpaceX's Falcon Heavy and NASA's Space Launch System rockets.

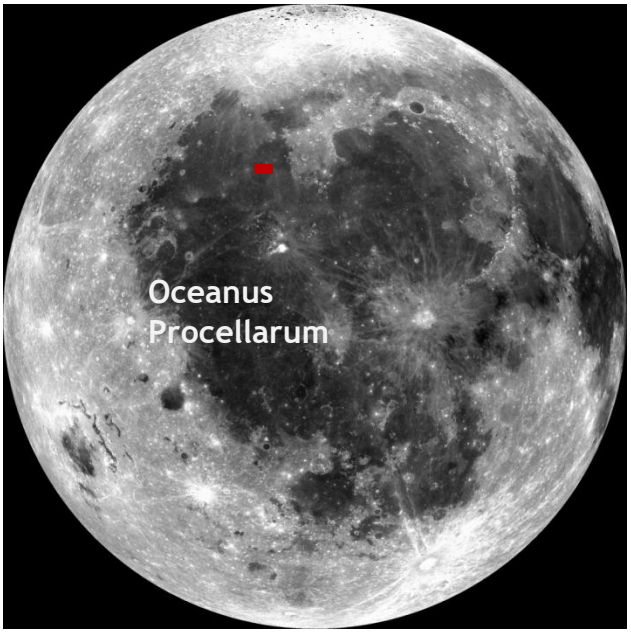
The Chang'e 5 spacecraft consists of an orbiter, re-entry capsule, lander, and ascender that are launched as a combined unit. The lander is equipped with a drill and sampling claw to collect material. After samples are collected, the ascender lifts off from the lunar surface and rendezvous with the orbiter. Samples are transferred to the re-entry capsule, and the ascender is jettisoned into the Moon. The orbiter returns to Earth where the capsule separates, re-enters, and descends by parachute to the ground.

Chang'e 5 Landing Site

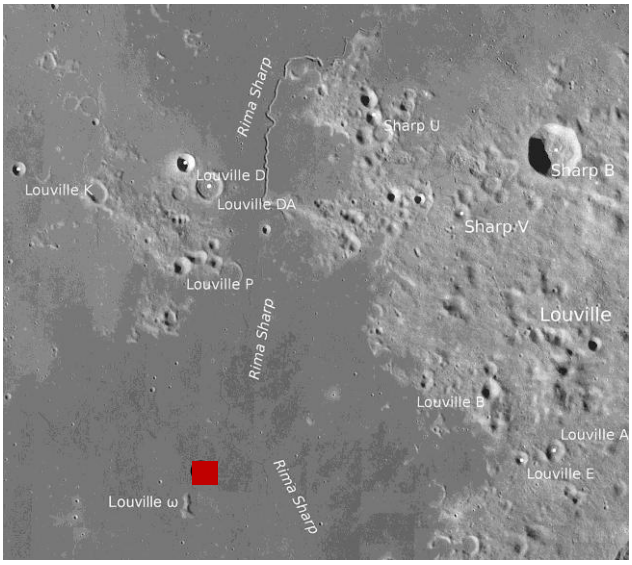
About 15% of the Moon's near side is covered by dark basaltic plains which are called maria or "seas". (The name is based on early astronomers' mistaken perception of the features as actual oceans.) The Oceanus Procellarum (Ocean of Storms) is the largest lunar mare stretching more than 2,500 km (1,600 mi) across and covering about 4,000,000 km^2 (1,500,000 mi^2). It may have been formed by volcanic eruptions that covered an impact basin with a thick, nearly flat layer of basalt. This basalt has been estimated to be as young as around one billion years old which is unexpected since most of the Moon's interior heat may have dissipated three billion years ago. So, scientists are very interested in what other heat sources may have been involved with the late volcanic activity.

Several robotic probes have landed in the Oceanus Procellarum. These landings focused mainly on locations around the Moon's equator. In 1966, the Soviet Union landed two spacecraft – Luna 9 and Luna 13. The United States exploration efforts included Surveyor 1 in 1966 and Surveyor 3 in 1967. In November 1969, the Apollo 12 mission, which was the second manned lunar landing, landed about 165 meters (541 ft) from the Surveyor 3 spacecraft.

The landing site for the Chang'e 5 mission is located in the northeastern part of the Oceanus Procellarum near an isolated volcanic formation called Mons Rümker. The site includes some of the youngest basalts on the Moon with a limited amount of ejecta from nearby craters and basins. It also surrounded by the Rima Sharp which is the longest lunar sinuous rille. Rilles are channel-like structures that were formed by lava flows and underwent mechanical and thermal erosion.



Overall Location of Chang'e 5 Landing Area
NASA/LROC/ASU image, - PD, via lpi.usra.edu
The landing region, which is indicated by the red rectangle, is located in northeastern Oceanus Procellarum (Ocean of Storms).



Close-up of the Chang'e 5 Landing Site
NASA/LROC/ASU image, - PD, via Wikimedia Commons
The red square indicates the landing site in the Mons Rümker area and adjacent Rima Sharp.

Chang'e 5 Mission Highlights

Some mission highlights are presented with the following photos and videos:

Launch of the Chang'e 5

Screenshot from China News Service YouTube video, - CC_BY_SA-3.0, via Wikimedia Commons
The Chang'e 5 was launched on November 23, 2020 from the Wenchang Space Launch Site on Hainan Island.

Artist Rendering of the Chang'e 5 Orbiter and Lander Separating from the Third Stage Booster
Screenshot from China News Service YouTube video, - CC_BY_SA-3.0, via Wikimedia Commons

Chang'e 5 Landing
(From CNSA Watcher YouTube channel archives) **This time lapse video depicts the Chang'e 5 descending and landing in the Mons Rümker area.**

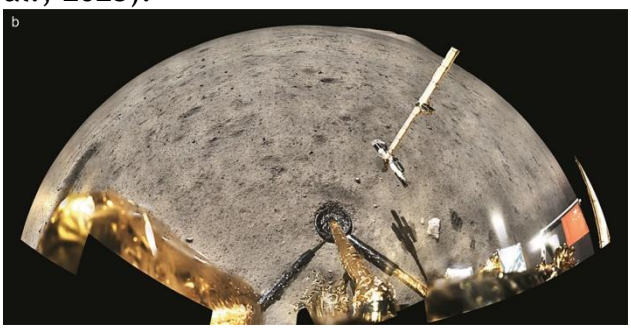
Chang'e 5 Mission Highlights
(From CNSA Watcher YouTube channel archives) **This video shows highlights from lander separation, landing, sample collection, and return to Earth.**

Animation of Chang'e 5 Earth Re-entry and Landing
(From CNSA Watcher YouTube channel archives) **This computer animation depicts the Chang'e 5 capsule's skip re-entry procedure and landing on the ground.**

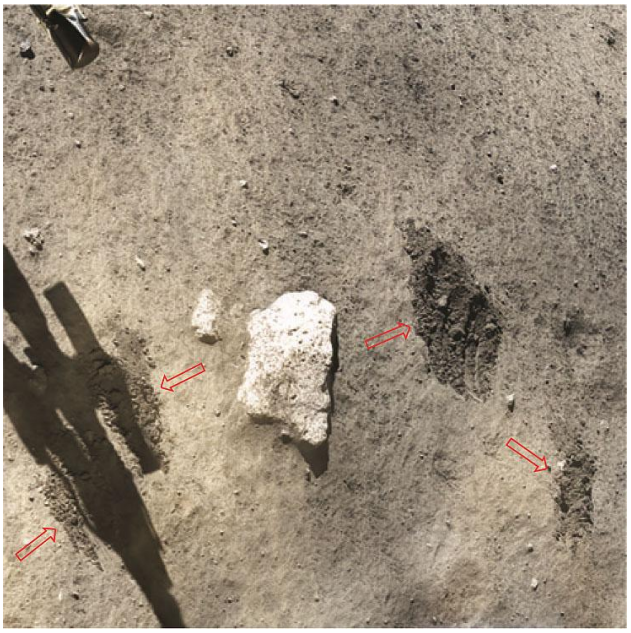
Chang'e 5 Return Capsule
Screenshot from China News Service YouTube video, - CC_BY_SA-3.0, via Wikimedia Commons
The return capsule, which weighed about 300 kg (660 lb), landed on December 16, 2020 in south central Inner Mongolia. It was safely secured for the trip to the China Academy of Space Technology headquarters in Beijing.

Chang'e 5 Sample Analysis

The Chang'e 5 collected 1,731 g (61.06 oz) of lunar materials which included 1,471.28 g (51.90 oz) scooped from the surface and 259.72 g (9.16 oz) collected after drilling 1m (3.28 ft) into the lunar regolith (Zhang et al., 2023).

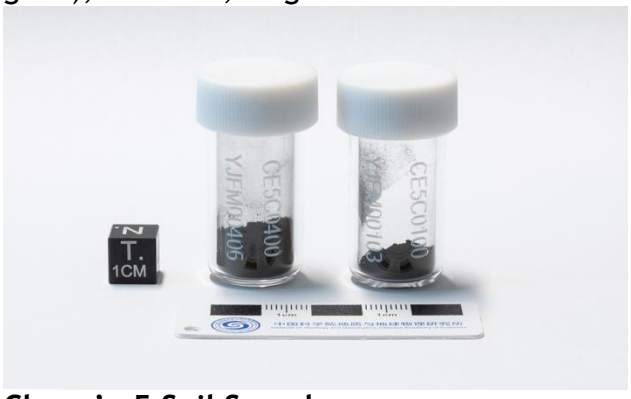


Panorama of the Chang'e 5 Landing Site
China Lunar Exploration Data Release image, https:/moon.bao.ac.cn, Figure 1b, (Li, C. et al., 2022), - CC_BY_SA-4.0 International, downloaded from https://academic.oup.com
This panoramic image was created by combining 120 images captured by the Chang'e 5 onboard camera. The horizontal field of view is ~220°. The sampling area is located to the right of the lander footpad.



Close-up of the Chang'e 5 Sampling Area
China Lunar Exploration Data Release image, https:/moon.bao.ac.cn, Figure 1c, (Li, C. et al., 2022), - CC_BY_SA-4.0 International, downloaded from https://academic.oup.com
The arrows of this close-up image show where samples were collected.

Most of the samples are a gray-black fine-grained regolith. The particle size varies from 1.40-9.35 μm, while the average bulk density measured for three samples was 1.2387 g/cm^3 (Li, C. et al., 2022). A few small fragments varying from 1 mm to 1 cm are present in the material and may be classified as basaltic clasts, agglutinates (rock, mineral, or glass fragments welded by glass), breccias, or glass.



Chang'e 5 Soil Samples
Hui Ren photo, - CC_BY_SA-4.0 International, via Wikimedia Commons

The basaltic clasts consist mainly of pyroxene (predominantly augite), feldspar (mostly bytownite), olivine (mostly fayalite), and ilmenite, but also include minor amounts of troilite, potassium feldspar, quartz, tranquilliyite, apatite, merrillite, baddeleyite, and zircondite. This composition correlates with the soil samples which suggest that they are both derived from the weathering of local basaltic bedrock. The age of the basalt was determined to be 2,030 ± 4 Ma using radiometric lead isotope dating (Li C. et al., 2022). This represents the youngest known lunar basalt.

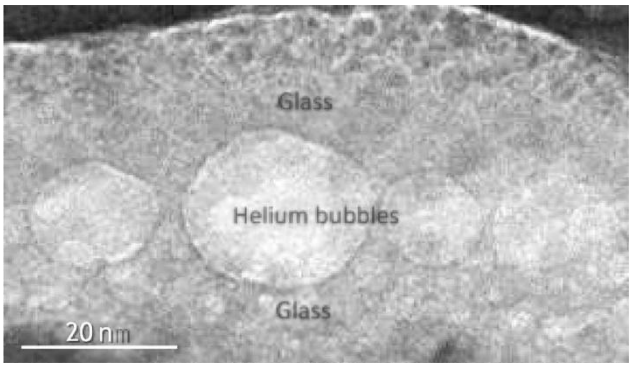
A comparison of the Chang'e 5 soil samples with those from the Apollo and Luna missions noted the following (Li, C. et al., 2022):

- Chang'e 5 samples are finer, better sorted than the Apollo and Luna materials which have a larger mean size.
- Chang'e 5 soils have lower Al_2O_3 (10.8%) and CaO (11%) content but higher FeO (22.5%).
- The Chang'e 5 material has a relatively low amount of SiO_2 (42.2%) but is still within the range of the Apollo samples (38-48%).
- According to the mare basalt classification scheme used with the Apollo and Luna missions, the Change'e 5 soils belong to a low-Ti/low-Al/low-K basalt species.
- Water content (in form of OH and H_2O, ranging from ~30 ppm to ~120ppm) is roughly comparable to the Apollo samples. An exception, however, was noted with a rock in the sampling area where the reflectance spectra estimated an amount of ~180 ppm (Lin, C. et al., 2022).

Detection of Helium-3 (^{3}He)

Helium-3 (^{3}He) is an isotope of helium with two protons and one neutron. The isotope is a key element for nuclear fusion and may potentially become a new clean source. The occurrence of the helium-3 is rather limited on the Earth due to the shielding effects of its magnetic field. The Moon, however, has been subjected to intense solar wind irradiation which suggests that significant quantities of ^{3}He may have been implanted into the lunar regolith.

The Chang'e 5 samples were found to contain approximately 6% particles of ilmenite ($FeTiO_3$) (Li, A. et al., 2022). These particles are covered with a glassy layer which include spherical helium-3 bubbles around 5-25 nm in diameter. The bubbles may have formed as high-energy ions of the solar wind implanted ^{3}He atoms into the ilmenite lattice, but the trapped atoms later diffused into the glass due to repeated lunar hot-cold cycles.



Glassy Ilmenite Sample with Helium-3 Bubbles

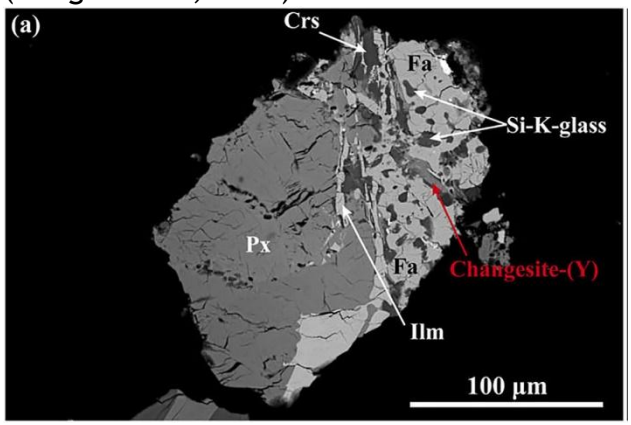
Figure 2b from (Li, A. et al., 2022), - CC_BY_SA-4.0 International, via iopscience.iop.org

This transmission electron microscopy (TEM) image shows helium-3 bubbles in a glassy ilmenite particle. The occurrence of the ^{3}He in the glass may allow for easy extraction by mechanical methods, such as milling. The finding has fueled speculation on a future lunar "helium-3 rush" and mining activities on the Moon.

New Moon Minerals

New or potentially new minerals have been discovered in the Chang'e 5 samples. One new species is Changesite-(Y) [$(Ca_8Y)\square Fe^{2+}(PO_4)_7$] which is named after Chang'e, the

Moon goddess in Chinese mythology. The phosphate mineral was found in basalt fragments and was approved by the IMA in August 2022. Crystals have a trigonal structure and occur as colorless, columnar forms with lengths varying from ~2 to 30 μm (Yang and Du, 2024).



Changesite(Y) in Basalt Fragment
Figure 4(a) from (Yang and Du, 2024), - CC_BY_SA-4.0 international, via Wikimedia Commons

This Back Scattered Electron (BSE) image shows a tiny changesite-(Y) crystal. Some associated minerals include fayallite (Fa), pyroxene (Px), ilmenite (Ilm), plagioclase, cristobalite (Crs), baddeleyite, and troilite.

Changesite-(Y) is the sixth new mineral found on the Moon, and China is the third country to make such a discovery. A list of lunar minerals, formulas, and type localities appears in the following table:

Mineral Name	Formula	Type Locality/ Mission
Pyroxferroite	$(Fe,Mn,Ca)SiO_3$	Sea of Tranquility /Apollo 11
Armalcolite	$(Mg,Fe^{2+})Ti_2O_5$	Sea of Tranquility /Apollo 11
Tranquillityite	$Fe^{2+}_8(ZrY)_2Ti_3Si_3O_{24}$	Sea of Tranquility /Apollo 11 Ocean of Storms/ Apollo 12
Yoshiokaite	$(Ca,Na)[Al(Al,Si)O_4]$	Fra Mauro Highlands/ Apollo 14
Oxycalciobetafite[1]	$Ca_2(Ti,Nb)_2O_6O$	Fra Mauro Highlands/ Apollo 14
Changesite-(Y)	$(Ca_8Y)\square Fe^{2+}(PO_4)_7$	Ocean of Storms/ Chang'e 5

An analysis of a Chang'e 5 glass bead revealed two new, previously unknown phases of rutile (TiO_2) with trigonal and triclinic crystal structures. These polymorphs may be space weathering by-products that were deposited after a high-velocity micrometeorite impact on the lunar regolith (Zeng et al., 2024). Note that terrestrial rutile belongs to the tetragonal crystal system and has three polymorphs anatase (tetragonal), akaogiite (monoclinic), and brookite (orthorhombic). The new lunar phases may or may not be considered as valid new species given the IMA's strict requirements on new minerals along with recent changes in polymorph nomenclature.

Chang'e 6 Mission

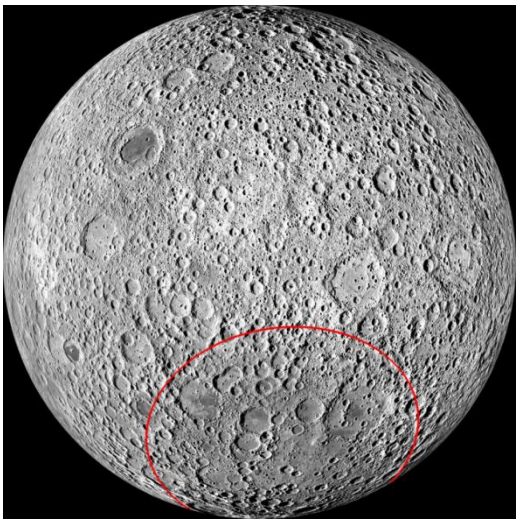
Building on the success of the Chang'e 5 mission, the Chang'e 6 was launched on May 3, 2024. The objective involved landing and retrieving samples from the far side of the Moon.

Chang'e 6 Launch
(From CNSA Watcher YouTube channel archives)
This video shows the successful Chang'e 6 launch.

[1] IMA approval is still pending.

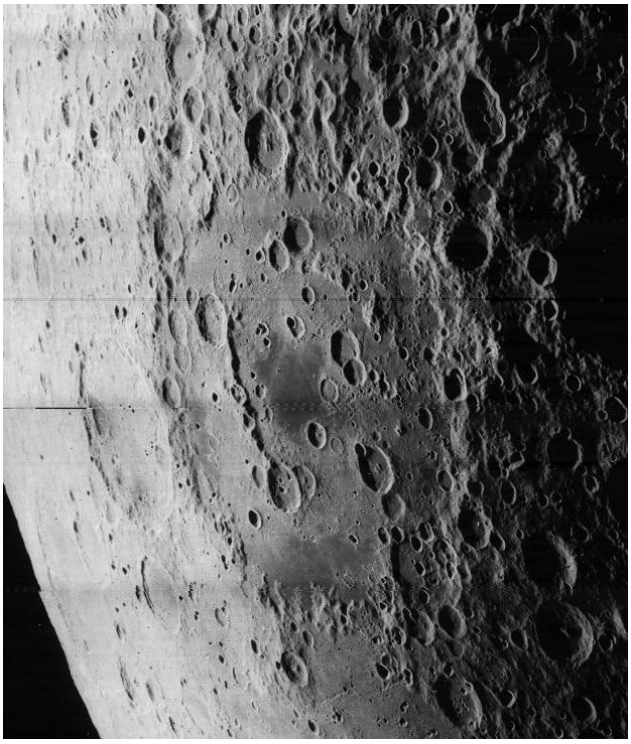
Landing Site

The far side of the Moon is the lunar hemisphere that always faces away from the Earth. Its terrain, which is more rugged than the near side, has relatively few dark, flat maria areas. The South Pole-Aitken basin is the largest (2,400x2,050 km/1,491x1,274 mi) and most ancient (~4.25 Ga) of these impact basins.



Far-Side of the Moon
NASA/GSFC/LROC/ASU image, - PD, via Wikimedia Commons
Image acquired 2014
This mosaic image was created from Lunar Reconnaissance Orbiter data. The red circle indicates the South Pole-Aitken basin.

Located within the South Pole-Aitken basin is the Apollo crater, a large double-ringed impact feature with a diameter of 247 km (153 mi) and 492 km (306 mi) for its inner and outer rings. After the initial impact, parts of the crater were flooded by mare basalts.



Apollo Crater
James Stuby image based on NASA photo, - CC0 1.0 UPDD, via Wikimedia Commons
The original image was acquired by NASA's Lunar Orbiter 5 spacecraft in 1967 and was reprocessed in 2013.

Chang'e 6 Landing Site
NASA/GSFC/LROC/ASU photo, - PD, via Wikimedia Commons
Field of view: 190 km (118 mi) across

The Chang'e 6 landing site is located in a southern plain of the Apollo crater. This view of the site was captured by the Lunar Reconnaissance Orbiter Camera. The dark area at the center is a basaltic mare deposit. The bluer coloration indicates higher-titanium flows, while redder areas are lower-titanium material.

Mission Highlights

The Chang'e 6 used essentially the same spacecraft configuration as the Chang'e 5, but the payload included several instruments from other countries – France's Detection of Outgassing RadoN (DORN), Sweden/ESA's Negative Ions at the Lunar Surface (NILS), Italy's laser retroreflector (INRRI), and Pakistan's ICUBE-Q cubestat. A mini-rover was also added.

The Chang'e 6 probe arrived at the Moon on May 8th and orbited for 20 days to survey for a suitable landing site. The ICUBE-Q cubesat was also released during this time. On June 1st, the lander separated from the orbiter and touched down in the southern part of the Apollo crater.

Chang'e 6 Landing
(From CNSA Watcher YouTube channel archives)
This is a time lapse video of Chang'e 6 landing sequence.

Using a robotic scoop and drill, the Chang'e 6 collected a total of 1,935.3 g (68.3 oz) of samples which was stored in the ascender.

Chang'e 6 Sample Collection
(From CNSA Watcher YouTube channel archives)
This China Aerospace video shows the collecting and storing of lunar soil samples.

The mini-rover was deployed and traveled a short distance to capture photos of the lander and ascender.

Chang'e 6 Lander and Ascender
©CNSA/ESA photo, from:
https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/First_detection_of_negative_ions_on_the_Moon
This photo was taken by the Jinchan mini-rover.

The ascender lifted off from the lunar surface on June 3rd and docked with the orbiter on June 6th. Samples were transferred to the return capsule, and the orbiter left lunar orbit on June 21st. The capsule separated from the orbiter on June 25th and landed in Siziwang Banner province in the Inner Mongolia Autonomous Region.

Chang'e-6 Returns to Earth
This Guardian News video documents the landing and recovery of the Chang'e-6 sample return capsule.

References

Li, A., X. Chen, L. Song, G. Chen, W. Xu, J. Huo, M. Gao, M. Li, L. Zhang, B. Yao, M. Ji, Y. Zhang, S. Zhao, W. Yao, Y. Liu, J. Wang, H. Bai, Z. Zou, M. Yang, and W. Wang (2022) Taking advantage of glass: capturing and retaining helium gas on the Moon. *Material Futures* 1(3): 8 p.

Li, C. H. Hu, M. Yang, Z. Pei, Q. Zhou, Z. Ren, B. Liu, D. Liu, X. Zeng, G. Zhang, H. Zhang, J. Liu, Q. Wang, X. deng, C. Xiao, Y. Yao, D. Xue, W. Zuo, Y. Su, W. Wen, and Z. Ouyang (2022) Characteristics of the lunar samples returned by the Chang'e 5 mission. *Natural Science Review* 9: nwab188.

Lin, H., S. Li, R. Xu, Y. Liu, X. Wu, W. Yang, Y. wei, Y. lin, Z. He, H. Hui, H. He, s. Hu, C. Zhang, C. Li, G. Lv, L. Yuan, Y. Zou, and C. Wang (2022) In situ detection of water on the Moon by the Chang'e-5 lander. *Science Advances* 8(1): 6 p.

Yang, J. and W. Du (2024) High-pressure minerals and new lunar mineral changesite-(Y) in Chang'e-5 regolith. *Matter and Radiation at Extremes* 9, 027401.

Zeng, X., Y. Wu, W. Yu, B. Mo, Y. Wen, X. Zhao, X. Li, X. Zhang, and J. Liu (2024) Unusual Ti minerals on the Moon produced by space weathering. *Nature Astronomy* 8: 732-738.

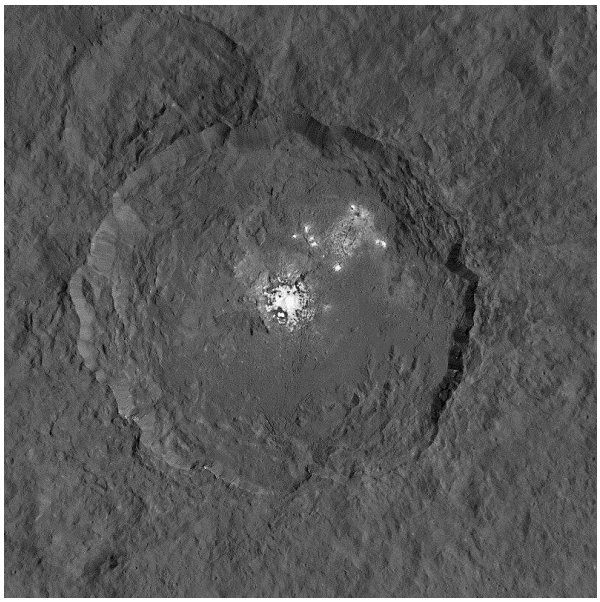
Zhang, T., Y. Pang, T. Zeng, G. Wang, S. Yin, K. Xu, G. Mo, X. Zhang, L. Wang, S. Yang, Z. Zhao, J. Qin, J. Gong, Z. Zhao, X. Tong, Z. Yin, H. Wang, F. Zhao, Y. Zheng, X. Deng, B. Wang, J. Xu, W. Wang, S. Yu, X. Lai, and X. Ding (2023) Robotic drilling for the Chinese Chang'e 5 lunar sample-return mission. *The International Journal of Robotics Research* 42(8): 586-613.

◊ ◊ ◊

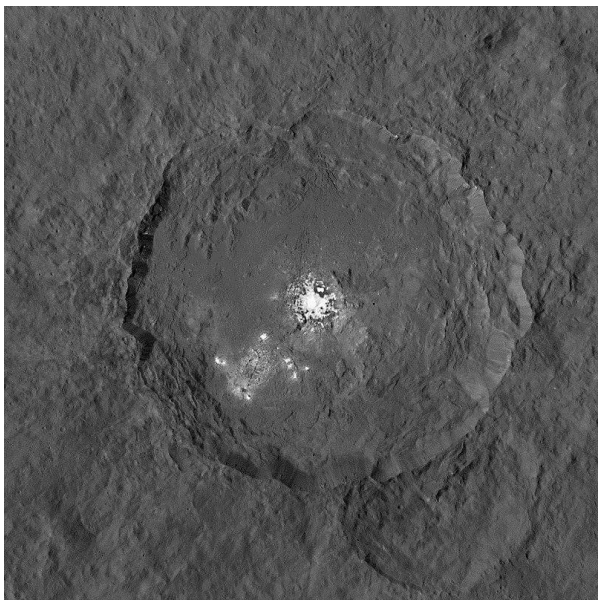
Crater/dome illusions

From Wikipedia

In astronomical imaging and Earth imaging, the **crater illusion**, also known as the **dome illusion** or **crater/dome illusion** is an optical illusion which causes impact crater and other depressions to appear raised as domes or mountains. It is believed to be caused by our being accustomed to seeing light from overhead. When some images are taken from orbit, the light from the sun is nearly horizontal. This is the only time shadows are seen. Our brains are tricked into thinking that the interior of the crater is above the surrounding terrain instead of below it.



This is an image of the Ceres' Occator Crater by the NASA spacecraft Dawn as originally released by the space agency on September 9, 2015.
Photo by: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA via Wikipedia



This is an image released by NASA of the Occator crater on the dwarf planet Ceres which has been rotated to change the position of the shadows and create the illusion of a dome.
Photo by: NASA/JPL-Caltech/UCLA/MPS/DLR/IDA via Wikipedia

Arizona Rocks 134

Text by Ray Grant
Photos courtesy of Poozeum

109 West Railroad Avenue, Williams, Arizona 86046

DINOSAUR POOP! In May a museum opened in Williams, Arizona. It is the Poozeum and it is a museum of dinosaur poo (poop, coprolites) started by George Frandsen. Coprolite is the scientific term for fossil feces. Coprolites are not part of the actual animal and are referred to as trace fossils.

I have not been there but it is on my list of places to see. The information here is from the website www.poozeum.com:

> **"The Poozeum is an extraordinary FREE dinosaur poop-themed museum and gift shop nestled in the heart of Williams, Arizona—the gateway to the Grand Canyon. Our museum is a captivating fusion of a natural history museum, art gallery, and carnival sideshow, offering visitors an unforgettable experience. Explore thousands of authentic fossilized specimens from around the world, including the colossal Barnum—the largest coprolite ever discovered."**

There are 8,000 pieces of fossil poop from George Frandsen's collection on display at the Poozeum. So if you are planning a trip north, here is one more place to visit. Think about what you can tell your friends and family about what you saw.

George Frandsen at his museum

Inside the Poozeum

Dinosaur skeleton at the Poozeum

AZ Mining, Mineral & Natural Resources Education Museum Update July 2024

https://ammnre.arizona.edu/

Catie Carter Sandoval
cscarter@email.arizona.edu
703.577.6449

Help support the museum at:
http://tinyurl.com/SupportMM-NREMuseum

If you have driven past the museum building at 1502 W. Washington St. lately, you may have noticed several new "No Trespassing" signs surrounding our property. We recently installed these permanent signs after several discussions with Arizona Department of Public Safety officers about the safety and security of our building on the Capitol Mall. The signs cite A.R.S. 13-1502, Criminal Trespass in the Third Degree, and make it clear that our building is state property and trespassers can be removed and potentially prosecuted.

In outreach and exhibit news, July has been a slower month but we have many plans on the horizon, including installing a display at the Denver Gem & Mineral Show in September and assisting with a new exhibition at the City of Phoenix's South Mountain Environmental Education Center this fall. As usual, we welcome all ideas and suggestions from our museum friends and stakeholders. If you know an institution that would be interested in working with us on a mineral display or outreach opportunity, let us know!

Meanwhile, we have been consistently meeting with our Governor-Appointed Advisory Council and in August we will be employing them for some in-person discussions about the museum's mission, audience, and central themes. We look forward to updating you about those conversations soon.

New signs surrounding our building on Washington St.

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society next meeting

September 18, 2024

Meetings are the third Wednesday at 7pm, doors open at 6:30

Everyone is welcome!

www.pinalgeologymuseum.org

Ray Grant ray@pinalgeologymuseum.org

Pinal Geology and Mineral Museum

Summer hours for July & August, are Fridays from 10 to 3, admission is free.

Groups can arrange special visits please call 520-723-3009.

Museum will open 4 days again starting week of September 2nd admission is free.

On July 15, the Pinal Geology and Mineral Museum set up a table at the welcome back for teachers and staff of the Coolidge Unified School District and on July 22 the table was set up again for the Imagine Schools welcome back meeting. There were rocks to look at and information about the museum. Every person was given a tumble polished jasper or agate for a good luck stone and with information about visiting the museum and how to contact the museum for field trips.

Museum's volunteer Erica at museum table for welcome back teachers meeting.
Christine New photograph

Sun City Rockhound Mineral Museum
Sundial Recreation Center
14801 N. 103rd Ave.
Sun City, AZ 85351
scrockmuseum@gmail.com
623-428-6442

C. Sandoval photo

Winter Hours
October – April
10 am to 1 pm
Closed Thurs., & Sunday
Summer Hours
May-September 10am-1pm
Saturdays only

Sun City Rockhound Club and Mineral Museum Summer Projects

By Carol Bankert-George Vice President

The club members continue working on museum projects during the summer months. Taking advantage of our reduced museum hours and staying out of the summer heat! We have been working with local meteorite specialist, Bob Holmes, to complete an installation on meteorites. This exhibit showcases some of Bob's meteorite collection. The museum is thrilled to spotlight Bob and part of his collection. We hope you plan to stop by to see this collection while on loan to the Sun City Mineral Museum.

Bob Holmes with intern Krysten Sarkissian

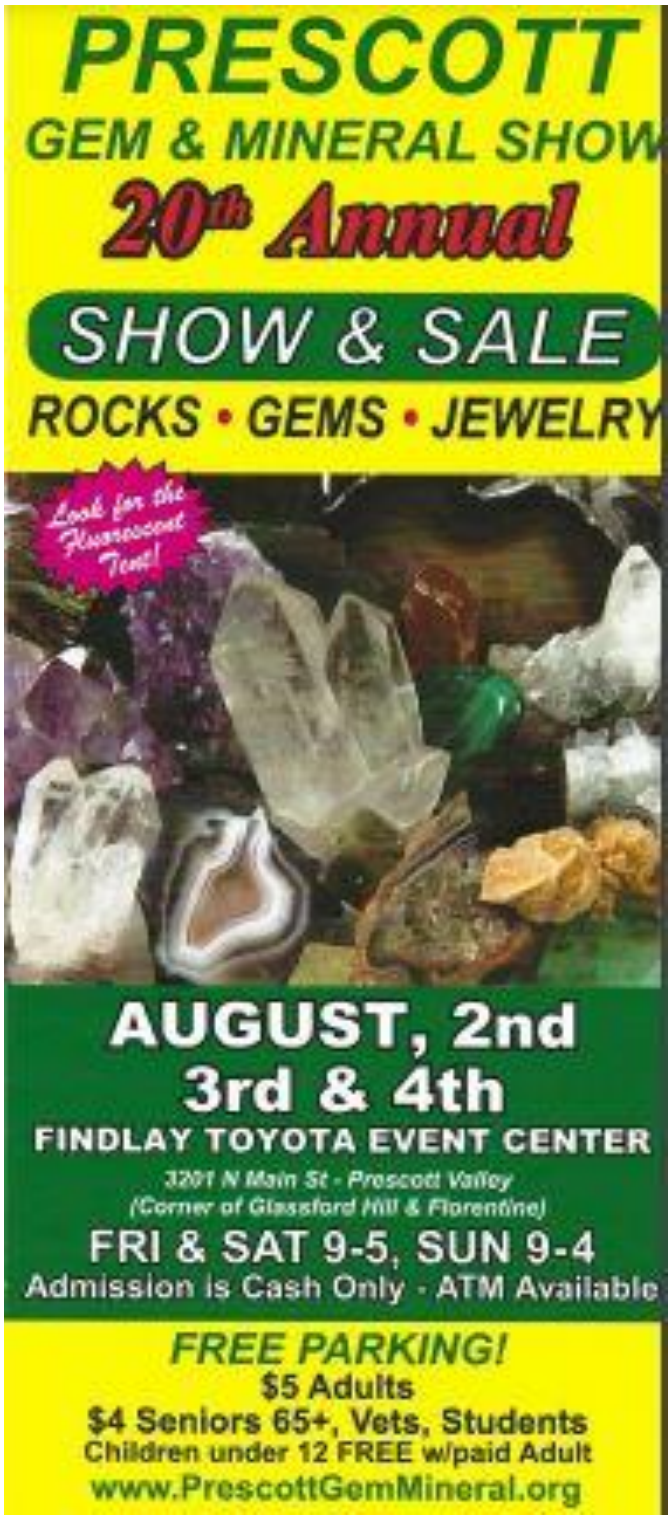
As reported in the last newsletter we are also working on new displays featuring Arizona rocks and minerals. One of the new displays was inspired by AMMNRE with a thrift store find of a teachers study collection box distributed in the 1990's by the Arizona Mining and Mineral Museum and the Arizona Department of Mines and Mineral Resources. The kit was not complete, and to the rescue was none other than Shirley Coté of ESM! She donated to the museum missing specimens. The museum is very appreciative of Shirley's donation. The new display should be completed by end of August.

Club members Roz Shafer and Carol Bankert-George

Look for updates on our progress in the next ESM newsletter.

The museum does offer private party tours. Clubs and private individuals interested can contact the museum at scrockmuseum@gmail.com.

Arizona Rock and Gem Shows



Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: August 8, 2024, 6:30 pm
www.ajrockclub.com
@ Club Lapidary Shop
2151 W. Superstition Blvd., Apache Jct.

Daisy Mountain Rock & Mineral Club
Meetings are on the 1st Tuesday
(unless a Holiday then 2nd Tuesday)
Next Meeting: September 3, 2024, 6:30 p.m.
Please go to their website for more info
www.dmrmc.com
@ Anthem Civic Building
3701 W. Anthem Way, Anthem, AZ

Maricopa Lapidary Society, Inc
Note: New meeting day
Meetings are on the 3rd Tuesday
Next Meeting: August 20, 2024, 7:00 pm
www.maricopalapidarysociety.com
@ North Mountain Visitor Center
12950 N. 7th St., Phoenix, AZ

Mineralogical Society of Arizona
Meetings are on the 3rd Thursday
(Except December & June)
Thursday, September 19, 2024, 7:30 p.m.
Franciscan Renewal Center, (Piper Hall),
5802 E. Lincoln Drive, Scottsdale, AZ
www.msaaz.org

Pinal Geology & Mineral Society
Meetings are on the 3rd Wednesday
Next Meeting: September 18, 2024, 7:00 pm
In person meeting
www.pinalgeologymuseum.org
351 N. Arizona Blvd., Coolidge

West Valley Rock & Mineral Club
Meetings are on the 2nd Tuesday
Next Meeting: August 13, 2024, 6:30 pm
www.westvalleyrockandmineralclub.com
Buckeye Community Veterans Service Center
402 E. Narramore Avenue, Buckeye, AZ

Gila County Gem & Mineral Society
Meetings are on the 1st Thursday
(unless a Holiday then the next Thursday)
Next Meeting: August 1, 2024, 6:30 pm
www.gilagem.org
Club Building
413 Live Oak St, Miami, AZ

Wickenburg Gem & Mineral Society
Meetings are on the 2nd Friday
(February & December on the 1st Friday)
Next Meeting: September 13, 2024, 7:00 pm
www.wickenburggms.org
@ Coffinger Park Banquet Room
175 E. Swilling St., Wickenburg

ESM's Meeting Notice

ESM's next meeting will be at North Mountain Visitor Center, 12950 N. 7th St., Phoenix, on Tuesday, TBA 2024, at 6:30 p.m.

BECOME A MEMBER!

Join the Earth Science Museum's

esi: Earth Science Investigation team

IS IT TIME TO RENEW YOUR MEMBERSHIP?
Please renew today! ☺☺☺

_ _ _ _ _ _ _ _ cut here _ _ _ _ _ _ _ _ _

ESM Earth Science Investigation Team Membership Form

_____ New Member _____ Renewal

Membership levels:

_____ ESI Family $20

_____ ESI Individual $10

Membership benefits:

- Monthly e-newsletter *Earthquake*
- Official team membership card
- Knowledge that your contribution is making a difference in earth science education.

MANY THANKS TO OUR MAJOR DONORS!

AZ Leaverite Rock & Gem Society

Flagg Mineral Foundation
www.flaggmineralfoundation.org

Friends of the AZ Mining & Mineral Museum

Maricopa Lapidary Society
http://maricopalapidarysociety.com/

Mineralogical Society of AZ
www.msaaz.org

Payson Rimstones Rock Club
https://www.rimstonesrockclub.org/

Sossaman Middle School

White Mountain Gem & Mineral Club
www.whitemountain-azrockclub.org

Sun City Rockhound Club & Mineral Museum
https://suncityaz.org/recreation/clubs/rockhound-club-mineral-museums/

Wickenburg Gem & Mineral Society
http://www.wickenburggms.org
www.facebook.com/pages/Wickenburg-Gem-and-Mineral-Society/111216602326438

West Valley Rock and Mineral Club
http://www.westvalleyrockandmineralclub.com/

Staples Foundation
www.staplesfoundation.org

Anita Aiston	Will & Carol McDonald
Peter & Judy Ambelang	Debbie Michalowski
Stan & Susan Celestian	Janet Stoeppelmann
Russ Hart	Dennis & Georgia Zeutenhorst

_ _ _ _ _ _ _ _ cut here _ _ _ _ _ _ _ _ _

Name: _____

Address: _____

City, State, Zip: _____

Email: _____

Phone Number: _____

Mail form & payment to: Earth Science Museum
3215 W. Bethany Home Rd., Phoenix, AZ 85017

For Office Use Only

Card given/mailed: _____

Database updated: ☐ Distribution Lists updated: ☐

Card ID # _____ Expires: _____

Earth Science Museum
3215 W. Bethany Home Rd.
Phoenix, AZ 85017

Phone:
602-973-4291

Editor E-Mail:
scote@earthsciencemuseum.org

We're on the Web!

Visit us at:

www.earthsciencemuseum.org

Mission
Our Mission is to excite and inspire all generations about earth sciences through educational outreach.

Vision
We envision a community where students and the general public have curiosity about, passion for, and understanding of the underlying principles of earth sciences.

For more information about the ESM, how to become a member or how to arrange for a school visit or Community function, go to: www.earthsciencemuseum.org.

NOTICE:
ESM's next meeting will be at North Mountain Visitor Center, 12950 N 7th St, Phoenix, on Tuesday, TBA 2024, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

EARTH SCIENCE MUSEUM
NON-PROFIT BOARD OF DIRECTORS

Harvey Jong	President
Mardy Zimmermann	VP Outreach
Shirley Coté	Secretary/ Treasurer

Cindy Buckner, Doug Duffy, Ray Grant, Bob Holmes, Chris Whitney-Smith

Earth Science Museum
3215 W. Bethany Home Rd.
Phoenix, AZ 85017