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

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ESM OUTREACH UPDATE

Mardy Zimmermann, Outreach Coordinator

Outreach

There are no ESM outreach activities to report this month.

Earth's Mini-Moons and Quasi-Moons

By Harvey Jong

On September 29, 2024 the Earth acquired a new "mini-moon" when asteroid 2024 PT_5 started its 57-day flyby of our planet. The small 11 m (36 ft) wide asteroid represents a relatively uncommon occurrence of an observed temporary satellite.

What is a Mini-Moon and a Quasi-Moon?

A mini-moon is defined as a small natural celestial body that is captured by Earth's gravity and temporarily orbits the planet. If a mini-moon makes at least one equivalent revolution around the Earth, it may be designated as a temporarily-captured orbiter, (TCO), while a temporarily-captured flyby (TCF) refers to an object that makes less than one equivalent revolution. A temporary satellite may orbit Earth for a few weeks or months before the object either enters the atmosphere or is ejected away into space.

A quasi-moon is a celestial object that is also affected by Earth's gravity, but has a more complex gravitational relationship. The object may assume a stable orbit around the Sun which periodically brings it close to the Earth. Its trajectory, however, may be influenced by gravitational perturbations involving the Moon, Sun, and other planets; resonance effects with the Earth; and forces related to solar or thermal radiation. But it is not a true satellite since it is not gravitationally bound to the Earth like the Moon.

Both terms are informal designations which are not recognized as part of the official nomenclature by organizations, such as the International Astronomical Union (IAU). It is interesting to note that Arizona has played an important role in discovering and characterizing Earth mini-moons and quasi-moons.

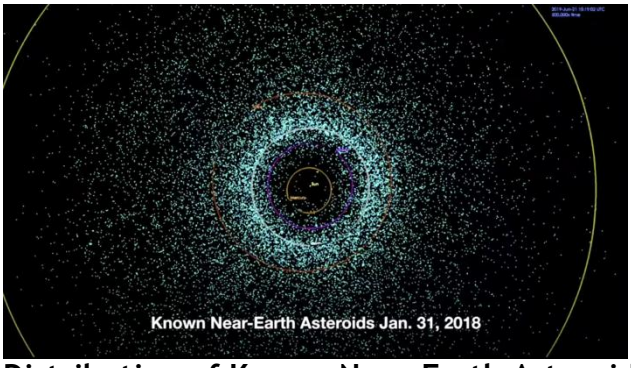
Origins of Mini-Moons and Quasi-Moons

Mini-moons and quasi-moons are part of the collection of Near-Earth Objects (NEOs) that include asteroids and comets with perihelion distances less than 1.3 astronomical units (au) (194.5 million km, 120.8 million mi). Near-Earth Comets (NECs) involve an additional requirement of having orbital periods less than 200 years. Most NEOs are asteroids which are referred to as Near-Earth Asteroids (NEAs). As of October 2024, NASA reported a total of 35,899 NEAs which includes[1]:

- 11,015 larger than 140 meters (459 ft)
- 14,000 estimated asteroids larger than 140 meters (459 ft) left to be found

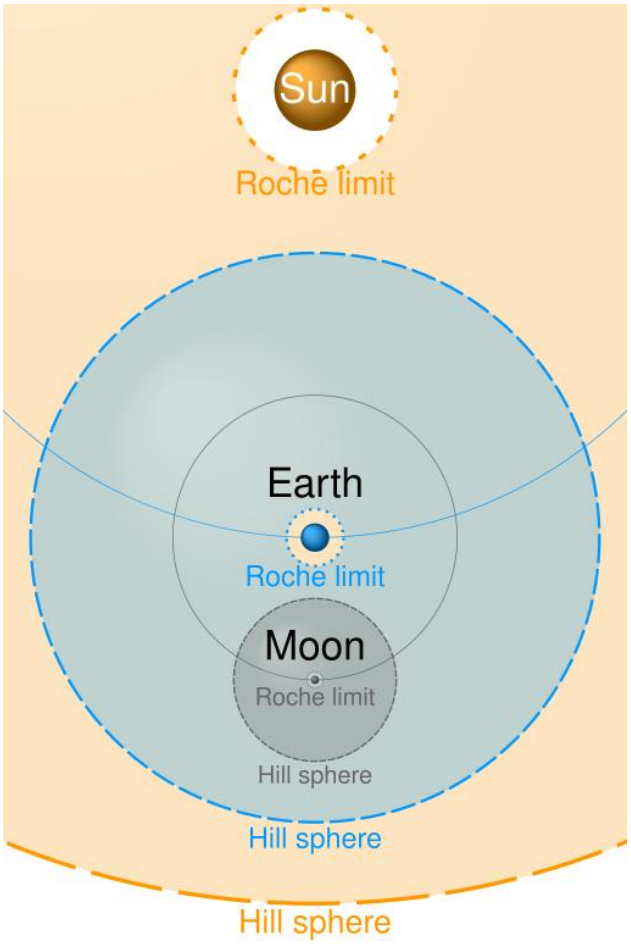
[1] Based on monthly update from NASA's Planetary Defense Coordination Office, https://science.nasa.gov/science-research/planetary-science/planetary-defense/near-earth-asteroids/

- 864 larger than 1 km (3,281 ft)
- 50 estimated asteroids larger than 1 km (3,281 ft) left to be found
- 16 passed closer to Earth than the Moon in the last 30 days
- 116 passed closer to Earth than the Moon in the last 365 days



Distribution of Known Near-Earth Asteroids
Screen capture of NASA/Jet Propulsion Lab animation, - PD, via https://www.youtube.com/watch?v=vfvo-Ujb_qk&ab_channel=NASAJetPropulsionLaboratory

Near-Earth asteroids and comets may become temporary satellites if they come within the Earth's gravitational sphere of influence which is known as the Hill sphere. A Hill sphere, which was defined by American astronomer George Hill (1838-1914), is the region around a celestial body where its gravitational potential represents the dominant force in attracting satellites. In the case of the Earth, the radius of its Hill sphere is ~1.47 million km (913,415 mi; 0.0098 au). [Note that the average distance to the Moon is approximately 385,000 km (239,000 mi) which is within the radius of Earth's Hill sphere]



Comparison of the Hill Spheres of the Sun-Earth-Moon System
Cmglee graphic, - CC_BY_SA-4.0 International, via Wikimedia Commons
This diagram (not drawn to scale) shows the Hill spheres of the Sun, Earth, and Moon along with Roche limits which are the distances where an object will be destroyed by gravitational tidal forces. The shaded areas denote regions where satellites may assume stable orbits around each body.

Notable Mini-Moon and Quasi-Moon Examples

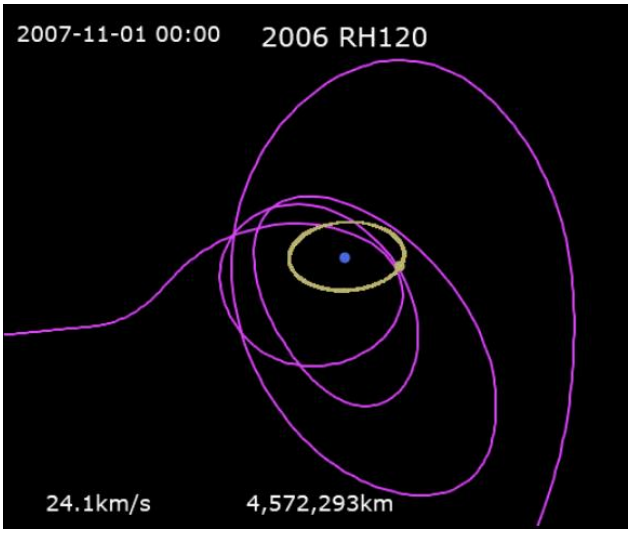
Throughout its history, the Earth has probably captured millions of temporary satellites. But given their very small size and transient nature, only few of these objects have been recently observed.

Asteroid 2006 RH_{120}[2]

Asteroid 2006 RH_{120} was the first Earth mini-moon to be observed (Anderson and Lo, 2016). The tiny asteroid, which has a diameter of about 2-3 m (6.5-9.8 ft), was discovered on September 14, 2006 by Eric Christensen of the Catalina Sky Survey near Tucson. It remained in temporary orbit around the Earth until July 2007, but was never more than 1.74 million km (1.08 million mi, 0.0116 au) from the planet.

Screen Capture of NASA Animation of 2006 RH_{120}
NASA animation, - PD, from NASA Space News video
https://www.youtube.com/watch?v=HnXtPQY5Yxw&ab_channel=NASASpaceNews

Some controversy developed on whether 2006 RH_{120} was actually a natural object. An initial spectrographic analysis seemed to be consistent with the white titanium-oxide paint used on a Saturn V rocket, and the 2002 discovery of J002E3, an object in a similar orbit, was determined to be the Saturn IV-B rocket stage from the Apollo 12 lunar mission. Photometric observations with the 10 m Southern African Large Telescope (SALT), however, confirmed that it was a natural body (Kwiatkowski et al., 2009).



Trajectory of Asteroid 2006 RH_{120}
Screen capture from Phoenix7777 gif animation, - CC_BY_SA-4.0 International, via Wikimedia Commons
This visualization shows the orbital trajectory of 2006 RH_{120} during the temporary capture from April 2006 to November 2007. The Earth appears in blue, while the Moon and its orbit are shown in yellow.

Asteroid 2016 HO_3 (468219 Kamoʻoalewa)

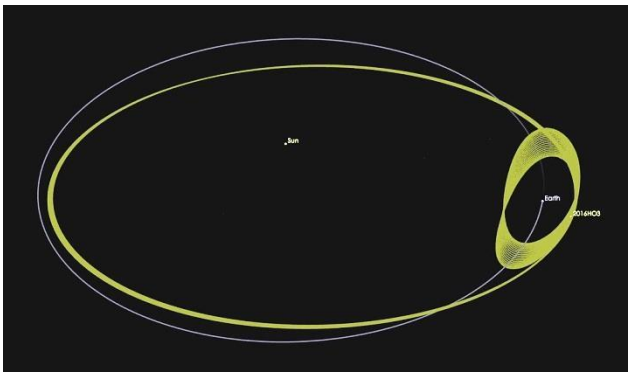
This small asteroid was first detected on April 27, 2016 by the Pan-STARRS 1 asteroid survey telescope of the Haleakalā Observatory in Hawai'i. It was initially named 468219 Kamoʻoalewa (The name is derived from the Hawaiian words *ka* "the", *mo'o* "fragment", *a* "of", *lewa* "to oscillate), but was later designated as 2016 HO_3. 2016 HO_3 is approximately 46-58 m (151-190 ft) in diameter and represents the fifth quasi-moon to be discovered among the seven currently known Earth quasi-moons (da la Fuente Marcos and da la Fuente Marcos, 2016).[3]

[2] The Minor Planet Center makes provisional designations of asteroids using a naming system where the first element indicates the year of discovery; the first letter is the half-month; and the second letter and subscripted numerical suffix indicates the order of discovery within the half-month where each letter corresponds to the first 25 discoveries in the half-month.

[3] As of 2023, the seven known Earth quasi-moons include (164207) 2004 GU_9, (277810) 2006 FV_{35}, 2013 LX_{28}, 2014 QL_{339}, (469219 Kamo'oalewa) 2016 HO_3, 2020 PP_1, and 2023 FW_{13}

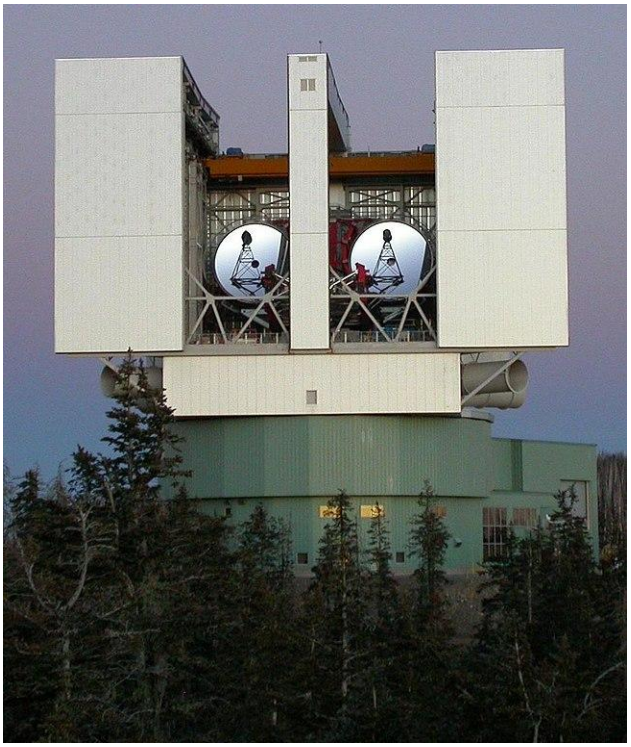
2016 HO_3 has the most stable orbit among the known quasi-moons, and estimates indicate that the asteroid will remain in its current orbit for the next 300 years (Sharkey et al., 2021). It orbits the Sun at a distance of 0.90-1.0 au with an average period of 365 days.

For half of this period, the orbital trajectory places the object closer to the Sun, and 2016 HO_3 appears to move ahead of the Earth. During the other half, 2016 HO_3 is farther from the Sun and falls behind the Earth. This oscillating pattern makes the asteroid appear as if it is moving elliptically around the Earth.



2016 HO_3 Around the Sun and Path Around the Earth
NASA/JPL-Caltech visualization, - PD, via Wikimedia Commons
This diagram shows the elliptical path that 2016 HO_3 traces around the Earth as the asteroid orbits the Sun.

In 2021, a detailed study of 2016 HO_3 was conducted using the Large Binocular Telescope on Mount Graham in southeastern Arizona and the Lowell Discovery Telescope near Happy Jack, Arizona.



Large Binocular Telescope
NASA photo, - PD, via Wikimedia Commons
The Large Binocular Telescope is an optical telescope that is located on Mount Graham in southeastern Arizona. It is part of the Mount Graham International Observatory and UA Steward Observatory. The telescope design consists of two linked 8.4 m (330 in) mirrors which is equivalent to a single 11.8 m (460 in) mirror telescope. Observations started on October 12, 2005.

Do you want to visit the observatory on Mt Graham?

Eastern Arizona College's Discovery Park Campus is the official visitor's center for the telescopes on Mount Graham. They conduct weekend tours of the Mount Graham International Observatory. Weather permitting, the tours begin in **mid-May** and go through **mid-November**. Because permits are required to enter the endangered red squirrel refugium, advance reservations are required.

Actually, the tour will be much more than just a visit inside LBT's enclosure. The tour features a trip up scenic Mount Graham, focusing on the mountain's rich geology, history, and diversity of life; a lunch near the summit of the mountain; and a guided tour of the observatories — The Submillimeter Telescope, the Vatican Advanced Technology Telescope, and the Large Binocular Telescope!

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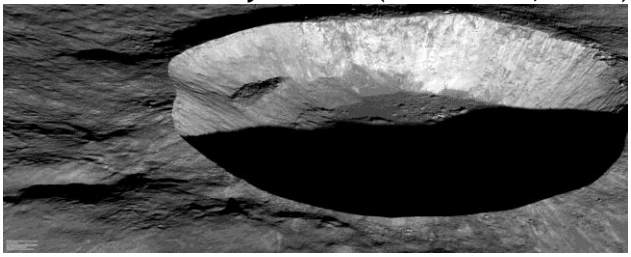
Fax: (928) 428-8081
E-mail: discoverypark@eac.edu
Web Site: http://www.eac.edu/discoverypark/mgio.shtm

Lowell Discovery Telescope
SSSR2000 photo, - CC_BY_SA-3.0, via Wikimedia Commons
The Lowell Discovery Telescope (formerly called the Discovery Channel Telescope) is a 4.3 m (170 in) optical telescope located in the Coconino National Forest near Happy Jack, Arizona. Construction was completed in February 2012, and the first images were captured in April 2012. It is operated by the Lowell Observatory and represents the fifth largest telescope in the continental U.S.

One of the key study findings involves the asteroid's reflectance spectrum which indicates a silicate-based composition. The spectrum also contains redder wavelengths which suggest a match for a lunar-like material (Sharkey et al., 2021). This result led to a rather controversial hypothesis that 2016 HO_3 may have a possible lunar origin. Specifically, the asteroid may have been a fragment flung into space when an asteroid impacted the Moon creating a crater with a diameter 10-20 km (6.2-12.4 mi) or larger in the last few million years. The Giordano Bruno [22 km (13.7 mi) diameter, 1-10 Ma age] crater on the far side of the Moon may be the most likely source (Jiao et al., 2024).



Sunset Over Crater Giordano Bruno
NASA/GSFC/ASU Lunar Reconnaissance Orbiter Camera image, - PD, via Wikimedia Commons

The hypothesis will be tested by China's Tianwen-2 (formerly known as Zhenghe-A) asteroid-sample return mission. Currently, the spacecraft is scheduled to be launched in May 2025. A key objective of the probe's over 10-year mission involves collecting samples using two different methods: a touch-and-go technique like the one used on OSIRIS-REx (see the June 2022 and October 2023 newsletters) and an ambitious anchor-and-attach approach to drill into the asteroid.

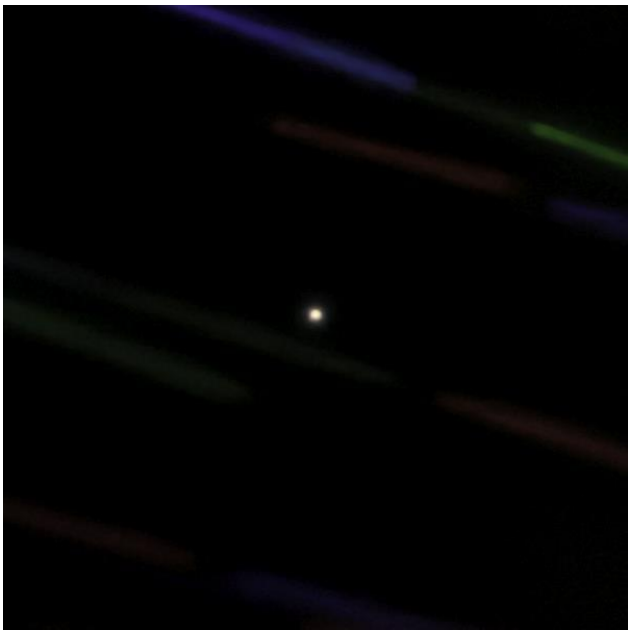
Asteroid 2020 CD_3

Asteroid 2020 CD_3 was discovered on February 15, 2020 by astronomers Theodore Pruyne and Kacper Wierzchoś at the Mount Lemmon Observatory as part of the Catalina Sky Survey. It was found as a very faint 20th magnitude object located about 0.0019 au (280,000 km; 180,000 mi) from Earth.

Screen Capture of NASA Animation of 2020 CD_3
NASA animation, - PD, from NASA Space News video
https://www.youtube.com/watch?v=HnXtPQY5Yxw&ab_channel=NASASpaceNews
The size of 2020 CD_3 is very small with an estimated diameter of around 1.2 +0.4 to -0.2 m (3.9 +1.3 to -0.66 ft) (Fedorets et al., 2020).

Shortly after its initial discovery, a global observation effort involving 23 researchers in seven countries and several telescopes was launched. The scientists confirmed that the

object is a natural body and represents the second Earth mini-moon discovered after 2006 RH_{120}.



Color Composite Image of 2020 CD_3
International Gemini Observatory/NSF National Optical-Infrared Astronomy Research Laboratoy/AURA/G photo, - CC_BY_SA-4.0 International, via Wikimedia Commons
Image captured on February 27, 2020
This image of 2020 CD_3 was acquired with the 8-meter Gemini North telescope on Hawai'i's Mauna Kea Observatories. Note that the photo combines three images using different filters. The faint color streaks are artifacts of the relative motion of background stars.

A trajectory analysis indicates that 2020 CD_3 may have been captured by the Earth around 2016-2017 and escaped Earth's gravity around May 7, 2020. The asteroid's distance to Earth varied between 0.2-4.5 Earth-Moon distances due to interactions with the gravity of the Earth and the Moon. Its final close approach to the Earth occurred on February 13, 2020 at a distance of about 41,000 km (25,000 mi). [Note that the nominal altitude of the geosynchronous orbit for telecommunication and weather satellites is 35,786 km (22,236 mi)]

Orbit of 2020 CD_3
Tony873004 graphic, - CC_BY_SA-4.0 International, via Wikimedia Commons
This diagram depicts the trajectory of 2020 CD_3 as it was temporarily captured by the Earth's gravity and later ejected away from the Earth-Moon system. Note the gray band indicates the orbit of the Moon.

Asteroid 2024 PT_5

Asteroid 2024 PT_5 was discovered on August 7, 2024 by astronomers Carlos de la Fuente Marcos and Raúl de la Fuente Marcos using data from the Asteroid Terrestrial-impact Last Alert System (ATLAS) in South Africa. The object orbits the Sun, but will make a close approach to Earth between September 29, 2024 and November 25, 2024. As it passes just outside of Earth's Hill sphere, 2024 PT_5 will become temporarily captured by Earth's gravity, but it won't complete a full orbit around the planet. The asteroid will reach a minimum distance from Earth of 0.012 au (1.8 million km, 1.1 million mi) on January 9, 2025 (de la Fuente Marcos and de la Fuente Marcos, 2024).

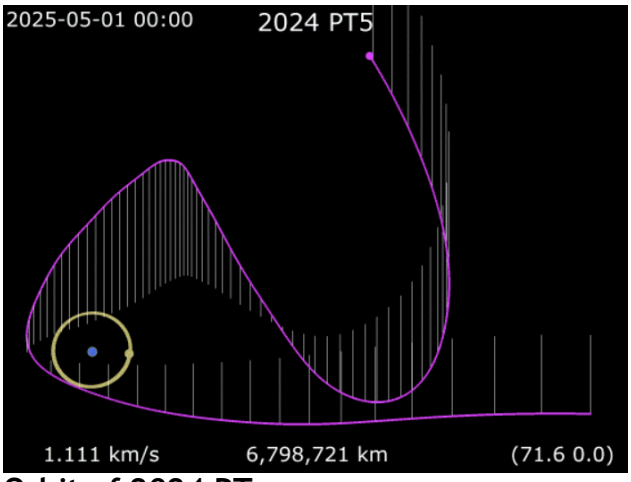
2024 PT_5 is a faint small object which at the time of discovery had a magnitude of 27.6 ± 0.3. Note that a full Moon has brightness around magnitude -12.5, and since absolute magnitude is a logarithmic scale the difference in the new mini-moon's brightness is about 1.1 x 10^{16} times. So, viewing 2024 PT_5 is beyond typical amateur astronomer telescopes and binoculars. According to astronomer Carlos de la Fuente

Macros, observation requires a telescope with a diameter of at least 30 inches (0.8 m) coupled with a very sensitive image sensor (Lea, 2024).

Screen Capture of NASA Animation of 2024 PT_5

NASA animation, - PD, from NASA Space News video https://www.youtube.com/watch?v=HnXtPQY5Yxw&ab_channel=NASASpaceNews

2024 PT_5 is most likely an asteroid from the Arjuna belt. This group of asteroids follows orbits similar to the Earth's and is located at about the same distance from the Sun.



Orbit of 2024 PT_5

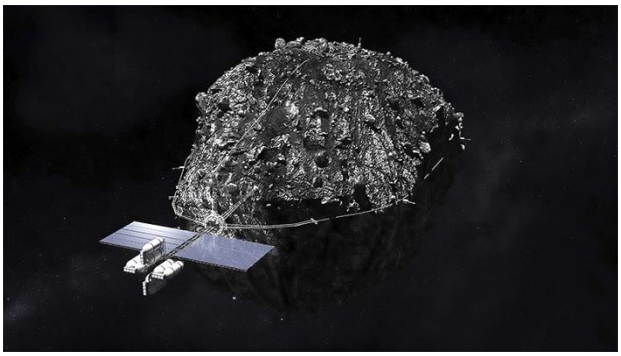
Screen capture of Phoenix7777 animation, - CC_BY_SA-4.0 International, via Wikimedia Commons

The close approach of 2024 PT_5 is depicted in this graphic. The Earth appears in blue, the Moon in yellow and 2024 PT_5 in magenta.

Mini-Moon and Quasi-Moon Opportunities

Mini-moons and quasi-moons provide scientists opportunities to observe the gravitational interactions between the Earth and other celestial bodies. This information can help with planetary defense efforts by improving the predictive models used in tracking potentially hazardous objects.

The temporary satellites might also supply an important initial stepping stone towards future asteroid mining. Their close approach in near-Earth orbit may permit relatively low-cost missions to explore the objects. The resulting knowledge and experience may help in identifying and developing potential mining targets.



Asteroid Mining Involving a Harvester Concept

Deep Space Industries illustration, via spinoff.nasa.gov

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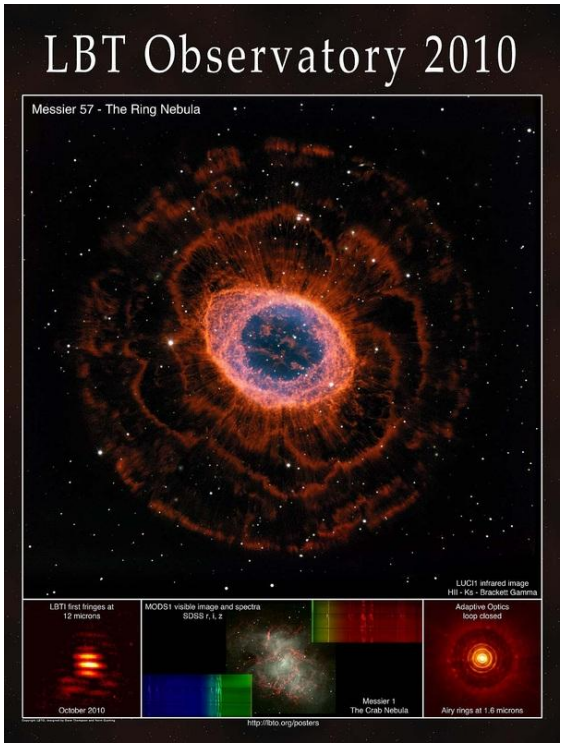
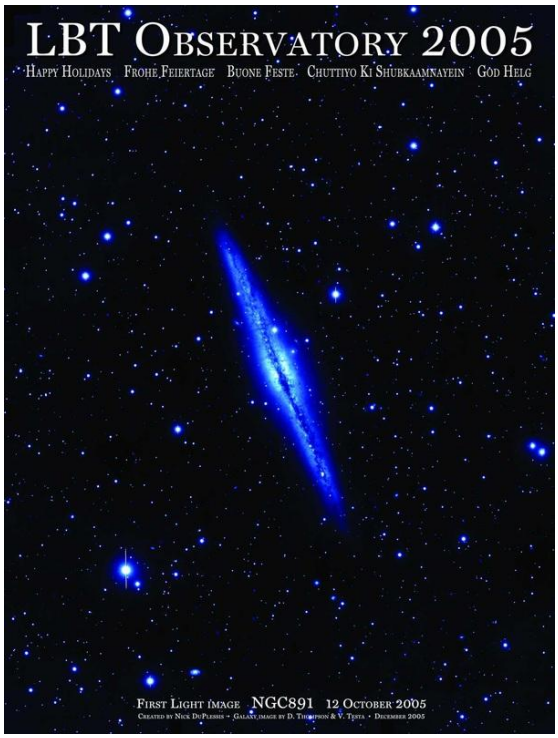


Infrared image of the Ring Nebula in the constellation Lyra



First light image of NGC891, a spiral galaxy in the constellation Andromeda

Arizona Rocks 137

Text by Ray Grant
Photographs from Picacho Peak State Park website

Up for another state park with geology tours? Geologist Tom Buckley, (see Arizona Rocks 136) is also doing geology tours at Picacho Peak State Park. If you have driven to Tucson on I-10, you passed the park. It is about 70 miles south of Phoenix and from the highway it looks quite spectacular. The peak is about a 1600 feet elevation change and there is a trail to the top.

About the geology, this is from the park website: *"Picacho Peak State Park provides a unique snapshot of the volcanism, crustal extension, tilting, faulting, mineralization, and erosion that defined this area over the past 23 million years."*

The geology tours are once a month, the next one is on Saturday, November 16 from 8 to 10 and registration is required. There is also a self-guided tour. It is two miles total with a 900 feet elevation change and 11 stops. The self-guided tour brochure is available on line or at the visitor center. The tour has stops showing the volcanic rocks, the faulting, and the hydrothermal mineral deposits. Hydrothermal solutions have deposited iron, copper, and other minerals as veins mainly along faults. The geology tour goes to the saddle on the Hunter trail. This trail continues on to the peak top, and is listed as difficult with steel cables in some areas.

Check the park website for more information about tours, trails, and the geology. https://azstateparks.com/picacho

One of the hydrothermal veins seen on geology tour

Trail to the top of the peak

View from the top of Picacho Peak

Picacho Peak showing saddle that is the end of the geology tour.

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

https://ammnre.arizona.edu/

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703.577.6449

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

Back in 2021, we assisted with a new exhibit at Phoenix City Hall called "From Mine to Medallion." The purpose of the exhibit was to connect Arizona's copper mining history with a public art installation of 300 copper medallions running along Central Avenue. We loaned the "Gallery @ City Hall" over 25 specimens, including native copper, copper sulfide and oxide minerals, and mining artifacts. All were from historic Arizona localities that contributed, or still contribute to, our state's mining heritage and mineral wealth. The exhibit ended in late 2023 and was ready to move to a new location, so when were offered another opportunity to help again at the City of Phoenix's South Mountain Environmental Education Center (SMEEC), we jumped at the chance. As with all our loans and collaborations, this is a great opportunity to utilize our collection and share it with others (SMEEC is a free, public visitor center) while our museum is still in development. We recently completed installation of "From Mine to Medallion" and the mineral specimens look great.

In fact, we are not only loaning minerals for SMEEC's special exhibit, but also for their brand new permanent exhibits. The center is currently undergoing a major renovation and exhibit build out in celebration of South Mountain Park and Preserve's 100th Anniversary in 2024, and will reopen this fall. For their new displays on Arizona mining and ores, we are loaning them ore specimens of copper, gold, silver and base (mixed) metals. We are happy to work with organizations like SMEEC that serve the community in meaningful ways. If you have similar suggestions for collaboration, let us know! Thanks for your support!

Sneak preview of special exhibit "From Mine to Medallion" at the South Mountain Environmental Education Center. The center reopens this fall.

This native copper with gypsum from the Ray Mine will be on display in "From Mine to Medallion."

This gold ore from the Max Delta Mine, South Mountains, will be on display in the main exhibit area. Small amounts of pyrite and chalcopyrite are visible in the quartz.

Please Note:

We are planning a pre Christmas sales day on Saturday December 7 (10 - 4) and everyone is welcome to bring a table and set up to sell (minerals, fossils, jewelry) at no charge to them.

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society next meeting

Wednesday, November 20, 2024

Meetings are the third Wednesday at 7pm, doors open at 6:00

Meeting Program**: "Tips on how to identify minerals" by Ray Grant and Dana Slaughter**.

Everyone is welcome!

www.pinalgeologymuseum.org

Ray Grant ray@pinalgeologymuseum.org

Pinal Geology and Mineral Museum

September – May hours are Wednesday – Saturday from 10-4, admission is free.

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

On Monday October 21 a ribbon cutting ceremony for the new entrance was held at the Museum. At the ceremony a certificate of appreciation from Congressman Elijah Crane was presented. Also a donation was given the museum by Florence Copper and Les Presmyk cut the ribbon for the Flagg Foundation that sponsored the new entrance.

Les Premyk cutting ribbon for Flagg Foundation for new entrance to the museum

Certificate of Appreciation for the museum from Congressman Elijah Crane

Sophie Dessert presenting Florence Copper donation to Board members of the museum

Mckya Lamb, presenting Certificate of Appreciation for the museum from Congressman Elijah Crane to Ray Grant and observed by Coolidge Mayor, Jon Thompson

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 Mineral Museum New Displays

By Carol Bankert-George Vice President

The museum completed two new displays in October.

First, the museum is hosting a new guest display from the S.A.L.T. (Studying Ancient Lifeways and Technologies) organization. Peter Huegel – board member of the organization and frequent guest speaker for the Rockhound Club worked with the museum's intern, Krysten Sarkissian, in designing the display.
The new display showcases some of the many skills that are taught through the organization. The Sun City Mineral Museum is honored to have this display from the S.A.L.T. organization.

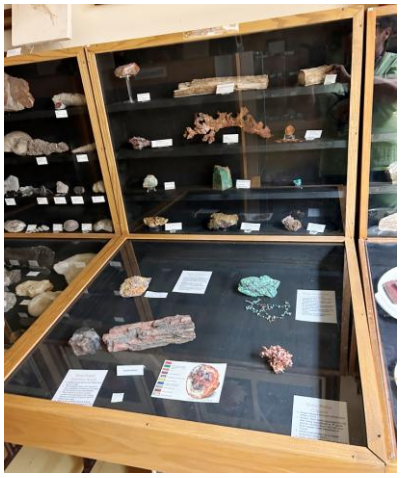
To find out more about this organization check out their website at www.saltskills.com.

The second is a display of 4 Arizona state symbols: wulfenite, state mineral, turquoise, state gem, petrified wood, state fossil and copper, state metal.

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

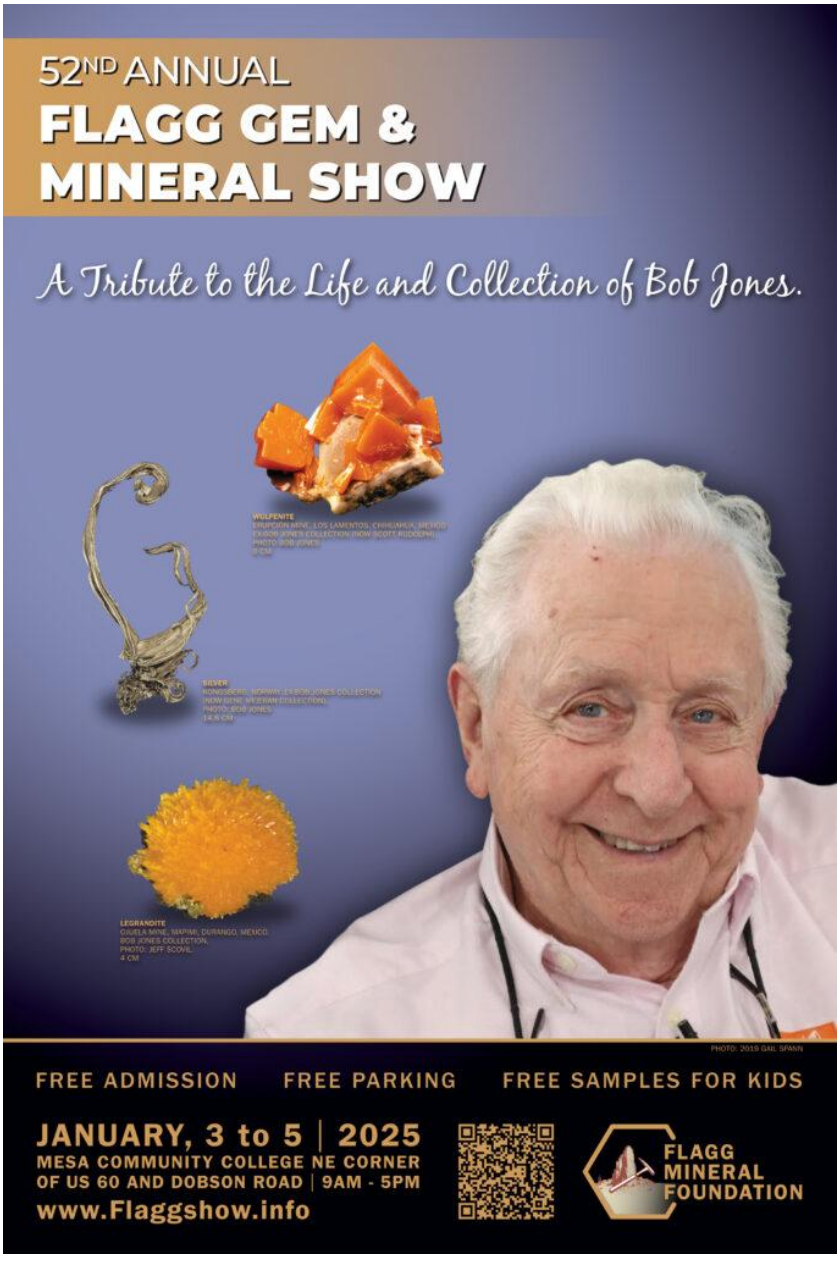
Peter Huegel, board member from SALT Organization, working with our intern Krysten Sarkissian on the museum's new guest cabinet display.

Parts of the new SALT, guest cabinet display



New Arizona State symbols display. Included are: turquoise, petrified wood, wulfenite, and copper

Arizona Rock and Gem Shows



Daisy Mountain Rock and Mineral Show - 03/01/2025

Start Date: 03/01/2025
End Date: 03/02/2025
Hours: Sat 9:00-5:00 Sun 10:00-4:00
Venue: The Anthem School
Address:
41020 N Freedom Way
Anthem , AZ 85086
Website: http://www.dmrmc.com/
Types: Rock & Mineral Shows

Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: November 14, 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: November 5, 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: November 19, 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, November 21, 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: November 20, 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: November 12, 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 November 7, 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: November 8, 2024, 7:00 pm
www.wickenburggms.org
@ Coffinger Park Banquet Room
175 E. Swilling St., Wickenburg, AZ

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.

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esi: Earth Science Investigation team

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Please renew today! ☺☺☺

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ESM Earth Science Investigation Team Membership Form

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_____ 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

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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!!!

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