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

September 2024
Volume 13, Issue 9

ESM OUTREACH UPDATE

Mardy Zimmermann, Outreach Coordinator

Outreach

Teachers and students are just getting settled after being away for the summer; there are no ESM outreach activities to report this month.

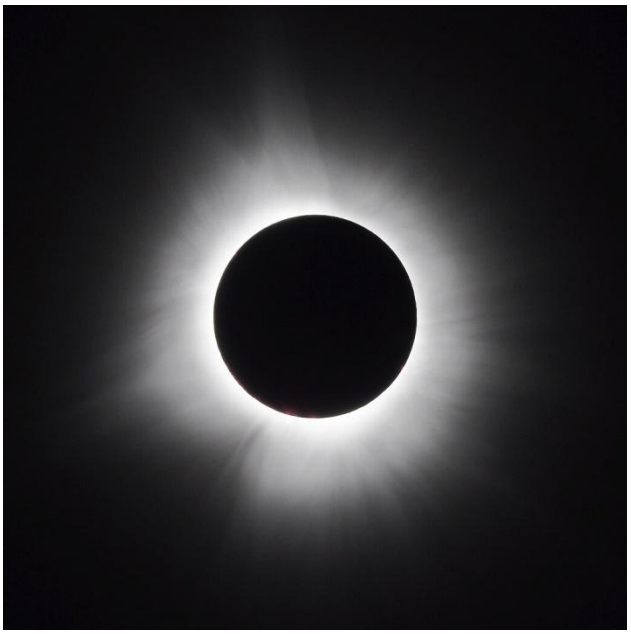
Discovery of the Earth's Third Global Energy Field

By Harvey Jong

Earth's gravitational and magnetic fields are well known, defining features of the planet. But a third fundamental global energy field, which was hypothesized over 60 years ago, has recently been measured for the first time by NASA scientists (Collinson et al., 2024). This field is known as the ambipolar electric field.

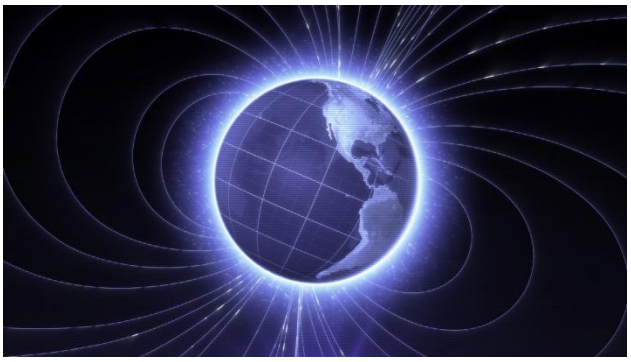
Earth's Ambipolar Electric Field

Since the late 1960s, satellites orbiting over the Earth's poles have detected charged particles streaming from the ionosphere into space. This outflow has been studied by scientists who proposed different processes for the escaping ions. Heating from intense sunlight has been suggested as a source driving high energy ions. But many particles with low energy were found to be traveling at supersonic speeds. One possible hypothesis involves an analog to the solar wind which accelerates particles of the solar corona into space.



Solar Corona of the 2024 Total Solar Eclipse
Jim Vajda photo, - CC_BY_SA-2.0, via Wikimedia Commons
Image captured on April 8, 2024 from Oxford, Ohio

This mechanism was dubbed the polar wind (Banks and Holzer, 1968).



Conceptualization of the Earth's Ambipolar Electric Field and the Polar Wind

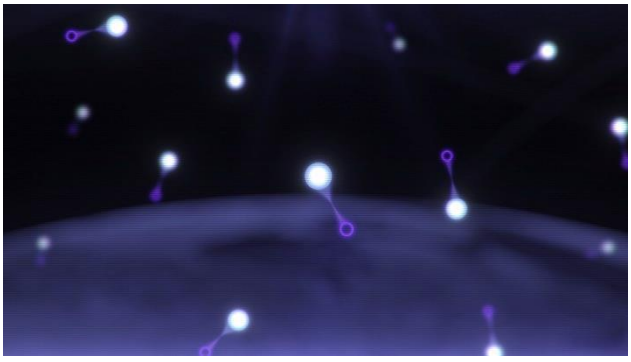
NASA/Conceptual Image Lab/NASA Goddard Space Flight Center, - PD, via svs.gsfc.nasa.gov

The blue glow represents the newly discovered ambipolar electric field. The field expands the atmosphere by lifting and preventing the separation of particles of the ionosphere, similar to inflating a balloon. Some of the particles, however, are ejected into space along magnetic field lines over the poles creating the polar wind.

Origins of the Ambipolar Electric Field

Around 250 km (150 mi) above the Earth, atoms in the atmosphere break apart into negatively charged electrons, and positively charged ions. The electrons are very light with a mass of 9.109×10^{-31} kg and can readily escape to space with slight additions of energy. The ions weigh thousands of times more than the electrons and tend to sink toward the ground. If acted solely upon by gravity, the two groups of particles would drift apart over time.

But given the opposite electric charges, an electric field develops to tether particles preventing their separation. This electric field is bidirectional – the ions pull the electrons down as they sink with gravity, while the electrons lift the ions higher as they attempt to escape to space. The bidirectional nature of this connection along with the fact that the field's effects are strongest at the poles leads to the name – the ambipolar electric field. (Ambi- is a Latin prefix meaning "both".)



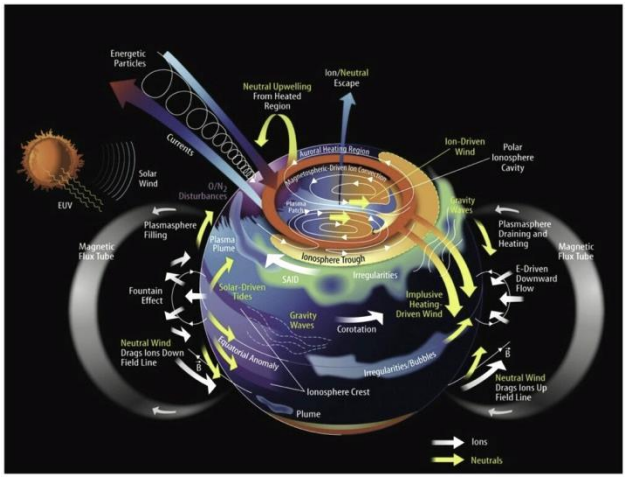
Conceptualization of the Particle Interactions that Lead to the Ambipolar Electric Field

NASA/Conceptual Image Lab/NASA Goddard Space Flight Center, - PD, via svs.gsfc.nasa.gov

This image shows large white ions pulling electrons downward and smaller purple electrons tugging ions upward.

Measuring the Ambipolar Electric Field

Several factors contribute to the challenge of measuring the ambipolar electric field. First, the particle interactions associated with this field occur in the ionosphere which is a very dynamic and complex region of the Earth's atmosphere.



Features of the Earth's Ionosphere-Thermosphere System

NASA Goddard Space Flight Center graphic, - PD, via Wikimedia Commons

The inosphere is an electrified layer of the upper atmosphere that extends roughly 80 to 644 km (50-400 mi.) above the surface. A variety of complex phenomena are involved in particle movements and interactions. The white arrows correspond to ions, while the yellow arrows indicate neutral particles.

The density of ions and electrons in the ionosphere varies with time and space depending on solar wind activity, geomagnetic disturbances, and atmospheric conditions. In addition, the ambipolar

electric field is superimposed with other fields generated in the ionosphere.

Another complication involves the very small magnitude of the ambipolar electric field and the limitations of measurement techniques which include space-based instruments or ground-based observation. Theoretical studies have estimated that the field strength may be as low as 1×10^{-6} V/m (Li et al., 2021).

Spacecraft sensors typically measure electric fields by monitoring the electrical potential between two separated probes. Detecting low values, however, would involve a very large electrode spacing that is not feasible with current satellite designs. Additional issues include sensor calibration and difficulties in distinguishing the ambipolar field from other ionospheric fields.

Ground-based methods involve indirect measurements using radar systems and magnetometers. These approaches, though, lack the resolution and accuracy necessary to detect the ambipolar field.

Endurance Mission

The Endurance mission is a NASA-funded project with the objective of making the first direct measurement of the Earth's global electric potential. Work began in 2016 on a proposal which called for a collaboration between three nations: the U.S. in building and flying the rocket, the Kingdom of Norway in operating the launch facilities, and the United Kingdom in providing radar ground support. The mission is named in honor of the ship that Sir Ernest Shackleton and his crew sailed to explore Antarctica.

The *Endurance* Trapped in Pack Ice
Underwood & Underwood photo/Library of Congress archive/No. 212295, - PD, via Wikimedia Commons
1916 photo

This photo of the *Endurance* was taken during the Imperial Trans-Antarctic Expedition of 1914-1917. The expedition attempted to make the first land crossing of Antarctica, but the ship was trapped and crushed by ice.

Several flight requirements were identified for the Endurance mission to make its ground-breaking measurement:

1. Launch into open magnetic field lines, away from the polar cusp and auroral zones
2. Fly as vertically as possible
3. Fly above the neutral exobase transition region (Note that the exobase is the lowest part of the exosphere where atmospheric particles hardly collide and

particles with sufficient velocity can escape into space. The exobase transition region is ~ 500 km (310.7 mi) above the surface.)

4. Fly in daytime
5. Launch during a geomagnetically quiet time
6. Launch during low Extreme Ultraviolet (EUV) conditions to minimize photoelectron scattering

Launch Vehicle and Launch Site

Unlike the far-flung, big budget asteroid and lunar sampling missions described in previous newsletter articles, the Endurance project used a low cost sounding rocket to carry instruments on a suborbital flight. This type of rocket may reach altitudes ranging from 48 to 1500 km (30 to 930 mi). The apogee of the Endurance rocket was ~768 km (477 mi), while the duration of the flight was ~19 minutes.

In order to meet the requirement of launching into open magnetic field lines, the northernmost launch site in the world, the Svalbard Rocket Range or SvalRak, was selected. The launch range is located at Ny Ålesund in Svalbard, a Norwegian archipelago in the Arctic Ocean.

Topographic Map of Svalbard
Oona Räisäen (Mysid) photo, - CC_BY_SA-4.0 International, via Wikimedia Commons
The red dot indicates the location of Svalbard Rocket Range.

Oriole III-A Sounding Rocket
NSROC ME/NASA drawing, - PD, via nasa.gov
The Oriole III-A is a three stage, solid fueled rocket that has been used extensively by NASA for suborbital missions.

NASA Research Station at the Svalbard Rocket Range
Jerzy Strzelecki photo, - CC_BY_SA-3.0, via Wikimedia Commons

The Svalbard Rocket Range is owned by the Andøya Space Center and has been used by various space agencies since 1997. Given its location at the 79th parallel north, the site is well situated for launching rockets to investigate the Earth's magnetic field.

Assembly of the Endurance Rocket
Brian Bonsteel/NASA photo, - PD, via nasa.gov

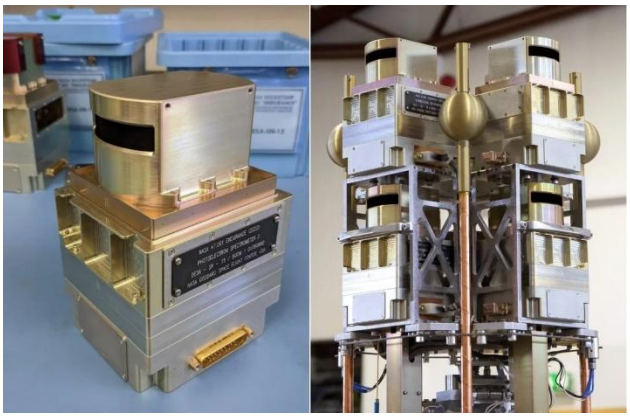
Endurance Launch from Ny Ålesund, Svalbard on May 10, 2022
Brian Bonsteel/NASA photo, - PD, via nasa.gov

Science Objective and Mission Payload

The specific science objective of the Endurance mission involves determining the magnitude, nature, and vertical structure of Earth's ambipolar electric potential drop across the exobase transition and beyond (Collinson et al., 2022). The Endurance payload included six instruments:

1. Photoelectron Spectrometer – measured field-aligned electron energy distributions from 10 eV to 1 keV
2. Sweeping Langmuir Probe – measured the spacecraft floating potential (needed for correcting energy spectra, plasma density, and electron temperature)
3. Electric Fields Instrument – detected electric 2-axis DC fields and waves
4. Neutral Mass Spectrometer & Ionization Gauge – determined neutral densities by species from 160 to 500 km (99.4 to 310.7 mi) and total density
5. Magnetometer – determined the bulk DC magnetic field orientation with respect to the payload
6. Panoramic Camera – captured color photographs near apogee for public outreach

The Photoelectron Spectrometer, which used a new type of plasma analyzer, represented the key instrument of the mission. It consists of 8 identical Dual Electron Spectral Analyzer (DESA) sensors that provide high resolution electron energy measurements ($\triangle E/E$ of 0.5%).



Dual Electron Spectral Analyzer (DESA) Sensor and the Endurance Photoelectron Spectrometer
Left: Gly Collinson/NASA photo; right Brian Bonstell/NASA photo, - PD, via nasa.gov

The DESA sensors are designed to monitor the energy of photoelectrons. Photoelectrons are caused by photoionization and have discrete, constant energies. Some photoelectrons may escape from the Earth along open magnetic field lines at the polar cap, but others are decelerated by the ambipolar field. So, Endurance observed how the energy spectra of photoelectrons evolved between altitudes from 250 km to 768 km. The electric potential drop can be determined from energy shifts in the spectra.

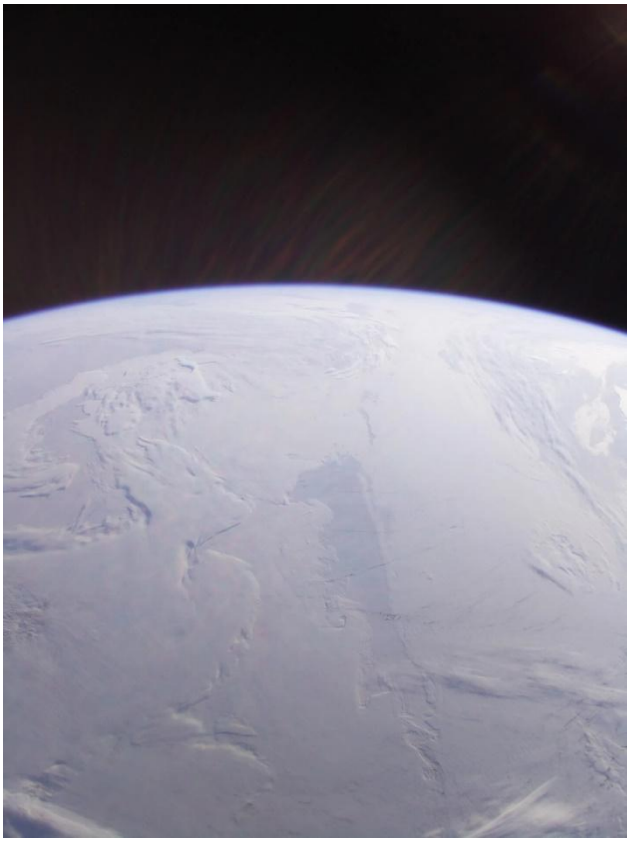
Flight Measurements

The Endurance collected data over a 518 km (322 mi) altitude range during the upleg and downleg segments of its suborbital flight. This data was supplemented by the European Incoherent Scatter Scientific Association's (EISCAT) radar measurements of the ionosphere and geomagnetic activity. After careful correction of the spacecraft's potentials and ionospheric/geomagnetic conditions, a difference of 0.55 volt with an uncertainty of 0.09 volt was observed in comparing the potentials measured from 250 km to 768 km (Collinson et al., 2024).

In a NASA press release[1], Glyn Collinson, the principal investigator of the Endurance project, commented:

"A half a volt is almost nothing — it's only about as strong as a watch battery, but that's just the right amount to explain the polar wind."

[1] NASA Discovers a Long-Sought Global Electric Field on Earth, August 28, 2024, Miles Hatfield and Rachel Lense, https://science.nasa.gov/science-research/heliophysics/nasa-discovers-long-sought-global-electric-field-on-earth/



North Polar as Seen from the Endurance
Nasa photo, - PD, via nasa.gov
This photo was taken when the Endurance reached its apogee of 768 km (477 mi). Note that the faint red and green streaks above the horizon are due to lens flare.

References

Banks, P.M. and T.E. Holzer (1968) The polar wind. *Journal of Geophysical Research, Space Physics* 73(21): 6846-6854.

Collinson, G.A., A. Glocer, R. Pfaff, A. Barjatya, S. Bissettm, K. Blix, A. Breneman, J. Clemmons, F. Eparvier, T. Gass, R. Michell, D. Mitchell, S. Imber,·A. Ghalib, H. Akbari, G. Ansted, L. Baddeley, H. Bahr,·G. Bain, B. Bonsteel, H. Borgen, D. Bowden, D. Bowker,T. Cameron, M. Campbell, P. Cathell, D. Chornay, R. Clayton, L. Conser, L. Davis, S. Donohue, L. J. Eilertsen, C. Etheridge, N. Graves, I. Häggstrøm, P. Hanssen, H. Haugh, E. Helgesen, J. Henderson, K.R. Herseth, J. Hickman, K. Jensen, T. Jester, E. Johnson, H. Johnson,

A. Kavanagh, M. King, D. Knight, R. Laman, T. Lankford, R. Lien, M. Lester, G. Marsh, S. Martin, N. Morris, L. Nguyen, R. Nelson, W. Ogundere, K.H. Osbakk, D. Page, J. Polidan, D. Raley, R. Raymond, E. Robertson, G. Rosanova,T. Rosnack, B. Serabian, R. Simonsen, J.A. Søreng, J. Sveen, D. Swanson, R. Swift, P. Uribe, H. Valentine, F. Waters, L. West, and T. Wilson (2022) The Endurance rocket mission *Space Science Reviews* 218:39.

Collinson, G.A., A. Glocer, R. Pfaff, A. Barjatya, R. Conway, A. Breneman, J. Clemmons, F. Eparvier, R. Michell, D. Mitchell, S. Imber, H. Akbari, L. Davis, A. Kavanagh, E. Robertson, D. Swanson, S. Xu, J. Miller, T. Cameron, D. Chornay, P. Uribe, L. Nguyen, R. Clayton, N. Graves, and the Endurance Mission Team (2024) Earth's ambipolar electrostatic field and its role in ion escape to space. *Nature* 632: 1021-1025.

Li, K., S. Haaland, and Y. Wei (2021) A new concept to measure the ambipolar electric field driving ionospheric outflow. *Journal of Geophysical Research, Space Physics* 126(2)

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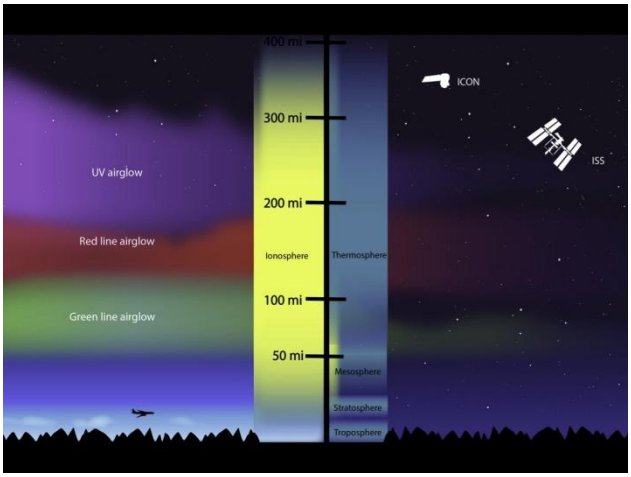
Some Interesting Facts about the Ionosphere



Layers of the Ionosphere
NASA/GSFC graphic, - PD, via svs.gsfc.nasa.gov

- Home to all the charged particles in Earth's atmosphere
- Where Earth's atmosphere meets space
- Constantly changes, sometimes unpredictably
- Home to many satellites, including the International Space Station
- Plays a crucial role in radio communications by reflecting radio waves back to Earth
- Varying electron density may cause slight delays/errors with GPS signals
- Influenced by both Earth and space weather
- Constantly glows and interacts with solar activity to produce auroras
- Helps protect against harmful cosmic rays

Ionosphere and Aurora as Seen from the International Space Station
NASA photo, - PD, via science.nasa.gov

Airglow Captured in France
J. looten photo, - CC_BY_SA-4.0 International, via Wikimedia
Airglow as seen at the Château de Lossse on January 2023.

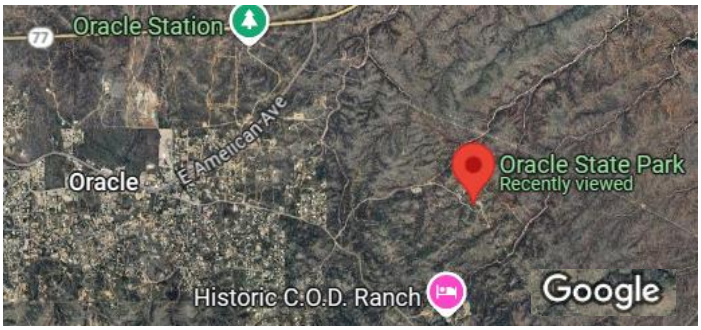
Arizona Rocks 136

Text by Ray Grant
Photographs from Oracle State Park website

Arizona is the best state to see geology, and here is another place to visit. It is Oracle State Park at the north end of the Santa Catalina Mountains (3820 E Wildlife Dr, Oracle, AZ 85623). I have never been there and had not heard anything about the park until recently. The following is a description of what they are doing:

> "We are thrilled to let everyone know that Oracle State Park Geology Tours will resume on October 27 at 8:00am! The tour has been enhanced with new rock samples, fossils, information, and illustrations. Tom Buckley, park geologist, has created a post tour packet for all participants that provides maps and a new "Geology of Featured Trails at the Park" pamphlet with photos from Ranger Michael Bain. Tours will be held once per month through April. For more information & registration, check out our events page at: https://azstateparks.com/oracle/events"

The website has a copy of the Self -guided Geology Tour, and there are Virtual Geology Talks about the park and surrounding area for you to watch. You can visit the park any time and do your own tour. It is now on my list of places to visit and thanks to geologist Tom Buckley for putting this all together.



AZ Mining, Mineral & Natural Resources Education Museum Update September 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

For the first time in several years, our museum returned as an exhibitor at the Denver Gem & Mineral Show, held from September 12th-15th. The show was held in coordination with the Hardrock Summit at a brand new location, the Westin Westminster hotel, and both Curator Catie and Executive Director Marta attended. This year's theme was "Mineral Oddities" and we decided to showcase some strange and unusual specimens from our collection, including pseudomorphs, bird's nests or "cave pearl" formations, chalcocite, malachite and azurite-replaced petrified wood, "needle ore" hematite, and a few others, including a fun find from our gift shop inventory: a clock carved into a quartz crystal. In addition to installing an exhibit at the show, we were able to do some Colorado museum research at the Western Museum of Mining and Industry in Colorado Springs (which had incredible working mining equipment), the Denver Museum of Nature and Science, the Colorado School of Mines Museum of Earth Science, and the Molly Brown House Museum. There was a lot of support for our project among show attendees, private collectors, and fellow museum colleagues. We look forward to hopefully attending again next year. Thank you for your support!

Museum Executive Director Marta Bones in front of the mineral display at the Denver Gem and Mineral Show

Chromium petrified wood from Mackelprang Wash, Navajo Co., AZ

Aragonite post-mining "bird's nest" from Bisbee, Cochise Co., AZ

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society next meeting

October 16, 2024

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

Meeting October 20 – Speaker: Stan Celestian - Pseudomorphs - "Imposters of the Mineral Kingdom". It will consist of two parts. The first will be a brief historical look at how mineralogists perceived pseudomorphs and explained their formation. The second will be a modern interpretation of the various types of pseudomorphs and how they form with visual examples of each.

Stan taught Geology, Physics, Physical Science and Astronomy at Glendale Community College for 30 years along with teaching Geology classes at Arizona State University for 10 years. Stan was the first NASA ambassador to the Solar System in Arizona. He was also a state director for the Science Olympiad. Now fully retired, he continues with his passions of geology, astronomy, woodworking, photography as well as golf.

Pseudomorph of glauberite
Stan Celestian collection and photo

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 wrapping up Summer Projects
By Carol Bankert-George Vice President

The Mineral Museum will resume our 5 day a week schedule starting October 2nd. Hours open are 10 am to 1 pm daily, closed Thursday and Sunday.

Our final summer projects this past month included a review and upgrade to museum lighting. New LED light fixtures were installed in all specimen display cabinets. These new light fixtures are not only energy efficient, but much brighter for a better view of the specimens on all display shelves.

Our fluorescent room also had an inspection by Bill Garner from Way Too Cool fluorescents. Bill comes by to do a periodic review of our UV lights to ensure they are in tip top shape. He also donated additional specimens for display in our fluorescent room which will be added in the next month along with a few new purchased fluorescent minerals. If you haven't come for a museum tour, please consider doing so now with the extended hours.

Club member Roz Schafer with the new '50 States' display

Part of the new and improved fluorescent room display

Bob Holmes with the recently completed meteorite display on loan from Bob

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

West Valley Rock & Mineral Club
Buckeye's 10th Annual

Helzarockin'
GEM & MINERAL SHOW

October 11 • 12 • 13 • 2024

9 a.m. - 5 p.m. Fri-Sat
9 a.m. - 2 p.m. Sun
Adults $4 ★ kids under 13 free

★ NEW LOCATION! ★

Buckeye Equestrian & Events Center
10300 S Miller Road
Buckeye, Arizona
West Open Air Arena

rocks, gems, minerals, fossils
jewelry, beads, slabs, cabs
scavenger hunt and rock painting
panning for gold
food & drinks available

Alice: 602-329-2539
Kim: 505-759-1655
Nikelle: 619-277-6268
westvalleyrockandmineralclub.com

50th ANNUAL HUACHUCA MINERAL, GEM, JEWELRY and FOSSIL SHOW
12th AND 13th, OCTOBER 2024
THE MALL AT 2200 EL MERCADO LOOP, SIERRA VISTA, AZ
For Information; Contact Maudie Bailey,
gmbailey@msn.com, 520 249-1541

SEDONA GEM & MINERAL SHOW

October 19th & 20th, 2024

The Sedona Gem and Mineral show will be held on the third weekend of October at the Sedona Red Rock High School, located at 89A and Upper Red Rock Loop Road in West Sedona.

Admission is only $5 (cash only); cards are accepted by vendors with children 12 and under free. Free Parking! This event benefits our non-profit Sedona Gem and Mineral Club Scholarship Fund.

General Admission $5- under 12 FREE
Sat. November 9th 9am-5pm
Sun. November 10th 9am-4pm

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gemclub.info
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Over 40 Vendors Best Rock Contest Raffle
Door Prizes Kid's Area Silent Auction
Hassayampa Elementary School
251 South Tegner Street Wickenburg, AZ
9am - 5pm Saturday • 10am - 4pm Sunday

Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: October 10, 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: October 1, 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: October 15, 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, October 17, 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: October 16, 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: October 8, 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 October 3, 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: October 11, 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

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

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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
3215 W. Bethany Home Rd.
Phoenix, AZ 85017