



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, 2026
Volume 15, Issue 9

Lost in Escarpment - A New Hypothesis on the Mystery of the Grand Canyon's Great Unconformity

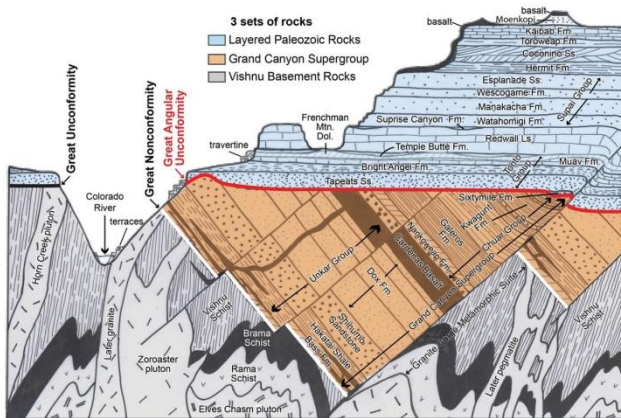
By Harvey Jong

The Grand Canyon provides a comprehensive, well-exposed record of the Earth's geologic history. More than 180 stratigraphic units have been identified in the area, and the oldest layers, which make up the Vishnu Basement Rocks, date back to 1,840 million years ago. Gaps, however, occur in the exposed rock sequences and are called unconformities (See [AZ Rocks #45](#)). At least 14 known unconformities are found in the Grand Canyon, but this article will focus on a recent investigation involving the Great Unconformity.

indicated in different colors: the Vishnu Basement Rocks appear in gray; the Grand Canyon Supergroup is represented in orange; and Layered Paleozoic Rocks are displayed in light blue. The three major unconformities include Great Nonconformity, Great Angular Unconformity, and Great Unconformity.

The Great Unconformity

The Great Unconformity was first observed in 1869 by American geologist and explorer John Wesley Powell (1834-1902). He used the term to refer to the contact where the Layered Paleozoic Rocks overlie the Vishnu Basement Rocks. A gap of up to 1.2 billion years (or about 25 percent of the Earth's history) in the rock record occurs at this contact.



Stratigraphic Column of the Exposed Rocks of the Grand Canyon

National Park Service/U.S. Department of the Interior diagram, - PD, via Wikimedia Commons
This 2021 revision of the Grand Canyon stratigraphic column shows individual geologic formations along with major unconformities. Three sets of strata are



Great Unconformity Above Granite Gorge

Laurie Crossey photo, - PD, via nps.gov
The white line indicates the Great Unconformity.



Close-up of the Great Unconformity

Chris M. Morris photo, - CC_BY_SA-2.0, via Wikimedia Commons

This photo shows the Tapeats Sandstone (age of 508-507 Ma) overlying the Vishnu Basement Rocks (nominal age of 1,750 Ma).

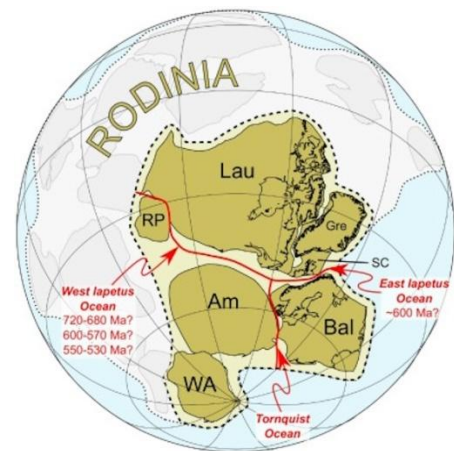
The size of the Great Unconformity varies across the canyon where 1.2 billion years of rock is missing in the western side, while a difference of only 250 million years occurs on the east. This variability reflects different interactions of geological processes. It should also be noted that the Great Unconformity isn't just a local feature of the Grand Canyon. The geological boundary appears at different locations across the planet.

Origins of the Great Unconformity

For more than a century, geologists have debated the mechanisms responsible for the mysterious billion or so year gap of the Great Unconformity. A key question involves how and when buried rock layers were brought to the surface (a process known as exhumation) and underwent massive erosion. Different hypotheses have been proposed which include:

1. Assembly of Rodinia

The ancient supercontinent, Rodinia (from the Russian word "родина" for "motherland" or "to give birth"), was assembled through a series of accretionary and collisional events that occurred between 1,300 and 900 Ma. These events combined with the mantle upwelling that developed below the supercontinent led to extensive episodes of mountain building and erosion.



Rodinia Supercontinent ca. 900 Million Years Ago

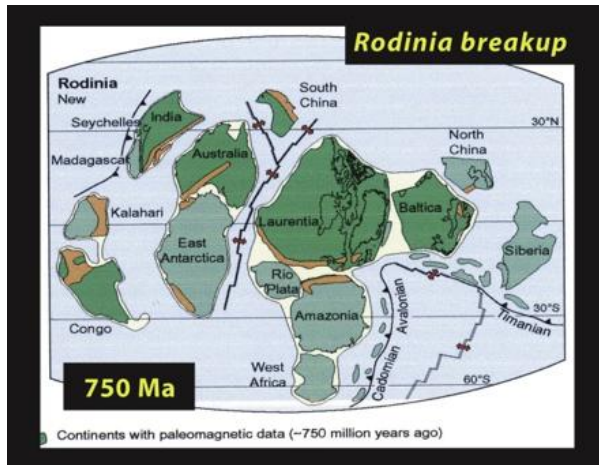
Boris Robert, Mathew Domeier und Johannes Jakob illustration, - CC_BY_SA-4.0 International, via Wikimedia Commons

This diagram shows one possible reconstruction of the Rodinia supercontinent. The abbreviations correspond to the following: Lau:Laurentia; Gre:Greenland; SC:Scotland-Ireland; RP:Rio de la Plata; Am:Amazonia; WA:West Africa; Bal:Baltica.

2. Breakup of Rodinia

Rodinia gradually broke up around 850-717 Ma due to a rising mantle superplume. This plume may have initiated the breakup either by doming, cracking, and driving plate movement or by stretching and thinning the

continental lithosphere. Widespread rifting and magmatic activity occurred with the fragmentation of the supercontinent.



Reconstruction of the Rodinia Breakup

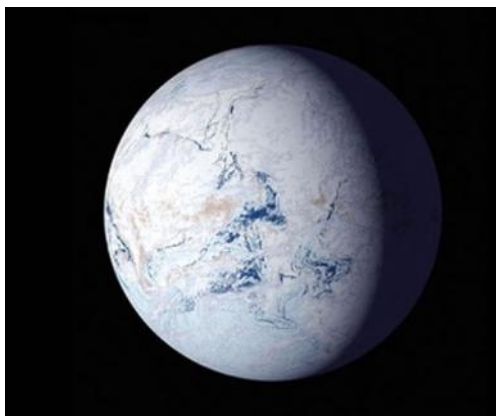
Diagram 13.5 from Snowball Earth Teaching Slides - Causation,

<https://www.snowballearth.org/week13.html>, Accessed September 18, 2026

This diagram shows a reconstruction of the breakup and dispersal of the Rodinia supercontinent ca. 750 Ma based on (Meert and Torsvik, 2004).

3. “Snowball Earth” glaciation

During the Cryogenian Period (717 to 635 Ma), a glaciation event, known as “Snowball Earth”, covered the entire planet with ice. The continental ice sheets scoured a vast area and were an efficient excavator of rock (Kellner et al., 2019).



Snowball Earth

NASA artist illustration, -PD, via astrobiology.nasa.gov

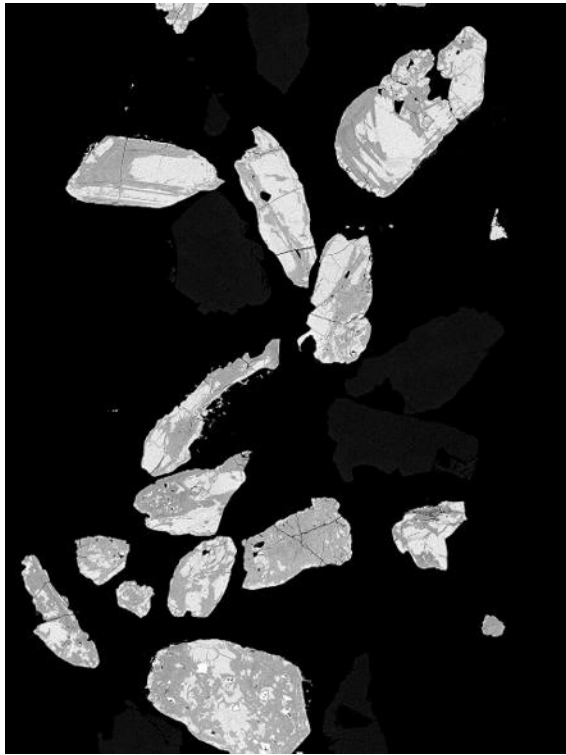
4. Multiple Great Unconformities

The Great Unconformity represents a composite of multiple Great Unconformities that involved a combination of tectonic events. The resulting uplift and erosional episodes varied in time and geography (Flowers et al., 2020).

Thermochronology

Thermochronology is a technique used to study the thermal history of rocks. This method provides insights into the timing and magnitude of erosion that led to the Great Unconformity. Examining rocks above and below the unconformity may indicate what processes were involved, how long the erosion occurred, and when sedimentation resumed. In addition to erosion, thermochronology may offer clues about the exhumation history of rocks. Rocks cool as they are exhumed, so their cooling history reflects the movement of rock layers.

One widely used thermochronology method relies on the radioactive decay of uranium and thorium to helium (^4He). The ^4He atoms can become trapped in the crystal lattice of zircon and exhibit a temperature dependent diffusion rate. At temperatures above 220 °C (428 °F), the ^4He will completely diffuse out of a zircon crystal, but at lower temperatures the ^4He will be retained until there is no effective loss. The amount of ^4He can be used to infer how long a zircon and its associated host rock resided at a certain temperature and depth.



Zircon Grains

Kallerna photo, - CC_BY_SA-4.0 International, via Wikimedia Commons

This SEM image depicts a group of zircon grains used for radiometric dating. The thickness of the grains is about 100 μm .

Recent thermochronology findings have fueled the debate about the origin of the Great Unconformity. Some geoscientists point out that the technique supports the glacial erosion hypothesis (Keller et al., 2019), while others suggest that it provides evidence of erosion due to multiple tectonic events before the Snowball Earth period (Flowers et al., 2020).

Great Escarpment of Laurentia

A recent study published in *Geology* proposed a new hypothesis that the Grand Canyon's basement rocks were progressively exhumed as a result of a huge escarpment that formed during the breakup of Rodinia (Gernon et al., 2026).



Trace of the Great Escarpment of Laurentia

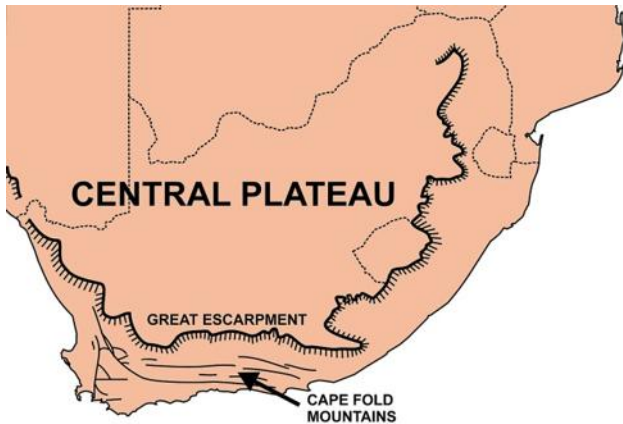
Figure 1C. from (Gernon et al., 2026), annotations to map licensed from deeptimemaps.com

This map depicts the ancient landscape around 65 Ma and shows the extent of the Great Escarpment of Laurentia. Note that the Grand Canyon is located along the continental escarpment.

Using plate tectonic reconstructions and landscape evolution data, the researchers developed a model of an escarpment that may have ringed most of western Laurentia, the geologic core of North America. The formation of this “Great Escarpment of Laurentia” may have started around 800-750 Ma when Rodinia’s fragmentation led to mantle-driven uplift and faulting. Rifting produced kilometer-high (0.6 mi) cliffs around the continental margins. With millions of years of erosion, the steep slopes shifted inland. The model suggests that in areas near the escarpment’s steep terrain erosion may have removed as much as 8 km (4.8 mi) of rock. Locations away from the cliffs, however, may have been weathered

to a lesser degree. This provides a potential explanation for not only how the Grand Canyon's basement rocks were brought to the surface but also the variations seen across the Great Unconformity.

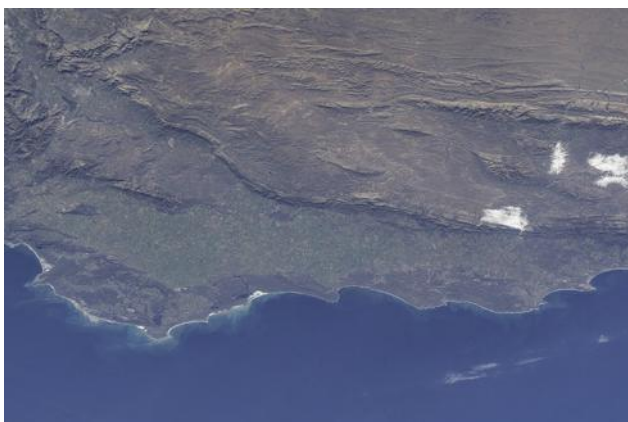
The proposed ancient continental escarpment has modern day equivalents in South Africa and Brazil.



The Great Escarpment Surrounding the Southern African Central Plateau

Oggmus map, - CC_BY_SA-4.0 International, via Wikimedia Commons

The South African Central Plateau is ringed by the Great Escarpment which formed about 120 Ma during the breakup of the supercontinent Gondwana. The elevation of the escarpment's edge varies from 1 km (0.62 mi) in the east which experienced extensive erosion to 3 km (1.86 mi) near the border of Lesotho.



View of the Great Escarpment from Space

NASA/iss071e230776 photo, - PD, via Wikimedia Commons

This photo, which was taken on June 27, 2024 from the International Space Station, shows the steep slopes of the Great Escarpment.

References

Flowers, R.M., F.A. Macdonald, C.S. Siddoway, and R. Havranek (2020) Diachronous development of Great Unconformities before Neoproterozoic snowball Earth. *Proceedings of the National Academy of Sciences USA*, 117 (19): 10172-10180

<https://doi.org/10.1073/pnas.1913131117>

Gernon, T.M., T.K. Hincks, W.J. Rugen, S. Brune, J. Braun, and S. Marshak (2026) Exhumation of Grand Canyon's basement along the Great Escarpment of Laurentia. *Geology*, <https://doi.org/10.1130/G55133.1>

Keller, C.B., J.M. Husson, R.N. Mitchell, W.F. Bottke, T.M. Gernon, P. Boehnke, E.A. Bell, N.L. Swanson-Hysell, and S.E. Peters (2019): Neoproterozoic glacial origin of the Great Unconformity, *Proceedings of the National Academy of Sciences USA*, 116(4): 1136-1145

<https://doi.org/10.1073/pnas.1804350116>.

Meert, J.M. and T.H. Torsvik (2004) Paleomagnetic constraints on Neoproterozoic 'Snowball Earth' continental reconstructions. In (Eds. G. Jenkins, M. McMenamin, L. Sohl and C. McKay) *The extreme Proterozoic: geology, geochemistry, and climate. AGU Geophysical Monograph* 144.

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Arizona Rocks 160

by Ray Grant

This a follow up to Harvey Jong's "A Tale of two Faults" from last month's newsletter. Here is a post from the Arizona Geological Survey about Arizona active faults and earthquakes



Arizona Geological Survey at the University of Arizona

a day ago · 🌐

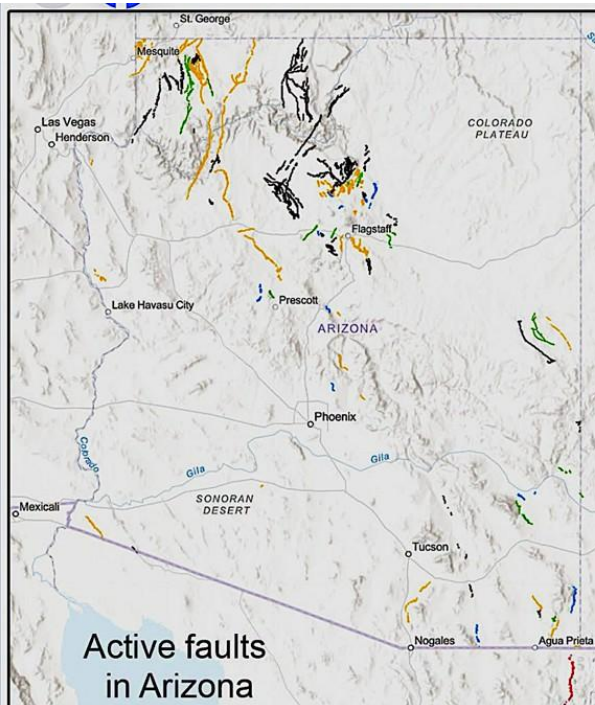
...

What's shakin'?! The ground of Arizona could be, because the state has a moderate seismic hazard, with over 100 active fault systems and thousands of historic earthquakes, as shown in the map from the Arizona Hazards Viewer. 🌵

So join us one month from today, on October 15 at 10:15 am (Arizona time) for the Great Arizona ShakeOut! ShakeOut is an annual earthquake preparation exercise to practice what to do in the event of an earthquake: Drop, Cover, and Hold On!! 😬

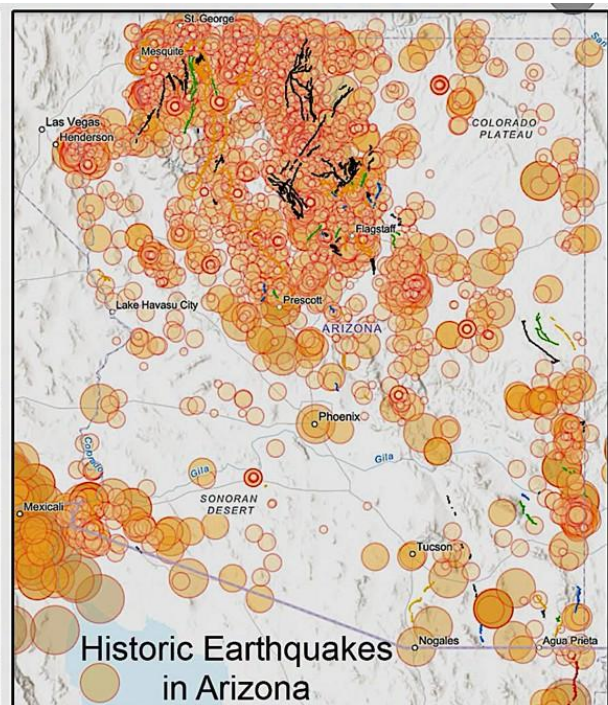
Head to shakeout.org/arizona to register and access online resources related to earthquake safety! 🏠

#Arizona #earthquake #earthquakepreparedness #shakeout #greatarizonashakeout



Active faults

- Historical (<150 years)
- Holocene to latest Pleistocene (<15,000 years)
- Late Pleistocene (<130,000 years)
- Middle Pleistocene (<780,000 years)
- Quaternary (<2,600,000 years)



Earthquakes

Magnitude

- > 6 to 7.5
- > 4.4 to 6
- > 2.9 to 4.4
- > 1.3 to 2.9
- < 1.3



[Home](#)
[Other ShakeOuts](#)
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[Register Here!](#)
[Why Participate?](#)
[Who is Participating?](#)
[How to Participate](#)
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GET READY TO SHAKEOUT!

This year's International ShakeOut Day is October 15, when millions of people worldwide will participate in earthquake drills at work, school, or home!

At 10:15 a.m. (local time) on 10/15, you can join people across Arizona practicing [earthquake safety](#). While we encourage you to participate with everyone, you can [register](#) your ShakeOut drill for any day of the year, and drill at a time of your choice. You can also include people in multiple locations through video conferencing.

If Possible



DROP!

Using Walker



LOCK!

Using Cane



DROP!

Using Wheelchair



LOCK!

[Start here](#) to be included in the **2026 Great Arizona ShakeOut!**

LEARN THE LATEST

[ShakeOut Participant Update Newsletters](#)

[How to Participate](#)
Information for individuals, schools and many types of organizations

[Who is Participating?](#)
Lists by county, area, & category

[ShakeOut Resources](#)
Manuals, posters, & much more

Download [Audio recordings](#) to play during your drill

Over 26,000 participants registered
19 days 0 hours until the 2026 Arizona ShakeOut






PLAN YOUR DRILL

[Why Drop, Cover, and Hold On?](#)

CHECK THE STATS

PLAY AND SHARE

Drill Manuals and Other Planning Documents

[Powerpoints for leading ShakeOut Drills \(Online or In-Person\)](#)

For grades K-4, grades 5-12, higher education, and all other organizations; plus a version in Spanish)

Workplaces

ShakeOut Drill Manual for Businesses ([PDF](#))
 ShakeOut Drill Manual for Non Profits and Other Organizations ([PDF](#))
 Countdown to ShakeOut for Organizations ([English](#) | [Other Languages](#))
 Benefits to Participating Businesses ([PDF](#))
 Earthquake Safety in Stores ([English](#) | [Other Languages](#))

[ResilientWorkplace.org](#)

Seven Steps to a Resilient Workplace
 Disaster Resilient Business Toolkit
 QuakeSmart Community Resilience Program

Schools and Childcare

[K-12 Schools Drill Planning, Educational, and Preparedness Resources](#)

Earthquake Safety For Parents and Care Providers of Young Children and Infants ([English](#) | [Other Languages](#))

Higher Education

[Registration Guidelines and Participation Resources for Higher Education Institutions](#)



Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society next meeting

October 21, 2026

Meetings are the third Wednesday at 7pm, doors open at 6:00 so stop in early to have a look around and see what is new--we have added new displays and will have new loaned specimens on display!

www.pinalgeologymuseum.org

Ray Grant ray@pinalgeologymuseum.org

Pinal Geology and Mineral Museum Winter Hours

The museum is open Wednesday through Saturday from 10 - 4
admission is free.

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

THE PINAL GEOLOGY AND MINERAL SOCIETY WELCOMES

MO GARRETT
Guest Speaker

Cataloguing your Collection
and How to Avoid the Garage Sale Blues

GARAGE SALE - AS-IS ROCKS

PINAL GEOLOGY AND MINERAL SOCIETY

7PM, WEDNESDAY, OCTOBER 21
351 N. ARIZONA BLVD, COOLIDGE, AZ 85128

**Sun City Rockhound Mineral Museum
Sundial Recreation Center
14801 N. 103rd Ave.
Sun City, AZ 85351**

The museum offers private party tours for schools, clubs and individuals. We'd love to show off our museum to your club or private group. If you are interested, please contact the museum at scrockmuseum@gmail.com.

Please take a minute to check out our new website at scrockmuseum.com.

**A Slab of Arizona's Deep Past
Carol Bankert-George
Museum Director Emeritus**

Two hundred million years ago, a tree fell in what is now northeastern Arizona. It never rotted. Instead, silica-rich groundwater seeped into its cells, mineral by mineral, until every fiber the wood had turned to stone of many colors. A large piece of that ancient log is now part of our museum collection in the form of a stunning polished petrified wood slab from Holbrook, Arizona.

The slab comes to us courtesy of Doug Duffy and Shirley Coté, founding members of the Earth Science Museum. Doug and Shirley and the team at ESM have been steady friends of the Sun City Mineral Museum and club for a few years now. This is only the latest of a string of donations that they have made to the museum and our club. We are endlessly grateful for their support, and for donations like this one which let our club members and visitors view a piece of Arizona's Triassic past in plain sight.

Next time you are in the museum stop by display case number 18 and look down. This new piece is located between two large ammonites. Perfect 'roommates. It is not every day you get to look at a quarter billion-year-old tree.



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



Shirley and Doug by the "Rockhound Café"
An exhibit originally from the old AZ Mining and Mineral Museum. A collection of rocks and minerals that look like food collected by Margaret and Arlis Nixon.



**Shirley and Doug's donation of petrified wood
between two large ammonite fossils.**



**The color purple is rare
in petrified wood and is
due to manganese
dioxide.**

Arizona Rock and Gem Shows

The 2026 Sedona Gem and Mineral show will be held on October 3rd & 4th - start planning ahead. (We are breaking tradition from our normal 3rd week show!)

Annual Show

Sedona Gem and Mineral Club

October 3-4, 2016

Sat. 10-5, Sun. 10-4

Adults \$5 Cash Only

Children 12 and under Free

Free Parking

Sedona Red Rock HS

995 Upper Red Rock Loop Rd

Annual show

Helzarockin' Gem & Mineral Show

West Valley Rock & Mineral Club

October 9-11, 2026

Buckeye Equestrian & Events Center

Fri. 9-6, Sat. 9-6, Sun. 9-4

Adults \$5

Under 13 Free

10300 S Miller Rd

Buckeye, AZ

Gila County Gem & Mineral Society

Show and sale

November 7, 2026

Bullion Plaza Cultural Center &

Museum Yard

150 Plaza Circle

Sat. 9-2

Free Admission

Miami, AZ

Wickenburg Gem and Mineral Show Nov 28 & 29, 2026

Free Admission

gemclub.info

Jewelry

Fossils

Minerals



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

54TH ANNUAL

FLAGG GEM & MINERAL SHOW

A TRIBUTE TO PAUL HARTER



MALACHITE PS. AZURITE, QUARTZ
REDWATER MINE, YAVAPAI, ARIZONA
EVAN & MELISSA JONES COLLECTION
PHOTO BY JEFF SCOVIL



JAN
8 TO 10 **2027**



MALACHITE PS. AZURITE
BISBEE, COCHISE, ARIZONA
PAUL HARTER COLLECTION
PHOTO BY JEFF SCOVIL



ROSASITE, MALACHITE PS. AZURITE
SILVER HILL MINE, GLENN, COCHISE, ARIZONA
PETE VALESEN COLLECTION
PHOTO BY JEFF SCOVIL



VANADINITE PS. WULFENITE
ROWLEY MINE, THESAL, PUNTERO ROCK MTS., MARICOPA, ARIZONA
PETE VALESEN COLLECTION
PHOTO BY JEFF SCOVIL



MALACHITE PS. AZURITE, QUARTZ
LIVE OAK MINE, YAVAPAI, ARIZONA
PAULA & LES FRESWYTH COLLECTION
PHOTO BY JEFF SCOVIL

MESA COMMUNITY COLLEGE NE CORNER
OF US 60 AND DOBSON ROAD
FRI-SAT 9AM - 5PM | SUN 9AM - 4PM
www.Flaggshow.info



FREE ADMISSION | FREE PARKING | FREE SAMPLES FOR KIDS

Arizona Rock and Gem Clubs



Apache Junction Rock & Gem Club

Meetings are on the 2nd Thursday
 Next Meeting: October 8, 2026, 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 6, 2026, 6:30 p.m.
www.dmrmc.com
 @ Anthem Civic Building
 3701 W. Anthem Way, Anthem, AZ



Maricopa Lapidary Society, Inc

Meetings are on the 3rd Tuesday
 Next Meeting: October 20, 2026, 7:00 pm
www.maricopalapidarysociety.com
 @ North Mountain Visitor Center
 12950 N. 7th St., Phoenix, AZ



Mineralogical Society of Arizona

Meetings are usually on the 3rd Thursday
 (Except June & December)
 Next Meeting: October 15, 2026
 Meeting Location: Franciscan Renewal
 Center, Piper Hall
 5802 E. Lincoln Drive, Scottsdale,
 Go to our website for more info.
www.msaaz.org



Pinal Geology & Mineral Society

Meetings are on the 3rd Wednesday
 Next Meeting: October 21, 2026, 7:00 pm
www.pinalgeologymuseum.org
 351 N. Arizona Blvd., Coolidge



West Valley Rock & Mineral Club

Meetings are on the 2nd Tuesday
 Next Meeting: October 13, 2026, 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 1, 2026, 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 9, 2026, 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 2026, 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.msaaaz.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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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 2026, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

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