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
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May, 2026
Volume 15, Issue 5

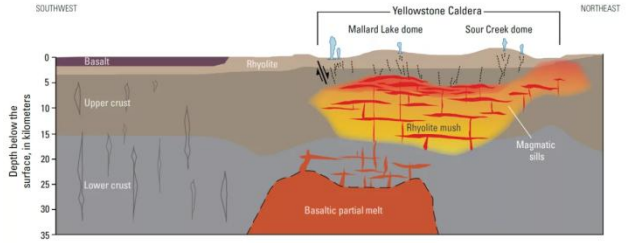
A New Mechanism Influencing Large Volcanic Eruptions

By Harvey Jong

Large volcanic eruptions [Volcanic Explosivity Index (VEI) ≥ 7] are complex events that involve both internal and external processes. Internal processes may be influenced by a variety of different mechanisms, such as magma recharge and volatile exsolution. This article will explore some of these mechanisms including a new hypothesis involving volatile resorption.

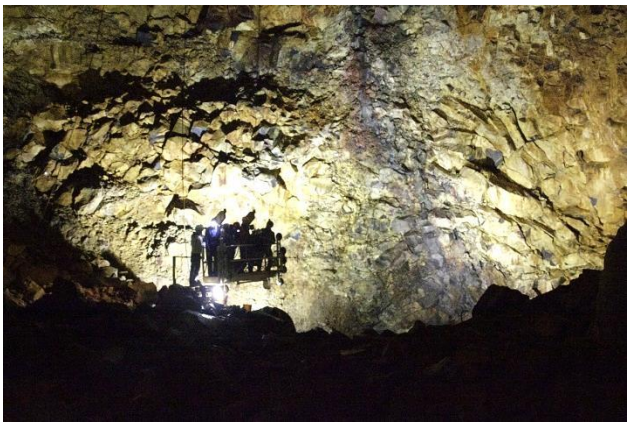
Magma Chamber

We will begin by examining a key volcanic feature – the magma chamber which is often referred to as the heart of a volcano. As magma rises towards the surface, it may accumulate in bodies of varied sizes, shapes and depth. Some smaller, sill-like chambers may be completely molten, while most chambers are partially molten.



Magma System of the Yellowstone Caldera
Fig .5 from Yellowstone Volcano Observatory 2023 Annual Report

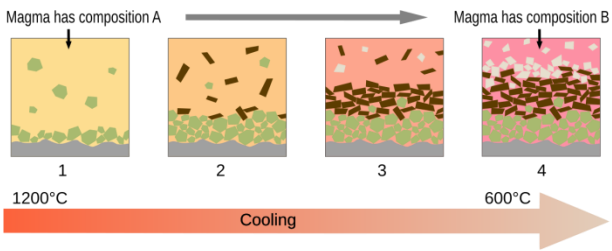
This drawing depicts the stacked magma reservoirs beneath the Yellowstone Caldera. The magma body in the upper crust includes a number of magmatic sills which contain higher amounts of molten material (about 28 percent) than their surroundings. A deeper reservoir in the lower crust supplies magma to the upper body.



Inside the Former Magma Chamber of the Þríhnúkagígur Volcano
Uaiecs photo, - CC_BY_SA-3.0, via Wikimedia Commons

The Þríhnúkagígur Volcano is a dormant volcano located in western Iceland near Reykjavik. It features a former magma chamber that extends 213m (699 ft) deep and is accessible by a custom-built elevator platform.

With the cooler temperature of the surrounding host rock, magma begins to solidify and undergoes chemical changes. The composition is modified through the process of fractional crystallization, and the growth of phenocrysts within the melt leads to a layered crystalline "mush" or matrix.



Fractional Crystallization

Woundloper diagram, - CC_BY_SA-3.0, via Wikimedia Commons

This diagram illustrates how magma composition changes as the temperature decreases. In the first frame, olivine begins to crystalize from the melt. The second frame shows olivine and pyroxene forming, while pyroxene and plagioclase appear in the third frame. Only plagioclase is crystallizing in the last frame. The resulting condensed rock accumulates at the bottom of the magma chamber.

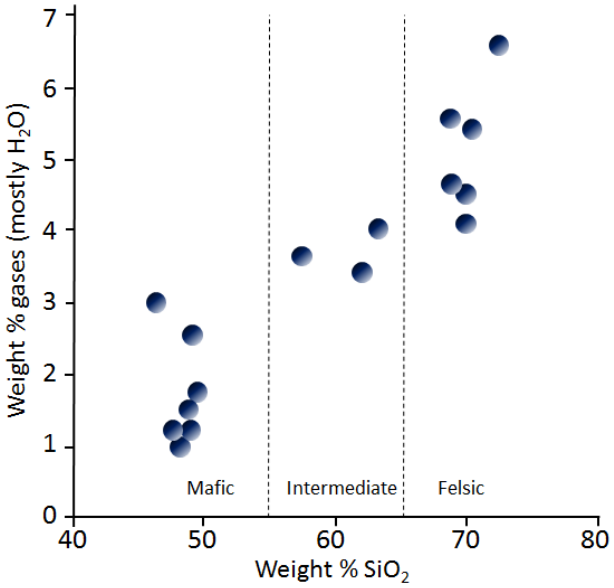
Structural changes to the magma chamber may occur from faulting which creates isolated compartments. These compartments may develop independently with different stages of solidification, composition, and thermal and mechanical properties (Gudmundsson, 2012). Stresses and pressures may be higher for one or more compartments, and this can lead to the overpressure conditions that will eventually trigger an eruption.

Magma Recharge

Magma recharge involves intrusions of new magma into a magma chamber. This influx introduces heat and volatiles which mix with existing materials and can mobilize a previously stagnant body. Periodic injections of magma can dramatically change the chamber's overall volume, composition, and density (Malfait et al., 2014). Subsequent pressure and buoyancy forces can contribute to overpressure, destabilization, and a potential eruption.

Volatile Exsolution

Magmas may contain dissolved gases or liquids which are collectively called volatiles. Water vapor (H_2O) is the most abundant volatile, while carbon dioxide (CO_2) and sulfur dioxide (SO_4) represent the next most frequent occurrences. The amount of volatiles varies with different magmas and associated temperature and pressure conditions.



Variations in the Volatile Content of Magmas

Fig. 4.2.2 from (Earle, 2019), - © 2019 Steven Earle, CC_BY_SA-4.0 International, via opentextbc.ca

This graph displays a generalized relationship of volatile content with different types of magmas. Mafic magmas typically have 1% to 3% volatiles, intermediate magmas contain 3% to 4%, and felsic magmas have 4% to 7%. Although volatiles are only a minor constituent, they play a significant role in the properties and dynamics of magmas.

The solubility of volatiles depends on pressure, temperature, and composition of magmas. Magma located deep in the crust may include volatiles in a saturated equilibrium state. But, as the magma rises, the volatiles tend to separate with decreasing pressure, cooling, and crystallization. The releasing of volatiles forms gas bubbles and is known as volatile exsolution.

By mixing and mingling with different magma phases, the bubbles lower the magma density and lead to an increase in volume and pressure in the magma chamber. The greater buoyancy of the magma allows it rise more readily where lower pressures result in further exsolution.

Overpressure builds in the chamber that may ultimately culminate in an eruption.

Mentos Soda Eruption
woodleywonderworks photo, - CC_BY_SA-2.0, via Wikimedia Commons

A popular (and very messy) way of demonstrating volatile exsolution involves dropping Mentos mints into a bottle of carbonated soda. As the mints sink to the bottom of the bottle, they react with the dissolved carbon dioxide in the soda by providing nucleation sites. Rapid de-gassing is produced. The resulting bubbles, which are lighter than the soda, rise and expand. A sudden confined pressurization is created which leads to a dramatic sticky eruption.

Magma "Boiling"

Volatile exsolution involves two different phases. The first phase is driven by the decompression of a rising magma where the confining pressure from surrounding rock decreases. The amount of volatiles that can dissolve in the magma decreases, and the magma reaches a point where it can no longer contain all the dissolved volatiles and gas bubbles are released. This is referred to as "first boiling".

The second phase is related to the cooling of magma and subsequent crystallization which produces a residual melt. The concentration of volatiles in this melt reaches a point where the melt can no longer hold all the dissolved volatiles and bubbles form. This is known as "second boiling".

Volatile Resorption

While volatile exsolution is widely recognized as a potential trigger for volcanic eruptions, it may have less influence with large magma systems given the inherent difficulties in building up eruption conditions. A recent study noted that with a large magma body exsolution has to outpace volatile loss from passive degassing and viscous relaxation of the crust (Keller et al., 2026). This requires rapid crystallization rates that are difficult to maintain with a large-volume magma reservoir. As a result, exsolution may not directly trigger large eruptions, but may instead control magma compressibility and chamber growth. With the presence of gas bubbles, an exsolved magma phase exhibits a high degree of compressibility. This dampens the chamber pressurization introduced by magma recharge and delays the onset of an eruption. A larger eruption may, however, result from the additional magma stored in the chamber.

The study's researchers proposed that volatile resorption, a process that is counterintuitive and opposite of exsolution, may play a key role in "priming" a magma chamber before an eruption. Using a thermal-mechanical magma chamber model, they demonstrated that resorption can occur with rapid magma recharge. The repeated magma injections cause crystal melting which increases the fraction of molten material in a chamber. This increase along with the added pressure from magma recharge helps drive the diffusion of exsolved volatiles, such as H_2O, back into the melt. The loss of exsolved H_2O decreases magma compressibility which can lead to a faster rate of chamber pressurization than with exsolution. This accelerated pressurization may shorten the timeline for an eruption.

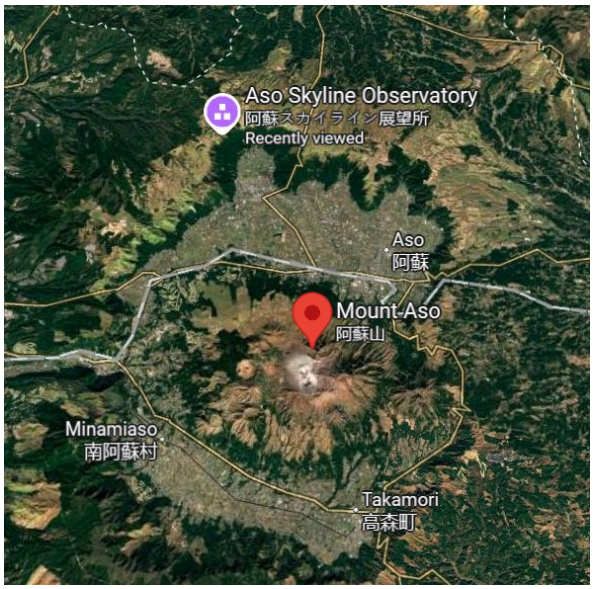
The volatile resorption model was evaluated with a natural case study involving past

eruptions of Mount Aso, a volcano located on the island of Kyushu in Japan.

Location of Mount Aso
Map by Alexrk2, - CC_BY_SA-3.0, via Wikimedia Commons

Mount Aso is one of most active volcanic complexes in Japan with 172 confirmed eruptive periods.[1] It includes one of the largest calderas in the world, measuring around 120 km (74.6 mi) in circumference. The caldera was formed from four gigantic eruptions, and the last eruption, known as the Aso-4 eruption, occurred ~90,000 years ago With a VEI of 8, it represents the world's second largest eruption in last 100,000 years. The interval leading up to the Aso-4 eruption, was the focus of the evaluation. Over 12,000 simulations were run which indicated H_2O resorption may have occurred prior to the Aso-4 eruption. This finding is consistent with an analysis of apatite-bearing volcanic rock samples that shows a shift from water saturated conditions to the unsaturated conditions during the Aso-4 event (Keller et al., 2026).

[1] From Global Volcanism Program, 2026, Asosan (282110) *in* [Database] Volcanoes of the World (v. 5.3.5; 31 Mar. 2026), Distributed by Smithsonian Institution, compiled by Venzke, E., accessed May 21, 2026.



Mt. Aso – Google Maps

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Top visitor questions in Yellowstone's thermal areas

Yellowstone Caldera Chronicles is a weekly column written by scientists and collaborators of the Yellowstone Volcano Observatory. This week's contribution is from Michael Poland, geophysicist with the U.S. Geological Survey and Scientist-in-Charge of the Yellowstone Volcano Observatory, and Mindy Dottellis, interpretive ranger with Yellowstone National Park in 2025.

When in a place as otherworldly as Yellowstone, it's only natural to find yourself brimming with questions at each turn of the trail.

Fear not, for all inquiries are welcome. You may come across a ranger during your travels who would be more than happy to answer your burning questions, but in case you don't, we've compiled the top questions according to the Yellowstone rangers themselves!

The most common questions across all of the park's thermal basins are about the temperature and acidity of the water. This varies tremendously between areas. All geysers are boiling, but water in hot springs can range from just a few degrees below boiling to barely warm to the touch. Norris Geyser Basin is the hottest thermal area in the park. Research drilling in the 1960s found a temperature of 237 °C (459 °F) about 330 meters (1,087 feet) beneath the surface! Mammoth Hot Springs is one of the coolest because the water travels quite a distance from the heat source beneath Yellowstone Caldera—there are no geysers, and the maximum water temperature is about 73 °C (163 °F). The answer to the question, "when does Mammoth erupt?" is "never."

The acidity also varies. Most thermal basins are either mostly acidic or mostly neutral. Areas with lots of geysers and colorful hot springs are mostly neutral, while areas with mud pots and gassy vents that smell like rotten eggs are mostly acidic. Norris Geyser Basin is an outlier, with both neutral and acidic features, often in close proximity. Steamboat Geyser is the tallest geyser in the world and has a neutral pH, whereas nearby Echinus Geyser is the largest acidic geyser in the world. The acid concentration is relatively low—akin to orange juice—so the acidity doesn't cause burns on contact. The water temperature is a far bigger hazard.

Visitors also commonly ask how the boardwalks are built. Designing infrastructure that can be safely installed and stand up to Yellowstone's unforgiving environment is challenging. Geologists map out safe areas for boardwalks based on thermal surveys, but the paths sometimes must be moved because of changes in hydrothermal activity.

And what about the animals? Based on the footprints and poop, animals clearly love thermal ground. Do they get burned? While they mostly avoid the hottest water, animals occasionally make mistakes and fall into thermal pools. Most animals avoid drinking thermal water, which can be toxic, but they still eat plants that have high amounts of silica and other compounds derived from thermal water. This can contribute to unhealthy teeth, and animals that live mostly in thermal areas tend to have shorter lifespans than those that live outside thermal areas.

At Norris Geyser Basin, a common question is "Where is Norris Geyser?" In fact, there isn't any such feature. The basin is named

Guardian Geyser and Norris Geyser Basin, Yellowstone National Park.

for the second superintendent of Yellowstone National Park, Philetus W. Norris. Visitors also ask about the characteristic blue color of the water, which in most cases is due to high silica content.

In the Old Faithful area, visitors often wonder about how predictions are made.

Visitors watching an eruption of Old Faithful Geyser from the Old Faithful Inn's balcony.

Geyser timing often depends on the preceding eruption. At Old Faithful Geyser specifically, a shorter-than-usual 2-minute-long eruption means that the next eruption may occur after about 60 minutes, whereas the more common 4–5-minute-long eruptions are followed by a quiet interval of about 94 minutes, give or take about 10 minutes. Because of this, it is not possible to forecast eruption times more than one eruption in advance.

At Mammoth Hot Springs, visitors are curious about the travertine terraces. This material

Angel Terrace, Mammoth Hot Springs, Yellowstone National Park. Travertine deposits are abundant in the area. Photo by JoAnn Holloway, 2003.

forms because hot water interacts with ancient marine sediments beneath the ground and brings calcium carbonate to the surface. As the water degases carbon dioxide, the travertine precipitates out, resulting in the characteristic formations.

For an area that has been studied for more than 150 years, Yellowstone is still full of mysteries, and research in every field, from archaeology to zoology, is ongoing. So stay curious out there and ask away! There are truly no dumb questions when in Yellowstone National Park.

Many thanks to the Yellowstone National Park interpretive rangers who contributed their perspectives for this article, and especially Ian Hall and Sarah Gleeson.

Arizona Rocks 156

Text & photos by Ray Grant

Four Peaks Mine

In the gem world, Arizona is well known for the amethyst from Four Peaks. Maricopa County. The early history of the location is vague. Jim McDaniels is given credit for finding the deposit in the early 1900s. There is also a legend that the Spanish found it in the 1700s and that there is amethyst in the Spanish crown jewels from Four Peaks. The property was patented in 1942 and has been worked intermittently up until the present day. It has produced large quantities of amethyst, but only a small percentage has the rich red-violet color for which the deposit is famous. Today the current owners, Four Peaks Mining Company, have a shop at the Arizona Boardwalk on East Via de Ventura in Scottsdale where the OdySea Aquarium and Butterfly Wonderland are located. They have Four Peaks amethyst for sale, cut stones and specimens. They have a small exhibit of Arizona Minerals and a reproduction of a small mine tunnel for you to visit. In the winter months they offer a helicopter tour to the mine and private parties can also schedule a trip to the mine.

Four Peaks amethyst showing red-violet color

Four Peaks Mining store at the Arizona Boardwalk

Mine reproduction at Four Peaks Mining shop

Four Peaks amethyst exhibit at Tucson show

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society next meeting

September 16, 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
museum open Fridays & Saturdays from 10 - 4
admission is free.
Groups can arrange special visits, please call 520-723-3009.

The Pinal Geology and Mineral Society's next meeting will be September 16, 2026

Have a great summer!

Arizona Fossil Fest at the museum on May 9 with all the educational tables for people to learn about fossils.

The museum had a booth at the Coolidge Public Library "Unearth a Story Event" on May 28th.

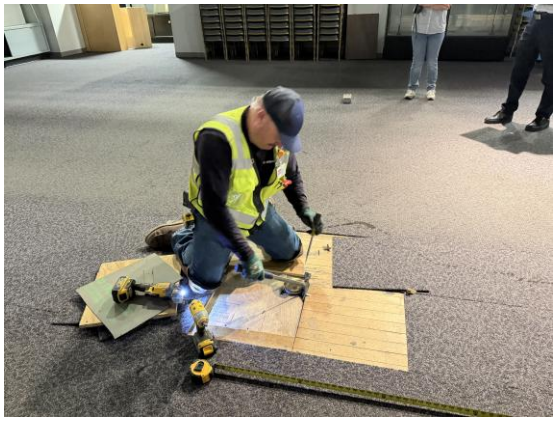
AZ Mining, Mineral & Natural Resources Education Museum Update May 2026

https://ammnre.arizona.edu/

Catie Carter Sandoval
cscarter@email.arizona.edu
703.577.6449

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

This spring was filled with outreach, collaboration and excitement as we inch closer to our goal of starting Phase 1 renovations at our historic building at 1502 W. Washington St. As we now begin the summer, the museum team is continuing to work with our design-build team of Gensler and Kitchell to prepare the building for construction. Most recently, we brought in structural engineers to evaluate the walls and floors; specifically, which walls can be modified or removed and how much weight the original maple wood floor can support. Part of this process involved exploratory demolition, where pieces of the walls and floors on the first floor were removed to expose the supporting elements inside. It was neat to see this process and we are one step closer to our goal.



Exploratory demolition of the wood floor in the main gallery included removing pieces of the floor to expose the joints, electrical setup, and crawlspace below.

Contractors and members of the design-build team in the museum's pit.

Photo from the 1990 renovation process showing work on the floor in the auditorium, later the museum's main gallery.

Another photo from the 1990 renovation with workers framing the mezzanine level of the main gallery.

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.

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

Unique Flexible Sandstone - the rock that bends

By Carol Bankert-George
Museum Director Emeritus

Here is another specimen we got to really appreciate during a summer deep cabinet cleaning that will surprise even long-time visitors and club members.

Most rocks do exactly what you expect. They're solid, solid as a rock as the saying goes, but this one is freakishly not what you expect.

One of the museums' more interesting specimens is flexible sandstone. This specimen is from North Carolina and was donated by Robert Dorman. It looks perfectly ordinary at first glance. It's pale in color, gritty, and flat. But pick it up and something unexpected happens, it bends!

This specimen, while it is named sandstone, is really itacolumite, which is a porous quartzite, whose quartz grains are loosely bound by mica, which is naturally flexible, and other flat, plate-like minerals. The grains are more or less hinged, rather than cemented as in ordinary sandstone. The loose structure allows thin slabs to flex or bend, it's not dramatic, but it's real and it never fails to surprise. Here's another strange attribute; the flexibility only works when this specimen is dry. If you wet it, it goes stiff like any other ordinary rocks.

Itacolumite Is found in a handful of places worldwide; Brazil, India, South Africa, and the Appalachian region of the United States, including North Carolina where our specimen is from. In Brazil, it's closely associated with diamond bearing formations, which gives it an extra layer of geological intrigue.

We are reminded that every specimen has a story—and sometimes, a surprise—waiting to be discovered. You can view this unusual specimen in our main gallery in display case number 4. It's one of those specimens that must be experienced to be believed.

Club member and Museum volunteer Karin Schardt holding and bending the museum specimen of flexible sandstone.

Arizona Rock and Gem Shows

ANNUAL SHOW
White Mountain Gem and Mineral Club
July 10-12, 2026
Fri. 9-5, Sat. 9-5, Sun. 10-4
Adults $5, Kids 17 and under free
Elks Lodge
805 E. Whipple
Show Low, AZ
whitemountain-azrockclub.org

22nd Annual Prescott Gem & Mineral Show
Prescott Gem & Mineral Club
July 31,2026 - August 2,2026
Fri. 9-5, Sat. 9-5, Sun. 9-4
$5 Admission,
$4 Seniors, Vets and Students
Children Under 12 Free
Findlay Toyota Center
3201 N Main St
Prescott, AZ
https://www.prescottgemmineral.org/

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

Arizona Rock and Gem Clubs

Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: June 11, 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: June 2, 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: June 16, 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: June 18, 2026
Meeting Location in Scottsdale:
To Be Announced
Go to our website for more info.
www.msaaz.org

Pinal Geology & Mineral Society
Meetings are on the 3rd Wednesday
Next Meeting: September 16, 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: June 9, 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: June 4, 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: June 12, 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.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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scote@earthsciencemuseum.org

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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 2026, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

Earth Science Museum
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