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

March 2025
Volume 14, Issue 3

ESM OUTREACH UPDATE

Mardy Zimmermann, Outreach Coordinator

March Outreach

By Shirley Coté

At the March 18th monthly meeting of the Maricopa Lapidary Society, ESM board member, Shirley Coté, provided members and guests with Part II of her presentation on mineral identification.

Shirley started with a recap of Part I of the program, that was presented in January, to the group.

In Part II, Shirley continued with the physical properties of minerals starting with metallic and non-metallic minerals. Metallic minerals are shiny, usually opaque, and produce a black or dark colored streak when drawn across a streak plate (unglazed porcelain tile).

Most minerals are non-metallic and their luster's can be described as vitreous, resinous, pearly, silky or adamantine.

Interestingly, the minerals graphite, molybdite and talc have a greasy feel to them due to their crystalline structure and weak forces that hold their layers together.

Streak is the color produced by a fine powder of the mineral when scratched on a streak plate. Often it is different than the color of the mineral in non-powdered form.

Some minerals break like glass along smooth curved surfaces called conchoidal fracture. Others have fibrous and/or splintery breakage like ulexite and kyanite. Copper can be hackly having a jagged fracture with sharp edges. Some minerals have irregular and uneven surfaces.

Alternatively, cleavage is when mineral crystals contain planes of atoms along which the bonding between the atoms is weaker than along other planes, and will break easily along the weaker planes. A good example of basal cleavage is muscovite mica.

Muscovite mica showing basal cleavage

Here you can see cleavage planes in halite

Some minerals have cleavage in two directions at 90˚ or two directions not at 90˚; some in three directions at 90˚ or three directions not at 90˚. Fluorite has cleavage in four directions resulting in beautiful octahedrons. Some minerals have six directions of cleavage called dodecahedral cleavage, but not all dodecahedron minerals have cleavage like garnets.

Specific Gravity is the relative density, (weight of substance divided by the weight of an equal volume of water). Metallic minerals like gold, silver and galena have a high specific gravity. Whereas non-metallic minerals like quartz, talc and ulexite have a low specific gravity.

Tenacity is the resistance of a mineral to breaking, crushing, or bending. Tenacity can be described as: brittle, malleable, sectile, ductile, flexible or elastic.

Hardness is a minerals resistance to scratching. Hardness is determined by scratching the mineral with a mineral or substance of known hardness. Hardness is determined on the basis of Mohs' relative scale of hardness exhibited by some common minerals; from softest to hardest they are: talc, gypsum, calcite, fluorite, apatite, orthoclase, quartz, topaz, corundum and diamond.

Some other physical properties are magnetism, electrical conductivity, inclusions, bi and tri-color, striations, odoriferous, taste, fluorescence, poisonous and radioactive.

Now, on to the test!

This mineral is soft enough to be scratched by your fingernail. What is it?

This mineral has a pearly luster, can be scratched with your fingernail and feels greasy. What is it?

Does this mineral have fracture or cleavage? This mineral has the tenacity of being elastic. What does elastic mean?

Does this mineral have cleavage or fracture? What is this mineral and what is its crystal habit?

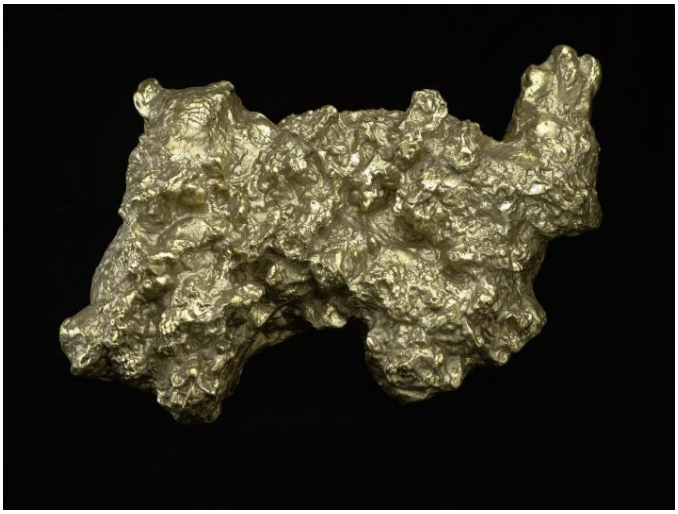
The Formation of Gold Nuggets in Quartz Veins and the Role of Earthquakes

By Harvey Jong

Gold is often associated with quartz, and the formation of nuggets in quartz veins has represented a perplexing problem for geologists. This article explores some of the theories that have been proposed on how these nuggets formed and includes findings of a new possible connection to earthquakes.

Nugget Issues

Some of the largest known gold nuggets, such as the "Welcome Stranger", were found in alluvial deposits. But these massive glimmering hunks are believed to be the weathered remnants of vein deposits that formed from hydrothermal solutions.



Replica of the "Welcome Stranger" Gold Nugget

Rodney Start photo, - CC_BY_SA-4.0 International, via collections.museumsvictoria.com.au

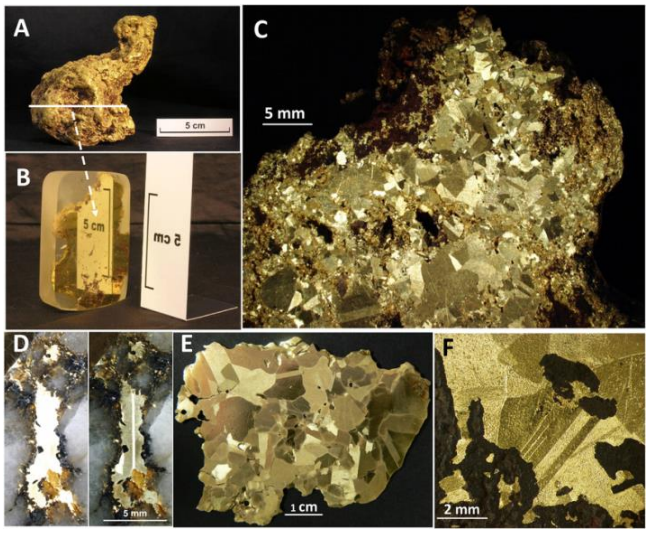
The "Welcome Stranger" was the largest alluvial gold nugget ever discovered. It was found in 1869 by Cornish miners John Deason and Richard Oates in Victoria, Australia. The nugget measured 61 cm (24 in) across and weighed 72 kg (158.7 lb). It sold for around 10,000 pounds sterling and was melted down into gold bars.

Gold nominally has a low solubility in mineralized fluids (measured in parts per billion), and a huge volume of solution would be required to make a sizable gold nugget. So, this raises issues about how the concentration of gold was dramatically increased and how the gold deposition was localized to a small portion of a vein.

Origin of Gold Nuggets

The origin of gold nuggets has been a long standing debate, and theories about their formation have been based on some speculation. Although nuggets have significant economic value among prospectors and collectors, their scientific value has been perceived as limited given the few published studies.

One key area of dispute involves whether nuggets originated from primary deposits or developed as a result of secondary enrichment. The occurrence of nuggets in alluvial settings along with their morphology suggested a secondary origin, but a recent investigation which examined nugget interiors revealed polycrystalline structures indicative of primary deposition (Butt et al., 2020).

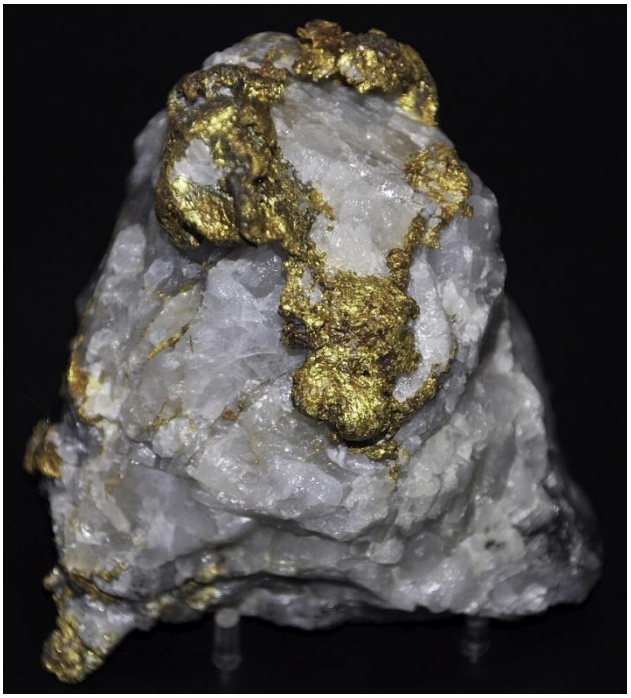


Polished and Etched Gold Nugget Interiors
Fig. 12 from (Butt et al., 2020), - CC_BY_SA-4.0 International, via researchgate.net
These polished sections of various gold nuggets from Western Australia exhibit polycrystalline structures with extensive twinning. This finding is contrary to concentric growth patterns expected with secondary formation.

Over the years, a number of theories on how nuggets formed in quartz veins have been proposed:

Hydrothermal Precipitation

Hot, water-rich fluids carrying dissolved gold ions percolate through rock fractures. As the fluid cools, gold precipitates out of solution and forms small particles in quartz veins. These particles become larger through either continued deposition or consolidation with other particles. In addition, the quartz veins may have developed from the interactions of the hydrothermal solutions with the surrounding host rocks.



Gold-Quartz Hydrothermal Vein
James St. John photo, Carnegie Museum of Natural History specimen, -CC_BY_SA-2.0, via Wikimedia Commons
Witwatersrand, South Africa
This sample is from a deep subsurface gold mine that is part of the largest single gold producing district in the world. The gold fields of Witwatersrand have produced 2 billion ounces over a century of mining and still have estimated reserves of 1,161 billion ounces.

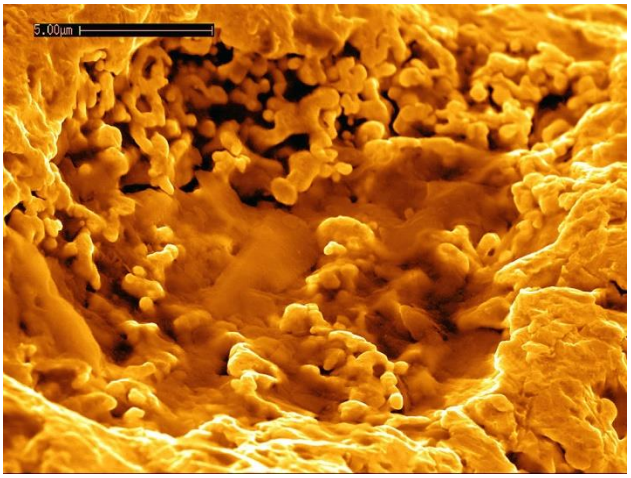
Sulfur-Driven Gold Deposition

Alteration of acidic host rocks may produce sulfate-bearing fluids. Reactions in these fluids generate sulfur ion radicals (S_2^-, S_3^-, S^{+6}) or hydrogen sulfide complexes (HS^-, H_2S) which bond with gold ions. The resulting compounds transport the gold leading to concentrations thousands of times higher than the surrounding rocks. Gold may be deposited along crevices or cracks in quartz veins where the solutions experience localized changes in temperature or pressure.

Alunite [$KAl_3(SO_4)_2(OH)_6$]
James St. John photo, - CC_BY_SA-2.0, via Wikimedia Commons
Marysvale area, Sevier River Valley, Utah
Alteration of alunite is associated with high sulfidation gold deposits. A common feature of these deposits is the presence of fractured, vuggy silica due to intensive acid leaching.

Microbial Assisted Deposition

Microorganisms, such as bacteria and archaea, may be involved in dissolving and precipitating gold. The survival rate of microbes can be enhanced by using gold to detoxify immediate cell environments, provide a source of metabolic energy, or serve as a metal center for enzymes (Reith et al., 2007). In the process, gold-bearing sulfide minerals may be broken down releasing gold.



Bacteria (*Ralstonia metallidurans)* on Gold Grain
CSIRO photo, - CC_BY_SA-3.0, via Wikimedia Commons
This colored scanning electron image shows a bacterial biofilm on a gold grain from the Hit or Miss Mine in northern Queensland, Australia. The bacteria precipitate gold from aqueous gold (III) tetrachloride (Reith, et al., 2006).

The Role of Earthquakes

Seismic activity can influence the formation of gold nuggets in quartz veins. Overall, earthquakes can create new rock fractures or expand existing ones along with altering the flow of hydrothermal fluids. Gold can subsequently precipitate and accumulate on exposed quartz surfaces to form nuggets.

Some specific gold deposition mechanisms triggered by earthquakes have been proposed:

Flash Vaporization

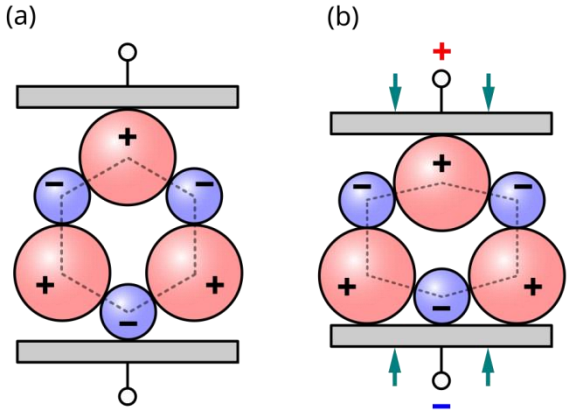
Flash vaporization is a phase change that occurs when a fluid is heated and exposed to a sudden pressure drop causing it to rapidly form a low-density vapor. Such conditions may be created by earthquakes where the rapid movement of rocks along faults results in frictional heating. This movement can

also produce cavities in which extreme pressure drops may occur. Mineralized solutions that are present in a fault system may undergo flash vaporization. Such flash vaporization results in rapid co-deposition of silica and gold to form gold-enriched quartz veins (Weatherley and Henley, 2013).

Synthetic Vapor Deposited Gold Crystals
Alchemist-hp photo, - CC_BY_SA-3.0 Germany, via Wikimedia Commons
These dendritic gold crystals, which were vapor deposited from a reaction with chlorine gas, have a purity of >99.99%.

Piezoelectric Deposition

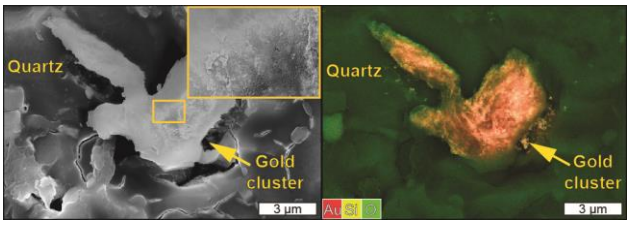
Certain materials, such as quartz, exhibit the piezoelectric effect where an electrical charge is generated when the substance is subjected to mechanical stress.



Simplified Model of a Quartz Crystal Between Two Electrodes
MikeRun diagram, - CC_BY_SA-4.0 International, via Wikimedia Commons
This diagram shows how mechanical pressure shifts the positive and negative charge centers in a quartz crystal creating a dipole and electrical voltage at the electrodes.

Earthquakes can induce stress in quartz, and the resulting electric fields may influence the movement and concentration of dissolved gold ions in fluids. This hypothesis was tested by Monash University geologists who reported their results in a recent *Nature Geoscience* article (Voisey et al., 2024).

The researchers conducted an experiment to simulate the conditions that quartz might experience during an earthquake. They immersed quartz crystals in a gold-bearing solution and used a motor to shake the crystals. The samples were examined with a scanning electron microscope which revealed that the stressed quartz not only deposited gold on its surface but that gold nanoparticles tended to accumulate on existing gold grains.



Gold Deposited onto Quartz Via Piezoelectric Reactions
Chris Voisey, Scanning Electron Image & Energy Dispersive Spectrographic Map, Copyright © Australian Science Media Centre Inc., scimex.org, September 3, 2024, https://www.scimex.org/newsfeed/electricity-generated-by-earthquakes-might-be-the-secret-behind-giant-gold-nuggets
The scanning electron image on the left shows the texture of the deposited gold grain which is composed of multiple gold nanoparticles stuck together, while the

energy dispersive spectroscopic map on the right indicates the chemical composition of the sample area.

The finding that an initial gold particle may act as a focal point for further growth suggests a possible explanation of how large gold nuggets may form in quartz veins. Stress from repeated earthquakes generates piezoelectric voltages that cause gold ions to separate from solution and effectively "electroplate" existing gold particles. Over time, this process could lead to significant gold accumulations and eventually produce large nuggets.

References

Butt, C.R.M., R.M. Hough, and M. Verrall (2020) Gold nuggets: the inside story. *Ore and Energy Resource Geology* 4-5: 100009.

Reith, F., S.L. Rogers, D.C. McPhail, and D. Webb (2006) Biomineralization of gold: biofilms on bacterioform gold. *Science* 313(5784): 233-236.

Reith, F., M.F. Lengke, D. Falconer, D. Craw, and G. Southam (2007) *The ISME Journal* 1: 567-584.

Voisey, C.R., N.J.R. Hunter, A.G. Tomkins, J. Brugger, W. Liu, Y. Liu, and V. Luzin (2024) Gold nugget formation from earthquake-induced piezoelectricity in quartz. *Nature Geoscience* 17: 920-925.

Weatherley, D.K. and R.W. Henley (2013) Flash vaporization during earthquakes evidenced by gold deposits. *Nature Geoscience* 6: 294-298.

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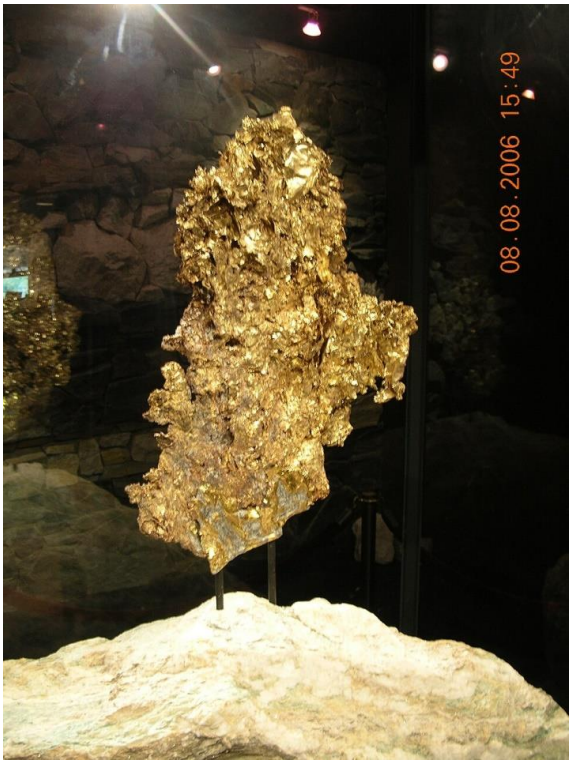
Other Largest Known Gold Nuggets

Many of the largest known nuggets have been melted down for their gold content, but here are a few existing nuggets:

Hand of Faith Nugget
FF23-fr photo, - CC_BY_SA-3.0, via Wikimedia Commons
Found in Kingower, Australia in 1980 by metal detector
Weighs 27.2 kg (60 lb, 875 troy oz)



Ironstone "Crown Jewel"
MikeVdP photo, - CC_BY_SA-3.0, via Wikipedia
Found in Jamestown, California in 1992
Weighs 20 kg (44 lb)

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Arizona Rocks 142

Text by Ray Grant
Photos from National Park website

This month's story is about an Arizona fossil locality. You can't visit it, but the story is most unusual. Recently, PBS had a show that included the Rampart Cave in the Grand Canyon. I have passed it on many river trips but never visited because from the river it is a 300 foot straight up climb. The cave has fossil animal remains from between 40,000 and 11,000 years old.

It is most famous for Shasta Ground Sloth fossils and coprolites. The Shasta Ground sloth was about the size of a grizzly bear, weighing more than 500 pounds. There are at least two layers of sloth dung. One was deposited from 40,000 to 24,000 years ago and the other from 13,000 to 11,000 years ago. These deposits are several feet thick and showed that the sloth ate a variety of desert plants. The cave had a gate, but in 1976 someone broke in and started a fire which destroyed 70% of the deposits. The cave also had fossil bones from other extinct mammals including a mountain goat, a horse, and a vampire bat.

Historic photograph of the sloth dung deposit in Rampart Cave. The apparent boulders are balls of sloth dung.
NPS photo, September 1938.

Historic photograph of a Shasta ground sloth skull from Rampart Cave. These sloths did not have teeth in the front of the skull, only in the cheeks.
NPS photo, September 1936.

A restoration of **Nothrotheriops shastensis**, the Shasta ground sloth.
By FunkMonk (Michael B. H.); Own work, CC BY-SA 3.0.

A restoration of Nothrotheriops shastensis, the Shasta ground sloth.
By FunkMonk)Michael B. H.); Own work, CC BY-SA 3.0

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society next meeting

April16, 2025

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

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.

Our April meeting will have Phil Richardson talking about "Contemporary Collecting in Utah".

Steve Reynolds and Julia Johnson sign copies of their book, Roadside Geology of Arizona for club members at March meeting. See Arizona Rocks 140 (February newsletter for more about their book).

Second Annual Museum Book Give-a-way on Saturday March 22

AZ Mining, Mineral & Natural Resources Education Museum Update March 2025

https://ammnre.arizona.edu/

Catie Carter Sandoval
cscarter@email.arizona.edu
703.577.6449

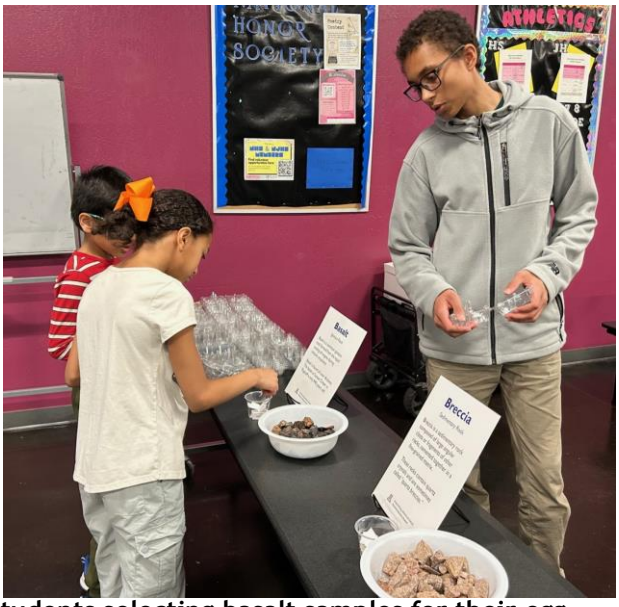
Help support the museum at:
http://tinyurl.com/SupportMM-NREMuseum

We recently brought our favorite outreach activity, "egg carton minerals," to a local charter school's annual Science Night. This was our third year visiting this school and the students ranged from fourth to twelfth grade. This year, we chose six new specimens to highlight, including three rocks and three minerals. They were: basalt (igneous rock), breccia (sedimentary rock), schist (metamorphic rock), pyrite (mineral), beryl (mineral), and carnelian agate (mineral). As with last year's activity, each rock or mineral was accompanied by a sign listing some basic facts and properties, with small printed labels for easy specimen identification. We brought enough material for over 200 six-count egg cartons, and the majority of it was gone by the end of the evening.

I asked the students to name their favorite rock or mineral and this year's popular choice was the agate, followed by the beryl and basalt! I also wrote down various comments to save for future museum discussions. Some of them included "Is mining a good career?" "I saw a volcano erupting in Hawaii, is this the same type of rock?" and "Where can you find cool rocks in Arizona?"

While we have been doing egg carton activities for a few years, it's worth mentioning that we originally learned how to implement this activity by modeling the efforts of Mardy Zimmermann first with the Leaverite Rock and Gem Club and then the Earth Science Museum. Thank you, Mardy and ESM, for setting the gold standard for the egg carton program. This is a fantastic educational activity and we look forward to doing it again soon.

Student holding assembled egg carton with six specimens: basalt, breccia, schist, pyrite, beryl and carnelian agate.



Students selecting basalt samples for their egg cartons.

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

In addition to participating in STEAM events, 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.

C. Sandoval photo

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

Steve Ruff Receives Friends of Museum Honor

Recognized for Outstanding Contributions to the Sun City Rockhound Club

By Carol Ann Hewett

On February 14th in a prestigious ceremony, Dr. Steve Ruff, a renowned planetary geologist at Arizona State University (ASU), was honored with the first Friends of Museum Honor. This accolade celebrates his significant contributions to the Sun City Rockhound Club. The award was a suggestion from a beloved long-time member of the club Joe Chan who recently passed away. Joe and his wife Eliz volunteered at the museum weekly, led field trips and were very dedicated members.

Dr. Ruff has been a guest speaker at our club meetings annually for 20 years. He has participated in an annual field trip to ASU School of Earth and Space Exploration which is always extremely popular and fascinating.
Dr. Steve Ruff is a highly respected figure in the field of planetary geology. With a distinguished career at ASU, he has made remarkable strides in our understanding of planetary surfaces, particularly Mars. His research has made substantial contributions to our understanding of Martian geology, enhancing multiple NASA missions and scientific publications. Dr. Ruff's involvement with the Sun City Rockhound Club exemplifies his dedication to community engagement and education.

The award recognizes Ruff's dedication to education, community engagement, and scientific excellence. It highlights his efforts to make geology accessible and engaging to a wider audience. In celebrating this achievement, we not only honor Dr. Ruff's individual accomplishments but also highlight the importance of community involvement and education in the sciences. His work serves as a shining example of how one person's passion and dedication can make a profound difference in the lives of many, fostering a greater understanding and appreciation of our natural world.

If you would like to watch Dr. Ruffs videos about Mars. Go to You Tube Mars Guy. Follow on Instagram/marsguyofficial.

Dr. Steve Ruff accepting the honor.

Arizona Rock and Gem Shows

Arizona Rock and Gem Shows

Gila County Gem & Mineral Society

Spring Show & Sell

Saturday, April 26, 2025 **10:00 am to 4:00 pm**

Bullion Plaza Cultural Center & Museum Lawn

150 Plaza Circle, Miami, AZ 85539

Annual show
Mohave County Gemstoners

May 3, 4, 2025

Sat. 9-5, Sun. 9-4
Free admission and parking
Mohave County Fairgrounds
2600 Fairgrounds Blvd.
Kingman, AZ

Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: April 10, 2025, 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: April 1, 2025, 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: April 15, 2025, 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)
April 17, 2025
@ 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: April 16, 2025, 7:00 pm
www.pinalgeologymuseum.org
351 N. Arizona Blvd., Coolidge

West Valley Rock & Mineral Club
Meetings are on the 2nd Tuesday
Next Meeting: April 9, 2025, 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 April 3, 2025, 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: April 11, 2025, 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 2025, 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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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 2025, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

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