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

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ESM OUTREACH UPDATE

Mardy Zimmermann, Outreach Coordinator

Start a Rock Collection

Guest article by Tony Occhiuzzi
Photos by Ray Grant and Diana Occhiuzzi

On Saturday, September 17th at the Pinal Geology & Mineral Museum in Coolidge, AZ, Ray Grant and Tony Occhiuzzi hosted an open 1-1/2-hour workshop for 7-12-year-old students on "Making A Rock Collection." With 15 enthusiastic young rock hounds in attendance plus parents, they received a brief introduction on the 3 rock types by Ray Grant. After each rock type was explained, students were given 4 samples from that particular group until all students had 12 organized samples plus labels. Diana Occhiuzzi added tissue paper and rubber banded each egg carton for the students.

The second part of the program Tony gave a brief explanation of rocks, minerals, crystals and fossils showing large hand-held specimens for viewing. With all students standing around Tony in a circle, he crushed a sample of coal and then asked the students "with enough heat and pressure" could he produce a diamond? 13 out of the 15 students said yes, only 2 young ladies said NO WAY! Then with a small Herkimer Crystal (hidden in his hand) from Diamond Point Payson, AZ, Tony squeezed the crushed coal with his hand to produce a crystal to fool the students for the "science trick." Because of two very observant and correct young ladies, they each received a large Shark's Tooth for answering correctly.

Another part of the program was called "Is It Science or Is It Magic?" Tony presented a demo called "A Shot of Red Eye," changing a clear liquid into a strawberry color and then back to clear again using household products of ammonia and vinegar. Seeing the surprised look on the students faces always makes the demo a hit.

The third and final part of the program was allowing all 15 students a chance to build a second egg carton of their choice from 26 additional specimens. Thanks to Catie Carter-Sandoval and Kelli Wakefield for providing rock samples. Tony and Diana Occhiuzzi for providing samples, display bowls, egg cartons, tissue paper and rubber bands. Thanks to Robert Hole for the set up of tables and chairs and assisting in the program. A "Big Thanks" to Ray Grant for providing the Pinal Geology and Mineral Museum and handouts for the lesson on "Making A Rock Collection."

Tony doing his "Shot of Red Eye" magic trick

Of Microbes and Minerals

By Harvey Jong

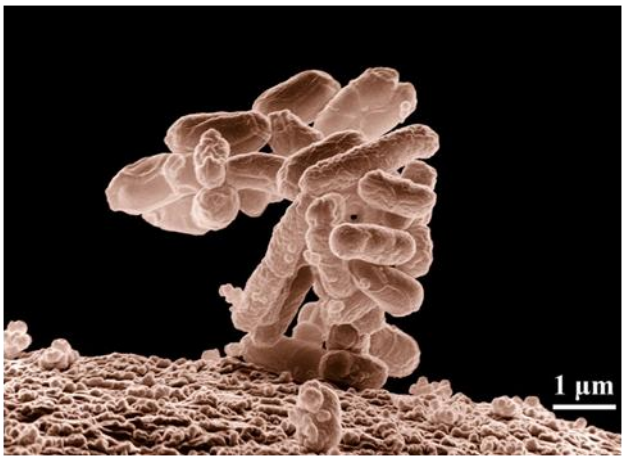
A recent overview of mineral-microbe interactions in the *National Science Review* and a *MIT News* story about the role of microbe evolution in Earth's oxygenation inspired this article which explores some aspects of geomicrobiology.

What is Geomicrobiology?

Geomicrobiology is an interdisplinary study of the interaction between microorganisms and the Earth's environment. Specifically, it examines the effects of microbial growth and activity on minerals and metals. These interactions drive the Earth's biogeochemical cycles, influence mineral dissolution and precipitation, and concentrate metals.

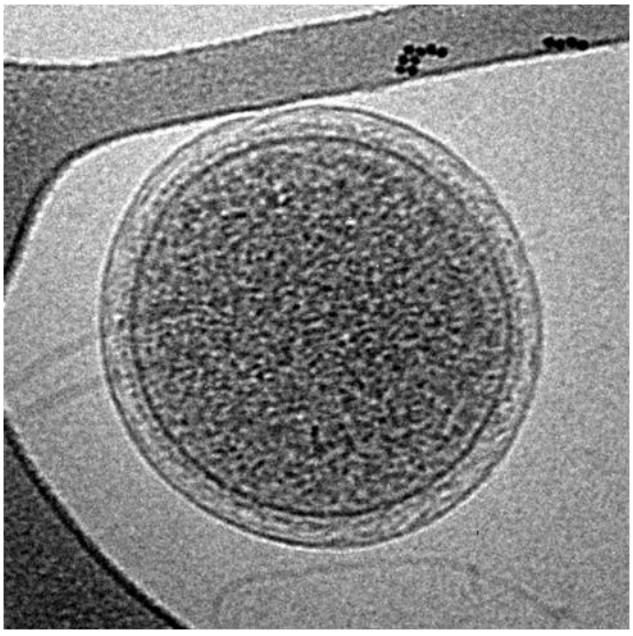
Microbes refer to organisms that cannot be seen with the naked eye and include a wide variety of life forms:

Bacteria are prokaryotes (single cells which do not have enclosed organelles or nuclei) with cell walls made of peptidogylcan (a polymer of sugar and amino acids). They use glycolysis to produce cellular energy; divide and replicate by binary fusion; and may be pathogenic as indicated by frequent news headlines about bacterial contamination found at restaurants or in food products.
Example: Escherichia coli (E. coli)



Low-temperature Electron Micrograph of an E. coli Cluster
Christopher Pooley, USDA photo – PD, via Wikimedia Commons

Archaea are prokaryotes with cell walls made of protein. They also divide and replicate by binary fusion, but do not use glycolysis and may be found in extreme environments.
Example: Archaeal Richmond Mine acidophilic nanoorganisms (ARMAN) were recently discovered in acid mine drainage solutions with a pH of 0.5 to 1.5 (Baker et al., 2006).



Cryogenic Transmission Electron Microscopy Image of ARMAN Cell
Brettjbaker photo – PD, via Wikimedia Commons
From Richmond Mine, Iron Mountain biofilm
Field of view: 576 nm

Eukaryotes are single or multi-celluar organisms with enclosed nuclei and mitochrondria. They have cytoskeletal structures and reproduce by mitosis.
Examples: algae, protozoa, fungi

Blepharisma Japonicum (Protozoan Species Found in Japan)
Frank Fox, mikrofoto.de photo – CC_BY_SA-3.0, via Wikimedia Commons

Microbes represent Earth's oldest life-form, and evidence of their presence has been found in stromatolites dating back to around 3.5 billion years ago.

Stromatolite
Didier Descouens photo – CC_BY_SA-4.0, via Wikimedia Commons
Strelley Pool Chert, Pilbara Craton, Western Australia, Australia

The age of the Strelley Pool Chert formation has been dated to 3.43 billion years old, but there is some controversy over whether the stromatolites are actual microbial fossils or artifacts of sedimentary processes. Stromatolites of more recent geological ages (middle Precambrian and Miocene) are found in Arizona. (See **Arizona Rocks 82**)

Types of Mineral-Microbe Interactions

Since the origin of life on Earth, minerals and microbes have experienced a close co-evolution. Minerals provide sources of energy and nutrients to support microbial growth, while the metabolic activities of microbes are involved in dissolving and forming minerals. These interactions, such as the Great Oxidation Event, have played a key role in determining the overall habitability of the Earth.

Great Oxidation Event

The oxygenation of the Earth's atmosphere may have started around 2.4 billion years ago and is attributed to oxygenic photosynthesis by cyanobacteria. The process of building up oxygen in the atmosphere involved several stages. Each stage represented a different equilibrium state between sources that produced O_2 and sinks that absorbed O_2.

As an oxygen source, photosynthesis may be represented by the following simplified equation:

$H_2O + CO_2 + \text{light energy} \leftrightarrow CH_2O + O_2$

It is important to note that the equation is reversible due to respiration or decay. So, to ensure a net increase in oxygen, the organic carbon by-products need to be buried and possibly lead to the following reaction:

$CO_2 \rightarrow C + O_2$

Another key source of oxygen involves buried pyrite (FeS_2) which may release O_2 via the following reactions:

$Fe(OH)_3 + 2H_2SO_4 \rightarrow FeS_2 + 15/4\ O_2 + 7/2H_2O$
$FeO + 2SO_2 \rightarrow FeS_2 + 5/2O_2$

There are many sinks for absorbing oxygen and may involve weathering or volcanic activity. Banded iron formations consist of sedimentary rocks with alternating layers of iron oxide and chert. They provide evidence of the oxygenation of the Earth's oceans along with an example of how weathering may absorb oxygen via the following equation:

$FeO + 1/4O_2 \rightarrow 1/2Fe_2O_3$

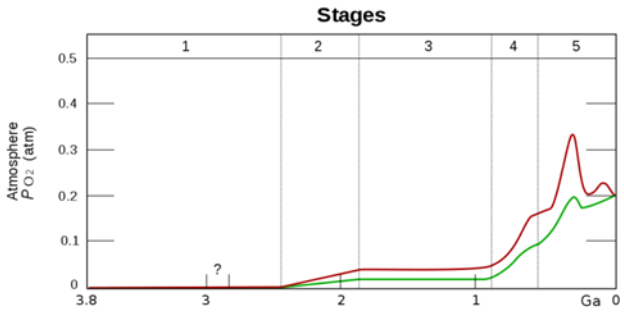
Negaunee Iron-Formation
James St. John photo – CC_BY_SA-2.0, via Wikimedia Commons

This banded iron formation is found in the Marquette Iron Range of Michigan's Upper Peninsula. It has been dated to 1.874 to 2.11 billion years old and consists of alternating layers of hematite, red chert, and specular hematite or magnetite. The rock from this formation has been given a varietal name of "jaspilite".

Surface and underwater volcanoes may release a variety of gases that combine with oxygen:

$H_2 + 1/2O_2 \rightarrow H_2O$
$CO + 1/2O_2 \rightarrow CO_2$
$H_2S + 2O_2 \rightarrow H_2SO_4$
$H_2O + SO_2 + 1/2O_2 \rightarrow H_2SO_4$

After the emergence of photosynthesis, the atmosphere contained a low concentration of oxygen for 1.5 billion years. Oxygen accumulation didn't start to accelerate until around 700 million years ago, and several hypotheses have been proposed on what might have triggered the transition to the atmosphere's present day oxygen content of 21% (by volume).



Oxygen Build-up in the Earth's Atmosphere
Diagram by Heinrich D. Holland, modified by Loudubewe - CC_BY-SA-3.0, via Wikimedia Commons
The red and green lines represent the range of estimates.
Stage 1 (3.85-2.45 Ga): Practically no O_2 in the atmosphere, possibly some O_2 in shallow oceans.
Stage 2 (2.45-1.85 Ga): Some O_2 production around 0.02-0.04 atm, but absorbed in oceans and seabed rock.
Stage 3 (1.85-0.85 Ga): Start of O_2 emissions from oceans, but absorbed by land surface.
Stages 4 & 5 (0.85 Ga-present): All O_2 sinks filled, O_2 accumulates in atmosphere.

Increased tectonic activity has been suggested as a possible catalyst where volcanoes released large amounts of carbon dioxide, while tectonic plate movements buried organic carbon. The CO_2 emissions led to climate warming, increased rainfall, and delivered more mineral nutrients to the

oceans. This enabled the cyanobacteria population to rise (Eguchi et al., 2019).

A more recent hypothesis appeared in a *MIT News* story and involves a geochemical feedback loop intertwined with microbial evolution (Shang et al., 2022). As noted earlier, photosynthesis creates organic carbon by-products, and oxygen is consumed when this material decays. Some microbes (from the SAR202 bacterial group), however, have been found with the ability to only partially oxidize organic matter. The partially-oxidized organic matter or POOM may bind with minerals in ocean sediments preventing further oxidation. This leads to a process that allows oxygen to build up as the microbes produce more and more POOM. Phylogenetic analysis indicates that ancestors of this bacteria date back before the Great Oxidation Event and that the number of species with the metabolic trait increased significantly around the time when oxygen in the atmosphere spiked.

The Great Oxidation Event created tremendous opportunities for biological and mineralogical diversity. In the case of minerals, estimates indicate that the number of species increased from 1500 to more than 4000 (Hazen and Ferry, 2010).

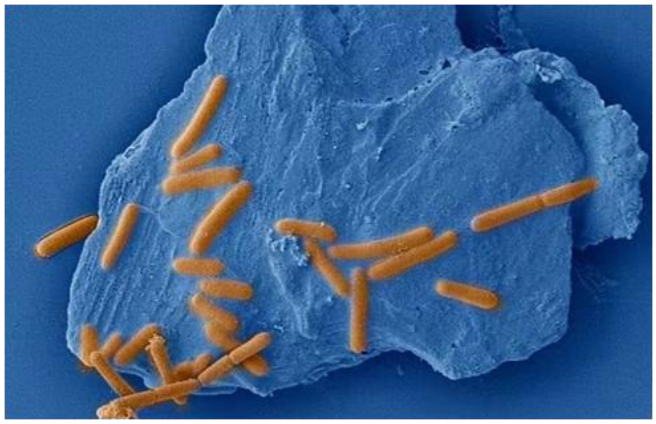
Biomineralization

Biomineralization is the process where living organisms produce minerals. Over 60 different minerals or mineral precursors have been identified in organisms (Lowenstam and Weiner, 1989).

Partial List of Biogenic Minerals

After Table 2.2 in (Lowenstam and Weiner, 1989)

Aragonite	Goethite	Opal
Barite	Greigite	Protodolomite
Birnessite	Gypsum	Pyrite
Brushite	Hieratite	Sphalerite
Calcite	Hydrocerussite	Struvite
Celestite	Hydrotroilite	Todorokite
Dahllite	Hydroxylapatite	Vaterite
Earlandite	Jarosite	Vivanite
Ferrihydrite	Lepidocrocite	Weddelite
Fluorapatite	Mackinawite	Whewellite
Fluorite	Magnetite	Whitlockite
Galena	Monohydrocalcite	Wurtzite
Glushinskite	Octacalcium phosphate	



Anaerobic Bacteria on Molybdenite
©Science China Press photo, via eurekalert.org

Microbes are involved in the dissolution, precipitation, and transformation of minerals. Their role can be grouped into two types of mineralization:

1. Biologically Controlled Mineralization (BCM)

In BCM, various anions and cations enter a microbe through transmembrane proteins. Once inside the cell, metabolic processes interact with the ions to produce minerals. The minerals reach super-saturation and precipitate inside the cell's membrane.

2. Biologically Induced Mineralization (BIM)

   With BIM, minerals may form when anions in either a microbe's extracellular polymers or surface bind with external cations or the microbe excretes anions which combine with cations outside the cell to precipitate minerals.

BCM Example: Formation of Ore Deposits

Ore deposits involve a sequence of processes that concentrate metals or other commodities so that they can be mined economically. For example, copper ore deposits in desert environments may undergo secondary enrichment where descending acidic groundwater reacts with primary sulfide minerals and results in the localized precipitation of different secondary copper minerals. This enrichment is usually assumed to be abiogenic, but a recent investigation of the Las Cruces deposit in southwest Iberia, Spain has discovered in situ colonies of sulfate-reducing microbes. (Tornos et al., 2019).

Open Pit of the Las Cruces Mine
Pablo Ruíz Velasco photo – CC_BY_SA-2.0, via Wikimedia Commons
Las Cruces Mine, Gerena, Spain
This photo was taken in 2016.

Specifically, microbial aggregates were found accreting and forming covellite (CuS) crystals attached to vein walls. This suggests that microbial sulfate reduction may act as a possible control in the formation of secondary copper deposits.

BIM Example: Origins of Azurite and Malachite

The copper carbonates, azurite [$Cu_3(CO_3)_2(OH)_2$] and malachite [$Cu_2(CO_3)(OH)_2$], provide an example of how microbes may induce mineralization. The formation of azurite requires a CO_2 partial pressure that is orders of magnitude greater than atmospheric levels, and carbon and oxygen isotope analysis indicates that chemosynthetic microbial CO_2 is the likely source (Melchiorre, 2015). So, when CO_2 levels greatly exceed atmospheric levels, azurite will form, but malachite develops as the amount of CO_2 decreases. This explains the occurrence of specimens with fine, inter-banding of azurite and malachite.

Azurite and Malachite
Marie-Lan Taÿ Pamart photo of Galerie de Minéralogie et de Géologie du Muséum specimen – CC_BY_SA-4.0 International, via Wikimedia Commons
Morenci, Greenlee County, Arizona

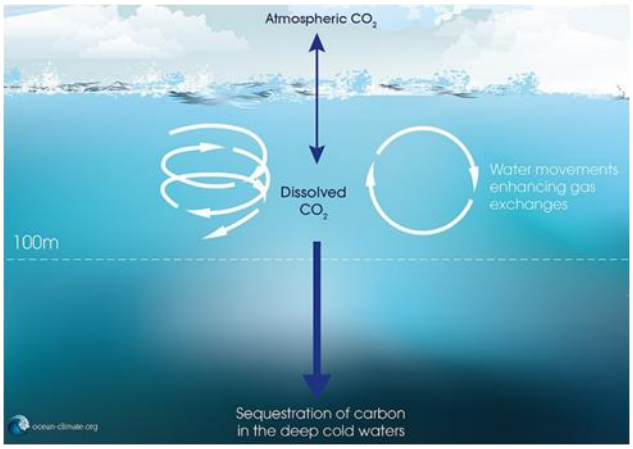
Mineral-Microbe Interactions in the "Anthropocene" Epoch

The "Anthropocene" is a proposed geologic epoch that is associated with significant human-caused impact on the Earth's environment. Global physical, chemical, and biological changes from greenhouse gas emissions; disposal of heavy metals; and the unrestrained use of antibiotics, plastics, and synthetic fertilizers, have been used to justify the naming of a new epoch.

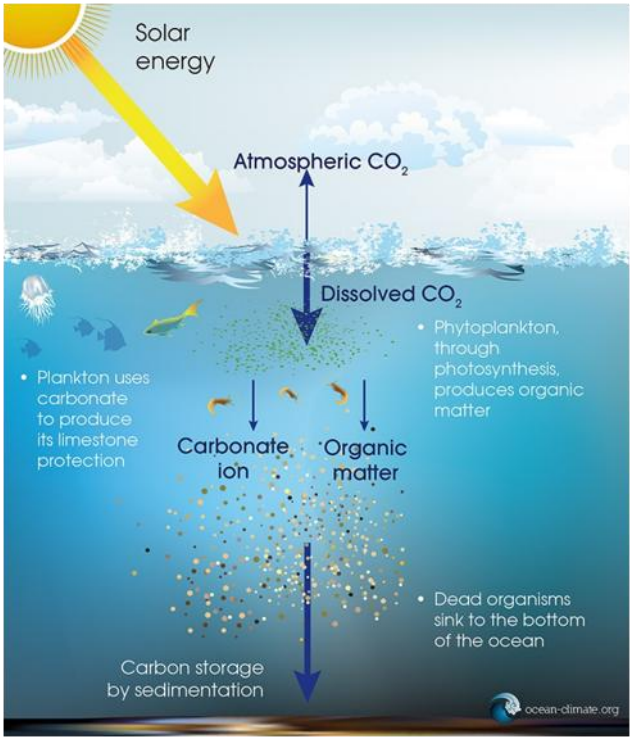
Mineral-microbe interactions may be applied in addressing some environmental issues. For example, bioleaching may provide a more "environmental-friendly" way of extracting metals and rare earth elements from low-grade ores and mine tailings. Similarly, microbial induced dissolution of minerals may replace certain fertilizers and increase soil fertility without harmful runoff effects.

To remediate toxic heavy metal contamination, microbe-mineral suspensions may be introduced to precipitate/incorporate these metals into biomineral concentrates. Microbes may also help degrade organic pollutants through redox reactions.

Lastly, microbes might be employed in carbon sequestration. Much of the Earth's carbon is held in the oceans as dissolved inorganic carbon (CO_2, H_2CO_3, HCO_3, CO_3^{2-}), dissolved organic carbon, or particulate organic carbon. Three processes or "pumps" are involved in these pools of carbon and include a physical (solubility) carbon pump, a carbonate carbon pump, and a biological carbon pump.



Physical (Solubility) Carbon Pump
Info graphic courtesy of ocean-climate.org



Biological Carbon Pump
Infographic courtesy of ocean-climate.org

A fourth process, a "microbial carbon pump", has been proposed where microbes would transform short-lived dissolved organic carbon into a more resistant, long lasting state.

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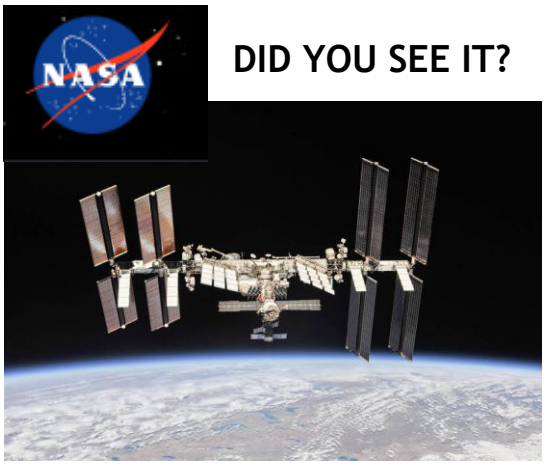
International Space Station



DID YOU SEE IT?

On September 15, 2022, ESM board members, Doug Duffy and Shirley Cote sat in their backyard and watched as the International Space Station flew over their home in Phoenix between 7:15 & 7:23 p.m. Its trajectory was from the southwest to the northeast.

The space station looks like an airplane or a very bright star moving across the sky, except it doesn't have flashing lights or change direction. It will also be moving considerably faster than a typical airplane (airplanes generally fly at about 600 miles (965 km) per hour; the space station flies at 17,500 miles (28,000 km) per hour).

The ISS circles the Earth every 90 minutes and is in orbit around the Earth at an average altitude of 248 miles (400 kilometers). Traveling at about 17,500 miles per hour gives the crew 16 sunrises and sunsets every day. In the more than 15 years that people have been living onboard, the Station has circumnavigated the Earth tens of thousands of times. In one day, the station travels about the distance it would take to go from Earth to the moon and back. The moon is, on average, 238,855 miles away so 477,710 miles to the moon and back.

You can track the station at the following NASA webpage:

https://spotthestation.nasa.gov/tracking_map.cfm

The tracker shows where the Space Station is right now and its path 90 minutes ago (-1.5 hr) and 90 minutes ahead (+1.5 hr). The dark overlay indicates where it is nighttime in the world.

AZ Mining, Mineral & Natural Resources Education Museum Update September 2022

https://ammnre.arizona.edu/

Catie Carter Sandoval
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703.577.6449

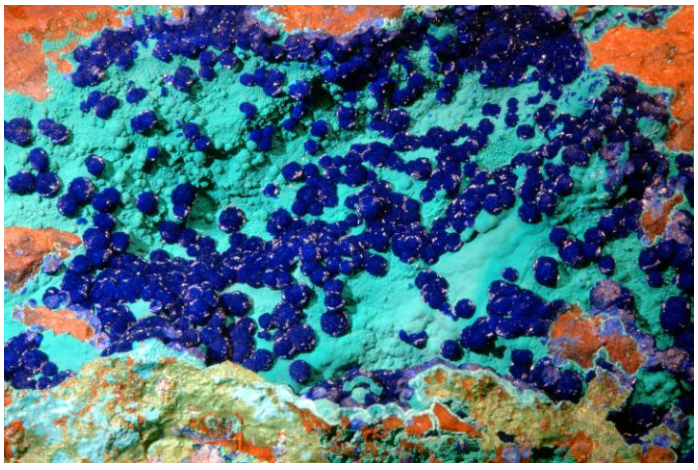
Help support the museum at:
http://tinyurl.com/SupportMM-NREMuseum

As the museum begins planning our renovations, we invited Representative Gail Griffin (LD-14) to the museum to share updates and discuss her vision. As our supporters may remember, Rep. Griffin was responsible for passing Senate Bill 1530 (2016), which established a new natural resources museum, and Senate Bill 1415 (2017) which permanently transferred ownership of the Mining and Mineral Museum building and mineral collection from the State of Arizona to the University of Arizona. This past spring, Rep. Griffin sponsored another bill, House Bill 2653 (2022), designating a one-time appropriation of 12 million dollars to the museum for capital improvements. The appropriation was integrated into the FY 2023 Arizona state budget and passed in June.

We recently welcomed Rep. Griffin back into our building to hear what we've been up to and get her input about potential programming ideas. She imagines a high-tech museum that inspires future engineers and bridges the gap between the consumer and Arizona's natural resource industries, including mining and agriculture. We're thankful that Rep. Griffin continues to be a champion for the museum and we look forward to working with her more as we continue development.

University of Arizona Assistant VP for City of Phoenix and State Relations Sabrina Vazquez, Rep. Gail Griffin, and Museum Curator Catie Sandoval in front of the main gallery stairs.

Native copper (photo by Jeff Scovil)



Azurite, chrysocolla (photo by Jeff Scovil)

Arizona Rocks 112

Text by Ray Grant
Photos by Bill Yedowitz

Many years ago, when I was much younger, I made a trip to the top of Mount Humphreys the highest point in Arizona (12,633 feet above sea level). One of the things I was looking for were places where lightning hit the rock and melted it.

The San Francisco Peaks are a stratovolcano that erupted between one million and 400,000 years ago. There are six summits surrounding the interior valley. Two appear unnamed and the others are Mount Humphreys, Agassiz Peak at 12,356 feet, Fremont Peak at 11, 969 feet, and Doyle Peak at 11,464 feet. Past Arizona Rocks have more about the geology of the volcanic field.

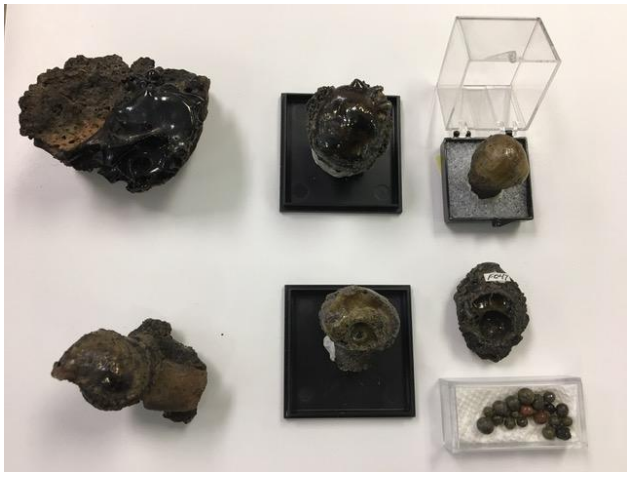
The area is all above tree line and subject to intense lightning and hikers are warned not to climb when there are storms in the area. What I saw on my hike to the top were black melted areas on the volcanic boulders I did not think to look for loose fulgurites, but now I know. Pictured here is a loose piece of melted rock (a fulgurite) and even more interesting droplet fulgurites formed when the lightning melts the rock and the droplets are scattered through the air.

You can hike to the top or can take a gondola ride at the Snowbowl to 11,500 feet. Check online for information about hiking restrictions and about the times and tickets for the ride and again watch out for lightning. If it can melt volcanic rock into glass spheres imagine what it could do to you.

San Francisco Peaks, Ray Grant photograph

Droplet fulgurites from Mount Agassiz, the biggest one is 6 mm and the smallest is 3.5 mm. Bill Yedowitz collection and photograph

Fulgurite from Mount Agassiz, an inch and a half across (Bill Yedowitz collection and photograph)



Bill's collection of fulgurites from Mt. Agassiz

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society meeting

October 19, 2022

www.pinalgeologymuseum.org

Ray Grant raycyn@cox.net.

The Museum is open from 11 to 4,
Wednesday through Saturday

Masks are now optional at the Museum. Please bring your own mask if you wish to wear one. We will have some masks on hand at the Museum, but cannot guarantee to provide them.

October 8 – Rock Art Day, Stop by the Museum and create some rock art
October 12-15 - National Fossil Week, come visit our fossils
October 15 – National Fossil Day Celebration – crafts and more
October 19 – Meeting, Presentations by David T., on Tucson Mountain Geology; Bob Hole, on Arizona Geology Places
November 12 – Full STEAM Ahead! A celebration of Science, Technology, Engineering, and Math
November 16 – Meeting, Presentation by Mesa Community College Speaker TBA
November 24 – Thanksgiving, Museum Closed
December 10 – International Mountain Day Celebration – special activities and crafts about mountains and volcanoes
December 21 – Meeting, Presentation by Robert McCord, Curator of Paleontology, AZ Museum of Natural History
December 25 – Christmas, Museum closed
December 31 – New Years Eve, Museum closed
January 1 – New Years Day, Museum closed

Parent/Teacher Resource Page

HTTPS://WWW.EARTHSCIWEEK.ORG/NEWSLETTER

EARTH SCIENCE WEEK UPDATE - Recap
September 2022

START EARTH SCIENCE WEEK WITH EARTHCACHE DAY – SUNDAY, OCTOBER 9

What better place is there to learn Earth science than outdoors? Earth Science Week 2022 will begin with the 15th annual International EarthCache Day on Sunday, October 9. The public is invited to explore this exciting and educational geoscience experience along with the Geological Society of America, which runs the global EarthCache program in partnership with Geocaching HQ, and AGI, which coordinates Earth Science Week.

International EarthCache Day is a time when EarthCachers around the globe learn about the Earth. Each of these individuals hunts for an EarthCache, a place that can be found with a GPS device.

EarthCachers participate in a kind of "treasure hunt" called geocaching. The treasure that is found at an EarthCache is a lesson about the Earth science. Learn more at EarthCache.

MINERALS DAY RETURNS ON MONDAY, OCTOBER 10

Since 2020, the Mineralogical Society of America (MSA) and AGI have been leading the celebration of Minerals Day, and this celebration of minerals is returning on Monday, October 10, during Earth Science Week 2022. Minerals Day raises awareness of and appreciation for minerals among the general public as well as students and teachers of all ages and at all levels.

AGI and MSA have developed materials and collaborated with geoscience partners in government agencies, professional associations, private corporations, and other groups — such as museums, libraries, and rock and mineral clubs, to name just a few — to make an impact with Minerals Day.

Offering educators and families with innovative ways of providing young people with the education tools they need to succeed, AGI and MSA are proud to join forces through Minerals Day in rallying the minerals, mining, and mineralogical studies communities to help meet this challenge. Look for relevant information and resources on AGI's Minerals Day page and MSA's Minerals Day page.

PLAN FOR UPCOMING EARTH OBSERVATION DAY – TUESDAY, OCTOBER 11

You're invited to take part in Earth Observation Day during Earth Science Week 2022. Earth Observation Day (Tuesday, October 11) aims to engage students and teachers in remote sensing as an exciting and powerful educational tool.

The event is a STEM educational outreach event of AmericaView and its partners. AmericaView is a nationwide partnership of remote sensing scientists who support the use of Landsat and other public domains remotely sensed satellite data through applied remote sensing research, K-12 and higher STEM education, workforce development, and technology transfer.

For lessons and activities by AmericaView and other organizations, as well as additional Earth Observation Day resources, please see the program website.

Guidebook PDF Ensures 'No Child Left Inside' Day – Tuesday, October 11

Wouldn't it be great to dedicate a day to "No Child Left Inside," a time for outdoor activities enabling young people to experience the inspiration of Earth science first-hand? To help you do just that, the NCLI Day Guide is available in both online and PDF format for easy printing, viewing on a smartphone, and using outdoors.

This free guide provides everything you need to start planning your own NCLI Day event, including any of 17 outdoor learning activities recommended for elementary, middle, and high school students. Begin now to plan your NCLI Day event for summer or fall, when young people can wade into ponds, climb hills, and search the skies to learn Earth science. And remember to include appropriate safety measures.

Find the NCLI Day Guide, including the PDF version, at No Child Left Inside Day. Have a great NCLI Day!

Art Contest Spotlights National Fossil Day – Wednesday, October 12

Earth science and fossil artists, this contest is for you! The National Park Service is looking for submissions for the National Fossil Day 2022 Art Contest.

In celebration of the 150th anniversary of Yellowstone National Park and the 50th year anniversary of Fossil Butte National Monument, this year's contest theme is " The Age of Mammals in our National Parks and Monuments." Do a little research to learn about fossils from a particular national park. Pick a relevant fossil, specific prehistoric organism, prehistoric reconstruction, and/or a collage of all the above from any of the 279 National Park Service areas that have fossils.

Art can be in the form of a photograph, a painting, a drawing, or a sketch. All physical artwork should be able to fit inside a 13"x 17" envelope or smaller. Digital entries must be at least between 300 to 600 DPI and in jpeg format. Don't wait until National Fossil Day — Wednesday, October 12, during Earth Science Week 2022 — to create your artwork!

All submissions must be received by mail by 5 p.m. ET Saturday, October 1, 2022. For more information and guidelines, visit the National Fossil Day Art Contest webpage.

Geoscience for Everyone Day: All Are Invited – Thursday, October 13

Join the Earth Science Week team in encouraging everyone — including women, minorities, and people with a range of abilities — to explore geoscience careers on "Geoscience for Everyone Day," Thursday, October 13, 2022.

Open a young person's eyes to the world of Earth science. In doing so, you'll be supporting the efforts of AGI member societies such as the Association for Women Geoscientists and the National Association of Black Geoscientists in raising awareness of the remarkable opportunities available in the Earth sciences. Learn more about Geoscience for Everyone Day online.

If you're an educator, invite a geoscientist to speak to your students. If you're a geoscientist who's not sure where to start, see "Be a Visiting Geoscientist," a guide designed for geoscience professionals who want to actively support education. You can provide unique enrichment opportunities, based on your education and experience.

Celebrate Geologic Map Day – Friday, October 14

Welcome to Geologic Map Day, a special event designed to promote awareness of geologic mapping and its vital importance to society.

As an extension of the National Cooperative Geologic Mapping Program, Geologic Map Day focuses the attention of students, teachers, and the general public on the creation, study, uses, and significance of geologic maps for education, science, business, and a variety of public policy concerns.

Organizing partners of Geologic Map Day are the United States Geological Survey, the American Association of State Geologists, the National Park Service, the Geological Society of America, the National Aeronautics and Space Administration, and the American Geosciences Institute. The event is celebrated on the Friday of AGI's Earth Science Week (www.earthsciweek.org), a public awareness campaign that reaches over 50 million people each year with educational resources, information, and activities promoting awareness of Earth science. Please join us!

International Archaeology Day – Saturday, October 15

Earth Science Week 2022 reaches its climax with International Archaeology Day on Saturday, October 15. The event is a celebration of archaeology and the thrill of discovery!

Every October, the Archaeological Institute of America (AIA) - an Earth Science Week partner - and archaeological organizations across the United States, Canada, and elsewhere present archaeological programs and activities for people of all ages and interests.

Whether it is a family-friendly archaeology fair, a guided tour of a local archaeological site, a simulated dig, a lecture or a classroom visit from an archaeologist, the interactive, hands-on International Archaeology Day programs provide the chance to indulge “your inner Indiana Jones.”

Check out AIA’s map of events, the ArchaeoMadness calendar, and other educational resources on the International Archaeology Day website (www.archaeological.org/archaeologyday). In addition, see the “What Will Survive?” learning activity (https://www.earthsciweek.org/classroom-activities/what-will-survive), from the 2014 Earth Science Week Activity Calendar.

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48th ANNUAL HUACHUCA MINERAL, GEM, AND JEWELRY SHOW

8th AND 9th OCTOBER 2022
2200 EL MERCADO LOOP,
SIERRA VISTA, AZ
For Information;
Contact Maudie Bailey, gmbailey@msn.com,
520 249-1541

Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: October 13, 2022, 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 4, 2022, 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
Meetings are on the 1st Monday
(unless a Holiday then 2nd Monday)
Next Meeting: October 3, 2022, 7:00 pm
www.maricopalapidarysociety.com
@ North Mountain Visitor Center
12950 N. 7th St., Phoenix

Mineralogical Society of Arizona
Meetings are on the 3rd Thursday
Next Meeting: October 20, 2022, 7:30 pm
Please go to their website for more information
www.msaaz.org
@ Franciscan Renewal Center
Room: Padre Serra
5802 E. Lincoln Dr., Scottsdale

Pinal Geology & Mineral Society
Meetings are on the 3rd Wednesday
Next Meeting: October 19, 2022, 7:00 pm
In person meeting
www.pinalgeologymuseum.org
@ Artisan Village
351 N. Arizona Blvd., Coolidge

West Valley Rock & Mineral Club
Meetings are on the 2nd Tuesday
Next Meeting: October 11, 2022, 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 6, 2022, 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 14, 2022, 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 2022, at 6:30 p.m.

BECOME A MEMBER!
Join the Earth Science Museum's

esi: Earth Science Investigation team

IS IT TIME TO RENEW YOUR MEMBERSHIP?
Please renew today! ☺☺☺

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

Sossaman Middle School

White Mountain Gem & Mineral Club
www.whitemountain-azrockclub.org

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
Peter & Judy Ambelang
Stan & Susan Celestian
Russ Hart
Will & Carol McDonald
Debbie Michalowski
Janet Stoeppelmann
Dennis & Georgia Zeutenhorst

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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.

_ _ _ _ _ _ _ _ cut here _ _ _ _ _ _ _ _

Name: _____

Address: _____

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Phone:
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Editor E-Mail:
scote@earthsciencemuseum.org

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 2022, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

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