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

Doug Duffy and Shirley Coté, ESM board members and Daisy Mountain Rock and Mineral Club members, attended the Daisy Mountain R&G Show in early March. To give Stan and Susan Celestian a break at the clubs "Dr. Rock" table, Doug and Shirley volunteered to engage with visitors, answer their questions and identify rocks and minerals.

Photo by Bill Freese

Doug and Shirley brought a poster showing the elements and explained to attendees that it is helpful to know the symbols for the eight most abundant elements in the Earth's crust as the chemical composition of the minerals they find will include combinations of two or more of these elements.

(O) Oxygen - 46.1%	**(Ca)** Calcium - 4.15%
(Si) Silicon - 28.2%	**(Na)** Sodium - 2.36%
(Al) Aluminum - 8.23%	**(Mg)** Magnesium - 2.33%
(Fe) Iron - 5.63%	**(K)** Potassium - 2.09%

In addition to the samples of the common rock forming minerals and the common rocks, they brought samples of Mohs hardness scale from talc to diamond (albeit an industrial diamond which was not all that attractive). Hardness is one of many physical properties of minerals used in the process of identifying them.

Photo by S. Coté

Poster by USGS

In case you were wondering, the 9th and 10th most abundant elements in the Earth's crust are **(Ti)** Titanium – 0.565% and **(H)** Hydrogen – 0.14%

Green Chromophores - The Wearing of the Green by Minerals

By Harvey Jong

Green has become synonymous with St. Patrick's Day celebrations which include green clothing, green beverages, green food, green rivers, and green fountains.

Fountain Hills Fountain on St. Patrick's Day 2017
Corey Taratuta photo, - CC_BY_SA-2.0, via Wikimedia Commons

The color is the inspiration for this article which explores some causes of green in minerals.

Occurrence of Green in Minerals

At the time of this article, a search of mindat.org's database for IMA-approved minerals with the color "green" returned 1,272 species. Note that these results also include various hues or tints described as being "greenish". This represents 21.6% of the 5,901 approved minerals and is the third most common color after yellow and colorless (See the table below).

Color	Number of Minerals
Red	768
Orange	420
Yellow	1,618
Green	1,272
Blue	638
Indigo	7
Violet	113
Colorless/clear	1,447

Occurrence of the Colors of the Rainbow and Colorless in IMA-approved Minerals
Note that the total number of minerals exceeds 5,901 since some minerals may have multiple colors.

Allochromatic vs. Idiochromatic Minerals

With respect to color, minerals may be described as being either allochromatic, or idiochromatic[1]. Allochromatic minerals refer to species that are typically colorless but may appear in different colors due to either the presence of impurities or exposure to radiation. Quartz is a common example of an allochromatic mineral. With idiochromatic minerals, the color is determined by the inherent chemical composition leading to a "self-colored" designation. Malachite is an example of an idiochromatic mineral.

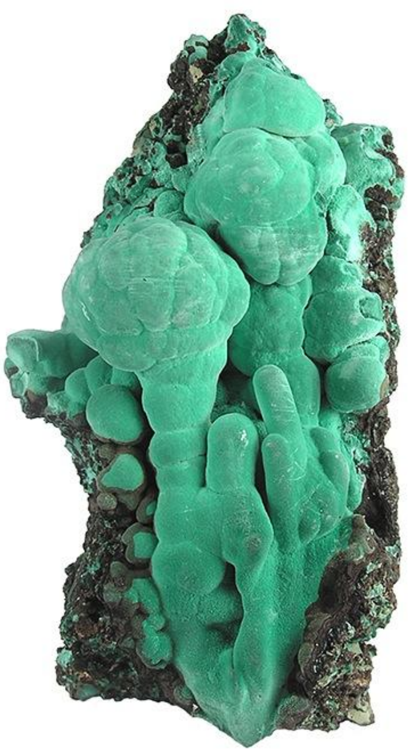
Chromophores

Classifying minerals as either allochromatic, or idiochromatic, however, does not provide insights into what specifically causes a mineral to be green, especially if the species may occur in a variety of different colors. So, we'll have to examine the coloring agents, known as chromophores, and the processes involved in the selective absorption of wavelengths of light.

Copper Chromophore

[1] Some minerals may be identified as pseudochromatic or "false colored". Their varying colors involve optical effects, such as diffraction. Precious opal is an example.

To begin the discussion, we'll take a look at the earlier example of malachite. Malachite is a copper carbonate hydroxide [$Cu_2(CO_3)(OH)_2$], and the cupric (Cu^{2+}) ion is the chromophore responsible for its familiar bright green color.



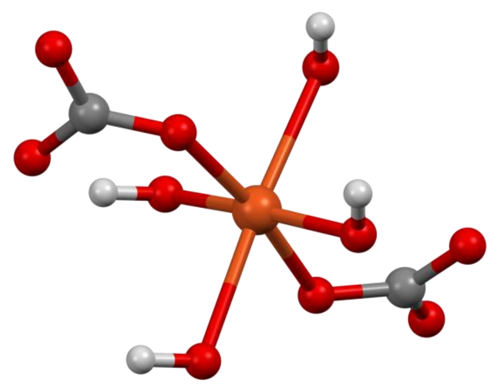
Malachite
Rob Lavinsky photo, iRocks.com, -CC_BY_SA-3.0, via Wikimedia Commons
Bisbee, Warren district, Arizona
Dimensions: 10.5 x 6.3 x 5.6 cm

The Cu^{2+} ion, however, is also present in azurite, $Cu_3(CO_3)_2(OH)_2$, and produces a deep blue color. So, what accounts for the different colors?

The color difference may be explained by crystal field theory which describes how electron orbital states in transition metal compounds may have different energy levels. This theory introduces a bonding model where electrostatic field interactions between ions account for many transition metal mineral properties, such as magnetism and color.

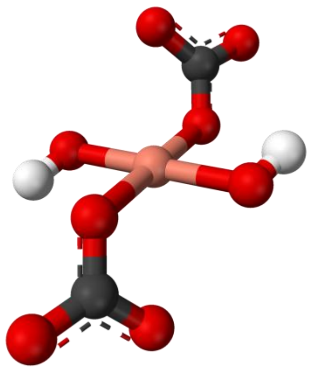
Copper is a transition metal element and forms compounds which are known as coordination complexes. In these complexes, a central metal acceptor ion is bonded to an array of donor atoms or molecules which are called ligands. The number of ligands defines the coordination number and is associated with a geometric structure.

Malachite has a coordination number of six and is said to have octahedral coordination. Note that malachite actually has an elongated octahedral structure due to the length of Cu-OH bonds, and this has been referred to as tetrahedral distortion.



Ball-and-Stick Model of the Octahedral Coordination of Malachite
Model created by Ben Mills using CCDC Mercury 3.8, - PD, via Wikimedia Commons
Color code:
- Copper, Cu: orange-brown
- Carbon, C: grey
- Oxygen, O: red
- Hydrogen, H: white

Azurite has a coordination number of four and a square planar structure.



Ball-and-Stick Model of the Square Planar Structure of Azurite
Model created by Ben Mills, - PD, via Wikimedia Commons
Color code:

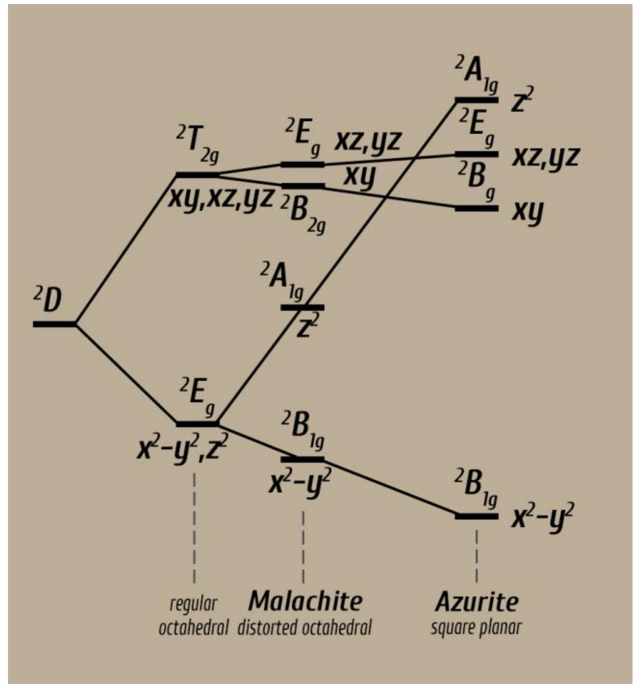
- Copper, Cu: orange-brown
- Carbon, C: grey
- Oxygen, O: red
- Hydrogen, H: white

The coordination geometry affects the charge distribution of the outer electrons of the central copper ion. Due to electrostatic repulsion, the electron orbitals which are closer to the ligands will have a higher energy than those further away. This effectively splits the orbitals into different energy levels.

Copper has 29 electrons, and these electrons are arranged according to specific rules in different orbitals. Its outer electrons involve 3d orbitals as shown in the following electron configuration of copper:

$$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^1$$

The d orbitals split into different energy levels based on the mineral's coordination geometry. The following diagram shows how orbital energy levels change going from a regular octahedral structure, to malachite's distorted octahedron, and finally to azurite's square planar arrangement.

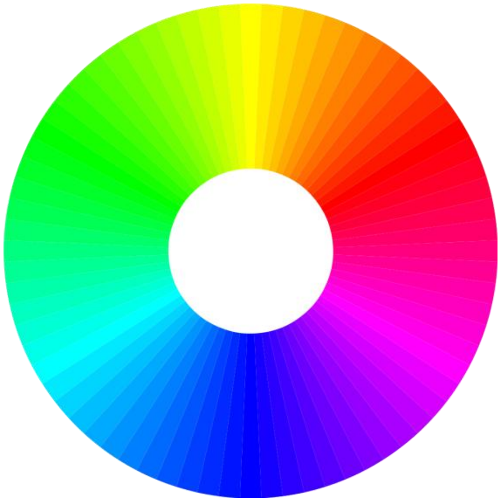


Splitting of Cu^{2+} Electron Orbitals in Malachite and Azurite
Harvey Jong diagram, after Marfunin (1979) Fig. 113a

When a mineral is illuminated by a light, photons will excite electron orbitals from their initial ground state to a higher energy state. A range of wavelengths of light may be absorbed based on the energy level of these transitions. The wavelength of light absorbed is related to the orbital energy difference, Δ_o, as described by the following equation:

$$\Delta_o = hc/\lambda$$

where h is Planck's constant (6.582×10^{-16} eV sec), c is the speed of light (3.0×10^{17} nm/sec), and λ is the wavelength (nm).



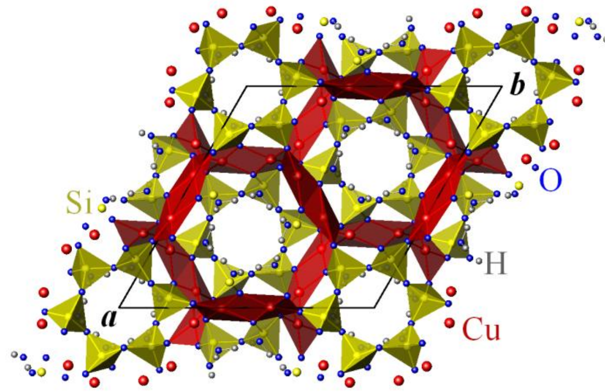
RGB Color Wheel (72 Colors)
László Németh graphic, - CC-1.0-Universal PD, via Wikimedia Commons

Reviewing the color wheel and using subtractive complementary colors, we find that the green of malachite involves orbital energies that absorb photons in the red-violet range. Azurite's blue color is related to energy differences that correspond to photons in the orange-yellow range.

<u>Examples of Other Green Minerals Involving Copper</u>

Dioptase
Rob Lavensky photo, iRocks.com, - CC_BY_SA-3.0, via Wikimedia Commons
Mammoth-St. Anthony Mine, Tiger, Pinal County, Arizona
Dimensions: 4.3 x 2.6 x 1.4 cm

Dioptase, a copper cyclosilicate hydrate, $Cu_6Si_6O_{18}\cdot 6H_2O$, consists of silicate rings interconnected by copper atoms surrounded by a deformed octahedron of four oxygen atoms and two water molecules.



Dioptase Crystal Structure
Diagram created by Perditax, - PD, via Wikimedia Commons

The octahedron, however, is rather distorted, and the structure may alternately be considered as a square planar configuration with four copper-oxygen bonds (Newnham and Santoro, 1967). The blue-green color might be a possible consequence of this skewed geometry.

Arizona's 79 Mine has produced some exceptional specimens of lustrous, apple-green smithsonite. Historically, the green color has been attributed to copper, and the term "cuprian" smithsonite has been used in describing these smithsonites. A microchemical study, however, revealed that the color is due to inclusions of hemimorphite, aurichalcite, a manganese and copper oxide, copper carbonate, and manganese carbonate in solid solution (Frisch, et al., 2002).

Smithsonite with Calcite
Flagg Mineral Foundation specimen
Harvey Jong photo
79 Mine, Hayden, Gila County, Arizona

<u>Chromium Chromophore</u>

Chromium is another transition metal element that can act as a green chromophore. Perhaps, the best known mineral colored by chromium is emerald, the green variety of beryl. Beryl (beryllium aluminum silicate, $Be_3Al_2Si_6O_{18}$) is an allochromatic mineral which may occur in a variety of colors.

Emerald's distinctive green color involves the substitution of aluminum (Al^{3+}) ions with chromium (Cr^{3+}). Vanadium (V^{3+}) and iron (Fe^{2+} or Fe^{3+}) impurities may also be present, and the relative amounts determine a particular shade of color.

Beryl (var. Emerald) and Calcite
Rob Lavinsky photo, iRocks.com, -CC_BY_SA-3.0, via Wikimedia Commons
Coscuez Mine, Muzo, Columbia
Dimensions: 4.5 x 4.5 x 2.5 cm; the emerald crystal is 4 cm long, 10.1 mm thick

Grossular is a calcium-aluminum member, $Ca_3Al_2(SiO_4)_3$, of the garnet mineral group. Its name is derived from *grossularia*, the botanical name for gooseberry, and refers to the berry's green color. As an allochromatic mineral, grossular may also be found in various shades of red, orange, yellow, and brown.

The presence of chromium (Cr^{3+}) and vanadium (V^{3+}) impurities may produce a variety with a bright, saturated green color. This variety is known as tsavorite which is named after the Tsavo National Park in Kenya where the grossular discovered in 1974.

Grossular (var.Tsavorite)
Rob Lavinsky photo, iRocks.com, - CC_BY_SA-3.0, via Wikimedia Commons
Merelani Hills, Arusha Region, Tanzania
Dimensions: 0.9 x 0.6 x 0.6 cm

Iron Chromophore

According to the *CRC Handbook of Chemistry and Physics*, iron is the fourth most abundant element in the Earth's crust. So, as expected, it is a common chromophore for several minerals.

Iron has two main oxidation states, Fe^{2+} and Fe^{3+}, which are readily interchangeable. Ferrous iron (Fe^{2+}) may form complexes with a green color, while ferric iron (Fe^{3+}) compounds may appear yellow.

Tumbled Peridot Stones
Harvey Jong photo, ESM Volcanic Rocks & Minerals Display specimen
Peridot Mesa, San Carlos Apache Indian Reservation, Gila County, Arizona
Dimensions: varies from 6-22 mm

Peridot is the gem variety of olivine. Olivine is a magnesium iron silicate, $(Mg,Fe)_2SiO_4$, and forms a solid-solution series with forsterite (Mg_2SiO_4) as one end member and fayalite (Fe_2SiO_4) as the other end member. It is one of the few idiochromatic gemstones, and depending on the iron (Fe^{2+}) content the color can vary from yellow green to olive green to brownish-green.

Elbaite (var. Verdelite)
Rob Lavinsky photo, iRocks.com, - CC_BY_SA-3.0, via Wikimedia Commons
Cruzeiro Mine, Minas Gerais, Brazil
Dimensions: 4.2 x 2.5 x 2.2 cm

Elbaite is a member of the tourmaline group and has a chemical formula of $Na(Li_{1.5}Al_{1.5})Al_6Si_6O_{18}(BO_3)_3(OH)_4$. It is an allochromatic mineral with a wide range of colors. If the color is predominantly green, it may be called the varietal name, verdelite. This name also implies that the color doesn't involve the presence of chromium or vanadium.

(Chrome tourmaline is used for this variety.) Instead, substitution of aluminum ions with iron in the ferrous (Fe^{2+}) and ferric (Fe^{3+}) states is responsible for the green color.

When illuminated by a light source, intervalence charge transfer between adjacent iron ions occurs where:

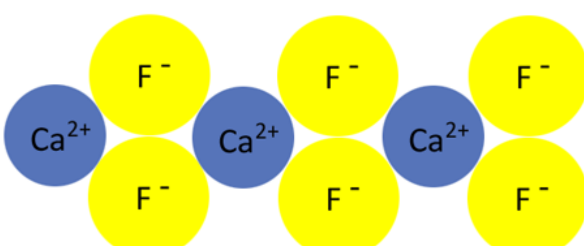
Fe^{2+} ion (at site 1) + Fe^{3+}ion (at site 2)
changes to:
Fe^{3+} ion (at site 1) + Fe^{2+} ion (at site 2)

This transfer of electrons from one ion to another ion results in the absorption of red wavelengths of light.

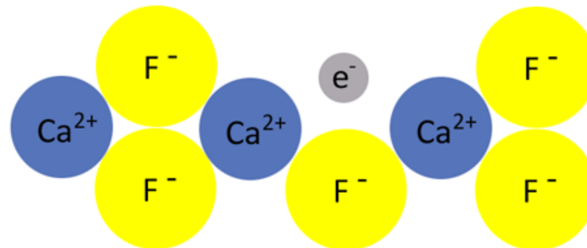
Color Centers

Color centers involve crystal defects where ions are displaced from normal lattice locations either during mineral formation or radiation exposure. There are several types of color centers, and one form is an electron color center where a free electron substitutes for a dislocated ion.

Fluorite, a calcium fluoride, (CaF_2), is an example of an allochromatic mineral whose color is related to an electron color center. In a regular crystal lattice, fluorite's calcium and fluorine ions are arranged in the following pattern:



A fluorine atom may be moved from its normal site due the exposure to a radioactive source, and this displacement creates a vacancy. A free electron is trapped in the vacancy.



This electron can subsequently transition to a higher energy level by absorbing energy of a photon which diminishes the associated wavelength of light.

The range of wavelengths that are selectively absorbed and the resulting fluorite color may be influenced by the presence of rare-earth elements.

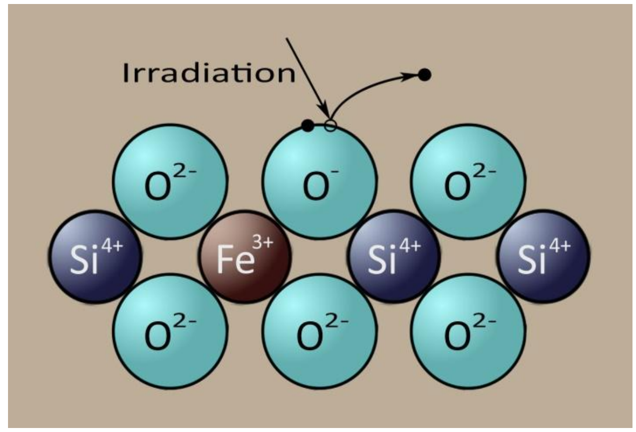
Green Weardale Fluorite
Rob Lavinsky photo, iRocks.com, -CC_BY_SA-3.0, via Wikimedia Commons
Rogerley Mine, Weardale, County Durham, England, UK
Dimensions: 12.9 x 10.3 x 5.4 cm
For green fluorites and particularly for specimens from Weardale, England, investigations have shown that samarium (Sm^{2+}) along with the color center is responsible for the coloration (Bill, et al., 1967).

Green Fluorite Octahedrons
Rob Lavinsky photo, iRocks.com, - CC_BY_SA-3.0, via Wikimedia Commons
Homestake-Jack Pot Mine, Oatman district, Mohave County, Arizona
Dimensions: 8.7 x 7.4 x 5.7 cm

Hole Color Centers

Hole color centers represent another type of color center, and we'll conclude with a rare and somewhat controversial example, prasiolite, a green variety of quartz. Prasiolite has also been called "green amethyst" which the Federal Trade Commission has ruled as being a misleading description. The deceptive term comes from heat treating normal amethyst to produce a green color.

The purple color of amethyst starts with the substitution of some silicon ions with ferric iron (Fe^{3+}). In order to maintain overall charge neutrality, a proton may be attracted around the substitution site. This weakens the force on the electrons of the oxygen ions, and radiation can eject an outer electron. The proton traps the electron, while the missing electron, which is called a hole, leads to different energy levels for the remaining unpaired electron. Transitions of the unpaired electron to these energy levels will result in the selective absorption of wavelengths of light.



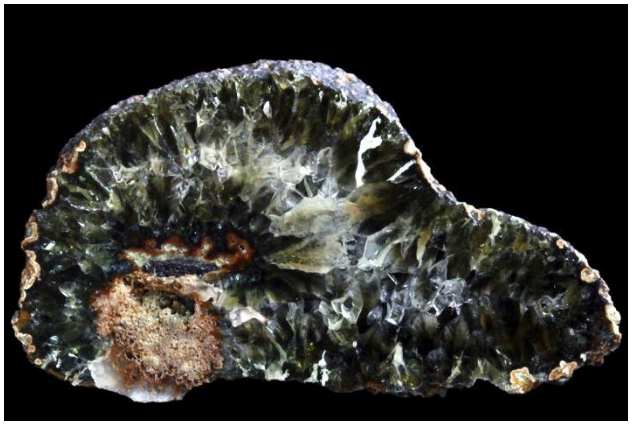
Hole Color Center in Amethyst
Harvey Jong diagram, after Nassau (1983) Fig. 9.5

Heating amethyst will modify its color. A recent study reported the following changes for different temperatures (Cheng and Guo, 2020):

Temperature	Color Change
< 360 °C	No significant change
360-380 °C	Violet begins to fade and gradually becomes colorless
420-440 °C	Changes to light green (prasiolite)
440-580 °C	Gradually changes to yellow (citrine) and deepens until 580 °C. Becomes colorless due to irreversible destruction of color centers along with a phase transformation to β-quartz

The investigators also noted that the amethyst color center is the most unstable at 420 °C.

The narrow temperature range associated with the green coloration may explain the limited number of natural prasiolite deposits. Mindat.org lists only 8 worldwide localities which include Thunder Bay, Ontario, Canada; the Gamsberg area in Namibia; several sites in Poland's Lower Silesia region; and Banwell Hill, England, UK.



Prasiolite Geode
Lech Darski photo, - CC_BY_SA-3.0, via Wikimedia Commons
Płóczki Górne, Lower Silesia, Poland

Płóczki Górne is known for agates which are hosted in basaltic rocks. The agates are made predominately of length-fast chalcedony and may be accompanied by black aggregates of carbonaceous material. The organic compounds were probably deposited from low-temperature hydrothermal fluids (Dumańska-Słowik et al., 2018). This may be an indication of a favorable environment for natural prasiolite formation. Prasiolite was first discovered in the early 1800's in the Lower Silesia region.

Faceted Brazilian Prasiolite
Mauro Cateb photo, - CC_BY_SA-4.0 International, via Wikimedia Commons

This faceted gemstone shows the characteristic light, leek green color of prasiolite. The name is derived from the Greek word *prason (πράσον)* for leek. Most of the prasiolite on the gem market comes from Brazil and may involve heat treated amethyst.

References

Bill, H., J. Sierro, and R. Lacroix (1967) Origin of coloration in some fluorites. *The American Mineralogist* 52: 1003-1008.

Cheng, R. and Y. Guo (2020) Study on the effect of heat treatment on amethyst color and the cause of coloration. *Scientific Reports* 10: 14927.

https://doi.org/10.1038/s41598-020-71786-1

Dumańska-Słowik, M., T. Powolny, M. Sikorska-Jaworowska, A. Gaweł, L. Kogut, and K. Poloński (2018) Characteristics and origin of agates from Płóczki Górne (Lower Silesia, Poland): a combined microscopic, micro-Raman, and cathodoluminescence study. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy* 192: 6-15.

Frisch, P.L., V.W. Lueth, and P.F. Hlava (2002) The colors of smithsonite: a microchemical investigation. *23rd Annual New Mexico Symposium* Nov. 9-10, 2002, Socorro, New Mexico.

Nassau, K. (1983) The physics and chemistry of color. John Wily & Sons, New York: 454 p.

Newnham, R.E. and R.P. Santoro (1967) Magnetic and optical properties of dioptase. *Physica Status Solids (b)* 19(2): k87-k90.

AZ Mining, Mineral & Natural Resources Education Museum Update March 2023

https://ammnre.arizona.edu/

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

On Tuesday, March 7th, we gathered a small group of Monday Crew volunteers to service the outdoor mining equipment. The crew included Bill Yedowitz, Dick Zimmermann, Shirley Cote, Doug Duffy, Andre Meek (joining us from the Superstition Mountain Museum) and new volunteer, Phil Mounier. Activities included checking and inspecting all equipment including the crusher and mucker, cleaning the belt on the Swallow Mine 5-stamp mill, cleaning out the cistern, and running the mill. The crew also cleared the yard of palms and trash and made the area look good as new. It was great to get the crew together and share memories of former Monday Crew leader and millman Charlie Connell, who passed away one year ago.

In addition to our regular activities, we have been working with the new design-build team, led by Kitchell Construction, to begin plans for renovation and museum buildout. So far, the group has made several site visits, taken 3D photos and mapped the building, and begun assessing critical electrical and structural issues. They also met with Bill and the Monday Crew on the 7th to learn more about the mining equipment. We expect to make more progress throughout the year and are excited about changes to come.

Next month we'll share updates about the Flagg Foundation's 30th Annual Minerals of Arizona Symposium, which is being held at the museum on March 31 and April 1 and will be the last event in the building before renovations. Thank you for your continued support!

Monday Crew volunteers (L-R): Dick Zimmermann, Phil Mounier, Bill Yedowitz, Doug Duffy, Shirley Coté and Andre Meek

Millmen cleaning out the cistern for the stamp mill

Running the Swallow Mine 5-Stamp Mill

Arizona Rocks 118

Text and photos by Ray Grant

I am giving a talk about Australian Opal at the Pinal Geology and Mineral Society meeting in Coolidge on Wednesday April 19 and I wanted to include something about Arizona opal in the program, and thought it would be of interest for Arizona Rocks. So here is some information about Arizona opal.

Opal is unusual in that it does not meet the definition of a mineral, but is kept as one for historical reasons. It is tridymite, cristobalite, amorphous silica, or some mixture of this plus water. The two major types of opal are common opal and precious opal. Precious opal shows the play of colors that make it an important gem stone.

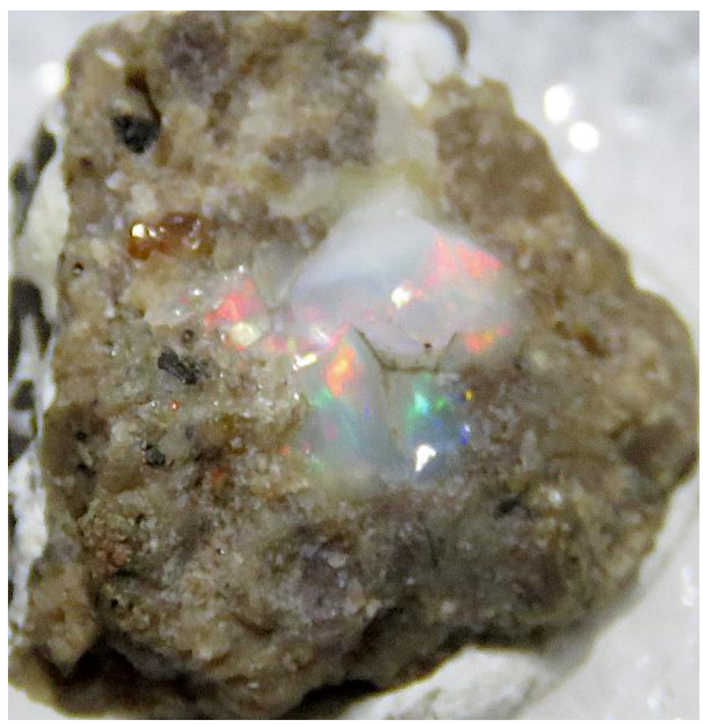
Mindat.org has over a hundred localities for opal in Arizona, but only one area is for precious opal. It is the Blue Fire Opal Claim and other claims near Ruby, Santa Cruz County. Blue Fire is being mined at present and you can buy opal cabochons from Southern Skies Opal on the internet or visit Sunrise Jewelers and Trading Company in Tubac, Arizona.

I also have a specimen of precious opal from the Arthur Flagg Collection. The locality is given as Morgan City Wash which is west of Lake Pleasant, Maricopa County. It is a small specimen and I have no other information about the location.

There are other reports of precious opal, but without specimens, they are suspicious and may be for the Morgan Wash locality. They are in Minerals of Arizona, Arizona Bureau of Mines Bulletin 181 that has: “Reported from the vicinity of Morristown; In pink rhyolite at an undisclosed locality near Castle Hot Springs.”

It would be good to keep your eyes open if in that area, who knows what opals are there.

Opal from Blue Fire Opal Claim near Ruby, Arizona, Jeff Scovil photograph



Flagg Opal specimen from Morgan City Wash, Maricopa County, specimen 0.5 inches across

Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society meeting

April 19, 2023

www.pinalgeologymuseum.org

Ray Grant ray@pinalgeologymuseum.org

The Museum is open from 11 to 4,

Wednesday through Saturday

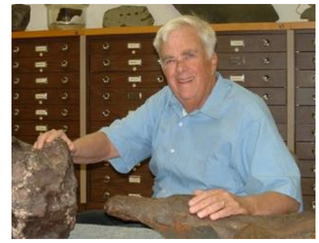
Masks are now optional at the Museum. Please bring your own mask if you wish to wear one. We will have some masks on hand at the Museum, but cannot guarantee to provide them.

We've been holding in-person meetings since September, with a wide range of speakers. Meetings are the third Wednesday at 7pm, doors open at 6:30.

We're also hosting special days at the museum, running member-only field trips, and have greatly expanded our newsletter.

Wednesday April 19, at our monthly meeting Dr Ray Grant returns to give a presentation on Australian Opal. Doors open at 6:00, meeting starts at 7pm. There will be a selection of Australian minerals for sale from 6 to7 before the meeting, plus door prizes, and refreshments. Come early buy a mineral and enjoy the Museum.

FROM ARIZONA STATE UNIVERSITY:



In Memory: Center Founding Director Carleton B. Moore

(September 1, 1932 - February 10, 2023)

It is with great sadness that we bid a final farewell to Center founding director Professor Carleton B. Moore, who passed away February 10, 2023.

Carleton moved to ASU in 1961 at the request of George Fales (longtime meteorite enthusiast, ASU benefactor, and Center philanthropist) to head the newly formed Center for Meteorite Studies. Over the next several decades, Moore not only expanded the Center and ASU's research portfolio, but directly affected the course of science history.

It was Moore who set up the very first carbon isotope analyses at NASA's Lunar Receiving Laboratory to study samples returned by the Apollo missions, after his labs at ASU proved to be the only ones in the world capable of the difficult analyses. The analyses of Apollo samples set the precedent for the study of all types of planetary materials by researchers in the future.

Moore set up and opened the first Meteorite Museum at ASU, making the Center's incredible collection of space rocks available for public viewing as he continued to acquire and study new meteorites.

It was Moore's team who first identified organic molecules in extraterrestrial material, in 1969, pushing the search for the origins of life on Earth in a new direction.

In 1981, Asteroid 5046 Carletonmoore was named in recognition of Moore's immense contributions to the science of meteoritics, and the mineral carletonmooreite, discovered at ASU, was named in his honor in 2021.

Carleton officially retired in 2003. This only meant he came in a little less often to ASU, however, and he was regularly on campus for the next 15 years, checking in on the collection he built, bringing chocolates to Center researchers, and having lunch at the University Club. His immense knowledge of meteoritics and the ASU collection were especially valued by Center researchers after his retirement, who joked about needing to record everything he said (and actually did just that on more than one occasion – many of these conversations are preserved at ASU).

Over the course of his storied career, Carleton touched innumerable lives. He encouraged young scientists just starting their own meteoritics journeys, mentored undergraduate and graduate students who went on to prosperous careers of their own, and was a favorite at outreach events with the public, where he gracefully took on the identification of hundreds of potential meteorites (most of which were meteorwrongs) and gifted surprised youngsters with small meteorites from his personal collection. He will be missed, but will live on in the hearts of all who knew him, in the many scientific advances he published, in the meteorite collection he built, and in the research center he led for over 40 years.

Wordsearch: Minerals of Pinal County

(all are common in Arizona)

P	T	A	Z	U	R	I	T	E	D	U	M	A	L	A	C	H	I	T	E
X	W	B	F	T	O	O	P	E	M	Q	V	T	X	D	J	K	D	T	B
H	W	Y	U	H	L	I	J	A	R	O	S	I	T	E	J	H	O	Y	M
G	O	L	D	O	L	O	M	I	T	E	J	G	N	R	D	D	A	C	U
B	Y	K	J	P	J	M	H	S	B	W	Q	R	U	T	I	L	E	I	S
L	N	X	A	I	P	I	A	F	L	U	U	T	Q	P	Q	E	U	V	C
M	U	E	F	O	L	X	H	Y	I	L	A	U	E	J	K	N	H	G	Q
C	B	E	R	Y	L	M	C	K	N	F	R	R	A	W	T	W	A	Y	V
L	H	A	F	W	C	I	E	R	A	E	T	Q	I	S	J	X	L	N	I
B	J	G	O	L	D	M	N	N	R	N	Z	U	R	I	O	X	I	B	T
C	A	Y	P	U	U	C	Z	I	I	I	E	O	V	L	V	F	T	E	E
A	L	T	Y	C	Y	O	S	X	T	T	C	I	K	V	A	M	E	B	G
H	K	Q	O	U	X	Z	R	T	E	E	E	S	R	E	N	R	E	L	E
L	F	O	P	A	L	H	J	I	K	G	T	E	G	R	A	P	Q	C	B
B	V	N	C	N	O	V	N	I	T	M	M	F	Y	N	D	Y	R	Y	L
N	U	X	J	O	C	J	S	P	A	E	O	Y	P	X	I	R	D	J	G
Z	C	X	C	J	P	B	V	F	A	U	Q	V	S	Y	N	I	W	I	V
C	H	A	L	C	O	P	Y	R	I	T	E	G	U	O	I	T	V	L	N
X	N	Z	S	Z	I	R	E	A	D	A	N	Z	M	I	T	E	L	I	H
X	V	K	L	A	W	X	O	R	S	F	G	S	B	W	E	T	U	O	Q

Azurite
Beryl
Chalcopyrite
Copper
Dolomite
Epidote
Fluorite
Gold

Gypsum
Halite
Ilmenite
Jarosite
Kaolinite
Linarite
Malachite
Muscovite

Opal
Pyrite
Quartz
Rutile
Silver
Turquoise
Vanadinite
Wulfenite

Word search courtesy of the Pinal County Historical Society & Museum

6th ANNUAL GILA COUNTY GEM & MINERAL SOCIETY

"SPRING SHOW & SELL"

The Gila County Gem & Mineral Society is having their 6th annual Gem & Mineral "Spring Show & Sell Event" on Saturday April 1st from 10am – 2pm.

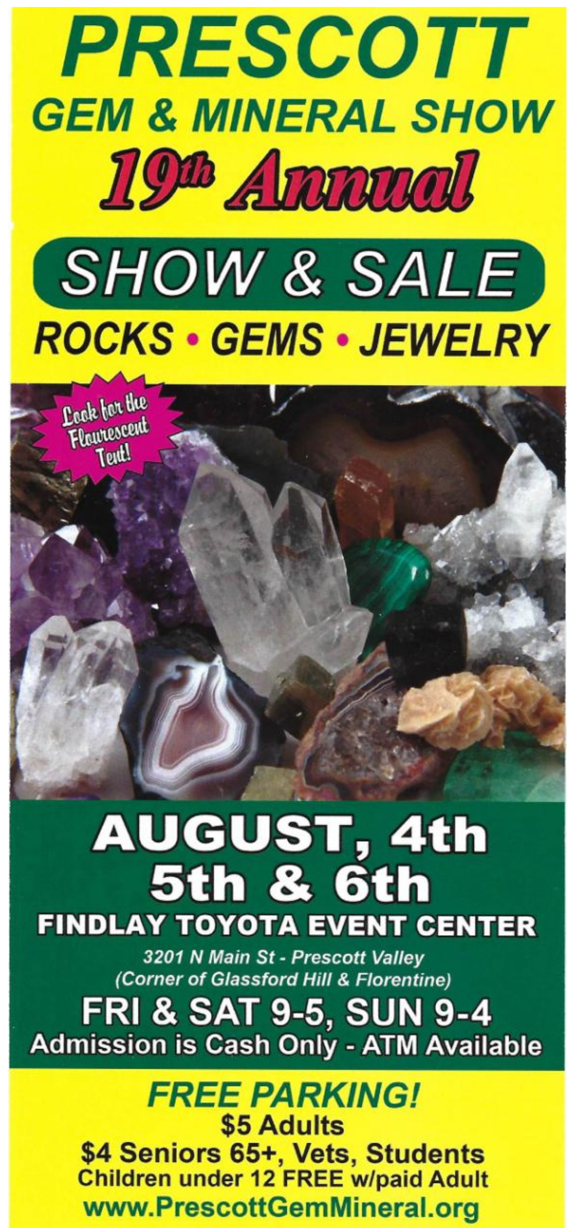
Our event will again be held in the parking lot of Oasis Insurance at 411 W Live Oak (Highway 60). Come and see what we have to offer for sale, make your own rock covered copper tree, grab some popcorn and a drink, and visit with other rock hounds and jewelry makers.

Mohave County Gemstoners
Rock, Gem & Mineral Show
Annual Show
May 6-7, 2023
Sat. 9-5, Sun. 9-4
Free Admission & Parking
Mohave County Fairgrounds
2600 Fairgrounds Blvd.
Kingman, AZ

White Mountain Gem and Mineral Club
Annual Show
July 14-16, 2023
Fri. & Sat. 9-5, Sun. 10-4
Adults $4, Children with an adult free
Show Low Elks Lodge
805 E. Whipple
Show Low, AZ

West Valley Rock & Mineral Club
Annual Show
October 6-8, 2023
Fri. & Sat. 9-5, Sun. 9-2
Adults $3, Children under 13 free
Buckeye Arena
802 N. 1st Street
Buckeye, AZ

Huachuca Mineral and Gem Club
49th Annual Show
October 14-15, 2023
Sat. 9-5, Sun. 10-4
Free Admission & Parking
Sierra Vista Mall
2200 El Mercado Loop
Sierra Vista, AZ



Apache Junction Rock & Gem Club
Meetings are on the 2nd Thursday
Next Meeting: April 13, 2023, 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 4, 2023, 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: April 3, 2023, 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
(Except December)
Next Meeting: April 20, 2023, 5:00 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: April 19, 2023, 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: April 13, 2023, 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 6, 2023, 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 14, 2023, 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 2023, at 6:30 p.m.

BECOME A MEMBER!

Join the Earth Science Museum's

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

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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.

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
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Phone:
602-973-4291

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 2023, at 6:30 p.m.

THANK YOU FOR YOUR CONTINUING INTEREST & SUPPORT!!!

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