EARTHQUAKE

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

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

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April 2023

Volume 12, Issue 4

ESM OUTREACH UPDATE

Mardy Zimmermann, Outreach Coordinator

There were no outreach events this month.

Minerals Found in Diamonds

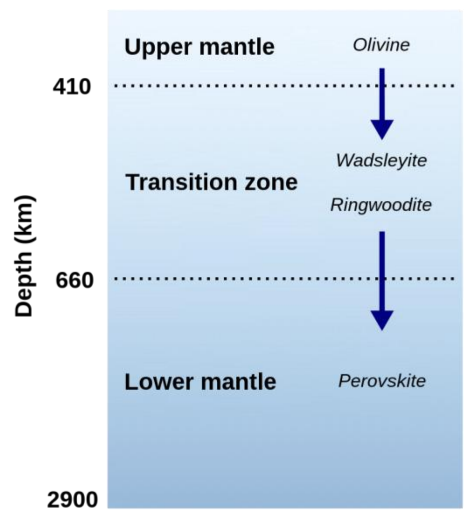
By Harvey Jong

Diamond is one of April's birthstones, so an article with a diamond theme seemed appropriate. A lot, however, has been written about this highly sought-after gemstone (such as the Feb. 2022 article on black diamonds), so we will focus on the minerals found in diamonds and explore some interesting recent discoveries involving "superdeep" diamonds.

Diamond with Unidentified Inclusion
Giuliofranzinetti photo, - CC_BY_SA-4.0 International, via Wikimedia Commons
Dimensions: 1 x 1 mm

While mineral inclusions may detract from a diamond's value as a gemstone, these tiny embedded mineral samples can provide geoscientists with a wealth of information about the composition and conditions inside the Earth.

Diamond's physical strength along with its chemical resistance and inertness create an ideal container for sampling the mantle which is largely inaccessible. Note that currently the deepest drilled hole is the Kola Superdeep Borehole which reached a depth of 12,262 m (40,230 ft.) – only about a third of the way through the Baltic Shield continental crust. Due to a lack of funding, drilling was stopped in 1994, and the project was mothballed.



Mineral Transformations in the Mantle
B. Jankuloski diagram after Smcminn1234, - CC_BY_SA-4.0 International, via Wikimedia Commons

Diamond inclusions along with seismic waves have suggested that the mantle may be divided into several layers which are associated with different mineral phase transformations.

Extracting data from inclusions and applying results towards mantle studies involves some special tools and techniques. Such analysis often entails laser cutting the minerals from the host diamond. But recent advances in instrumentation, such as micro-Raman spectroscopy, have enabled non-destructive in-situ measurements.

One key parameter that researchers need to determine is the depth in the Earth where the diamonds formed. Depths may be estimated using elastic geobarometry which examines the difference in the elastic properties of an inclusion and diamond. Specifically, this method relies on the inclusion remaining at the pressure when it was entrapped by the diamond. The stiffness of the diamond constrains the inclusion from expanding when the diamond is brought to the surface. The residual pressure produces an elastic strain, and a depth may be inferred if the inclusion's elasticity is known.

Estimating the depth for shallow "lithospheric diamonds" (< 200 km [124 mi.]) is relatively straightforward, but "sub-lithospheric" or "superdeep" diamonds present difficulties due to higher temperatures and pressures (Alvaro et al., 2022). These diamonds may undergo plastic deformation and modify the stress state of inclusions as they rise to the surface. Diamond plasticity and its effects on inclusions are not well understood, so depth calculations may be associated with significant uncertainties.

Mineral Inclusions in Lithospheric Diamonds

More than 90% of the mineral inclusions in diamonds are of lithospheric origin (Kjarsgaard, et al., 2022). Based on the main types of host rock of these diamonds, the inclusions may be classified into two suites – eclogitic (e-type) or peridotitic (p-type) minerals.

Eclogitic (E-type) Mineral Inclusions

Eclogite is a metamorphic rock that consists of almandine-pyrope hosted in sodium-rich pyroxene (omphacite). The rock name which means "chosen rock" was created by René Haüy in 1822. Eclogite forms at a very high pressure, but the geodynamic mechanisms that are involved are still being debated.

Eclogite
Woudloper photo, - PD, via Wikimedia Commons
Western Gneiss Region, Norway
Dimensions: Scale is indicated by the one Euro coin which has a diameter of 23.2mm (0.91 in.)

Although eclogites are estimated to make up a minor part (< 5%) of the lithospheric mantle, a relatively high proportion of diamonds are found in this rock type (Tappert and Tappert, 2011). According to Stachel, 2014, the eclogitic mineral suite includes:

Common Inclusions	
Mineral	**Chemical Formula**
Grossular-almandine-pyrope	$(Ca,Fe^{2+},Mg)_3Al_2(SiO_4)_3$
Omphacitic clinopyroxene	$(Ca,Na)(Mg,Fe^{2+},Al)Si_2O_6$
Fe sulfides	Various, usually Ni-poor
Occasional Inclusions	
Rutile	TiO_2
Coesite	SiO_2

Rare Inclusions	
Kyanite	$Al_2O(SiO_4)$
Corundum	Al_2O_3
Ilmenite	$Fe^{2+}TiO_3$
Magnetite	$Fe^{2+}Fe^{3+}{}_2O_4$
Fe-Mg-chromite	$(Fe^{2+},Mg)Cr^{3+}{}_2O_4$
Phlogopite	$KMg_3(AlSi_3O_{10})(OH)_2$
K-feldspar	$KAlSi_3O_8$
Titanite	$CaTi(SiO_4)O$
Staurolite	$Fe^{2+}Al_9Si_4O_{23}(OH)$
Zircon	$Zr(SiO_4)$
Moissanite	SiC
Calcite	$CaCO_3$
Dolomite	$CaMg(CO_3)_2$

Peridotitic (P-type) Mineral Inclusions

The other main diamond host rock is peridotite which is a coarse-grained, ultramafic (< 45% silica) igneous rock. The term encompasses a number of different intrusive igneous rocks and is derived from the gemstone peridot, the deep yellow-green variety of olivine.

Peridotite is believed to be the dominant rock type in the upper 400 km (249 mi.) of the Earth's mantle. It usually contains olivine as its primary mineral and may be classified based on the content of this magnesium iron silicate. Kimberlite, which forms in volcanic pipes, is a rather rare, but well-known, diamond-bearing variant with at least 35% olivine.

Diamond in Kimberlite
James St. John photo, - CC_BY_SA-2.0, via Wikimedia Commons
Kimberley, South Africa
Seaman Mineral Museum collection

According to Stachel, 2014, the peridotitic mineral suite includes:

Common Inclusions	
Mineral	**Chemical Formula**
Cr-pyrope	$Mg_3(Al,Cr)_2(SiO_4)_3$
Olivine	$(Mg,Fe)_2SiO_4$
Enstatite	$Mg_2Si_2O_6$
Cr-diopside	$Ca(Mg,Cr)Si_2O_6$
Mg-chromite	$MgCr_2O_4$
Fe-Ni sulfides	Various
Rare Inclusions	
Coesite	SiO_2
Mg-ilmenite	$(Fe^{2+},Mg)TiO_3$
Magnesite	$MgCO_3$
Calcite	$CaCO_3$
Native iron	Fe
Zircon	$Zr(SiO_4)$
Phlogopite	$KMg_3(AlSi_3O_{10})(OH)_2$
Yimengite	$K(Cr,Ti,Fe,Mg)_{12}O_{19}$

It is interesting to note that a survey of 2,844 inclusion-bearing diamonds found that 65% contained peridotitic minerals, 33% included eclogitic minerals, and the remaining 2% involved minerals from other host rock types (Stachel, 2014).

Garnet Inclusion in a Diamond
Photo by Stephen Richardson, University of Cape Town, South Africa, - CC_BY_SA-2.5 Generic, via Wikimedia Commons

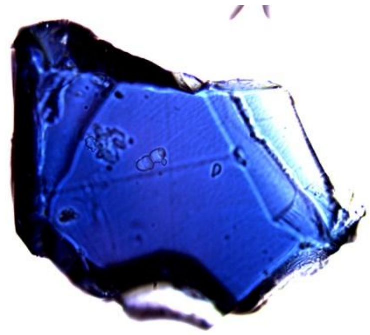
The first description of a mineral inclusion in a diamond may have involved garnet. In 1645, John Evelyn, an English writer best known as a diarist, noted in his travels around Venice "a diamond which had growing in it a faire ruby". Since the occurrence of ruby as a diamond inclusion is very rare, the inclusion was most likely a peridotitic garnet (Stachel et al., 2022).

Some New Mineral Discoveries

Several new mineral discoveries have involved sub-lithospheric or superdeep diamonds. We'll start with ringwoodite which occurs in the mantle's transition zone and generated some sensational news headlines, such as "Rare Diamond Confirms That Earth's Mantle Holds an Ocean's Worth of Water"[1].

Ringwoodite

Ringwoodite is a high-pressure polymorph of forsterite, a magnesium silicate (Mg_2SiO_4). The mineral was first synthesized in 1958.



Synthetic Ringwoodite

Jasperox sample & photo, - CC_BY_SA-3.0, via Wikimedia Commons

Dimensions: ~150 µm across

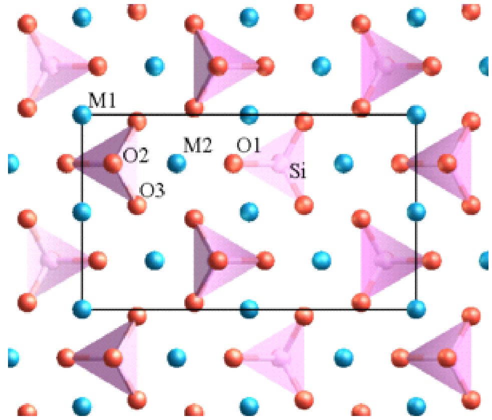
In 1969, it was discovered in the Tenham meteorite and named after A. Edward "Ted" Ringwood (1930-1993), an Australian experimental geochemist and geophysicist who studied polymorphic phase transitions of mantle minerals. Seismic observations, in conjunction with high-pressure experiments, inferred that this mineral may be present in large quantities in the mantle transition zone at a depth of 525-660 km (326-410 mi.). This represented a somewhat controversial finding given the lack of direct evidence that ringwoodite was actually present in the Earth. In 2014, however, the first terrestrial occurrence of ringwoodite was discovered in a diamond inclusion (Pearson et al., 2014). The colorless to light brown irregular host diamond was found in the alluvial deposits of Brazil's Juína district and weighed only 0.09 g.

[1] Becky Oskin, Live Science article, March 12, 2014 featured in *Scientific American.*

Annotated Image of Diamond JUc29 with Ringwoodite Inclusion
Photo by Graham Pearson, University of Alberta, - CC_BY_SA-4.0 International, via Wikimedia Commons
Juína, Brazil
Dimensions: diamond is 3mm wide, ringwoodite inclusion is ~40 µm

Later another diamond containing ringwoodite was described by Tingting et al., 2022. It was found at the Karowe Mine in northeast Botswana.
https://www.researchgate.net/publication/363852163/figure/fig1/AS:11431281095912139@1668052631403/Photomicrographs-of-inclusions-within-a-type-IaB-gem-diamond-from-the-Karowe-mine.png
Photomicrographs and SEM Images of Inclusions Within a Type IaB Diamond
Photos by Tingting Gu, Gemological Institute of America, copyrighted images via researchgate.net
Karowe Mine, Botswana
Field of view: 0.91 mm
Close-up of an inclusion containing an assemblage of hydrous ringwoodite (Rw), enstatite (En), and ferropericlase (Fp).

Ringwoodite has a spinel crystal structure that can incorporate water as hydroxyl (OH) groups.

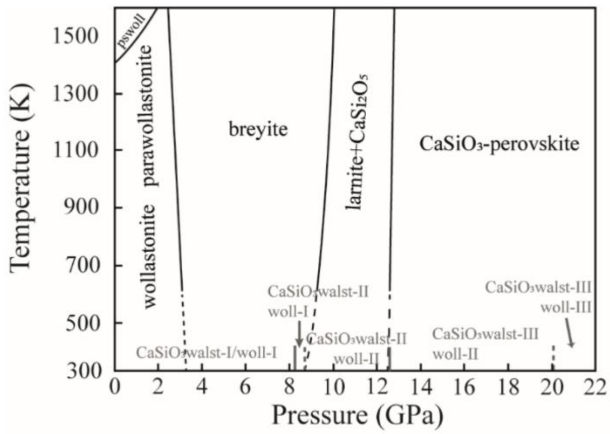


Structure of Olivine
Diagram created by andreww, - PD, via Wikimedia Commons
Oxygen atoms are shown in red, silicon in pink, and blue indicates magnesium/iron ions. Hydroxyl group substitutions mainly occur at the magnesium sites, but a minor, but still significant, amount may involve silicon (Ye et al., 2012).

Synthetic samples may contain up to about 3 wt% H_2O (Kohtstedt et al., 1996), while the H_2O content of a ringwoodite inclusion was conservatively estimated to be 1.4 wt%. This discovery suggested a highly controversial hypothesis that the mantle transition zone could be a major repository for water and represent the ultimate origin of the water in the Earth's hydrosphere (Pearson, et al., 2014).

The Lower Mantle and Perovskite-Type Minerals

The lower mantle is the region from 660-2,900 km (410-1,802 mi.) below the Earth's surface. It is associated with very high pressures (24-127 GPa) and temperatures (1900-2600 K) which lead to different mineral phase transformations:



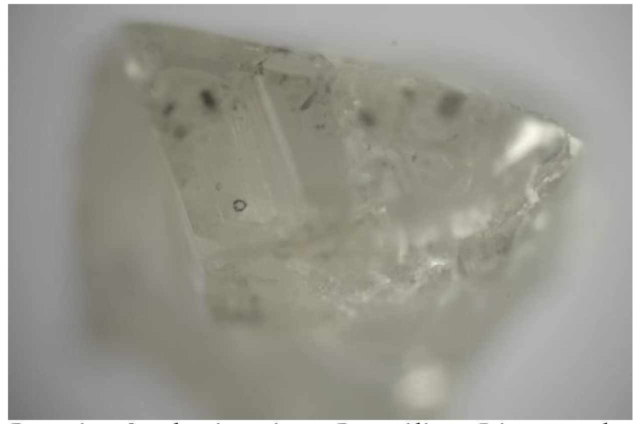
Phase Diagram of $CaSiO_3$ up to 22 GPa and 1500 K
Figure 1 from Milani et al., 2021, - CC_BY_SA-4.0, via https://doi.org/10.3390/min11060652
Note that $CaSiO_3$-perovskite is now known as davemaoite which will be described later.

The predominant mineral phase involves perovskite-type silicates or perovskites which have crystal structures based on the general formula ABX_3, where A and B are cations of different sizes and X is an anion that bonds to both cations. This structure was first observed in the mineral perovskite, a calcium titanium oxide ($CaTiO_3$).

High-pressure perovskites were first synthesized in the 1970s, and a few species, such as bridgmanite, were later identified in meteorites. More recently, inclusions in diamonds have provided direct or circumstantial evidence of natural occurrences in the lower mantle.

Breyite

Since 1991, alluvial diamonds from the São Luiz placer deposits, Juína area, Mato Grosso, Brazil have been studied for their mineral inclusions. One inclusion involves a silicate perovskite that may have originated in the lower mantle. The mineral was approved as a new species in 2021 and named breyite in honor of Gerhard P. Brey (b. 1947), a German mineralogist, petrologist, and professor at the Goethe-University, Frankfurt, Germany.



Breyite Inclusion in a Brazilian Diamond
Photo by Frank Brenker, Goethe University Frankfurt, licensed content with no usage restrictions, courtesy of EurekAlert!/AAAS, via https://www.eurekalert.org/multimedia/777931

The inclusion used in identifying breyite was approximately 140 x 150 x 100 µm. Breyite is transparent, colorless, has a vitreous luster, and is not fluorescent. It may be associated with ferropericlase (Mg,Fe)O and perovskite ($CaTiO_3$). Breyite's simplified chemical formula is $Ca_3Si_3O_9$, and it has a triclinic crystal structure. The cyclosilicate represents the second most abundant mineral inclusion after ferropericlase in superdeep diamonds (Brenker, et al., 2021).

Four different processes have been proposed on how the mineral forms (Brenker, et al., 2021). One theory involves superdeep diamonds that grew either in the deeper portion of the transition zone or in the lower mantle and originally contained $CaSiO_3$-perovskite (davemaoite) inclusions. As the diamonds rose to the upper mantle, the $CaSiO_3$-perovskite was transformed into the lower pressure polymorph of breyite. The depth for this transformation is not known, but 270-300 km (168-186 mi.) has been suggested since the associated pressures and temperatures may have allowed plastic deformation and volume changes of the diamonds.

Davemaoite (formerly $CaSiO_3$-Perovskite)

Laboratory studies in the 1970s suggested that two of the most common mineral phases in the lower mantle include magnesium silicate ($MgSiO_3$) perovskite and calcium silicate ($CaSiO_3$) perovskite. In 2014, a natural occurrence of $MgSiO_3$-perovskite was found in the Tenham meteorite, and the mineral was named bridgmanite in honor of Percy Bridgman (1882-1961) who received the 1946 Noble Prize for Physics for his high-pressure research (Tschauner et al., 2014).

Identifying a natural specimen of $CaSiO_3$-perovskite, however, has been more challenging since this perovskite is stable only at pressures greater than 200,000 atmospheres (20 GPa) (Liu and Ringwood, 1975). When removed from a high-pressure environment, it transitions to lower pressure mineral phases, such as breyite or wollastonite.

A discovery was eventually made in the inclusions of a diamond from the Orapa Mine in central Botswana. This involved finding the right diamond in which the $CaSiO_3$-perovskite survived the ascent to the surface and determining unambiguously that this diamond formed at a depth in the lower mantle.

Identification and characterization of the tiny 4x6 µm and 4x16 µm inclusions required some rather amazingly precise analytical tools. To determine the crystal structure, synchrotron x-ray diffraction and fluorescence was performed using the Argonne National Laboratory's Advanced Proton Source. Intense x-rays were focused down to a 0.5x0.5 µm spot which produced the expected diffraction pattern and fluorescence data of $CaSiO_3$-perovskite.

To confirm the identification, both infrared (IR) and Raman spectroscopy were used. Cubic perovskites have three IR-active modes and no Raman-active modes. Two of the expected three IR-active modes were observed, while no Raman peaks were detected.

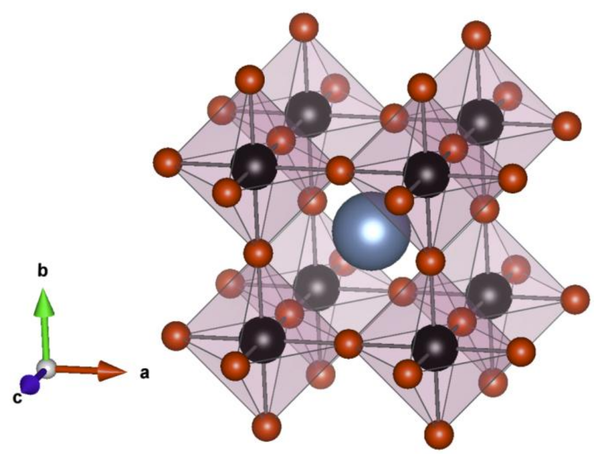
The chemical composition of the inclusions was determined using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). A laser with a 100 µm diameter beam was used to excavate 5-8 µm and 80-100 µm below the surface of the polished diamond sample to reach the $CaSiO_3$-perovskite. The laser, then, generated fine, ablated particles, and these particles were introduced to a plasma torch. The resulting excited ions were analyzed with a mass spectrometer.

Diamond Sample that Contained Davemaoite
Aaron Celestian photo, courtesy of the Natural History Museum of Los Angeles County
Orapa, Botswana

Dimensions: The original diamond was 4 mm wide and weighed 81 mg. A 0.5 mm thick plate was cut and polished from this crystal.

The two round spots surrounded by burn marks indicate where the LA-ICP-MS analysis was performed.

In 2020, the International Mineralogical Association approved $CaSiO_3$-perovskite as a new mineral. Researchers named the mineral, davemaoite, after Ho-Kwang (Dave) Mao (b. 1941), a Chinese-American geophysicist who made several discoveries in high-pressure geochemistry and geophysics (Tschauner et al., 2021).



Structure of Davemaoite
VESTA model constructed by Hiroooooo, - CC_BY_SA-4.0 International, via Wikimedia Commons
Silicon atoms are shown in black, oxygen ions are red, and calcium appears as steel blue

In addition to being one of the main components (estimated to be around 5-7 percent) of the lower mantle, davemaoite may also represent an important repository for radioactive elements, such as thorium and uranium. Experimental studies of synthetic aluminum-rich $CaSiO_3$-perovskite have shown an ability to contain large amounts of uranium (up to 4 at.% U) (Gréaux et al. (2009).

Trace amounts of potassium were detected in the davemaoite inclusions which suggest that the mineral may be a lower mantle equivalent of garnet which can accommodate and store large cations. This leads to an interesting implication that davemaoite may serve as a host of radioactive heat sources in the Earth's mantle (Tschauner et al., 2021).

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

https://ammnre.arizona.edu/

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

On Friday, March 31st and Saturday, April 1st the museum hosted the Flagg Mineral Foundation's 30th Annual Minerals of Arizona Symposium. This was the second consecutive year that the symposium has been held at the museum since it closed in 2011. The symposium's theme this year was 'Celebrating the Field Collector' and it featured presentations from several esteemed collectors, including Barb Muntyan, Les Presmyk, Stan Celestian, Tony Potucek, Gary Fleck, Jeff Langland, Graham Sutton, Steve Scott, John Rakovan, Jeff Scovil, and Jeff Smith. The event also included mineral sales from local dealers. The weekend was a great success with a good turnout of Flagg Foundation members and friends of the museum. It was a fun opportunity for visitors to see the building before we begin renovations. We will be taking a break from hosting during that time for the next year or two but hope to resume hosting in the future, and we're excited about how the museum will look next time we welcome this group.

Symposium attendees listening to Stan Celestian talk about collecting to build teacher and educational earth science kits.

Ray Grant and Jeff Scovil checking out mineral specimens for sale at the Shannon & Sons Minerals booth

In other news, we also finished a new exhibit at the Arizona Senate building on the Capitol Mall at 1700 W. Washington St. The exhibit is located in the third floor lobby area and consists of several wall-mounted display cases. There are five themes exhibiting mineral specimens spanning all of Arizona's fifteen counties. The first theme is ‘Arizona Quartz and Calcite,’ which includes exceptional varieties of quartz and calcite from localities around the state. ‘Arizona Building Stone and Industrial Minerals, includes quarried stone and industrial minerals like coal and gypsum. ‘Arizona Gemstones and Lapidary Art’ features a carved sphere collection from the former AZ Mining and Mineral Museum’s lapidary shop as well as both rough and cut material. ‘Arizona Fossils and Petrified Wood’ includes classic rainbow wood and neat fossil specimens from across the state. Last but not least, ‘Arizona Copper and Copper Minerals’ showcases iconic green and blue copper carbonates, shiny copper sulfides, and stunning native copper from historic AZ mines. If you are attending a legislative session or touring the Capitol Mall, we recommend you visit this exhibit as well as our long running display at the State Capitol next door, which includes mineral specimens by county, Arizona State symbols, and touchable larger specimens.

View of the five wall cases comprising our new exhibit the AZ Senate building on the Capitol Mall.

Finally, on the development front, we’re making exciting progress with our contractors and architects as we move closer towards our goal of a new natural resources museum. We’ll keep you updated about any big developments. Thanks to all for your continued support.

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Arizona Rocks 119

Text and photos by Ray Grant

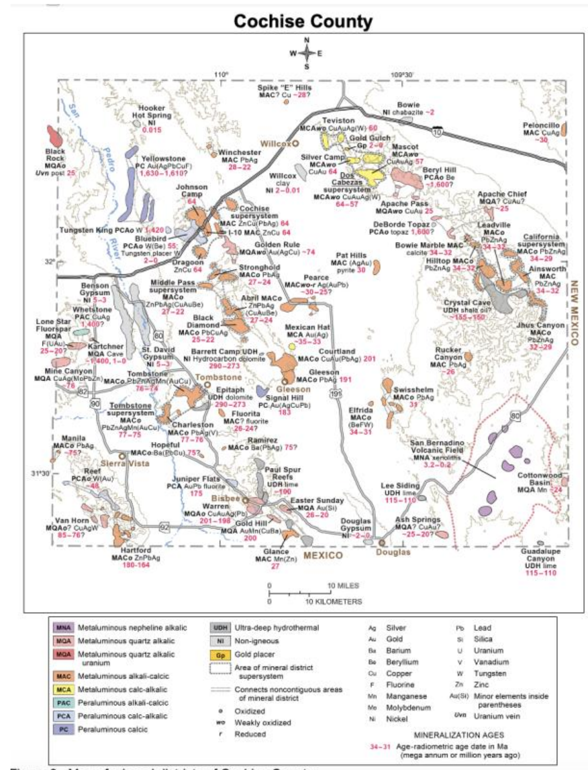
If you are interested in Arizona mining, mining history, minerals, or geology, there is a new book you need to have. It is Arizona Mineral Districts v.1, Cochise and Santa Cruz Counties by Jan Rasmussen and Stanley Keith.

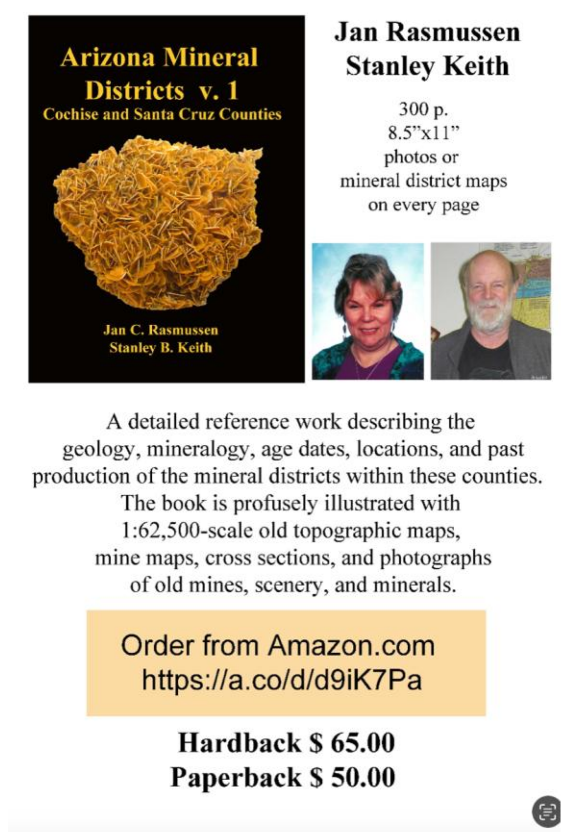
The project started with the new mineral district maps that they did for the 4th edition of the Mineralogy of Arizona. They updated the old district maps and for as many of the mineral occurrences reported in the book as possible the district the mineral came from is given.

In their new book for each district shown on the map there is information about the age, the geology, the minerals, location (latitude, longitude and township, range), and the mines found there. Production data from the mines in the district when available is given, and there are maps, mineral photographs, historical photographs, and additional references.

For mineral collectors there are great uses for this book. If you have a specimen from or an interest in a specific mine or area, you can get the background information. If you are interested in exploring for new locations look for a district of interest and get the information you need to go exploring. For example, I opened the book to the Leadville District in Cochise County. The minerals listed include anglesite, cerussite, galena, and scheelite and there is long list of mines in the district. Might be a place to research more and make a trip.

Order at https:a.co/d/d9iK7Pa. To me, this is one of the best publications I have seen about Arizona mining and minerals, I am anxiously waiting for the other counties to be finished.





Pinal Museum and Society News

351 N. Arizona Blvd., Coolidge, AZ

Pinal Geology and Mineral Society meeting

May 17, 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 May 17, at our monthly meeting:

May program will be Richard Sichling about Mineral Collecting in Arizona. Meeting starts at 7 and the Museum will be open at from 6 to 7 for a sale of Arizona Minerals. Come get some new specimens and help the Museum.

Box of fossil shark's teeth from Florida for kids' activities donated by Steve Scott

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

Mineralogical Society of Arizona
June 3-4, 2023
Sat. 9-5, Sun. 9-4
$5 adults, $3 MSA members, 12 & under free
El Zaribah Shriners Auditorium and Event Center, 552 N 40th Street
Phoenix, 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: May 11, 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: May 2, 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: May 1, 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: May 18, 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: May 17, 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: May 9, 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: May 4, 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: May 12, 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.

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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

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ESM Earth Science Investigation Team Membership Form

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Membership benefits:

- Monthly e-newsletter *Earthquake*
- Official team membership card
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Visit us at:

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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
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