In conjunction with the Mineralogical Society of America and the Tucson Gem & Minerals Society®, Friends of Mineralogy is pleased to announce the 43rd Annual Tucson Mineral symposium

"Shades of Green: From apatites to zeunerites – more than just emeralds."

Saturday, February 15, 2025
from 10 AM to 5:00 PM.

The 43rd Tucson Mineral Symposium
Tucson Convention Center, Tucson, AZ

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Acknowledgments

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The 43rd FM-TGMS-MSA Tucson Mineral Symposium

Theme " Shades of Green: From apatites to zeunerites – more than just emeralds."
Saturday, February 15, 2025,
Tucson Convention Center, Tucson, AZ

10:00 AM Opening of symposium

10:00-10:15 AM Introduction by symposium chair, **Mark Jacobson**

10:15 – 10:45 AM **Nathan Renfro** – Through the Lens: The Microworld of Green Minerals

10:45 - 10:55 AM break

10:55 - 11:25 AM **Nicole Ahline,** Nathan Renfro, and Aaron Palke – Gemological Characterization of Emeralds and Hiddenite from Alexander County, North Carolina

11:25- 11:35 AM break

11:35 – 12:05 AM **William "Bill" Stephens** – Geology and Mineralogy of the Wavellite Occurrence at Mount Pleasant Mills, Snyder County, Pennsylvania

12:05 - 1:30 PM Lunch

1:30 – 2:00 PM **Jim Clanin** – Emeralds from Panjshir Valley, Afghanistan

2:00 - 2:10 PM break

2:10 - 2:40 PM **Peter Megaw** – Los Verdes...Green Minerals from Mexico

2:40 - 2:50 PM break

2:50 – 3:20 PM **Kenneth C. Zahn** – My 45-Year Love Affair with Maryland's State-Line Pit "Gem Serpentinite" (Williamsite/Antigorite)

3:20 – 3:40 PM extended break

3:40 – 4:10 PM **Benjamin Murphy and Anne Fulton** – Cr-azy Green and Red Minerals: On the Occurrence and Genesis of Chlorite-Fuchsite-Ruby Rocks of the Granite Mountains, Wyoming

4:10 – 4:20 PM break

4:20 – 4:50 PM **Markus Raschke** – Mushistonite from Xuebaoding: from 'Panda Ore' to quantum spin system

4:50 PM close of symposium

The 43rd FM-TGMS-MSA Tucson Mineral Symposium

Through the Lens: The Microworld of Green Minerals

Nathan Renfro, Senior Manager
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There are a number of green minerals which contain interesting inclusions. From apatite to zircon, inclusions in these minerals provide information about the geologic conditions that existed at the time the mineral was formed. Emeralds which get their green color from chromium and vanadium contain an abundance of inclusions that represent the genetic conditions which they form. Tourmalines typically are elbaite or dravite varieties are also often colored green by iron or occasionally copper and they also can showcase several interesting and remarkable inclusions that tell the story of their formation. Demantoid garnets also contain interesting inclusions related to their metamorphic growth environment and they are generally colored green by iron or chromium. Some minerals are idiochromatic meaning that the color is intrinsic to their chemical composition rather than trace element impurities. Malachite is such a mineral and can showcase interesting microfeatures when observed with the microscope. Peridot is also an idiochromatic variety of the mineral olivine whose color is a result of a significant amount of iron in its crystal structure and it also contains a wide variety of inclusions that represent the various environments which it forms.

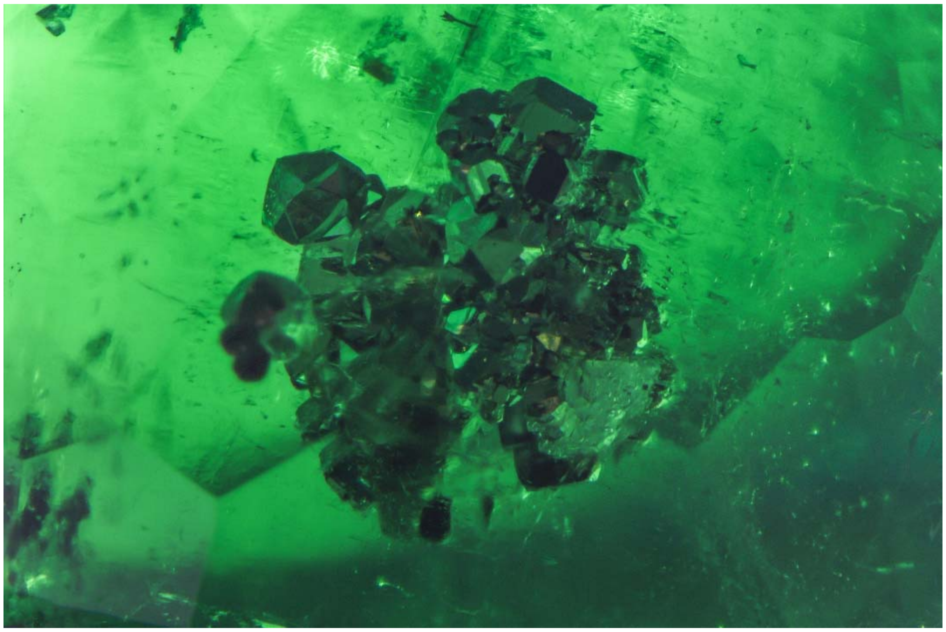

Figure 1. A cluster of pyrite crystals is present in this bright green emerald from Colombia. Field of view 4.79mm.

There are also many interesting green minerals that occur as inclusions in other mineral hosts. These would include green fluorite, sometimes colored green by samarium, in colorless topaz or vibrantly colored green tangeite, who's color results from vanadium, in quartz. Green micas such as fuchsite which owe their color to chromium are sometimes encountered in minerals like quartz. Green spinel inclusions are also sometimes encountered in blue sapphires.

This presentation will showcase a wide cross section of minerals both as a green host mineral as well as a green inclusion in a non-green mineral host.

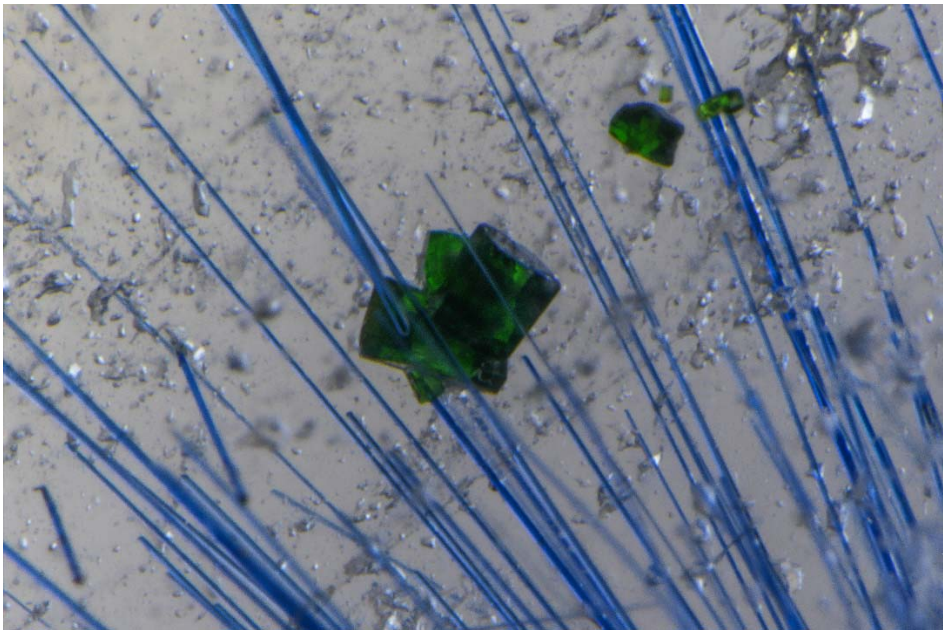

Figure 2. Vibrant green inclusions of tangeite are delicately perched on needle-like inclusions of papagoite in a quartz host from South Africa. Field of view: 3.35mm.

Nathan Renfro – Speaker Biography

Nathan Renfro, a native of western North Carolina, developed an interest in minerals during his late teens, which was sparked by his grandfather's rock collection. In 2006 he completed his undergraduate studies in geology and then went on to enroll at GIA for the resident Graduate Gemologist (GG) program as a recipient of the William Goldberg Diamond Corporation scholarship. After finishing the Graduate Gemologist program at GIA, he was hired by the GIA laboratory as a diamond grader and soon transferred to the Gem Identification department in 2008. Since then, Mr. Renfro has authored or co-authored more than one hundred gemological articles and lectured to several gem and mineral groups throughout the Unites States. His primary areas of gemological interest are photomicrography and identification of inclusions, gemstone cutting and defect chemistry of corundum. Mr. Renfro is currently the Senior Manager of the Colored Stone department in Carlsbad, CA and New York, NY. He is also a microscopist in the Inclusion Research Department. Mr. Renfro is the editor of G&G's Microworld quarterly column which is published in the journal Gems and Gemology, where he is also a member of the editorial review board. Mr. Renfro also completed his FGA in 2014.

The 43rd FM-TGMS-MSA Tucson Mineral Symposium

Gemological Characterization of Emeralds from North Carolina, United States

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The Robert Mouawad Campus,
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*presenter,

Emerald deposits in North America are few and far between. Of the known deposits, the emeralds discovered in the piedmont region of North Carolina have both a historical significance and a gemological distinctiveness (Kunz 1907). Known as "Green Bolts" by the local population prior to their world-renowned fame, these emeralds are characterized by their colorless core and green rim body color and a chemistry that differentiates them from other geographical origins.

When discussing North Carolina emeralds, hiddenite must also be brought into the conversation. Hiddenite is the green variety of the gem species spodumene, $LiAlSi_2O_6$, and was named after William Hidden. He was one of the miners who discovered the gemstone in neighboring pockets in which the emeralds were unearthed in. These mines in Alexander County are currently the only known significant locality in which this stone is found in North America.

Here, we will discuss the history as well as the chemistry, and other characteristics, that can aid in the identification of North Carolina emeralds and hiddenite, focusing on the mines in Alexander County (figure 1), as well as Mitchell County.

Figure 1: Left: A hiddenite rough measuring 1.15 inches tall and weighing 12.87 carats and a faceted emerald cut hiddenite weighing 0.57 carat. Right: A rough emerald and a cut-cornered modified brilliant emerald weighing 2.83 carats. All four of these stones are from the Adams Farm, Alexander County. Emeralds courtesy of Eric Frtitz. Photos by Robert Weldon/GIA©

References

Kunz, G. F. (1907). *History of the gems found in North Carolina*. Raleigh: Uzzell. p. 37-48.

Nicole Ahline - Speaker Biography

Nicole Ahline, originally from Chicago, Illinois, completed her undergraduate studies in geology at Cornell College in 2015. In 2016 Miss Ahline enrolled at GIA for the Graduate Gemologist (GG) program earning her GG credentials in that same year. Miss Ahline has also completed the Gem-A Gemmology Diploma program in 2020. In 2016, she was hired by GIA as a gemologist in the gem identification department and is now a supervisor. While at GIA she has been a frequent contributor to Gems & Gemology, and has given lectures on numerous gemological topics. Miss Ahline's current research interests include geographic origin of corundum and emeralds and origin of color in colored diamonds.

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Geology & Mineralogy of the Wavellite Occurrence, National Limestone Quarry, Mount Pleasant Mills, Snyder County, PA

Bill Stephens, PG.
President Stephens Environmental Consulting, Inc.
FM-PA Chapter President
FM-National President
EFMLS Region IV & V RVP

Quality collectible Wavellite was discovered approximately 25 years ago at the National Limestone Quarry at Mount Pleasant Mills (NLQ-MPM), Pennsylvania. The quarry, located approximately 40 minutes north of Harrisburg in Snyder County PA has become a mecca for collectors. This quarry mines limestone mainly of the Keyser and Tonoloway Formations that occur within Lime Ridge. Like many quarries exploiting these formations, minerals such as calcite, dolomite, strontianite, celestite and fluorite are found at this quarry and have been of interest to collectors for decades. The discovery of Wavellite in 2000 by the owner has piqued interest in this particular location.

A "green" mineral was discovered by the Mount Pleasant Mills quarry owner Eric Stahl in the early 2000's while clearing a perimeter roadway on the upper bench of the quarry along the southerly property line. He invited a local rockhound/expert collector or two to investigate, they did some digging and confirmed the species to be wavellite. They mined a bit, word got out and clubs began asking permission to come and dig.

Wavellite and associated species identified (and confirmed by laboratory testing by Ron Sloto) at the site including planerite, turquoise, variscite, vauxite and cacoxenite, all of which are phosphates, are largely of mineralogical interest. Non-specimen grade wavellite has been mined around the turn of the 20th century at another site in PA to make matches and wavellite is known from other quarries. (Stefanic, Michael, Master's Thesis) These phosphates occur in siliciclastic rocks of the Ridgeley member of the Old Port Formation, which is younger than the Keyser Formation it overlies. The beds of the Ridgeley that contain Wavellite occur in a relatively narrow zone of near vertical dipping beds that run roughly parallel to the perimeter road along the southern quarry boundary.

The type and classic locality for specimen quality Wavellite in the US is in Arkansas, and many mineralogy/mineral books that have example photographs of Wavellite will show a color specimen from Arkansas. Specimens from NLQ-MPM rival any from Arkansas in size and quality, and the deposit is just being explored. MPM Wavellite was not documented in the literature beyond an abstract two paragraphs long in a proceedings book (Rochester I believe) from the mid-2000's until Ron Sloto published his article on the Phosphate Minerals of Lime Ridge in a recent issue of the Mineralogical Record (Vol. 53, September -October, 2022.

I first visited this site in 2015 (I think) and had great success. I went back several times as the first time the adit was open and we were able to get at the veins in solid rock, not spoils. I and others got some killer specimens. I prepared my first Power Point Presentation that year and have updated and amended it almost every year since. Our understanding of the deposit has been greatly enhanced by two machine digs I conducted, the first in March of 2022 with Ryan Klockner of Geology365 and current President of FM NJ Chapter, and the second in March of this year (2024) with Tommy Greene (a.k.a. "The Craft Miner" of the North Jersey Club.

During the 2022 dig, machine-assisted excavation and documentation of wavellite veins was conducted 5 days over a period of about a month, with other geologic work ongoing.

Mapping of the entire quarry was accomplished by drone mapping mission following the 2022 machine dig, with surveyed ground control points employed to constrain the 3D model and orthomosaic. There were some problems with the model due to the relief and some contours are off a few feet, but the mission was largely a success and yielded very high-resolution color orthomosaic and snapshot of the quarry just before the latest shots.

Following the 2022 dig, additional structural data including strike and dip measurements on bedding, joints and fractures were taken remotely by Total Station and calculated using a spreadsheet developed by Oneida University and modified by myself for field application. This “proof of method concept” was also applied at the New Paris Quarry with great success and demonstrates how structural measurements can be taken with the corresponding position coordinates for those areas inaccessible for direct measurement. The structural analysis is ongoing, but what has become clear, and what we will show is that mineralization of collectible crystals in both the quarry and the Ridgeley member of the Old Port Formation is controlled by brittle deformation events. Phosphate mineralization appears to be a post-Alleghenian epigenetic event, associated with renewed tectonism of undetermined age.

The 2024 machine dig moved from the easterly limits of the west pit approximately 35 feet east and as much as 20 feet below the level of the road. Hundreds of specimens were recovered. Of particular note was the general shift in exterior color from dark green to yellow. Though Ryan’s 1 inch yellow ball matrix specimen remains the largest free standing individual crystal, many others were discovered and yellow became the dominant color in a zone we refer to as the “Lemon Drop” zone. That zone was completely dug out during the 2024 machine dig, and the eastern adit was reopened and producing wavellite at the end of our dig. The 2024 machine dig was followed by an exclusive joint field trip hosted by FM-PA and CPRMC, also attended by the Franklin club the first Saturday in April. Approximately 125 individuals were in attendance and many fine specimens were recovered along with a trilobite.


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EXHIBIT_1: Digital Drone Orthoimagery
Sources: USGS, Cecil County GIS Dept., SECI, USDA


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FIGURE_2: Digital Drone Orthoimage MPM 04-13-2022
West (upper) Wavellite Pit Post-Dig
COPYRIGHT 04-13-2022
Sources: USGS, Cecil County GIS Dept., SECI, USDA

Photograph 1. of the Westerly (Upper) Wavellite Adit/Pit. Previously existing spoils that were used to build up and berm the road. New spoils that do contain specimens of Wavellite overlooked during the exploration. The active workings extend below the cardboard box easterly into the wall. The westerly side of the pit contains no Wavellite. Wavellite extends from the lower left (westerly, exposed) shoulder of the excavation to 3 feet off the southerly wall (road), down about 16 feet and easterly toward the easterly pit.

Photograph 2. Extent of excavation near the end of the 2024 machine dig. Tommy Greene pointing out wavellite crystals in the breccia zone which is quite soft and crumbly at this depth (fault gouge, weathering).

Figure 1. (left) The best specimen from the "Lemon Drop" zone, Breccia zone, 2024 dig.

Figure 2 (left) Wavellite "Astroturf" after pressure washing with water, from the of 2022 dig.

Figure 3 (right) "Pina Colada" Wavellite after pressure washing with water, from the of 2022 dig.

Figure 4. Still need needs some cleaning after pressure washing with water. Love the Shimmer, from the 2022 dig.

Figure 5. “Peas Popping” after pressure washing with water, from the 2022 dig.

William “Bill” Stephens – Speaker Biography

Bill Stephens is a licensed Professional Geologist (DE, GA, NC, PA, SC, UT, VA), (MS, AL Pending), current President of FM-PA Chapter and FM National, Immediate Past President of the Eastern Federation of Mineralogical and Lapidary Societies, Inc. (EFMLS, 2022-2024) and President of Stephens Environmental Consulting, Inc., a full-service environmental consulting, engineering, and surveying company serving in the Mid-Atlantic Region since 1995. Bill is also the current EFMLS Region IV & V RVP, and a past VP of Programs for the Delaware Mineralogical Society.

Bill holds a BS and MS in Geology for the University of Pittsburgh main campus (1982, 1988). Bill did his master’s thesis in northwestern Sonora MX, producing a first generation 1:50,000 scale map of part of the Cucurpe quadrangle. Rocks mapped within Basin and Range faults blocks included 1.1 billion year old pink micrographic granite and older crystalline rocks over brittle deformed clastic and marine rocks of late Jurassic to early Cretaceous age, exposed in a window through Tertiary volcaniclastic and extrusive rocks. Bill has contributed to scholarly articles on his thesis findings as well as other important work including but not limited to publications on Fort Hollingsworth, a War of 1812 fort in Elkton, MD, Periglacial features on the Delmarva Peninsula and Bill recently co-authored a privately published book on the discovery of world class “Herkimer Diamond” quartz crystals. Bill has become a sought after speaker for many clubs as well as providing professional development seminars for the Professional Geologist community and the Maryland Society of Surveyors at their annual conventions.

Bill started collecting about age 11, after being inspired by a National Geographic article on gems of the Eastern Appalachians. Family and later college buddy collecting trips focused on collecting mainly in North Carolina, with incidental trips to southeastern PA locations including Phoenixville, French Creek and Cornwall. More recently Bill has developed a passion for "machine digs", including Diamond Hill, Hogg Mine, sites in Herkimer and two machine digs for Wavellite at Mount Pleasant Mills. Machine digs provide the opportunity to acquire meaningful understanding of these deposits and mining history. Bill has done extensive mapping at Mohawk Valley Mineral Mining in Sprakers, NY and a private quartz mine known as “Area 52” in Canajoharie, both newly opened private Herkimer Diamond Mines. Bill has mapped the now regionally famous Wavellite occurrence at the National Limestone Quarry at Mount Pleasant Mills, Snyder County PA. Bill uses his resources, including geological knowledge, GIS skills, survey equipment and drones to develop programs designed to inspire others and help collectors to be more successful in their collecting adventures.

Emeralds from Panjshir Valley, Afghanistan

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Figure 1. An emerald from Panjshir Valley.

Emeralds have been known to come from Panjshir Valley, Afghanistan for nearly 1,000 years but it was not until Russia invaded Afghanistan in 1979 that many Afghan minerals made their debut on the world market.

Outsiders rarely get to see what has been mined in Panjshir Valley in the recent years. A short project in 2018 – 2019 gave me inside view of their mining techniques and amazing production. I received 31 videos and numerous photos that were sent by the miners as I asked questions on their mining techniques. They wanted a GPR to show them where pockets existed so they would stop blowing them up with the high explosives. Aria Gems hired me to validate/substantiate their need for a $50,000 GPR.

Just as the Taliban took control of Afghanistan in 2020 the miners dynamited all the mine entrances closed so they could no longer be worked and moved out of Afghanistan. The family clan I worked with said they had several million carats of rough emerald crystals in vaults in Dubai waiting to be cut and sold on the world market.

Jim Clanin - Speaker biography

Jim Clanin has 50 years of experience in mining and consulting in the gemstone industry. He has mined for gems and minerals specimens in 11 different countries that include Madagascar, Kenya, Tanzania, Nigeria, Mozambique, Mexico, Brazil, Afghanistan, Pakistan, the United States, and the United Kingdom. Major gemstones Jim has mined include ruby, emeralds, sapphire, green and red garnets, tourmaline, beryl and the accessory minerals associated with these deposits.

Clanin, based on his mining experience, wrote and had published *"The Fundamentals of Mining for Gemstones and Mineral Specimens"* (2012) ISBN 978-0-615-50108-6, a practical handbook on the art of mining and collecting gemstones and mineral specimens. He has developed and worked pegmatites including the Cryogenie mine, (AKA Lost Valley Truck Trail Prospect), Warner Springs, San Diego County, California as well as the famous Mt. Mica Mine, Paris Hill, Oxford County, Maine, both in the US. Recently, Jim consulted and is helping develop the red spinel deposit of Mahenge, Tanzania, that occurs in a crystalline marble deposit. He has visited with and advised the miners at the Chumar Bakhoor deposit of green and pink fluorite on muscovite at 15,000 feet in northern Pakistan as well as having taught gem mining methods to artinsal miners in Nigera and Pakistan.

Los Verdes…The Green Minerals of Mexico

Dr. Peter K.M. Megaw
(pmegaw@megawexploration.com)

Mexico is a large country, roughly the size of the western third of the USA, endowed with a wide range of deposit types, many of which have seen nearly 500 years of mining activity. The most productive of these-both of ores and green minerals-include Porphyry Copper Deposits like Milpillas and Luz del Cobre; Carbonate Replacement Deposits (CRDs) such as Ojuela, Santa Eulalia, Charcas and Concepcion del Oro; Epithermal veins including Guanajuato, Santa Barbara, Moctezuma and Guanacevi; and Volcanic-related deposits such as Cerro de Mercado and Mesa del Opalo.

The deep, primary zones in these deposits produce relatively few green minerals, but datolite, ludlamite, vivianite, fluorite, titanite, fluorapatite, epidote, tourmaline, milarite and daylight luminescing hyalite opal are notable primary green minerals that grace many collections.

But Mexico's brightest greens are dominantly found in the oxidized, secondary zones of the metalliferous deposits- especially those with appreciable copper, arsenic and tellurium. Probably the best known green secondary species from Mexico are the adamites produced in quantities for decades from Ojuela, along with related austinite and zincolivenite and the panoply of greens produced from the short-lived, but spectacular Milpillas mine which gave us some of the world's best malachite pseudomorphs after azurite and the world's finest volborthite, brochantite and vesigneiete. Micro and rare species collectors are all familiar with the broad palette of tellurium-related greens from Moctezuma including emmonsite, carlfriesite, cesbronite, xocomecatlite- all but emmonsite being type species for the locality. Less well known, but delightful to collect are the malachite pseudomorphs after azurite from Concepcion del Oro, green smithsonites and adamite from Santa Eulalia and green quartz from Santa Eulalia and Naica. Super-rare greens include cuprotungstite from Sonora, arsendescloizite from Ojuela and spangolite from Concepcion del Oro.

Join me on a colorful journey through Los Verdes de Mexico and the geological events that made them.

Peter K. M. Megaw – Speaker Biography

Dr. Peter K.M. Megaw, is a Consulting Geologist (Ph.D. University of Arizona) and a dedicated mineral collector since first setting foot in Santa Eulalia in 1977. He moved to Tucson in 1979 and quickly joined the Tucson Gem and Mineral Society, taking on the job of Exhibits Chair for the TGMS Show in 1984. His mineral collecting has come to focus almost exclusively on Minerals of Mexico and he has spoken and written extensively on specimen localities there. A combination of the above led him to be awarded the Carnegie Mineralogical Award for 2009. More recently, his in-depth 2018 article for *Mineralogical Record* on the Santa Eulalia Mining District in Chihuahua, Mexico received the FM award for Best Article in *Mineralogical Record.* He is also a contributing editor for *Rocks and Minerals* and occasionally writes for *Mineralogical Monographs*.

My 45-Year Love Affair with Maryland's State-line Pit Serpentine (Williamsite/Antigorite)

Kenneth C. Zahn
kczahn@littleappletech.com

The mining history and widespread distribution of chromite-bearing serpentinite within the Maryland-Pennsylvania-Delaware "Serpentine Barrens" Upland Piedmont belt is an important chapter in early-American entrepreneurship and industrial wealth-building in Maryland. In 1808 or 1810, it was brought to the attention of industrialist Isaac Tyson's son (Isaac Tyson Jr.) that disseminated chromite-bearing rocks were present on Bare Hills land north of the Tyson estate near Cold Stream north of Baltimore. There quickly followed many additional serpentine barrens chromite discoveries of disseminated, massive, and placer chromite deposits in PA and MD by Isaac Tyson Jr., who promptly acquired or leased the land and began mining nearly all the significant properties between ~1811 and 1833. The Tyson family holdings formed a virtual world-wide monopoly on the source of highly profitable chromium salt sales for pigments and for leather tanning from ~1828 and 1850 after earlier sources (said to be crocoite from Russia) ran dry. Discovery of large deposits of Turkish chromite in 1848 began to dilute Tyson's monopoly position by 1850. Between 230,000 and 280,000 tons of chromite ore from Tyson's holdings were processed by ~1874.

Two of the largest deposits, the Wood Mine (in PA) and the State Line Pit (in MD) along the MD-PA border north of Conowingo Dam on the Susquehanna River, were unusual for the presence of a translucent bright apple- or emerald-green accessory serpentine mineral termed "williamsite" -- at Wood Mine, as stringers abutting thick, 40-60-degree dipping chromite veins or projecting from the chromite into the common serpentine wall rock, but at State Line Pit, as an abutting sheath surrounding a very steeply dipping to nearly vertical podiform body of massive chromite. (I'll use here the "older" varietal term williamsite rather than the more-recently decided term of the material as just one form of microfibrous antigorite. (Ask me why at Q & A)). Williamsite at both localities share a similar antigorite composition but somewhat different habit from other antigorites. Grains/inclusions of chromite within the beautiful williamsite are sparse in number in the brightest of the translucent pieces. Unlike the other typical serpentine varieties (lizardite and chrysotile) and the several common antigorite varieties that are splintery or clearly fibrous in habit (e.g., picrolite, etc.), State Line Pit williamsite is easily polished without any undercutting or splaying even when being facetted.

The color of the translucent material is usually attributed primarily to minor chromium -- a reasonable conclusion, given the chromite inclusions and the abutting chromite matrix -- but nickel is increasingly cited, as most analyses note the presence of nickel in low concentrations but generally higher than those of chromium. Green nickel-containing minerals are also found as minor accessory minerals at both locations, but deep green tremolite has not been cited as present. Samuel Gordon's projections of the origin of the serpentine minerals are the serpentinization of peridotite or pyroxinite at the Wood Mine and hydrothermal metamorphism of enstatite at State Line Pit. Possible mechanisms for the sharp differentiation of the bright green williamsite stringers or sheath at the two sites from the immediately abutting massive chromite have generally not been discussed in detail in the literature, except to note that formation of the chromite deposits preceded serpentinization. Thin section microscopy, SEM, and XRF/XRD analytical results on bright green williamsite from the State Line Pit deposit will be briefly discussed in the presentation. No remnant olivine was noted in a thin section of State Line Pit williamsite prepared in 2023, although clearly present in a thin section of Wood Mine williamsite according to Gordon in 1921.

Now, for the interesting "rest-of-the-story" of a unique sequence of events that cemented my 45-yr fascination with this gemmy emerald/apple-green serpentine variety starting in an Aberdeen Proving Ground, MD, motel parking lot on a hot summer day in 1980, you'll have to attend the February 2025 Friends of Mineralogy Symposium at the TGMS show in Tucson, or listen in online via live-streamed Zoom.

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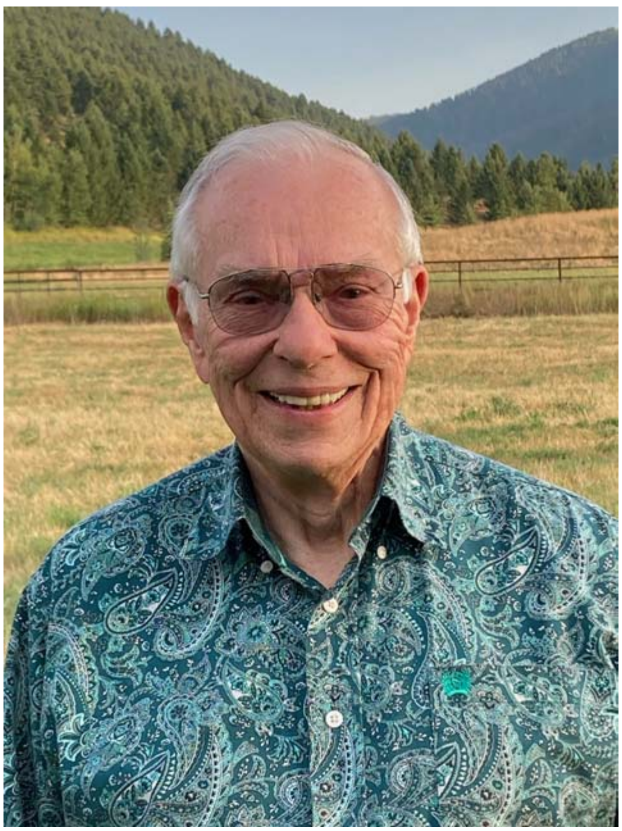
Kenneth Zahn – Speaker biography.



Ken Zahn grew up in Pennsylvania, through his 13th birthday in 1949, but worked (at a dog kennel in Tucson, Arizona, on North (Swan Road at Old Ft. Lowell Rd) from age 13 though 19 due to family circumstances in Philadelphia. Receiving a track scholarship to the U. of Arizona, he planned to teach high school chemistry and coach track as a career. After field collecting trips starting in 1955 with his mining engineering college buddies underground in Washington Camp, Patagonia, Globe, Butte, Tombstone, and along the Colorado River north of Yuma, he “fell in love” with geology and mineral collecting but couldn’t financially afford to shift his major studies from education and chemistry to geology and mineralogy. They remained a dream and a hobby. At the U. of A., he completed a B.S. in Education (1959), a B.S. in Chemistry (1960), and an M.S. in Organic Chemistry (1960). As a Distinguished Graduate from the University’s ROTC program, he was offered a Regular Army commission, and began a 26-year career as a Nike Hercules Missile Officer (2 yrs), an Assistant Professor at the U.S. Military Academy at West Point, NY (3 yrs), and a Chemical Officer while leading research, development, testing, special studies, intelligence analysis, defensive training, contingency planning, and forensic science activities (21 yrs). He reconnected with his mother, sister, and brother in Philadelphia in 1960 on the way to a nuclear air defense artillery missile assignment in Germany. He attended the University of Illinois’ Graduate School of Chemistry in Sept.,1964 and completed his PhD. In Organic Chemistry in Sept.,1967. Geology and mineral collecting stayed pretty much “low key” until an assignment as Commander of the Army’s large Criminal Investigation Laboratory in Georgia in 1977, where he re-energized his hobby by joining local clubs and collecting GA amethysts, SC garnets, and NC garnet, corundum, and rubies. With a follow-on assignment to Aberdeen Proving Ground, MD, in the summer of 1980, he joined local clubs in both Maryland and Pennsylvania, while serving as Deputy Commander, U.S. Army Chemical Research, Development, and Engineering Command, then retiring to Salt Lake City, Utah, in 1985, where teaching at Utah Valley State College and collecting UT topaz, bixbyite, bertrandite, red beryl, and Dugway geodes, took over. Taking a Group Leader's position and, later, a Program Manager's position at Lawrence Livermore National Laboratory in CA, from 1990 to 2004, collecting axinite and benitoite filled in. In 2004, Ken and Carol settled in Bozeman, MT; Ken attends pegmatite symposia, served as President of the Northwest Federation of Mineralogical Societies in 2019-2020, leads area field trips, and provides program presentations to clubs in the Northwest. He collects minerals from pegmatites and skarns in Montana's Boulder Batholith granites, and completed Mineralogy and Optical Mineralogy and Igneous and Metamorphic Petrology courses at Montana State University in 2022-2023 at age 87 – his first (finally !!) formal Mineralogy education, since "falling in love" with the science 70 years earlier in 1955.

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Cr-azy Green and Red Minerals: On the Occurrence and Genesis of Chlorite-Fuchsite-Ruby Rocks of the Granite Mountains, Wyoming, USA

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The Archean rocks of the Wyoming craton offer a rich diversity of economic mineral resources, mineral specimens, and lapidary materials, from orogenic gold deposits and lithium-bearing pegmatites to nephrite jade and cabochon-grade ruby. Here, we examine the occurrence of corundum var. ruby associated with dark green chlorite and bright green fuchsite within the Granite Mountains of central Wyoming. Although ruby has only been well documented from one locality in this region, the Red Dwarf deposit, corundum in general and ruby specifically appears to occur in association with chlorite and fuchsite throughout greenstone belts of the central Wyoming craton. Known corundum localities in the Granite Mountains occur within and on the margins of the Sacawee block, a domain of ca. 3.3 Ga basement gneiss with younger (ca. 2.86 Ga), tectonically interleaved, amphibolite-facies supracrustal rocks that were variably deformed within the ca. 2.65-2.63 Ga Oregon Trail Structural Belt (e.g., Chamberlain and Mueller, *Earth's Oldest Rocks*, 2019). Locally, these supracrustal rocks contain metamorphosed komatiite flows and metasedimentary rocks derived from such ultramafic lithologies. We examine two specific ruby localities to illustrate the genesis of chlorite-fuchsite-ruby rocks in the Granite Mountains. At the first locality, the Three Wave No. 2 Claim in the vicinity of West Sage Hen Rocks, ruby occurs within high-strain rocks as elongate subhedral to euhedral, purple-red, opaque, double-tapering prisms aligned in the plane of foliation within chlorite pods that occur alongside supracrustal rocks within an anastomosing shear zone.

Figure 1. Fuchsite-chlorite schist with ruby porphyroblasts.

Very rarely, relict spinefex texture can be found within the nearby rocks. The ruby crystals are variably retrograded; some have fuchsite and quartz-muscovite reaction rims, whereas others are sharp crystals sheathed in chlorite with no reaction rims. Given the observed rock types and rock fabrics at this locality, the chlorite-ruby±fuchsite rocks here are interpreted to have formed by deformational juxtaposition of low-silica rocks and aluminum-rich rocks and by associated fluid infiltration and metasomatism. The association of tourmaline with these chlorite-ruby rocks suggests the role of magmatic fluid infiltration in facilitating this metasomatism. Consequently, these chlorite-ruby rocks can be viewed as similar to classic "black-wall"-type corundum occurrences. An age of ca. 2.65 Ga on a nearby shear zone (Grace et al., *Can. J. Earth Sci.*, 2006) is interpreted to also apply to the formation of ruby in this portion of the Granite Mountains, making the rubies from this locality among the oldest in the world. At the second locality, the Red Annetelope Claims, located immediately south of the Red Dwarf deposit, corundum var. ruby occurs as subhedral to anhedral clots with well-developed fuchsite reaction halos. Although small bodies of metamorphosed ultramafic rocks are recognized in the vicinity of this locality, the fuchsite-ruby clots themselves occur within amphibolites and quartzofeldspathic gneisses. The rocks at Red Annetelope Claims are only moderately strained, so deformational processes appear to be less important in giving rise to corundum at this locality. Instead, corundum at Red Annetelope is interpreted to be the product of metamorphism of komatiite-derived silt/clay lenses within quartzofeldspathic sediments, similar to the model proposed for the ruby-fuchsite rocks of Mysore, India. In general, corundum formation from ultramafic igneous rocks and derived sedimentary lithologies is likely widespread throughout the incompletely mapped and underexplored central Wyoming craton.

Benjamin Murphy (left) and Anne Fulton -- Speaker Biographies

Benjamin Murphy and Anne Fulton are geoscientists and mineral collectors based in Golden, Colorado. Although aluminum oxides (corundum, chrysoberyl, and spinel) are their main mineralogical interest, they are avid field collectors and will happily pick up any nice rock they encounter. They have a particular interest in hard-to-get-to localities off the beaten path and in esoteric, scientifically unique localities. Benjamin is a PhD geoscientist, and he works as an electromagnetic geophysicist in the mining sector. Anne has two Masters degrees in volcanology and economic geology, she is currently completing her Graduate Gemologist degree with GIA, and she works as a metalsmith and as a pro-animal activist. They are very active with the Friends of Mineralogy Colorado Chapter, with Benjamin currently serving as President and Anne serving as Webmaster and Graphics Design chair.

Mushistonite from Xuebaoding: from 'Panda Ore' to quantum spin system

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The region around Xuebaoding (5,588 m, 18,333 ft) in the Minshan mountain range, western Sichaun, with its W-Se-Be deposits has emerged as a world-class specimen locality for large and exceptionally gemmy scheelite, cassiterite, and beryl. Since their discovery in the 1950's the mineralized muscovite-rich quartz veins have been prospected and extensively mined by artisanal miners. The veins intrude Triassic metamorphic schist and carbonate rock and are of a greisen-type deposit associated with small alkali granite intrusions. The globally unusual association of abundant scheelite, beryl, and cassiterite, and underlying cogenetic occurrence of W, Sn, and Be mineralizations, have long raised fundamental questions about underlying petrogenesis and ore forming processes. However, extreme vertical relief with localities at elevation up to 5,000 m (16,400 ft), have limited systematic geologic field work and *in situ* sample access.

In systematic field work since 2017, we have addressed questions of the exact locations, spatial extent, and mineralogical variations between a range of >100 localities over an area of ca. 30 km x 50 km. Our most recent work has since provided insight into the mineralogy of the beryl with its unusual tabular habit [1], constraints on ore forming processes [2,3], and the distinct W-mineralization with only scheelite and of different crystal habit outside the Xuebaoding W-Sn-Be core zone [4].

Recent interest has been drawn into the associated rare Sn-bearing minerals mushistonite and kësterite. Typically black metallic kësterite often occurs as large (up to few cm) single crystals or crystal aggregates, sometimes completely and evenly coated by lustrous bright green mushistonite (Fig. 1). Following the discovery in the early 1990s by local miners, and finding specimen of exceptional quality, these crystals were briefly thought to be a new species, and distributed in the mineral market as "Panda Ore" or "Pandaite" in reference to the Giant Panda still roaming the area and occasionally seen by the miners in the wild.

Fig. 1. Multiply intergrown tetrahedrons of kësterite with coating of mushistonite and malachite, 5.0 cm x 5.0 cm x 3.5 cm, MIM Museum, Photo James Elliott.

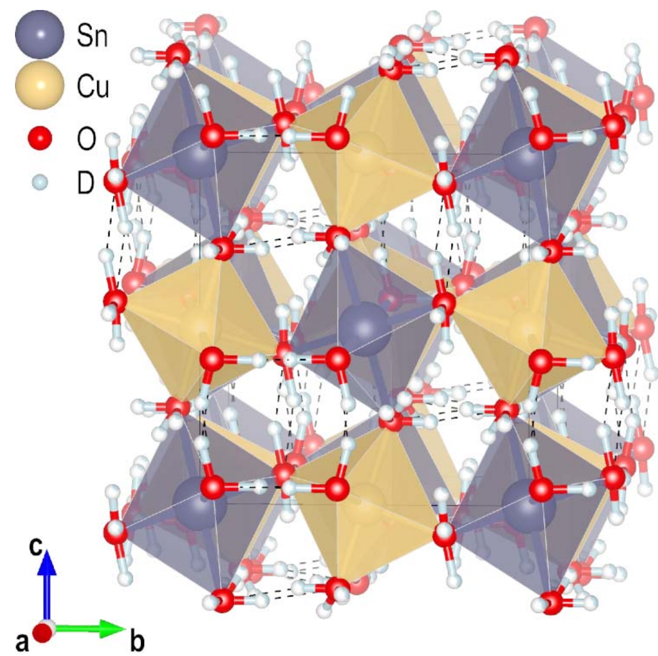

Fig. 2. Proposed crystal structure of $CuSn(OH)_6$ with double perovskite structure and orthorhombic space group P*nnn* [figure from Häußler et al. [7].

Mushistonite, with an ideal formula of $Cu^{2+}Sn^{4+}(OH)_6$ is a rare mineral that typically forms in the oxidized zones of tin deposits, often replacing stannite. Despite what seems a simple formula and general perovskite lattice structure the exact crystal symmetry has remained elusive for decades. Both the originally proposed tetragonal crystal structure [5], as well as the later refinement as cubic [6], were shown to be inconsistent. Most recent work based on X-ray and neutron diffraction refined the structure as orthorhombic with space group *Pnnn*, with a hydrogen bonded network of OH^- ions [7] (Fig. 2). Surprisingly, and what attracted much interest in the field of quantum condensed matter physics, $CuSn(OH)_6$ exhibits correlated proton disorder and is a quantum spin system with a frustrated magnetic sublattice. Despite much research into perovskite *oxides* with transition-metal cations because of their superconducting properties and exhibiting complex magnetic phases, the closely related class of perovskite *hydroxides* has attracted yet little attention.

In this talk I will highlight the mineralogical questions associated with the Xuebaoding mineral deposit with an emphasis on mushistonite and related Sn-mineralization. I will also touch on its properties as a quantum material where exotic macroscopic properties result from collective microscopic quantum phenomena – a research field traditionally pursued on synthetic compounds, yet with a growing number of natural minerals or nature inspired structural or compositional motives being explored. I will also cover aspects of the previously undocumented artisanal mining history, related to the cultural history of the Sino-Tibetan borderlands, and conclude with emergent challenges for future geoscience research in China in light of the shifting geo-political landscape.

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Markus Raschke – Speaker Biography

Markus Raschke is professor at the Department of Physics at the University of Colorado at Boulder. His research is on the development of novel nano-optical spectroscopy and microscopy techniques with applications to single molecules, quantum materials, and fundamental control of light matter interaction. Based on a long personal interest in field collecting minerals his research also ventured into geology and mineralogy, with projects in Washington, Colorado, and the Sichuan Mountains in Tibet/China. He received his PhD in 2000 from the Max-Planck Institute of Quantum Optics and the Technical University in Munich, Germany. Following research positions at the University of California at Berkeley, and the Max-Born-Institute in Berlin, he became faculty member at the University of Washington, followed by his appointment in Boulder in 2010. He is fellow of the Optical Society of America, the American Physical Society, the American Association for the Advancement of Science, and The Explorers Club.

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