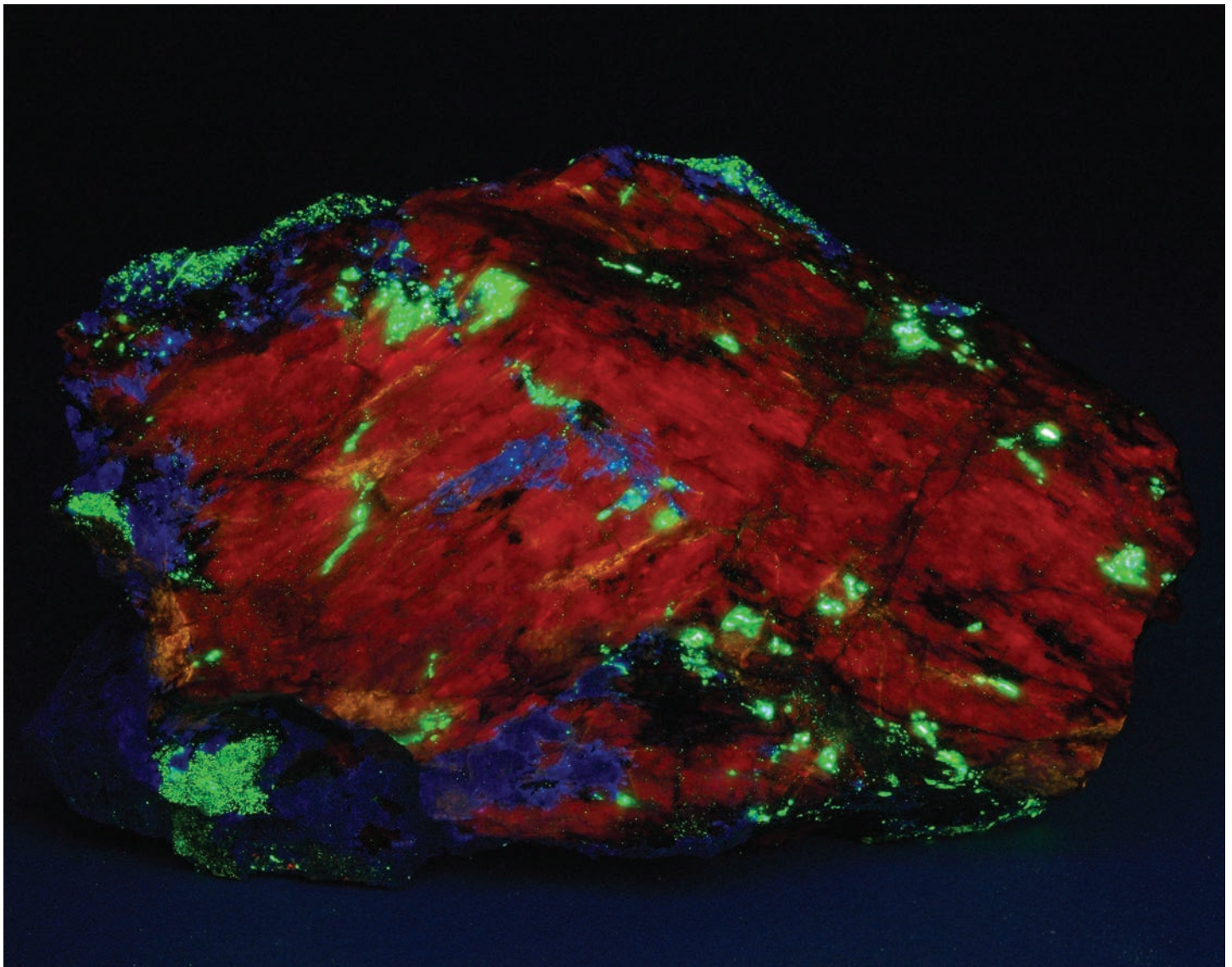


THE PICKING TABLE

JOURNAL OF THE FRANKLIN-OGDENSBURG MINERALOGICAL SOCIETY

VOL. 57, NO. 2 – FALL 2016

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- **THE GEOLOGIST**
- **STABLE ISOTOPES OF SECONDARY CARBONATES AT FRANKLIN AND STERLING HILL**



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| Swap & Sell | Chester S. Lemanski, Jr. |



Bill Harpell of the Franklin Mineral Museum made a strong fashion statement during a rainy Miners Day with a pair of outrageously fluorescent "willemite shoes," complete with calcite accents. *Earl R. Verbeek photo.*

THE PICKING TABLE

VOL. 57, NO. 2 – FALL 2016



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The Picking Table is the official publication of the Franklin-Ogdensburg Mineralogical Society, Inc. (FOMS), a nonprofit organization, and is sent to all members. *The Picking Table* is published twice each year and features articles of interest to the mineralogical community that pertain to the Franklin-Ogdensburg, New Jersey, area.

Members are encouraged to submit articles for publication. Articles should be submitted as Microsoft Word documents to Richard J. Keller, Jr. at: PTMemberFeedback@gmail.com.

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ABOUT THE FRONT COVER

Coarse-grained bustamite (fl. red SW) with hardystonite (deep blue), willemite (green), and minor clinohedrite (orange), from the site of Mill #2 (Palmer Mill) at Franklin. Though bustamite is best known as a LW-fluorescent mineral, rare specimens from the "Mill site" fluoresce bright red SW. This fine example, measuring 4.5 × 2.4 × 2.4 inches (11.5 × 6 × 6 cm), is from the collection of Ron DeBlois. *Earl R. Verbeek photo.*



FRANKLIN-OGDENSBURG MINERALOGICAL SOCIETY

FALL AND WINTER 2016 ACTIVITY SCHEDULE

COMPILED BY TEMA J. HECHT

600 WEST 111TH STREET, APT. 11B

NEW YORK, NY 10025

thecht@att.net

SATURDAY, SEPTEMBER 10, 2016

**NORTH JERSEY MINERALOGICAL SOCIETY

SWAP.

9:00 AM – 5:00 PM

Sterling Hill Mining Museum.

SATURDAY, SEPTEMBER 17, 2016

9:00 AM – NOON

FOMS Field Trip

Collecting at the Hamburg Quarry
of Eastern Concrete Materials, Inc.,
on Route 23 just north of Hamburg.

Meet at the scale house to sign releases.

Hard hats, leather shoes (preferably steel tipped),
gloves, and safety glasses **required**.

Weight of individual specimens is limited to 25 lbs.

Bulk collecting/loading of specimens is strictly prohibited.

10:00 AM – NOON

FOMS Micro Group

Franklin Mineral Museum.

BYO microscope and minerals.

Call Ralph Thomas for information: 215-295-9730.

1:30 PM – 3:30 PM

FOMS Meeting

Franklin Mineral Museum.

Lecture: *Geology and Mineralogy of
the Inwood Marble, NYC, NY*, by Charles Merguerian.

SATURDAY AND SUNDAY, SEPTEMBER 24 AND 25, 2016

**60TH ANNUAL FRANKLIN-STERLING
GEM & MINERAL SHOW

Sponsored by the Franklin Mineral Museum.

Franklin Middle School, Washington St., Franklin, New Jersey.

9:00 AM – 5:00 PM Saturday (indoors)

10:00 AM – 4:00 PM Sunday (indoors).

The ticket price covers the show, *The Pond Swap-and-Sell*,
and admission to the Franklin Mineral Museum:

\$7.00 per day for adults, \$4.00 per day for children (6-16).

The Pond Swap-and-Sell, sponsored by the FOMS,

takes place outdoors on the school grounds

from 9:00 AM – 6:00 PM on Saturday, and from

10:00 AM – 5:00 PM on Sunday. Show admission required.

**The FOMS Annual Banquet starts at 6:30 PM on Saturday
at the Lyceum Hall of the Immaculate Conception Church,
located at the south end of Franklin's Main Street.**

Tickets may be obtained at the FOMS show table for \$20.00.

**The meal is an all-you-can-eat buffet;
soda, tea, and coffee are included.**

◆BYOB◆

After the banquet there will be an auction
for the benefit of the FOMS.

Please plan on donating a good specimen, artifact, book, etc.!

** Saturday and Sunday:

Events at the Sterling Hill Mining Museum.

For more information, please call: (973) 209-7212.

Or you can visit the website at

www.sterlinghillminingmuseum.org

SATURDAY, OCTOBER 15, 2016

9:00 AM – NOON

FOMS Field Trip

Collecting at Lime Crest (Braen Stone of Sparta) Quarry,
Limecrest Road, Sparta, N.J.

Meet 15 minutes before starting time at the gate.

We will enter as a group and the gates will be closed.

Hard hats, leather shoes (preferably steel tipped),
gloves and glasses required.

10:00 AM – NOON

FOMS Micro Group

Franklin Mineral Museum.

BYO microscope and minerals.

Call Ralph Thomas for information: 215-295-9730.

1:30 PM – 3:30 PM

FOMS Meeting,

Franklin Mineral Museum.

Lecture: *A Trip to the Blanchard Mine and Hansonburg Mining District*, by Alan Benson.

6:00 PM – 10:00 PM

****Nighttime Mineral Collecting,
Sterling Hill Mining Museum.**

Collecting permitted on the Mine Run Dump and in the Passaic Pit and “saddle” areas. For museum members only. \$5.00 admission fee plus \$1.50 for each pound of material taken. For more information, call 973-209-7212.

SATURDAY, OCTOBER 22, 2016

****27th Annual ULTRAVIOLATION,**

a Show-Swap-Sell Session featuring fluorescent minerals only. First United Methodist Church, 840 Trenton Road, Fairless Hills, Pennsylvania. 9:00 AM – 4:00 PM, \$2 donation. **“If your rocks don’t glow, you’re at the wrong show.”** Table space available. For information, call 856-663-1383 or e-mail ultraviolation@yahoo.com.

SATURDAY, NOVEMBER 19, 2016

9:00 AM – NOON

FOMS Field Trip

Collecting at the Taylor Road site. Meet and park at the Franklin Mineral Museum, and walk from there. **Do not park on Taylor Road!** Fee charged.

10:00 AM – NOON

FOMS Micro Group

Franklin Mineral Museum.

BYO microscope and minerals.

Call Ralph Thomas for information: 215-295-9730.

1:30 PM – 3:30 PM

FOMS Meeting,

Franklin Mineral Museum.

Lecture: *Ice Crystals*, by Johan Maertens.

MINERAL OF THE MONTH — HARDYSTONITE

Bring your specimens of hardystonite for show-and-tell, and a discussion led by Steven Kuitens.

7:00 PM – 10:00 PM

****Night Dig on the Buckwheat Dump,**

for the benefit of the Franklin Mineral Museum.

Doors open at 6:30 PM for check-in and mineral sales. Admission \$10.00 adult, \$8.00 children 3-12 years of age. Poundage fee charged. **Call for details: 973-827-3481.**

SATURDAY, DECEMBER 3, 2016

9:00 AM – 4:00 PM

****FLUORESCENT MINERAL SOCIETY MEETING**

GeoTech Center, Sterling Hill Mining Museum.

Speakers include Donna Beaton, (*Determinants of Color in Natural and Treated Tanzanite*), Andrea Cavagna (*Particles, Waves, and Starlings*), Howie Green (*The Perception of the Fluorescent Mineral Enthusiast in the Eyes of the Great and Powerful*), and Mark Cole (*Photography of Fluorescent Minerals for the Beginner and the Expert*).

Lunch will be served (\$10.00 contribution).

◆BYOB◆

Reservations necessary!

Please contact Howie Green: royalp53@verizon.net.



Scheduled activities of the FOMS include meetings, field trips, and other events. Regular meetings are held on the third Saturdays of March, April, May, June, September, October, and November, and generally comprise a business session followed by a lecture. FOMS meetings are open to the public and are held at 1:30 PM, usually in Kraissl Hall at the Franklin Mineral Museum, 30 Evans St., Franklin, N.J. (check listings for exceptions).

Most FOMS field trips are open only to FOMS members aged 13 or older. Proper field trip gear required: hard hat, protective eyewear, gloves, sturdy shoes.

**Activities so marked are not FOMS functions but may be of interest to its members. Fees, and membership in other organizations, may be required. Any information in this schedule, including fees, is subject to change without notice.

Thanks go to Mark Dahlman, Pat Hintz, Bernard Kozykowski, Richard Keller, Ralph Thomas, Howie Green, the Franklin Mineral Museum, and the Sterling Hill Mining Museum for this information.

President's Message

MARK DAHLMAN

11906 SCOVELL TERRACE
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contactmdd@gmail.com

These days it seems quarries are more likely to become off limits than to reopen to collectors, so it's great news to hear that we, FOMS, will be allowed back into the Lime Crest Quarry in Sparta! The quarry was dewatered and operations resumed several years ago, and FOMS is the only club to be allowed back in to collect specimens. Mindat lists 44 valid mineral species from this famous location. Many impressive specimens from the quarry can be seen in the Franklin Mineral Museum's Kraissl Hall, where we hold our society meetings. Please see the schedule of events for further details. Thanks go to Rich Keller and Bernie Kozykowski for continuing to arrange great field trips for us!

I'm also very pleased to announce that this fall, FOMS will start a program for junior rockhounds. The program, Future Rockhounds of America, or FRA, is provided to us free of charge because of our membership in the American Federation of Mineralogical Societies. The participants, ages 9 to 16, can earn badges by completing activities in a wide variety of topics. For

example, FRA members can earn the Rocks and Minerals badge by learning about the three rock types, developing and using a mineral ID kit, and building a mineral collection. There are currently 20 badges including Fossils, The World in Miniature (micromounting), Lapidary Arts, Field Trips, and Fluorescent Minerals. The FRA handbook, available on the Amfed.org website, makes interesting reading for adults, too. We will begin our FRA meetings in October. Please see our society website – FOMSNJ.org for the meeting time and location.

Since this is my last president's message, I'd like to once again thank our board of directors, the *Picking Table* staff, and all of you who volunteered to support FOMS. We've been able to enjoy *The Picking Table*, field trips, the FOMS website, our Facebook page, and FOMS speakers as a result of these people. Because of our club members' volunteer efforts, we've also had reliable minutes, accounting and membership processing, the spring shows, as well as the fall banquet and auction. Thanks to you who support FOMS – you've made a real difference. ✂

From the Editor's Desk

RICHARD J. KELLER, JR.

13 GREEN STREET
FRANKLIN, NJ 07416
FranklinNJ@hotmail.com

Another calendar year has flown by and once again, it's time for the fall issue of *The Picking Table*. We have a real treat for our members in this issue. Most of you have perused the FMM Species List Committee's listing of all mineral species that occur in the local area (see the Fall 2015 issue of the *PT*). Most of you, too, are familiar with the one-page list of local fluorescent species that is printed in every fall show bulletin. The latter list has been maintained by Richard Bostwick since the 1980s. Now, however, we present to you the first of two parts of a much-expanded list, also authored by Richard Bostwick, that offers far more descriptive detail on the local fluorescent species than has appeared in print before.

One thing that any self-respecting publisher hopes to achieve is an issue that its readers don't look at just once and never pick up again. We feel we have accomplished that in this issue, as well as the next one. We are confident that readers will refer to these issues time and time again, whenever

they add a new mineral to their collections. This is what I found myself doing when I first obtained my copy of Ervan Kushner's *An Abbreviated Manual of Franklin Minerals*. This manual, copies of which are still available, contains brief descriptions of all the area's known minerals as of 1970. Naturally it's been added to over the years, and my copy even has handwritten additions and corrections. Richard Bostwick's present contribution fills the same purpose for the fluorescent species, and is up-to-date, accurate, and intended to be helpful to collectors wishing to identify and learn more about their own specimens.

Naturally this issue has a lot more to offer. Inside you will find a previously unpublished manuscript by Jack Baum, a paper on the origin of some of the secondary carbonate minerals in the local area, and much more. So, take this issue to your collection of fluorescent Fr-Og minerals and find out, once and for all, "what's what." ✂

Happenings at Sterling Hill

WILLIAM KROTH

PRESIDENT, STERLING HILL MINING MUSEUM
30 PLANT STREET, OGDENSBURG, NJ 07439
bill.kroth@shmmuseum.org

Good things continue to occur at the Sterling Hill Mining Museum, and the first half of 2016 brought two golden opportunities to our facility.

First: Board member, Mike Pierce got a lead on a 1942, all-metal, 33-foot-long caboose that since 2010 had been parked in the mud in the Borough of Fanwood's recycling yard. The borough, with help from a federal grant, in recent years had attempted to restore this classic N-4B "northeastern type" caboose, but various roadblocks, labor problems, and environmental/health concerns prevented the project from moving ahead. Ultimately the caboose became loaded with graffiti and was a community eyesore. Mike presented a proposal to the borough and met with town officials. Early this spring, Fanwood drafted and voted on a resolution that would give us the caboose for a nominal charge of \$10.00! We simply had to give them a time schedule of when it would be removed and when it would be restored. Mike arranged to have it loaded on a huge flatbed trailer by a contractor friend who jacks homes damaged by high winds and waves. The caboose was finally delivered to Sterling Hill on August 3 and now rests in the yard adjacent to the Rock Discovery Center. Tom Hauck and his son Jason will be handling the restoration once the caboose is sandblasted. Because the paint contains lead, we will have the sandblasting work performed by a licensed lead-abatement company. Several new steel panels will replace corroded sections and the improper and broken windows will be replaced with the correct units. The caboose is in terrific shape, and fortunately all of the graffiti actually helped to protect the steel over the years!

The New York, Susquehanna and Western Railway has already installed a 40-foot-long siding track near our pavilion for the caboose's final display location. The railroad volunteered all labor and materials, and had the siding



The caboose rounds the corner on Passaic Avenue into Sterling Hill Mining Museum's main entrance. Three months of restoration is expected to get this into great condition!

complete in a few hours. Right now, we have the two caboose trucks sitting on the rails, waiting to receive the caboose. It will be lowered by crane as soon as the restoration is complete. The caboose will be painted in New Jersey Zinc Company colors with the appropriate script and will be a wonderful focal point for visitors. It will be open for folks to walk through and will serve to explain one aspect of the ore-processing procedure at Sterling Hill; in this case, transportation by rail to Palmerton, Pennsylvania.

Second: More than ten years ago, the Franklyn Ellis family donated funds for us to build the Ellis Astronomical Observatory at the north end of our property. Since then, literally thousands of visitors have been able to see stars, galaxies, nebulae, and planets through the 20-inch reflecting telescope. While this program has been a total success, one problem always plagued us—the weather. Clear skies suitable for observing here in New Jersey occur only about 40% of the time, so we cannot make firm reservations until a day or two prior to the observing

event. And even then, we are sometimes surprised from clouds that had not been forecasted. Gordon Powers (board member and observatory co-director) and I would joke about perhaps someday being able to construct a planetarium on the property; however, the cost of a professional planetarium would be an order of magnitude more than that of our observatory. For those who do not understand the difference between an observatory and a planetarium, please let me explain: An *observatory* is a domed building with a telescope that allows direct observation of the heavens through our atmosphere, usually at night. One person looks through the telescope at a time. Because the telescope must be maintained at the same temperature as the air, observers can become very uncomfortable, especially in the winter months when skies are clearest. A *planetarium* is a building that contains an interior dome and a light projector. The dome serves as a screen that presents images of the night sky to many seated visitors at once. The planetarium can be used rain or shine, day or night. The room is always at a comfortable temperature, and soft chairs make it a very enjoyable experience!

In late May 2016, Gordon Powers brought a local newspaper article to my attention. It stated that a nearby regional high school (Lenape Valley Regional High School) in Stanhope, N.J, was dismantling a 53-seat, 30-foot-diameter professional planetarium to make room for forensic science labs. What we thought would certainly be a “long shot” turned out to be a very simple and *welcome* transaction. Several Board of Education members and many in the community initially resisted retiring the facility, which served schoolchildren in Sussex, Warren, and Morris Counties. But now, Sterling Hill would continue the presentations to adults and students rather than retiring the planetarium to storage. Everyone was delighted to give the planetarium a second chance at our museum. The replacement cost of the equipment we were to receive was more than \$400,000. The Board of Education needed a monetary offer to start, so I made an offer of \$2,500. They seemed most interested in having the planetarium continue its educational role in the community, and they were delighted that we were immediately available to do the dismantling ourselves at no cost to them. The planetarium assembly consists of a control console, projector, 53 seats, and 30-foot-diameter aluminum dome made up of nearly 80 pie-shaped, curved aluminum panels, bolted together with more than 3,000 fasteners. Upon talking to the manufacturer (Spitz Planetariums, Inc.), we further learned that this model (the 512) is the finest of its type. It is still totally serviceable, and they still carry all of the critical parts. Built in 1973, the projector is the last of its kind.



The planetarium, prior to removal from Lenape Valley Regional High School. The star-and-planet projector is under the center of the 30-foot-diameter dome.

This is an electro-mechanical-optical system capable of giving razor-sharp star images on a totally dark background! Current planetarium models are basically “PowerPoint” projectors that are inherently incapable of projecting on a totally black sky background. More than 400 man-hours were required to disassemble and relocate the planetarium, and we finished with four days to spare!

Mike Pierce will be our architect and engineer on the new planetarium building project. Mike is exploring costs on a 25-foot-tall, prefabricated metal building, approximately 40 ft. on a side, that will fit between the present Ellis Observatory and the four cylindrical loading bins of the conveyor tower in our northerly parking lot. The building will have extra space for an office and display cabinets for astronomy-related items. It will also serve as a much needed additional assembly hall for all type of events. We have already met with the Ogdensburg Land Use Board and their attorney, and we were informed that because we already have an astronomical observatory, the planetarium is an acceptable use. We hope to have the new planetarium up and running by early 2018.

I would personally like to thank the Sterling Hill planetarium demo-and-moving team of Mike Pierce, Gordon Powers, Dave DeWitt, and Denise Kroth. We now have a great opportunity to further expand our science education horizons with a wonderful planetarium, rain or shine, day or night! Please stop by and see how we are doing! ✕

The 44th Annual New Jersey Earth Science Association Gem & Mineral Show

APRIL 23 AND 24, 2016

STEVEN M. KUITEMS, DMD
14 FOX HOLLOW TRAIL
BERNARDSVILLE, NJ 07924

This annual spring show is always marked by its emphasis on rocks and minerals from beyond Franklin and Ogdensburg. Anticipating this, my family and I were further delighted when our experience of the show was bracketed by two sightings of beautiful New Jersey wildlife. On our way to the show, an adult bald eagle flew about fifteen feet over our car after we spotted it crossing Franklin Pond. On our way home after show takedown, my son and I stopped to watch a large black bear on the shoulder of Cork Hill Road. It kept returning to a large tree while making low-pitched calls, and a minute later we saw why, when two cubs came scrambling down from the tree to follow their mom. Sussex County is still full of surprises for show attendees.

At the show itself, we started with the white-light displays. Dr. Bradley Plotkin filled two display cases, the first titled “Pseudomorphs From New Jersey Basalt and Diabase.” This included a remarkable pseudomorph of quartz after glauconite that fit inside its quartz cast like a sword in a sheath. Brad’s second case was “Minerals From the Collection of Wallace Gould Levison (1846-1924),” which included some fine Franklin, New Jersey, specimens acquired from James McGovern, such as a large bementite, a classic “caswellite” (now known to be a pseudomorph of garnet after mica), a fine old-time bustamite, and a classic crystal of Franklin tourmaline (now fluor-uvite). Levison was also an inventor, scientist, and mineral collector, and this case included his annotated specimen catalog, his illustration of a patented ultraviolet lighting system, and examples of his cobalt glass UV filters.

Steve Sanford’s case was titled “Colorful but Instructive” and featured fascinating specimens that illustrated many dynamic geological processes seen in the Franklin and Sterling Hill orebodies, including intrusions, folding, breccias, and chemical reactions. Your reporter’s case, “Franklin Classics in Shades of Purple,” exhibited for the first time a specimen of quartz, variety amethyst, from the Sterling Mine. Also displayed were purplish hodgkinsonite, sussexite, vesuvianite, corundum, and nine other purple minerals. John Sanfaçon presented “Jasper, Chert, and Flint” (varieties of microcrystalline quartz) in many colorful mixtures and patterns, including a 2.4-billion-year-



A quiet moment during the feeding frenzy for Gerry McLoughlin’s specimens on the first day of the show. Pat Hintz, Jim Van Fleet, Scott Allen, and Alex Kerstanski (red, navy blue, checked, and brown jackets, respectively) hold specimens while Mark Boyer (green jacket) lamps a possible purchase. *Tema Hecht photo.*

old Kambab green jasper from Madagascar, and a fine red and green Imperial Jasper from Zacatecas, Mexico. Juan Gonzalez’ case featured miniature specimens exhibited in an elegant dollhouse-scale room.

Bob Horn exhibited a case of New Jersey dinosaur footprints in red Triassic sandstone/shale, including several noteworthy sharp prints from the UBC Quarry in Clifton. Arlene



A mineral collector's dream house in miniature: Juan Gonzalez' display of thumbnail specimens featured this charming dining room. Where did he find a shark tooth that small? *Tema Hecht photo.*



L-R, Mark Dahlman, Paul Shizume, John Sanfaçon, Gary Kerstanski, Alex Kerstanski, and Richard Bostwick, after putting show equipment back into storage at show's end. *Tema Hecht photo.*

Castleman's "Bones Through the Ages" display included many vertebrate fossils, but I especially liked the variety of mammal teeth from the Badlands of Sioux County, Nebraska. Richard and Elna Hauck's "Quartz from Brazil" exhibit featured a stunning foot-high specimen of rose quartz crystals on a pale smoky quartz crystal, some extraordinary agates, and a flawless quartz sphere. Two cases were put in by Brendan and Connie Dunn. Highlights of the first case, "Zeolites," were a spectacular red heulandite on quartz from Maharashtra, India, and a large pink chabazite with laumontite from the New Street Quarry in Paterson, New Jersey. The second case, "Native Copper and Copper-Bearing Minerals," included notable malachite specimens from Katanga Province, Zaire, and a well-crystallized copper from Calumet, Michigan. Bernard Kozykowski presented two cases of "Crystal Classics" from worldwide localities, but my favorites were two New Jersey specimens from the Upper New Street Quarry in Paterson, a superb white analcime on prehnite, and a brown stilbite rosette. The Sterling Hill Mining Museum's case displayed a single large specimen of crystallized fluorite from Hardin County, Illinois, while the Franklin Mineral Museum presented "Minerals of the Franklin Marble," with well-crystallized examples of corundum, edenite, spinel, fluorapatite, fluoruvite, dravite, pyrite, arsenopyrite, and meionite.

The fluorescent mineral exhibits were, as expected, weighted in favor of our local zinc mines. Richard Keller's imaginative case, titled "Ye Olde Mill Site," was a whimsical reminder of the collecting many of us enjoyed on the Mill Site in Franklin, the Fluorescent Mineral Capital of the World. Small specimens of willemite, calcite, hardystonite, wollastonite, and even margarosanite were placed on a bed of fluorescent sand, with

a miniature pick, shovel, collecting bucket, and sorting screen. The Franklin Mineral Museum's display, "I'm Seeing Red," had a fine selection of local minerals that fluoresce bright red under shortwave UV, including calcite, roeblingite, axinite-(Mn) and bustamite. The next case in line was "Sterling Hill Muck Pile," a jumble of willemite-and-calcite ore specimens arranged as they might have looked after a blast, before being trammed to the crusher and hoisted to the mill for processing. "Franklin Delights" was the title of your author's case, which this year featured a large crimson-fluorescing bustamite, a remarkable ring-shaped, yellow-fluorescing esperite, and several clinohedrites, all under shortwave and all from the Franklin Mine. Then came Andrew K. Mackey's "Last of the New Jersey Zinc Mine Finds," a case with seven large willemite-rich ore specimens recovered from the Sterling Mine's mill complex after the mine closed. The sixth Franklin-related case was Alex Kerstanski's "Extraordinary Esperites and More," featuring outstanding and often large specimens of this distinctive bright-yellow-fluorescing mineral, many of them collected in the Franklin Mine by Alex's grandfather. A so-called "wispy esperite," with wavy veinlets of esperite in hardystonite, stood out, while one large clinohedrite-dominated specimen, with its bright orange fluorescence, was a delightful contrast.

"Longwave Classics," Brendan and Connie Dunn's third case at this show, included a well-crystallized, brightly fluorescent fluorite from the White Rock Quarry, Clay Center, Ohio; a rare green-fluorescing datolite from Lake County, California; and a deep-red-fluorescing ruby corundum from the Mundarara Mine, near Longido, Arusha Region, Tanzania. Then came "Greenlandic Classics" from Pat Hintz's ever-

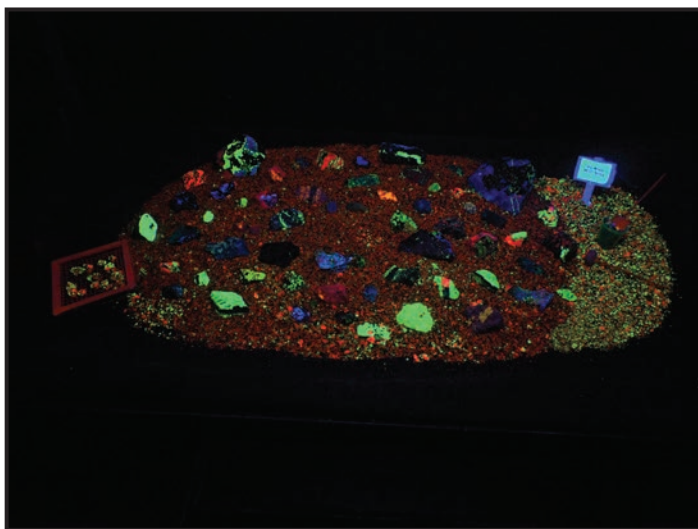
expanding stash, including some he collected on-site at the Ilímaussaq Alkaline Complex. There were several outstanding bright-orange-fluorescing sodalities, and of course some choice tugtupites, two of which were mimetoliths (“picture rocks”), one a tugtupite face, and the other a nonfluorescent swan swimming in a tugtupite lake. Pat’s interests also include spheres – “Spheres of the World,” in fact, as the display included not only several from the Sterling Mine, but also an orange-fluorescing tremolite sphere from Balmat, St. Lawrence County, New York, and one of manganoan calcite from the Huaron Mine, Ancash, Peru, with swirling patterned red fluorescence. Case number 10, Jeff Cessna’s “Whatever Piqued My Interest,” was a fluorescent potpourri for the eyes. Particularly memorable were red-fluorescing halite crystals on a sagebrush twig from the Salton Sea, Imperial County, California, and matched specimens of orange-fluorescing svabite in red-fluorescing calcite from Nordmark, Sweden. Three Franklin specimens of note were a rare bright-orange-fluorescing johnbaumite, a calcite in willemite that looked just like a red-fluorescing rose, and a miniature specimen called “Eye of Sauron” with a franklinite pupil rimmed in willemite on a background of violet-fluorescing hardystonite.

I was gladdened by the presence of several new exhibitors, and the creativity shown in many of the displays. Here’s a special thank-you for all who exhibited and helped make this show possible.

The recent loss of our fellow collector Gerry McLoughlin was marked by the sale of much of his collection at the show’s Outdoor Swap-and-Sell. Our heartfelt thanks to Gerry’s partner, Letty Moon, and his friend Claude Poli for making this sale possible; it gave many of us a chance to take home a specimen to remember him by. ✂



John Compton (right, holding specimen) gamely tries to smile after plunking down a wad of cash for a specimen of fibrous wollastonite with margarosanite and minehillite during the show auction at Sterling Hill, while auctioneer Van King looks on. *Tema Hecht photo.*



Rich Keller’s imaginative, miniature display featuring the Palmer mill site. The collecting bucket is a fluorescent plastic shot glass. *Tema Hecht photo.*



Jeff Cessna’s display, boldly going where no one had gone before, by mixing Franklin-Sterling Hill specimens with others “from away” – and it worked! *Tema Hecht photo.*

Fluorescent Minerals of Franklin and Sterling Hill, N.J., Part 1

A 2016 CHECKLIST BASED ON OBSERVATIONS OF CONFIRMED SPECIMENS

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[Editor's note: This is one-half of a greatly augmented version of the familiar fluorescent minerals checklist that Richard Bostwick has been maintaining for years. The second half will appear in the next issue of *The Picking Table*.]

INTRODUCTION

The minerals of Franklin and Sterling Hill have been collected and studied for more than two centuries and mined for almost that long. The district's unique mineralogy, its obvious potential for exploitation, and its proximity to New York City and Philadelphia have drawn scientists, mining engineers, investors, mineral collectors, and tourists to the area since the early decades of this country's independence. Zincite from the Franklin area, described in 1810 by Archibald Bruce, was one of the first minerals to be described in the United States by an American naturalist, and patriots of the American Revolution are commemorated in the mineral names franklinite (1819) and jeffersonite (1822). Though zinc mining ended here in 1986, the area variously called Franklin and Sterling Hill, the Franklin-Ogdensburg area, the Franklin Mining District, and FrOg for short, today has a mineral museum and a mining museum, both of which allow on-site collecting of local minerals, and two history museums. This is the United States' only world-class mineral locality east of the Mississippi River that is regularly accessible to tourists and mineral collectors.

Franklin and Sterling Hill have more mineral species overall, including more fluorescent minerals, than any other mineral locality in the United States. It's notable that of 370 mineral species found here as of July, 2016, 98 fluoresce, and of that 98 about a third fluoresce brightly. However, long before fluorescent minerals were collected and displayed as such, the Franklin Mining District was considered one of the great American mineral localities. Crystallized examples of franklinite, rhodonite, and willemite (to name just three) were treasured in private collections and museums across the country and in Europe, and the locality was famous for the large number of unusual, rare, and unique minerals that occur here. It's ironic that the current fame of Franklin and Sterling Hill is in part bolstered by the title "The Fluorescent Mineral Capital of the World," bestowed by the New Jersey legislature

in 1968. Still there is no denying that the best and brightest of the local fluorescent minerals, properly displayed, have a high "Wow" factor, and merit that honor. The classic "red and green" combination of calcite and willemite from these two mines is the most widely distributed and appreciated on our planet, and collectors from around the world continue to seek esperite, clinohedrite, turneaureite, and other Franklin rarities, as well as wollastonite and barite from both mines.

HISTORICAL OVERVIEW

Such is the fame of the fluorescent minerals of Franklin and Sterling Hill that they have been mentioned in the scientific and mineral-hobby literature for more than a century. In 1903 George Kunz and Charles Baskerville examined the entire mineral collection of the American Museum of Natural History, as well as thousands of gemstones, for fluorescence and phosphorescence. To stimulate these responses they exposed the collections to ultraviolet light from an iron arc, X-rays from a Crookes' tube, and "emanations" from radium and actinium compounds. They reported that willemite from Franklin, N.J., kunzite, and some diamonds were "the three most responsive minerals" to all these forms of energy. They also noted the "distinct red glow" of Franklin calcite under ultraviolet light, and the "very marked peculiarities of color" of fluorescent willemite and calcite in combination. "These effects were so characteristic that it required but a moment to identify the specimens in various parts of the collection as being from Franklin, N.J."

Charles Palache, in a short article published in 1928, listed about a dozen minerals from Franklin whose fluorescence was visible under the iron arc, and added a few more in his 1935 monograph about all the minerals then known from the district. Palache's article appears to be the first checklist limited to the fluorescent minerals of Franklin and Sterling Hill, and

since then there have been many checklists and articles on that subject, notably Robert W. Jones, Jr.'s 1964 book, *Nature's Hidden Rainbows*. Readers interested in the growth of this list over the years can browse through the programs of the annual Franklin-Sterling Gem & Mineral Show, going back to the two-page mimeographed program handed out at the First Annual Mineralogy Exhibit of the Franklin Kiwanis Club in October 1957. This included a fluorescent mineral checklist with 25 entries. The 2015 checklist, printed in the program of the 59th annual show, had 96 entries, with minimal descriptions; this present checklist has 98 entries and the descriptions have been expanded in the hope of enabling readers to make better guesses about fluorescent minerals in their collections.

The growth of the Franklin and Sterling Hill fluorescent mineral checklist can be linked directly to the many advances in the technology of ultraviolet energy sources since the days of radium emanations, X-rays, and the iron arc. Chief among the pioneers whose efforts directly benefited scientists, prospectors, miners, and mineral collectors was Thomas S. Warren of Ultra-Violet Products, Inc., now UVP, Inc. His M-12 Mineralight, a battery-powered 12-volt UV handheld lamp that fit in a backpack or lunch pail, was used extensively by prospectors and mine operators during the tungsten boom of the late 1930s and early 1940s, as well as the uranium boom that followed. Tom also manufactured line-operated UV handheld lamps and display lamps for collectors and museums, and made the collecting of fluorescent minerals a popular hobby. Those who followed in Tom's wake, notably Harry Wain of Raytech, Inc., and his successor, Tom Heffron, did much to advance these aspects of the mineral hobby. More recent innovators like Don Newsome of UV Systems, Inc., and William Gardner of Way Too Cool, Inc., have created improved and more powerful portable and display lamps that have made possible the impressive displays now in many museums, institutions, and homes around the world, and brought increased attention and prestige to what was once a neglected niche of the mineral hobby. The Fluorescent Mineral Society, founded in 1971, now has about 500 members worldwide, a newsletter and journal, and a significant presence on the Internet at uvminerals.org. The primary forum for information about the fluorescent minerals of Franklin and Sterling Hill is *The Picking Table*, the journal of the Franklin-Ogdensburg Mineralogical Society, Inc., whose website is fomsnj.org.

The range of UV wavelengths available to mineral hobbyists has also expanded. Mercury-arc lamps that until about the year 2000 were limited to longwave (360 nm) and shortwave (254 nm) lamps now include 305 nm midwave lamps, 290 nm longwave LED flashlights, and most recently the intense blue light (BL) lamps that were developed for underwater photography of fish, corals, and other undersea life forms, and are now being directed at minerals.

CAVEAT LECTOR! (Let the reader beware!) This checklist is not a full treatise, so descriptions of the minerals and their fluorescences are not and cannot be all-inclusive. Also, while mineral fluorescence can be a powerful tool for mineral identification, its accuracy is dependent on a number of factors. Chief among these is visual familiarity with the many different minerals and mineral assemblages found at Franklin and Sterling Hill. Next is the knowledge that mineral species in some groups can be extremely difficult to tell apart on sight, and thus may require one or more identification methods, from measuring hardness and specific gravity to performing chemical tests or optical, XRD, XRF, Raman, and other determination techniques. Sight-identification of minerals at Franklin and Sterling Hill, whether in daylight or under UV, can be difficult or impossible for amphiboles, apatites, carbonates, feldspars, garnets, humites, post-mining minerals, pyroxenes, serpentines, secondary uranium minerals, and zeolites. Most Franklin and Sterling mineral specimens are, in fact, sight-identified, and since fluorescence can mislead even experienced collectors, more conclusive identification methods are often necessary. Misidentifications based on fluorescence alone are common, with an understandable bias in favor of rare and expensive minerals.

Since many published descriptions of mineral fluorescence are confined to the nominal color categories of red, orange, yellow, green, blue, violet, and white-to-pale-yellow (a.k.a. "cream"), keep in mind that at Franklin and Sterling Hill there are not only multiple candidates for each nominal fluorescent color, but some minerals that can fluoresce more than one such color. To aid identification, this checklist includes additional descriptive information: color modifiers such as blue-green, green, yellow-green; brightness, from very bright to very weak; mineral assemblages; specific localities where known; cautions about when sight-identification is risky or impossible; and other bits and pieces of information that may aid more accurate identification on the part of the reader. The Franklin and Sterling Hill area is one of the greatest and most complicated mineral localities on Earth, and should be approached with respect and willingness to learn, but the rewards of a careful approach are more than worth the trouble.

ABBREVIATIONS USED THROUGHOUT THIS CHECKLIST

FL = fluoresce, fluoresces, fluorescing, fluorescence.

PH = phosphoresce, phosphoresces, phosphorescing, phosphorescence.

UV = ultraviolet radiation, also known as ultraviolet light, the portion of the electromagnetic spectrum adjacent to and shorter in wavelength than 400 nanometer (nm) visible violet light: energy from 100 to 400 nm in wavelength.

SW = shortwave ultraviolet radiation, also known as UVC: energy from 100 to 290 nm in wavelength. Most of the output of the filtered mercury-arc shortwave lamps used today is at 254 nm.

MW = midwave ultraviolet radiation, also known as midrange UV and UVB: energy from 290 to 320 nm. UVB is widely used for tanning lamps, which peak around 305 nm.

LW = longwave ultraviolet radiation, also known as black light and UVA: energy from 320 to 400 nm. Most LW display lamps peak at 366 nm, though some peak at 350 nm. LW “flashlights” peak at 390 nm.

BL = blue light, peaking at 445 nm (Mazel and Verbeek, 2014).

Note: UV-blocking goggles should always be worn when using SW, MW, and LW lamps. BL-blocking goggles must be used with BL lamps in order to observe fluorescence.

THE FLUORESCENT MINERALS OF FRANKLIN AND STERLING HILL

[Note: Mineral nomenclature in this fluorescent mineral checklist conforms to the 2015 list of local mineral species compiled by the FOMS Mineral List Committee. Neither scrupulous accuracy nor completeness can be guaranteed in a checklist of this scope, but comments and additional information are welcome and should be e-mailed to rbostwick@att.net.]

Albite: FL red of weak to moderate brightness SW, weaker MW and LW, no PH. Albite is a white feldspar that occurs sparingly in calcsilicate bodies at Franklin and Sterling Hill, as veinlets in the lamprophyre dikes of the Buckwheat Pit, and as small crystals in vugs in the Buckwheat Dolomite. Albite is also found in the Franklin Marble as crystals up to 5 cm. Masses of pale gray feldspar that FL moderately bright pale blue SW, associated with typical red-FL calcite, were found on the 900 level at Sterling Hill and sold as albite, but it is not known whether this feldspar has been analyzed.

Anorthite: Reported to FL weak pale yellow SW or weak red SW, no PH. A rare feldspar from the Franklin Marble, from the corundum-margarite assemblage found in the Sterling Hill motor shanty drifts on 340 and 430 levels. Also reported as pale gray tabular crystals up to 5 cm in calcite from the Fowler Quarry.

Aragonite: Generally FL and PH white to pale yellow (“cream”) of moderate brightness, best LW, weaker MW and SW. Rarely FL green SW due to uranyl. Aragonite is a product of weathering, common throughout the Franklin and Sterling Hill area as fluorescent crusts and coatings on outcrops, dump specimens, glacial till, and in marble quarries. Note that many such coatings, including the flowstone now being deposited in drifts on the adit level in the Sterling Mine, and the impressive

stalagmites, stalactites, and “mine pearls” found in that mine during post-1986 specimen recovery efforts (Jehle, 1995) are probably calcite, but few examples have been analyzed. The most desirable aragonite specimens from the district are crystal groups, generally of radiating habit, from Sterling Hill’s “Mud Zone,” but attractive examples exist from Franklin with flat radiating sprays of pale pink aragonite on granular franklinite-willemite ore.

Axinite-(Mn): Previously called manganaxinite, axinite. FL orange-red to red SW, with brightness ranging from very bright to weak; generally weak LW and weaker MW. PH can be observed under ideal conditions but is extremely weak, and much axinite-(Mn) is nonfluorescent. In visible light, axinite-(Mn) ranges in color from nearly white to pale yellow to orange-yellow and yellow-orange. Crystals rarely FL well but are popular with collectors, as vein and vug assemblages with axinite-(Mn) are usually attractive and often include rare crystallized minerals. Axinite-(Mn) is a major fluorescent mineral in the so-called “Parker Shaft Suite,” especially when paired with margarosanite, and can also be associated with prehnite, clinohedrite, xonotlite, nasonite, and other minerals of the altered-calcsilicate assemblage at Franklin. Axinite-(Mn) FL orange-red SW, like roebingite and most calcite, but can be distinguished from them by its lack of obvious PH. Relatively abundant at Franklin, axinite-(Mn) is rare at Sterling Hill, and examples from the several finds there do not FL. The closely related mineral axinite-(Fe) was found in the Palmer Shaft area and in the Gooseberry mine but is nonfluorescent.

Barite: Typically FL bright “cream” (very pale yellow) SW, moderately bright MW and weak LW, with no PH, from both mines. Sterling Hill barite can also FL and PH yellow SW, MW, and LW.

Franklin barite typically occurs in grains from 1 to 10 mm across in a matrix of red-FL calcite. These grains can be disseminated in calcite, in layers of disseminated grains, or as nearly solid layers of barite grains in calcite. Nonfluorescent andradite is often present in such specimens, and green-FL willemite is less common but an enhancement when present. Barite plays a similar role in “Third Find” wollastonite specimens (q.v.). Two less common assemblages from Franklin are cm-plus grains of barite in calcite, associated with franklinite and reddish-brown willemite, and barite grains and masses with orange-FL fluorapatite, rhodonite, willemite, and franklinite, also in calcite. At Franklin, fluorescent barite was occasionally found with hardystonite and clinohedrite, and a few specimens of nonfluorescent barite have films of clinohedrite along cleavage planes. Barite is rarely found with esperite, and it is relatively scarce in the altered calcsilicate assemblage where it occurs with axinite-(Mn) and other minerals, and may or may not FL.

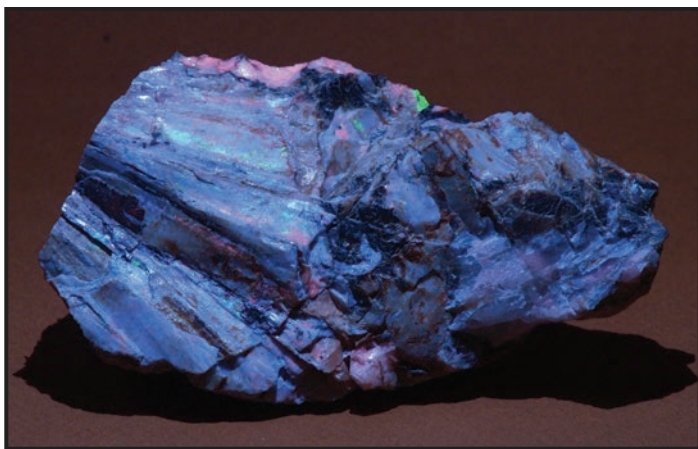


Figure 1. A very rich specimen of Franklin, N.J. barylite with apparent bright blue FL, associated with red-FL calcite, green-FL willemite, and nonfluorescent serpentine. This is photographed as Lawson Bauer and Charles Palache first saw barylite, under an unfiltered iron arc unit. Under the filtered SW UV mercury-arc lamps now in use, the FL of barylite from Franklin, N.J., is relatively weak, and the bright blue color seen here is due to stronger FL caused by SW wavelengths in the iron arc that are shorter in wavelength than those in mercury-arc lamps, and enhanced by reflected visible blue light from the unfiltered iron arc. The specimen is about 5 inches (13 cm) long. Franklin Mineral Museum specimen, *Jeff Glover photo*.

Perhaps the oddest fluorescent barite from Franklin was found on the site of Mill No. 2 (a.k.a. the Mill Site) by Stuart Schneider and occurs as white plates in a 2-mm-thick vein in dark brown andradite. The plates FL and PH moderately weak cherry-red SW with some white “clouding,” and appear to FL weak white MW. The mineral was initially thought to be wollastonite and is so described in Schneider (2004) on page 100, where there are photographs of a specimen in visible light and under SW. EDS analysis has since confirmed the strong presence of Ba, S, and O, which perfectly fits barite, BaSO_4 .

Barite at Sterling Hill was long thought to be scarce, a white vein mineral with weak white FL SW, usually associated with bladed rhodonite crystals. Then in the 1970s and 1980s, limited numbers of “golden barite” specimens were found: honey-colored barite in solid veins 1 to 3 mm thick in ore, and as small crystals in seams of drusy friedelite crystals. This so-called “golden barite” FL and PH moderately bright yellow SW, MW, and LW. There are also a few examples of small white barite crystals from Sterling Hill in veins that FL and PH white under SW, MW, and LW. However, in the early 1990s, when underground mineral recovery was a priority for the Sterling Hill Mining Museum, “cream”-FL barite as layers of grains in red-FL calcite, similar to typical Franklin barite in calcite in appearance, FL, and lack of PH, was found in the footwall of the east limb of the orebody on the 600, 700, and 900 levels. Of these, the 900-level specimens, which were not common, have moderately bright but well-balanced FL; the 600-level specimens have extremely bright barite in

moderately bright calcite; and the 700-level specimens, by far the most abundant, have bright and well-balanced FL of barite and calcite. The 700-level find has provided the largest display specimens of barite and calcite from either mine.

There were several other occurrences of fluorescent barite at Sterling Hill. The most display-worthy assemblage was found on the 600 level during the Hauck era; it’s capable of five-color fluorescent specimens that can include “cream”-FL barite, orange-FL fluorapatite/johnbaumite, orange-FL zircon, red-FL calcite, all best under SW, and sphalerite that FL orange, best LW. In the Mark Boyer collection is a large example of an unusual barite in white plates that FL weak blue-cream SW but FL and PH fairly bright “cream” LW and are associated with abundant pale-green willemite. This specimen has a Lawson Bauer label giving the locality as 1100 level, and the white plates have been recently confirmed as barite through XRD analysis by James Van Fleet (personal communication, Mark Boyer, 2016). Sterling Hill’s North Orebody has produced masses of nonfluorescent pinkish-lavender cherty sussexite with 2- to 3-mm rims of white barite that FL weak pale green and “cream.”

Barylite: FL moderately weak violet SW, with brief PH, under modern filtered mercury-arc SW lamps. Barylite is a rare Franklin mineral that is much more impressive when seen under an unfiltered iron arc unit, as Bauer and Palache saw it (Fig. 1). What they termed “vivid blue fluorescence” we now know is a combination of blue light from the iron arc, reflected by barylite, and moderately bright violet FL emitted by barylite in response to the UV in the iron arc spectrum. The mistaken belief that barylite FL bright blue under mercury-arc shortwave lamps, plus its Mohs hardness of 7, led many collectors to misidentify, as barylite, margarosanite mixed with feldspar (Mohs 6). A more reliable guide to identifying authentic barylite is the use of an iron arc on specimens that conform to the barylite assemblage described by Palache (1935). Specimens not from that assemblage are almost guaranteed not to be barylite (Gaines and Bostwick, 1983).

Bassanite: FL and PH violet SW; very rare. From Sterling Hill. Small white masses on vein material that consists partly of red-FL calcite.

Bianchite: FL blue-white SW with weak PH, with weaker FL and PH under MW and LW. A post-mining mineral that forms fibrous coatings on “red ore” from Sterling Hill. (“Red ore” and “black ore” were terms used by miners and staff to describe the two main types of ore at Sterling Hill, based on the color of willemite in the ore. “Red willemite” could be anywhere in a range of hues from pinkish tan to brick-red to dark reddish brown, while “black willemite” is gray or black.)

Bustamite: Most bustamite from Franklin is nonfluorescent or FL weak red under LW. However, so-called “bubble-gum pink” bustamite, usually associated with hardystonite, clinohedrite, and willemite, can FL moderately bright cherry-red, usually brightest LW. In a few notable examples from Franklin’s Mill Site, bustamite in the above assemblage FL brighter SW than LW; the SW combination of cherry-red, violet, orange, and green FL is very pleasing. Red-FL LW bustamite also FL red BL (Mazel and Verbeek 2014). Bustamite occurs at Sterling Hill but is rare and nonfluorescent.

Cahnite: FL and PH “cream” SW, MW, and LW, but its FL is moderately weak and often zoned. This rare Franklin classic is generally found as small colorless tetrahedral crystals and interpenetrating twins in a variety of vein occurrences.

Calcite: The most abundant mineral in the Franklin Marble that hosts the two zinc orebodies, and the major gangue mineral in both orebodies. Calcite from the orebodies typically FL bright orange-red, generally best SW, with a distinctive and brief red-orange PH referred to locally as “flash.” The brightness of calcite’s orange-red FL ranges from very bright to very weak, and some examples FL red to pink under MW and LW, but calcites with orange-red, red, and pink FL usually PH as described. The two other Franklin minerals with similar FL SW are roeblingite and axinite-(Mn). Roeblingite’s FL and PH are identical to those of calcite but weaker, while axinite-(Mn) can FL as brightly as calcite but lacks noticeable PH.

In numerous occurrences throughout both zinc orebodies, calcite can FL white, “cream,” yellow, orange, green, blue, and violet-blue in addition to the more typical range of orange-red to red and pink FL, and in some examples calcite will FL different colors under different wavelengths of UV. Specimens

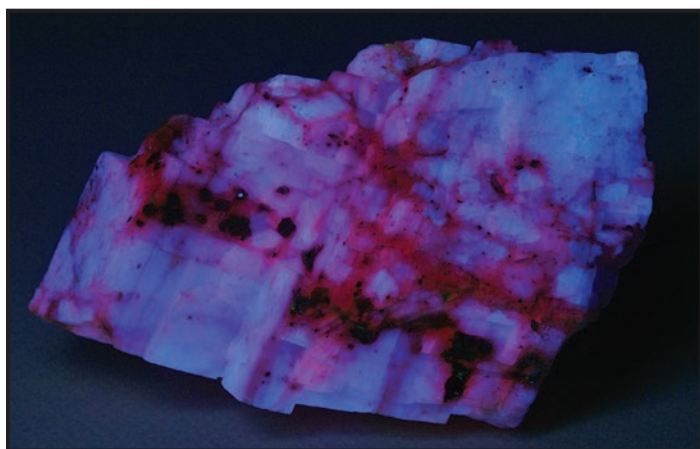


Figure 2. Calcite from the Buckwheat Dump, Franklin, N.J. that FL typical red under SW UV, but under MW UV has zones of red FL and blue-violet FL. Small grains of blue-FL sphalerite are also present. Calcite showing similar FL is also known from Sterling Hill. Mark Boyer specimen, 4.0 x 2.8 x 2.2 inches (10 x 7 x 5.5 cm). *Earl R. Verbeek photo.*

have been seen with two and three different varieties of FL calcite. Most FL calcites also exhibit PH. Calcite in fact has the greatest variety of fluorescent hues of any mineral from Franklin and Sterling Hill, more than can be described in detail, so a few examples will have to suffice. One “oddball” calcite found at Franklin and Sterling Hill FL bright orange-red SW but in MW and LW has areas that FL violet-blue (Fig. 2). Another unusual calcite from Sterling Hill occurs as thin veins and coatings in zincite-rich ore, and FL and PH bright orange under SW. This was first thought to be Sterling Hill clinohedrite, but as it dissolved rapidly in dilute HCl it was believed to be orange-FL calcite. It has now been analyzed by James Van Fleet as a mixture of calcite and yellow-FL willemite (personal communication, Mark Boyer).

Massive calcite in the Franklin Marble is generally nonfluorescent except within the manganese halo surrounding the orebodies, but can FL and PH in a variety of colors, rarely bright. Often FL calcite is found as coatings on nonfluorescent calcite. Luckily, calcite in or out of the orebodies can often be identified by its rhombic cleavage, low hardness (3), and/or its ability to fizz when exposed to 10% HCl. However, as discussed under aragonite, coatings of calcium carbonate formed under surface conditions are common in the district and often fluorescent. Whether they are thin coatings most easily seen under UV, or thicker coatings and cave formations (speleothems) like flowstone, stalagmite, stalactites, and “mine pearls,” they are more likely to be calcite than aragonite, but few examples have been analyzed.

Canavesite: FL and PH moderately bright “cream” LW and MW. Canavesite is a rare mineral that forms small clusters of white fibers in seams on granular franklinite-willemite “red ore” from Sterling Hill. Canavesite probably FL similarly under SW but in the analyzed specimen examined, the willemite-rich matrix FL so brightly that the weaker FL of canavesite cannot be observed.

Celestine: FL and PH “cream” of moderate brightness SW, MW, and LW, brightest SW. Celestine occurs at Franklin and Sterling Hill as small colorless-to-white crystals and as vein fillings; pale-blue vein fillings from Sterling Hill can be very attractive. One of the better localities for celestine was 820 pillar on 1200 level at Sterling Hill, where lean franklinite-calcite ore was riddled with solution cavities lined with small but well-formed celestine crystals.

Cerussite: FL moderately bright yellow to orange-yellow LW and MW, less bright SW. Cerussite is a weathering product of galena, and was considered rare in the district until it was found in moderate abundance in the early 1990s around the perimeter of the Passaic Pit at Sterling Hill. It is found in crusts, masses, and crystals, usually on or with galena.

Chabazite: FL moderately bright green SW, weak green MW and LW. The activator is probably uranyl. Chabazite has been found at both Franklin and Sterling Hill in small amounts but is best known from a find at Sterling Hill, where it occurs as tan crystals, some of which are 2 to 3 mm across, in vugs in a matrix of white feldspar, calcite, and dark green pyroxene.

Charlesite: FL moderately bright pale blue SW, but charlesite is often coated with thin crusts of cream-FL gypsum. Formerly known as ettringite, this Franklin rarity is found in the altered calcsilicate assemblage as white crusts and flattened hexagonal “flying saucer” crystals with clinohedrite, ganophyllite, prehnite, hancockite, roebingite, etc. FL pale green BL when viewed through blue-blocking goggles (Mazel and Verbeek, 2014).

Chondrodite: FL bright to weak yellow to orange-yellow to yellow-orange, best SW. Chondrodite is a member of the humite group and is fairly common in the Franklin Marble as yellow to orange to brown grains, typically several mm across. Chondrodite is closely related to norbergite, which is usually paler in color and generally has brighter FL SW, but lighter-colored chondrodite and darker-colored norbergite can look and FL alike.

Chrysotile: Rarely FL “tan” of moderate to weak brightness LW, weaker MW and weakest SW. Chrysotile is the most abundant member of the serpentine group at Franklin and Sterling Hill, is typically tan to dark brown in color, and occurs in a variety of assemblages from both mines. Lighter-colored chrysotile with a cherty appearance, notably from Sterling Hill’s North Orebody, is the most likely to FL.

Clinohedrite: FL bright orange SW with persistent PH, and FL yellow-orange BL. It FL moderately weak orange MW but can FL somewhat brighter LW. Clinohedrite is one of the signature fluorescent minerals of Franklin. In the calcsilicate assemblage, clinohedrite usually occurs as thin coatings on hardystonite, though it can form coatings on other minerals in that assemblage such as bustamite and diopside. A few specimens exist of clinohedrite coatings one centimeter thick on hardystonite, and thinner coatings can form crystal druses or exhibit radiating and plume-like habits.

In the altered calcsilicate assemblage, clinohedrite is likely to form coatings on axinite-(Mn), and is rarely found in amethyst-tinted crystals associated with ganophyllite, charlesite, pennantite, and other rare minerals. Clinohedrite is also found in a few simpler assemblages: as veins of small colorless crystals in a black matrix; as a pale amethyst-colored crack-filling in granular franklinite-willemite ore; as dull gray to dull purplish masses, often with a “corroded” appearance, in franklinite-willemite ore; and as chalky white masses with

altered hardystonite. Clinohedrite has been found sparingly on the Parker Dump, the Mill Site, and rarely at the lowest levels of the Buckwheat Dump.

Corundum: FL moderately bright cherry-red LW and brighter cherry-red BL, FL moderately weak red MW and weaker SW. A mineral of the Franklin Marble, corundum is typically found in calcite as rounded reddish-pink grains and crude hexagonal crystals less than 1 cm across, though some are larger. Grayish-blue corundum is less common and nonfluorescent, but most of the pale pink to deep red and pinkish-red grains and crystals of corundum FL cherry-red. The best-known find occurred in the Sterling Mine, outside the orebody in the motor shanties on 340 and 430 levels near the West Shaft, where “ruby corundum” was associated with blue-green margarite plates, rutile crystals, arsenopyrite crystals, zircon crystals, and other minerals. Otherwise, fluorescent corundum has been found in the local quarries in the Franklin Marble, and in so-called “pockets” near the surface where corundum has been wholly or partly etched out of its calcite matrix.

Cuspidine: FL bright orange-yellow SW (Fig. 3a) with brief orange-red PH, but FL violet MW (Fig. 3b) and weak orange-yellow LW. Franklin is the second world locality for cuspidine. The first was Monte Somma in Italy, where cuspidine was found as dogtooth-shaped crystals (hence the name) in blocks of metamorphosed limestone ejected from the volcano. Franklin cuspidine was for more than 80 years the rarest mineral from Franklin because the known supply had been used up in 1899 during analysis. After Pete Dunn tracked down and confirmed the identities of some original Parker Shaft museum specimens in the mid-1980s, Dru Wilbur noticed an unusual fluorescence in a chunk of Franklin ore from the debris of a demolished house, and had it analyzed (Wilbur, 1999). In the ensuing “Cuspidine Rush” the mineral was found to have been collected earlier on the Parker Dump, Buckwheat Dump, and Franklin Mill Site (Bostwick, 1999), and was recognized by Chuck Sloan in a Franklin specimen collected on the worldwide minerals section of the Sterling Hill Mining Museum’s Mine Run Dump. Subsequent collecting on the Buckwheat Dump has yielded the finest known display specimens of fluorescent cuspidine.

The assemblage found in the Parker Mine in the 1890s includes colorless blobs of cuspidine with hardystonite, clinohedrite, nasonite, and pale blue crystals of glaucochroite. Specimens from the Franklin dumps typically include masses and grains of colorless, tan, or gray cuspidine with willemite, franklinite, hardystonite, and purplish glaucochroite in a matrix of calcite. An unusual cuspidine assemblage, once believed to be massive barite with hardystonite and clinohedrite, was determined to be cream-FL SW fluorite with hardystonite and cuspidine

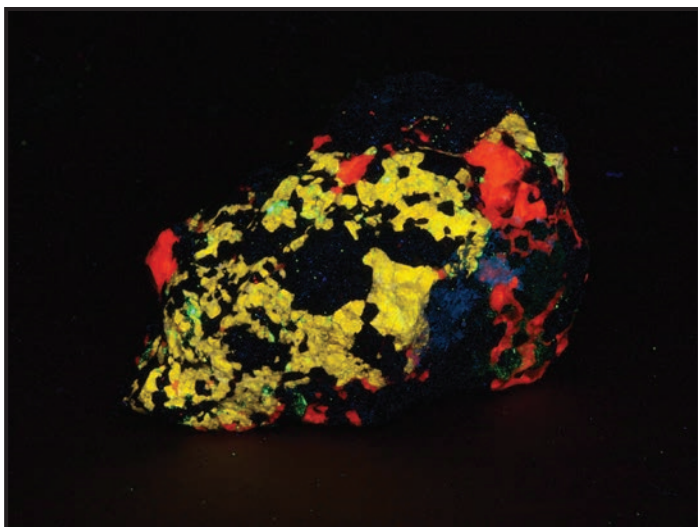


Figure 3a. Orange-FL cuspidine under SW UV with red-FL calcite, green-FL willemite, and nonfluorescent franklinite, from the Buckwheat Dump, Franklin, N.J., 2.6 x 1.6 x 1.2 inches (6.5 x 4 x 3 cm). *Earl R. Verbeek specimen and photo.*



Figure 3b. Mottled pink-and-violet-FL cuspidine under MW UV, with dull red-FL calcite, green-FL willemite, and nonfluorescent franklinite, from the Buckwheat Dump, Franklin, N.J. Compare to Figure 3a. This clearly shows the color shift under MW UV that is a distinguishing feature of Franklin cuspidine. To the eye cuspidine's FL color under MW is usually more violet than pink. *Earl R. Verbeek specimen and photo.*

(Cianciulli, 2001). For years, cuspidine from the Buckwheat Dump was sold locally as johnbaumite, but johnbaumite does not PH, nor does it have a violet tint under MW.

Datolite: FL moderately bright to weak “cream” SW, weaker MW and LW. Glassy colorless crystals and cavity fillings of datolite are found in the altered calcsilicate assemblage at Franklin with hancockite, axinite-(Mn), clinohedrite, willemite, etc.

Diopside: FL fairly bright pale blue SW, but FL moderately weak pale orange-yellow MW, weaker LW. One of the more common fluorescent minerals from the Franklin Marble, diopside occurs in blocky grains in a matrix of nonfluorescent calcite, and even though diopside usually has a pale yellow tint in daylight, a SW UV lamp is by far the easiest way to find it. The FL of diopside from the marble is much like that of tremolite from the marble, but diopside is a pyroxene and tremolite is an amphibole, and the two are easily distinguished by their forms (see tremolite).

One exceptional find of blue-FL diopside in red-FL calcite, at the edge of the orebody's “manganese halo,” was made in 1991 in the footwall of the west limb on the Sterling Mine's 700 level. Massive diopside, pale tan to brown at Franklin and greenish brown at Sterling Hill, is found in the calcsilicate units of both orebodies but does not FL.

Dolomite: FL and PH moderately bright to very weak red SW, progressively weaker under MW and LW. The brightest fluorescent dolomite from the district is the less-bright-red-FL component of “crazy calcite,” an intergrowth of calcite and dolomite from Franklin and Sterling Hill (Bostwick, 2000). The choicest examples, with brightly FL calcite and moderately bright FL dolomite, are from Franklin and are likely to include grains and/or thin veins of green FL willemite. The more abundant “crazy calcite” from Sterling Hill, with less brightly FL dolomite, is likely to include grains of sphalerite and patchy coatings of hydrozincite, but generally lacks willemite.

An unusual form of fluorescent dolomite, found at Sterling Hill by Robert Hauck and analyzed by James Van Fleet, consists of tan coatings on very lean ore (mostly orange-red-FL calcite), from the east limb exposure. This dolomite FL pink SW, pink and tan MW, and tan LW.

Dundasite: FL pale yellow SW, MW and LW; rare. Dundasite was found at Sterling Hill, in radial acicular habit, in weathered galena from the periphery of the Passaic Pit (Lapham, 2002).

Dypingite: FL and PH moderately bright pale blue to white SW, MW, and LW. Almost all dypingite from the district came from Sterling Hill, some from the North Orebody and some from “red ore” workplaces in the main orebody. Most Sterling Hill dypingite occurs as abundant sub-mm white hemispheres on weathered surfaces of ore. On some specimens these occur in parallel rows that have been described as “Eskimo housing developments.” Dypingite has also been reported from a single find at the Franklin Mill Site in a matrix rich in green serpentine.

Epsomite: FL “cream” LW, violet MW; an uncommon weathering mineral from Sterling Hill, first reported as 1/8-inch fuzzy coatings on fractures in gneiss (Dunn, 1995).

Esperite: FL very bright lemon-yellow SW (Fig. 4), weaker MW and LW, with very weak PH. Another of the hallmark fluorescent minerals of the district, esperite occurs in the calcisilicate assemblage first mined through the Parker Shaft in the 1890s. It was once moderately abundant on the Parker Dump, but because it resembled hardystonite in daylight it was not noticed as a separate mineral until 1928, when specimens of the newly discovered mineral larsenite were examined under the iron arc. Esperite, originally named calcium larsenite, is often associated with hardystonite; these two minerals, with clinohedrite, willemite, and calcite, are the fluorescent components of Franklin’s legendary five-color fluorescent specimens. Esperite also typically occurs with franklinite, zincite, and glaucocroite, and is rarely associated with barite, fluorapatite, and even hydrozincite.

Esperite often replaces hardystonite, and much of esperite’s appeal “under the lamp” comes from the variety of patterns formed during the replacement process, and the sharp contrast between the bright lemon-yellow FL of esperite and the relatively weak blue-violet FL of hardystonite. Favorite patterns have names, notably “wispy esperite” and “spiderweb esperite.” Also popular are hardystonite crystal sections replaced by esperite in whole or part, in a matrix of red-FL calcite. Complete replacements are often called esperite crystals, though actual esperite crystals are extremely rare and very small. In any case, though much esperite was collected in the Franklin mine by staff and workers in the 1940s and 1950s, this bright yellow-FL mineral continues to gain in popularity and price with the years. Small amounts of esperite are still being found on the lowest levels of the Buckwheat Dump and on private property adjacent to the Parker Dump.

Fluorborite: FL moderately bright “cream” SW, in colorless to white and ivory-colored grains averaging several mm in size, from the Braen Franklin Quarry, the Lime Crest Quarry in Sparta (now Braen Stone of Sparta), the Bodnar Quarry in Hamburg, and elsewhere in the Franklin Marble. The matrix is nonfluorescent calcite. Fluorborite has also been found as a fibrous white vein filling in the orebodies at Franklin and Sterling Hill and may FL similarly.

Fluorapatite: FL orange to bluish orange in both zinc orebodies, usually brightest SW but occasionally as bright MW, and weaker LW. Fluorapatite in the Franklin Marble FL moderately bright to weak greenish-blue SW, weaker MW and LW. Fluorapatite and other members of the apatite supergroup do not PH. The activator for orange-FL apatites in the district is Mn^{2+} , and the bluish FL is caused by rare earth elements

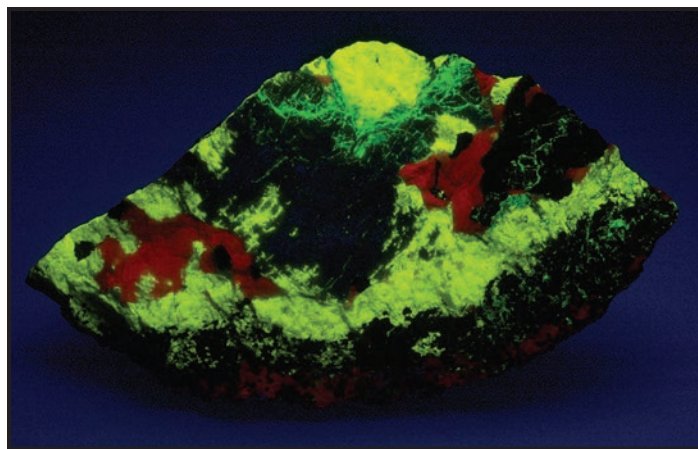


Figure 4. An outstanding “four-color” fluorescent showpiece from Franklin, N.J., photographed under SW UV: esperite (yellow), hardystonite (blue-violet), willemite (green), and calcite (red). Besides the bright colors and well-balanced visual pattern, this specimen shows esperite replacing hardystonite (left center) and a delicate filigree of willemite veinlets. On display at the Franklin Mineral Museum: FMM-6359, 7.1 x 4.0 x 2.4 inches (18 x 10 x 6 cm). *Earl R. Verbeek photo.*

(REE). The bluish-orange FL of some apatites in the orebody, called “orchid,” “peach,” and other terms, is probably caused by a mixture of Mn^{2+} and REE.

Fluorapatite is the most abundant member of the apatite supergroup at Franklin and Sterling Hill; it occurs in nearly every mineral assemblage in the zinc orebodies, and throughout the Franklin Marble. Fluorapatite ranges in color from colorless to white to gray, gray-green, green, blue-green, green, greenish blue, deep blue, tan, and reddish brown; in general, the lighter the color, the brighter the FL. Fluorapatite in the orebodies is usually massive, though it is known in crystals, and a few giant crystals on the order of 30 cm (12 inches) long were found at Sterling Hill. Most fluorapatite in the zinc orebodies is associated with calcite, andradite, franklinite or magnetite, and willemite. Less common assemblages are fluorapatite with rhodonite and barite, fluorapatite with sphalerite, fluorapatite with hardystonite and/or esperite, fluorapatite with scheelite, and fluorapatite with hancockite and related minerals.

Fluorapatite and other apatite supergroup minerals seem to attract arsenic, and because all analyzed apatites from the Franklin and Sterling Hill zinc orebodies were found to include arsenic (Palache, 1935), many were thought to be svabite, the arsenic-dominant analog of fluorapatite, and labeled as such. Since after much subsequent analytical work no confirmed examples of svabite have been found at Franklin or Sterling Hill, svabite is no longer on the list of species from the district. The arsenic-OH-dominant apatite species johnbaumite is found in both zinc orebodies, and the arsenic-Cl-dominant apatite species turneaureite occurs at Franklin, but both are relatively rare and almost always gray in color, so almost all of the blue-green, green, and greenish-blue apatite in the orebodies is

fluorapatite. Putative johnbaumite and turneaureite specimens that are not dead-ringer visual matches for analyzed specimens should be analyzed.

Fluorapatite in the Franklin Marble is greenish-blue to bluish-green, is known from all the local marble quarries, and usually occurs as crystals in a matrix of nonfluorescent calcite.

Fluorapophyllite-(K): FL and PH weak white SW. Previously known as fluorapophyllite, it is found in colorless crystals of typical form as much as 1.2 cm across, and is best known in specimens found during the sinking of the Palmer Shaft, associated with epidote, hedenbergite, garnet, and crystals of pyrite and axinite-(Fe). Specimens from this assemblage were also found at the Franklin Mill Site.

Fluorite: The variety chlorophane, relatively abundant in both orebodies and on the Buckwheat Dump, is the best-known fluorite from the district. It is “sherry-colored” (pinkish tan to reddish-brown) in daylight, and FL and PH moderately bright blue-green SW, MW, and LW when freshly broken. However, it rapidly loses its blue-green FL and PH on exposure to light, and FL conventional weak blue-violet thereafter. Chlorophane also thermoluminesces blue-green, but after heating it loses that property as well. When freshly exposed, as seen in place in “black ore” at Sterling Hill, fluorite var. chlorophane is sensitive enough to phosphoresce after brief exposure to a miners’ cap-lamp. Chlorophane’s unusual luminescent properties can be preserved by wrapping freshly broken specimens in lightproof paper, plastic, or aluminum foil, and keeping them away from light. Fluorite var. chlorophane may be collected on the Buckwheat Dump in Franklin, associated with either red-FL calcite or orange-FL fluorapatite, or both.

Otherwise fluorite is relatively common, if not abundant, in both orebodies and the Franklin Marble. Collectors not preoccupied with fluorescence prefer the small but sharp, clear fluorite crystals from vein assemblages in the orebodies and vugs in the Buckwheat Dolomite, and rarely the colorless, blue, or violet crystals from vugs in the Franklin Marble. Fluorite is also widespread throughout the Franklin Mining District in vein assemblages and as grains and masses in multiple assemblages. Fluorite’s appearance and FL are not always predictable, and it has been mistaken for barite at Franklin (see cuspidine), and at Sterling Hill when white-FL SW fluorite grains in red-FL calcite were thought to be barite until their phosphorescence was noticed. Fluorite with violet-blue FL LW is often present in vein assemblages at Sterling Hill, including the “Persian Carpet” vein specimens described in more detail under sphalerite and zincite.

Suffice it to say that fluorite from one orebody or the other has been reported to FL white, pale yellow, greenish-yellow, blue-green, green, and blue-violet, occasionally with FL color changes from SW to MW to LW. Fluorite that FL “cream” SW

and violet-blue LW is also found at the Edison iron-mining property east of Ogdensburg, associated with orange FL fluorapatite, brightest MW, but Edison mine specimens are usually weathered and do not resemble those from Franklin and Sterling Hill.

Colorless, blue, and violet fluorite from the Franklin Marble may FL weak violet-blue LW or be non-FL.

Fluor-uvite: FL moderately bright to weak orange-yellow SW. Formerly known as uvite, earlier as tourmaline, this member of the tourmaline group is one of the crystal classics from the Franklin Marble, popular with collectors long before its FL was known. It is found as equant hemimorphic crystals in shades of green and brown, some as large as 4 cm across.

Genthelvite: FL blue-green of varying brightness LW, SW, and MW, rarely FL yellow to orange MW. Genthelvite is rare at Franklin, where it occurred in small amounts in the petedunnite assemblage (Boyer and Orosz, 2006) and in other assemblages (Cianciulli and Verbeek, 2006). At Sterling Hill, genthelvite was found in the early 2000s on the east side of the Passaic Pit, in the footwall of the east limb of the orebody, in what became known as the “Genthelvite Trench.” There it was found in masses, the largest about 6 cm across, and in smaller masses and well-defined crystals with rhodonite, feldspar, quartz, galena, powellite, calcite, and other minerals (Cianciulli and Verbeek, 2003). Because of its greenish fluorescence, genthelvite was initially mistaken for willemite or chabazite, but genthelvite FL moderately bright blue-green, is brighter LW than SW, and does not PH, while willemite FL bright yellowish green SW, FL less brightly MW and LW, and is often PH. See Leavens et al. (2009).

Gerstmannite: FL “dull olive-green” LW, brighter BL (Mazel and Verbeek, 2014). The weak fluorescence of gerstmannite under LW had been suspected earlier, but, as like other pale-colored reflective minerals it reflects visible light emitted by UV lamps, in general such reactions have been too ambiguous to report as fluorescence. However, examination of gerstmannite under 445 nm BL confirms its weak green fluorescence LW.

Greenockite: FL cherry-red LW. Greenockite and its dimorph hawleyite are known from Franklin and Sterling Hill as bright yellow films and crusts, and at Sterling Hill as crystals, but confirmed specimens of either species are rare, and yellow coatings of other minerals are often misidentified as greenockite. Red-FL LW greenockite in the form of small yellow-orange grains in calcite has been tentatively identified from Franklin. Palache (1935) described, as greenockite, thin yellow crusts on dolomite with green fibrous willemite from the Hamburg Mine, but noted “determination of the mineral is unsatisfactory.” Subsequent

analysis of a specimen from this find showed it to be hawleyite. An example of purported greenockite from the Hamburg Mine, seen in the Brush collection at Yale, included a handwritten note, “CdS mixed with ZnS,” initialed SLP (Samuel L. Penfield). Several small pieces from this find have been observed by the author to FL orange rather than red LW, the orange response probably due to sphalerite, but similar Hamburg mine specimens have red-FL yellow crusts that have not been analyzed.

Grossular: FL cherry-red LW; very rare. Pink massive grossular is fairly common in Franklin’s altered calcsilicate assemblage, and almost all of it is nonfluorescent, but there has been one report of small grains of pink grossular that FL as described. Three specimens are known from Franklin with masses of white granular grossular that FL cherry-red LW, associated with axinite-(Mn) and gahnite (Verbeek and Carr, 2011; Yeates and Verbeek, 2014).

Guerinite: FL and PH pale yellow SW, MW and LW. A rare, white, fibrous post-mining mineral on nonfluorescent calcite, found at Sterling Hill by John Kolic.

Gypsum: FL and PH moderately bright to weak white, pale yellow, and blue SW and MW, weakest LW. Gypsum is a late-stage mineral at both Franklin and Sterling Hill, present in vein and cavity fillings and as small crystals coating drift walls. Most gypsum is nonfluorescent or partly fluorescent, as is the case with the well-known occurrence in Sterling Hill’s “Mud Zone” where gypsum var. selenite has filled solution cavities in lean ore. At Sterling Hill there are also examples of massive gypsum and anhydrite on fluorescent lean ore, with veinlets of secondary green-FL willemite and orange-FL sphalerite at and near the gypsum-ore contact.

Hardystonite: FL violet to violet-blue SW, MW, and LW, with variable brightness. Another signature mineral of the Franklin calcsilicate assemblage, hardystonite was first described in 1898 in specimens from the Parker Shaft, and was eventually found to be widely distributed underground. For years it was abundant on the Parker Dump, where it had been discarded because of its lead content, and it was believed to be unique to Franklin until small amounts were found at the Desert View Mine in San Bernardino County, California (Verbeek and Van Fleet, 2014). At Franklin, hardystonite is commonly associated with clinohedrite, esperite, willemite, and calcite, and specimens with three, four, and five of these fluorescent species occur in a variety of attractive visual patterns. Especially prized are examples of hardystonite crystals, exposed in cross-section in red-FL calcite. Hardystonite is also found with FL bustamite and rarely with FL barite.

Hedyphane: FL orange, usually of moderate to weak brightness MW, weaker SW, and very weak or nonfluorescent LW; no PH. Hedyphane, a member of the apatite supergroup, occurs at Franklin in veins with rhodonite and axinite-(Mn), and as masses in the barylite assemblage. The most common type, with FL as described, is dull yellowish-tan hedyphane in veins about 1 cm thick with brownish-red rhodonite (Figs. 5a, 5b). Honey-yellow hedyphane with similarly weak FL occurs as masses with barylite, calcite, and serpentine. White to cream-colored hedyphane that FL weak orange is found, sometimes in crystals, in thin veins with crystals of axinite-(Mn) or bladed rhodonite crystals. There was one exceptional find of white hedyphane that FL bright orange SW, in a vein with bright pink rhodonite; an excellent example is on display in the Franklin Mineral Museum.



Figure 5a. Massive tan hedyphane, a fairly rare species in the Apatite Supergroup, in a vein with dark red rhodonite on granular franklinite-willemite ore, from Franklin, N.J. On display at the Franklin Mineral Museum: FMM-7428, 7.9 x 6.3 x 5.1 inches (20 x 16 x 13 cm). *Earl R. Verbeek photo.*

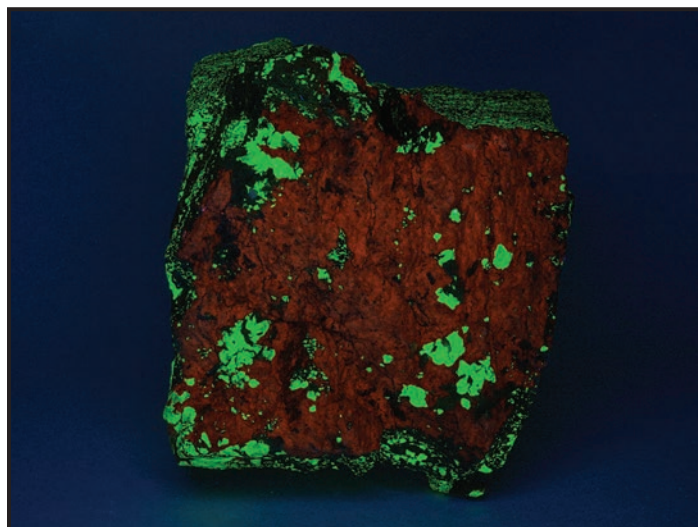


Figure 5b. Hedyphane FL orange (no PH), best under MW UV, with willemite (FL green). Franklin hedyphane’s FL is usually weak under SW UV and nonexistent or very weak under LW UV. This is one of the largest and richest hedyphane specimens from Franklin. *Earl R. Verbeek photo.*

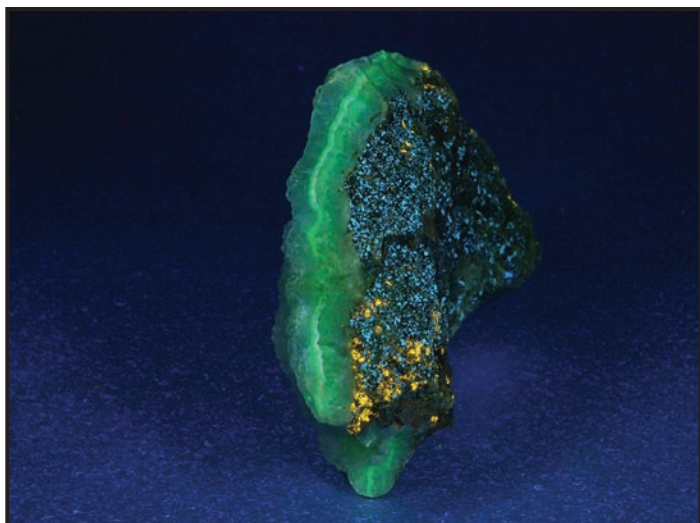


Figure 6. A hemimorphite crystal crust on matrix from the Passaic Pit area at Sterling Hill, viewed from the side under SW UV. The layers of hemimorphite are highlighted by a green-FL zone dating from a time when the zinc-silica-rich hydrothermal solution that deposited the hemimorphite included a low percentage of the uranyl ion, UO_2^{2+} . Most hemimorphite from the Noble and Passaic pits is uranyl-free, and FL and PH weak white to “cream.” The matrix consists of insoluble remnants of portions of the Franklin Marble and the zinc orebody that were dissolved to form the Mud Zone, here including fragments of yellow-FL norbergite and blue-FL diopside. 6.3 x 4.0 x 2.4 inches (16 x 10 x 6 cm). Richard C. Bostwick specimen, *Earl R. Verbeek photo.*

Hemimorphite: FL and PH moderately bright to weak white and pale yellow SW, MW, and LW. Less commonly FL green, orange-yellow, blue. Previously called calamine, hemimorphite was abundant in the weathered zones of the Sterling Hill orebody, especially in the Noble and Passaic Pits, where it was found in massive layers 15 to 30 cm (6 to 12 inches) thick that were mined for zinc in the 1870s. The curved ridges of crystals on the surfaces of the hemimorphite layers led to their being called “maggot ore” by the miners. Hemimorphite was also found in the underground portions of the Sterling Hill Mud Zone as honeycombed masses rich in small lustrous crystals.

At Franklin hemimorphite was fairly rare, found as crystals on limonite from the Precambrian oxidized zone in the north end of the mine, and as small crystals in vugs in Buckwheat Dolomite.

Green-FL hemimorphite, brightest SW (Fig. 6), is uranyl-activated and can usually be seen in depositional layers where layered hemimorphite masses from the Sterling Hill open pits have been broken across. A notable exception was found in the Passaic Pit in 1995 when smooth white crusts of green-FL hemimorphite were found lining cavities in a large boulder. Orange-yellow-FL and blue-FL hemimorphite from Sterling Hill are both rare. Another fluorescent aspect of Sterling Hill hemimorphite specimens from the open pits is

the underlying layer of insoluble minerals from the Franklin Marble, cemented yellow-FL and blue-FL grains of what are probably norbergite and diopside, and yellow-FL scales of mica, probably phlogopite.

Hexahydrite: FL and PH white of moderate to weak intensity SW, MW and LW. A white powdery efflorescent mineral associated with mcallisterite on “red ore” from Sterling Hill.

Hodgkinsonite: FL weak cherry-red MW, weaker LW. A vein mineral from Franklin, prized for its purple-red color and attractive crystals. It was also found at Sterling Hill in reddish crystal druses on “red ore.” The use of UV-blocking goggles is recommended when viewing hodgkinsonite under UV, to block violet light emitted by the UV lamp and reflected from the specimen.

Holdenite: FL dull orange BL (Mazel and Verbeek, 2014). This previously unreported FL was observed in a specimen of Sterling Hill holdenite, a pink vein-filling on granular willemite-calcite ore.

Humite: FL weak pale yellow SW. Identified by Dr. Robert Jenkins in a few specimens from the Farber Quarry, now the Franklin Braen Quarry, where it was found in yellowish-tan to greenish-tan 1-cm grains in calcite.

Hydrotalcite: FL “cream” of moderate brightness LW. A rare Franklin mineral found as mm-sized tabular hexagonal crystals associated with gahnite, hodgkinsonite, willemite, and calcite.

Hydroxyapophyllite-(K): FL and PH weak white SW. An unusual occurrence described in Palache (1935) as apophyllite: “Groups of pale-pink crystals, showing only the unit pyramid and the base, implanted on crumbly limestone, were found in the mine at Franklin, on the 300-foot level, north.” Specimens are rare and the crystal clusters are fragile.

Hydrozincite: FL bright blue SW, with moderately weak gray, white, and pale yellow FL MW and LW. Easily identified by its vivid blue FL in SW and its powdery white appearance in daylight, hydrozincite is widespread at Franklin and Sterling Hill, on the dumps and in the orebodies, as an alteration product of sphalerite or zincite. In the most eye-catching specimens it coats red-FL calcite. Some attractive specimens were found on the Franklin dumps, but most of the better specimens have come more recently from the east limb exposure of the Sterling Hill orebody on the surface near the fill quarry. Pale yellow FL LW has been observed in Sterling Hill hydrozincite, but it has not been determined whether this FL is due to another mineral formed at the same time.

[Editor's note: Species I through Z will be discussed in the next issue of *The Picking Table*.]

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Compiling a list of this sort has more than one slippery slope. The vast majority of Franklin and Sterling Hill mineral specimens in museums and private collections have been sight-identified by visual comparison with analyzed specimens, hopefully by curators and collectors who have seen a lot of analyzed specimens and are familiar with the overall mineralogy of the area. However, since "mistakes have been made," and science keeps trudging on, the author of this checklist has always tried to base his listings on direct observations of analyzed specimens, while keeping up with advances in mineralogy. In this he has had much help from many collectors and a few museum curators. Notable among the latter is Pete J. Dunn of the National Museum of Natural History, now retired, who allowed access to the national mineral collection. Neither Pete, nor the estimable and helpful gentlemen and ladies mentioned in the acknowledgements, bear any responsibility for errors in this checklist, and deserve much of the credit for whatever merits it has.

This list is dedicated to Tema Hecht, who in spite of seeing clearly my personal shortcomings, and the enormous amount of baggage I brought to our relationship (much of it in the form of books and rocks), has, since 1989, actively participated in the mineral hobby; volunteered for FOMS, the Sterling Hill Mining Museum, and the Franklin Mineral Museum; photographed many specimens; and supported my collecting and writing activities. I also acknowledge that my first wife, Susan Sanford (Steve Sanford's sister), was supportive of my mineral-related activities

while our marriage lasted, and allowed me to keep my mineral collection when we divorced. For that, too, I am deeply grateful.

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The Geologist

JOHN L. BAUM

(1916 – 2011)

RESIDENT GEOLOGIST, NEW JERSEY ZINC COMPANY

A mining company deals with diminishing assets or reserves and will eventually work itself out of business unless it can secure replacement resources. This is where the geologist is needed in the mining business. He or she prospects, determines the value of mineral deposits, assists the miners in following the values underground or on the surface where the values are not evident. There are many branches of geology, and today the geology student usually graduates from a Department of Geology and Planetary Science. This geologist for the New Jersey Zinc Company was fortunate in having the Franklin office as his home base (Fig. 1) while others were assigned as required to other mines or exploration offices. Separations from home for extended periods were common.

Some prospecting is done by noting certain plants. In Franklin people will see a plant named bladder campion, which grows where there is zinc in the soil. It can also be found along galvanized guard rails. In Vermont, the New Jersey Zinc Company found a small orebody by analyzing the ash of the second year's growth of the hemlock trees.

For one project, we sampled the soil over a rock formation that elsewhere was known to contain zinc, and we took 36,000 samples from two feet down within a formation from the Hudson to the Delaware Rivers. This project took years, required its own laboratory for analysis, and needed permissions from the landowners. We even sampled a prison farm and elsewhere a golf course. As a result, further work was required on a number of prospects.

We surveyed from the air—measuring magnetics, radioactivity, and electromagnetics—using a helicopter and a twin-engine plane at low levels because the Franklin and Sterling Hill orebodies were known to be magnetic and finding another would be a triumph. Such a signal was found under Hamburg and it was necessary to obtain exploration leases on a number of properties, one of which contained a factory, so that we had to negotiate for another property on which to relocate the factory in case of successful exploration drilling. We knew from surface measurements that we would encounter another Franklin type ore or useless 6% magnetite iron. We did—to find, on drilling, magnetite.

To learn as much as possible about the Franklin and Sterling orebodies, they were mapped by geologists who visited every working place and mapped the characteristics of every passageway on and between each level. These included every opening used for access of miners and equipment as well as chimney-sized openings, called raises, used for dumping ore

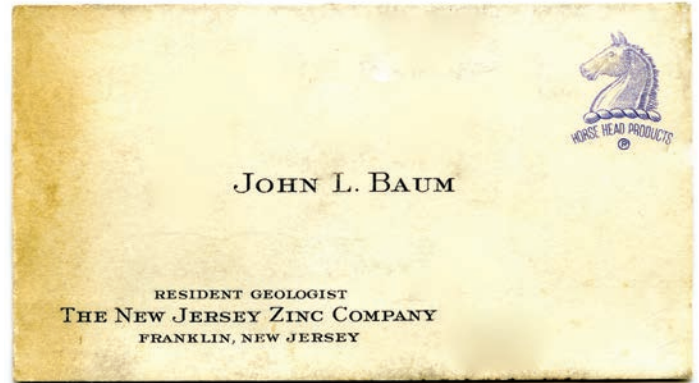


Figure 1. Jack Baum's business card as a geologist for the New Jersey Zinc Company. *Courtesy of the Franklin Mineral Museum archives.*

and moving fill between levels and openings above worked-out ore to support the walls of the resulting openings. Mapping the north wall in a raise where the only supports were 4" × 4" timbers wedged between the walls, in a magnetic orebody where a compass was of no use, required a good sense of orientation. Such mapping started in the early 1930s and continued until mining ceased. This geologist was required to interpret the cause of a fatal accident involving a mine locomotive and a man-car in an old passage over a forgotten worked-out opening. There had been workings here long ago at different times and years later heavy equipment was introduced. Mapping of these old workings explained the tragedy: Here widely spread shear zones in the supporting rock below angled upwards to a more closely spread zone of weakness in the passage above, causing the eventual collapse of the wedge.

A program of deep drilling from the surface on grids of a size to encounter an additional Franklin-Sterling orebody kept this geologist and his assistants outdoors visiting drill rigs six days a week, winter and summer, for years. The deepest hole was 6,000 feet. We learned how to straighten off-course holes and to measure the temperature at a depth of 7,050 feet without actually going down that far, using a deep hole from the depths of the Sterling Mine. It was 96°F at the bottom of the hole. The drill cores were all recorded in text and diagram and all angles were measured. The cores were placed in trays and stored in a building in racks. We also restudied old cores and split new ones in order to dissolve the rock to recover and study the insoluble residues under the microscope. The hope was to find layers that might be traced from hole to hole and



Figure 2. A specimen of ilmenite from the New Jersey Zinc Company prospect at Allard Lake, Quebec. Specimen measures 6.7 × 6.7 × 1.0 inches (17 × 17 × 2.5 cm). Franklin Mineral Museum specimen, formerly in the collection of John L. Baum. *Earl R. Verbeek photo.*

thus reveal hidden structures, because at that time many experts believed the orebodies were deposited along pre-existing folds. Eventually we determined by underground mapping that the ores were folded *subsequent* to their deposition. The experts had been misled.

When it began to look as though titanium would replace zinc as the white pigment of choice after World War 2, the Franklin geology department was called upon to locate a suitable source of raw material for the Zinc Company. We searched the literature and visited field occurrences of both fossil beaches and hard rock in this country and Canada. In the end, in partnership with the Kennecott Copper Company, we located an enormous deposit of ilmenite (Fig. 2) at Allard Lake in Quebec, where today a standard-gauge railroad carries the ore to the St. Lawrence River for transport to the giant electric furnaces of the Quebec Iron & Titanium Company at Three Rivers, Quebec. Here molten iron of the richest grade is produced with titanium slag. The slag is highly sought-after for the production of titanium white. The Zinc Company developed these treatments at its Palmerton plant, which made acid as a byproduct of producing zinc from its sphalerite ores. The Franklin Geology Department made the necessary studies of the exploration drill cores to determine size of crushing for optimum separation of the desirable ilmenite hematitic ore from the feldspar host rock.

Also in that part of Quebec, inland of the St. Lawrence River, there are fossil beaches that we prospected for titanium with great hope and little enthusiasm, because the biting flies were merciless. All villages were on land between tributaries and the St. Lawrence River, where the breeze would discourage the bugs. Our help was all French-Canadian, some of whom spoke English but not many. This geologist learned to talk to the bugs in both languages. Our exploration tool was a post-hole auger with two-foot segments by which with a pipe wrench on one occasion we achieved a depth of 20 feet. We bagged the sand

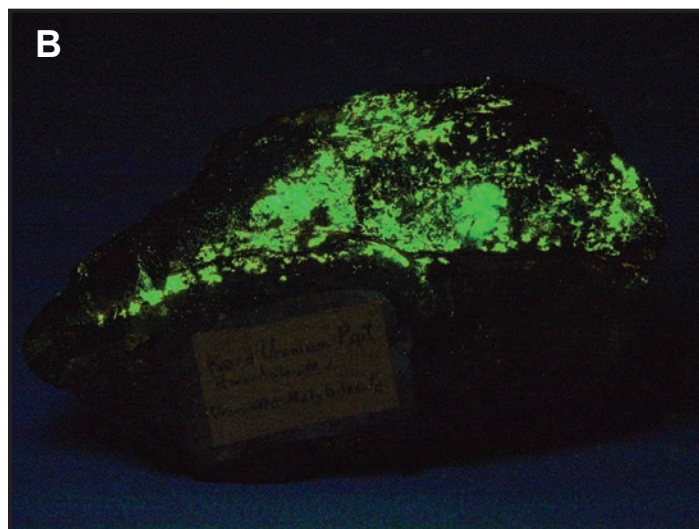


Figure 3. A sawn specimen of uraninite and molybdenite in Precambrian gneiss from the Kord Uranium Prospect, Riverdale, N.J., which was located where the Algonquin Gas Transmission Pipeline crosses Route 23, behind the present-day Pier 1 Imports. Radioactivity is 12 times background at a distance of six inches (15 cm). Under shortwave ultraviolet light, the associated uranyl salts fluoresce bright green. Specimen measures 3.1 × 1.8 × 1.0 inches (8 × 4.5 × 2.5 cm). Franklin Mineral Museum specimen, formerly in the collection of John L. Baum. *Earl R. Verbeek photos.*

after dividing the hoisted intervals into samples for analysis, enclosed suitable identification, and then attempted to crimp the stiff bag necks and tie them as tightly as possible with what was called “salmon cord” used for weaving fish nets in that country but resembling chalk line. It wasn’t easy because the bags had been used in local paper mills and had contained a caustic chemical. Our hands were raw but we bagged enough samples to fill a barge—on which the bags eventually were delivered to our Palmerton plant for analysis—and we could reconstruct our lines of holes. After all that, the Canadian sand project was abandoned. We decided that all we had gotten was experience in a foreign land.

We performed the same exploration in the New Jersey pinelands near Lakewood one winter, using a truck-mounted auger and found enough value that after the Zinc Company decided it was not interested, another company established an operation. Part of our work was on the Lakehurst Naval Air station; it was entirely illegal, but we appeared so official that passing officers in a jeep and a subsequent helicopter inspection apparently cleared us.

The uranium excitement many years ago gave my office two years’ work prospecting in New Jersey and elsewhere. We used a radiation detector of considerable sensitivity and toured the upland areas. Although we found nothing of commercial interest, we came home with numerous radioactive specimens

from old iron mines and previously unexplored properties. An interesting locality was found alongside Route 23 near Riverdale, N.J. (Figs. 3A and 3B) — as well as nearby several barrels of uranium yellow-cake concentrate, which interested the Atomic Energy Commission when we reported them, because they shouldn’t have been there. This geologist was called upon to help in appraising a practicing uranium mine in Colorado, as well as localities in Vermont and the Adirondacks.

Because the Zinc Company did business with printing and paper companies, we were asked to locate sources of clay to be used to make thin paper opaque, and this geologist spent some time in Maryland and Vermont on this project. Quite some time was taken answering requests of landowners throughout the Northeast for examination of their land, in many cases out of their hopes that, before they sold the property, a trained geologist might find something where no one else ever had.

An important part of the geologist’s duties was teaching the new hires the Company’s philosophy and methods, the techniques of underground mapping, safety, care of equipment, record-keeping, map-making, and — very important — when to discuss Company business and when to keep one’s mouth shut! (Figure 4).

John L. Baum

November 20, 2008 ✂



Figure 4. A sign Jack Baum kept on his desk—“demotivational” office humor from a bygone age! *Courtesy of the Franklin Mineral Museum archives.*

A Tribute to Gregory B. Anderson

(1931-2016)

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Greg Anderson, a great friend of the Franklin Mineral Museum, passed away on March 17. Each fall for about 15 years, Greg came from San Diego to the Franklin-Sterling Gem and Mineral Show to assist with museum mineral sales in Kraissl Hall. This imposing man of 6' 7" with a broad smile, great laugh, and a large hat used his knowledge as a dealer of fluorescent minerals to help collectors identify the various colorful examples for sale. These sales had a major impact on the museum's income each year of the show. Greg also purchased fluorescent specimens wholesale from the museum, which he sold at the Tucson show under a large black tent on the show floor.

Greg and John Cianciulli, a former museum curator, had similar job experiences with rehab counseling and training for prisoners, and they became close friends discussing their past experiences during his visits to the museum. They also enjoyed eating at the old Fone Booth restaurant in Franklin, where they ordered large prime ribs that Greg claimed were better than any available in San Diego restaurants.

Prior to his annual visits to Franklin, Greg and his energetic wife, Eve, visited family and friends in Philadelphia and the Hartford area where Greg was born. When he was a young boy, his father brought him to Franklin to collect on the Buckwheat Dump. His interest in "glowing" rocks resulted from these visits. Let us not forget this significant Franklin Mineral Museum volunteer and wonderful character in the mineral hobby. ✂



Greg Anderson in February 2012, at the annual Tucson Gem and Mineral Show. *Tema Hecht photo.*

Carbon and Oxygen Isotopes of Secondary Carbonates at Franklin and Sterling Hill

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INTRODUCTION

Franklin and Sterling Hill host a spectacular diversity of minerals with a wide variety of textures. Of particular interest to collectors are vein specimens containing rare mineral species, or brightly fluorescent ones, or both. Vein assemblages were described by Dunn (1995), who distinguished between open veins, often containing well-formed secondary crystals of ore and other minerals, and closed veins, which do not contain open void space. In general, open veins contain more complex assemblages and host some of the rarest mineral species, while closed veins are more mineralogically simple.

Most of the vein minerals at Franklin and Sterling Hill are ascribed to hydrothermal activity after the thermal peak of regional metamorphism that affected the deposits (e.g., Frondel and Baum, 1974). While the ore deposits were still deep in the crust, hot, rock-derived fluids locally dissolved the primary minerals and precipitated a variety of secondary minerals, including, in some cases, re-precipitating minerals that had been present earlier. These fluids were likely produced by metamorphic reactions breaking down carbonates and hydrous minerals, and may have included some fluids present in the original sedimentary rocks. As the ore deposits cooled, the temperature and chemistry of the fluids, and the mineral assemblages formed from them, changed accordingly. In addition, successive episodes of faulting increasingly provided permeability pathways for influx of fluids derived from external sources, with the last minerals forming from surface fluids at low temperatures. As one example, Johnson et al. (1990) described willemite-bearing closed veins and wall rock from Sterling Hill, and documented stable isotope ratios and mineral compositions consistent with infiltration of metamorphic fluids after peak deformation and temperatures. However, the genesis of many of the vein minerals at both Franklin and Sterling Hill remains poorly constrained, as do, in particular, the numerous products of weathering and low-temperature alteration at both deposits.

This study presents oxygen and carbon isotope data for carbonates from open and closed veins, as well as from a number of other notable secondary mineral occurrences

at Franklin and Sterling Hill: the Buckwheat Dolomite, the Passaic Pit and underlying Mud Zone at Sterling Hill, the gossan (weathered) zone near the top of the northern part of the west limb of ore at Franklin, and modern speleothem-related features from Sterling mine workings. These isotope results help constrain the origin of the fluids from which the minerals formed and provide estimates of their relative temperatures of formation.

OXYGEN AND CARBON ISOTOPE ANALYSIS

Stable isotopes are a powerful tool for understanding the origin and temperature of mineralizing fluids. For example, water containing isotopically light ^{16}O is more easily evaporated than water containing ^{18}O , which means that atmospheric water (and thus our inland rivers, lakes, marshes, etc.) is relatively richer in ^{16}O than seawater. This in turn provides one means of distinguishing lacustrine from marine carbonate rocks. Thus, $^{18}\text{O}/^{16}\text{O}$ ratios of minerals can sometimes be used as a fingerprint for the original source of fluids, as meteoric (atmospheric) water, seawater, and water from magmas all have distinct $^{18}\text{O}/^{16}\text{O}$. If the source of fluid is independently known, then the temperature of mineral precipitation can be calculated from mineral $^{18}\text{O}/^{16}\text{O}$. Carbon isotopes (^{13}C and ^{12}C) are also useful indicators in minerals, especially in distinguishing between organic and inorganic sources of carbon in fluids.

Representative carbonate samples from the Franklin Mineral Museum, Sterling Hill Mining Museum, and the collections of the authors were analyzed for carbon and oxygen isotopes using dual-inlet gas source mass spectrometry at Colgate University (Peck et al., 2005). Approximately five milligrams of each sample was reacted *in vacuo* in Rittenberg vessels with phosphoric acid (H_3PO_4) immersed in a 50°C constant-temperature bath. Reaction times for calcite and aragonite were typically 24 to 48 hours, while some samples (such as azurite, dolomite, and rhodochrosite) were reacted for 48 to 72 hours. Evolved CO_2 was cryogenically purified in a vacuum line and analyzed using a Thermo Finigan Delta Plus Advantage stable isotope mass spectrometer. Oxygen isotope ratios were corrected using phosphoric acid fractionation factors in Table 1.

CARBON AND OXYGEN ISOTOPES OF SECONDARY CARBONATES AT FRANKLIN AND STERLING HILL

WILLIAM H. PECK, MATTHEW F. SHRAMKO, AND EARL R. VERBEEK

Table 1. Carbon and oxygen isotope ratios of secondary carbonates, Franklin and Sterling Hill zinc deposits.

| Sample no. | Mineral | Mine | $\delta^{13}\text{C}$ (‰ PDB) | $\delta^{18}\text{O}$ (‰ SMOW) | Ref | Note |
|------------------------|---------|------|----------------------------------|-----------------------------------|-----|---|
| GROUP 1 SAMPLES | | | | | | |
| B1 | Cal | S | 0.07 | 15.82 | 1 | Friedelite + Cal + barite + hetaerolite vein |
| B2 | Cal | F | -0.79 | 10.88 | 1 | Cal + Wlm vein cutting ore |
| B3 | Dol | F | -0.32 | 19.55 | 2 | Curved, grey Dol in vug, Buckwheat Dolomite |
| B4 | Cal | S | -1.91 | 17.38 | 1 | Hematite + Cal vein in ore |
| B5 | Cal | F | -0.75 | 11.16 | 1 | Cal + Wlm vein |
| B6 | Cal | S | 0.17 | 16.08 | 1 | Wlm + Cal + friedelite vein |
| B7 | Cal | S | -0.17 | 21.42 | 1 | Chalcopyrite-lined Cal vein |
| D2B | Cal | S | -0.90 | 14.52 | 1 | Passaic Pit Bst skarn: Aug + gahnite + biotite + grey Cal |
| D3B | Cal | S | -0.79 | 14.47 | 1 | Passaic Pit Bst skarn: Aug + spessartine + grey Cal |
| D8W | Cal | S | 0.12 | 14.79 | 1 | Passaic Pit Bst skarn: Rdn + actinolite + white Cal |
| D10W | Cal | S | -0.21 | 15.01 | 1 | Passaic Pit Bst skarn: Late galena + white Cal in altered skarn |
| FMM-418 | Cal | F | -1.63 | 16.24 | 3 | Massive pink Cal + Srp |
| FMM-419 | Cal | S | -0.85 | 13.90 | 1 | Sp + 'onion skin' Cal + chlorite(?) |
| FMM-446 | Cal | S | -2.28 | 15.16 | 3 | Cal vein(?) containing Frk + Wlm ore |
| FMM-2874 | Cal | S | 0.42 | 10.61 | 1 | Ivory to orange fault Cal containing Frk + Wlm + Cal ore |
| FMM-1851 | Cal | S | -1.41 | 16.36 | 3 | Massive Cal + Srp + Wlm + Frk |
| | Cal | " | -1.44 | 16.27 | 3 | |
| FMM-5136 | Cal | S | -1.38 | 15.14 | 1 | Magnesianriebeckite + Sp + Cal |
| FMM-5138 | Cal | F | -1.42 | 11.04 | 1 | Cal + Rdn vein in ore? |
| FMM-5177 | Cal | S | -2.34 | 10.66 | 1 | Cal vein in andradite + Wlm + Cal + apatite rock |
| FMM-5692 | Cal | F | -1.23 | 12.18 | 1 | Caryopilite + friedelite + Cal vein in Frk + Wlm + Cal ore |
| FMM-6157 | Cal | F | -2.10 | 10.49 | 1 | Cal + Wlm + Rdn vein in andradite |
| FMM-6193 | Dol | F | 0.02 | 19.77 | 2 | Curved, grey Dol in vug, Buckwheat Dolomite |
| FMM-6218 | Cal | S | -0.69 | 13.98 | 1 | Cal + Dol + Srp |
| FMM-6254 | Cal | F | -0.81 | 17.48 | 1 | Skutterudite(?) + nickeline + pimelite + Cal |
| FMM-6378 | Cal | S | -1.27 | 20.68 | 1 | Sussexite + pyrochroite + Cal + Znc +Srp |
| FMM-6442 | Cal | F | 0.65 | 19.74 | 1 | Salmon Cal veins in white Cal |
| | Cal | " | 0.48 | 21.44 | 1 | White Cal vein host |
| FMM-7014 | Rds | F | -1.08 | 17.72 | 3 | Rds + Wlm vein assemblage |
| FMM-7350 | Cal | S | -0.80 | 20.92 | 1 | 'Dead zone' vein Cal |
| | Cal | " | 0.49 | 15.49 | 1 | Host rock ore between veins |
| | Cal | " | 0.02 | 21.08 | 1 | 'Dead zone' vein |
| | Cal | " | 0.40 | 15.63 | 1 | Host rock ore |
| | Cal | " | 0.38 | 15.99 | 1 | Host rock ore |
| | Cal | " | 0.41 | 16.08 | 1 | Host rock ore |
| FMM-7368 | Cal | S | -2.32 | 17.79 | 1 | Cal + sussexite + Wlm vein in ore + Srp |
| FMM-7381 | Dol | F | -0.36 | 21.77 | 2 | Wlm + Srp + Dol vein |
| FMM-7874 | Cal | S | 0.66 | 15.02 | 1 | |
| SC57 | Cal | | -0.46 | 11.62 | 1 | Cal + Frk |

CARBON AND OXYGEN ISOTOPES OF SECONDARY CARBONATES AT FRANKLIN AND STERLING HILL

WILLIAM H. PECK, MATTHEW F. SHRAMKO, AND EARL R. VERBEEK

| Sample no. | Mineral | Mine | $\delta^{13}\text{C}$ (‰ PDB) | $\delta^{18}\text{O}$ (‰ SMOW) | Ref | Note |
|---------------------------------|---------|------|----------------------------------|-----------------------------------|-----|--|
| GROUP 2 SAMPLES | | | | | | |
| B8 | Sid | F | -4.54 | 24.99 | 4 | Massive siderite |
| B10 | Cal | S | -5.47 | 25.24 | 1 | Cal + Frk + Wlm vein |
| B11 | Cal | S | -9.69 | 24.43 | 1 | Mine workings ‘Cal raft’ |
| B12 | Cal | S | -10.02 | 25.01 | 1 | Mine workings ‘Mine pearl’ |
| FMM-388 | Cal | S | -5.34 | 27.19 | 1 | Open breccia with Cal + barite(?) + todorokite(?) |
| FMM-449 | Rds | S | -4.69 | 22.81 | 3 | |
| FMM-453 | Arg | S | -5.64 | 24.77 | 5 | Mud/oxidation zone Sterling Hill |
| FMM-6441 | Cal | S | -4.76 | 25.05 | 1 | ‘Nailhead’ Cal in ore solution vug, manganese oxidation zone Sterling Hill |
| FMM-6444 | Arg | S | -7.14 | 25.08 | 5 | Fracture surface of altered ore, oxidation zone Sterling Hill |
| FMM-6448 | Arg | S | -6.79 | 25.08 | 5 | Mud/oxidation zone Sterling Hill |
| FMM-7297 | Cal | S | -5.10 | 24.99 | 1 | ‘Water crystal’ Cal + todorokite, manganese oxidation zone Sterling Hill |
| GROUP 3 SAMPLES | | | | | | |
| B9 | Az | S | 1.47 | 30.31 | 6 | Copper-enriched mud/oxidation zone |
| B14 | Az | S | -0.71 | 30.04 | 6 | Copper-enriched mud/oxidation zone |
| B15 | Az | S | 3.54 | 29.89 | 6 | Copper-enriched mud/oxidation zone |
| OTHER SAMPLES (see text) | | | | | | |
| EV Set 1A | Dol+Mal | S | -11.66 | 27.81 | 1 | Adjacent to Passaic Pit |
| | Mal | “ | -13.22 | 28.21 | 7 | |
| EV Set 1B | Mal | S | -2.65 | 30.12 | 7 | Adjacent to Passaic Pit |
| | Dol | “ | -2.76 | 24.02 | 2 | |
| EV Set 2B | Az | S | -4.84 | 23.86 | 6 | Noble Pit |
| | Cal | “ | -0.56 | 19.37 | 1 | |
| Hydroz 1 | Hzc | S | -8.87 | 26.35 | 1 | Passaic Pit |
| Hydroz 2 | Hzc | S | -5.12 | 29.88 | 1 | Saddle north of Noble Pit |
| B13 | Cal | S | -41.75 | 6.47 | 1 | Mine workings stalagmite |
| | Cal | “ | -39.57 | 6.51 | 1 | |

Notes: Arg= aragonite, Aug= augite, Az= Azurite, Bst: bustamite, Cal= calcite, Dol= dolomite, Frk= franklinite, Hzc= hydrozincite, Mal= malachite, Rdn= rhodonite, Rds= rhodochrosite, Sp= sphalerite, Sid= Siderite, Srp= serpentine, Wlm= willemite, Znc= zincite. F= Franklin, S= Sterling Hill

References for phosphoric acid fractionation: (1) Swart et al. (1991); (2) Rosenbaum and Sheppard (1986); (3) Böttcher (1996); (4) Carothers et al (1988), (5) Kim et al. (2007), (6) Melchiorre et al. (2000)

Stable isotope ratios are reported in Table 1 using δ notation in parts per thousand (‰), where carbon isotopes are expressed relative to a marine carbonate reference standard (Pee Dee Belemnite calcite, PDB):

$$\delta^{13}\text{C} = \left(\frac{^{13}\text{C}/^{12}\text{C}_{\text{Sample}}}{^{13}\text{C}/^{12}\text{C}_{\text{PDB}}} - 1 \right) * 1000 \quad (1)$$

Oxygen isotopes are reported relative to Standard Mean Ocean Water (SMOW):

$$\delta^{18}\text{O} = \left(\frac{^{18}\text{O}/^{16}\text{O}_{\text{Sample}}}{^{18}\text{O}/^{16}\text{O}_{\text{SMOW}}} - 1 \right) * 1000 \quad (2)$$

RESULTS AND DISCUSSION

Analyzed carbonate samples can be grouped into four main categories based on stable isotope ratios, which correlates with mineral occurrence and geologic setting:

Stable Isotope Group 1

Most carbonate minerals from vein and alteration assemblages at Franklin and Sterling Hill (Group 1) have a distinct range of carbon and oxygen isotope ratios that overlap those of Franklin and Sterling ore and barren Franklin Marble, with on average slightly lower carbon isotope ratios (See Figure 1). Group 1 are the majority of samples examined,

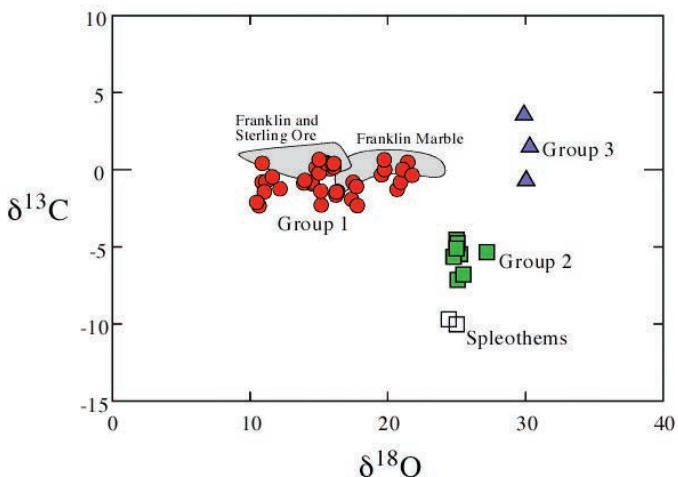


Figure 1. Carbon and oxygen isotope ratios of Group 1, 2, and 3 secondary carbonates from Franklin and Sterling Hill. Shaded fields are of unmineralized Franklin Marble (Peck et al., 2006) and Franklin and Sterling Hill ores (Johnson et al., 1990; Peck et al., 2009).

Figure 2. Fibrous to splintery, ivory-colored to pale orange calcite from a fault zone at Sterling Hill. A fragment of granular franklinite-willemite-calcite ore, visible at top, is embedded in the calcite. Franklin Mineral Museum specimen 2874, 5.3 × 4.3 × 1.8 inches (13.5 × 11 × 4.5 cm). *Earl R. Verbeek photo.*



Figure 3. Massive pink rhodochrosite cementing dark slivers of granular franklinite-willemite zinc ore from a fault zone at Sterling Hill. The rhodochrosite appears to be a post-faulting mineral that filled lenticular voids that earlier had opened during faulting; it is equigranular and shows no textural evidence of shearing or fibrous habit. Both sides of this specimen are slickensides. Franklin Mineral Museum specimen 446, 4.7 × 4.7 × 2.0 inches (12 × 12 × 5 cm). *Earl R. Verbeek photo.*



Figure 4. A vein of coarse-grained, white to pale pink calcite with subordinate willemite in a matrix of massive brown andradite with minor willemite and calcite. This specimen, from Franklin, is no. 5177 in the collection of the Franklin Mineral Museum and measures 4.7 × 4.3 × 3.1 inches (12 × 11 × 8 cm). *Earl R. Verbeek photo.*

and include common features such as fibrous mineralization along faults, calcite + serpentine alteration assemblages, “dead-zone” willemite veins, massive rhodochrosite from a fault zone, and calcite + rhodonite, pyrite + calcite, and hematite + calcite veins; examples are shown in Figures 2-5. This group also includes some of the more unusual mineral associations, such as friedelite + calcite ± allactite, nickeline + calcite, magnesioriebeckite + calcite + sphalerite (Fig. 6),

and sussexite + pyrochroite + calcite (Fig. 7). Additionally included in this group is calcite from an unaltered, peak-metamorphic, bustamite-bearing skarn and an altered, genthelvite-bearing skarn (Leavens et al., 2009), both from a small trench in the Passaic Pit, and pink calcite samples from Franklin and Sterling Hill. Almost all specimens in Group 1 are “closed veins” or massive minerals in alteration assemblages, and include mineral assemblages associated with both low-



Figure 5. Highly fluorescent and phosphorescent, ivory-colored to pale orange, intergrown columnar grains of willemite with dark brown serpentine and gray dolomite, all part of a well-layered vein sequence from the Franklin mine. Franklin Mineral Museum specimen 7381; 3.5 × 2.4 × 1.6 inches (9 × 6 × 4 cm). *Earl R. Verbeek photo.*



Figure 7. A section through a hydrothermal “rare mineral pod” from the North Ore Body at Sterling Hill, consisting of black pyrochroite, pinkish-tan sussexite, white calcite, and secondary orange zincite, with (far right) some dark brown serpentine. Specimens such as this come from the deep levels of the mine in an area that has experienced pervasive hydrothermal alteration. Franklin Mineral Museum specimen 6378, 9.5 × 3.9 × 3.0 inches (24 × 10 × 7.5 cm). The photographed face of this specimen has been sawn and sprayed with lacquer to show the textural relations. *Earl R. Verbeek photo.*

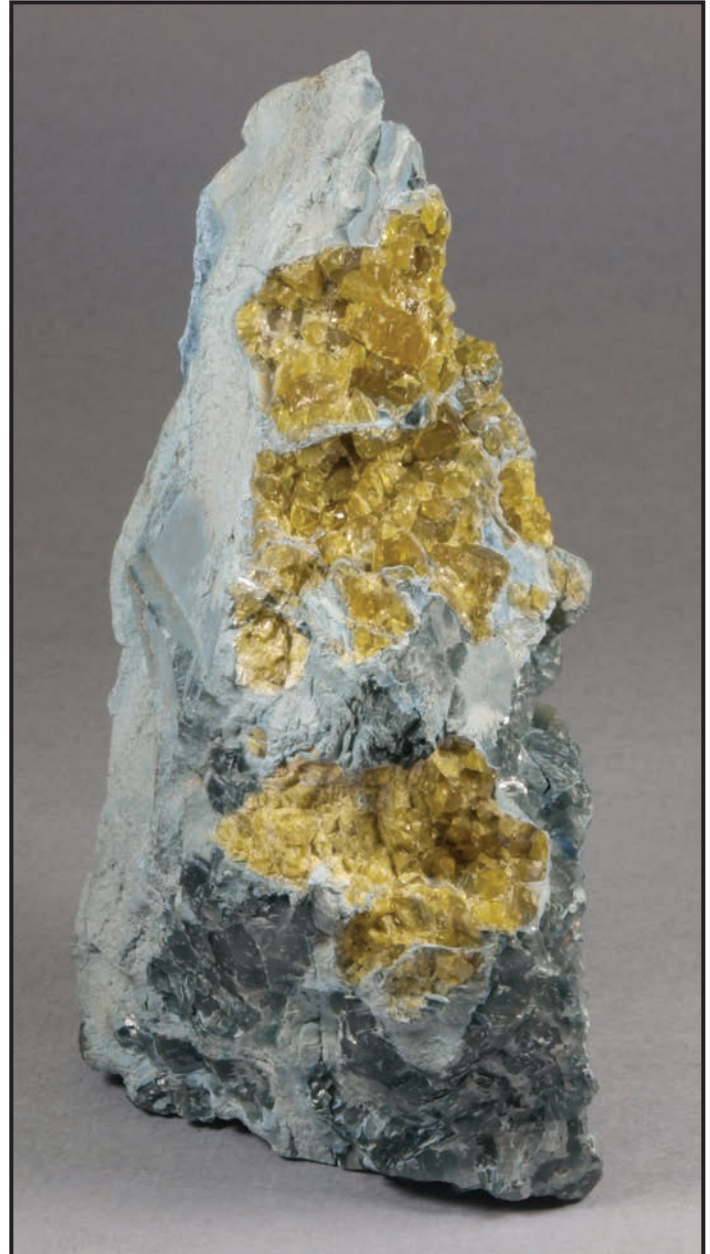


Figure 6. Pale blue magnesioriebeckite with large, anhedral masses of oil-green sphalerite and dark grayish blue masses of included calcite, from Franklin. Franklin Mineral Museum specimen 5136, 6.5 × 3.1 × 2.4 inches (16.5 × 8 × 6 cm). *Earl R. Verbeek photo.*



Figure 8. Intergrown radiating aggregates of translucent, pale brown, spiky aragonite crystals, most several cm long, from the Mud Zone (oxidation zone) at Sterling Hill. The pale orange-tan, fine-grained material, only a small bit of which is visible in the photograph, is probably cemented silt and sand washed into the Mud Zone from above. Franklin Mineral Museum specimen 6448, 7.0 × 4.7 × 3.1 inches (17 × 12 × 8 cm). *Earl R. Verbeek photo.*



Figure 9. Late-stage calcite lining solution cavities in altered (weathered) franklinite-rich ore from Sterling Hill. Some of the franklinite has altered to coatings of limonite, and many of the small vugs where calcite used to be are now filled with todorokite. This is a good example of “nailhead calcite” in spheroidal groups of discoidal crystals. This specimen comes from the “manganese zone” (oxidation zone) peripheral to the Passaic Pit and underlying Mud Zone at Sterling Hill. Franklin Mineral Museum specimen 6441, 8.0 × 4.3 × 2.6 inches (20.5 × 11 × 6.5 cm). *Earl R. Verbeek photo.*



Figure 10. Crystals of translucent, nearly colorless to white calcite (the classic “water crystals”) thickly lining vugs in highly altered ore from the “manganese zone” at Sterling Hill. The limonitic areas on the photographed face mark areas of boxwork where calcite was once present; associated with them are fine-grained masses and coatings of silvery-black todorokite. Franklin Mineral Museum specimen 7297; 5.9 × 4.3 × 3.5 inches (15 × 11 × 9 cm). *Earl R. Verbeek photo.*

temperature and high-temperature alteration. Although genetically unrelated, samples of euhedral vug-filling dolomite crystals from the Buckwheat Dolomite have isotope ratios that overlap the above samples.

Most Group 1 samples have oxygen isotope ratios similar to ore-bearing rocks at Franklin and Sterling Hill, suggesting that fluids that interacted with these rocks were either locally derived, or were of low-enough volume that they came into equilibrium with the host rocks, resulting in little to no isotopic contrast between secondary and primary carbonate minerals. A similar relationship is seen for carbon isotopes, suggesting that carbon in the veins and alteration assemblages was for the most part derived from the host rocks. The slightly lower carbon isotope ratios of veins than host rocks may indicate some dissolution of graphite (which has lower $\delta^{13}\text{C}$, Peck et al., 2006) in the vein-forming fluids. Some Group 1 veins have higher oxygen isotope ratios, such as the salmon calcite veins from Franklin ($\delta^{18}\text{O} = 19.7\text{‰}$) and “dead-zone” willemite veins from Sterling Hill ($\delta^{18}\text{O} = 20.9$ and 21.1‰). The most straightforward interpretation of these values is derivation from metamorphic fluids (from either the ores or other nearby metasediments) at temperatures lower than the peak of metamorphism. Johnson et al. (1990) analyzed mineralized fractures associated with brightly fluorescent willemite from Sterling Hill and came to a similar conclusion. The specimen microsampled by Johnson et al. showed a ~4‰

contrast in $\delta^{18}\text{O}$ between fractures and host rock, indicating channelized fluids. A similar relationship is seen in the “dead-zone” willemite vein sample analyzed in this study, which shows a $\sim 5\%$ difference in $\delta^{18}\text{O}$ between veins and host rock. Vug-lining crystals from the Paleozoic Buckwheat dolomite share these general characteristics ($\delta^{18}\text{O} \approx 20\%$, $\delta^{13}\text{C} \approx 0\%$), also pointing towards rock-buffered fluids and relatively low formation temperatures (Cummings, 1988).

Stable Isotope Group 2

A group of mostly open-vein minerals (Group 2) has higher oxygen isotope ratios and lower carbon isotope ratios than those of Group 1 (Fig. 1). These samples are from a variety of open-vein and vug associations (Table 1), for the most part contain very well-formed crystals, and all but one are from Sterling Hill. Notable textures in Group 2 are the spectacular aragonite clusters from the Sterling Hill Mud Zone (Fig. 8) and the rosettes of “nailhead calcite” and “water crystal” calcite from manganese-enriched areas within and peripheral to the Mud Zone (Figs. 9 and 10). Other Group 2 associations include skeletal open-breccia calcite (Fig. 11) and aragonite lining dissolution openings. The single siderite sample in this group is from Franklin.



Figure 11. An open breccia from Sterling Hill, containing several generations of calcite. The oldest, the massive white to pale tan material at lower left, is skeletal and strongly etched by solution. The white “ribs” of calcite are probably later. The latest calcite, strongly colored pink, is in parallel plates and needles that collectively form a boxwork texture inherited from some former mineral no longer present. Also present are small masses of a medium-brown, very fine-grained mineral in delicate plumose masses; this resembles todorokite. Franklin Mineral Museum specimen 388, 5.3 × 3.5 × 3.5 inches (13.5 × 9 × 9 cm). Earl R. Verbeek photo.

Group 2 samples have oxygen and carbon isotope ratios distinct from their host rocks at Sterling Hill and Franklin. Low carbon isotope ratios point to an external source of carbon for these carbonates, and high oxygen isotopes could indicate either a precipitation temperature lower than that of Group 1 and/or an external fluid source. Given the open-vein nature of the mineralization and its low-temperature mineral associations, it seems likely that surface fluids played a role in their formation. This would be consistent with the distinct $\delta^{13}\text{C}$ values, which are similar to the low $\delta^{13}\text{C}$ in soil carbonate and speleothems worldwide (Cerling, 1994; McDermott, 2004). For example, a speleothem from Howes Cave, Schoharie County, New York, has $\delta^{13}\text{C} = -9.1 \pm 0.6\%$ ($n=3$; Peck, unpub. data). In cave systems, low $\delta^{13}\text{C}$ values in carbonates are derived from soil CO_2 from the land above, and for the most part are controlled by the character of local vegetation.

The temperature and fluid source which precipitated the Group 2 carbonates cannot be independently determined, but modern examples of calcite precipitation from mine water can be examined directly. Two examples of modern speleothem calcite in the Sterling mine workings were analyzed and appear to reflect isotopic equilibrium: a “mine pearl” and a “calcite raft,” both from terrace pools at the adit-level shaft station. The mine pearl and calcite raft are isotopically similar, with $\delta^{18}\text{O} = 34.0$ and 34.6% and $\delta^{13}\text{C} = -10.0$ and -9.7% (Fig. 1). These specimens formed from meteoric water at the ambient temperatures of the mine, so are useful for comparison to the Group 2 samples.

Using an average mine temperature of 13°C , the calculated $\delta^{18}\text{O}$ for the water from which the mine pearl and calcite raft formed is $-5.8 \pm 0.3\%$ (Fig. 12). This $\delta^{18}\text{O}(\text{water})$ value is used in calculation of the formation temperatures for the Group 2 samples. This oxygen isotope ratio is within the range for modern precipitation in Sussex County, which ranges from a high $\delta^{18}\text{O} \approx -5.6\%$ in August to a low $\delta^{18}\text{O} \approx -14.5\%$ in January (Bowen, 2015). Natural speleothems often have oxygen isotope ratios that reflect evaporation before percolation into the cave environment (raising the $\delta^{18}\text{O}$), and also typically show uneven growth over the year (making the fluid that precipitates most of the carbonate biased towards a certain part of the year; McDermott, 2004). Calculations at substantially higher temperatures, perhaps locally present when the mine was active, yield $\delta^{18}\text{O}(\text{water})$ values outside the range of local precipitation.

Most Group 2 samples yield low yet realistic temperatures when the $\delta^{18}\text{O}(\text{water}) = -5.8\%$ is used for thermometry calculations (Fig. 12). Group 2 calcite averages $10.6 \pm 4.2^\circ\text{C}$ (1σ , $n=6$) and aragonite is $15.5 \pm 0.9^\circ\text{C}$ ($n=3$). The siderite sample in this group yields a temperatures of $\sim 30^\circ\text{C}$. Higher $\delta^{18}\text{O}(\text{water})$ than assumed could also have been present, caused by water-rock interaction and exchange, and this would result in higher calculated temperatures.

Lower $\delta^{18}\text{O}(\text{water})$, such as those expected during glacial periods, yield temperature calculations that are unrealistically low; for example $\delta^{18}\text{O}(\text{water}) \approx -9\text{‰}$ yields mineralization temperatures near 0°C . On balance, the modern speleothem best-fit $\delta^{18}\text{O}(\text{water}) = -5.8\text{‰}$ seems to yield the most realistic temperatures for Group 2 samples: low temperatures for calcite and aragonite and a slightly higher temperature for siderite (Fig. 12). The relatively low temperatures calculated for Group 2 samples are consistent with their formation in open veins and vugs relatively close to the surface, compared to the higher-temperature appearance of the closed-vein Group 1 samples.

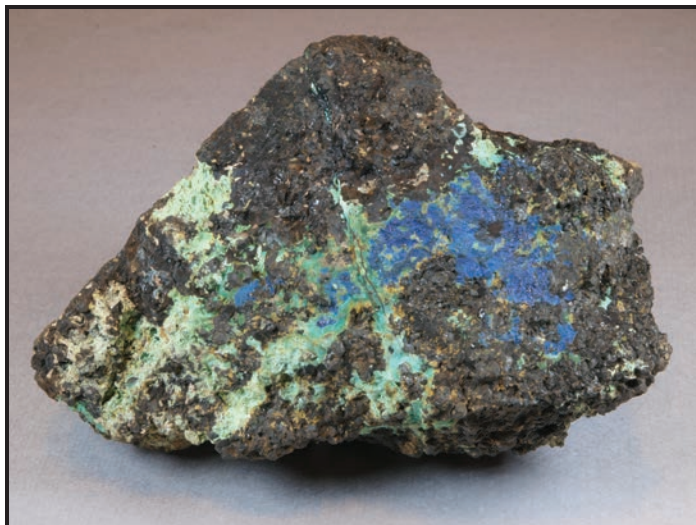


Figure 13. Massive azurite with subordinate chrysocolla in altered ore from Sterling Hill. Franklin Mineral Museum specimen 6196, $5.9 \times 3.9 \times 3.0$ inches ($15 \times 10 \times 7.5$ cm). Earl R. Verbeek photo.

Stable Isotope Group 3

Three azurite samples from Sterling Hill were analyzed and have $\delta^{18}\text{O} \approx 30\text{‰}$ and $\delta^{13}\text{C} = -0.7$ to 3.5‰ . All three of these samples are from the “copper zone” peripheral to the Mud Zone at Sterling Hill and were probably collected in 960 stope (or possibly 920 stope) above 340 level. A similar specimen from the same locality is shown in Figure 13. These copper carbonates are Group 3 (Fig. 1), and are distinct in that they have relatively high $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$ values. The high $\delta^{18}\text{O}$ values are consistent with formation at relatively low temperature. Using $\delta^{18}\text{O}(\text{water}) = -5.8\text{‰}$, the calculated formation temperature of these azurites averages $19.6 \pm 1.0^\circ\text{C}$ ($n=3$), which is similar to other azurites worldwide (Melchiorre et al., 2000). This temperature is higher than the modern average surface temperature, but could correspond to temperatures at $\sim 600\text{-}700$ m ($\sim 1,970\text{-}2,300$ ft) depth. Carbon isotopes of these azurites are similar to the Sterling Hill ore and the Franklin Marble, which may indicate that the carbon is derived from local rocks, as opposed to the Group 2 carbonates, which show a large component of surface carbon. This relationship is not commonly observed in other studies of copper carbonates (e.g., Melchiorre et al., 2000), and may indicate that this part of Sterling Hill was for the most part closed to influx of surface carbon. Taken together, the depth estimate of 600-700 m and the apparent lack of surface carbon in these azurite samples suggests they may have formed when the Sterling Hill orebody was still overlain by Paleozoic sedimentary rocks, during which time the Mud Zone was not open to the surface.

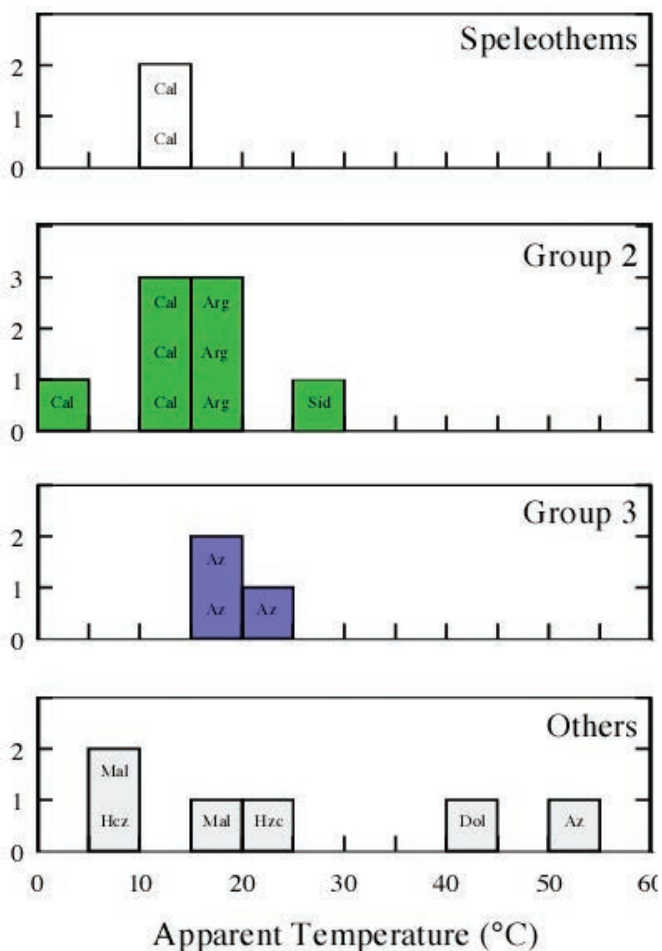


Figure 12. Apparent temperatures of formation of low-temperature secondary minerals, using $\delta^{18}\text{O}(\text{water}) = -5.8\text{‰}$ (the best-fit value for modern speleothems; see text). Carbonate-water isotope fractionations from Carothers et al. (1988), Melchiorre et al. (1999, 2000), Horita (2014), and Kim et al. (2007, 2008).

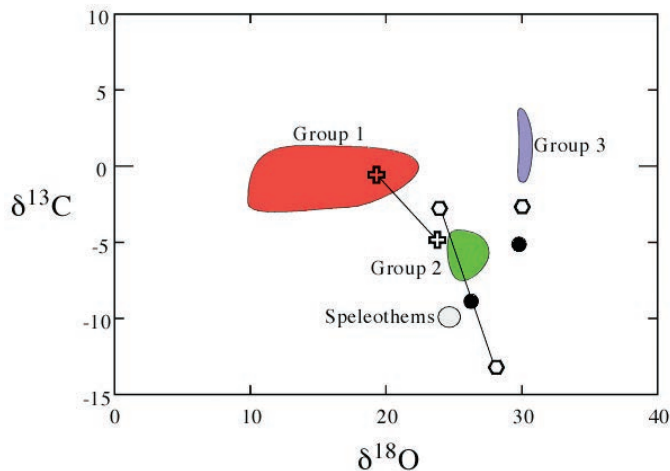


Figure 14. Carbon and oxygen isotope ratios of other secondary carbonates from Franklin and Sterling Hill. Filled circles= hydrozincite, Hexagons= Passaic Pit ridge crest, Crosses= Noble Pit high ground. Tie-lines link minerals from the same hand sample.

Miscellaneous Samples

Some samples do not fit well in the three isotope groups, and probably represent very low-temperature alteration near the surface. Hydrozincite was analyzed in two samples, one from the cement of an open calcite breccia in the Passaic Pit and the other as an alteration product of sphalerite in a sample from the high ground north of the Noble Pit. These samples have $\delta^{18}\text{O} = 26.4$ and 29.9‰ and $\delta^{13}\text{C} = -8.9$ and -5.1‰ , respectively (Fig. 14). The isotope fractionation behavior between water and hydrozincite is not known, but if the fractionation factors for calcite are used (after Boni et al., 2003) the two hydrozincite samples yield calculated temperatures of formation of 22 and 8°C , using the isotope value of water from the Group 2 calculations.

Three isotopically heterogeneous samples containing copper carbonates were also examined. Two are from a locality near the crest of the ridge separating the fill quarry from the Passaic Pit, about two meters west of the footwall contact of ore. This alteration represents a very geologically recent, low-temperature process, as evidenced by the malachite root casts found at this locality. These samples contain chalcocite, the source of the copper for the secondary copper minerals that formed in this area; these include malachite (dominant), aurichalcite, and azurite (rare). Malachite from these rocks has similar oxygen isotopes ($\delta^{18}\text{O} = 28.2$ and 30.1‰) to Group 3 azurite, but has lower carbon isotope ratios ($\delta^{13}\text{C} = -2.7$ and -13.2‰). Following the Group 2 calculations, the malachite in these two samples yields calculated formation temperatures of 18 and 10°C , but the samples' markedly different carbon

isotopes indicate that they formed from fluids with different carbon sources or mixtures of sources (Fig. 13). Dolomite from sample 1B has higher $\delta^{18}\text{O}$ than other low-temperature secondary carbonates, which may indicate that the analyzed material was a mixture of primary (high-temperature) and secondary carbonate, or formation from water with lower $\delta^{18}\text{O}$ (such as those present during glaciation). A third sample from a locality adjacent to the Passaic Pit contains chalcopyrite + bornite + azurite. This azurite is distinctly different from Group 3 azurite, with $\delta^{18}\text{O} = 23.9\text{‰}$ and $\delta^{13}\text{C} = -4.8\text{‰}$ (Fig. 13), which yields an apparent formation temperature of 54°C . This apparently high temperature is likely misleading, and the $\delta^{18}\text{O}$ may actually reflect precipitation from water that had previously exchanged oxygen with host rocks.

Finally, the most unusual sample analyzed is a post-mining stalagmite from (or from near) the 800 level of the Sterling mine. This sample has the most extreme isotope signature of the dataset, with $\delta^{18}\text{O} = 6.5\text{‰}$ and $\delta^{13}\text{C} = -40.7\text{‰}$. The $\delta^{13}\text{C}$ value of this sample is extremely low and geologically unlikely, and the $\delta^{18}\text{O}$ yields an unreasonably high calculated formation temperature ($>100^\circ\text{C}$) when combined with meteoric water $\delta^{18}\text{O}$ values, even though the stalagmite is known to have formed at ambient temperatures in the mine (13°C). This sample was almost certainly collected from the midlevel working areas of the Sterling mine, where much of the available carbonate was derived by rapid leaching of cement used to prepare rigid working surfaces in backfilled stopes. Carbonate grown from cement examined in other studies has been shown to have disequilibrium stable isotope ratios, perhaps as the result of kinetic fractionation effects and incorporation of atmospheric CO_2 (e.g., Krishnamurthy et al., 2004). Whatever the cause, the isotope ratios of the stalagmite are not directly comparable to the other samples examined.

CONCLUSIONS

Secondary carbonates at Franklin and Sterling Hill have oxygen and carbon isotope ratios that show formation in three primary settings. Most carbonate alteration and closed vein formation (Group 1) appear to be formed from locally derived fluids after the peak of metamorphism of the deposits, or precipitation from fluids that were of sufficiently low volume that they had isotopically equilibrated with their host rocks. Some open veins and other low-temperature alteration products have carbon and oxygen isotopes that are consistent with low-temperature formation from surface water (Group 2). This includes modern carbonate precipitation in the mine workings at Sterling Hill. Lastly, azurite from the copper-enriched part of the Mud Zone in the Passaic Pit (Group 3) has oxygen isotopes that point towards low-temperature formation from surface fluids, but rock-derived carbon.

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Losing a Good Friend

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PHOENIX, AZ 85070

The fluorescent mineral community lost a strong supporter and friend on March 22, 2016, when, after almost a 3-year battle with cancer, Gerry McLoughlin passed away. Gerry is survived by his partner of 23 years, Letty Moon. Gerry and Letty lived in Roslyn, Pennsylvania.

I first met Gerry back in the mid-1980s at the Mill Site in Franklin, New Jersey. I went up there to do some collecting. When I arrived, I saw a small group of guys who had dug a huge pit. I said to myself, "Wow, these guys are serious collectors." When I introduced myself, it turned out that one of the guys was Gerry. We ended up becoming very good friends over the next 30 years, and even shared a room selling at the Tucson show one year. Every time Debbie and I visited Franklin for the show, we always enjoyed spending some time with Letty and Gerry.

Gerry was extremely enthusiastic about the hobby of fluorescent minerals. He did as much field collecting as he could, and was an avid collector of Franklin/Sterling Hill. I never got to really see all of his collection when I visited him at his home one year, but what I did see was spectacular!

I will always remember the excitement in his eyes as he showed me one of his favorite "seven-color sphalerite" specimens he had collected at the Buckwheat Dump.

Several times over the years, I was disappointed when I arrived at a dealer's booth only to find out that Gerry had beaten me to the best specimens! He was truly a lover of the hobby and the hunt. For any of you who have visited my home to purchase specimens, you know that I literally have hundreds of flats in the garage. To this day, Gerry McLoughlin has been the only person to ever go through EVERY single flat! While visiting for a couple of days, Gerry asked me if he could stay up late one night and go through the flats. I told him, "No problem, but I'm going to bed." The next day while I was at work, Gerry called me and told me he stayed up all night and went through every single flat. Now that is dedication!

Not only was Gerry a fluorescent mineral collector, he was a great guy. We often shared many long conversations and good jokes. Visiting the Franklin show without seeing Gerry there will be strange for sure. We're all going to miss him. Rest in peace, Gerry. ✂



Letty Moon and Gerry McLoughlin in Franklin during the April 2011 mineral show. *George Polman photo.*



Tramming waste rock via horse-drawn car on the Buckwheat Dump during the period of the operation of the Taylor Mine, circa 1890s. View is looking toward the west. This photo is from an album in the archives of the Franklin Mineral Museum.

