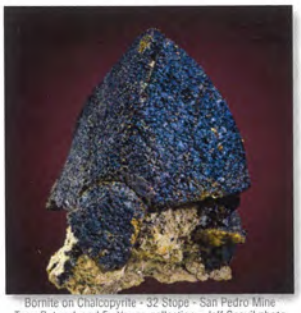
Amethyst - Hopkinton, Rhode Island
Dr. John Rakovan

30TH ANNUAL

Celebrating the Field Collector

FRIDAY MARCH 31ST, SATURDAY APRIL 1ST, 2023

MINERALS OF ARIZONA SYMPOSIUM

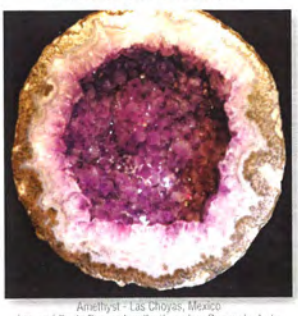


Bornite on Chalcopyrite - 32 Stope - San Pedro Mine
Tony Potucek and Ex Young collection - Jeff Scovil photo

Vanadinite - Grey Horse Mine
Les and Paula Presmyk collection - Jeff Scovil photo

Calcite and Quartz - Las Choyas, Mexico
Les and Paula Presmyk collection - Les Presmyk photo

Azurite - ApexMine, St.George, Utah
Steve Scott collection - Steve Scott photo



Amethyst - Las Choyas, Mexico
Les and Paula Presmyk collection - Les Presmyk photo

UARIZONA MINING, MINERAL AND NATURAL RESOURCE EDUCATION MUSEUM

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Titles	Presenter(s)	Times		Page
Friday Agenda:				
Dealer Set-up		9:00 AM	1:00 PM	
Registration and Dealer Sales		1:00 PM	2:00 PM	
The One Percent Rule, Specimen Retrieval in the Pikes Peak Granite, Colorado.	Barbara Muntyan	2:00 PM	2:45 PM	5
Collecting Adventures from the Red Cloud to Brushy Creek Mine, Viburnum, Missouri	Les Presmyk	2:45 PM	3:30 PM	9
Registration and Dealer Sales		3:30 PM	5:00 PM	
Saturday Program Agenda:				
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Welcome and Opening Remarks	Catie Sandoval and Les Presmyk	8:30 AM	8:45 AM	
Collecting to build Teacher and Educational Earth Science Kits	Stan Celestian	8:45 AM	9:30 AM	11
The San Pedro Mine, New Mexico	Tony Potucek	9:30 AM	10:15 AM	15
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The Great Grey Horse Vanadinite Adventure	Gary Fleck	10:30 AM	11:15 AM	17
Arizona Fossil Collecting	Jeff Langland	11:15 AM	12:00 PM	19
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An Update on the Apex Mine, St. George, Utah	Steve Scott	1:45 PM	2:30 PM	23
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THE ONE PERCENT RULE:
Specimen Retrieval in the Pikes Peak Granite of Colorado.

by Barbara Muntyan

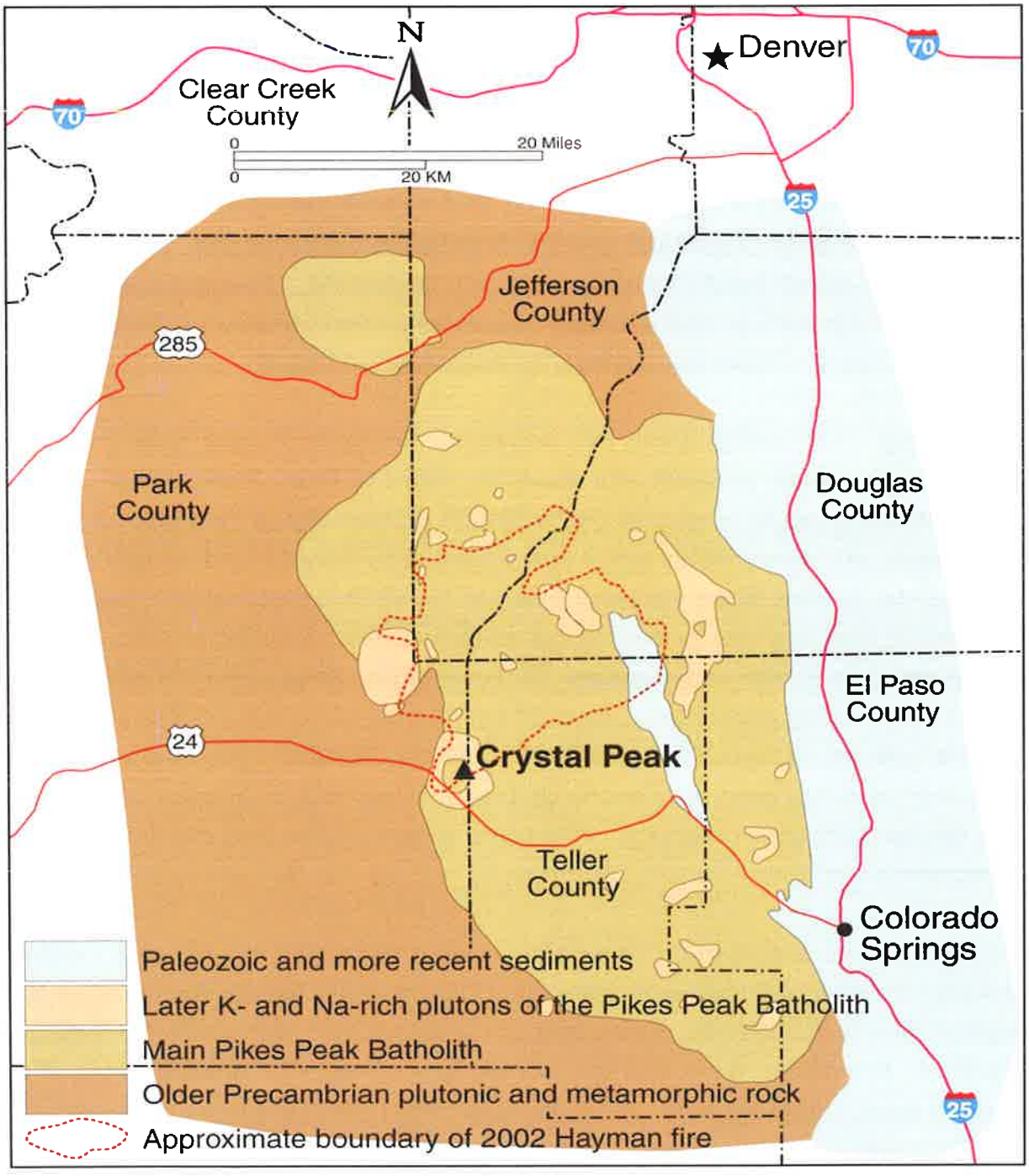
John Muntyan and I moved from Illinois to Colorado in 1971, and thus began our journey to become expert mineral field collectors. John had a degree in Physics, having done work in single crystal optics, and I grew up in New York City spending many hours at the American Museum of Natural History's Morgan Gem and Mineral Hall. Both of us knew a lot about mineralogy, but it was all book learning, without opportunity to become field collectors for ourselves. That all changed with our move to Colorado.

Colorado is one of this nation's most highly mineralized states, being blessed with many public lands rich in well-crystallized specimens, especially in granitic deposits. One of the most important was the Pikes Peak Batholith. This deposit had been known for a century, and along with the furor of gold prospecting in Colorado's Mineral Belt, the Batholith was found to contain topaz, beryl, fluorite, quartz and amazonite. So significant were these deposits, that the jewelry company Tiffiany & Company hired Chinese laborers to mine the pegmatite veins west of Colorado Springs for amazonite and topaz.

Many years ago in an article about this well-known Colorado mineral collecting locality, I wrote that for every ten prospect pits scratched into the Pikes Peak granite using hand tools, one would prove to lead to a concentration of crystallized material; and for every ten such leads, one would finally result in a pocket of well-crystallized amazonite, smokey quartz, goethite, fluorite, albite, hematite or topaz in various pleasing combinations. That statistic meant that only one percent of our collecting effort resulted in success. And we were considered to be well above-average field collectors. Keep in mind that it was before Joe Dorris began using excavators, and even before many amateur collectors owned four-wheel drive vehicles. Between the early 1970s and mid-1990s our year had a rhythm which resulted in three out of every four weekends from mid-March to mid-November being spent in Lake George specimen collecting. Fifty years later, I believe that one percent statistic still holds true.

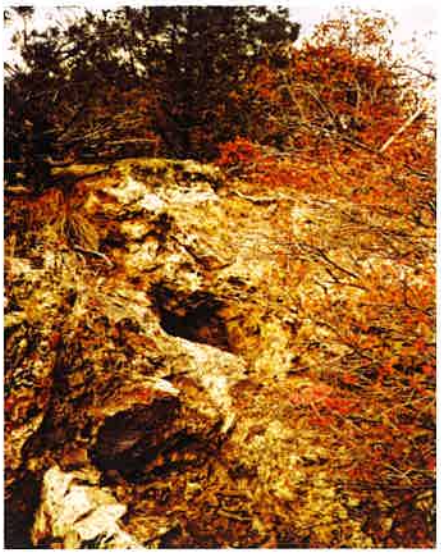
Remember, we were successful collectors in the days before the use of heavy mechanized equipment. The Pike National Forest lay west of Denver and Colorado Springs at an altitude of roughly 6,500 to 7,500 feet. It was open ponderosa forest: various off-road trails, easily accessible by four wheel drive, too high altitude for snakes, and offering vistas of rolling hills near a paved State highway. Both John and I had high-stress jobs. It was good to be out in Nature with our small daughter and yellow lab dog.

One of the appeals of collecting in the Pikes Peak granite was that each pocket was a surprise package with various combination of species, all reasonably large and well-formed, found in a beautiful scenic vista. Another appeal was that serious field collectors all knew each other, and many became life-long friends. Larry and Carmen Piekenbrock became our digging partners and close friends. We collected together all over Colorado for many years. John and I were founding members of the Colorado Chapter of Friends of Mineralogy. We also began to publish articles about mineral localities: I wrote them and John took most of the photographs. Fifty year later this is still my passion.



Crystal Peak

Quartz scepter



Following a Quartz dike

Checking a Hoard

Wedged into a pocket

Microcline Baveno

Amazonite, Quartz

Fluorite

Amazonite, Quartz

Zircon

Collecting Adventures from the Red Cloud to the Brushy Creek Mine, Viburnum, Missouri.

by Les Presmyk

Although my underground collecting career began during Thanksgiving weekend, 1969 with my first trip to the Apache mine, I did not have a camera to record these events until a few years later. But I really began this effort in 1982 when Mike New, who was working at the Ojuela Mine near Mapimi for Delma Perry, invited me down to help him lower his new compressor into the mine. Then, in the mid 1990s, Wayne Thompson finally realized he needed Tony Potucek and I to map the new decline at his San Francisco mine project east of Magdalena, Sonora, Mexico. Then with the start of the Red Cloud project that I got really serious about photographing our mining efforts.

Les Presmyk - San Francisco mine

Red Cloud Mine Field Trip 1997

In 1995, Wayne Thompson and James Horner purchased the Red Cloud property and I was enlisted to put together the mine plan and oversee the operation. After having spent over 30 years as a collector and 20 years as a mining engineer, this was my first opportunity to bring my profession and my hobby/avocation together. We successfully open pitted the Red Cloud vein (success was measured in being cost effective with no reportable injuries and of course, the discovery and extraction of one of the two greatest pockets at the mine).

Wulfenite on quartz - Red Cloud
Jeff Scovil photo

In the next few years, I was invited by Mike New (Top-Gem Minerals) to examine the Erupcion mine near Los Lamentos, Chihuahua, Mexico and then provide consulting on the their Brushy Creek mine calcite project.

On their first visit to the Brushy Creek mine, Mark Kielbaso and I explored the two water courses lined with up to 12 inch calcite crystals, many with the characteristic iridescent marcasite on some of the crystal faces. We found numerous ball-peen hammer heads scattered throughout, obvious signs of former collecting efforts. Miners and mechanics

had even taken two inch thick boards and five gallon buckets, over 200 feet into the water course to fashion a raft to get across what we named Lake Salem. Never mind there were plenty of great specimens to collect without needing to build a raft but I guess this was an example of someone thinking the crystals were somehow going to get better at the other end of this small lake.

Quartz Prospect claim - Jeff Scovil photo

Other projects have included mining quartz crystals (Arizona or Payson Diamonds) west of Tonto Village in Gila County. In 1996 I was at the Arizona Mining and Mineral Museum one Friday afternoon when this couple came in and gave a flat of quartz crystals on matrix they had just dug in this area. Up to this point, I have only ever seen one matrix specimen and here was a whole flat of them. I immediately wanted to know where they had found them and then they asked if I wanted to come up to see what they were doing. By the time they returned the following winter from Idaho, we had an approved plan of operations and started our small mining operation.

100 level, Holbrook mine

I went underground for the first time in Bisbee in 1978 at the Southwest Mine. Back then, I drove my truck up to the concrete portal, dropped everyone off and parked in the large parking lot east of the PD Mercantile building, and within sight of the Bisbee police station. When we came out of the mine in mid afternoon that Saturday, we just walked down to the truck, put away our tools and lights, and walked up the gulch to St. Elmos to get a cold drink. My, how times have changed! The last time I was underground there was over 20 years ago on the 100' level of the Holbrook mine, spending the night in one of the small caverns encountered over 100 years digging calcite specimens.

Eddie Lopez in the Higgins Mine, Bisbee

Collecting to build Teacher and Educational Earth Science Kits

by Dr. Stan Celestian

Everyone at this Symposium is engaged in Earth science and understands how important it is to the world today. From natural disasters, to climate, to the mining and manufacturing of the materials needed for our modern technologies, and even where it is safe to live, it is clear that basic knowledge in Earth science is critically important to our way of life and for the future.

BUT, a **problem** exists. For many years the interest in providing classes in the Earth sciences has dwindled in our public schools.

American Geosciences:

"Public schools are dropping Earth science from the curriculum. Geoscience enrollments at higher education institutions are faltering, and some colleges and universities are closing relevant departments.

https://www.americangeosciences.org/content/earth-science-curriculum-or-not

Geological Society of America:

"To meet the environmental challenges and natural resource limitations of the twenty-first century, and to inspire future generations of scientists, Earth-science education must be integrated into science education across all public and private schools, starting in kindergarten and continuing through twelfth grade. Earth-science curricula should be delivered by teachers with direct training in Earth-science education."

https://www.geosociety.org/gsa/positions/position4.aspx

Science Daily:

"Only one of the nation's 50 states requires a year-long Earth/ Environmental Science course for high school graduation, whereas 32 states require a Life Science course, and 27 require a Physical Science course, according to the report. Only six states require that students are taught Earth Science concepts as part of their graduation requirements."

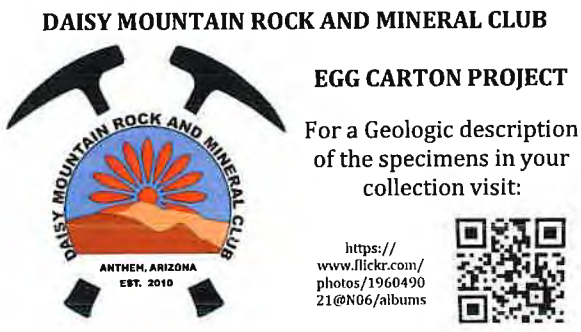
https://www.sciencedaily.com/releases/2013/10/131017174045.htm

From the Taylor and Francis Group - Newsroom:

Numbers of Earth scientists taking undergraduate degrees in the US and UK are declining, and the UK government has listed a range of Earth science jobs as 'shortage occupations' – which may partly be due to the decline in Earth science education in schools. https://newsroom.taylorandfrancisgroup.com/international-survey-paints-bleak-picture-of-school-level-earth-science-education/

What can "We" do as individuals or as a group?

From a personal perspective I have found that having a specimen in hand, whether it be a rock, mineral or fossil, spurs curiosity. This leads to investigation, and in my case, a career in the teaching of Earth Sciences. Will providing youngsters a set of rocks that includes minerals and fossils spur their interests? Perhaps it will for a few days..., or even more.



This presentation is specifically about the mission of the **Daisy Mountain Rock and Mineral Club Egg Carton Project**, but can be generally applied to other groups that offer that opportunity. At the Daisy Mountain Rock and Mineral Club this is accomplished by providing Geologically accurate specimens along with a Geologic guide (both photographically and verbally). It is intended to answer questions they may have, and through additional images, enhance their interest in Geology through these specimens.

THE EGG CARTON PROJECT - The Process

1. Properly Identify the Specimens. This is fairly straightforward for the common minerals, but occasionally a little complicated for rocks.
2. Determine the specimen's quality. Is it a "representative sample"?
3. Determine the quantity available. Is there enough to provide hundreds of samples.
4. **COLLECT**
5. Trim to appropriate egg carton size.
6. Label each specimen
7. Store
8. Present at events

a. obtain egg cartons

b. provide identification sheet

c. Link to DMRMC Egg Carton Project Website

It is also of importance to expand on the basic idea that the Earth Sciences can be the

starting point for developing interests in other fields of science including geochemistry, geophysics, paleontology, petrology, gemology, crystallography, environmental geology, economic geology, hydrology, and so on.

What's in it for the field collector?

Aside from the virtuous contribution to education, there are the educational observations that are associated with being in the field just looking at Nature and Geology. Combine this with "purpose" and the research needed for collecting, and the field collector learns as a student of science.

Stan Celestian
Waddell, AZ

The Minerals of the San Pedro Mine, New Placers District, Santa Fe County, New Mexico USA

by Tony L. Potucek

San Pedro Mine, Santa Fe Co., NM
Photographer unknown, NM Tech Museum photo archives, Socorro, NM

The San Pedro mine in New Mexico is one of the older mines in the Southwestern USA, with the first mentioned mining by non-Indigenous people in 1839, although earlier mining had been noted since the 1500's. Of much lesser consequence is that the San Pedro was the first underground mine where the author collected minerals, beginning in 1971. Introduced to the mine by an alumni geologist of the University of New Mexico while the mine was under care and maintenance, it became the author's preferred underground collecting location, even surpassing the famous Kelly mine renown for smithsonite.

Bornite on chalcopyrite - 32 Stope - San Pedro Mine - Jeff Scovil photo - Ex Young collection.

The San Pedro mine is a limestone-tactite skarn hosted Cu-Au-Ag orebody located in the San Pedro Mountains, midway between the New Mexico cites of Albuquerque and Santa Fe. The mine is best known for producing numerous Japan Law twin quartz crystal groups and North America's largest chalcopyrite crystals, up to 10 centimeters (cm) on an edge. Limestone replaced by marble and attendant volume losses during contact metamorphism in the tactite skarn produced numerous cavities and openings. Crystals of quartz, chalcopyrite, calcite, pyrite, hematite and garnet variety andradite line the openings. Less commonly, fluorite, sceptered amethystine quartz and scheelite occur. Supergene alteration and oxidation of the chalcopyrite produced coatings of covellite, chalcocite, bornite and malachite. Of particular note are the highly aesthetic lustrous groups of fine thin wire gold specimens occurring with calcite which have been found by collectors in several areas of the San Pedro mine.

While the San Pedro mine still is capable of producing fine specimens of all of the minerals listed above, the San Pedro Mining Company still owns the mine. The Company maintains vigilance on the mining property and collecting in the mine and on the property is forbidden.

The Great Grey Horse Vanadinite Adventure

by Gary Fleck

In 1976 Andy Clark and I had a conversation with Curt Van Scriver and Mike New about potential collecting opportunities in Arizona. Several localities were mentioned but the one that caught our attention was a vanadinite mine between Superior and Kearny. This was close to where we lived and Andy and I were off to find the mine.

Vanadinite - Grey Horse - Presmyk collection - Jeff Scovil photo

As we explored the workings there was evidence of others who had preceded us. Footprints in the dusty drifts were the evidence but there was not much in the way of collectible vanadinite. A fair amount of color but no large crystals. Then, we decided to go down a short winze and what we found was amazing. No footprints and more importantly, and open seam of vanadinite crystals.

Vanadinite - GreyHorse - Mark Hay specimen and photo

Over the next several months we collected plates of vanadinite. Everything had to be hoisted up that winze, which in itself was quite a feat. From a collecting standpoint, the good news was most of the vanadinite was covered with calcite which helped hold the crystals onto the matrix. The bad news was the vanadinite crystals were coated with a layer of white calcite. Fortunately, a friend knowledgeable in chemistry figured out a safe way to clean the calcite off without affecting the vanadinite.

At about this same time, the earth science complex was being constructed at the Arizona-Sonora Desert Museum and the curator, Bill Panczner, asked us if we would sell the museum a complete pocket so it could be reconstructed in their mine drift. Today you can see this pocket in the mine drift portion of the museum.

A number of years later I returned to the mine and opened up the drift at the bottom of the winze, with the hope of finding more vanadinite and being able to carry the specimens directly outside, rather than having too hoist everything up the winze. Unfortunately, there were no more big pockets to be found.

Vanadinite
Grey Horse Mine, Pinal Co., AZ
Tony Potucek specimen and photo

Adventures in Fossil Collecting: Arizona and Beyond

by Jeffrey Langland, PhD

Jeff Langland's father, Leo Langland, was a geologist for the Arizona Department of Transportation. As such, he was raised with weekend outings to various mines and collecting sites. Although he did not become a geologist himself, his exposure to collecting as a child became part of his life. Jeff has been collecting in Arizona and beyond for the past 50 years. He has explored deep into many mines collecting excellent mineral specimens as well as discovering unique and exciting fossil sites. As a husband and father, Jeff has exposed his family to the exciting world of field collecting and how nature can be a bonding experience. This talk will focus on various sites and specimens from Arizona that have produced many museum quality fossils. As a field collector, Jeff is always looking for new sites to explore. Jeff will discuss fossil collecting sites and specimens he has collected not only from Arizona, but from various sites throughout the United States and even out of the country. As a long-time field collector, Jeff will show the value, fun, and excitement in personally finding your own specimens.

Collecting Adventures in the Southwest U.S. and China

by Graham Sutton

Graham had his first exposure to minerals during a family vacation to Colorado when they stopped at a rock shop in Ouray. Yes, it was none other than the Columbine Rock Shop owned by Benjy Kuehling. But it wasn't until he took a geology course from Ray Grant and then went to the Red Cloud mine during Christmas break that the hook was set. After running a landscape business and mining landscape rock quarry did he turn his full attention to mining and selling minerals. By 1985 at the age of 21, he committed himself fully to the mineral business.

Numerous collecting partners and mentors include Bob Lane and Bill Hawes. He first worked for Bryan Lees at the Sweet Home Mine in 1991, returning to work full time in 1998. Early mining efforts and projects centered around the southwest United States and northern Mexico and include the Grand Reef mine, the La Sal azurite property, the San Francisco mine in Sonora Mexico, the Red Cloud mine, and the Purple Cow Ledge near Quartzsite. In addition, he collected the "chimney" of calcite crystals from the 29 Mine, Viburnum, Missouri for Top-Gem Minerals.

Once he returned to Collector's Edge in 1998, he worked at the Sweet Home Mine until Bryan Lees closed the mine in 2004. His project management continued with Bryan and includes properties all over the world. The Benitoite Gem mine in California, the Red Lead mine in Tasmania, Kazakhstan dioptase, the jeremejevite project, and the Twin Creeks, Nevada orpiment all succeeded under Graham's capable management.

For the past 15 or so years Graham has been concentrating his efforts in China. Various mining projects have kept him busy, along with establishing a various import businesses ventures which include mineral display cases and LED lighting. And, the past five years have turned him into a real estate and mineral sales office developer, which we all know as Mineral City in Tucson.

FIELD COLLECTING, APEX MINE
ST. GEORGE, UTAH
By Steven W. Scott

LOCATION TOPOGRAPHY

The Apex Mine is located on the east slope of the Beaver Dam Mountains between 5,300 and 5,850 feet elevation in southwest Utah. The towns of St. George and Bloomington, Utah are seen off to the east of the mine. The mine is on the border of the Colorado Plateau and the Basin and Range Province and has similar geology to the breccia pipe mineral deposits in Arizona. Karen Wenrich did an excellent talk on the Apex Mine Geology at the 2015 Flagg Symposium. The mine site is surrounded by a Pinyon Juniper forest and thick brush that is very similar to what's found in the Central Arizona Mountains. The area has all four seasons.

FIELD COLLECTING BACKGROUND

Collecting rocks has always been a big part of my life. As a little kid I remember climbing under the house and going through my dad's metal milk crates full of rocks that he had collected in the Mojave Desert. I also searched the open lots near the house where unbeknown to me, a neighbor had dug holes to bury lapidary rock waste, which I gladly unburied. Yes, I was a field collector at a very young age. Collecting rocks, bugs, seashells and anything that was anomalous kept me out of trouble with my parents and was highly encouraged.

Taking courses in geology at Northern Arizona University in the mid 1970's I took a keen interest in invertebrate fossils and I started to build a self collected educational fossil collection. After college when I started teaching Earth Science in Las Vegas, Nevada I assembled other rock collections to use in my classroom. Assembling educational collections of field collected minerals became my passion. It required a great amount of time acquiring new specimens and upgrading the collections. Over the years collections were assembled for classroom teaching, the Clark County School District Museum Without Walls, and for education conferences. Individual specimens were provided to teachers, students, and museums. During the 1980's I traveled the state of Nevada visiting active mines and historical mine sites. I took geology courses and joined the local rock/ gem clubs. It gave me multiple opportunities to collect rocks and minerals and also to meet wonderful influential people that helped encourage me along the way. During this time a small group of mineral collectors I met got together and we formed the Great Basin Chapter of the Friends of Mineralogy.

Most of my serious field collecting began in Southern Nevada collecting pegmatites along the Colorado River and collecting underground in the Goodsprings District. During the 1990's I started field collecting Middle Triassic Ammonites in Nevada and assorted

minerals throughout the state. Then in the 2000's (and currently) I started field collecting Florida fossils and Apex Mine minerals.

My current Field Collected Collections:

1.) Nevada Minerals
2.) Southern Nevada Pegmatites
3.) Middle Triassic Nevada Ammonites
4.) Florida Fossils
5.) Apex Mine Minerals

FIELD COLLECTING THE APEX MINE

Back in the late 1990's I was visiting a mineral collecting friend and on his book shelf he had a beautiful, sparkly azurite specimen. Asking where he found it, he said the Apex Mine in southern Utah. Since it was not too far away, I asked if he would take me there collecting and he said yes! At the time I was looking for a local collecting area to find some colorful minerals. My wife had commented that I had too many black and white minerals in my collection and needed to diversify.

The first couple of collecting trips were successful finding one nice specimen on each trip. I was intrigued with the thought that maybe the specimens were coming out of the dump higher up. I wanted to find out where. The dump slopes were extremely steep but being careful I was able to check out every blue and green rock that I could see. Back at home I started researching the mine and the best information came from the USGS Bulletin 1577, 1986 by Lawrence R. Bernstein. It was a very good introduction to the geology, mining history, and minerals of the mine. During the following years I was able to trace where the mineral float came from on the dumps. I call the areas "Honey Holes" because of the large number of specimens that I found.

Site 1: 2005, Upper dumps, Rock Platform Site: I think the area was near the upper mine adit and mineral specimens along with mine artifacts were found concentrated together in a small area. Mix of nice auricalcite, azurite, malachite, and fossils replaced by zinc minerals.

Site 2: 2006, Upper dumps, Rock Cliff Site: A very productive site. Specimens were found along the edge of a limestone rock layer. Some nice fossils, azurite, and malachite found.

Site 3: 2007, Middle dumps, Hidden Tree Site: Specimens were found in mine tailings behind a tree. A good variety of minerals, azurite, malachite, and cuprite.

Site 4: 2016, Lower dumps, Road Trench Site: After the 2011 major reclamation project a lot of mineral specimens were uncovered especially where the old road was located. This area previously had few mineral finds. Malachite and azurite epimorphs, sulfides, auricalcite, excellent azurite, chrysocolla, rosasite, and smithsonite were found here.

Honey Hole Collecting

A collecting trip to a Honey Hole site lasted as long as it took to fill a backpack and maybe a bucket or a canvas bag (about 2-4 hours). I would estimate that on average I would collect about 60 pounds of specimens a trip. No trimming or cleaning at the dig site. Most specimens were covered with mud and clay only hinting at what was underneath. At home they were cleaned with the garden hose and water spray gun.

The specimens collected on average were,

15% waste rock

80% kids rocks

5% collector quality rocks

!% went into my personal collection

Most of my field collecting occurred in the month of October.

Winter was cold and the days short especially on the east slope of the mountain. Snow on the ground was common. The ground would be frozen making it hard to dig.

Spring was usually windy and the weather was unpredictable. I was also coaching track and had little free time to collect.

Summer was hot with temperatures commonly reaching 90 to a 100 degrees. Monsoon rains occur occasionally. Gnats and biting flies were a constant nuisance.

Fall was mostly dry and usually had the best weather for collecting.

I always tried to avoid people and other collectors. Saturday was the day not to collect as there was always a lot of people around. Mornings were the best collecting times. Usually in the late afternoon it would start getting busy on the roads mostly with ATV riders. Most collectors I met were looking for cutting material or pretty rocks. There were also a few old bottle collectors. Occasionally there were signs of serious mineral collectors, camping sites and large excavations, but I never ran into any. I think most collectors traveled to the area in the late spring and early summer.

The Apex Mine not only had a large variety of minerals but also had some important variations of them.

MINERALS FOUND

copper, cuprite, azurite, malachite, brochantite, chrysocolla, chalcocite, chalcopyrite, bornite, covellite, talnakhite, enargite, pyrite, cyanotrichite, aurichalcite, rosasite, smithsonite, adamite, hydrozincite, hemimorphite, bayldonite*, zincolivenite, goethite, limonite, hematite, jarosite, plumbojarosite, cobalt wad, alunite*, wulfenite*, calcite, quartz, barite, * new minerals for the mine

Thanks to Bart Cannon and Robert Housley for microprobe and Raman spectrometer identification work.

PSEUDOMORPHS	EPIMORPHS
malachite after azurite	malachite after gypsum
azurite after gypsum	azurite after gypsum
rosasite after malachite-azurite	goethite after gypsum
	plumbojarosite after gypsum
	rosasite after gypsum
	smithsonite after gypsum

FOSSIL REPLACEMENTS

Corals Syringopora and Chaetetes replaced by:

azurite, malachite, smithsonite,
aurichalcite, conichalcite, hemimorphite,
goethite / limonite

Dissolution of fossil gastropods, brachiopods, and an ammonite, creating a mold filled by minerals.

MINE SITE AND MINERAL COLLECTING SUMMARY, 1983 – PRESENT

1983	Mine exploration and drilling
1984	Reclaim upper dumps
1985-1987	Mining and dump removal (germanium & gallium ore), 1987 Mine closure
1998	First collecting trip to site
2003-2008	Yearly mine site reclamation
June 2003	Major wildfire, north side of dumps completely burnt
2003-2004	Major surface collecting finds
2005	Upper dumps, Rock Platform dig collecting
2006-2007	Upper dumps, Rock Cliff dig collecting
2007-2010	Middle dumps, Hidden Tree dig collecting
Dec. 2010	Major mine site flooding
Fall 2011	Removal of mine buildings, removal of roads, covering of mine adit, slope re-contouring of lower dumps and reclamation of mine site
2011-2016	Collecting lower dump area
2016-2019	Lower dumps, Road Trench dig collecting
2020-2023	Very little collecting

ONGOING RESEARCH

The Apex Mine has had a number of name changes throughout its history:

Pen Mine

Dixie Mine

Dixie Apex Mine

Apex Mine*

*Sometimes called the St. George Apex Mine, Mindat had used this mine name as a separate location using a reference from a USGS Bulletin 79, 1966 and a location that neither existed. Unfortunately some minerals have a wrong locality label. Hopefully this was corrected last year by notifying Mindat.

There was a Utah Geological & Mineralogical Survey, Bulletin 79, August 1966, A Directory of The Mining Industry of Utah, 1965. This is what I believed caused the confusion.

There was very little early Mining History documentation that I could find until one day I found a 1904 article doing an online search:

S.L.M.R. 3-30-1904, The Dixie Copper Mine in Washington County, Utah

I some how guessed right away that SLMR was the Salt Lake Mining Review. When I did an online search of the Salt Lake Mining Review I found a University of Utah digital catalog of all the newspapers in the state of Utah. Next I looked up Dixie Copper Mine and a large list of newspaper articles appeared that gave an account of what was happening at the mine around the turn of the century. From 1889-1904 and on and off afterwards the mine was known as the:

Dixie Copper Mine

With this information I was able to gather a more complete history of the mine.

Apex Mine History summarize on the next six pages:

Year	Dixie Apex Mine Utah History	References
1872-1874	Area copper discoveries	Salt Lake Mining Review, Don Maguire 3-30-1904
1883	Tutsagubet Mining District Organized	State of Utah Archives & Records Service
1883	Nephi Fawcelt, William Webb & Brigham Jarvis were hauling wood and discovered ore. They showed it to John Pymm who had it assayed at 38 % copper They located the Apex and Morning Star Claim; Shipped 12 tons to Sandy, Utah	Washington County News from Salt Lake Herald July 9, 1899
1884	Erastus Snow, Anthony Ivins & F.L. Cushing acquire claims and formed the Dixie Apex Copper Mining Company They leased it for a 5 month lease then closed mine	Salt Lake Herald, 7-9-1899 Salt Lake Mining Review, 3-30-1901 7-9-1899 SLH
1889-1893	Dixie Copper Mine ore shipped to Swansea, Wales & Denver, CO	Ore Deposits of Utah, 1920
1890-1894	Samuel Adams & S.G. Higgins, Lease	SLH 7-9-1899
1892	Wooley, Lund & Judd, build smelter in St. George, UT	Salt Lake Mining Review, 3-30-1901
	Dixie Mining Company; Dixie Copper Mine	University of Utah,Bulletin12, The Mining Industry of Utah December 1919
1891	Thomas Judd driving tunnel cuts into top of huge cave. Mine known as the Pen Mine in early times.	Iron County News, 2-21-1891
	Cave was approximately 300 feet deep. A tunnel was driven 300 feet below the discovery shaft and 400 feet into the hill. Galena was mined for lead.	Salt Lake Republic, 12-25-1891
1892	Dixie Mining & Smelter Company, operated the Dixie Copper Mine producing some silver at 16 oz per ton and 58 % copper Self fluxing ore for smelter	Salt Lake Republic, 12-1-1892
1892	Dominick "Don" Maguire, of Ogden Utah a mining engineer was appointed Chief of Territory's Department of Mines and Minerals (Utah) in August 1892. He was directed to collect a comprehensive collection of Utah minerals for the Columbian Exposition 1893 (Chicago's World Fair)	Exhibiting Mormonism 2011

Year	Dixie Apex Mine Utah History	References
1882	Don Maguire, Chief Department Mines & Mining Utah World's Fair Commission	Utah at the World's Columbian Exposition, by Utah World's Fair Commission, 1884
	Page 33, In the Utah Territory Precious & Decorative Stones Exhibit, good quality malachite is found at the Dixie Copper Mines at St. George. Page 92-93, Copper from the mines of Dixie andCopper bullion was obtained from the smelting works of Wooley, Lund & Judd at St. George. Page 94, All the localities were visited by me (Mcguire) personally and the mineral products there taken there from and shipped to Salt Lake City then prepared and shipped to Chicago.	
	Don Maguire won awards for his garnet & topaz collection	
	Many of the 1893 Exposition specimens were transferred to the University of Utah School of Mining	
	Don Maguire, born June 13, 1852, died January 7, 1933	
1894	Don Maguire staked claim: Clay Canyon Variscite	High Beam Research, Doc. July 1, 2010
1894	Copper and Lead strike: Apex Mine	Salt Lake Herald, 5-3-1894
1894	Suspension of operation due to depressed copper prices	SLH, 6-28-1894
1899	Postmaster Pymm and Adams & Son lease	SLH, 4-19-1899
	John & Seth Pymm and Samuel Adams lease	SLH, 5-3-1899
	Dixie Mining Company	
	St. George Copper Mining Company constructs Smelter at mine site	Washington County News, 8-19-1899
1900	"The Famous Dixie Copper Mine of St. George" W.F. Snyder Company acquires majority mine stock and takes control of mine. Eastern owner Mr. Tucker renames Dixie Copper Mine to the: Utah & Eastern Copper Mining Company of New Haven, CT (until 8-29-1906) Shaft Workings: 24-31% lead, 24% copper, 11-23 oz silver/ton Dixie Mine Ore: Green and Blue Malachite (Malachite & Azurite) Red and Black Oxide (Cuprite) Native Copper Copper Glance (Chalcocite) Utah and Eastern Copper Mining Co. now has a 50 man payroll	Salt Lake Mining Review, 3-30-1901

Year	Dixie Apex Mine Utah History	References
1900	"The writer has only found two places for Gem Malachite They are the Dixie Copper Mine, Washington County, Utah and the other locality is the Copper Queen Mine, Bisbee, Arizona" Don Maguire	Mines & Minerals, Page 255 January, 1900
1900	Page 79 & Page 365, Dixie Mining & Smelting Company, Dixie Mine, St. George, Utah has Copper & Iron Ores on display.	Report of The Commissioner General for The United States to the International Universal Exposition, Paris, 1900, Volume IV, February 28, 1901, Washington County Government Printing Office, 1901
1904	Dixie Copper Mine Shem smelter built closer to mine site Ore is Azurite, Malachite, Cuprite, and Black Oxides	Salt Lake Mining Review, 3-30-1904 By Don Maguire
	"As might be expected of a copper property in limestone, caves are frequently found in the Dixie, from the roof and walls which we find stalactites from the richest malachite ever found in an American Mine. Unfortunately many of the richest of the gems are sent to the smelter, when if saved, they would have brought far more as rare mineral specimens for the cabinet than they would possibly bring by casting them into the furnace for copper values they contain." Don Maguire	
1904	Universal Exposition in St. Louis, USA: Utah Eastern Copper Company, St. George, copper ores, page76.	Official Catalog of Exhibitors
1904	Dixie Mine	Deseret Evening News 12-17-1904
1905	Fire destroys mine records and maps	USGS Preliminary Report on the Apex and Paymaster Mines A.R. Kinkle, 1951
1905	August 1905, Cave-in of shaft, New tunnel almost complete, mining on the 1,100 level. "Ore melts like Leaf Lard in a Kettle"	Deseret Evening News 10-19-2005
1906	Company workers: 51 miners, 25 smelter workers and 75 men building road to Acoma the nearest railroad town.	Salt Lake Herald 8-7-1906
1907	Shem Smelter closes	Washington County News, 6-18-1908
1908	Full mine operation	
1909	Mine closed due to depressed copper prices	Ore Deposits of Utah, professional paper 111, 1920

Year	Dixie Apex Mine Utah History	References
1911	Mine visit October: Mine closed and not accessible.	Ore Deposits of Utah, Professional Paper 111 1920
	Two tunnels: one is a 125 ft below outcrop and one at 305 ft below the outcrop. Inside that tunnel is a 900 ft winze down to a level with a 100 ft winze. Dixie Mine, Utah & Eastern Copper Company	
1915	Utah & Eastern Copper Company leases the Dixie Copper Mine and is shipping ore Shipping ore	Washington County News, 6-24-1915 WCN, 8-19-1915
1919	"Cave-in" at Dixie Mine	WCN, 6-5-1919
1929	Dixie Copper Mine reopens 2-8-1929	Iron County News 2-13-1929
	as The Apex shipping ore 15% copper	
1929-1932	Mining production	USGS, Preliminary report on the Apex and Paymaster mines, Washington County, Utah, by A.R. Kinkle, 1951
1936-1938	Mining production	
1940	Don Maguire collection: "He had a wonderful collection, of superior quality and money value, too. Upon his death it was given to St. Mary's of the Wasatch." Jacob P. Lambert	Millard County Chronicle, 8-22-1940
1941	Mine owner Emerald Cox opens mine October 1941	
1940's-1950's	John Raymond Kemple leases mine. Ore trucked to the railroad at Cedar City and shipped to the smelter.	The Apex Mine by James E. Kemple, Washington County Historical Society
1943	Superb malachite and azurite mineral specimens recovered from the Dixie Apex Mine near St. George Alfred M. Buranek, report	Minerals Year Book 8-12-1943
1940's-1960's	Numerous mineral publications reporting gem malachite, azurite and malachite after gypsum mineral specimens.	
1945	No access above 1330 level; mining between the 1330-1400 levels Galena found in lead oxides, 10 man crew: 6 underground, 2 above ground and 2 truck drivers to deliver ore to Cedar City.	Kinkle report, 1951
1947-1983	Mine site activity but little ore production	USGS, Bulletin 1577, 1986
1884-1962	7900 metric tons of copper, 475 MT of lead, 180,000 oz of silver and minor zinc & gold	

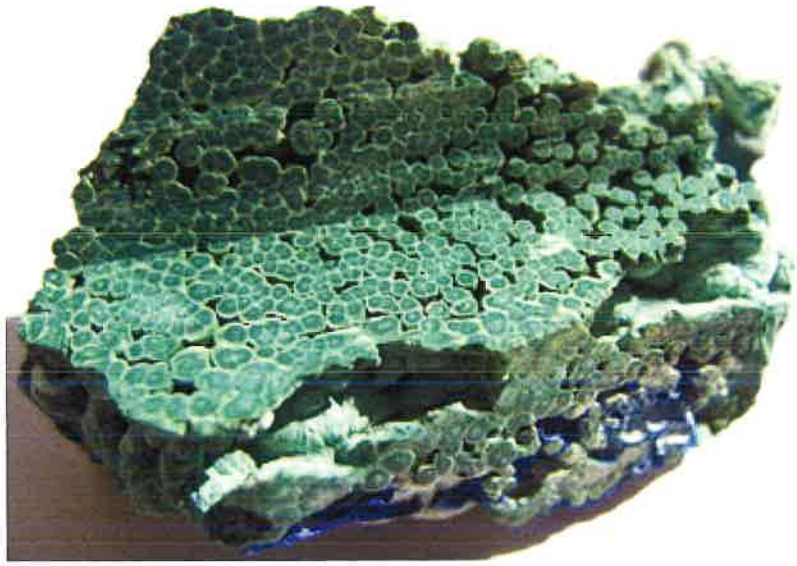
Year	Dixie Apex Mine Utah History	References
1965	Ruth Brown displays large collection of Apex Mine mineral specimens at the Tucson Gem & Mineral Show.	Mineralogical Record, A Fifty Year History of the Tucson Show, 2004, Page 35 by Bob Jones
1983	Exploration drilling for Gallium and Germanium, 8,835 feet of boreholes drilled.	Lalonde report, unpublished Musto Explorations, Vancouver, Canada
1985-1986	Galium and Germanium mining, Gallium found in plumbian jarosite and Germanium found in goethite, hematite and limonite.	USGS Report 97-88, 1997 by Robert O. Rye and Charles Alper
1984-1985	Reclaim upper dump	
1985-1987	Ore from dump removal & underground mining	
1986	four day mine visit in 1985 by the author	USGS bulletin 1577, Geology & Mineralogy of the Apex Germanium-Gallium Mine, Washington County, Utah by Lawrence R. Bernstein, 1986
1986	Geologist Karen Wenrich visit	The Apex Mine- A Colorado Plateau-type solution-collapse breccia pipe and a Tsumeb, Namibia analogue. by Karen J. Wenrich and Earl R. Verbeek 2014
1988	Musto Apex operation shut down	
1990	Hecla Mining will reopen Apex Mine. They bought the mine in 1989 for 5.5 million from St. George Mining Corp., a subsidiary of Musto Will try new solvent extraction technology being used by Cominco to recover germanium.	Deseret News Feb. 3, 1990
2003-2008	Mine site reclamation, Tech-Cominco	
2003	Large mountain range fire around mine site, June	
2008	"The Apex Mine is known for its Azurite and Malachite casts after gypsum crystals with hollow centers. At one time prismatic inter grown clusters of these casts were popular and expensive. Individual casts were up to almost a foot long. Today they are more curious than valuable. At one time they were commonly available at western gem and mineral shows, but today you rarely see them. Even if thousands of specimens are found, a hundred years after the mine is closed, collectors think they are fairly rare items." Rock Currier	Mandat Best Minerals project, Azurite Nov. 3, 2008 Rock Currier
2010	December 21, major flooding of mine site	
2011	Major mine site reclamation of roads, mine adits, dumps and the removal of buildings was done by the owners, Tech Corp.	

Year	Dixie Apex Mine Utah History	References
	"Azurite is comparable in quality to anything from Bisbee. The old Apex Mine produced into the early 1960's and was known for such quality, though rarely." Rob Lavinsky	Arkenstone auction site
2018	The Colorado School of Mines Mineral Museum has malachite & azurite stalactites from the Dixie Copper Mine on display with a label dated 1892. After inquiring about specimens, I (Steve Scott) was told they were from the Maguire Collection (no first name), donated in 1948. With the coincidence of the 1892 date and the Maguire name I can only assume that the specimens were collected by Don Maguire in 1892 as he was gathering specimens for the Columbian Exposition in 1893.	Communication with Ed Raines Curator, CSM Museum

Azurite and malachite, 7cm.

Rosasite after Azurite - 1cm crystal

Steve Scott next to the Paymaster Mine headframe on the Apex Mine property



Malachite after gypsum, 4.5cm

Azurite and malachite replacing coral. 6cm.

Zincian malachite (cuprozincite) and hydrozincite after gypsum with azurite, hemimorphite and malachite, "The Knight" - 4cm

Amethyst Scepters, Ashaway Village, Hopkinton, Rhode Island

by John Rakovan, New Mexico Bureau of Geology and Mineral Resources, New Mexico Institute of Mining and Technology, Socorro, NM.

The amethyst and milky quartz from Hopkinton are arguably the most significant mineral specimens ever found in the State of Rhode Island. This small site has produced hundreds of specimens but the demand for these, now classics, far exceeds the overall production. Originally thought to be igneous in origin, fluid inclusion studies including oxygen and hydrogen isotope analyses shows that they are the result of precipitation from meteoric waters. Three stages of quartz growth occurred at the site with two appearing to be transitional and the final stage occurring after a hiatus in time. Initial quartz formation was as colorless, transparent crystals, some up to 20+ cm in length with a simple morphology dominated by prism faces. Most of the clear quartz is covered by a thin, later stage of growth with finely alternating layers of clear and milky quartz. The milky quartz is the result of a very high density of fluid inclusions that scatter light, giving the white color and opacity. The density of inclusions is so high that light transmission, even in thin section, is highly inhibited. This is one of the most distinguishing characteristics of specimens from the site. The high degree of opacity gives most of the milky quartz a porcelain-like appearance. Another characteristic of the milky quartz is that the terminating rhombohedral faces (r{101} and z{011}) are smooth while the prism faces are macroscopically rough with complete coverage by small subordinate crystals. These are all in parallel orientation with the main crystal on which they lie and thus comprise portions of that single crystal but are morphologically distinct. It is proposed that the subordinate crystals arise from multiple growth centers during crystal growth by 2D nucleation and spread. It appears that the transition from clear to milky quartz was abrupt but continuous, without a hiatus in growth.

The third stage of quartz formation involved the precipitation of transparent amethyst of variable color saturation from faint violet to a deep purple. Most frequently, the amethyst occurs as "scepter caps" or homoepitaxial overgrowths that only cover a portion of one end of a milky quartz stem. These overgrowths are typically equant in habit, with the base of the amethyst overgrowth terminated and forming a reentrant with the stem when the amethyst cap covers any of the prism faces. This type overgrowth produces a scepter with a mushroom like appearance. Growth of amethyst on fracture surfaces of milky and clear quartz suggest a hiatus in growth between these generations during which natural breakage of specimens occurred.

Some of the finest specimens recovered are on display at the National Museum of Natural History in Washington, the American Museum of Natural History in New York, Harvard Mineralogical Museum in Cambridge, and the British Museum, London.

BIO: John Rakovan

On September 1, 2022 Dr. John Rakovan took the position of State Mineralogist and Mineral Museum Director at the New Mexico Bureau of Geology and Mineral Resources (NMBGMR), a research division of the New Mexico Institute of Mining and Technology (New Mexico Tech). Prior to this John was a professor of mineralogy at Miami University in Oxford Ohio for 25 years. He has also been an Executive Editor Rocks & Minerals magazine since 2001. He has broad research interests including crystal growth, structural and morphologic crystallography, mineral-water interface geochemistry, and mineral deposit formation. While a freshman in high school, John was involved in the discovery of the Hopkinton Rhode Island amethyst site with his longtime friend and mentor Sal Avella of Apple Valley Minerals in Smithfield, RI. His presentation will cover the discovery, geological history and specimen production of this now classic American mineral locality.

Amethyst on milky quartz. The scepter measures 3.8 x 5.5 cm.
John Rakovan specimen. Jeff Scovil photo.

Amethyst on milky quartz. The specimen measures
12.7 x 25.5 x 30.5 cm, and the largest scepter is 2.5 cm across.
John Rakovan specimen. Jeff Scovil photo.

Amethyst on milky quartz , Scepter measures 4 cm across cap. American
Museum of Natural History Specimen.
Harold and Erica Van Pelt photo.

Amethyst on milky quartz. 6.8 cm tall scepter.
Irv Brown collection. Benjamin DeCamp photo

Collecting at the Gillette Quarry in Haddam Neck, Connecticut

by Jeff Scovil

Mining at the Gillette Quarry in Haddam Neck, Connecticut began in the 1890s, initially for gem tourmaline and later for commercial grade mica, feldspar and beryl. Operations ceased with the end of World War II and the only activity since has been in the form of collecting by mineral collectors. Many fine tourmalines, beryl variety morganite, smoky quartz and fluorapatite have been recovered both from pockets in the pegmatite itself as well as off the dumps. The Gillette Quarry is a classic locality situated in the Middletown pegmatite and is one of come 300 pegmatites in the area.

Quartz Ellis Street Ext., Rte 72, New Britain, Connecticut. 5.4cm high. Jeff Scovil Photo

Elbaite - Gillette Quarry, Haddam Neck, Connecticut. 2.5cm high. Jeff Scovil photo

Quartz var. Smoky with fluorapatite and microcline
Gillette Quarry, Haddam Neck, Connecticut. 8.5cm wide. Jeff Scovil photo.

Eighteen Field Collecting Trips in Twenty-one Years (and Counting) to the Las Choyas Geode Deposit, Chihuahua, Mexico

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The complexity and beauty of geodes from the Las Choyas deposit have kept me excited and fascinated for over 21 years. Renowned for it's amethyst "coconut" geodes, I have discovered that the deposit also contains a fascinating array of agate nodules, geodes filled with intricate sedimentary patterns, faulted configurations, and oddities. My presentation will show examples of the wide range of complex material I have collected over the past two decades.

I did not start rock collecting as a youngster, but rather in college. As an accounting major, fortunately, one of my science options was a geology class. Near the end of the semester, in April of 1978, our professor invited us to go on a weekend mineral collecting field trip to Weston, OH and the notable Pugh Limestone Quarry just south of Toledo. I decided to participate. When we arrived, I wandered around the quarry floor, picking up pieces of crystal fragments and trying to figure out this mineral collecting thing. A couple of hours later I saw a commotion at the opposite side of the quarry. I arrived just in time to see my classmates, one of whom was George Polman, inside a giant vug (20 feet wide and 4 feet high) about 15 feet above ground in the quarry wall, attempting to safely lower 50 to 100 pound limestone plates. The plates were covered with beautiful orange scalenahedrons of calcite, blue celestine, and brown fluorite. When I returned to school, I changed my major to geology, started collecting geodes, and never looked back!

So, how did a rank and file field collector from Pittsburgh end up visiting the world famous Las Choyas geode deposit 18 times? The first 20 years of collecting occurred at the roadcuts and in the creek beds of southern Indiana. In 1999, I decided to put together an experimental one-hour program about geode-collecting in Mexico, which I still offer to local schools and other venues. I needed to find a reliable supplier of Mexican geodes. I was referred to Gem Center USA in El Paso, Texas, and began to regularly buy geodes from there. A year later, I flew to El Paso to meet with the owners, Hector and Jeannette Carrillo, and Jeannette asked if I would like to visit the mine. Of course I said yes! In 2001 I made the first of my 18 trips to the mine, several with my wife and daughter. Over the past 21 years, I have developed a deep personal and business relationship with the Carrillo family. I now have complete access to one of the most famous geode deposits on earth!

Las Choyas is far more complex than the "classic amethyst coconut geode" for which it is best known! The following information will summarize the geology, mineralogy, history of mining methods, geode formation, and variety of material I have discovered and observed over the past 21 years. Every trip holds opportunities to bring to light new information about the deposit. During my trip last November, I was able to confirm that an isolated erosional remnant of the Las Choyas geode deposit was discovered early in 2022 on an adjacent ranch (I will be discussing the details). With the collecting access I now have, my goal is to assemble and catalog the most complete reference collection of Las Choyas material possible.

History of the Deposit
The geodes of Las Choyas were discovered in 1960 when a cowboy who was herding cattle saw some odd round rocks lying on the ground. Broken pieces revealed beautiful crystals inside! The land on which the geodes were found belonged to Trinidad and Simona Carrillo (Hector Sr.'s parents). Their ranch, Rancho El Mesteño, covered approximately 131,000 acres.

Ramon Peña filed the first claim in 1961 and serious production begin in 1965. The first geodes mined by Peña were sold by Jim and Joe Miles of El Paso, Texas. Las Choyas geodes made their wider debut at the 1965 Phoenix Gem and Mineral Show. When Trinidad passed away in 1966, Rancho El Mesteño was divided among his five children, one of whom was Hector, Sr. In the early 1960's Hector had filed for his original four claims, which he called the Santa Rosa claims, at the southern end of the deposit. This area is where Gem Center USA began its mining.

Mining Methods

In the early days, geodes were just picked up off the ground in the area where the "geode tuff" cropped out on the surface. Then, gradually, the easy collecting ended, and shallow pits had to be dug to reach the geode-bearing zone. These were later followed by deeper and deeper hand-dug shafts, employing a wooden windlass system. The geode-bearing zone strikes roughly north-south and dips westward at an angle of approximately 10 degrees. When Gem Center moved in, they purchased a 1945 Bucyrus-Erie Drill Rig (percussion drilling method) to reach the geode-bearing zone, and employed a two wheeled carrier with an attached spool of steel cable stationed atop an active shaft. At the end of the cable was a 4-foot tall, 18-inch diameter steel bucket that was filled underground with waste rock. Miners were lowered down the drilled shaft by way of sitting in a rope sling that was hooked in front, like a bucket going down a well. At the surface, the steel buckets containing spoil at the end of the cable were emptied into a wheelbarrow, and one of the miners literally ran it up a spoil pile to dump it. This labor-intensive part of the mining process accounts for how approximately 1.5 square miles of white volcanic rhyolite ended up on the surface at Las Choyas over a 50-year period (one wheelbarrow at a time)! Gem Center excelled at the process of mining geodes by the classic room-and-pillar method, in which pillars of volcanic tuff are left behind for roof support. The underground workings resemble a classic 200 year old Pittsburgh coal mine, except it is white instead of black. Approximately three-fourths of the Las Choyas geode-bearing deposit thus remains intact, providing structural roof support for the mine. However, in 2010, the Carrillos ceased their underground mining activities. They acquired earth-moving equipment to strip the overburden and remine the pillars in the near-surface zones, creating a traditional high-wall. There are usually one to three excavators working at any given time year round. Tens of thousands of tons of geodes are still enclosed in the pillars that were left behind for roof support (Smith, 2010).

Geology

In the region surrounding the deposit, a thickness of more than 1,000 meters of Tertiary volcanic rock lies unconformably over Lower Cretaceous limestone of the Tectonic Belt. The north-south orientation of the mountains is evidence of the folding and faulting that occurred in the Late Tertiary; this large-scale structure dictates the way the geodes are mined. The area around the Las Choyas deposit is the product of five major geologic events that have been summarized by Keller (1977). First was the deposition of limestone during the Cretaceous, which was followed by uplift and erosion. This was followed 44-28 million years ago (mya) by Tertiary volcanic activity that blanketed the area with thin, widespread rhyolite ash-flow tuffs. Next, about 35 mya, there was emplacement of rhyolite domes, one of which is adjacent to the geode deposit (locally called Mesteño) and is believed to have had a significant effect on mineralization of the geodes. Lastly, Tertiary Laramie tectonics produced the north-northwest trending folds and faults that dominate the terrain today.

Model for the Formation of the Las Choyas Geodes

To create a geode, two processes must occur; first, the formation of a cavity or open space and its preservation in the rock, and then mineralization that coats the inside of the cavity wall with crystals. The geodes of Las Choyas occur in the open spaces of Tertiary ash-flow rhyolite tuff. Keller (1979) proposed that the process that led to the formation of the cavities and subsequent mineralization occurred as follows. During the Tertiary, a very hot ash-flow tuff came into

contact with the cold surface of the ground and cooled rapidly, forming a glassy base. As crystallization occurred in the highly gas-charged material, the metastable glass formed into round radial aggregates known as spherulites. As crystallization continued, the gas held in solution in the glass exsolved and collected around the centers of crystallization within the spherulites. If a sufficient amount of gas was exsolved and concentrated in the interior of the spherulite as a growing bubble, the spherulite expanded, thinned, and eventually broke down. A void in the now-solid basal unit of the ash-flow tuff resulted; this void is called the lithophasal cavity. Vados-zone groundwater migrated through the volcanic tuff and deposited silt in many of the open cavities. The next event is believed to be the critical one in forming the mineralization in the geodes. A series of rhyolite domes intruded the region during the Tertiary, one of them adjacent to the geode deposit. The intrusion caused heated groundwater to circulate above and below the geode tuff. The circulating groundwater became alkaline, causing the alteration of the siliceous glass and leaching of its silica. When the groundwater became supersaturated with silica, chalcedony was quickly deposited, creating the rinds of the geodes. As the groundwater became depleted in silica, the rate of crystallization slowed. Large quartz crystals then grew in the geodes to form the final layer. The continued heating of the groundwater by the adjacent intrusion led to several additional stages of mineralization, with the final stage resulting in many different iron and manganese oxides that occur as microcrystals in the geodes.

Mineralogy

The mineralogy of the Las Choyas geodes appears to be straightforward - lots of quartz. The crystallized quartz can be amethystine, smoky, milky, or colorless, and the chalcedony ranges from milky white to dark blue. The most abundant secondary mineral is calcite, which occurs in a variety of habits. Finkelman et al.(1972) identified fifteen different species that occur as microcrystals. Seven of these species are manganese oxides, some of which are considered quite rare. In all, eighteen different minerals have been found in the geodes:

Apatite (var. dahllite), $Ca_5(PO_4)_3(F,OH)$
Beidellite, $(NaCaO_{0.5})_{0.3}Al_2(Si,Al)_4O_{10}(OH)_2 \cdot nH_2O$
Calcite, $CaCO_3$
Cryptomelane, $K(Mn^{2+},Mn^{4+})_8O_{16}$
Goethite, FeOOH
Gypsum, $CaSO_4 \cdot 2H_2O$
Hematite, Fe_2O_3
Hollandite, $Ba(Mn^{4+},Mn^{2+})_8O_{16}$
Kaolinite, $Al_2Si_2O_5(OH)_4$
Mordenite, $(Ca,Na_2,K_2)Al_{12}Si_{10}O_{24}.7H_2O$
Opal, $SiO_2.nH_2O$
Pyrolusite, MnO_2
Quartz, SiO_2
Ramsdellite, MnO_2
Rancieite, $(Ca,Mn^{2+})Mn_4O_9.3H_2O$
Siderite, $FeCO_3$
Todorokite, $Na_{1-x}(Mn,Mg,Al)_6O_{12}.3\text{-}4H_2O$

Categorizing The Las Choyas Material

In addition to its classic, hollow amethyst geodes, the Las Choyas deposit is also filled with "solid" and "semi-hollow" nodules (up to 80% of the mined specimens). That is to say, some type of mineral matter or sediment has filled or partially filled the original lithophysal cavity and became silicified. These nodules may be beautifully banded agate or the cavities may be partially or completely filled with finely laminated silt and sediment, creating complex miniature silicified sedimentary structures (the miners nicknamed these "mudballs") . Some specimens display extremely detailed cross-bedding and miniature tectonic structures like folding and

faulting. In addition, there are specimens that exhibit layers which indicate several different depositional environments occurred during formation. In other words, there is a host of solid variations caused by an interesting and complex geochemical and tectonic history at the deposit. My observations have led me to categorize these geodes, nodules and semi-solids found at Las Choyas as classic, agate, mudballs, and oddities.

Summary

The Las Choyas geode deposit has produced world-class amethyst geodes, as well as beautiful agate nodules, fascinating geode/sedimentary specimens, oddities, and faulted geodes, many with microcrystals, that make the deposit unique and mineralogically complex. From my observations, the deposit is far from being depleted. Based on the geology and hydrogeology at the site, geodes can potentially be mined to a depth of approximately 700 feet (at which depth the regional water table will be encountered). Today the known outcrop of the geode-bearing layer is nearly 1.25 miles in length. In my humble opinion, the deposit will not be depleted in our lifetime!

REFERENCES

Finkelman, R., J. Matzko, C. Woo, J. White, and W. Brown. 1972. A scanning electron microscopy study of minerals in geodes from Chihuahua, Mexico. *Mineralogical Record* 3:205-12.

Keller, P.C. 1977. Geology of the Sierra Gallego area, Chihuahua, Mexico. Phd diss., University of Texas, Austin.

————-, 1979. Quartz geodes from near the Sierra Gallego area, Chihuahua, Mexico. *Mineralogical Record* 10:207-12.

Smith, J.R. 2010. The Las Choyas Geode Deposit, Chihuahua, Mexico. *Rocks & Minerals* 85:112-122.

Figure 1 (above). Classic amethyst geode;12cm in diameter, Las Choyas deposit. Jeff Smith photo and specimen.

Figure 2 (below). Cavity partially filled with quartz and silicified sediment, 18 cm in diameter, Las Choyas deposit. Jeff Smith photo and specimen.

Figure 3 (above). Agate nodule; 7cm in diameter,
Las Choyas deposit. Jeff Smith photo and specimen.

Figure 4 (below). An "odd" nodule filled with calcite; 8cm in diameter,
Las Choyas deposit. Jeff Smith photo and specimen.

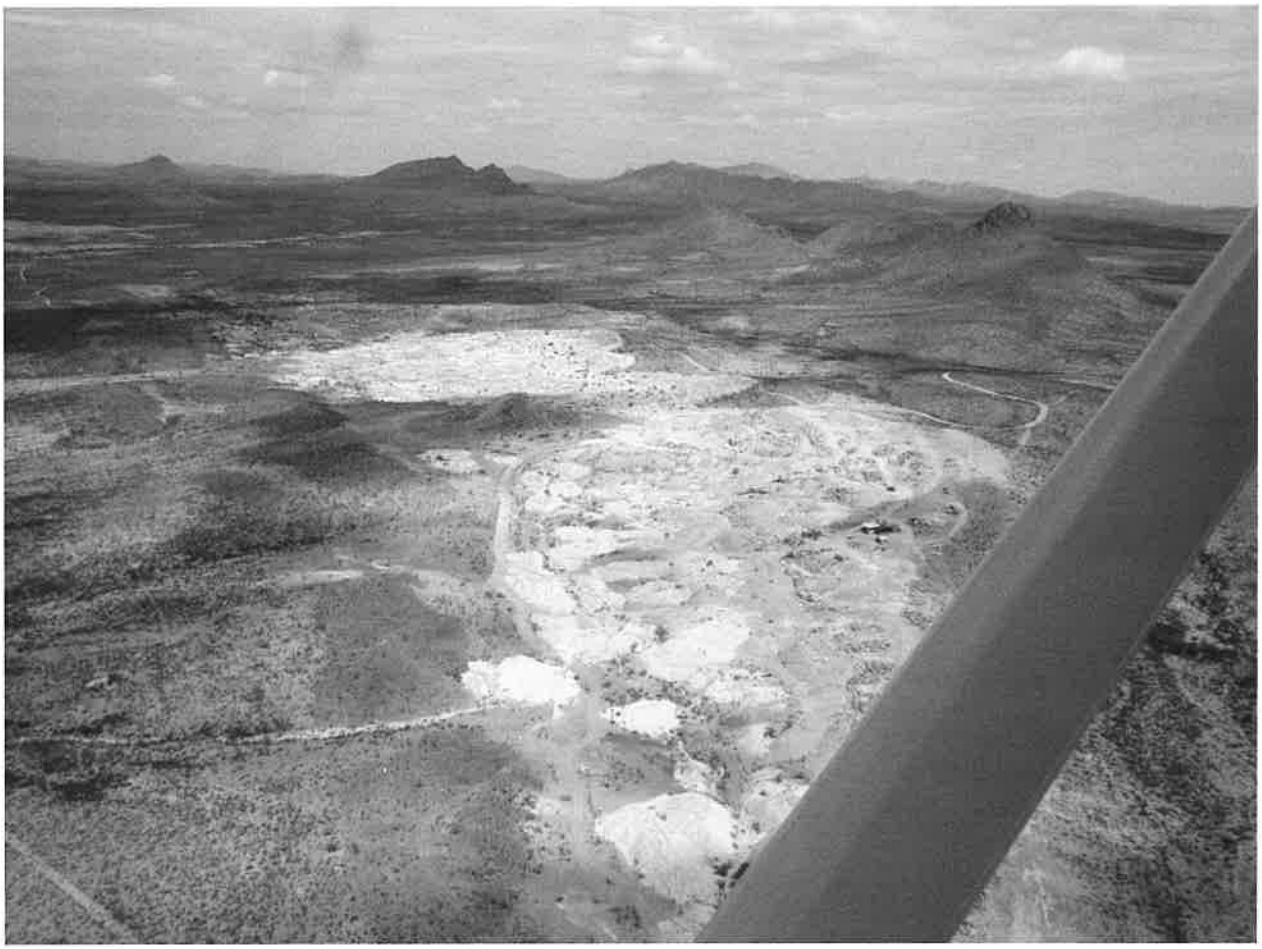

Figure 5. First aerial photo of the Las Choyas Geode Deposit, Chihuahua, Mexico, taken October 3, 2018. Jeff Smith photo.