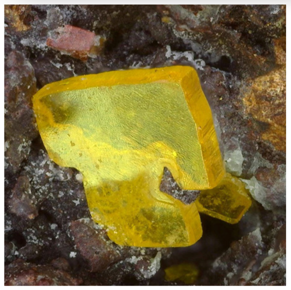
August 4 - 5, 2018

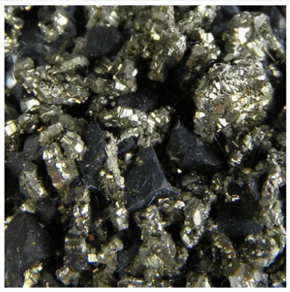
MINERALS FROM THE METALLIC ORE DEPOSITS OF THE AMERICAN SOUTHWEST

symposium

Program & Abstracts

Berthoud Hall
Colorado School of Mines
Golden, Colorado





MINERALS from the METALLIC ORE DEPOSITS of the AMERICAN SOUTHWEST

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Berthoud Hall
Colorado School of Mines
Golden, Colorado

Editor: Erin Delventhal

Sponsored by:
Friends of Mineralogy - Colorado Chapter
Colorado School of Mines Geology Museum
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Cover images (counter-clockwise from top left): Miners' camp on King Solomon Mountain, Silverton, Colorado, courtesy USGS; Smithsonite, Kelly Mine, New Mexico, courtesy of Rob Lavinsky; Wulfenite, Stephenson-Bennett Mine, New Mexico, courtesy of Michael Michayluk; Western Mineral Products Mill, Blanchard Mine, New Mexico 1916, courtesy of Ray DeMark & the New Mexico Bureau of Geology; Fluorite, Surprise Mine, New Mexico, courtesy of Philip Simmons & Mike Sanders; Pyrite on chalcopyrite, Gilman Mine, Colorado, courtesy of Rob Lavinsky; Single-jacking in the stope, Colorado, circa 1880s, courtesy of Ed Raines.

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Pete Modreski
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Acknowledgements

Nick Iwanicki
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Field Trips

Option 1: Phoenix Gold Mine, Idaho Springs, Colorado: "Tommyknocker Tour." $10.00 per person (cash only) with optional free gold panning for symposium attendees. 800 Trail Creek Road, Idaho Springs, CO 80452

Option 2: Hidee Gold Mine Tour, Central City, Colorado. $23.95 per person (cash or charge). 1950 Hidee Mine Rd, Central City, CO 80427

Sponsors

The Friends of Mineralogy - Colorado Chapter was founded in 1977 as a service organization with the purpose of increasing knowledge about minerals and their deposits.

The Colorado School of Mines Geology Museum features a prestigous collection of minerals from Colorado, many of which date to the early 1880s and were acquired by pioneers of Colorado mineralogy, as well as specimens from around the world.

The Friends of the Colorado School of Mines Geology Museum was founded in 2009 as a support group dedicated to promoting and assisting in the maintenance and expansion of the Colorado School of Mines Geology Museum.

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Geology Museum

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SCHEDULE

Friday, August 3, 2018

6:00 - 8:00 pm	**Reception at the Colorado School of Mines Geology Museum - 1310 Maple Street, Golden, Colorado** Appetizers, cash bar, and pre-registration

Saturday, August 4, 2018

7:30 - 8:30 am	**Registration, Berthoud Hall - 1516 Illinois Street, Golden, Colorado**
8:15	**Opening remarks**
8:30	*Frontier Mining Methods* - Ed Raines
10:00	**Coffee break**
10:20	*Minerals from the Cooke's Peak Base Metal Deposit, Luna County, New Mexico* - Phil Simmons
11:05	*Secondary Minerals of Ore Deposits in Utah* - Brent Thorne
12:00 - 1:30 pm	**Lunch break**
1:45	*The Blanchard Mine, Hansonburg District, Socorro County, New Mexico* - Erin Delventhal
2:30	*Accessory Minerals of the Silverton Caldera, San Juan Mountains, Colorado* - Robert Larson
3:15	**Coffee break**
3:35	*Exploring Mines and Mineral Collecting in the Magdalena Mining District of New Mexico in the 1970s* - Robert Hembree
4:20	*Carlin Type Gold Deposits, a Mineralogically Subtle 130 Million Ounce District* - Jeff Blackmon
5:05	*Rare Earth Elements in Uraninite - Breccia Pipe Polymetallic Uranium District, Northern Arizona, USA* - Karen Wenrich
5:50	**End of Saturday sessions**
6:30	**Cash bar at Table Mountain Inn, 310 Washington Avenue, Golden, Colorado**
7:00	**Banquet dinner**
8:30	Verbal auction to benefit the Colorado School of Mines Geology Museum - banquet ticket not needed to participate in auction

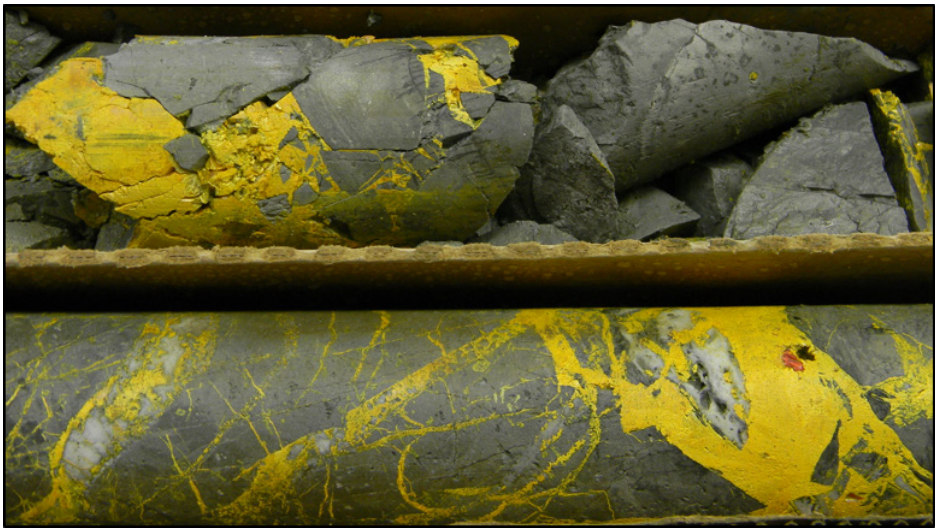
Sunday, August 5, 2018

8:45 am	**Opening remarks**
9:00	*The Gilman District* - Ed Raines
9:45	*Minerals of the Torpedo-Bennett fault zone, Organ Mountains, Doña Ana Co., New Mexico, USA* - Michael C. Michayluk
10:30	**Coffee break**
10:50	*Outstanding Minerals of the Metallic Ore Deposits of New Mexico* - Pete Modreski
11:35	*Pioneer Colorado Mineralogists: The Mines and Minerals of J. Alden Smith, Frederic Miller Endlich, and Jesse Summers Randall* - Mark Ivan Jacobson
12:20 - 1:30 pm	**Lunch break**
2:30	Field trips

Carlin Type Gold Deposits, a Mineralogically Subtle 130 Million Ounce District

Jeffrey Blackmon

The Carlin trend of north central Nevada is among the top 4 gold producing regions in the world, having produced approximately 100 million ounces with ~30 million ounces remaining in reserve. An additional 40 million ounces have been produced from adjacent trends, and including sub-economic low grade mineralization the total endowment of the region exceeds 350 million ounces. The district produced minor turquoise and copper in the late 1800's and early 1900's with first significant gold production in the 1930's from the Gold Quarry jasperoid. A one million ounce gold resource was then defined but deemed un-economic due to the fine grained disseminations being silica encapsulated and low grade. Truly disseminated carbonaceous limestone ore characteristic of the district was first produced in 1962, triggering a proliferation of open pit production from over 30 pits to date with 14 past and present underground operations. Although highly localized the most widely occurring gangue minerals of collector interest are stibnite, barite, realgar, and orpiment, including well over 100 species of microminerals having been identified.



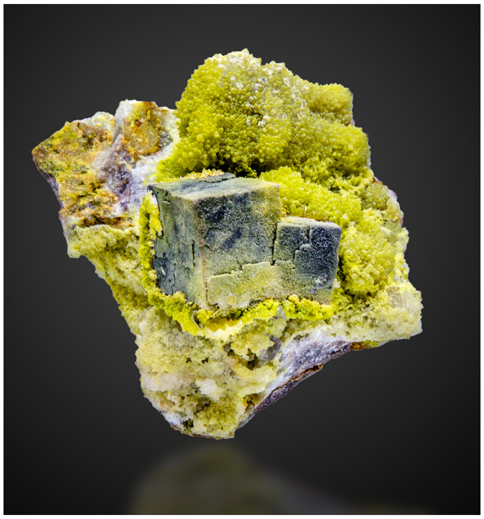
Orpiment and realgar breccia in a drill core, Twin Creeks mine, Nevada.

Growing up in northeast Georgia, Jeff found his passion for the earth sciences as a high schooler laboring at and surviving the Graves Mountain kyanite operation now more prominently known as the specimen rutile locality. Graduating from the University of Georgia in 1980, Jeff went to work for his metallic ore deposits professor Bob Carpenter, whose small consulting group co-discovered the 1.4 million ounce Ridgeway gold deposit (SC). After bouncing about the floundering metals industry of the 80's, 90's, and early 2,000's as contract and staff Exploration Geologist with Freeport, Tenneco, Noranda, Chevron, and others, he joined Newmont Mining Corp. in 2008. As Senior Geologist Jeff has been involved with a wide range of Nevada exploration and development projects, since 2011 serving as Exploration Manager at Long Canyon, Newmont's most recently developed domestic gold producer.

The Blanchard Mine, Hansonburg District, Socorro County, New Mexico

Erin Delventhal

The Blanchard Mine, located in the Hansonburg District in the northern Oscura Mountains, Socorro County, New Mexico, has earned it's place as a classic New Mexican locality through the production of widely available, high-quality mineral specimens - most notably the "Blanchard blue" fluorite (often associated with galena) as well as the discovery of the world's largest known linarite crystals. However, the rich mineralization at the Blanchard Mine produces a suite of other minerals that appeal to many varieties of collecting styles.



Mottramite on altered galena and quartz, Blanchard Mine, New Mexico. *Ray DeMark specimen, Erin Delventhal photograph.*

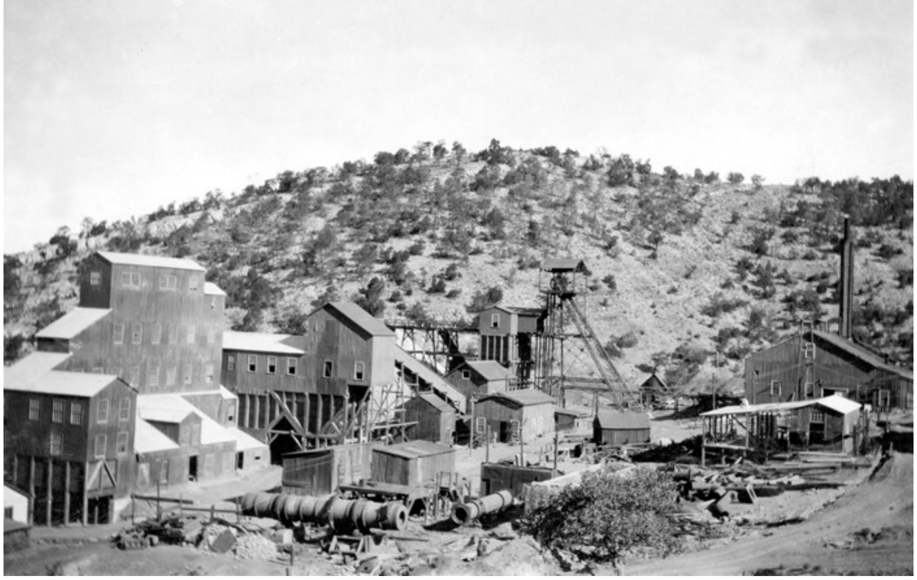
The history of the Blanchard Mine reaches into Native American and Spanish colonial history, but large-scale development began in the early 1900s. Numerous attempts were made to develop an economic source of lead at the Blanchard, but all were victim to the trials found in mining in a harsh and remote desert. Throughout the years, the Blanchard was utilized as a "collector's dream," with visitors arriving from around the globe to be led through the property by characters such as Ora Blanchard ("The Lady on the Mountain"), Sam "Rattlesnake" Jones, and, in present times, Ray DeMark and Mike Sanders.

The Sierra Oscura Mountains consist of basement Proterozoic granites and gneisses with overlying Pennsylvanian formations of marine limestone and shale with interbedded arkosic sandstone. Mineral deposits at the Blanchard Mine are concentrated as open-space fillings in fissures, fault breccia, and solution cavities that are primarily concentrated in the Council Springs limestone. The Blanchard Mine and the Hansonburg District as a whole have been the subject of numerous academic studies as one of the most prominent of the Rio Grande Rift deposits.

Erin Delventhal is by profession a photographer and graphic designer with a degree in mechanical drafting, but has had a passion for minerals from a young age, where her childhood was spent on field collecting trips with her family and a local mineral club. Her interest in the mineral world was rekindled after a trip to the Tucson Gem & Mineral Show in 2014. After returning home, she rejoined her local mineral club and has since served two years as a general board member, is serving in her second year as both secretary and newsletter editor, and has been honored by the club with "Rockhound of the Year" twice. She served as the lead volunteer during the opening stages of a new mineral museum, where she was able to further her knowledge of mineral specimens through identifying, cataloguing, and labeling a museum collection. She currently serves as a mindat.org manager.

Exploring Mines and Mineral Collecting in the Magdalena Mining District of New Mexico in the 1970s

Bob Hembree


Kelly Mine, 1916. *USGS photograph*

The Magdalena Mining District is in Socorro County, New Mexico approximately 28 miles west of Socorro along US Highway 60. The district was discovered in 1866 and produced lead, silver, gold, copper, and zinc until 1979. The largest production was from 1881 through 1919. Most of the major mines are in the central part of the district near the ghost town of Kelly. The most famous of these mines is the Kelly Mine from which the robins egg blue Smithsonite was produced. Other mines include the Waldo-Graphic, Juanita, Germany, Tip-Top, Linchburg, and Nitt among others. Most of the production from the district came from replacement deposits located in the Kelly limestone which is of Mississippian age.

During the 1970s while I was attending the New Mexico Institute of Mining and Technology (NM Tech) in Socorro several friends and I spent most of our spare time exploring and mineral collecting in the mines of the Magdalena and other mining districts of central New Mexico.

This paper will present our experiences exploring and collecting minerals in the mines of the Magdalena district. While the district is best known for fine specimens of Smithsonite many other fine specimens of oxide and other minerals have been produced.

Bob Hembree is a retired mining engineer and geologist who lives in Bailey, Colorado. He graduated for New Mexico Institute of Mining & Technology in 1975. After graduation he spent his career working at various mining operations around the US and in Kazakhstan. He has worked at operations that produced gold, silver, copper, lead, zinc, vanadium, and uranium. One of his more interesting positions was as manager of technical services at the Nyrstar zinc mines in Tennessee which included the Elmwood mine. He currently spends his time mineral collecting, fishing, building a model railroad, and occasionally consulting.

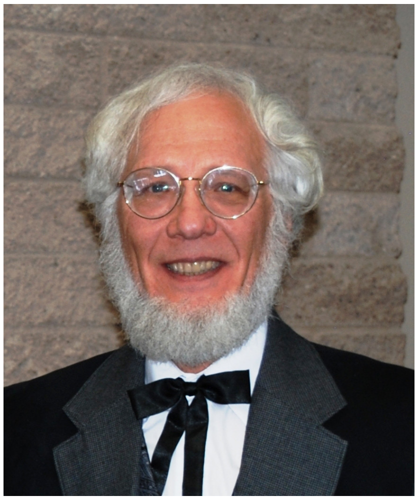
Pioneer Colorado Mineralogists: The mines and minerals of J. Alden Smith, Frederic Miller Endlich and Jesse Summers Randall

Mark Ivan Jacobson

J. Alden Smith, a self-taught mineralogist and successful newspaper publisher-owner from Bethel, Maine arrived to manage the Freeland lode in the Trail Creek district southwest of Idaho Springs in 1866. His experiences in Colorado led to a very successful career as the Colorado Territorial and later State Geologist, and mine superintendent for some of the most profitable mines in Boulder County. He was the mine superintendent for the American mine, Sunshine, Boulder County, a contract assayer, contract mine examiner, and frequently the county representative at mining expositions such as the 1870 St. Louis Agricultural and Mechanical Fair. In 1873, Frederic Miller Endlich, a German-educated mining engineer from Pennsylvania started as a field geologist-mineralogist with the Hayden Survey inspecting the gold and silver mines of Clear Creek, Gilpin and Boulder counties and advanced to being the field team geologist for the San Juan Mountains area. In later years, he helped successfully develop mines such as the Yankee Boy Mine in Colorado, Lake Valley mines of New Mexico, Kelsey Mine, Los Angeles County, California and the Santa Rita mine, Tucson, Arizona. While others profited from his work, his habit of making bad decisions led to his economic downfall. Jesse Summers Randall, a printer from Iowa moved to Georgetown in 1869 to care for his father during a medical emergency, and ended up becoming a printer-writer with the Colorado Miner newspaper of Georgetown. After starting his own newspaper, the Georgetown Courier, he became an advocate for developing the mines around Georgetown. Although his political activism against those in power isolated him from the elite in the community, he still devoted much effort to mineral collecting, and documenting Colorado mineral localities.

These three men were in contact with the major miners and mineralogists in Colorado starting in 1866 and contributed a series of “Mineral of Colorado” booklets from 1866, 1867, 1870, 1872-3, 1873, 1875, 1876, 1877, 1880, 1882, 1887, and 1893. Jointly, their activities have expanded our knowledge of minerals and mineral localities in Colorado. Most of the mineral localities that clubs collect at today were either exploited or documented by these three men.

Mark Ivan Jacobson is a geologist-mineralogist specializing in pegmatites. He obtained a BS in mineralogy-geochemistry from Pennsylvania State University in 1973 and a MS in sedimentary geology from the University of California at Berkeley in 1976. After graduate school, he worked for Amoco and Chevron in oil and gas development as an earth scientist, completing 35 years with Chevron before retiring in 2013. He has published numerous articles on the geology, mineralogy, and mining-collecting histories of pegmatites since 1978 as well as two major books: “Guidebook to the pegmatites of Western Australia (2007)” and “Antero Aquamarines: Minerals from the Mount Antero - White Mountain region, Chaffee County, Colorado (1993).” He has been a consulting editor for Rock & Minerals since 1984 and is currently president of the National Friends of Mineralogy. Currently, his latest book project, The emerald and hiddenite localities of Alexander County, North Carolina with W. Edward Speer is in the final stages of editing prior to publication.



Accessory Minerals of the San Juan Mountains, Colorado

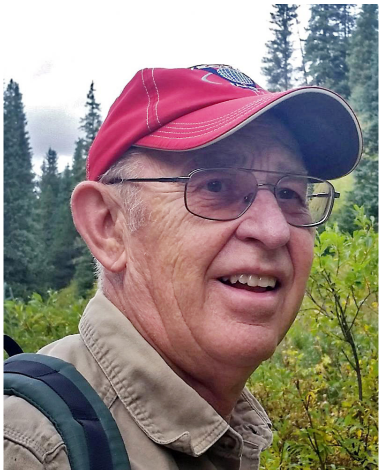
Robert A. (Bob) Larson

Ore Deposits within the San Juan Mountains have provided base and precious metals for our use and the benefit of our country since the late 1800s. These metals have been produced from classic sulfide minerals in breccia pipes, vein systems, and replacement-type ores. Although not sought after with the same intensity or interest as the ore-bearing minerals, accessory minerals, which were formed with and alongside the metallic minerals of hydrothermal origin, have been identified, classified and collected by miners, geologists, mineral collectors, rock-hounds and others throughout our history. These minerals have been used as indicators of potential ore, have defined the alteration haloes surrounding the ore, have been collected and made into jewelry by some, or simply collected and displayed for their uniqueness and beauty. Abundant, beautiful and plentiful quartz crystals, calcite, barite, fluorite, epidote and pyrite are found in mine dumps and ore stockpiles throughout the San Juan's. More exquisite rhodochrosite, rhodonite (now called pyroxmangite), covellite, enargite, scheelite, huebnerite and others adorn our museums and the mineral collections of many. Along with examples of a few of these minerals we will briefly discuss the geological environment within which these minerals and the associated ore deposits were formed.

Rhodochrosite, Grizzly Bear Mine, Ouray County, Colorado. *MMS specimen, Kentee Pasek photograph*

Calcite with Pyrite, Argentine Vein, Idarado Mine, Colorado. *MMS specimen, Kentee Pasek photograph*

Robert A. Larson is a Certified Professional Geologist and a Registered Land Surveyor with experience in mining, exploration and surveying throughout the United States, Canada, Mexico and Caribbean. Mr. Larson's mining experience includes base and precious metal mining, engineering and management for both surface and underground operations. Exploration experience includes precious metals, base metals, uranium, and industrial minerals in various geological environments. Mr. Larson was a geologist, mining engineer and production supervisor at the Idarado Mine; Project Manager at the Revenue-Virginius Mine; and has been a Consultant to the Camp Bird Mine, Ouray Silver Mines, the Ruby Trust Mine and others in the San Juan Mountains. In addition, he has provided numerous mineral property evaluations, mineral resource determinations and technical reports as part of Monadnock Mineral Services, LLC. Mr. Larson graduated with an Engineer of Mines degree from the Colorado School of Mines in 1968.



Minerals of the Torpedo-Bennett fault zone, Organ Mountains, Doña Ana Co., New Mexico, USA

Michael C. Michayluk

The Organ Mountains in Southern New Mexico are host to a rich assemblage of minerals and many metallic ore deposits. A particularly rich trend of mineralization occurs in the northern part of the range along a series of faults called the Torpedo-Bennett fault zone. Copper porphyry-type deposits at the Torpedo mine in the northern reaches of the fault zone generated copper-zinc skarns immediately adjacent to the porphyry system (Lueth and McLemore 1998). One such skarn was mined for Cu at the Memphis Mine, just adjacent to the Torpedo. An outward trend continues along the faults from the porphyry and skarn, followed by Pb-Zn-Ag replacement deposits (Lueth and McLemore 1998). The Stevenson-Bennett mine is a historically significant mine probably most famous for its exceptional wulfenite specimens, and is an example of this type of Pb-Zn-Ag replacement mineralization within the fault zone. Both the ore minerals and gangue minerals will be described in depth from each of the three deposits, the Torpedo, the Memphis, and the Stevenson-Bennett.

A doubly terminated hemimorphite crystal; Stevenson-Bennett Mine FOV about 8.5mm.
Michael C. Michayluk photograph

List of Minerals from the Torpedo Mine:

- Acanthite
- Azurite
- Brochantite
- Chalcocite
- Chalcopyrite
- Chrysocolla
- Copper
- Cuprite
- Gypsum
- Hemimorphite
- Kaolinite
- Malachite
- Pyrite
- Quartz
- Rosasite
- Smithsonite
- Turquoise

List of Minerals from the Memphis Mine:

Adamite
Andradite
Aragonite
Aurichalcite
Azurite
Baryte
Bismuthinite
Bismutite
Brochantite
Calcite
Cerussite
Chalcocite
Chalcopyrite
Chrysocolla
Conichalcite
Copper
Covellite
Cuprite
Diopside
Dolomite
Dyscrasite (?)
Epidote
Fluorite
Galena
Galenobismutite
Goethite
Hematite
Hemimorphite
Hetaerolite
Jarosite
Limonite
Linarite
Malachite
Massicot
Pyrite
Quartz
Rosasite
Scheelite
Sphalerite
Sulphur
Tetradymite
Vanadinite
Willemite
Wollastonite
Wulfenite

List of Minerals from the Stevenson-Bennett Mine:

Adamite
Anglesite
Aragonite
Aurichalcite
Beudantite Group
Brochantite
Calcite
Caledonite
Cerussite
Chlorargyrite
Chrysocolla
Descloizite
Dolomite
Duftite
Fluorite
Galena
Goethite
Gypsum
Hematite
Hemimorphite
Hydroniumjarosite
Jarosite
Limonite
Linarite
Malachite
Mimetite
Mottramite
Phosgenite
Plumbojarosite
Pyrite
Pyromorphite
Quartz
Rosasite
Siderite
Silver
Smithsonite
Sphalerite
Strengite
Vanadinite
Willemite
Wulfenite

Michael Michayluk graduated from Wayne State University (Detroit, Michigan) in 2013 with a Bachelor of Science in Geology. Multiple trips to Bancroft, Ontario, Canada, led by Dave Lowrie, instilled in him a passion for minerals and especially field collecting. In August 2014, he moved to Las Cruces to pursue a graduate degree in paleontology and was quickly distracted by southern New Mexico's mineralogical wealth. Michael has been field collecting the region for minerals ever since. In 2016 he started a very small company; New Mexico Mineralogical Research and Exploration. Our mission is to explore, study, and photograph poorly documented or undocumented mineral localities in New Mexico. Some of my focuses include Wind Mountain (Otero Co., NM) and the Organ District of the Organ Mountains (Doña Ana Co., NM).

Outstanding Minerals of the Metallic Ore Deposits of New Mexico

Peter Modreski

New Mexico's many mines, which played a major role in the settlement and development of the state, include deposits of a variety of metallic minerals: copper, gold, silver, lead, zinc, iron, manganese, tungsten, tin, uranium, molybdenum, and more.

What should we consider to be "metallic ore deposits"? What most comes to mind are those minerals, ores of the heavy metals, that are themselves metallic or submetallic in nature: they are the ores of what are traditionally thought of as the precious, base, and ferrous metals. Minerals of interest to collectors or mineralogists include the ore minerals themselves, which are mostly sulfides, oxides, and native elements; the "secondary" minerals formed in the zones of oxidation or supergene enrichment, which include many oxides, carbonates, sulfates, phosphates, arsenates, vanadates, and tungstates; and the "nonmetallic" gangue minerals such as quartz, calcite, barite, fluorite, and many more, some of which are mined in their own right for the mineral (e.g., fluorite) irrespective of whether other metallic ore minerals are present. It can of course be argued that all of these "nonmetallic" minerals still contain metals (e.g., calcium in fluorite), but for purposes of this symposium, I will concentrate on the minerals of what are perceived as the clearly "metallic" ore deposits, and skip over the deposits of fluorite, halite, potash, calcite, gypsum, and the like. New Mexico's uranium deposits are a bit unique among the metal ore deposits, as the minerals themselves (carnotite, tyuyamunite, uranophane, coffinite, uraninite (pitchblende) are not at all "metallic" in appearance.

Copper, spinel-twinned crystal group, Chino Pit, Santa Rita, Central District, New Mexico.
New Mexico Bureau of Mining and Geology, Mineral Museum, specimen #15352, length 10 cm, "the copper chile." J*eff Scovil photo, courtesy of Jeff Scovil and the NMBMG Mineral Museum.*

A list of the districts and mines in New Mexico that are of the most mineralogical interest, with some of the most notable minerals found in each, could include, in an approximate order starting with what are, arguably, the "best" localities:

- Santa Rita district, Chino mine, Grant Co. – copper, cuprite, azurite, libethenite, pyrite, turquoise
- Magdalena district, Kelly mine, Socorro Co. – smithsonite, aurichalcite, azurite, malachite, rosasite
- Hansonburg district, Blanchard mine, Socorro Co. – fluorite, galena, barite, linarite, brochantite, cerussite, spangolite
- Organ district, Stevenson (Stephenson)-Bennett mine, Doña Ana Co. – wulfenite, cerussite
- New Placers district, San Pedro mine, Santa Fe Co. – chalcopyrite, malachite, quartz, calcite, gold, pyrite, grossular-andradite

- Central district, Groundhog mine, Grant Co. – chalcopyrite, calcite, pyrite, quartz, sphalerite
- Fierro-Hanover district, Continental No. 2 mine, Grant Co. – azurite, magnetite, smithsonite
- Burro Mountains district, Tyrone mine, Grant Co. – azurite, copper, cuprite, libethenite
- Grants uranium district – andersonite, carnotite, coffinite, tyuyamunite, uranophane, zippeite

The above list is only an attempt at highlighting the districts that have produced the most outstanding specimens. The state has many other mines and districts that each have produced minerals of special significance. A list of more of these should include: the Black Range tin district, Catron Co. (cassiterite, hematite); the Cerrillos district, Santa Fe Co. (turquoise); Questa, Taos Co. (molybdenite, ferrimolybdite); the Macy and Petroglyph mines, Hillsboro, Sierra Co. (mimetite, vanadinite, willemite, wulfenite); the Alhambra mine, Blackhawk district, Grant Co. (native silver, acanthite, nickelskutterudite); Ortiz mine, Golden, Old Placers district, Santa Fe Co. (scheelite); Nancy (Tower) mine, Luis Lopez manganese district, Socorro Co. (hollandite ("psilomelane")); Bursum (US 60) mine, Luiz Lopez manganese district, Socorro co. (goethite); Lake Valley district, Sierra Co. (pyrolusite, ramsdellite); Commercial mine, Georgetown district, Grant Co. (descloizite); Copper Rose mine, San Lorenzo, Georgetown district, Grant Co. (copper pseudomorphs after azurite); Nacimiento mine, Cuba, Sandoval Co. (azurite, malachite, chalcocite). More could be added! And of course, many mines and placers throughout the state were localities for gold nuggets.

A very useful source for information about the names of past and present mining districts and mines in New Mexico, their geologic occurrence, metals present, and their economic importance is the NMBMG report by McLemore (2017); see https://geoinfo.nmt.edu/publications/maps/resource/24/. The appendix to this report is an Excel file with entries for 246 mining districts. The data in it include an approximate figure for the total dollar value of each district's production, which makes it interesting to see how the list of mines with the highest total values of production compares with those that are best known for producing good mineral specimens. The districts with the highest reported cumulative production (dollar values: B = billion, M = million) are:

- Grants uranium district, Bernalillo, Cibola, McKinley, Sandoval, Valencia Co., > **$7B**
- Burro Mountains district (includes Tyrone), Grant Co., > **$2B**
- Fierro-Hanover district, Grant Co., > **$2B**
- Santa Rita district (includes the Chino mine), Grant Co., > **$2B**
- Questa district, Taos Co., > **$100M**
- Central district (includes Bayard and the Groundhog mine), Grant Co., > **$60M**
- Lordsburg district, Hidalgo Co., > **$60M**
- Magdalena district (includes the Kelly, Graphic, Juanita mines), Socorro Co., > **$46M**
- Willow Creek district (includes Pecos and Terrero mines) San Miguel Co., > **$40M**

An excellent source for information about many of New Mexico's mineral occurrences are the abstracts of the papers given over the past 38 years at the New Mexico Mineral Symposium. All the abstracts are accessible online via the NMBMG website, and are searchable by title, author, year, and keywords, at https://geoinfo.nmt.edu/museum/minsymp/abstracts/home.cfml.

Classic references to all of New Mexico's mineral occurrences, and mining districts include Minerals of New Mexico, by Northrup (1959) and the update to it edited by Florence LaBruzza (Northup, 1996). Several classic localities are described in the New Mexico issue of The Mineralogical Record (vol. 20, no. 1, Jan.-Feb. 1989), including the Magdalena district (Ron Gibbs), Stephenson-Bennett mine (Janet Hammond), and the Hansonburg district (Taggart, Rosenzweig, & Foord). In regard to “most outstanding minerals of New Mexico), a paper I presented at the 2008 New Mexico Symposium (Modreski, 2008) may be of interest. In it, I focused on what minerals and localities from New Mexico were most represented in books about fine mineral specimens; I concluded that the joint runners-up for the title of “best” New Mexico locality were the Kelly mine for its smithsonite and the Chino mine for its crystallized copper.

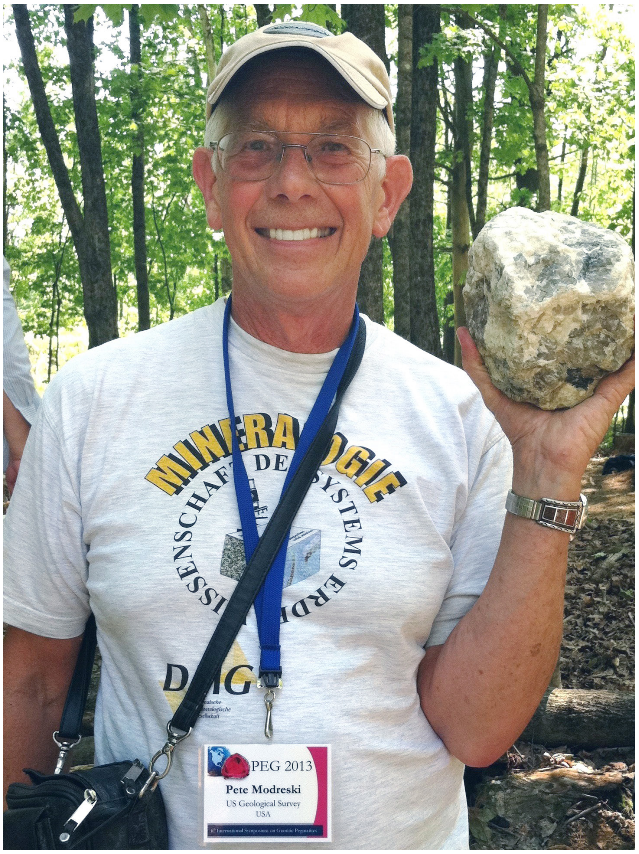
References

McLemore, Virginia T., 2017, Mining Districts and Prospect Areas in New Mexico. Resource Map 24, New Mexico Bureau of Geology & Mineral Resources. Map, 65 p. booklet, plus supplementary appendices and GIS data.

Modreski, Peter J., 2008, New Mexico’s classic mineral localities. New Mexico Mineral Symposium, Program & Abstracts, p. 8-9.

Northrup, Stuart A., 1959, Minerals of New Mexico, revised ed. Albuquerque N.M., University of New Mexico Press, 665 p. + map.

Northrup, Stuart A., 1996, Minerals of New Mexico, 3rd ed. Revised by Florence A. LaBruzza. Albuquerque N.M., University of New Mexico Press, 356 p.



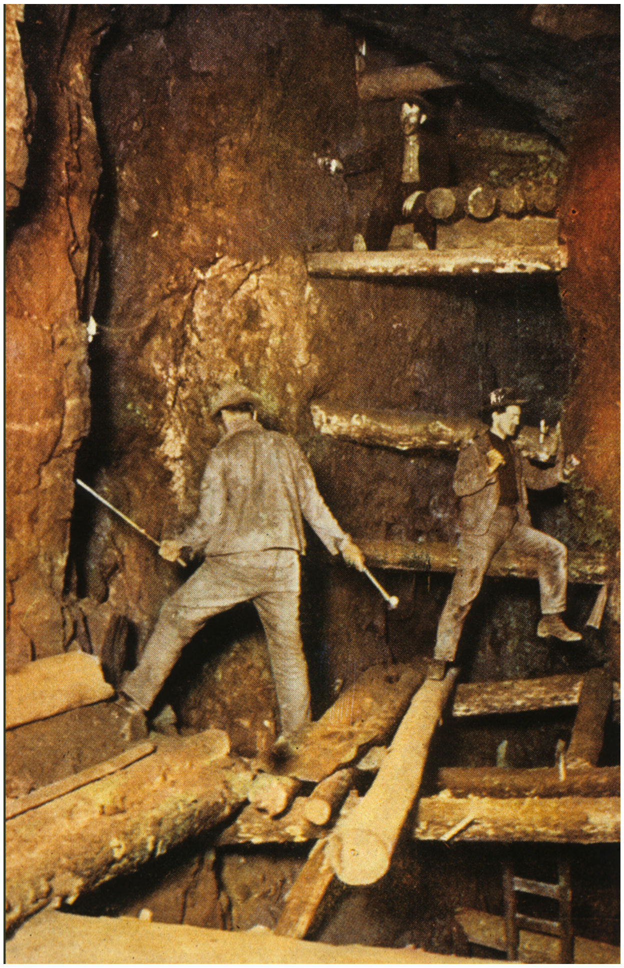
Dr. Peter J. Modreski has been a geochemist since 1979 with the U.S. Geological Survey, Lakewood, Colorado. He has a B.A. (chemistry) from Rutgers College and an M.S. and Ph.D. from Penn State (geochemistry). His research interests include mineralogy, ore deposits, Colorado geology, pegmatites, gemstones, luminescence, meteorites and impacts, alkaline igneous rocks, kimberlites, and volcanology. He is presently responsible for public and educational outreach at the USGS. Pete was a co-author of Minerals of Colorado (1997) and he is a Consulting Editor for Rocks & Minerals magazine and a Department Associate with the Earth Sciences Department, Denver Museum of Nature and Science.

Frontier Mining Methods

Ed Raines

The California gold rush introduced the idea of mining in the West to America. Discoveries of more mineral deposits created an industry that thrived on the western frontier using "older" technologies. Following the introduction of explosives to mining in the 17th century, mining and ore processing had become a six step process: (1) drilling holes in rock, (2) filling the holes with explosives, (3) blasting down rock, (4) loading and hauling the rock to the surface, (5) separating ore from waste rock, and (6) extracting metals from the ore. The first four steps are the basic underground mining operations that have been used since that time, but through the years, technology has modified the manner of accomplishing each of these tasks.

During the latter half of the 19th century the industrial revolution brought a plethora of technological innovations to the underground world of hardrock mining. New inventions and methods changed the tasks of drilling and blasting; mucking and haulage; and hoisting and lifting. As the task of mining went deeper underground, new conditions demanded new technologies such as timbering, ventilation, and pumping and drainage. Even the most basic of tasks—providing light to work underground—went through four major technological developments during the frontier days. By the outbreak of World War I, hardrock mining had entered the modern age, and the frontier technologies of the early gold rushes had become relics of the past.



Single-jacking in the stope. Hand-colored postcard circulated in the 1880s. Originally reported as being from Cripple Creek, but later reported as Leadville and other districts.

The Gilman District

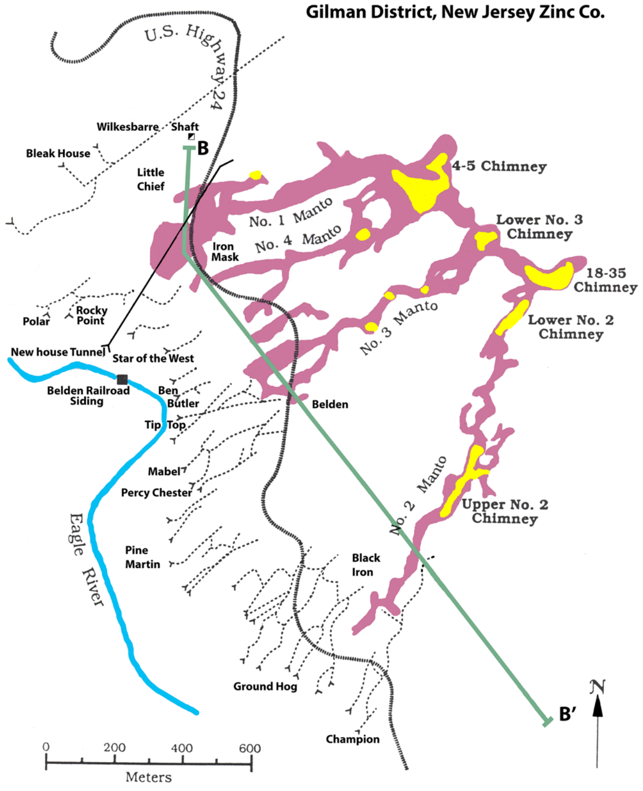
Ed Raines

According to a secondary source, a lone prospector, James Denney (Denning??), discovered iron-stained gossans at a contact of the Leadville limestone with a porphyry sill among the cliffs above the Eagle River in 1874. Because this occurrence was similar to those which characterized the fabulous deposits at Leadville, a group of Leadville would-be-entrepreneurs grubstaked two veteran prospectors to explore the cliffs above the Eagle River. By 1878 several important claims had been staked and by 1880 some mines were producing oxidized ores consisting of silver-bearing galena partially altered to cerussite and anglesite. Within a couple of years, the Denver & Rio Grande Railroad completed a narrow gauge line along the river to just below the workings. The eventual success of the fledgling district was insured when aerial trams were built to connect to the D&RG siding. In 1883, production reached 232,000 oz. of silver and 8,000 tons of lead.

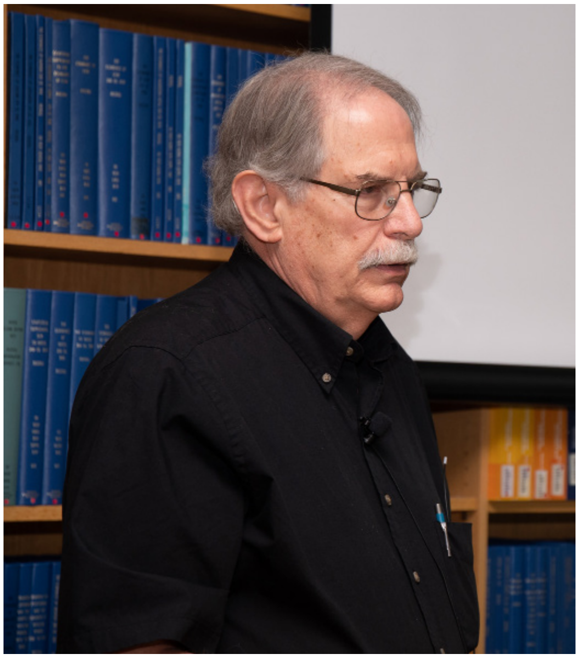
By the turn of the century, most of the oxidized ore deposits had been exhausted, and what remained below appeared to be mainly pyritic zinc ore consisting mainly of sphalerite and pyrite. Zinc production began to be of importance in 1905, when the Pittsburg Gold-Zinc Co. erected a roasting and magnetic separation plant. This zinc production attracted the attention of New Jersey Zinc, which began a program of acquisition in 1912 and was mining by 1915. By 1918, Empire Zinc Company, a subsidiary of New Jersey Zinc, had acquired both the Iron Mask and the Black Iron groups of mines. Ultimately, Empire Zinc consolidated most of the properties of the district into the Eagle Mine. In the late 1920s, mining reached copper-silver rich orebodies which provided the majority of production from 1931 to 1941. During the World War II and Korean War years, zinc prices recovered from a decade-long slump, and zinc joined copper production as the major war efforts of the Eagle Mine. Declining ore reserves and metal prices forced the closing of the zinc mining operations in 1974. In 1981, copper and silver mining were halted. In the years since the shutdown, various environmental issues have come into focus.

The main pyritic zinc orebodies produced specimens of lustrous black iron rich sphalerite crystals, shiny cubes and pyritohedrons of pyrite, galena cubes, gemmy golden barite prisms, rhombohedrons of dolomite, flattened rhombohedrons of both siderite and rhodochrosite, and stubby prisms of colorless apatite. Chalcopyrite crystals from the copper-silver ores vary in size from a few millimeters across up to fine crystals in excess of a centimeter across, however, much chalcopyrite exists as coatings and massive growths in these ores. The copper-silver orebodies also produced metallic-gray tetrahedrons of tetrahedrite, small cubes of galena, stubby greenish prisms of apatite, and irregular growths of polybasite, pyrargyrite, hessite, and other rarer silver minerals that only occasionally form as small euhedral crystals. The most important silver bearing mineral at the Eagle Mine is freibergite which only occurs as crusts, coatings, and fillings of microscopic crystals within the ores. Through the years, the amount of specimen material produced (from spectacular large specimens and as representative thumbnail specimens to purely "decorator rocks") has been truly phenomenal.

Manto and Chimney Orebodies, Claims and Adits at the Eagle Mine, Gilman District, New Jersey Zinc Co.



modified & adapted from Beaty, D. W. and G.P. Landis, 1990, Part IV. Stable Isotope Geochemistry, fig 31. In Beaty, D.W. and J.S Merchant, 1990, Origin of the ore Deposits at Gilman, Colorado, pp 193-265. In Beaty, D.W., G. P. Landis, and T.B. Thompson, eds, Carbonate-hosted Sulfide Deposits of the Central Colorado Mineral Belt, Economic Geology Monograph 7, 424 p.



Ed Raines, a geologist-mineralogist with expertise in petrology and geochemistry, is currently the Curator and Collections manager for the Colorado School of Mines Geology Museum, and a past President of both the Mining History Association (2014-15) and the Friends of Mineralogy - Colorado Chapter (1996-97). He has had published numerous papers on the mining history, geology and mineralogy of many Colorado mining districts, and frequently gives lecture programs on these topics. Several of Ed's papers have received best article of the year award from Friends of Mineralogy. He is the author of the book, Historic Photos of Colorado Mining (2009).

From 1995 to 2004 Ed served as the mining representative on the Boulder County Commissioner's Historical Preservation Advisory Board. In 1997 Ed Raines received the Clear Creek County Metal Mining Association's Golden Burro Award for his work in promoting the mining industry through his writing and lecture programs. In 2000 he received a special State Honor Award from Colorado Preservation Inc. for his work in historical preservation at Leadville. In 2005 he received a Square Nail Award for Historic Preservation work from the Boulder Roundtable. In 2002, he founded Geo-Historical Studies, a company specializing in consultation and special studies in Geology and Mining History.

Ed has taught adult, continuing education courses (Geology of the Front Range and Rock and Mineral Identification) through the Boulder Valley School District for more than twenty years. He has led geology and mining history field trips to Leadville, Creede, Cripple Creek, Central City, Georgetown, Silver Plume, Gold Hill, Caribou, Nederland, Jamestown, the eastern San Juan Volcanic Field, the Front Range Foothills, Rocky Mountain National Park and Clear Creek Canyon. He has organized and managed annual conferences for the Mining History Association at Gold Hill, Leadville and Creede.

Minerals from the Cooke's Peak Base Metal Deposit, Luna County, New Mexico

Phil Simmons

The Cooke's Peak deposits were first discovered by prospectors in the late 1870's and early 1880's. Lead ore was first recognized by Ed Orr in the form of silver-bearing galena in the large canyon northeast of the peak for which the mountain range was named, and soon after his discovery, two other prospectors named Taylor and Wheeler located the first economic orebodies in 1880. During these early years, Apaches under the leadership of Cochise and Geronimo continually harassed the prospectors, and it wasn't until the surrender of Geronimo in 1886 that the mines could settle down and start producing larger quantities of ore. Production reached its zenith around the turn of the 20th century at 1.5 million pounds of lead and 70,000 ounces of silver, but decreased substantially until 1905 when the majority of the small, high-grade lead deposits were exhausted (Jicha, 1954). However, halos of oxidized zinc ore were found rimming the lead-rich pods and mining picked back up until 1925 (Jicha, 1954). From this point forward, mining was sporadic until the district closed completely in 1965. Overall, the Cooke's Peak districts produced ~8.5 million pounds of lead, ~6.5 million pounds of zinc and ~71,000 ounces of silver.

Fluorite, Surprise Mine, Cooke's Peak District, Luna Co., New Mexico.
Mike Sanders and Phil Simmons photograph.

The Cooke's range consists of a granodiorite intrusive complex of late Cretaceous-early Tertiary age that intruded Proterozoic to Cretaceous sedimentary rocks. This intrusion resulted in the introduction of ore-bearing fluids into the overlying sedimentary rocks, creating replacement- type ore deposits (Carbonate Replacement Deposits, or CRD's) mostly confined to the dolomites of the Fusselman Formation. The small ore bodies are commonly lenticular in shape, and form "under broad arches" (Lindgren, Graton and Gordon, 1910) that were created by the upwelling of the igneous magmas. The presence of the overlying Percha Shale inhibited fluids from ascending further, and the mineralized bodies were concentrated near the contact between the dolomite and the shale. Once the primary (hypogene) ore bodies had been deposited and uplifted through extensional rifting, they were subjected to oxidizing fluids and formed a broad suite of secondary (supergene) minerals.

To collectors, the Cooke's Peak deposits are not famous for their metal production, but for the gangue minerals associated with ore minerals. Cooke's Peak has long been known for being the source of exceptional fluorite, and just recently a find of microcrystalline sidwillite has created much excitement within the micromounting community. Other species such as quartz, calcite, smithsonite, barite and rare molybdenum oxides are found in collectible specimens. Current collecting is underway on several mining claims, and exciting new specimens are being discovered every year.

References

Jicha, H.L. 1954. *Geology and Mineral Deposits of Lake Valley Quadrangle, Grant, Luna and Sierra Counties, New Mexico*. New Mexico Bureau of Geology and Mineral Resources Bulletin 37.

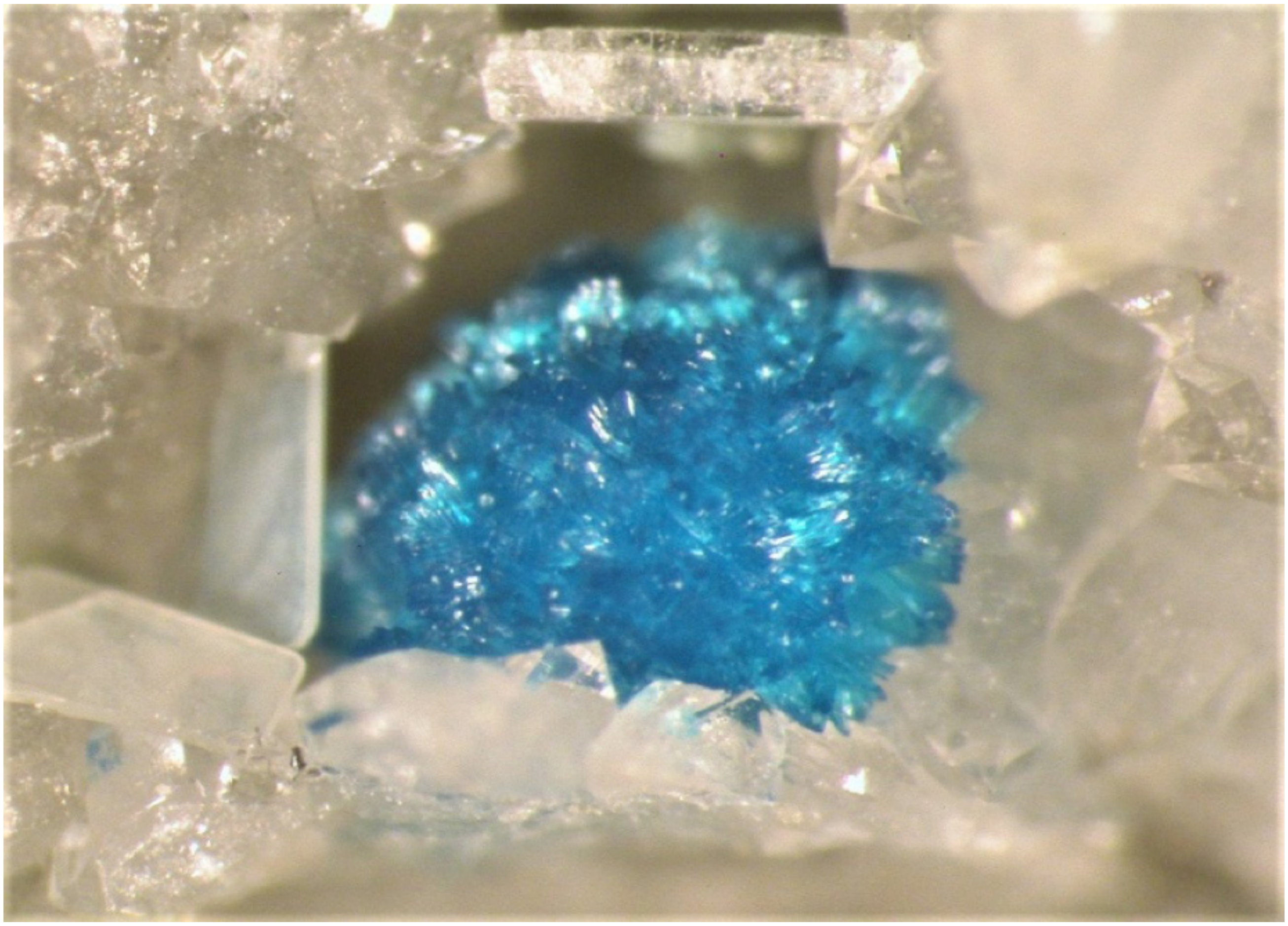
Lindgren, W., Graton, L.C., and Gordon, C.H. 1910. *Ore Deposits of New Mexico*. U.S. Geological Survey Professional Paper 68.

Phil Simmons has been collecting minerals as long as he can remember. He started collecting at age 3 and has never looked back, 31 years later. His first love will always be field collecting in New Mexico, and he has many fond memories of collecting at localities such as the Magdalena district, San Pedro mine, Lincoln County, Blanchard, Cooke's Peak, the Carlsbad Potash district and many, many more. He graduated from New Mexico Institute of Mining and Technology with a Bachelor's degree in Mining Engineering and a Master's degree in Exploration Geology. Since completing his Master's, he has started a full-time mineral business called Enchanted Minerals, LLC that focuses on New Mexico specimen collecting. He is excited to give a talk for the FMCC symposium, and hopes to impart at least a little of his love and enthusiasm for New Mexico minerals to others that enjoy this great hobby.

Secondary Minerals of Ore Deposits in Utah

Brent Thorne

Utah has an abundance of ore deposits. Most of the deposits are located within several geologic uplifts. These uplifts include the Oquirrah mountains, the Wasatch mountains, and the Tintic mountains. The ore deposits are usually associated with a intrusion of Igneous rock in the overlying limestone and dolomite.



Utahite, North Star District, Mammoth, Tintic District, Juab County, Utah. *Brent Thorne photograph*.

The Ophir District in the Oquirrah mountains and the Tintic District in the Tintic mountains have ore deposits with rare and unique secondary minerals. Two mines in the Ophir District and four mines in the Tintic District are of interest.

The two mines in the Ophir district are the Ophir Hill consolidated mine in Ophir canyon, and the Hidden Treasure mine in Dry canyon. Both mines are lead, zinc mines with minor trace elements. Of interest in the Ophir Hill mine is the minor element of tungsten. In the Hidden Treasure mine the minor element of interest is cadmium.

The four mines in the Tintic District are the Centennial Eureka mine, the Gold Chain mine, the North Star mine, and the Trixie mine. All the mines in the district were copper, lead and gold mines with minor silver, zinc, and bismuth. Tellurium minerals are also present.

The secondary minerals of the Ophir Hill Consolidated mine are mostly copper and zinc carbonates and sulfates with the exception of two tungstates. The secondary minerals include: azurite, aurichalcite, bronchantite, carbonatecyanotrichite, ophirite, orthoserpierite, scheelite, and spangolite.

The secondary minerals of the Hidden Treasure mine are also copper and zinc carbonates and sulfates with cadmium in the structure of one mineral. The secondary minerals include: anglesite, aurichalcite, brochantite, ktenasite, namuite, niedermayerite, orthoserpierite, and serpierite.

The secondary minerals of the Centennial Eureka mine, in the Tintic District, are mostly copper, lead and zinc arsenates with some rare tellurites and tellurates. The secondary minerals include: arsengoyazite, cesbronite, dugganite, eurekadumpite, jensenite, juabite, leisingite, utahite, xocomecatlite, and zemannite.

The secondary minerals of the Gold Chain mine are copper arsenates and tellurites. Included are: dugganite, eurekadumpite, juabite, juanitatite, macalpineite, richelsdorfite, and tyrolite.

The secondary minerals of the North Star mine include several tellurites and tellurates. These are: dugganite, eurekadumpite, leisingite, pararaisaite, quetzalcoatlite, teineite, utahite, and zemannite.

The secondary minerals of the Trixie mine include: dugganite, eurekadumpite, graemite, paratellurite, teineite, and tellurite.

Brent Thorne is a retired clinical pharmacist, mineral collector of rare species, and locality suites. He is a frequent contributor to mindat.org with over 3,800 photographs posted on the website and an avid field collector who has discovered or co-discovered fifteen new mineral species.

Rare-Earth Elements in Uraninite – Breccia Pipe Uranium District Northern Arizona, USA

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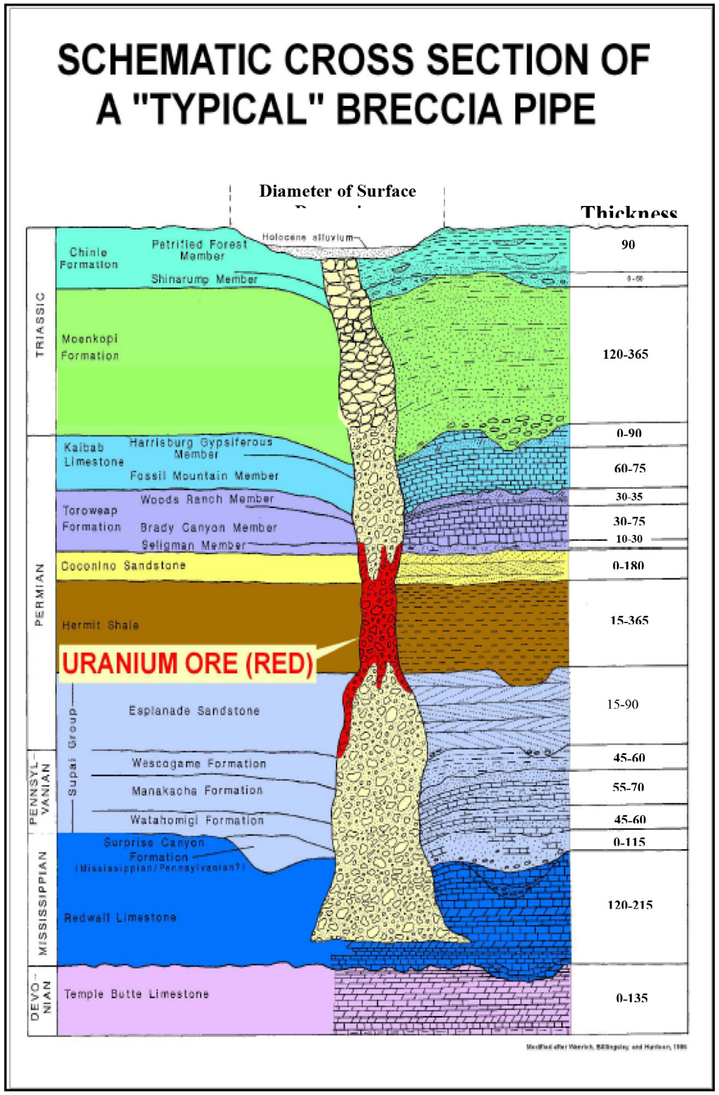
INTRODUCTION

Interest in rare earth minerals originated in 1883 with the development of incandescent gas mantles containing rare earth and zirconium oxides. The knowledge that the supply of REE will not be able to keep up with new and ever growing demands has been no secret in the geological community for years. However, it was not until it was presented to congress as a “potential shortage that could impact US renewable energy sources, communications and defense industries” that politicians and the public tumbled to how critical these metals are, and just how vulnerable the US currently is to supply disruption. In 2008 China produced 97% of the worlds REE (primarily from Bayan Obo), India 2.2%, Brazil 0.5% and Malaysia 0.3%. Up until 2002 the Mountain Pass REE Mine in California produced about 5% of the world’s REE supply. China’s lock on the world’s supply will be difficult to break. Starting in 2005, China put export taxes on REE of 15-20% and put on export restrictions. Forecasts predicted a critical shortage for the rest of the world outside of China by as early as 2012. Consequently, REE prices went up. Just as the Mountain Pass Mine was getting ready to go into production in 2012, China eased their export restrictions and the price of most of the REE plummeted downward. Three years later, in 2015 Mountain Pass mine went into bankruptcy.

REEs were extracted as a by-product of uranium mining in Canada during 1966-1970 and 1973-1977 at Elliott Lake and the Blind River deposits. The ore mineral, uraninite, contained sufficient REEs to make extraction of REE profitable from the raffinate fluids. From 1966 to 1970, uranium mines in the Elliot Lake district were the world’s major source of yttrium concentrate. All REEs except promethium have been detected in these ores. The Elliot Lake ores also contains about 0.11% uranium oxide (U_3O_8), and 0.028% REE oxides (Cranstone, 1981). The economic appeal of this occurrence is that the REE are concentrated in the uraninite, which was already being concentrated from the ore, so the REE are a bonus. “For a short period of time, HREEs were extracted from the raffinate fluids that emanated from the chemical processing of uraninite at Blind River, Ontario.” (Mariano et al., 2010). Since REEs are significantly concentrated within the uraninite from breccia pipes in northern Arizona, they likewise could be extracted from northern Arizona uraninite.

POLYMETALLIC NORTHERN ARIZONA BRECCIA PIPE DISTRICT

A unique polymetallic-rich uranium, solution-collapse breccia-pipe district lies beneath the plateaus and in the canyons of northwestern Arizona. It is known for its large reserves of high-grade uranium (average grade of 0.65% U_3O_8 – Wenrich and Titley, 2009) that were estimated by the US Geological Survey (USGS) to comprise over 40% of the USA’s domestic uranium resources (Finch et al., 1990). The breccia pipe uraninite contains REE enrichment similar to that of the Athabasca Basin uranium deposits in Canada, and their genesis is also associated with highly saline basinal brines. From 1980’s until about 2004, the price of most metals had been sufficiently depressed, such that little was done to explore or study the polymetallic ores, particularly the REEs, that are rich in the district’s uranium deposits. Since 2008, the price of most REEs has increased over 10-fold. This is true of all energy critical elements, including Co and Cu, also heavily enriched in the breccia pipe



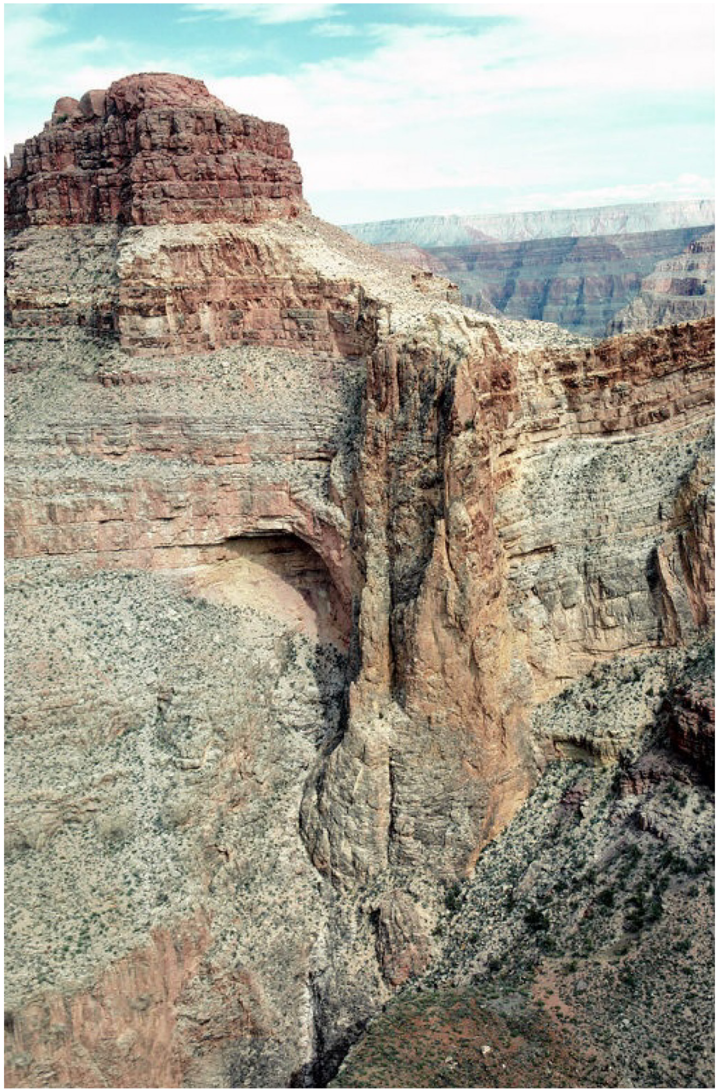


Figure 2a. Schematic cross section of a breccia pipe. The unit thickness shown for the Triassic Chinle and Moenkopi Formations represent their thickness range throughout the Grand Canyon region. Thicknesses for the upper Paleozoic strata correspond to the average unit thickness within the Coconino Plateau of the eastern Hualapai Indian Reservation. Uranium Ore in Red. Wenrich & Titley, 2008. **Figure 2b.** The Bat Cave Breccia Pipe is eroded and well-exposed along the canyon wall. It is about 200 feet in diameter and extends over 600 feet in elevation from the Redwall Limestone to the Esplanade Sandstone before its top is truncated by erosion. The pipe was formed by solution collapse of overlying sandstone shale and limestone into a cavern within the Redwall Limestone. This collapse process left a cylindrical column of broken rock above the cavern. Photo by Karen Wenrich.

ore. However, since 2011, REE prices have fallen. These important elements commonly comprise over 1% of the breccia pipe ore.

The northern Arizona metallic district can be thought of as a paleo-karst terrain, pock-marked with sink holes, where in this case most “holes” represent a collapse feature that has bottomed out over 3000 ft (850 m) below the surface in the underlying Mississippian Redwall Limestone. These breccia pipes are vertical pipes that formed when the Paleozoic layers of sandstone, shale and limestone collapsed downward into underlying caverns. A typical pipe is only approximately 300 ft (90 m) in diameter and extends upward as high in the stratigraphic column as the Triassic Chinle Formation. Although each breccia pipe in itself is not a huge ore deposit – up to 10 million lbs (4500 tU) of uranium per pipe – in total the resources in the district are enormous. Many of the various small, mineralized pipes are clustered together providing somewhat contiguous mineralization, which reduces the mining costs. The water table is deep below the orebodies, which lie at depths of 500-1600 ft (150-450 m) below the surface, sufficiently above the water table to minimize any potential contamination of the aquifer.

Mining activity in the Grand Canyon breccia pipes began during the nineteenth century, although at that time mining was primarily for copper, with minor production of silver, lead, and zinc. It was not until 1951 that uranium was first recognized in the breccia pipes. The intrinsic geology of these pipes, together with growing understanding of the nature of telethermal ores, (a classification category to which the base-metal deposits of the pipes belong), are important components in modeling their genesis. The metallized pipes are base-metal bearing and, regionally, bear a slightly later metal overprint of uraninite. A model was proposed for genesis of these ores as members of the class of Mississippi Valley Type (MVT) deposits, but with late stage uranium mineralization (Wenrich & Titley, 2008). U-Pb age determinations on uraninite gave ages of 200 and 260 Ma (Ludwig and Simmons, 1992) link the mineralization with Pangean time, events, and mid-continent MVT ores. Chemistry and fluid inclusion temperatures on sphalerite and dolomite of 80°-173° also link them with MVT deposits (Wenrich & Titley, 2008). Mixing of oxidizing groundwaters from overlying sandstones with reducing brines that had entered the pipes due to dewatering of the Mississippian limestone created the uranium deposits. Proximity to the west of the Cordilleran miogeocline and various uplifts to the east allow consideration of a basin-dewatering mechanism as the genetic mechanism (Wenrich & Titley, 2008).

REEs IN BRECCIA PIPE URANINITE

REEs are significantly enriched in much of the breccia pipe ore. Whole-rock analyses of uranium ore-bearing rock from across the district show REE enrichment that is not uncommonly 20 times average crustal abundance. A study of REE occurrence within uraninite was undertaken at the facilities of CREGU-GeoRessources, Lorraine University, Nancy, France using Laser Ablation ICPMS in conjunction with electron microprobe analyses of the uraninite (Lach et al., 2013). This research has confirmed that a significant percentage of the bulk rock REE content is tied up in the uraninite crystal structure (Table 1). Although the breccia pipe bulk rock REE content is not as enriched as in the carbonatites at Mountain Pass, CA, the breccia pipe uraninite contains concentrations of Nd that are, for example, around 15-20% of the Nd concentrations in the bastnaesite of Mountain Pass. Considering that at Mountain Pass the bastnaesite (REE ore mineral) has to be mined strictly for REE, the uraninite in the breccia pipes is already processed for the uranium. Hence, the Nd and other REE collected from the raffinate fluids are an added value to the profit. Additionally, the more valuable heavy REEs (HREEs) are enriched in the uraninite, whereas

	Bastnaesite Mountain Pass, CA (Calculated from Castor, S.B., 2008 into ppm metal in Bastnaesite)	**Bastnaesite** Bayan Obo, China 8B7 (Chao et al., 1997)	**Uraninite** Kanab North Breccia Pipe 452-F3-C887 (Wenrich et al., this publication)	**Uraninite** Sage Breccia Pipe Ore, AZ SA-22-1543 (Wenrich et al., this publication)	**Uraninite** Pinenut Breccia Pipe Mine, AZ A1 (Wenrich et al., this publication)	**Uraninite** McArthur River Deposit, Athabasca Basin H393-134.6 (Bonhoure et al. 2007)	**Uraninite** Shea Creek Deposit, Athabasca Basin 100-1, 759.2 (Bonhoure et al. 2007)	**Uraninite** Eagle Point Deposit, Athabasca Basin 90-20_2 (Mercadier et al. 2010)	**Average** Crustal Abundance
La	176400	195400	91	52	24	177	41	947	35.0
Ce	247185	333900	260	409	638	282	322	2070	65.0
Pr	20880	33070	31	127	208	53	205	2410	9.1
Nd	58513	90280	123	922	1188	167	1307	1958	37.0
Sm	4488	n.d.	24	588	397	141	694	2871	7.0
Eu	555	n.d.	8	189	124	134	231	1062	2.0
Gd	1116	n.d.	42	837	415	n.d.	n.d.	2431	6.4
Tb*	83	n.d.	7	120	59	n.d.	231	5721	1.1
Dy	181	n.d.	50	583	317	1161	1269	6450	5.8
Ho*	21	n.d.	11	90	47	n.d.	225	3931	1.3
Er*	32	n.d.	33	201	108	327	393	3332	3.9
Tm*	11	n.d.	4	19	12	n.d.	60	3110	0.5
Yb	11	n.d.	28	104	74	198	252	3165	3.1
Lu*	trace	n.d.	4	12	7	20	16	2238	0.5
Y	627	n.d.	346	2425	928	4240	7795	n.d.	30.0
LREE La-Eu	508021	n.d.	1747	2287	2579	955	2799	11318	
HREE Gd-Lu	1455	n.d.	1497	1966	1039	1706	2446	30378	

Table 1. Rare Earth Element analyses of uraninite from breccia pipe ores and Athabasca Basin ores compared with REE analyses from the two world class deposits, Mountain Pass and Bayan Obo, China. All samples in the table are REE concentrations in either uraninite or bastnaesite except for Bayan Obo where the REE is a whole rock composition.

the Mountain Pass CA and Bayan Obo, China ore deposit contain essentially little significant HREEs (Table 1).

REE PRIMARY & REMOBILIZED ORE-DEPOSIT SIGNATURES

Distinctive REE signature in uranium oxides is directly related to the variability of the mineralizing processes and geological setting between uranium deposit types (Mercadier et al., 2011). All the uranium oxides from unconformity related deposits, such as the Eastern Alligator district in Australia and Athabasca Basin district in Canada, are characterized by a bell-shaped REE pattern centered on dysprosium. This type of pattern seems to be characteristic of uranium oxide primary ore deposited from high salinity basinal brines. The Sage and Pinenut breccia pipes of northern Arizona have bell-shaped chondrite-normalized plots that are remarkably similar to the Athabasca Basin McArthur River (which currently produces 25% of the world's uranium) and Shea Creek uraninites (Bonhoure et al., 2007) (fig. 2B), with a normalized maximum centered on Sm-Eu-Gd. Interestingly, the Pinenut breccia pipe with its bell-shaped REE pattern is the oldest at, 260 Ma (Ludwig & Simmons, 1992) of those that were part of this study, suggesting it is primary ore (no age determination was completed on the Sage orebody by Ludwig & Simmons).

The REE element patterns of uraninite samples from three of the breccia pipe uranium mines (Pigeon, Kanab N, and Hack 2) have chondrite-normalized distributions that show some fractionation and a negative Eu anomaly. They distinctly resemble chondrite-normalized plots of uraninite samples (Mercadier et al., 2010) from the Athabasca Basin's Eagle Point deposit, but with overall lower REE content. The rocks from both the 3 breccia pipe orebodies and from Eagle Point show striking oxidation-reduction fronts within some of the ore (figs 1a & b). Such samples correspond to uranium oxides that are remobilized by oxidized meteoric fluids. These fluids mobilized the LREEs preferentially over the HREEs. Therefore, the uranium oxides from the redox front are characterized by LREE enrichment, which differ from the primary ores (figs 2), and clearly demonstrate their distinct conditions of formation from the primary ore (Mercadier et al., 2011). The HREE part of the chondrite-normalized distribution is preserved. The negative Eu anomaly of these samples could possibly be a result of oxidizing meteoric fluids albitizing the detrital feldspars in the clastic host rocks, permitting preferential incorporation of Eu over the other REEs, into the albite structure (similar to magmatic plagioclase creating a negative Eu anomaly).

The three uraninite orebodies (Pigeon, Kanab N, and Hack 2) that are more highly fractionated are younger, with ages of 200 Ma (Ludwig & Simmons, 1992), than the Pinenut 260 Ma ore with a bell-shaped REE pattern. All of the breccia pipe orebodies are believed to have formed due to a mixing of high salinity basinal brines (based on fluid inclusion results) and oxidizing ground waters (Wenrich & Titley, 2008). Hence, the primary ore, breccia pipe uraninite samples fit the same REE chondrite-normalized pattern as do uraninites from the primary uranium deposits of McArthur River and Shea Creek. Interestingly, the Pigeon, Kanab N, and Hack 2 mines all lie along a N45°E trend that is parallel to one of the two major fracture directions in northern Arizona. Consequently, they may have been more open to oxidizing ground waters than the Pinenut and Sage orebodies. More samples from each mine and from other uraninite deposits within the district will provide insight into the fluids containing the REEs However, the pipe in pipe structure in many breccia pipes proves secondary dissolution. It is quite possible that all of the breccia pipe orebodies have an older primary ore preserved and a later secondary oxidation/reduction front ore. The primary ore would be a higher U and REE grade.

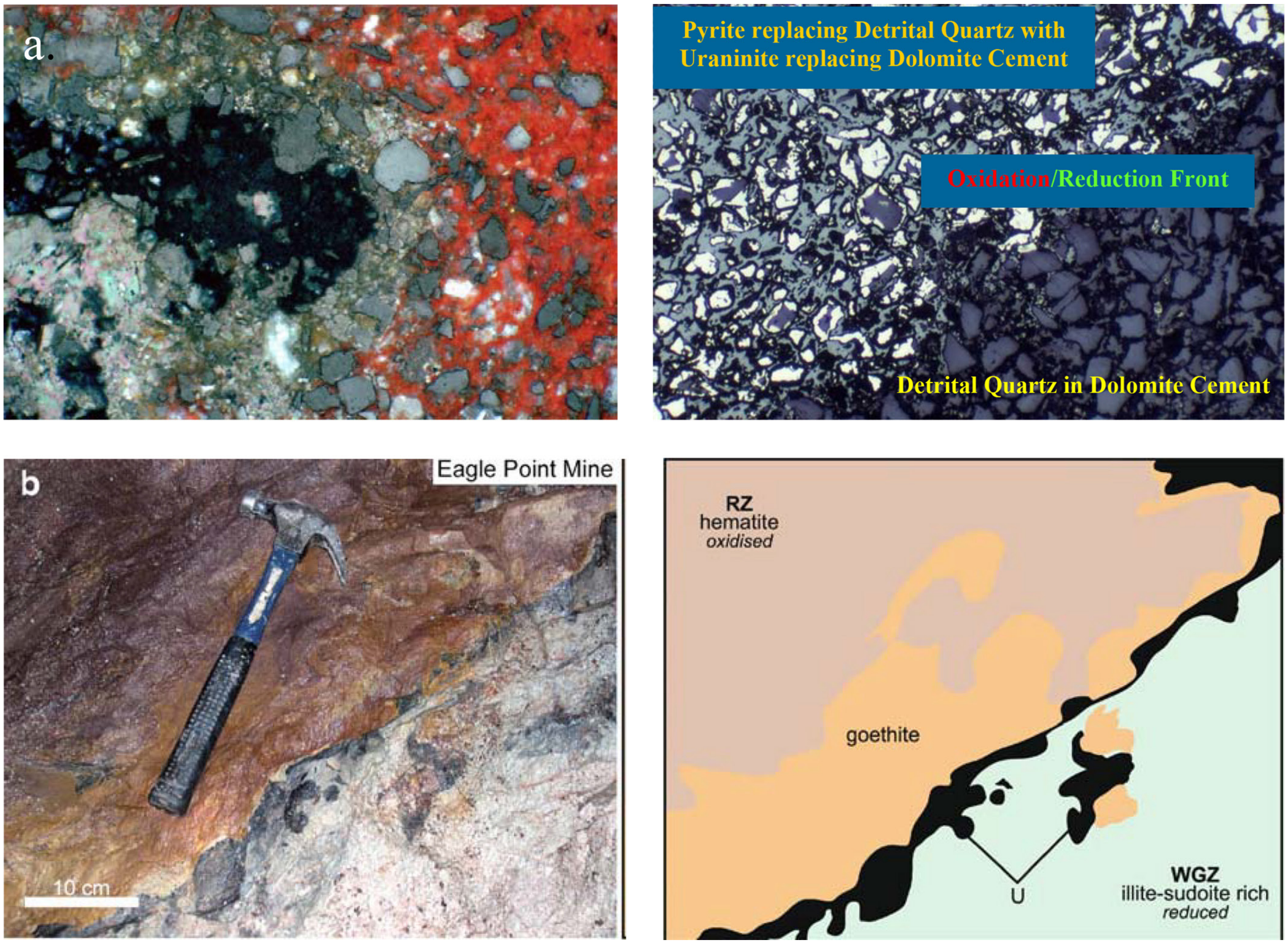


Figure 1. a. Photomicrograph of a uranium redox front at the Pigeon Mine breccia pipe, Arizona (Wenrich & Titley, 2008). **b.** Close-up of a typical uranium redox front in the Eagle Point mine, Athabasca Basin, Canada with hematite-rich oxidized red zone (RZ), goethite-rich uranium front (U)and the previously altered reduced white-green zone (WGZ). Mercadier et al., 2010.

BRECCIA PIPE URANIUM & REE RESOURCE ESTIMATES

The northern Arizona breccia pipe district contains the highest-grade uranium in the U.S. with the potential for reserves that greatly exceed any other province in the U.S. With an average grade of 0.65% U_3O_8, and an environment conducive to relatively low cost conventional mining, these deposits are still economic in the $45/lb cost category (Don Pillmore, oral commun., 2013). Unfortunately, in 2011, President Obama chose to issue an executive order withdrawing the million acres of northern Arizona land that encompassed most of the mineralized breccia pipes in the district. With the current emphasis by President Trump on strategic metals, which includes uranium and REE, these lands may be reopened to mineral exploration. Multiple approaches to uranium resource calculations by separate researchers have shown remarkably similar results. These can be summarized as follows:

1. A uranium resource estimate (referred to as resource endowment) based on industry drilling over the 1050 mi^2 (2719 km2) “mineralized corridor” of the breccia pipe district have been made by Spiering and Hillard, 2013, who defined a “mineralized corridor” within the Breccia Pipe uranium district where they believe most of the mineralized pipes lie. It provides a smaller focused area to work with where more data are available. However, these authors still believe that considerable mineralized rock abounds beyond this corridor on private and public lands (the NE quadrant of the Hualapai Reservation is an example). Spierling and Hillard, 2013 calculated the uranium resources

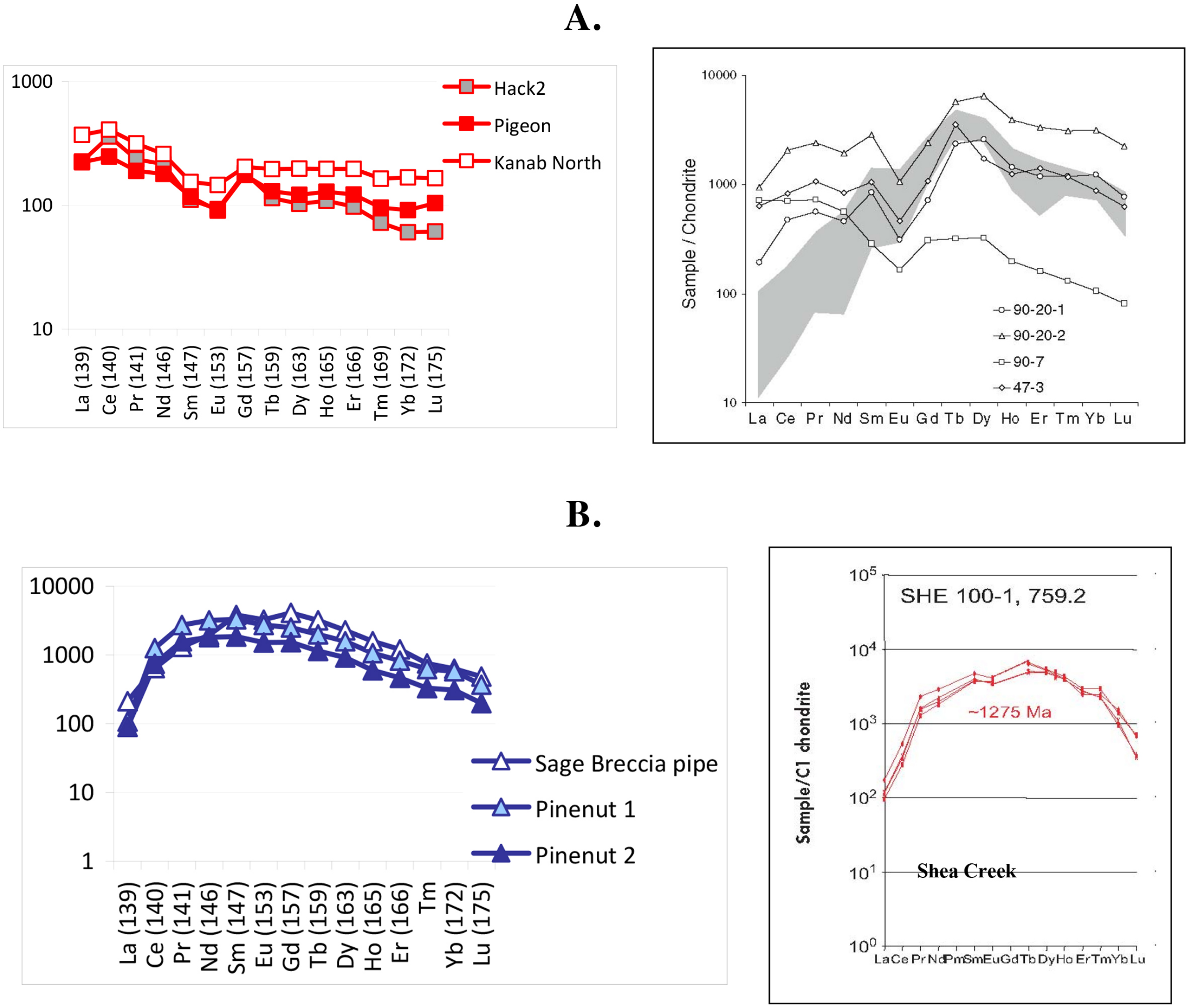


Figure 2. Chondrite-normalized REE patterns for uraninites from northern Arizona breccia pipe uranium ore deposits. **A.** The Hack 2 (643-N-C83), Pigeon (455-VR-C88), and Kanab North (542- F-C87) breccia pipe orebodies show fractionated REE patterns similar to the Eagle Point deposit, particularly sample 90-7 (Mercedier et al., 2011) in the Athabasca Basin. **B.** The Pinenut (A1) and Sage breccia pipe (SA-22-1543) orebodies show bell-shaped patterns similar to the Shea Creek (Bonhoure et al., 2007) Athabasca Basin unconformity uranium deposit. Data for all samples are shown in Table 1.

by (a) using VTEM airborne geophysics results and concluded that the mineralized corridor had 270 million lbs of U_3O_8 (122,500 tU) and (b) using known pipe density and concluded the corridor has 269 million lbs U_3O_8 (122,000 tU).

2. In 1987 the USGS (Finch et al., 1990) calculated the uranium endowment of the entire breccia pipe district. Spiering and Hillard, 2013, show that these calculations when applied to the "mineralized corridor" result in 375 million pounds of U_3O_8 (170,000 tU).

3. Using a control area of detailed surface mapping of solution-collapse features and mineralized rock (Wenrich et al., 1997) on the NE portion of the Hualapai Reservation, the current authors calculated that the "mineralized corridor" contains 260 million pounds of U_3O_8 (118,000 tU) (table 2) and the entire withdrawal area contains 385 million lbs U_3O_8 (175,000 tU) (table 2).

These 3 independent resource estimates average to 302 million pounds of U_3O_8 (137,000 tU). The estimate by Spiering and Hillard and that by Wenrich et al. (Table 2 this report) using completely different types of data within different geographic parts of the district (industry drilling vs detailed surface mapping) have come to remarkably similar resource endowment estimates—270 vs. 260 million lbs of U_3O_8 (118,000 tU versus 122,500 tU).

Yet, the USGS in 2011, within the final environmental impact statement for the breccia-pipe land withdrawal, arrived at a paltry 79 million lbs (36,000 tU)for its resource estimate. However, it appears no use was made of industry drilling (Spiering & Hillard, 2013) nor previous USGS maps (Wenrich et al., 1997) nor extensive resource calculations (Finch and others, 1990), but, rather, a 1987 non-peer reviewed elementary article written for the general public by Wenrich where it was stated that about 8% of collapse features and breccia pipes appeared to be mineralized. However, there were no data provided to support this statement. The USGS estimate contrasts sharply with the other three resource calculations, which are in striking agreement. It appears that the USGS data of 2011 ignored industry drilling and other resource calculations, including their own, which suggests an incomplete and potentially politically biased analysis.

4. A fourth approach is also applicable, which results in an estimate closer to the IAEA's reasonably assured resources (RAR)[1] rather than a resource endowment. Prior to 1989, over 110 9 breccia pipes were drilled; 71 of which were identified as having ore-grade mineralization (Sutphin and Wenrich, 1989). At an average of 2.9 million lbs (1300 tU)of uranium per pipe, the IAEA's RAR or 'indicated reserves' (USGS definition) total 206 million lbs (93,400 tU) of resources in the part of the district covered by Sutphin and Wenrich's map (1989). Of these 71 mineralized pipes, 9 became uranium mines, 27 are known to contain an orebody, and 46 were mineralized but had undergone insufficient drilling to identify an orebody. As the district is known to have very little low-grade mineralization, if a pipe is mineralized with ore-grade mineralization, the odds are high that it contains an orebody. Since 1989, there has been significant exploration for uranium in the northern Arizona breccia-pipe district and more pipes have been located that are known to be mineralized. Hence, this RAR estimate of 206 million lbs (93,400 tU) is probably not an unreasonable one based on the historic drilling undertaken in the district, but low because it only includes drilling prior to 1989, whereas the estimate of Spierling and Hillard (2013) include drilling data up to 2012.

The U.S. Energy Information Administration (EIA), (US Uranium Reserves Estimates, 2008) estimates that at $50/lb uranium the US reserves are 539 million lbs of U_3O_8. They state that the definition of "'reserves' for these estimates …corresponds, in general, to the category of 'Reasonably Assured Resources,' often used in international summaries of uranium reserves and resources…". Comparing the US RAR of 539 million lbs of U_3O_8 (244,000tU) and the RAR calculated above in item **4** to be 206 million lbs (93,400 tU), the breccia pipe district contains 38% of the US uranium reserves.

Using the minimum reserve calculation of 206 million lbs of U_3O_8 (93,400 tU) and the maximum endowment of 375 million lbs (170,000 tU), the mineralized corridor contains US $10–18 billion dollars in the US $50/lb uranium cost category and US $21–38 billion dollars in the US $100/lb uranium cost category. REE analyses of breccias-pipe uraninite ore (this study) in France showed the total REE content of the uraninite to be around 0.43%. Hence, between 471,000 lbs (214 tU) and 860,000 lbs (390 t) of LREE and between 405,000 lbs (184 t) and 737,000 lbs (334 t) of HREE could be produced from the breccia-pipe district. The more valuable HREE have a higher concentration in uraninite ores than in bastnaesite ores from the Bayan Obo and Mountain Pass districts. The value added by REE ($3.10/lb of U_3O_8) to the uranium ore would be between US

$639 million dollars and US $1.2 billion dollars (based on 2011 REE prices). The REEs, a strategic component needed for energy and industrial technology, coupled with the US $10–38 billion dollars of uranium, is a significant amount of money and energy reserves to lose from the US economy due to a land withdrawal scheme that has essentially no significant scientific or environmental basis, as shown in the final Environmental Impact Statement analysis. These monetary estimates do not include any value added components attributable to other metals that are significantly enriched (many reaching and exceeding 1%) in the breccia-pipe polymetallic ore. These metals include Ag, Co, Cu, Mo, Ni, Pb, V and Zn (Wenrich and Titley, 2008).[4]

CONCLUSIONS

Rare earth elements are significantly enriched in much of the breccia pipe ores. A study of REE within uraninite has confirmed that a significant percentage of the whole rock REE content is tied up in the uraninite crystal structure.

All the uranium oxides from unconformity related primary ore deposits from the Eastern Alligator district in Australia and Athabasca Basin district in Canada are characterized by a bell-shaped REE pattern centered on dysprosium. The Arizona Sage and Pinenut breccia pipes have bell-shaped chondrite-normalized plots that are remarkably similar to the Athabasca Basin's McArthur River and Shea Creek uraninites. The Pinenut breccia pipe, with its bell-shaped REE pattern, is the oldest, at 260 Ma (Ludwig & Simmons, 1992), in the district suggesting it is primary ore. The REE patterns of uraninite from Pigeon, Kanab N, and Hack 2 breccia pipes (age of 200 Ma) have chondrite-normalized distributions that show some fractionation and a negative Eu anomaly, similar to the Athabasca Basin's Eagle Point uranium deposit. The rocks from both these three breccia pipe orebodies and the Eagle Point uranium deposit show oxidation-reduction fronts within some of the ore, suggesting remobilization by oxidized meteoric fluids.

Multiple approaches to uranium resource calculations have been made by separate scientists: (1) Uranium resource estimates based on industry drilling within the 1050 mi^2 (2720 km^2) "mineralized corridor" have been made by Spiering and Hillard, 2013, to be 270 million pounds of U_3O_8 (122,000 tU). (2) In 1987 the USGS (Finch et al., 1990) calculated the uranium endowment of the entire breccia pipe district. Spiering and Hillard, 2013, show that these calculations when applied to the "mineralized corridor" give resources of 375 million lbs of U_3O_8 (170,000 tU). (3) A resource estimate (part of this study - Table 2) using detailed surface mapping of breccia pipes and mineralized rock (Wenrich et al., 1997) on the NE portion of the Hualapai Indian Reservation, showed that the "mineralized corridor" contains 260 million pounds of U_3O_8 (118,000 tU) and the entire withdrawal area 385 million lbs (175,000 tU). Uraninite analyses (this study) show the total REE content of the uraninite to be 0.43%. Hence, using the average uranium resource (302 million lbs U_3O_8 - 137,000 tU) of the above 3 estimates, 1.3 million lbs (590 t) of REE could be produced from the breccia pipe district "mineralized corridor", adding REE value to the uraninite of $936 million. Between 28% and 48% of the REE production would be the more valuable HREEs. The US is missing an opportunity to achieve some REE and other strategic metal independence by allowing the breccia-pipe uranium district to remain as withdrawn land from mineral entry.

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[4] Reasonably Assured Resources RAR) are defined by the IAEA as "uranium that occurs in known mineral deposits of delineated size, grade, and configuration such that the quantities which could be recovered within the given production cost ranges with currently proven mining and processing technology, can be specified."

Table 2. Methodology for calculating breccia pipe uranium resource endowment using mapped breccia pipe density

1. **Known Data with mapped breccia pipe density:**

Wenrich, K.J., Billingsley, G.H., and Huntoon, P.W., 1997, Breccia-pipe and geologic map of the northeastern part of the Hualapai Indian Reservation and vicinity northwestern Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-2440, 19 p., 2 plates (includes fifteen 7-1/2 minute quadrangles), scale 1:48,000.

Publication synopsis: Map[3] was the culmination of 10 years of mapping that (1) began from aerial photographs, (2) every circular feature mapped from the photos was flown over with a helicopter, and (3) every one appearing to be a potential collapse structure was field checked and its circumference mapped, and (4) each collapse feature on map was ground checked for anomalous radioactivity and any surface exposure of metal-bearing minerals. This detailed mapping of collapse features/breccia pipes was only done on the 536 mi^2. of the Hualapai Reservation on this 870 mi^2 map. So only the Hualapai Reservation portion of the map provides reasonably comprehensive surface field mapping of all exposed solution-collapse features.

Data from Hualapai Reservation Portion of Map

347 collapse features/breccia pipes

45 mineralized features (mineralized defined in publication as gamma radiation >2.5x background and/or exposed base-metal minerals).

536 mi^2 = area containing collapse features/breccia pipes

2. **Calculations:**

a. **13% are mineralized:** [45/347 = 13%]

b. **0.647 collapse features/breccia pipes per mi^2:** [347/536 mi^2]

c.[1] **0.08392 mineralized breccia pipes per mi^2:** [0.647x13%]

d. **132.6 mineralized breccia pipes in the 1 million acre land withdrawal[2]:** [0.08392 x 1580mi^2]

e. **23.2 million lbs U_3O_8 in 8 breccia pipes that have been mined: Wenrich & Titley, 2008**

f. **2.9 million lbs U_3O_8 per pipe:** 23.2/8.

g. **385 million lbs U_3O_8 in 1 million acre withdrawal (1590 mi^2):** 2.9 x 132.6 **(or 260 million lbs U_3O_8 within the 1050 mi^2 "mineralized corridor").**

Footnotes;

1. Although all collapse features are not breccia pipes, those showing surface expressions of mineralization are most likely breccia pipes. Few exceptions to this have been observed.

2. Although the area containing mineralized breccia pipes is several times greater than 1 million acres, the area of the land withdrawal probably contains the greatest density of mineralized pipes and has been referred to by Spiering & Hillard, 2013 as the "mineralized corridor".

3. The other 3 quadrants of the Hualapai Reservation are not part of or representative of the "mineralized corridor". The NE part of the Hualapai Reservation is.

REFERENCES CITED

Bonhoure, Jessica, Kister, Philippe, Cuney, Michel, and Deloule, Etienne, 2007, Methodology for Rare Earth Element Determinations of Uranium Oxides by Ion Microprobe: International Association of Geoanalysts Geostandards and Geoanalytical research, v. 31, n. 3, pp. 209-225

Castor, S.B., 2008, The Mountain Pass rare-earth carbonatite and associated ultrapotassic rocks, California: The Canadian Mineralogist, v. 464, pp.779-806.

Chao, E.C.T., Back, J.M., Minkin, J.A., Tatsumoto, M,. Junwen, Wang, Conrad, J.E., McKee, E.H., Zonglin, Hou, Qingrun, Meng, Shengguang, Huang, 1997, The sedimentary carbonate-hosted giant Bayan obo REE-FE-Nb ore deposit of Inner Mongolia, China: A cornerstone example for giant polymetallic ore deposits of hydrothermal origin. U.S. Geol. Surv Bull 2143, 76 pp.

Cranstone, D.A., 1981 Rare earths. Can. Miner. Yearb., 1979, pp. 365–371

Finch, W.I., Sutphin, H.B., Pierson, C.T., McCammon, R.B., and Wenrich, K.J., 1990, The 1987 estimate of undiscovered uranium endowment in solution-collapse breccia pipes in the Grand Canyon region of northern Arizona and adjacent Utah: U.S. Geol Survey Circular 1051, 19 p.

Lach, Philippe., 2012, Signature géochimique des terres rares dans les oxydes d'uranium et minéraux associés dans les gisements d'uranium : analyse par ablation laser couplée à l'ICP-MS et étude géochronologique, PhD thesis, Université de Lorraine, 298 p.

Lach, P., Mercadier, J., Dubessy, J., Cuney, M., Boiron, M.C. 2013, Improved in-situ quantitative measurements of rare earth elements in uranium oxides by Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry. Geostandards and Geoanalytical Research, on line.

Ludwig, K.R., and Simmons, K.R., 1992, U-Pb dating of uranium deposits in collapse breccia pipes of the Grand Canyon region: Economic Geology, v. 87, pp. 1747-1765.

Mariano, A.N.,Hedrick, J., and Cox, C., 2010, REE deposits on a world level – real and potential: Part I: SME Technical Program Abstracts, March 2010, p. 87.

Mercadier, Julian, Annesley, I.R., McKechnie, C.L., Bogdan, T.S., and Creighton, S., 2013, Magmatic and metamorphic uraninite mineralization in the western margin of the Trans-Hudson Orogen (Saskatchewan, Canada): A uranium source for unconformity-related uranium deposits. Economic Geology, v. 108, n. 5, pp 1037-1065.

Mercadier, Julien, Cuney, Michel, Cathelineu, Lacorde, Mathieu, 2011, U redox fronts and kaolinisation in basement-hosted unconformity-related U ores of the Athabasca Basin (Canada): late U remobilization by meteoric fluids: Miner Deposita, v. 46, pp.105-135.

Mercadier, Julian., Cuney Michel., Lach, P., Boiron, M.C., Bonhoure, J., Richard,A., Leisen, L., Kister, P. 2011, Origin of uranium deposits revealed by their rare earth element signature. Terra Nova, v. 23, p. 264–269.

Spiering, E.D. and Hillard, P.D., 2013, Estimates of the withdrawn uranium endowment of the Arizona Strip District, Northern Arizona: Society of Mining Engineers, 2013 Annual Meeting, Feb 25, 2013.

Sutphin, H.B., and Wenrich, K.J., 1989, Map of locations of collapse-breccia pipes in the Grand Canyon region of Arizona: U.S. Geological Survey Open-File Report 89-550, 1 plate with text, 1:250,000.

Wenrich, K.J., Billingsley, G.H., and Huntoon, P.W., 1997, Breccia-pipe and geologic map of the northeastern part of the Hualapai Indian Reservation and vicinity northwestern Arizona: U.S. Geological Survey Miscellaneous Investigations Map I-2440, 19 p., 2 plates (includes fifteen 7-1/2 minute quadrangles), scale 1:48,000.

Wenrich, K.J. and Titley, S.R., 2008, Uranium exploration in Northern Arizona breccia pipes in the 21st century and consideration of genetic models, in: Titley, S.R. and Spencer, Jon, Ores & Orogenesis: CircumPacific Tectonics, Geologic Evolution, and Ore Deposits: Arizona

Geological Society Digest 22, pp. 295-309.

Yang, K-F., Fan, H-R., Santosh, M., Hu, F-F., Wang, K-Y., 2011, Mesoproterozoic carbonatitic magmatism in the Bayan Obo deposit, Inner Mongolia, North China: Constraints for the mechanism of super accumulation of rare earth elements: Ore Geology Reviews, 10 pp

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Dr. Karen Wenrich graduated from 3 years of high school in Wiesbaden, Germany after spending her childhood being dragged around the U.S. by a father who was a colonel in the Air Force (a hump pilot during WWII, and later a lawyer in the JAG for the Air Force). She lived in Colorado Springs and Reno until she was 6-years old; her dad then piled Karen, her mother, and 3-month-old sister with all their possessions into a 48’ Studebaker and drove up the all-dirt Alcan Highway to Fairbanks, Alaska, where she attended first and second grade in a Quonset hut. Climbing on rocks as a child in the west was a way of life, which undoubtedly stimulated an interest in geology. Her uncle would ask her what she wanted to be when she grew up, and when she would reply “a geologist”, he would say, “You’ll outgrow it”.

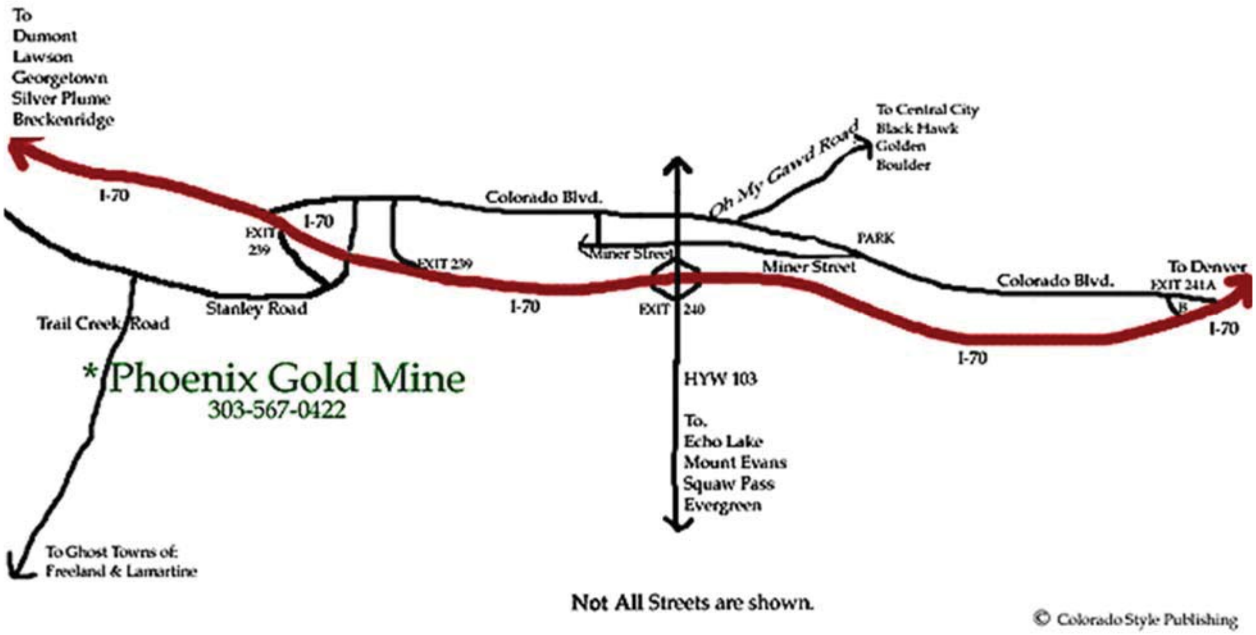
Tired of being uprooted, she set roots down at Penn State on a scholarship, and then a fellowship - she left Penn State with a B.S., M.S., and Ph.D. in geology/volcanology to return to Colorado for a job with the USGS. Karen’s Ph.D. was on “Trace and major element chemistry and the petrogenesis of lavas from the upper portion of Humphrey’s Peak, San Francisco Mountain, Flagstaff, Arizona.” Karen was quickly converted to an economic geologist by the USGS, where she worked for 25 years, which was followed by her present career, consulting for the mining industry. She has published over 175 papers, received several USGS outstanding performance awards and AAPG best paper presentation awards. She is an AIPG certified professional geologist and a fellow in the Society of Economic Geologists. Karen has a worldwide reputation as an expert in the geology and mineralogy of uranium deposits. From 2002-2005, Karen worked with diplomatic status for the International Atomic Energy Agency in Vienna, Austria, as their senior uranium geologist in charge of studying worldwide uranium resources. As an IAEA staff member, she shared in their receipt of the 2005 Nobel Peace Prize: “For their efforts to prevent nuclear energy from being used for military purposes and to ensure that nuclear energy for peaceful purposes is used in the safest possible way.” She has done extensive studies and mapping on the breccia-pipe uranium deposits of northern Arizona and elsewhere. In 2008, 2010, and 2011, Karen testified before the U.S. House Natural Resources Committee about the proposed bill to permanently bar the filing of mining claims on 1.1 million acres of federal lands north and south of the Grand Canyon. These efforts to prevent the bill from passing in congress were successful. However, President Obama subsequently withdrew the land as an executive order. In 2015 Karen married a Penn State geology classmate, Linton (Lenny) Wildrick (a hydrogeologist), who she had known for 45 years.

Phoenix Gold Mine Tour

Idaho Springs
Sunday 2:30pm

Tommyknocker Tour
$10 per person (cash only) – no checks or cc accepted
Optional free gold panning after the tour
(identify yourself as being with CSM Symposium)

Directions: Self Driving. Take I-70 West to the third exit for Idaho Springs, Exit 239 (about 30 minutes from Golden). This will put you on a little frontage road, follow it around the curve to the stop sign. Take a Left at the stop sign (Colorado Blvd.) and another immediately left (under I-70) on to Stanley Road, you will cross Clear Creek River. Go up Stanley Road about a mile and take a left on your first dirt road - Trail Creek Rd. Go up Trail Creek Rd. about a mile.



Lunch Note: If you want to eat lunch in Idaho Springs at Beau Jo's Pizza, you can get 15% off your meal if you mention that you are taking a tour of the Phoenix Gold Mine.**History:** The Phoenix Vein was originally discovered in 1871 by a man with the last name Miner. The original discovery site was located high in the cliffs above the Phoenix Counter of today. It was then sold to a Cornish Miner who was said to have made his fortune off the Phoenix and abandoned the mine. This Cornish miner worked the claim from the Rockford Tunnel located off Stanley Road. When he reached about 1,000 ft. in depth he intersected the Phoenix Vein. The Phoenix Vein was worked by the Cornish Miner until he was able to return home and retire in Cornwall, a very rich man. In the 1930's, a local real estate investor purchased the Phoenix Claim for the amount of back taxes - $20! The real estate investor never worked the claim and sold it to a Mr Gunderson, a farmer from Minnesota in 1934 for $5,000. Mr. Gunderson opened and worked the Phoenix Mine (where today's tour entrance is located). There are 3 levels going to a depth of 500 ft. The mine has been opened down to where the Rockford tunnel intersects the Phoenix vein. **The Phoenix Tour includes a look at the main level of this 1930's work.** Mr. Gunderson was forced to close the mine in 1943, also a very rich man from the ore of the Phoenix vein. The Phoenix and many other Gold and Silver mines would have been closed by the United States Government 1943. Attention was turned to mining the materials needed for war. At the time the United States Government would cover half the cost of recovering war materials, which helped the miners survive during that time. In the 1950's a man by the name of Al Simmons leased the mine from Mr. Gunderson. Taking on two partners, these men swept the gold dust left in the stopes and tunnels and each man made enough money to buy himself a brand-new Cadillac! It was not worked again until Alvin Mosch acquired the property and began his work on it almost 30 years ago.

Also seen on this tour is the tunnels and rooms of the Resurrections Vein. When Al's son was around 14 years old, he discovered the Resurrection vein outcropping above the west side of the Phoenix tour of today. After starting in on new ground near the original 1930 tunnel of the Phoenix, Al's mother located the Resurrection from a point inside the mine. Al's son David named the Vein the Resurrections figuring it was fitting considering the name of the mine. The Resurrection vein was mined through the original Phoenix Tunnel and which led up to the exposure of the High Grade ore found on the Phoenix vein in the deepest part of the main tunnel of the Phoenix Tour. Al never mined the High Grade and has enable many people over the past 20 some years to see just how the ore looks when it is still in the ground. Beyond this point on the tunnel it is much too dangerous and on unstable ground to extend the tour any farther down.

Historical mining tools, ladders, milling equipment, buckets, emergency equipment and much more is on display throughout the tour. You will be able to see Gold, Silver, Copper, Iron Pyrite, and Tellurium still in the earth.

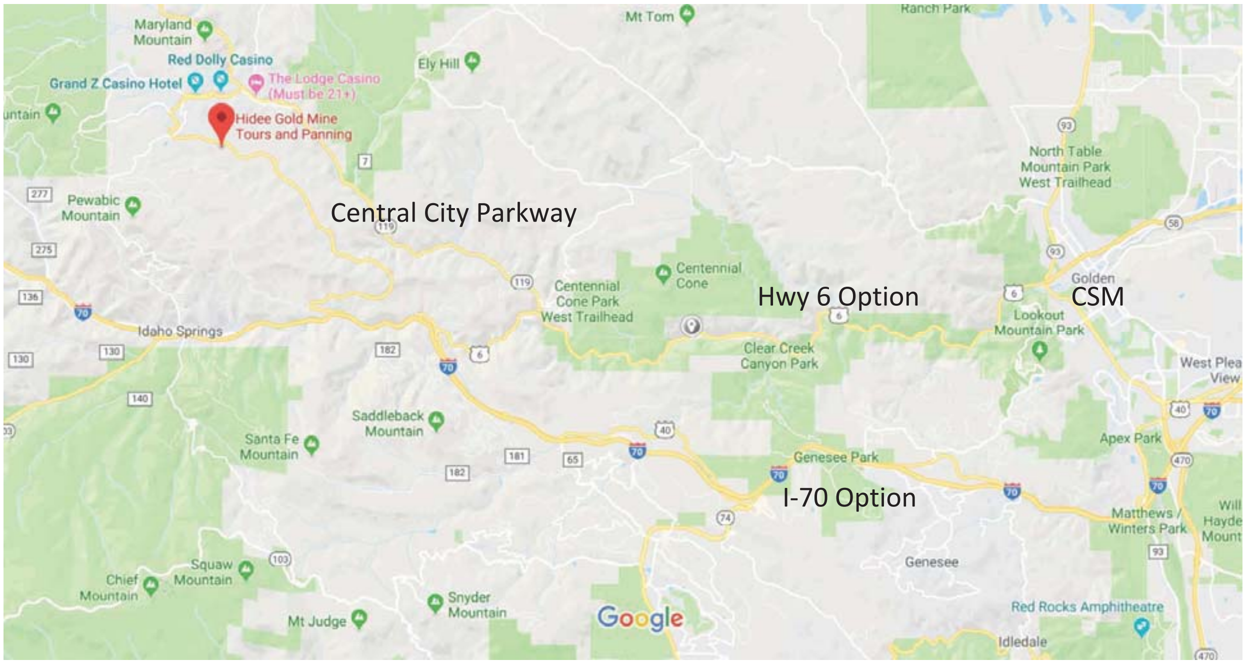
HIDEE GOLD MINE

Hidee Gold Mine Tour
Central City
Sunday 2:30pm

Ticket: $23.95 (cash or charge) – there will be an additional discount if a larger group attends so identify yourself with CSM Symposium

Optional gold panning after tour (additional $5 with tour purchase)

Directions: Self-Driving. Take I-70 West to Hidden Valley/Central City Exit 243 (about 17 miles from Golden). Take Central City Parkway north for 6.3 miles to Hidee Mine Rd. Turn left (west) on Hidee Mine Rd (look for a sign banner at the turn-off). Travel time is approximately 30 minutes to mine from Golden. **Option Route:** Take Hwy 6 west from Golden toward Central City and Blackhawk. At the stoplight, Hwy 6 and Hwy 119 split, take a left to I-70 West. Get on I-70 West and get off at the next exit (Exit 243, Central City Parkway). Follow directions above.



Logistics: This will be a geologic and history tour with knowledgeable tour guides. The Hidee Gold Mine is well lit with an average temperature inside the mine of 45° F, so a light jacket and closed toe shoes are recommended. The accessible workings are on the 135-foot level of an adit driven about 600 feet into the mountainside. The ground is level and the back height (ceiling) is generally above 6-foot tall, so little stooping is required. Visitors to the mine are welcome to try their hand at hard rock mining. You get to use a hammer and chisel to carve out a gold specimen from the 5-foot vertical main gold vein, yours to keep as part of the tour. The tour is approximately 1 hour long.

History: The mine was submitted for patent in 1896 and was first accessed by a shaft atop the ridge. The vein has been worked intermittently from then until present time. In the early 1980's, mine owner Charles "Choppo" Fetterhoff, a long-time miner in the region, decided to re-access the shaft via walk-in adit and give educational tours to grade schools, universities and mineralogists.

Choppo continued to work at the mine with his friend and business partner Ed Lewandowski until 1996 when after a long and colorful career in the mines of Clear Creek and Gilpin County he passed away leaving the operation of the Hidee in the hands of his friend Mr. Lewandowski.

The educational legacy of the Hidee began by "Choppo" in the 1980's continues today as we still give tours, work the vein, and explain the regions geology, mineralogy and history. Ore produced has been valued as high as 7.90 ounces gold, 14.60 ounces silver and 9.60% copper per ton. Assays of mine samples have been as high as 112 ounces gold per ton, 20 ounces silver and 16.5% copper per ton!

The Hidee sits in the heart of the Virginia Canyon - Glory Hole Area, reputed to be the richest square mile on Earth. Specimen quality Pyritic gold ore is the principal product. The mines in this area all told produced more than $5 billion (2012 gold value) in gold and silver since 1859.

The mine is presently being operated by Mark Greaves and Chris Stone of Hidee Gold Mine Tours LLC with the advice and help from their long-time mentor Ed Lewandowski.