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New Mexico EARTH MATTERS

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SMITHSONITE
Think Zinc Ore and More

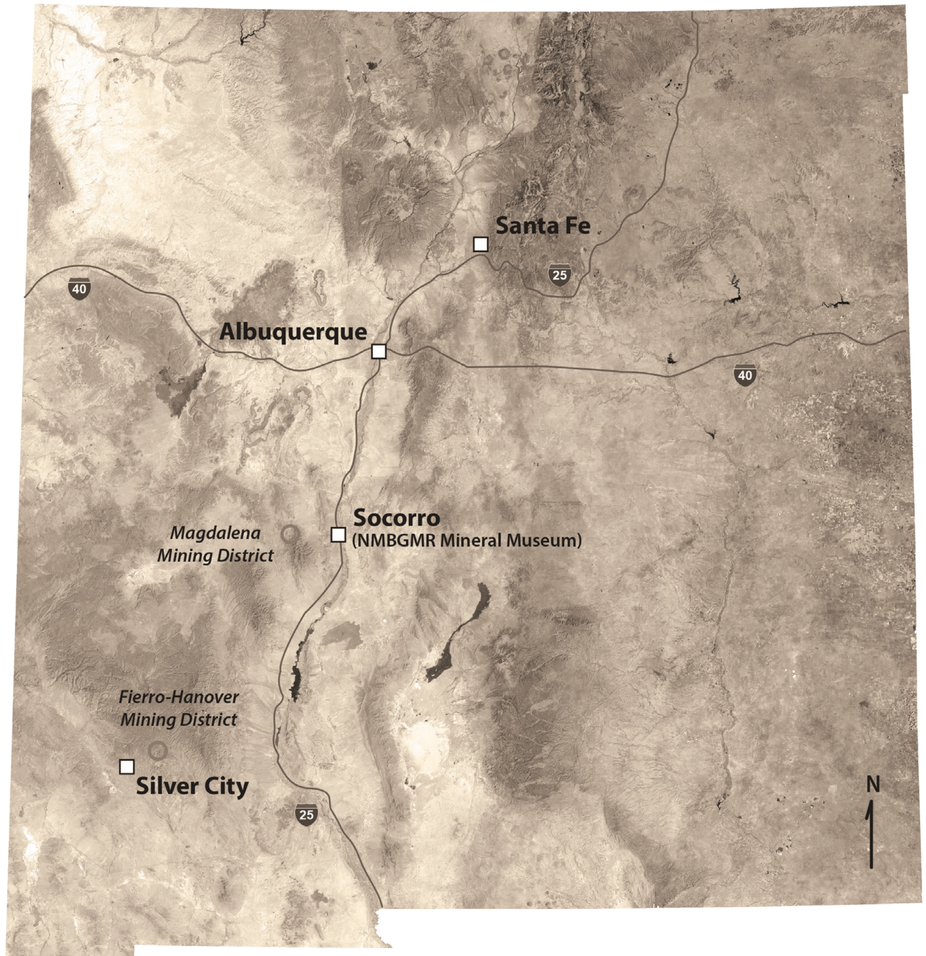
Smithsonite is one of the most beautiful and internationally recognized minerals from New Mexico. Mineral museums around the world seek out New Mexico smithsonite samples to display to their visitors. The mineral occurs in at least 25 mining districts in the state, and historically was an important primary zinc ore in several of New Mexico's largest and most significant zinc deposits, including the Magdalena and Fierro-Hanover mining districts.

Zinc (Zn) has a long history of use. Before it was ever isolated as a pure metal and recognized as a new element, it was unknowingly introduced into metal alloys in early metal production by the addition of zinc-containing ores. Zinc is a necessity for our current lifestyle; in terms of tonnage, it is the fourth most extracted metal resource worldwide after iron (Fe), aluminum (Al), and copper (Cu).

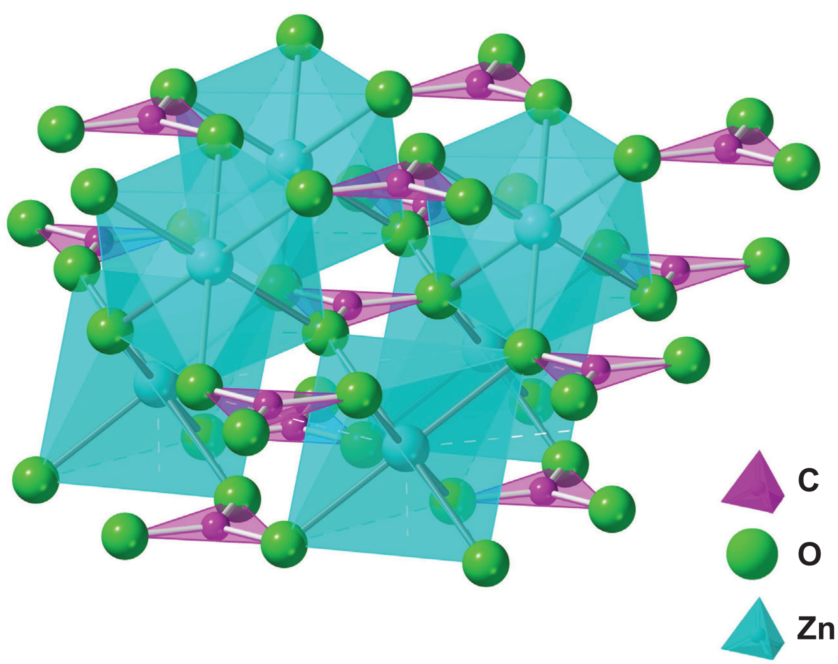
Today, most zinc is used to create a coating on other metals, particularly iron and steel, in a process called galvanizing, which prevents rusting. Galvanized steel is used in many applications where the metal is exposed to variable weather conditions, like in car bodies and bridges. Combined with other metals, zinc is still used to produce important alloys such as brass. Zinc is one of several metals used to create die castings. Since 1982, the United States penny has been manufactured mostly from zinc, with only a coating of copper (composing only 2.5% of the total).

Synthetic zinc oxide (ZnO) has many uses, including as a white pigment in paints, an ultraviolet light absorbent (such as in sunscreen lotion), and a catalyst in the manufacture of many different products (such as hydrogen peroxide). It is found in some rubber, glass, and ceramic products, as well as in paint as a corrosion inhibitor and for mildew control. Zinc is an essential trace element for all living things, and zinc oxide is added to fertilizers (especially in eastern New Mexico, where soils are depleted in zinc), animal feed, and vitamin supplements for this reason. Because of its antibacterial properties, it is also used in many cosmetics, medical products, and toiletries.

Smithsonite, aurichalcite, and goethite, Kelly mine, Magdalena mining district, Socorro County, NM. 7.6 cm (3 in.) tall. NMBGMR Museum #16315. Gift of Roy and Pamela Johnson. One of the New Mexico Bureau of Geology Mineral Museum's signature specimens. *Photo by Jeff Scovil*



The locations of New Mexico's two largest smithsonite-producing districts, the Magdalena and Fierro-Hanover mining districts.



Combined polyhedral and ball-stick schematic of the smithsonite atomic arrangement (i.e., calcite structure type). Spheres represent atoms, sticks represent bonds between atoms, and the transparent surfaces represent polyhedral surfaces, such as the blue octahedra, that describe the geometric arrangement of O atoms around the Zn and C atoms.

Mineralogy

Smithsonite is a zinc carbonate with the composition $Zn(CO_3)$. The Zn is bonded to six oxygen (O) atoms in octahedral coordination. These structural characteristics can be seen by the combined ball-stick (i.e., atom-bond) and polyhedral rendering of smithsonite's structure (below). Several cations (positively charged atoms), such as calcium (Ca), magnesium (Mg), manganese (Mn), iron, cadmium (Cd), cobalt (Co), and nickel (Ni), can substitute to varying degrees for Zn in smithsonite. Pure smithsonite is colorless, but with impurities such as the elements listed above, it can be almost any color of the rainbow. Colors of particular note in New Mexico smithsonite are the vibrant yellows of specimens from the Fierro-Hanover mining district and the blues and blue-greens of the Magdalena mining district. Microscopic inclusions of other minerals, acting as a pigment, can also impart color to smithsonite. The remarkable range of colors of smithsonite is poorly understood and is an active topic of research today to understand how chemistry affects crystal color.

In addition to demonstrating a wide range of colors, smithsonite crystals also exhibit a range of shapes. Well-developed crystals are rare. Examples of crystal clusters that resemble dumbbells or bow ties, resulting from a phenomenon known as crystal splitting, are more common. However, smithsonite is most often found as bubbly looking masses or encrustations, a shape called botryoidal, from the Greek word botrys, meaning "a bunch of grapes." In many instances, it is found replacing other minerals while retaining the shape and texture of those minerals, a phenomenon known as pseudomorphism. In some cases, smithsonite has replaced entire masses of limestone on the scale of many meters. This phenomenon has an important connection to the history of the Magdalena mining district (see p. 4).

Etymology

Historically, smithsonite was one of several zinc minerals that were collectively known as calamine (a term used to describe an ore of zinc). This is where calamine lotion, a topical medicine containing zinc, gets its name. Lapis calaminaris was a name used by Georgius Agricola (the "father of mineralogy") in 1546, and in 1747, Johan Gottschalk Wallerius simplified the term to calamine. James Smithson (1765–1829), a British mineralogist and chemist, was the first to recognize $Zn(CO_3)$ as a distinct mineral. In 1832, natural $Zn(CO_3)$ was named smithsonite by French mineralogist

Steep rhombohedral crystals of pink smithsonite from the Tsumeb mine, Namibia. 4 × 2 × 2.75 cm (1.6 × 0.8 × 1.1 in.). NMBGMR Museum #19303. Gift of Lawrence Grobl. *Photo by John Rakovan*

François Sulpice Beudant in honor of Smithson's contributions to understanding it as a distinct mineral species. After his death, Smithson's estate, as stipulated in his will, was used "to found in Washington, under the name of the Smithsonian Institution, an establishment for the increase and diffusion of knowledge." Thus, Smithson is the eponym for both smithsonite and the Smithsonian Institution. Ironically, Smithson never visited the United States during his lifetime, though today his tomb is in the Smithsonian Castle in Washington, D.C.

Smithsonite Formation, Localities, and Mining in New Mexico

The formation of zinc ore deposits is associated with varied geological and geochemical processes. One common thread is the precipitation (crystallization) of primary ore minerals from hot waters that are laden with dissolved solutes (known as hydrothermal solutions), especially metal cations such as Zn, lead (Pb), silver (Ag), Cu, and Fe. By far, the most important primary ore mineral of zinc is the sulfide mineral sphalerite (ZnS). Here, the Zn is combined with sulfur (S) rather than carbonate, as in smithsonite.

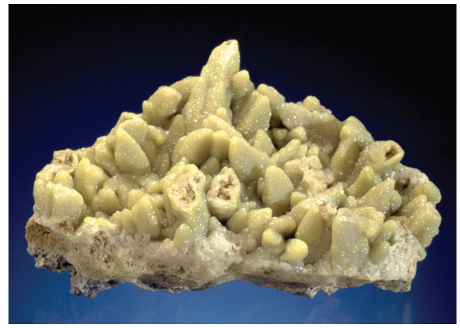
Primary ore minerals, such as sphalerite, can later be transformed or altered by lower-temperature and oxidizing fluids. This leads to the formation of new minerals, called "secondary," which may also be important metal ores. Smithsonite is a widespread secondary mineral derived from the oxidation of sphalerite by groundwaters that descend from above and travel through primary zinc ore deposits. It is particularly common in the oxidized zones of ore deposits that are hosted by limestone or marble, which are carbonate rocks that supply CO_3 in the formation of smithsonite.

The most significant smithsonite-producing deposits in New Mexico, including the Magdalena and Fierro-Hanover mining districts, fall into a class of ore deposits known by several names, including "carbonate replacement deposits." They are associated with igneous intrusions (magmas) that expel hydrothermal waters full of dissolved cations. Near the contact of the magma and surrounding carbonate rocks, a type of metamorphic rock composed mostly of calcium silicate minerals is formed. Farther from the intrusion, hydrothermal solutions partially or completely replace the carbonate minerals with primary ore minerals. Subsequent alteration of

Portrait of James Smithson by Henri-Joseph Johns, 1816. National Portrait Gallery, Smithsonian Institution. *Image from Wikimedia Commons*

Smithsonite with a trigonal dumbbell habit (split crystal), Othello mine, Cookes Peak mining district, Luna County, NM. 5 × 3.8 mm (0.2 × 0.15 in.). NMBGMR Museum #15633. *Photo by John Rakovan*

The C.T. Brown smithsonite, Kelly mine, Magdalena mining district, Socorro County, NM. A massive botryoidal specimen, 61 × 38 × 38 cm (24 × 15 × 15 in.), 34 kg (75 lbs). NMBGMR Museum #793. Another signature specimen of the New Mexico Bureau of Geology Mineral Museum. *Photo by Debra Wilson*



Smithsonite replacing calcite and maintaining the calcite crystal shape (i.e., a pseudomorph), Kelly mine, Magdalena mining district, Socorro County, NM. 8.8 cm (3.5 in.) wide. NMBGMR Museum #911. From the C.T. Brown collection. *Photo by Jeff Scovil*

primary sphalerite led to the formation of smithsonite, often exhibiting pseudomorphic replacements of primary ore minerals and host carbonate rocks.

Today, the Magdalena mining district is most associated with zinc, although it was initially developed for silver-lead ore. The hydrothermal fluids responsible for the formation of the deposits carried Pb, Zn, Cu, Ag, gold (Au), and other solutes into the rocks that host mineralization. Most of the smithsonite in the district is not the beautiful blue variety coveted by collectors but is milky white and almost indistinguishable in hand specimen from the calcite of the original limestone. The replacement preserved the texture of the original limestone, including fine-scale bedding and fossils, in such intricate detail that it went unnoticed for many years. In fact, Asa B. Fitch (manager and lessee of the Graphic mine in the Magdalena mining district), who knew that zinc was present in the sulfide ore component of the deposit, was perplexed by its absence in the secondary oxide mineralization. During early mining in the district, rock thought to be limestone was thrown into the mine dumps as waste until it was discovered that it was actually smithsonite, containing the "missing" zinc that had puzzled Fitch. This discovery is well noted in Fitch's memoirs (ca. 1905). Early on, he had noted the unusual weight of the limestone and had it assayed for Pb, of which it showed no trace. He subsequently forgot about this observation until years later when the question of the missing Zn became important because of its renewed market value. On a hunch, he sent similar samples for zinc determination (ca. 1903). The assay showed that the "limestone" samples contained 37% Zn! This realization in the Magdalena mining district led to the discovery of similar zinc deposits throughout the U.S. Southwest.

Although the smithsonite specimens from the Magdalena mining district are the most notable in New Mexico because of the abundance of specimens with beautiful colors, in terms of total tonnage of ore produced, the Fierro-Hanover area is the largest by far. The Magdalena mining district produced approximately 162,700 tons of zinc carbonate, while Fierro-Hanover produced nearly 1.5 million tons by about 1950. While the best smithsonite specimens from the Magdalena mining district are "Kelly blue" in color, the finest from Fierro-Hanover are bright yellow.

A panoramic view, looking north, of the surface plant, including the headframe (middle background), of the Kelly mine, Socorro County, NM, in 1916. Courtesy of U.S. Geological Survey, New Mexico Bureau of Geology and Mineral Resources, Historical Photograph Archives #1452.

Smithsonite Specimens in the New Mexico Bureau of Geology and Mineral Resources Mineral Museum

In the mineral collecting community, no species is more immediately associated with New Mexico than smithsonite. This recognition is almost solely due to the beautiful blue-to-green hues of specimens from the Kelly and other mines of the Magdalena mining district. In *American Mineral Treasures*, a widely accepted consensus of the 50 most important mineral specimen-producing localities in the United States, the Magdalena mining district was the sole locality included from New Mexico. Likewise, among the very limited number of specimens included in Peter Bancroft's highly respected book, *The World's Finest Minerals and Crystals*, is a botryoidal "Kelly blue" smithsonite from the Kelly mine.

Smithsonite, Empire mine, Fierro-Hanover mining district, Grant County, NM. 17.2 × 15.2 cm (6.8 × 6 in.). NMBGMR Museum #18865. *Photo by John Rakovan*

The mineral collection (then called the mineral cabinet) of the New Mexico School of Mines (today the New Mexico Institute of Mining and Technology, or New Mexico Tech for short) gained world renown by winning a gold medal at the St. Louis World's Fair in 1904. Records from the fair show that of particular note among specimens in this display were the many colorful examples of zinc ore, which were almost certainly smithsonite, from the Magdalena mining district, most notably the Kelly mine. The collection also took the gold medal at the 1915 Panama-California Exposition held in San Diego. Many of these specimens came to the collection through Asa B. Fitch and Coney T. Brown, two very important figures in the development of the Magdalena mining district.

Unfortunately, the many beautiful smithsonites in the School of Mines collection, which helped to clinch the abovementioned gold medals, were lost on July 5, 1928, when a fire burned Old Main Hall—which housed the mineral collection—to the ground. The collection was subsequently rebuilt and, in 1963, was transferred to the New Mexico Bureau of Mines (today the New Mexico Bureau of Geology and Mineral Resources [NMBGMR]), a research and service division of New Mexico Tech and the state geological survey. Today, the New Mexico Bureau of Geology's Mineral Museum has many smithsonite specimens from around the state on display, of which more than a dozen are of the "Kelly blue" type. Two of these have become the museum's signature specimens.

The first specimen of note also came to the museum from C.T. Brown. It would have been lost in the 1928 fire if Brown had not kept it for his personal collection until it was purchased for the museum in 1938, along with the rest of his collection. Known to us as the C.T. Brown smithsonite, NMBGMR Museum #793, it is a 61 × 38 × 38 cm (24 × 15 × 15 in.), 34 kg (75 lbs) specimen. It is one of the best of the larger blue-green Kelly smithsonite specimens preserved and for decades has been considered the signature specimen of the Mineral Museum. Contrary to popular belief, it is not the famed "Blarney Stone" (another, now lost Kelly smithsonite) used during annual St. Patrick's Day ceremonies in the early days at the New Mexico School of Mines.

Another smithsonite, which has more recently reached the status of "signature specimen," is NMBGMR Museum #16315. It is much smaller in stature, but to many is more appealing because of its size, quality, and form, with associated aurichalcite and goethite. Collected and donated to the museum by New Mexico Tech alumnus Roy Johnson, it is a stack of well-developed, three-dimensional spheroids in a stalactitic form.

The museum houses many other wonderful specimens, including some exceptional pieces of lapidary art (spheres, cabochons, and carvings) made from Kelly blue smithsonite and one of the finest large yellow smithsonite specimens preserved from the Fierro-Hanover mining district.

The NMBGMR Mineral Museum, located on the corner of Leroy Place and Bullock Boulevard on the New Mexico Tech campus in Socorro, is open Monday through Saturday (except for NMT holidays), and admission is always free. Call (575) 835-5490 or visit **geoinfo.nmt.edu/museum/** for more information.

Dr. John Rakovan

John Rakovan, a mineralogist and the senior Mineral Museum curator at NMBGMR, has been an executive editor for *Rocks and Minerals* magazine since 2001.

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Bureau News

Dr. Charles E. "Chuck" Chapin (1933–2024)

Chuck Chapin, director of the New Mexico Bureau of Geology and Mineral Resources from 1990–1999, passed away peacefully at his home in Albuquerque on March 14. He was 91.

Chuck, who grew up in Washington state and trained at Colorado School of Mines, began his career at New Mexico Tech in 1965. He joined the Bureau of Geology from the NMT Geoscience Department in 1970. He was a visionary, creative, and insightful geoscientist who shaped our thinking about Laramide tectonics, Cenozoic volcanism, and the Rio Grande rift in New Mexico. Chuck was a strong mentor and, during his career, provided valuable instruction and encouragement to many staff members at the Bureau of Geology, as well as to a wide group of geoscience students. He was a kind person with a good sense of humor who was unafraid to speak his mind.

"Heavy-duty fieldwork at Bonanza caldera, 2010." Peter Lipman on the left, Chuck Chapin on the right. *Photo provided by Peter Lipman*

Seager and Wirth receive Earth Science Achievement Awards

The 2024 service/policy award went to State Senate Majority Leader Peter Wirth, and was presented during a ceremony in the state capitol. Senator Wirth graduated from Stanford University with a BA degree in economics and Spanish in 1984. He later earned his juris doctor from the University of New Mexico School of Law in 1990. In 1992, Senator Wirth began his civil law work, which continues to this day, specializing in mediation and dispute resolution. Senator Wirth's public service to New Mexico shifted more firmly to state policy with his move to the state legislature. Throughout his tenure in the legislature, Senator Wirth has been a strong leader and advocate for environmental legislation.

The 2024 research/education award went to Dr. William Seager, an emeritus professor from New Mexico State University (NMSU) who spent his career investigating the complex geology of southern New Mexico. Dr. Seager graduated with a BS degree in geology from Syracuse University, where he almost became an artist. He later earned his MS degree under Vincent Kelley at the University of New Mexico; his thesis involved making a geologic map of the Jicarilla Mountains in south-central New Mexico. His PhD was awarded by the University of Arizona. In 1966, Dr. Seager became the second faculty member to join the nascent geology program within the Department of Earth Sciences at NMSU. He taught structural geology, tectonics, and field geology, and his research focused on field studies in southern New Mexico. He retired from the department in 1998 after 33 years of service. Perhaps Dr. Seager's finest professional achievement is his geologic map of the Organ and southern San Andres Mountains, east of Las Cruces.

Legislative funding increases for hydrogeology and geothermal research

During the 2024 New Mexico legislative session, the New Mexico Bureau of Geology and Mineral Resources received additional funding to support expanded research in hydrogeology and geothermal resources. The hydrogeology funding, a $1.1 million recurring appropriation, will begin to address state priorities in water—highlighted by the Water Policy and Infrastructure Task Force and the Governor's 50-Year Water Action Plan—to better understand the state's groundwater resources. The funding appropriated to the bureau to advance geothermal energy will support research and the dissemination of information about New Mexico's geothermal resources, focusing particularly on opportunities for advanced geothermal technologies and current challenges to geothermal development. The goal of the funding, which totals $1.5 million over three years, is to build the capacity to better understand New Mexico's geothermal potential.