

February 2010 Mineral of the Month: Sphalerite

Our specimens of this month's mineral, sphalerite, the primary ore of zinc, were collected at a classic locality—Tennessee's famed Elmwood Mine. Our write-up explains the history of the Elmwood Mine, sphalerite's unusual optical qualities, the many uses of zinc, and why the supply of mineral specimens is often erratic and unpredictable.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: ZnS Zinc Sulfide, almost always containing varying amounts of iron

Class: Sulfides

Group: Sphalerite

Crystal System: Isometric (Cubic)

Crystal Habits: Usually in tetrahedral habit, sometimes in the octahedral and dodecahedral habits; faces often slightly rounded; twinning common; also as cleavage, granular, compact, and botryoidal masses.

Color: Yellow, golden, yellow-orange, red, reddish-brown, brown, green, and black; rarely colorless or white.

Luster: Resinous to greasy; occasionally adamantine or submetallic.

Transparency: Usually translucent to nearly opaque; rarely transparent.

Streak: Pale yellow to light brown (always lighter than the specimen)

Refractive Index: 2.37-2.43

Cleavage: Perfect in six directions

Fracture: Uneven to subconchoidal; brittle.

Hardness: 3.5-4.0

Specific Gravity: 3.9-4.1

Luminescence: Often fluorescent and triboluminescent

Distinctive Features and Tests: Resinous luster, six-way cleavage, and yellow, reddish-brown, or greenish color. Can be confused with galena [lead sulfide, PbS] and siderite [iron carbonate, FeCO₃], but is less dense than galena, denser than siderite, and cleavage is distinctly different from both.

Dana Classification Number: 2.8.2.1.1

NAME The name "sphalerite," pronounced SFAY-leh-rite, derives from the Greek *sphaleros*, meaning "treacherous" or "deceitful," an allusion to its similarity to galena and other minerals. Sphalerite has also been known as "brunckite" and "marasmolite." Alternative mining-related names include "pseudogalena," "false galena," "blende," "zinc blende," "black zinc ore," "blackjack," "blackjack zinc," "mock lead," and "wild lead." Red sphalerite crystals are known as "ruby jack," "ruby blende," "ruby zinc," and "ruby sphalerite"; yellow crystals are called "honey blende," "honey zinc," and "honey sphalerite." A fluorescent, nearly pure, colorless-to-pale-green variety is known as "cleiophane"; an opaque, iron-rich variety is called "ferroan sphalerite" or "marmatite." In European mineralogical literature, sphalerite appears as *sflerit*, *sphalerit*, and *sphalerita*.

COMPOSITION: Sphalerite consists of zinc (Zn) and sulfur (S). Its ideal molecular weight is made up of 66.41 percent zinc and 33.59 percent sulfur. Sphalerite rarely occurs pure in nature and almost always contains varying amounts of iron. Sphalerite is one of the more abundant of the 350 sulfide minerals, which combine sulfur with one or more metals and are generally dense, brittle, dark in color, and more or less metallic in luster. Sphalerite crystallizes in the isometric system, in which three axes of equal length intersect at the crystal center and are perpendicular to their opposing faces. Variations of this basic cubic shape are the 4-faced tetrahedron, 8-faced octahedron, 12-faced dodecahedron, and 24-faced

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trapezohedron. Sphalerite most often crystallizes in the tetrahedral habit, and less commonly as octahedrons and dodecahedrons. Sphalerite occurs in carbonatites (calcium-rich igneous rocks) and calcareous (calcium-rich) sedimentary rocks with galena, fluorite, and cerussite; in hydrothermal veins with galena, arsenopyrite, and quartz; and in massive, lode, and disseminated replacement deposits with galena, pyrite, and chalcopyrite.

COLLECTING LOCALITIES: Fine sphalerite specimens come from the Elmwood Mine in the Mid-Tennessee Zinc-Mining Complex in Smith County, Tennessee. Other notable United States localities include the Coeur d'Alene district mines in northern Idaho; Cave-in-Rock and Empire districts on the Illinois-Kentucky line; Tri-State zinc-lead district near Joplin, Missouri; Red Dog zinc mine in northwest Alaska; Leadville district in Lake County, Colorado; and the Buckwheat Mine in Sussex County, New Jersey. France, Spain, England, Bulgaria, Germany, Mexico, China, Peru, and Australia also have notable sphalerite localities.

HISTORY, LORE, & USES: As the primary ore of zinc, sphalerite is mined extensively worldwide. Zinc was isolated and identified as an element in 1746 and initially was mixed with copper to make brass alloys. After 1900, demand for zinc increased sharply with the introduction of new applications in galvanizing steel and special alloys, and in the rubber, paint, chemical, and agricultural industries. Zinc is now the fourth most widely used metal after iron, aluminum, and copper. Nearly 11 million metric tons of zinc are mined each year. The leading producers are, in order, China, Australia, Peru, the United States, and Canada. The current price of refined zinc is \$1 per pound. Although too soft and brittle for general jewelry use, transparent sphalerite cuts into beautiful collector gems. We have handled brilliant tricolor orange-yellow-green gemstones cut from sphalerite from Las Manforas Mine, Refugio de Aliva, Picos de Europa Mts., Cantabria, Spain that will knock your eyes out! Sphalerite specimens are highly valued by mineral collectors. Metaphysical practitioners believe that sphalerite balances the masculine and feminine aspects of personality, assists in changing vocations, and enhances introspection.

ABOUT OUR SPECIMENS: Our specimens were gathered by professional collectors at a classic sphalerite locality: the Elmwood Mine near Carthage in Smith County in north-central Tennessee, 40 miles east of Nashville. The Elmwood zinc occurrence is a Mississippi Valley-Type (MVT) deposit, a carbonate-hosted, strata-bound deposit that is rich in lead and/or zinc. MVT deposits form when zinc- and/or lead-rich hydrothermal solutions penetrate deep limestone formations, dissolve calcite within the limestone, and precipitate lead and/or zinc sulfides as galena and sphalerite within the resulting voids. The Elmwood Mine, 1,300 feet deep and accessed by three vertical shafts and a declined tunnel, opened in 1974 and produced steadily until it was shut down for economic reasons in 2003. A recent attempt to reopen the mine was halted because of depressed zinc prices. When operating, Elmwood can produce 1,500 tons of sphalerite ore daily and is a prolific source of fine mineral specimens, notably sphalerite, fluorite, and world-class golden calcite. At this time, the future of the mine remains uncertain.

10 YEARS AGO IN OUR CLUB: Citrine, Conselheiro Pena District, Minas Gerais, Brazil. We sent out pretty, polished pieces. Back in 2000, in addition to our wholesale show at the Inn Suites, we also sold at the 4-day Tucson Gem & Mineral Show at the Tucson Convention Center. As you can imagine, doing both shows was completely exhausting, and we finally quite taking part in the TGMS Show after 2002. Selling there was never very profitable for us, as the show costs were high. But we would always sign up some new Club members and make a few good sales to wholesale and retail buyers there. Finally we realized it was just too much. Plus, starting in 2000, we had to get back and get ready for a show on the last weekend in February in North Hollywood, California, where we always sold more than we did at the TGMS at a fraction of the show fees! Sad to say, that show is no longer around, but we did finally get into the Castro Valley Gem & Mineral Show in the San Francisco Bay area, which more than made up for it.

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COMPREHENSIVE WRITE-UP

COMPOSITION

The chemical formula ZnS shows that sphalerite consists of two minerals, zinc (Zn) and sulfur (S). Its molecular weight is made up of 66.41 percent zinc and 33.59 percent sulfur. ZnS is an ideal formula that expresses a purity rarely found in nature. Sphalerite is one of the more abundant of the 350 sulfide minerals. Sulfides, in which sulfur is combined with one or more metals, tend to be dense, brittle, dark in color, and more or less metallic in luster. Sphalerite occurs in carbonatites (calcium-rich igneous rocks) and calcareous (calcium-rich) sedimentary rocks with galena [lead sulfide, PbS], fluorite [calcium fluoride, CaF_2], and cerussite [lead carbonate, PbCO_3]; in hydrothermal veins with galena, arsenopyrite [iron arsenic sulfide, FeAsS], and quartz [silicon dioxide, SiO_2]; and in massive, lode, and disseminated replacement deposits with galena, pyrite [iron disulfide, FeS_2], and chalcopyrite [copper iron sulfide, CuFeS_2]. Sphalerite is present in most hydrothermally emplaced base-metal deposits and is almost always associated with galena. Sphalerite is a trimorph with two other minerals that share the same chemistry, but have different crystal structures: matraite [zinc sulfide, ZnS , trigonal] and wurtzite [zinc iron sulfide, $(\text{Zn,Fe})\text{S}$, hexagonal and trigonal].

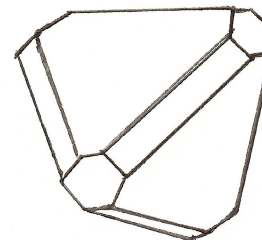


Figure 1. Tetrahedron crystal.

Sphalerite crystallizes in the isometric (cubic) system, in which three axes of equal length intersect at the crystal center and are perpendicular to opposing faces. Variations of this basic cubic shape are the 4-faced tetrahedron (as shown in Figure 1), 8-faced octahedron, 12-faced dodecahedron, and 24-faced trapezohedron. Sphalerite most often crystallizes in the tetrahedral habit and less commonly as octahedrons and dodecahedrons. Tetrahedrons are four-sided polygons with triangular faces. In sphalerite's crystal-lattice unit, sulfur ions occupy the eight corners of a cube and the middle of its six faces, and are shared with adjacent lattice units. Four zinc ions occupy interior positions within each cube. In this arrangement, the zinc and sulfur ions retain a 1:1 ratio (as in the formula ZnS) and have a tetrahedral coordination that produces sphalerite's predominant tetrahedral crystal habit. The sphalerite structure is analogous to that of diamond [carbon, C]. If the carbon ions in the diamond structure are alternately replaced with zinc and sulfur ions, the structure becomes that of sphalerite. Sphalerite crystals are often twinned as "spinel-twins," in which the tetrahedral crystal appears twisted in the middle so that the twin resembles an octahedron. Almost all sphalerite crystals exhibit some degree of twinning, although it is rarely complete. With four sulfur ions shielding each zinc ion within the crystal lattice, sphalerite's luster is usually resinous to greasy and not, unlike many sulfides, distinctly metallic. Because the covalent bonding between the sulfur ions of adjacent molecules is relatively weak, sphalerite is only moderately hard at Mohs 3.5-4.0. Weak covalent bonding also accounts for sphalerite's unusual, perfect, six-directional cleavage (picture the six cleavage directions of two tetrahedrons joined at their bases).

As an allochromatic (other-colored) mineral, sphalerite's colors are due to nonessential elemental impurities. When pure or nearly pure, sphalerite is transparent and colorless or white. Most sphalerite contains significant quantities of iron (ferrous, Fe^{2+}) and traces of such elements as cadmium, manganese, silver, indium, and gallium. Iron is always the predominant impurity in sphalerite, accounting for at least 2 or 3 percent and as much as 15 percent of its total weight. Accordingly, sphalerite's chemical formula is sometimes expressed as $(\text{Zn,Fe})\text{S}$ to indicate the variable replacement of zinc by iron. Because ferrous iron (Fe^{2+}) and zinc ions (Zn^{2+}) have similar ionic radii and the same electrical charge, iron, an abundant element that is always present in zinc-rich environments, substitutes easily for zinc in the sphalerite lattice. Iron is the chromophore that creates all common sphalerite colors, as well as varying degrees of translucency and near-opacity.

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In the Dana mineral classification number 2.8.2.1, (2) first identifies sphalerite as a sulfide, selenide (a selenium-bearing mineral), or telluride (a tellurium-bearing mineral). The subclassification (8) defines it by the general formula $A_mB_nX_p$, in which “A” and “B” can be zinc, iron, mercury, or cadmium, “X” can be sulfur, selenium, or tellurium, and the numerical ratio of $m+n:p$ equals 1. Sphalerite is then assigned to the sphalerite group (2) as the first (1) of six members. The other sphalerite-group members, all of which crystallize in the isometric system, are:

Stilleite zinc selenide ZnSe
Metacinnabar mercury sulfide HgS
Tiemannite mercury selenide HgS
Coloradoite mercury telluride HgTe
Hawleyite cadmium sulfide CdS

Sphalerite's relatively high specific gravity of 3.9-4.1 is due to its large content of zinc (atomic weight 65.38); its density range is due to variations in iron content. Sphalerite is among the few high-density minerals that can form transparent crystals. Dense, transparent mineral crystals profoundly affect the transmission of light. Sphalerite's index of refraction, a measure of the ability to bend light, is 2.37-2.43—nearly equal to that of diamond. Sphalerite's index of dispersion, a measure of “fire” or the ability to separate white light into its spectral components, is 3.5 times *higher* than that of diamond!

Zinc, the metallic component of sphalerite, ranks 24th among the elements in crustal abundance and is about as common as copper. Because of its high chemical reactivity, zinc never occurs in elemental form in nature. Pure zinc is a bluish-white, brittle metal with an atomic weight of 65.38, slightly higher than that of copper. Zinc is a major industrial metal with many applications (see “Technological Uses”).

COLLECTING LOCALITIES

As a relatively abundant and widely distributed mineral, sphalerite has many collecting localities. Our specimens are from the Elmwood Mine in the Mid-Tennessee Zinc-Mining Complex near Carthage in Smith County, Tennessee. The nearby Gordonsville and Cumberland mines also yield sphalerite specimens. Other localities in the United States include the numerous mines in the Coeur d'Alene, Murray, and Pine Creek districts in Shoshone County, Idaho. Noted Illinois sources include the Cave-in-Rock and Empire districts in Hardin County, the Galena District in Jo Daviess County, and the Illinois-Kentucky Fluorspar District in Pope County. In Wisconsin, sphalerite is found in the metal-mining districts of Grant and Lafayette counties. Alaskan sources include the Red Dog zinc mine near Kotzebue in northwest Alaska and the Green Creek district near Juneau. Among Colorado's localities are the Leadville district in Lake County, Creede district in Mineral County, Ouray and Sneffels districts in Ouray County, Alma district in Park County, Aspen district in Pitkin County, and Silverton district in San Juan County. Utah localities include the Bingham, Big Cottonwood, and Little Cottonwood districts in Salt Lake County, the North Tintic and Gold Hill districts in Tooele County, and the American Fork District in Utah County. The Tri-State (Joplin) lead district, covering parts of Cherokee County in Kansas, Jasper County in Missouri, and Ottawa County in Oklahoma, has produced fine sphalerite specimens. Transparent, fluorescent sphalerite has come from the Buckwheat Mine in the Franklin district, Sussex County, New Jersey.

European sphalerite sources include the Langeac, Auvergne and Rhône-Alpes mines in Savoie, France; the lead-zinc mines in the Italian provinces of Tuscany, Sardinia, and Liguria; the lead-zinc mines in Bavaria, Westfalen, and the Black Forest region of Baden-Württemberg, Germany; the lead-silver mines of Carinthia, Tyrol, Salzburg, and Styria, Austria; the historic Madan Orefield in southern Bulgaria's Rhodope Mountains; and the Río Tinto Mine in the Huelva District of Andalusia, Spain. In China,

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sphalerite is collected at the Yangangxian Mine at Yizhang, Chenzhou Prefecture in Hunan Province. Peruvian specimens come from the Huaron District in Alcides Carrión Province, Pasco Department; and the Julani District in Angaraes Province, Huancavelica Department. Bolivian specimens are collected at Bostillos, Oruro Province, Potosí Department. Among Mexico's localities are the Congreso-León Mine, Nuevo Casas Grandes, Chihuahua; the Bamboullita Mine at Moctezuma, Sonora; and the Refugio Mine near Choix, Sinaloa. Australian sources include the Broken Hill and New England districts in New South Wales. In Canada, sphalerite is collected at the LaFarge Quarry in Wentworth County, Ontario; and the Pine Point Mine in the McKenzie district, Northwest Territories.

JEWELRY & DECORATIVE USES

Although nicely colored, individual, transparent crystals are occasionally wrapped in silver wire as pendants, sphalerite is generally too soft and brittle for most jewelry uses. Sphalerite collector gems, however, are quite popular. They are difficult to cut because of sphalerite's six-directional cleavage and brittleness. But when properly faceted, sphalerite gems show brilliant colors that are eye-catching. Transparent sphalerite gems in yellow, orange, red, and green colors are very appealing and have a remarkable ability to refract and disperse white light. Sphalerite's unusually high indices of refraction and dispersion (see "Composition") create a play of light and "fire" that rivals that of colored diamonds. Sphalerite gems are usually fashioned in brilliant cuts to best show their high index of dispersion. Sphalerite collector gems range in weight from 2 or 3 carats to as many as 40 carats, and in value from \$30 to \$1,000 each.

Many of these gorgeous stones come from Las Manforas Mine, Refugio de Aliva, Picos de Europa Mts., Cantabria, Spain. When we traveled to Spain in 2007, we obtained some cutting rough and polished slices of this incredible sphalerite, showing translucent yellow and orange colors. The mine is closed, flooded, and now on public land, a triple whammy that means it is highly doubtful it will ever produce new material, so the only new material comes out of the collections of those fortunate enough to have had access in the past. We are always on the lookout for this sphalerite in any form, especially the brightly colored gemstones. We will let you know if we find more!

Aggregates of botryoidal crusts consisting of alternate layers of sphalerite, marcasite, galena, and the trimorphic mineral wurtzite $[(\text{Zn},\text{Fe})\text{S}]$ are mined in Poland and Germany, cut and polished as ornamental stones, and marketed as "Schalenblende." We have been blessed to carry many pieces of this beautiful stone over the years as polished slabs and cabs and always delight in its unique patterns and colors!

Individual and composite sphalerite specimens are in high demand among mineral collectors. Cabinet-sized, composite specimens with associated minerals such as purple fluorite, colorless quartz, and golden calcite, especially those from Tennessee's Elmwood Mine, sell for thousands of dollars each.

HISTORY & LORE

Sphalerite has been known since antiquity, when early metallurgists inadvertently used it to create the first brass (copper-zinc) alloys. In their crude smelting processes, mixed ores of copper and zinc were reduced to their metallic states and recovered as brass, which has greater hardness and better casting properties than either copper or bronze (the latter a copper-tin alloy). The nature of zinc, however, remained a mystery until relatively recent times. In 1546, German scholar Georgius Agricola (Georg Bauer, 1494-1555) referred to sphalerite as *blende*, from the German verb *blenden*, meaning "to blind" or "to conceal," a reference to the frequent inability of German miners of the era to differentiate worthless sphalerite from the valuable lead ore galena. Zinc itself was not isolated and identified as an element until 1746, when

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German chemist Andreas Sigismund Marggraf (1709-1782) reduced hemimorphite [basic hydrous zinc silicate, $\text{Zn}_4\text{Si}_2\text{O}_7(\text{OH})_2 \cdot \text{H}_2\text{O}$] with heat and charcoal to produce metallic zinc. Mineralogists correctly described sphalerite as zinc sulfide in 1824. The mineral continued to be called “blende” until 1847, when English mineralogist E. F. Glocken (vita unknown) renamed it “sphalerite,” from the Greek *sphaleros*, meaning “treacherous” or “deceitful,” a reference to the similarity with galena that Agricola had noted 300 years earlier.

Until the late 19th century, zinc was used only to alloy with copper to make brass. Zinc was then obtained by reducing such ores as smithsonite [zinc carbonate, ZnCO_3] or recovered as by-product of smelting lead, silver, and copper ores. Even as late as the 1890s, many miners considered sphalerite a worthless mineral that interfered with the smelting of other ores. Only after the development of modern applications (see “Technological Uses”) in the early 20th century did sphalerite become important as the primary ore of zinc. In 1918, sphalerite was among the first minerals to have its atomic structure defined by the newly introduced X-ray diffraction analytical method.

Modern metaphysical practitioners believe that sphalerite balances the masculine and feminine aspects of personality, assists in changing vocations, and enhances introspection. Sphalerite has appeared on the 2-leva postage stamp of Bulgaria in 1995, the 29-peseta stamp of Spain in 1994, and the 4.90-dinar stamp of Yugoslavia in 1980.

THE UNCERTAINTIES OF MINING AND MINERAL-SPECIMEN SUPPLY, or WILL I EVER SEE THIS MATERIAL AGAIN?

In last month's write-up on fluorite, we reported how changes in China's mining industry and the closure of many mines have affected the supply of Chinese mineral specimens. This month's mineral—sphalerite from Tennessee's Elmwood Mine—gives us an opportunity to discuss some of the factors that influence the operations of metal mines in the United States. This topic is timely, for the Elmwood Mine, despite its huge remaining reserves of zinc mineralization (see “About Our Specimens”), is currently closed and its future is uncertain. Because the supply of new Elmwood specimens has halted, their prices are at an all-time high, and are likely to go nowhere but up.

For a mine to be profitable, the value of its ore must be greater than the costs of mining it. Ore is defined as mineralization that is profitable to mine at the current time. Ore value is primarily, but not entirely, dependent upon the market price of the contained mineral commodity. Other factors that influence the value of ore include grade, amenability to concentration and smelting processes, and transportation costs to mills and smelters. Mining costs, on the other hand, are more complex and include expenses related to materials, equipment, labor, environmental compliance, general mine maintenance, fuel, utilities (electricity is a major expense in dewatering mines), property and production taxes, and long-term debt obligations.

In the case of the Elmwood Mine, profitability depends largely on the market price of zinc. In today's global market, metal prices can fluctuate radically and be difficult to predict. Since 2003, as an example, zinc prices have ranged from a low of 50 cents per pound to a high of \$3 (in

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current dollars). When the Elmwood Mine opened in 1974, the zinc price was 40 cents. It later rose to \$1, but by 2003 had fallen back to 50 cents because of oversupply from newer, larger, lower-cost zinc mines in Alaska and several foreign nations. Thus, in 2003, Elmwood was selling zinc for essentially the same price as it had in 1974, while several decades of inflation had greatly increased its operating costs. In 2003, when mining at Elmwood was no longer profitable, the mine owner suspended production and placed the mine on care-and-maintenance status to await higher zinc prices.

By 2007, just four years later, a booming world economy had driven the zinc price to a record high of \$3 per pound—more than enough to assure Elmwood a substantial operating profit. But after four years of inactivity, restarting the mine required a full year to dewater its lower levels, repair electrical systems, arrange new milling and smelting contracts, and hire and train a new work force. By early 2008, just as the mine was ready to resume production, the onset of the current global economic recession sent zinc prices plummeting. Unable to produce profitably, the mine returned to care-and-maintenance status. Because the substantial restart expenses could not be recouped through production, the mine owner was forced into bankruptcy. Whether Elmwood will ever produce again depends on future zinc prices, the costs of restarting the mine (longer periods of inactivity always increase restart costs), and the mine owner's willingness to assume the financial risk of another restart attempt.

The problems facing the Elmwood Mine are only some of the factors that determine whether mines can or cannot operate profitably. Other potential problems that mines face are labor strikes, declining ore grades, depletion of ore reserves, encountering geological problems such as "bad rock" or faults that require costly ground support or more extensive dewatering, and changing ore chemistry that can complicate milling and smelting procedures. Mines in some third-world nations, many of which have foreign owners, also face potential problems because of the possibility of civil unrest, nationalization, and changing governmental regimes.

More than 90 percent of the mineral specimens available today are collected from operating metal mines. When the operations of these mines are suspended, terminated, or disrupted for any reason, so, too, is the supply of mineral specimens. And specimen prices are determined by the same general factors that determine the prices of mineral commodities—supply and demand. Since the Elmwood Mine opened in 1974, collector demand for its specimens had been so strong that virtually all specimens were sold as soon as they became available and prices remained high. When the mine suspended operations in 2003 and its supply of specimens stopped, their prices soared. Interestingly, just before the mine closed, a number of savvy collectors invested heavily in top-grade Elmwood specimens, purchasing them at the "old" prices. These investments proved quite shrewd, since the mine has not reopened to date and the prices for Elmwood specimens have reached record levels and are continuing to increase. The point of the Elmwood story is this: Because metal mining is uncertain, so, too, is the supply, price, and future value of mineral specimens.

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TECHNOLOGICAL USES

As the primary ore of zinc, sphalerite provides about 95 percent of all newly mined zinc. Until the late 1800s, zinc was used only to mix with copper to make brass. Zinc became a bona fide industrial metal about 1900, when it was first used as the protective, corrosion-preventing coating on “galvanized” steel. In the galvanizing process, steel is coated with molten zinc. The zinc, which is chemically reactive, immediately forms a surface layer of impervious zinc oxide which protects the underlying steel from corrosion and rust. Today, about three-fourths of all zinc is used to galvanize steel, as an alloying agent in brass, in casting and specialty alloys, and in coinage (97.5 percent of the U.S. penny consists of zinc). Zinc compounds are also used extensively in the rubber, paint, chemical, and agricultural industries. Zinc is essential for human health, and regulates the function of some 300 enzymes in the body. The human body contains about three grams of zinc and has a daily requirement of 15 milligrams.

After iron, aluminum, and copper, zinc is the fourth most widely used metal with 11 million metric tons mined worldwide each year. The leading producers, in order, are China, Australia, Peru, the United States, and Canada. The price of refined zinc is currently about \$1 per pound. The smelting of sphalerite concentrates also yields most of the world's supply of the metals cadmium, gallium, and indium.

ABOUT OUR SPECIMENS

Our sphalerite specimens were collected at a classic locality: the Elmwood Mine in the Mid-Tennessee Zinc-Mining Complex near Carthage in Smith County, Tennessee. Carthage is in north-central Tennessee, 40 miles east of Nashville, 5 miles north of Interstate 40, and 25 miles south of the Kentucky line. A historic Tennessee town with a population of 2,200, Carthage is situated at an elevation of 515 feet in wooded hills on the north bank of the Cumberland River. The Carthage area overlies the Elmwood zinc deposit, one of the largest zinc deposits in the continental United States.

Economic geologists classify the Elmwood zinc occurrence as a Mississippi Valley-Type (MVT) deposit, which is a carbonate-hosted, strata-bound deposit rich in lead and/or zinc. MVT deposits, first recognized in, and named for, the greater Mississippi Valley, are also found in southeast Missouri, southeast Iowa, northwest Illinois, and southwest Wisconsin. Their geologically complex origin began with ancient, igneous and metamorphic basement rock that became buried with sediments that lithified into porous sandstone. This sandstone was later immersed in an ancient sea that deposited calcareous (calcium-rich) sediments that lithified into strata of limestone (a sedimentary rock consisting primarily of calcite). Low-temperature, acidic, hydrothermal solutions rich in zinc and/or lead rose from the basement rock and pooled into the porous sandstone. Finally, deep pressures forced the solutions from the sandstone into the overlying limestone formation. Certain impermeable limestone strata blocked the further upward movement of the hydrothermal solutions, causing them to migrate laterally. These solutions first dissolved calcite to create voids in the limestone, then, as their acidity decreased, precipitated lead and zinc sulfides as galena and sphalerite in the broad, horizontally oriented occurrences that are typical of MVT deposits.

At the Elmwood zinc deposit, the host limestone is of Ordovician age (about 500 million years old) and part of the upper Knox Group of the Mascot and Kingsport formations. The sulfide mineralization, which predominantly consists of sphalerite with very little galena, was emplaced at relatively low temperatures below 130° C. (266° F.). Associated minerals are calcite, galena, barite [barium sulfate, BaSO₄], celestine [strontium sulfate, SrSO₄], fluorite [calcium fluoride, CaF₂], pyrite [iron disulfide, FeS₂], quartz [silicon dioxide, SiO₂], and dolomite [calcium magnesium carbonate, CaMg(CO₃)₂]. Most of this mineralization was emplaced in massive form. But because voids in the altered limestone sometimes provided space for extraordinary crystal development, the Elmwood zinc deposit yielded a plethora of fine mineral specimens.

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Discovering the Elmwood zinc deposit was not easy. The deposit was more than 1,000 feet below the surface and impermeable limestone strata had prevented zinc-rich groundwater from reaching the surface and providing geochemical clues to the deposit's existence. Nevertheless, in the 1950s, geologists familiar with MVT deposits inferred the possible existence of such mineralization in north-central Tennessee. The New Jersey Zinc Company, which then operated zinc mines at Franklin, New Jersey, and Gilman, Colorado (both prolific sources of fine mineral specimens), began prospecting the region in 1964. With no geochemical clues to follow, geologists relied on gravimetric prospecting. Using highly sensitive, airborne gravimeters, they searched for miniscule, positive anomalies in the Earth's gravitational field that might indicate large, subterranean masses of unusual density. When airborne gravimetric surveys revealed a pattern of anomalies near Carthage, geologists initiated a costly program of exploratory core-drilling. In 1969, they struck pay dirt when drill-core samples from a depth of 1,300 feet revealed a massive MVT sphalerite deposit with an average grade of nearly four percent zinc.

New Jersey Zinc then developed the Elmwood Mine, which began production in 1974. Elmwood is a room-and-pillar mine served by three vertical shafts and one declined tunnel. From central shaft stations, close patterns of large, 16-foot-wide, 11-foot-high drifts extend through the layer of zinc mineralization. The rock between these drifts serves as the "pillars" that support the mine. During production, miners systematically enlarge the drifts to create 40-foot-wide, 20-foot-high stopes or "rooms." Finally, in carefully planned "retreats," miners blast out the pillars, which also consist of ore, allowing the mined-out rooms to collapse behind them. Four other nearby, shaft-accessed, underground mines—the Gordonsville, Cumberland, Carthage, and Stonewall mines—were later developed to better exploit the huge deposit. Along with Elmwood, these mines became known collectively as the Mid-Tennessee Zinc-Mining Complex, which, during the 1980s and 1990s, made Tennessee the nation's largest zinc producer.

In the 1980s, the New Jersey Zinc Company reorganized as the Jersey Minière Zinc Co. which, in 1995, sold out to the Savage Zinc Company, the American subsidiary of Australia-based Savage Resources, Ltd. Savage, which reorganized as Pasinco, Ltd., operated the mines for eight years, suspending operations in 2003 due to low zinc prices. By then, the Mid-Tennessee Zinc-Mining Complex had produced 30 million tons of sphalerite ore that yielded 2.6 billion pounds (1.2 million metric tons) of zinc. The remaining reserves in the Elmwood deposit amount to 26 million tons grading 3.25 percent zinc and containing 800,000 tons of elemental zinc.

Canada-based Strategic Resources Acquisition Corp. (SRA) subsequently bought the mine complex and in 2007, after zinc prices had soared to record levels, announced it would restart the Elmwood, Gordonsville, and Cumberland mines, with limited production beginning in January 2008, and full production scheduled for that July. But zinc prices collapsed just as limited production began and operations were suspended. Belgium-based Nyrstar NV then acquired the Mid-Tennessee Zinc-Mining Complex in May 2009 and continues with care-and-maintenance operations. At this time, there is no assurance that the zinc-mining complex will ever reopen.

The Elmwood Mine was not only a major source of zinc, but also of world-class mineral specimens. The first descriptions of the mine's superb specimens of golden calcite, purple fluorite, and sphalerite appeared in *The Mineralogical Record* in 1978, attracting the attention of mineral collectors worldwide. The crystal-filled voids in the Elmwood Mine ranged in size from a few inches to 40 feet. Within the largest voids, miners found calcite crystals up to eight feet long—too large to be removed intact from the mine. When Elmwood began production in 1974, the miners themselves collected the first specimens. But because of the specimens' extraordinary quality and value, the mine owner soon contracted with commercial collectors to gather specimens. Prior to the suspension of production in 2003, Top Gem, Inc., of Tucson, Arizona, collected and marketed Elmwood specimens. During the recent limited production of early 2008, Collector's Edge of Golden, Colorado, held the Elmwood contract and collected our sphalerite.

February 2010 Mineral of the Month: Sphalerite

Our specimens, which consist of sphalerite with only minor amounts of other minerals, have been trimmed with a circular diamond blade to remove an irregular matrix of massive sphalerite. Note first the weight or “heft” of the specimen in your hand. Its considerable weight reflects a specific gravity of about 4.0, meaning that the specimen weighs roughly 50 percent more than an equal volume of quartz.

The individual sphalerite crystals are equant and exhibit the same diameter in all directions, a shape that is common to the isometric crystal system. These crystals exhibit a tetragonal habit and form tetrahedrons with triangular faces, as depicted in the drawing in Figure 1. Although most are modified, distorted, and twinned, the generally triangular shape of many faces is readily apparent. At first glance, your specimen appears black or brownish-black and nearly opaque, indicating its high iron content of about 8-10 percent, which is typical of Elmwood sphalerite. Inspect the specimen closely under intense artificial light or direct sunlight to see that many of its smaller crystals are actually transparent to translucent and have a deep yellow-orange to orange-red color. A few specimens contain small crystals of colorless or white calcite or deep purple fluorite.

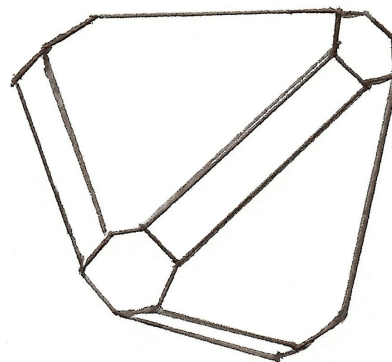


Figure 2. Tetrahedron crystal.

This is now the second time we have featured wonderful specimens of sphalerite from Elmwood. The first time was in December 1998, when we had only about 170 members. In our first year of operating our Club, we actually featured fluorite from Elmwood, back in June 1996, our fourth month! Of course, we had only a couple of dozen members at the time, and there were lots of Elmwood minerals available on the market then. It would be interesting to find out how much those fluorites are now worth! Of course, the primary reason for building our collections is our love for minerals in their vast array of colors, forms, habits, and combinations, but it is nice to know that the value of many of our better specimens will certainly appreciate as the years go by! (A full set of Mineral of the Month Club minerals and write-ups might someday be worth quite a bit--who knows?) Had you the forethought back in the 1990's to stock up on choice Elmwood pieces (and of course minerals from other now-closed localities) and hold them until now, you would no doubt have seen a significant increase in value.

Knowing this should encourage us to take good care of our collection: protect our specimens from damage, properly label all our specimens, keep an inventory of what we have and where we got it, how much we paid for it, and so forth. There's no telling how important your collection might become!

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