October 2007 Mineral of the Month: Fluorite

Certainly a favorite among collectors for its fascinating forms, colors, and fluorescence, fluorite has graced the cover of *The Mineralogical Record* no less than eight times!

PHYSICAL PROPERTIES

Chemistry: CaF_2 Calcium Fluoride
Class: Halides
Group: Fluorite
Crystal System: Isometric (Cubic)
Crystal Habits: Usually cubic or as penetration twins; less frequently octahedral and rarely dodecahedral; also granular, columnar, earthy, and as cleavage masses.
Color: White, colorless, violet, purple, blue, green, yellow, brown, amber, bluish-black, pink, and rose-red.
Luster: Vitreous
Transparency: Transparent to translucent
Streak: White
Cleavage: Perfect in four directions, forming an octahedron
Fracture: Uneven, brittle
Hardness: 4.0
Specific Gravity: 3.0-3.2
Luminescence: Often fluorescent and phosphorescent, sometimes thermoluminescent, and triboluminescent (see "The Many Types of Luminescence").
Refractive Index: 1.433
Distinctive Features and Tests: Best field indicators are cubic crystal form, excellent crystal development, perfect four-directional cleavage, and relative softness.
Dana Classification Number: 9.2.1.1

NAME

The name of this month's mineral, correctly pronounced FLOR-ite, is derived from the Latin *fluere*, "to flow," a reference to its ability to lower the melting temperature of metals in smelting processes. Because of its long use as a decorative stone and as a flux, fluorite has many alternative names, including "androdamant," "bruiachite," "Derbyshire spar," "fluor," "fluores," "fluoride of calcium," "fluoride of lime," "fluorspar," "fluorspath," "flusse," "flusspat," "liparite," "murrhina," and "spath vitreux." European mineralogists refer to fluorite as "fluorit," "fluorita," and "fluorin."

Fluorite also has several variety names based on color and other physical properties. "False emerald" is green, "false amethyst" is purple, "false ruby" is red, "fluorite rose" is pink, "rainbow fluorite" is multi-colored, and "blue john" has alternating bands of yellow, blue, and purple. "Chlorophane" is a thermoluminescent variety.

COMPOSITION

Fluorite now joins the honor roll of minerals that we have featured three times, along with pyrite and apatite. In our fourth month of operation, June 1996, we sent eager Club members purple fluorite cubes from the new find at the Elmwood mine, Carthage, Smith County, Tennessee. This mine is no longer producing, and you can be sure that the specimens we sent that month have greatly increased in value–wish we had obtained several flats for ourselves! In March 2002, fluorite became the first mineral to be featured twice, as we sent Club members the highly fluorescent, green fluorite from the Rogerley mine, Wearsdale, Durham County, England, our first and only featured mineral from England, so far.

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Fluorite's chemical formula CaF_2 identifies its elemental constituents as calcium (Ca) and fluorine (F). Calcium contributes 51.33 percent of fluorite's molecular weight; fluorine contributes 48.67 percent. Fluorite is a simple compound mineral, consisting only of a single cation (positively charged ion) and a single anion (negatively charged ion). Within the fluorite molecule, the +2 charge of the calcium cation (Ca^{2+}) balances the collective -2 charge of the double fluorine anion ($2F^{1-}$) to provide electrical stability. Fluorite is a member of the halides, a group of soft, brittle minerals in which a halogen element is the only anion. The halogen elements fall under Group VII A of the periodic table and include, in order of chemical activity, fluorine, chlorine, bromine, iodine, and astatine.

The fluorite molecule and lattice are held together primarily by ionic bonding, the attractive force that joins ions of distinctly metallic elements with those of distinctly nonmetallic elements. Ionic bonding is explained by electronic configuration, that is, the distribution of electrons within atoms that determines which atoms can react with others to form compounds. Electrons occupy space around the atomic nucleus in well-defined energy levels or "shells," with specific shells accommodating specific numbers of electrons. Elements are stable when their outer shells contain eight electrons (called a "stable octet"). Those with incomplete outer shells can react with other elements by gaining, losing, or sharing electrons to fill their outer shells and thus complete the stable octet.

The calcium atom has 20 electrons in four shells—2 in the inner shell, 8 in the second shell, 8 in the third shell, and 2 in the outer shell. It achieves stability by losing its two outer electrons, thus making the third shell with its eight electrons the outer shell. The loss of these two electrons creates a positively charged ion with a +2 charge (Ca^{2+}). Fluorine has only nine electrons in two shells—two in its inner shell and seven in its outer shell. To achieve stability, it borrows a single electron to fill its outer shell, thus creating a negatively charged ion with a -1 charge (F^{1-}). When a calcium atom contacts two fluorine atoms, the fluorine atoms borrow the two outer calcium electrons, transforming both the calcium atom and the two fluorine atoms into oppositely charged ions. Opposite charges attract, forming the ionic bond that joins the calcium and fluorine ions together in the stable fluorite molecule.

In the fluorite lattice, eight fluorine ions surround each positively charged calcium ion, while four calcium ions surround each negatively charged fluorine ion. This forms a cubic structure with identical ions at the corners of the cubes and at the center of the six faces. The alternating rows of calcium ions and fluorine ions are arranged in four axial directions and held together mainly by ionic bonding with only a small degree of covalent bonding. Because ionic bonding is weak, fluorite exhibits perfect four-directional cleavage and is relatively soft at Mohs 4.0.

It is interesting to compare fluorite with halite [sodium chloride, NaCl], our Mineral of the Month for July 2006. Both minerals crystallize in the isometric system, but different lattice arrangements give halite perfect three-directional cleavage and fluorite perfect four-directional cleavage. Because fluorite has two fluoride anions as opposed to halite's single chlorine anion, it has stronger overall ionic bonding. Accordingly, fluorite is much less soluble in water and considerably harder than halite (Mohs 2.0).

One of fluorite's most fascinating properties is its broad range of colors, which can be pale and subtle, or so intense as to be nearly opaque. As an allochromatic or "other-colored" mineral, fluorite's colors are not caused by essential elemental components or the nature of its crystal structure, but by traces of nonessential elements or lattice defects. When pure or nearly pure, fluorite is colorless. But most fluorite contains, among other elements, small amounts of iron and the rare-earth elements yttrium and cerium, which substitute for calcium in the crystal lattice. These impurities, called chromophores (color-causing agents), modify the manner in which the fluorite lattice absorbs and reflects the various wavelengths of white light. Iron imparts green and yellow colors to fluorite, while traces of yttrium and cerium impart pink and rose colors.

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Fluorite colors also have other causes, such as lattice defects called "color centers," which are created either by abnormal crystal growth or exposure to natural geophysical radiation. In fluorite, color centers form when fluorine ions are displaced from their normal lattice positions to create voids that fill with electrons. These "trapped" electrons absorb varying amounts of white-light energy that boost them to higher energy levels. To return to their normal levels, they release this excess energy in the form of visible light of specific wavelengths. The energy emitted by fluorite color centers is usually purple or violet. Yet another color-causing mechanism in fluorite that is still being studied is the presence of "loose" or unbound fluorine ions within the lattice. In some specimens, color is determined by a combination of the effects of chromophoric substitution, color centers, and unbound fluorine ions. Finally, fluorite often exhibits luminescent effects, as explained in the box below.

THE MANY TYPES OF LUMINESCENCE

Fluorite is a classic example of a luminescent mineral. The general term "luminescence" includes such effects as fluorescence, phosphorescence, thermoluminescence, and triboluminescence. Fluorite, perhaps because its crystal lattice often contains unbound fluorine ions, is one of the few minerals that can—but does not always—exhibit these four types of luminescence.

Luminescence must not be confused with the visible light emitted by materials when they undergo combustion or are heated nearly to their melting points (as in the tungsten filaments of incandescent light bulbs). Nor does luminescence rely on the reflection, transmission, or refraction of visible light. Luminescence occurs at ambient temperatures when certain minerals absorb electromagnetic, mechanical, thermal, and radiation energy. These forms of incidental energy excite certain electrons within the absorbing mineral, boosting them from normal-energy inner orbits to high-energy outer orbits. As they fall back to their normal orbits, they release their excess energy in the form of visible light.

In ***fluorescence****, ultraviolet (black) light energizes certain electrons in such minerals as fluorite, calcite, scheelite [calcium tungstate, $CaWO_4$], willemite [zinc silicate, Zn_2SiO_4], and halite, boosting these electrons to higher orbits where they immediately release their excess energy in a rainbow of visible colors. In a steady source of ultraviolet light, these electrons continuously absorb and release energy to maintain the state of fluorescence. The term "fluorescence" actually derives from "fluorite," which was the first mineral used to study this phenomenon.* ***Phosphorescence****, which is closely related to fluorescence, occurs when an ultraviolet light is turned off, yet a mineral retains its glow for a period of time because of the delayed, slow release of excess energy.*

Fluorite and certain other minerals can exhibit ***thermoluminescence*** *by emitting visible light when slightly heated. In this case, thermal energy excites the electrons, which then emit visible light as they fall back to their normal levels.* ***Triboluminescence****, also called "mechanoluminescence" or "fractoluminescence," results from breaking, scratching, or cleaving certain minerals. The mechanical stresses generated by physically breaking atomic bonds excite electrons, which release their excess energy in tiny, bright flashes of white and yellow light.* ***Radioluminescence*** *is produced when X-ray bombardment energizes the electrons of certain minerals.*

Color zoning, color banding, and multi-coloration, all common in fluorite, originate during the crystallization process. Fluorite veins form from the crystallization of hydrothermal solutions, with emplacement occurring rapidly or slowly, or in single or multiple phases. Fluorite formed in rapid, single-phase vein emplacement usually has a single color. But during slow or multiple-phase emplacement, the chemistry of the

hydrothermal solutions can change, resulting in well-defined color banding with two or more colors. Fluorite is relatively abundant and forms in several mineralogical environments. In epithermal (low-temperature) veins, it is associated with calcite [calcium carbonate, $CaCO_3$], rhodochrosite [manganese carbonate, $MnCO_3$], and chalcedony [microcrystalline quartz, silicon dioxide, SiO_2]. In hydrothermal replacement deposits, it occurs with galena [lead sulfide, PbS], pyrite [iron disulfide, FeS_2], sphalerite [zinc sulfide, ZnS], and barite [barium sulfate, $BaSO_4$], and it is a common gangue mineral with lead, zinc, and silver ores. Fluorite also occurs with albite [sodium aluminum silicate, $NaAlSi_3O_8$] and pyrite in carbonatites, with calcite and spinel [magnesium aluminum oxide, $MgAl_2O_4$] in the hornfels of contact metamorphic rocks, and occasionally with albite in granite pegmatites.

The Dana classification number 9.2.1.1 identifies fluorite as a halide mineral (9), while the subclassification (2) defines it as an anhydrous or hydrated halide with the general formula AX_2, in which "A" can be calcium, barium, or the rare-earth element yttrium (Y), and "X" is any halogen element. Finally, fluorite is in the fluorite group (1) as the first (1) of three members. The other two members, which share similar physical properties, are frankdicksonite [barium fluoride, BaF_2] and tveitite-Y [calcium yttrium fluoride, $Ca_{14}Y_5F_{43}$]. Like to see a nice specimen of tveitite-Y!

COLLECTING LOCALITIES

Among elements making up the crust of the earth, calcium (Ca) ranks fifth and fluorine (F) thirteenth, meaning that fluorite occurs in thousands of sites worldwide, so we can list only the better-known specimen or mining localities. Our specimens were collected at the Huangshaping lead-zinc mine near Huangshaping, Yizhang County, Chenzou Prefecture, Hunan Province, Peoples Republic of China. Lead-zinc operations within Chenzou Prefecture that also supply fluorite specimens are the Yaogangxian, Dongpo, Xianghualing, Chashan, and Xianghuapu mines. Other Asian localities include the Pouvya and Dodo mines at Tyumenskaya Oblast' in the Polar Urals of the Western-Siberian Region, and the Aunik fluorite-rare metals deposit at Buriatia in Transbaikalia in the Eastern-Siberian Region, both in Russia. Fine specimens come from Pakistan's Northern Areas, notably from the Nagir and Chumar Bakhoor area of the Hunga Valley in the Gilgit District, and the Baha and Apo Ali Gun areas near Baltistan.

European fluorite specimens come from the Lassedalen fluorite deposit and the Kongsberg silver mines near Kongsberg, Buskerud, Norway; the Manhem, Kåravet, and Finnbo mines at Falun, Dalarna, Sweden; the La Florina and Gloria mines at Hornachuelos near Córdoba, Andalusia, Spain; the Bella Fluorite mine at Pákozd in the Velencei Mountains of Fejér County, Hungary; the Badenweiler lead-mining district in the Black Forest region of Baden-Württemberg, Germany; and numerous marble quarries at Carrara in the Apuan Alps of Massa-Carrara Province, Tuscany, Italy. In England, fine specimens come from the Rogerley and Hollywell mines at Weardale in the North Pennines area, and from the historic Blue John and Old Tor mines and the Treak Cliff Cavern at Castleton, Derbyshire, both in Durham County.

In Africa, fluorite specimens occur in Namibia at the Okoruso Mine in the Otjiwarongo District and the Kombat Mine in the Grootfontein District, both in the Otjozondjupa Region. In Morocco, fluorite comes from the El Hammam Mine at Meknès in the Meknès-Tafilalet Region. Among South Africa's localities are the Aladdin Fluorite Mine at Sinkwazi in KwaZulu-Natal Province and the Marico Fluorspar Mine in the Marico Mining District of Northwest Province. In Zimbabwe, specimens occur in the many lead-zinc mines of the Hwange Mining District of the Matabeleland North District.

Fine South American specimens come from Peru's Huaron Mining District at Cerro del Pasco in Pasco Department and the Pasto Buena Mining District of Ancash Department. Bolivian specimens are collected at the Mururata and Chojlla mines in Sud Yungas Province of La Paz Department. In Australia, fluorite

occurs at the Sandy Creek fluorite deposit at Walwa in Victoria, the Cannington silver-lead-zinc deposit in the Mt. Isa-Cloncurry area of Queensland, and the Gulf Fluorite Mine at The Gulf in New South Wales.

Fine Mexican fluorite is found in the Cantera and Asturiana mines near Mun. de Zacatecas in Zacatecas, and at the China, Ojuela, and Reina mines at Mapimi in Durango. Canadian specimens are collected at the Rogers Fluorspar Mine at Madoc in Huntingdon Township, Hastings County, Ontario; at the Poudrett, Uni-Mix, and Desourdy quarries at Mont Saint-Hilaire, Rouville County, Québec; and at the potash mines at Penobsquis, Kings County, New Brunswick.

The United States has supplied many superb fluorite specimens, most notably from the Illinois-Kentucky Fluorspar District, which includes the mines of the Cave-in-Rock and Ozark-Mahoning subdistricts of Hardin County, Illinois, and those of the Babb, Commodore, Tabb, and Dike-Eaton subdistricts of Crittenden and Caldwell counties, Kentucky. Other notable sites include the aforementioned Elmwood mine, Carthage, Smiith County, Tennessee; the Capital and Ten-Acre quarries in Johnston County, Oklahoma; and the Kelly Island Stone Quarry at Clay Center in Ottawa County, Ohio. Colorado localities include the Sweet Home Mine at Alma, Park County; the Barstow Mine near Ouray in Ouray County; and the Browns Canyon Fluorspar District in Chaffee County. The William Wise Mine in Westmoreland, Cheshire County, New Hampshire, produces faceting-quality green fluorite. New Mexico's fluorite sources include the Fluorite Ridge Mining District in Luna County, the Hansonburg Mining District near Bingham in Socorro County, and the Pine Canyon Deposit near Tyrone in Grant County.

JEWELRY & DECORATIVE USES

Faceted fluorite gems were popular in Europe during the 1600s, when color varieties were known as "false emerald," "false ruby," and "false amethyst." As a gemstone, fluorite has both positive and negative qualities. It has excellent transparency, a range of pleasing colors, a vitreous luster, and it occurs in crystal sizes that can be cut into large gems. Unfortunately, at Mohs 4.0, it is too soft to endure everyday jewelry wear and its refractive index of 1.43 is among the lowest of all gem materials. Furthermore, fluorite's perfect four-directional cleavage makes cutting difficult. Despite these problems, limited numbers of fluorite cabochons and faceted gems are available today in pendant and brooch mounts. Fluorite collector gems—gems intended for display and study rather than jewelry use—are very popular in weights ranging from only a few carats to several hundred carats. The Smithsonian Institution in Washington, D.C. displays several spectacular fluorite gems, the largest weighing 492.1 carats.

Fluorite has served as a decorative stone since antiquity. The Egyptians carved figurines from massive fluorite as early as 2000 B.C. The Romans also carved fluorite, most notably the blue-purple-yellow banded "blue john" (the name derives from the French *bleu et jaune* or "blue and yellow") material mined in England. By 1500 A.D., the Chinese were carving blue and green massive fluorite into figurines with a jade-like appearance. Today, massive fluorite is fashioned into spheres, dishes, figurines, vases, and other ornamental objects.

Most of this colorful massive fluorite comes from China, in beautiful bands of color, mostly light green, amethyst-like purple, clear, and rarely, blue. Chinese geologists report that these massive deposits formed, layer by layer, directly from vapor. The clear zones consist of pure fluorite, while the lovely colors are imparted by trace elements trapped in the crystal structure during crystallization. We have sold thousands of beads, pendants, earrings, massage tools, animal figurines, bowls, cups, and vases made from this fabulous fluorite over the years. As explained, cubic fluorite crystals can easily be cleaved to make octahedrons, and this is commonly done with fluorite from China, southern Illinois, and other places. Chances are if you have such a loose crystal, it was cleaved by miners from one of these sources.

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Because of its affordability, large crystal size, often exceptional crystal development, and range of pleasing colors, fluorite, as both individual and composite specimens, is among the most widely collected of all minerals. One could build a large collection of unique examples of fluorite from around the world!

HISTORY & LORE

Greek metalworkers used fluorite smelting fluxes as early as 600 B.C. The Romans later mined fluorite in Spain and England as a smelting flux for both lead and silver ores. By 1500 A.D., German miners routinely used fluorite, which they called *flusse* or *flusspat*, as a smelting flux. In his classic *De re Metallica,* German scholar Georgius Agricola (Georg Bauer, 1494-1555) described in detail the use of *fluss spat*, which he called "*lapides igni liquiscentes*," literally "stones that become liquid in fire." Agricola renamed *flusspat* with the Latin word *fluere*, "to flow," a word that later became anglicized to "fluor" and "fluorspar."

In 1670, the German glassworker Heinrich Schwanhard (vita uncertain) treated *flusspat* with sulfuric acid to produce another acid that he called *flusspatäure* (literally "acid of *flusspat*") that could etch glass, a material previously thought to be impervious. The availability of *flusspatäure* imparted a new creativity to the art of glassmaking. Both fluorspar and *flusspatäure* clearly contained a mysterious and powerful unknown element, and identifying and isolating it became the goal of many leading scientists.

Although not yet isolated, the mysterious element in fluorspar was named in 1813. French physicist André Marie Ampère (1775-1836), aware of this element's hazardous nature, proposed the name *phtor*, the Greek word for "destructive." But English chemist Sir Humphry Davy (1778-1829) favored the word "fluorine" from the traditional "fluorspar." In 1826, researchers devised the words "fluoride" for fluorine-containing compounds and "hydrofluoric acid" (HF) for *flusspatäure*. Fluorspar received its current name—fluorite—in 1868.

At that time, researchers grossly underestimated the hazards of fluorine and some of its compounds. Those who lost their health or their lives by inhaling or having physical contact with the various acids and vapors produced from fluorite became known as "fluorine martyrs." Among these are the scientists Sir Humphrey Davy, Louis Jacques Thenard (for whom our August 1999 featured mineral, thenardite, was named), Joseph Louis Gay-Lussac, Jerome Nickels, and Pierre Louyet.

Finally, in 1886, French chemist Ferdinand Frederick Henri Moissan (1852-1907) isolated pure fluorine by electrolytically reducing hydrofluoric acid and potassium fluoride (KF). Moissan showed that fluorine was the most chemically reactive of all the elements. For his work with fluorine, Moissan was awarded the Nobel Prize for chemistry in 1906. When Moissan died a year later at age 55, his colleagues suspected that his death had been hastened by exposure to fluorine.

The Illinois General Assembly designated fluorite as Illinois' official state mineral in 1965, a time when the state was still the nation's leading fluorspar source. Fluorite has appeared on the 10-centime stamp of Switzerland in 1961, the 2-cent stamp of Namibia in 1991, the 80-tyiyn stamp of Kyrgyzstan in 1994, the 80-cent stamp of Kenya in 1977, the 5-franc stamp of France in 1986, and the 2.40-dinar stamp of Algeria in 1983. In testimony to its collector popularity, fluorite has also been featured on the cover of *The Mineralogical Record* eight times.

In the 1700s, physicians administered powdered fluorite to relieve the symptoms of kidney disease, and placed fluorite crystals against joints to alleviate the pain of arthritis and rheumatism. Today, metaphysical practitioners use fluorite crystals to calm the spirit and mind in preparation for meditation, to increase objectivity and concentration, and to clarify the decision-making process. Modern-day crystal believers

also assign special powers to individual fluorite colors, saying that green energizes the heart and mind, blue provides inner peace, purple focuses the mind, and yellow facilitates group communication.

TECHNOLOGICAL USES

Fluorite, which is still called "fluorspar" in its mining appellation, has many industrial uses, most importantly as a metallurgical flux in certain metal-smelting processes and in the production of high-purity stainless steel. Because of the fluorine ion's extremely high level of chemical activity, fluorite is a superb metallurgical flux that readily combines with chemical impurities to form volatile fluorides, which are driven off as vapors. Fluorite's calcium component combines readily with silicates to form calcium silicate, which is removed as slag.

Fluorite is the primary source of fluorine to manufacture hydrofluoric acid, an important feedstock for the chemical and pharmaceutical industries. An array of fluorocarbon compounds are used as refrigerants in home and automotive air conditioners, and in the manufacture of such fluoropolymers as the Teflon™-type materials widely used in valves, pipes, and cookware. Flawless, transparent fluorite was once cut into apochromatic lenses free of all chromatic and spherical aberrations for special infrared optical uses (synthetic fluorite is used today).

Large amounts of hydrofluoric acid are used to prepare uranium hexafluoride (UF_6), the key to gas-diffusion concentration of the uranium-235 isotope needed to fashion nuclear fuel rods and the fission components of nuclear weapons. Fluorite is also the feedstock for the production of aluminum fluoride [AlF_3] and synthetic cryolite [sodium aluminum fluoride, Na_3AlF_6], which are vital to aluminum smelting. In this process, alumina (refined bauxite ore) is dissolved in a molten mix of aluminum fluoride, synthetic cryolite, and fluorite prior to the electrolytic recovery of aluminum metal.

From our March 2002 fluorite write-up: "In 1915, one of the greatest advances in dentistry took place, when the population of certain areas of Colorado were found to have a low rate of dental decay. Research showed that the drinking water in these areas contained fluorides, fluorine combined with other chemicals. Despite the objections of opponents to what they call forced medication, most of the U.S. drinking water is now fluoridated, at a ratio of one part fluoride per million parts water. Tooth decay in the U.S. has declined tremendously since the introduction of fluorides. (When fluorine is added to drinking water as fluoride, it recombines with the hydroxylapatite in our teeth to form fluorapatite, which is more resistant to decay, and we have less cavities and dental problems as a result.)

"Fluorine also was used in combination with chlorine and carbon to form the chlorofluorocarbons, or CFCs, which are odorless and nonpoisonous liquids or gases such as Freon, that were used as a dispersing agent in aerosol sprays and as a refrigerant and in air conditioning. Now, of course, the use of CFCs is banned in the U.S. and other countries because of the damage the chlorine from CFCs is doing to the all-important ozone layer. How ironic it is that the gas whose discovery claimed the lives of prominent scientists is now beneficially used to prevent tooth decay but is not the ozone-harming part of the chlorofluorocarbon equation!"

Fluorspar is mined by both underground and open-pit methods, mostly from epithermal vein-type deposits. It has two commercial grades: Acid-grade fluorspar, used for chemical manufacturing, contains at least 97 percent fluorite; subacid-grade fluorspar, used as a metallurgical flux, contains less than 97 percent fluorite. Some 2.8 million metric tons of fluorspar, with an average value of $200 per metric ton, are mined worldwide each year, mostly in China. Fluorspar production in the United States halted in 1995, and the nation now imports nearly 700,000 metric tons each year.

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ABOUT OUR SPECIMENS

As noted previously, our fluorite specimens were collected at the Huangshaping lead-zinc mine near the town of Huangshaping, Yizhang County, Chenzou Prefecture, Hunan Province, Peoples Republic of China. Huangshaping (pronounced hwang-sha-PING) is located in southern China roughly 250 miles north-northwest of Hong Kong.

The Huangshaping mine, a small but rich source of lead and zinc, is located in the highly mineralized Xianghualing Polymetallic District that contains deposits of lead, zinc, tungsten, molybdenum, and copper ores. The origin of this mineralization began with the massive crustal deformation that accompanied the opening and closing of the ancient Tethyan Ocean. This crustal deformation included several orogenies or mountain-building episodes, among them the Triassic Indosinian Orogeny some 220 million years ago, the Jurassic and Cretaceous Yanshanian Orogeny between 180 and 120 million years ago, and the Tertiary Himalayan Orogeny just 40 million years ago. The origin of the Huangshaping mineralization is specifically related to the tectonic collision of the South China and North China cratons (stable sections of continental crust) and the westward subduction of the Paleo-Pacific Plate. The resulting tectonic stresses uplifted and fractured great sections of basement rock, enabling magma to surge upward into older carbonate sedimentary rocks.

These magmatic intrusions created two types of mineralization: skarns and magmatic hydrothermal deposits. Skarns form from metasomatism (the introduction of new elements into rock) during contact metamorphism. At Huangshaping, the intruding granitic magma introduced lead, zinc, sulfur, fluorine, and other elements into metamorphosing carbonate-rich limestone and dolomite. In hydrothermal emplacement, mineral-rich superheated solutions associated with the magma were forced into faults and fissures in the surrounding country rock to form vein- and replacement-type structures rich in lead and zinc sulfides.

Figure 1 Mine facilities at the nearby Xianghualing mine, showing the topography of the region. All photos courtesy of Collector's Edge Minerals, Inc.

Although the Huangshaping lead-zinc deposit has been known for a century, its commercial development didn't begin until 1967, when the newly established Hunan Nonferrous Metals Corporation began exploring the complex deposit. Production finally commenced in the mid-1980s. Today, the Hunan Nonferrous Metals Corporation, a privately held, international minerals resource company, controls two other underground lead-zinc operations not far from Huangshaping—the Hsikwangshan and Shizhuyuan mines.

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Figure 2 Mine buildings at Huangshaping. With the light reflecting off the roofs, the buildings look like cubes of Spanish pyrite–we've reached the point where everything looks like a mineral to us!

The Huangshaping lead-zinc mine is a shaft-served underground operation with 300 employees. The ore, quite rich by modern standards, contains four percent lead and eight percent zinc. The ore minerals are galena and sphalerite, with smaller, by-product amounts of wulfenite [lead molybdenum oxide, PbMoO4] and molybdenite [molybdenum disulfide, MoS_2]. The primary gangue minerals are fluorite, calcite, pyrite, and the selenite variety of gypsum [hydrous calcium sulfate, $CaSO_4 \cdot 2H_2O$].

Despite 20 years of intensive mining, Huangshaping still has proven reserves of 230,000 metric tons of zinc ore and 122,000 metric tons of lead ore. At the current rate of mining—about 100 metric tons per day—these reserves will last for more than a decade. Meanwhile, an extensive diamond-core-drilling program is currently delineating new ore bodies below the mine's 1,600-foot-deep lowest level that will likely extend production by as many as 15 more years.

Our fluorite specimens were collected by miners from vugs within veins of lead-zinc ore in the lower production levels of the mine. While ore production always receives priority, the current policy at Huangshaping and other mines of the Hunan Nonferrous Metals Corporation allows supervisors to authorize miners to collect valuable specimens in a manner that does not interfere with production.

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Other minerals are found here, including calcite in fascinating forms, so specimen-producing potential is high. Proceeds from the sale of these specimens are reportedly shared between the company, supervisors, and miners. Arrangements such as this, together with the development of many new metal mines, have now made China by far the world's largest source of quality fluorite specimens.

Figure 3 Collecting underground at the Huangshaping mine.

When examining your specimen, what do you notice first? Perhaps the lovely light green color. The color is due to minute amounts of iron ions that were trapped in the crystal lattice as it was forming. However, when viewed under longwave ultraviolet light, a pretty purple color is given off! Shortwave ultraviolet light seems to have no effect on our specimens.

Or you might have noticed the transparency of many of the crystals, allowing us a glimpse inside, to see the veils, inclusions, phantoms, and other fascinating growth features. Phantoms occur as a result of multiple layers of crystal growth, as explained in the last paragraph on page 3. A thin layer of another mineral may form on top of the original fluorite crystal growth, and then additional fluorite may grow and encapsulate it. This thin layer then may be visible within the crystal, having a rather ghostly appearance, hence the name "phantom." This can occur several or more times, so that some minerals have multiple phantoms. Do you see any in your specimen?

It may have been the sharpness of the crystals faces that caught your attention. Cubes are the most common form for fluorite, and we have lots of those, sometimes modified at the corners by octahedral faces. Penetration twins are often common, giving the appearance of two crystals that have been pushed into each other! Crystals that grow side by side can also infiltrate one another, leading to strange and mesmerizing crystals habits. How many of the features can you identify in your specimen?

Beautiful color, translucence that allows a look inside, incredibly sharp and excellent crystal forms, fluorescence under longwave light–our Huangshaping fluorite crystals have it all! One day, we may catch up to the *Mineralogical Record* in the number of times fluorite is featured!

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