March 2002 Mineral of the Month: Fluorite

"Several localities in England are famous for magnificent crystal groups." "Superb examples are furnished by English lead mines." "Most beautiful specimens have been found in great abundance in the iron mines of Northern England." "Fluorite is found in quantity in England . . . famous for their magnificent crystallized specimens." These are just a few of the quotes regarding the fabulous fluorites of northern England, where the mines have all been closed, with one exception, as we will see.

PHYSICAL PROPERTIES

Chemistry: CaF_2 Calcium Fluoride
Class: Halides
Dana's: Anhydrous and Hydrated Halides
Crystal System: Cubic
Crystal Habits: Crystals common, usually cubes, less often octahedrons; Frequently massive, coarse to fine granular; Occasionally earthy; Rarely, columnar, fibrous, or globular
Color: Colorless, white, and shades of purple, green, blue and yellow; Rarely, pink or red
Luster: Vitreous; Dull in massive varieties
Transparency: Transparent to translucent
Streak: White
Refractive Index: 1.434
Cleavage: Easy and perfect in four directions
Fracture: Flat conchoidal, splintery, or uneven
Hardness: 4
Specific Gravity: 3.18
Luminescence: Often fluorescent in shortwave and longwave ultraviolet light, usually blue, but other colors as well; Occasionally, triboluminiscent
Distinctive Features and Tests: Crystal shape; Prominent octahedral cleavage; Violently decrepitates in flame; Decomposed by hot concentrated sulfuric acid, giving off highly deadly poisonous fumes of hydrofluoric acid
Dana Classification Number: 9.2.1.1

NAME

The name, pronounced flū′ ŏr īt, was given in ancient times from the Latin *fluere*, "to flow," since it melts more easily than other minerals with which it was confused. Synonyms include fluor and fluorspar. A variety that produces green triboluminescence is called chlorophane.

COMPOSITION

Pure fluorite consists of the elements calcium and fluorine. Native fluorine is a pale, greenish-yellow gas, slightly heavier than air, poisonous, corrosive, and of penetrating and disagreeable odor, and when combined with other elements to form solids, is the 17th most abundant element in the crust of the earth.

Since the Middle Ages, scientists have been attempting to understand the nature and chemical composition of minerals. Several scientists have given their lives trying to ascertain the chemical composition of fluorite! Evidently they were able to isolate and identify the calcium in fluorite, but in their attempts to isolate fluorine by combining it with other compounds, they would end up creating highly toxic fluids and fumes! Some of the scientists killed by fluorine poisoning include Sir Humphrey Davy, Louis Jacques Thenard (for whom our August 1999 featured mineral, thenardite, was named), Joseph Louis

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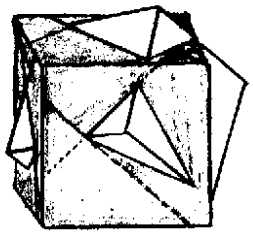
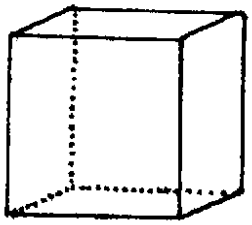
Gay-Lussac, Jerome Nickels, and Pierre Louyet. Finally, in 1886, a French scientist named Henri Moissan safely isolated and identified the gaseous element fluorine.

Before he perished from fluorine poisoning, Sir Davy had identified the element calcium in fluorite, in 1808. Calcium is a metallic element, the fifth most abundant in the earth's crust. Native calcium is never found in nature, but is always combined with one or more other elements. Our teeth and bones contain calcium, as do many of our bodily fluids essential to muscle contraction, the transmission of nerve impulses, and the clotting of blood.

The different colors of fluorite are due to trace (small) amounts of other elements or organic compounds that become trapped in the growing crystal. Often the trace elements are of the rare-earth elements group as we will see, giving us another reason for our special attraction to beautiful fluorite crystals. Large fluorite crystals are often composites of innumerable tiny fluorite crystals, and upon close examination of a crystal face, an uneven surface gives evidence of this kind of growth. Twins are common in fluorite, usually as interpenetrating cubes, twinned on crystal face {111}, as shown in the drawing to the right. Fluorite crystals are overgrown on other fluorite crystals, sometimes of a different color and crystal form, and sometimes a fluorite cube will show an octahedral growth underneath, as if in the later growth period, only the corners grew! So be sure always to look closely at fluorite crystals for phantoms and other signs of previous growth.



Fluorite octahedron



Fluorite cube

COLLECTING LOCALITIES

Fluorite is one of the most common minerals and beautiful specimens come from a number of places. Gorgeous pink-to-red octahedrons come from the Swiss and French Alps in Europe, and a well-known clear-to-yellow-to-purple fluorite called Blue John comes from North Derbyshire, England. Gorgeous specimens have been coming of late from Hunan Province, China, the Primorsky Kray region of eastern Russia, as well as wonderful specimens from Mexico, and many other places. We will delve into the home of our specimens in *About Our Specimens.*

JEWELRY & DECORATIVE USES

Though it has low refractive index (1.434) and dispersion (.007), fluorite is still quite desirable as a lapidary material because of its clarity and range of colors. Of course, its main drawbacks are its low hardness, its perfect cleavage in four directions that makes it difficult to cut and polish, and especially its brittleness. Fluorite breaks much too easily to be used in fine jewelry, and faceted stones should be used only for display in collections. A couple of large gemstones in collections are the 1,032-carat yellow fluorite called “Spirit of the Cave,” and a blue-violet and green stone weighing 3,969 carats.

In banded massive form, fluorite is a wonderful material for carvings and the like, as long as one realizes its fragile nature. There are several huge deposits in China currently producing large quantities of fluorite in alternating bands of purple, green, and occasionally blue, with clear zones in between. This fluorite is being carved into animals, massage tools, geometric shapes, egg, spheres, cups, bowls, candle holders, freeform sculptures, and other items of great beauty. It is also used for inexpensive pendants and earrings, but buyers should always be warned that one good whack is often all it takes to break it. Another

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beautiful massive variety is called rainbow fluorite and comes in bands of clear, yellow, and green, a wonderful stone for carvings and for inexpensive jewelry.

Of course, large, showy, fluorite specimens, often mixed with other minerals, make great decorative pieces for homes and offices. And we must mention the fluorite octahedrons that come from southern Illinois and other places in the Midwest, where the miners earn a little extra cash by taking six-sided cubes of fluorite and making them into octahedrons by placing a razor blade at just the right spot on each corner and tapping it with a small hammer, breaking off (or cleaving) each corner. The same thing can be done with a diamond, the hardest of all minerals.

TECHNOLOGICAL USES

Much can be said about fluorite as to its uses in our modern world, yet it has served mankind since ancient times as well. Crushed fluorite was added to molten glass to lower its melting point. Georgius Agricola, known as the Father of Mineralogy, described fluorite as being added to the smelting of ores in the mid-1500's.

Thirty years ago, three fourths of the world's annual production of fluorite was used as a flux in making steel. In an open-hearth steel furnace, fluorite is mixed in with scrap steel, pig iron, iron ore, and limestone and heated to the melting point of steel, about 3000°. The fluorite then combines with the impurities in the steel, forming a very free-flowing slag that is easily tapped off, leaving the purified steel behind.

Large quantities of fluorite are also used in the ceramics industry in the making of white enamel coatings for household fixtures and utensils, as well as decorative glazes used to ornament glass. Opal (or opalescent) glass contains fluorite, and special lenses were at one time made from fluorite because of its unique optical characteristics.

Fluorine is extracted from fluorite and used in a number of applications. Teflon, a plastic made with fluorine that is very resistant to most chemical action, is used as a coating on the inner surface of frying pans and other kitchen utensils to reduce the need for fat in cooking, and for making engine gaskets and dashboard accessories in cars. The space industry experimented with using fluorine as rocket fuel, but it proved too volatile and dangerous.

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!

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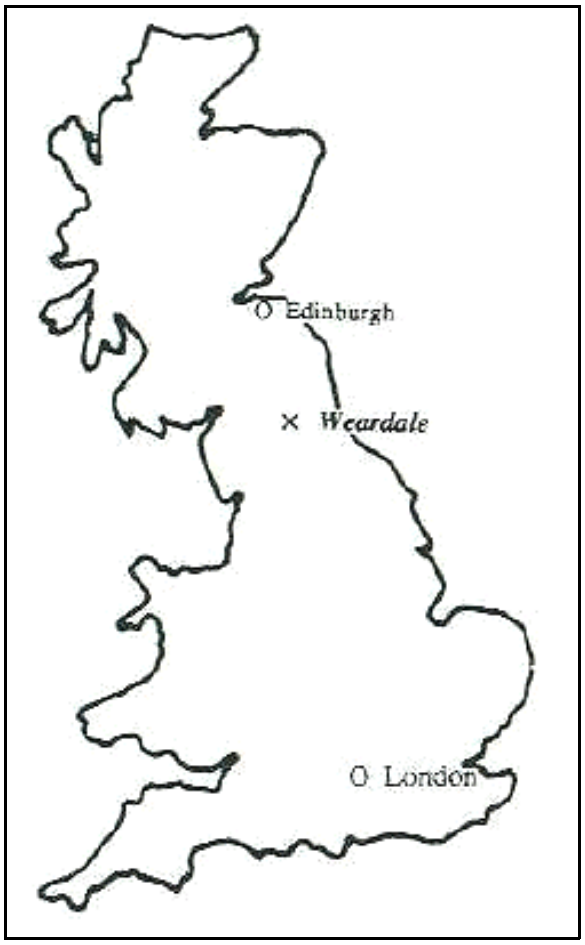
HISTORY & LORE

Fluorite has been known since ancient times as an ornamental material and was used by the Romans for carved drinking cups, bowls, and vases. Many other peoples, including the Chinese and native Americans, used it for ornaments and images. Native Americans used fluorite for carving effigies. In 18th century England, Blue John fluorite from Castleton, with its concentric bands of purple, blue, and white, was carved into vases, goblets, bowls, and cups, including a magnificent chalice of purple and white Blue John fluorite used by Queen Elizabeth II.

To modern-day crystal power believers, fluorite has a number of beneficial abilities, with specific powers assigned to many of the colors. In general, fluorite is believed to be able to stabilize and bring order to chaos, impart impartiality and unbiased reasoning, increase ability to concentrate, and to see both reality and truth behind illusion, among other powers. Green fluorite is said to eliminate negativity in a room.

ABOUT OUR SPECIMENS

"Several localities in England are famous for magnificent crystal groups." "Superb examples are furnished by English lead mines." "Most beautiful specimens have been found in great abundance in the iron mines of Northern England." "Fluorite is found in quantity in England . . . famous for their magnificent crystallized specimens." The reference books indeed have reverence for English fluorite!



Map courtesy of UK Mining Ventures

The Weardale district in County Durham, which includes the Rogerley mine where our specimens were dug, is in the heart of the fine fluorite producing area the above quotes were gushing about. This district sits in the northern Pennines or Pennine Chain, the principal highland region, said to form the backbone of northern England. Mining commenced in the region around Weardale in the twelfth century, with an emphasis on silver. At that time, Weardale was a forested area used as a hunting preserve by its owners, the Bishops of Durham.

By the 18th and 19th centuries, this forest was gone and mining for lead reached its zenith in the Weardale district. In the 19th century, iron ore was also mined from near surface-deposits of siderite [$Fe^{2+}CO_3$] and ankerite [$Ca(Fe^{2+},Mg,Mn)(CO_3)_2$] from some of the mines as was zinc. Declining lead prices in the 1800's forced the closure of many mines in the district. However, many were able to remain open as demand for fluorspar increased, as a flux used in steelmaking, as previously explained. Now the fluorite, which had been consigned to the dumps or used as backfilling, was of value. Fluorspar mining continued in Weardale throughout the 20th century, until the 1990's when competition from

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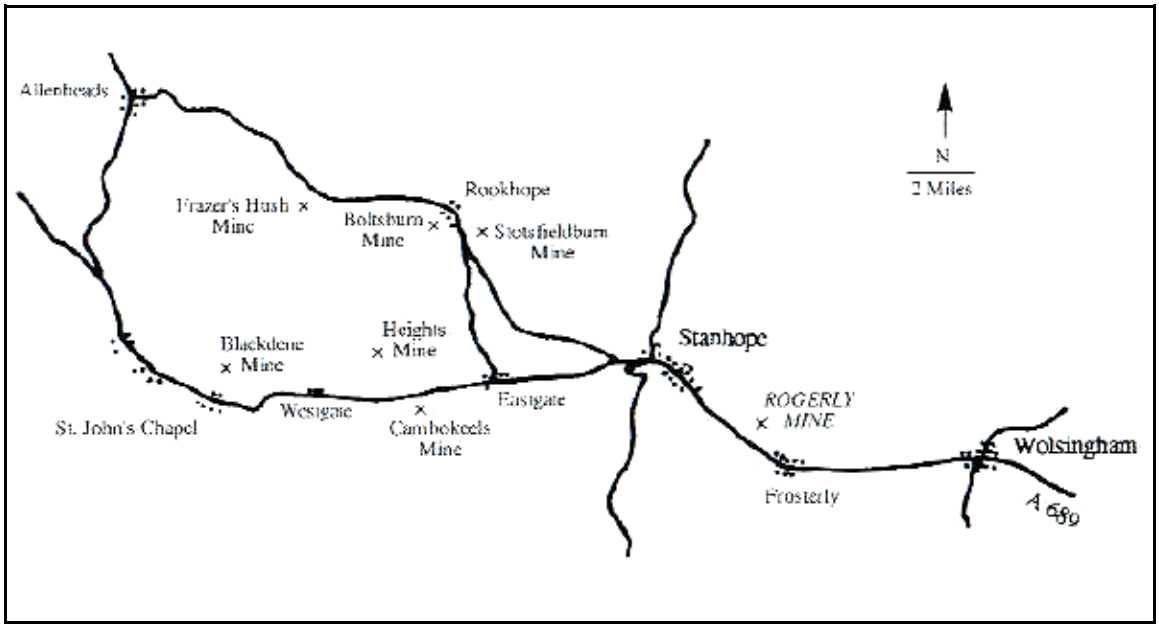

Important towns, villages, and specimen-producing mines in Weardale. Map courtesy of UK Mining Ventures

overseas sources (such as China) made it no longer economically viable. From 1666 through 1985, almost one million tons of lead was produced from Weardale, and two million tons of fluorite between 1850 and 1984!

Fortunately for mineral collectors, during the peak years of production in the Weardale district, interest in mineral collecting was high in England, and many of the mining companies allowed miners to collect and sell fine specimens to dealers and collectors. This is how many of the phenomenal fluorite specimens mentioned above came to grace collections the world over.

In the 1970's, a group obtained leases to work the Rogerley Quarry for commercial mineral specimens, a concept new in England at the time. This quarry had been a source of limestone used as flux for nearby iron foundries in the 19th century, and had long been abandoned. However, the team set their sights on a previously unworked fluorite vein, and, working only on weekends, managed to tunnel into the side of the quarry, where they discovered a number of wonderful specimens over the next 25 years. Health problems forced the sale of the venture to another group in the late 1990's, and specimen production continues, at a higher tunnel on the quarry wall. Much more information about the mineralogy and the ongoing collecting activities at the Rogerley mine can be found online at www.ukminingventures.com or by ordering a back issue of the January/February 2000 issue of Rocks & minerals magazine from Heldref Publications at (202)296-6267 or www.rocksandminerals.org.

Our specimens were collected in the past couple of years at Rogerley. The crystals are mainly cubes with many penetration twins, very much typical of fluorite. Some hint at the glassy, bottle-green color best known from Rogerley, but of course crystals of exceptional clarity and color sell for many times more than the Club price. The matrix is mainly silicified limestone, meaning that the original limestone has been replaced by silica [SiO_2], and as a result is very hard, making specimen recovery on matrix that

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much more difficult. A few of our pieces had some small octahedrons of galena [PbS], which are coated with a thin alteration layer of anglesite [$PbSO_4$]. Some of the fluorite crystals are lacking in luster because of a thin layer of another mineral that is included in it.

Of course, the most striking feature of our specimens is that they are, as the Mineralogical Record put it, "fiercely fluorescent." The enclosed "Fluorescence in Minerals" will give you some insight as to this phenomenon. In Weardale fluorite, it has long been thought that the fluorescence was caused by the presence of REE (rare earth elements) that cause lattice defects in the crystal structure which result in color centers. (For an explanation of color centers, see the March 2001 Topaz write-up under *Jewelry & Decorative Uses*.) This has been proven by testing on Rogerley fluorite, which has been analyzed and found to contain small amounts of the rare earth elements (also known as rare earth metals) yttrium, lanthanum, cerium, neodymium, samarium, europium, gadolinium, dysprosium, erbium, and ytterbium.

If you bring your specimen into sunlight, you will notice that some corners of the crystals give off a blue color, evidence that ultraviolet light from the Sun is affecting fluorescence to the point it can be seen even in broad daylight! And in a dark room under longwave UV light, the fluorite gives off the eerie blue-white color that English fluorite is so highly priced for by sophisticated collectors. So we will want to be alert when visiting shows and museums for more examples of the classic fluorite from northern England.

And when we examine our specimens, may we feel part of a long line of nature lovers who have appreciated the beauty of English fluorite under different wavelengths of light!

References: Mineralogy, John Sinkankas, Van Nostrand Reinhold Company; Dana's New Mineralogy, Richard V. Gaines, et al, John Wiley & Sons, Inc.; Fleischer's 1999 Glossary of Mineral Species, Joseph A. Mandarino, The Mineralogical Record, Inc.; Manual of Mineralogy, 21st Edition, Cornelia Klein & Cornelius S. Hurlbut, Jr., John Wiley & Sons; Dana's Minerals and How to Study Them, Fourth Edition, Cornelius S. Hurlbut & W. Edwin Sharp, John Wiley & Sons; Getting Acquainted with Minerals, George Letchworth English, McGraw-Hill; The Curious Lore of Precious Stones, George Frederick Kunz, Dover Publications, Inc.; Love Is In The Earth, Melody, Earth-Love Publishing House; The Rogerley Mine, Weardale, County Durham, England, Jesse Fisher, Rocks & Minerals January/February 2000

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