

Mineral of the Month Club March 2016

BARITE

This month's featured mineral is blue barite from the classic Stoneham locality in Weld County, Colorado. Our write-up explains barite's mineralogy and many uses; our special section discusses crystal structure as defined by the six crystal systems.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: BaSO₄ Barium Sulfate, usually containing traces of strontium or lead, sometimes containing traces of calcium or iron.

Class: Sulfates

Subclass: Anhydrous Sulfates

Group: Barite

Crystal System: Orthorhombic

Crystal Habits: Usually as intergrown clusters of bladed prisms or thick-to-thin, tabular crystals with sharp, often-beveled edges; also as granular, massive, fibrous, stalactitic, radiating, earthy, rosette, laminated, geodic, and globular-concretion forms.

Color: Most often white, gray, smoky, or colorless; also pale shades of yellow, gold, amber, brown, pink, and blue.

Luster: Vitreous to pearly

Transparency: Transparent to translucent

Streak: White

Cleavage: Perfect in one direction, good in a second, distinct in a third.

Fracture/Tenacity: Uneven; brittle.

Hardness: Mohs 3.0-3.5

Specific Gravity: 4.3-4.6

Luminescence: Often fluoresces yellow or orange under long-wave ultraviolet light; sometimes phosphoresces greenish-white or bluish-white.

Refractive Index: 1.634-1.648

Distinctive Features and Tests: Best field indicators are prismatic or tabular crystals with sharp, often-beveled edges; and unusually high density for a light-colored, transparent to-translucent mineral.

Dana Classification Number: 28.3.1.1

NAME: The name "barite," pronounced BARE-ite, stems from the Greek *barytēs*, meaning "weight" and alluding to the mineral's substantial density. Alternate names include "astapia," "baryntine," "barytite," "barytes," "boulonite," "calk," "calstronbarite," "dreelite," "schoharite," "tiff," "yellow spar," "blue spar," "golden spar," "heavy spar," and "barium spar." "Bologna stone" and "Bolognian spar" refer to a phosphorescent variety. Strontium-rich barite is known as

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“barian celestine,” “celestobarite,” and “barytocelestine.” Lead-rich barite is called “plumbobarite”; “calcareobarite” is a calcium-rich variety. In the United Kingdom, Canada, and Australia, the spelling is “baryte.” In European mineralogical literature, barite appears as *barit* and *barita*.

COMPOSITION & STRUCTURE: Barite, which consists of 58.84 percent barium (Ba), 13.74 percent sulfur (S), and 27.42 percent oxygen (O), is one of the nearly 200 members of the sulfate class of minerals. Sulfates consist of one or more metallic elements bonded to one or more sulfate radicals. In the sulfate radical (SO₄)²⁻, four oxygen ions 4O²⁻ positioned at the corners of a tetrahedron surround a single sulfur ion S⁶⁺. Although the physical properties of sulfates vary widely, most are light in color, transparent to translucent, fragile, and relatively soft. Because of its unusually strong ionic bonding, barite is one of the hardest sulfate minerals. As an allochromatic (other-colored) mineral, barite’s colors are due to traces of nonessential, chromophoric (color-causing) elements or to defects in the crystal structure. Barite exhibits a wide range of pale colors. Pure barite is colorless, but impurities such as iron and calcium alter its light-absorption characteristics to create golden, brown, smoky, yellow, and amber colors. Blues are caused by lattice imperfections called “color centers” that form when natural geophysical radiation displaces electrons from their normal orbital positions. As the most abundant barium-bearing mineral, barite occurs in carbonatites (carbonate-containing igneous and metamorphic rocks); in mesothermal and epithermal vein deposits; in massive, hydrothermal-replacement deposits; and as seam fillings and intergranular cements in limestone, sandstone, and other sedimentary rocks.

COLLECTING LOCALITIES: Barite sources in the United States are located in Colorado, Iowa, Arizona, Nevada, California, Illinois, Arkansas, Missouri, and Tennessee. Other localities are in Peru, Brazil, China, Germany, Greece, Sweden, Switzerland, Italy, England, France, Russia, South Africa, Mexico, Namibia, Australia, and Canada.

HISTORY, LORE & USES: Barite was described as a mineral species and named in 1837. Because it is soft and brittle, it has little use in jewelry. Barite crystals, usually in hues of gold or blue, are occasionally wrapped in silver wire for wear as pendants, usually for metaphysical purposes. Barite has many applications in science and industry, and in manufacturing consumer products. Barite ores are sandstones that contain as much as 50 percent barite by weight. Worldwide, open-pit mines produce 9.2 million metric tons of barite annually. Finely ground, refined barite sells for about \$180 per metric ton. Ninety percent of the barite supply is used to manufacture drilling fluids or “muds” for oil- and natural-gas-drilling operations. Barite is also the feedstock for the production of barium chemicals and barium metal. Because of its large molecular size and mass that readily absorbs X-rays and gamma rays, barite has many important uses in the medical and nuclear fields. According to modern metaphysical practitioners, barite helps heal the Earth, creates initiative to pursue dreams, facilitates independence, and enhances friendship, love, and harmony.

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ABOUT OUR SPECIMENS: Our specimens were collected at a classic blue-barite locality—a site near Stoneham in Weld County in northeastern Colorado. The tiny settlement of Stoneham, located at the junction of Colorado routes 14 and 17, is 125 highway miles northeast of Denver. At an elevation of 4,500 feet, Stoneham is located on the gently rolling high plains near Pawnee National Grassland. The collecting site, a low escarpment called the Chalk Cliffs, is four miles north-northeast of Stoneham. During the Oligocene Epoch some 25 million years ago, intense volcanic activity to the southwest produced dense clouds of calcium- and barium-rich ash that settled in layers to form the White River shale formation. Groundwater percolated downward through the shale, dissolving calcium and barium mineralization, then redeposited it as calcite and barite within seams of the lower shale strata. After erosion reduced the surface, the Chalk Cliffs remained as an isolated remnant of the once-overlying Oligocene shale. Today, the Chalk Cliffs appear as steep, rapidly eroding bluffs and deep gullies with exposed layers of soft shale and clay that contain seams filled with crystals of yellow calcite and blue barite. The crystal-filled seams and pockets within the shale-clay layers range in length from several inches to many feet. The barite is sometimes associated with drusy, white-and-yellow calcite. The blue color of the barite crystals is due to deformation of the crystal lattice caused by radiation emitted by trace amounts of radium. Barite crystals were first reported at the Chalk Cliffs in the late 1870s. By the 1950s, Stoneham was recognized as one of the top barite localities in the United States. But quantities of specimens became available only after commercial collectors began working the site with mechanical equipment in the 1990s. The site includes both public and private land. Because the private land at this site, which yielded the best specimens, is now closed, the prospects for future specimen availability are uncertain.

COMPREHENSIVE WRITE-UP

COMPOSITION & STRUCTURE

Barite's chemical formula BaSO_4 indicates that it contains the elements barium (Ba), sulfur (S), and oxygen (O). Its molecular weight is made up of 58.84 percent barium, 13.74 percent sulfur, and 27.42 percent oxygen. The chemically simple barite molecule consists of a single cation (positively charged ion) and a single anion (negatively charged ion). Barite's cation is the barium ion Ba^{2+} with its +2 charge. Its anion is a radical, which is a group of ions of different atoms that acts as an entity in chemical reactions. Barite's anion is the sulfate radical $(\text{SO}_4)^{2-}$, in which four oxygen ions positioned at the corners of a tetrahedron surround a single sulfur ion. The four oxygen ions 4O^{2-} each have a -2 charge and a collective -8 charge; the sulfur ion S^{6+} has a +6 charge. This total -2 anionic charge balances the +2 cationic charge to provide the barite molecule with electrical stability.

Barite is one of nearly 200 members of the large and complex sulfate class of minerals. Sulfate minerals consist of one or more metallic elements bonded to one or more sulfate radicals. In the sulfate radical $(\text{SO}_4)^{2-}$, the two negative charges are distributed evenly across the four oxygen ions. This enables the sulfate radical to bond to many different metal cations in various

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configurations that can accommodate such anions as hydrogen and halogen ions, and hydroxyl (OH^-), carbonate (CO_3^{2-}), and nitrate (NO_3^-) radicals. Many sulfate minerals are hydrous with attached molecules of water (H_2O) known as “water of hydration”; many are also rare. Although the physical properties of sulfates vary widely, most are light in color, transparent to translucent, fragile, and relatively soft.

Within barite’s closely packed crystal lattice, 10 oxygen ions surround and shield each barium ion so that the mineral exhibits no metallic properties. The barite lattice has both covalent and ionic atomic bonding. Strong covalent bonds with shared electrons join the sulfur and oxygen ions within the sulfate radicals. Ionic bonding occurs between the barium ions and the sulfate radicals, and also links the molecules within the crystal lattice. Ionic bonding is the force that joins positively charged, metallic ions with negatively charged, nonmetallic ions or radicals. In barite, the positively charged, divalent barium ion Ba^{2+} is attracted to the negatively charged, divalent sulfate radical (SO_4^{2-}). Because ionic bonding is inherently weak, most sulfates have varying degrees of solubility in water. But because barite’s unusually close atomic packing strengthens its ionic bonds, it is insoluble in water, resistant to alteration, and substantially harder (Mohs 3.0-3.5) than most other sulfates. Ionic bonding normally exerts omnidirectional strength, but barite’s orthorhombic crystal structure modifies this directionality. The orthorhombic system is characterized by three mutually perpendicular axes of different lengths, an arrangement that is reflected in barite’s bladed-prismatic and tabular habits. Because its ionic-bonding strength varies directionally with its unequal axial lengths, barite exhibits perfect cleavage in one direction, good in a second, and distinct in a third.

As an allochromatic (other-colored) mineral, barite’s colors are caused by traces of nonessential, color-causing elements called “chromophores,” or by defects in the crystal lattice. Barite exhibits a wide range of pale colors. Pure barite is colorless, but impurities such as iron and calcium distort the lattice and alter its light-absorption characteristics to produce gray, brown, and yellow hues; traces of manganese create pale-pink colors. Blue colors in barite are due to “color centers.” These are imperfections in the crystal lattice that form when natural geophysical radiation energizes and displaces electrons from their normal orbital positions. These energized electrons come to rest in vacant lattice positions called “traps,” where they absorb only certain wavelengths of visible light, while reflecting others. Many barite varieties are fluorescent under ultraviolet light. Some are also phosphorescent, continuing to emit visible light after incident-light sources have been removed.

Barite, the most abundant barium-bearing mineral, occurs with anhydrite [calcium sulfate, CaSO_4], apatite-(CaF) [formerly fluorapatite, calcium fluorophosphate, $\text{Ca}_5(\text{PO}_4)_3\text{F}$], and calcite [calcium carbonate, CaCO_3] in carbonatites (carbonate-containing igneous and metamorphic rocks); with calcite, quartz [silicon dioxide, SiO_2], and fluorite [calcium fluoride, CaF_2] in mesothermal and epithermal vein deposits; and with gypsum [hydrous calcium sulfate, $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$], dolomite [calcium magnesium carbonate, $\text{CaMg}(\text{CO}_3)_2$], and cerussite [lead carbonate, PbCO_3] in massive, hydrothermal-replacement deposits. It also occurs as

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intergranular cements and seam fillings in sandstone, limestone, and other sedimentary rocks. Sandstones containing as much as 50 percent barite by weight are the only ores of barite.

Barium, a soft, heavy, silvery metal, is one of the alkaline-earth metals listed under group IIA of the periodic table of elements along with beryllium (Be), magnesium (Mg), calcium (Ca), strontium (Sr), and radium (Ra). Because of their high chemical reactivity, alkaline-earth metals burn readily when heated in air and do not occur free in nature. Barium has a relatively high atomic weight of 137.33 (2.5 times that of iron) and a melting point of 1341° F. (727° C.). Because it oxidizes in air and reacts violently with water, elemental barium is stored in petroleum or other oxygen-free liquids to prevent contact with air and water.

The Dana mineral-classification number 28.3.1.1 identifies barite as an anhydrous sulfate or anhydrous acid sulfate (28). The subclassification (3) defines it by the general formula $A^{2+}XO_4$, in which "A" is a divalent ion of barium, strontium, or lead. "X" is the sulfur ion S^{6+} . Barite is then assigned to the barite group (1) as the first (1) of three members, the other two being celestine [strontium sulfate, $SrSO_4$] and anglesite [lead sulfate, $PbSO_4$]. All barite-group members crystallize in the orthorhombic system and differ chemically only in their metal cations. With their similar electrical charges and ionic radii, strontium and lead easily substitute for barium and are often accessory components of barite. Barium and strontium substitute for each other so readily that barite and celestine form a complete, graded, solid-solution series, with intermediate phases known as barian celestine, celestobarite, or barytocelestine. Barite also forms a partial, graded, solid-solution series with anglesite, with intermediate phases known as plumbobarite.

COLLECTING LOCALITIES

Our barite specimens were collected at the Chalk Cliffs near Stoneham in Weld County in northeastern Colorado, a classic locality for blue barite. Other Colorado localities include the Book Cliffs near Grand Junction, Mesa County; the Black Cloud Mine in the Leadville district, Lake County; the Rico Argentine Mine at Rico, Dolores County; the Wagon Wheel Gap Mine at Wagon Wheel Gap, Mineral County; and the Sunnyside Mine in the Silverton district, San Juan County.

Specimens are also collected at the Linwood Mine near Buffalo in Scott County, Iowa. Arizona sources include the Blue Ball Mine in the Globe-Miami district, Gila County; the Grandview Mine at Horseshoe Point, Grand Canyon National Park, Coconino County; the Mammoth Mine in the Mammoth district, Pinal County; and the Weldon Mine in the Osborn district, Pima County. In Nevada, barite occurs in Elko County at the Seventy-Six Mine in the Charleston district, the Judy Mine in the Cave Creek district, and the Big Bird and Barite claims in the Merrimac district. Other localities are the Cargo Muchacho district mines in Imperial County and the Lalkar Quarry at Santa Cruz in Santa Cruz County, both in California; the Cave-in-Rock mines in the Illinois-Kentucky Fluorite District, Hardin County, Illinois; the McKnight,

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Henderson, and Gap Mountain mines in the Fancy Hill district, Montgomery County, Arkansas; the lead mines in Morgan, Texas, St. Louis, and Washington counties, Missouri; and the Sweetwater district mines in Roane County and the Falls Branch-Greeneville district mines in Sullivan County, both in Tennessee.

In Europe, barite is collected at the Clara Mine at Oberwolfach, Black Forest Region, Baden-Württemberg, Germany; the Milos Mine, Milos Island, Kykládes District, Aegean Islands, Greece; the Muscadroxius-Tres Montes Mine at Silius, Sardinia, Italy; the Garpenberg Nora Mine, Garpenberg, Hedemora, Sweden; the Serpiano Mine at Serpiano, Ticino, Switzerland; Bromley Hill at Nenthead, Alston-Moor district, North Pennines, Cumbria, England; and the Les Farges Mine at Ussel, Limousin, France. Other sources include Dalnegorsk, Primoskiy Kray, Far-Eastern Region, Russia; the Elandsrand Mine at West Rand, Mpumalanga Province, South Africa; the Naica Mine at Naica, Chihuahua, Mexico; and the Rosh Pina Mine in the Lüderlitz District, Karas Region, and the Tsumeb Mine at Tsumeb, Otjikoto Region, both in Namibia. Australian specimens come from the Kintore Mine at Broken Hill, Yancowinna County, New South Wales; and Big Spring at Fitzroy Crossing, Ashburton Down, Western Australia. Canadian localities include the Bailey Mine at Madoc, Madoc Township, Hastings County, Ontario; Mont Saint-Hilaire, Rouville County, Québec; and the Rock Candy Mine at Grand Forks, Greenwood district, British Columbia.

Barite is collected in Peru at Cerro Huarihuyn at Miraflores, Huamalíes Province, Huánuco Department; the Casapalca Mine at Casapalca, Huarochiri Province, Lima Department; and the Herminia Mine, Julcaní district, Angaraes Province, Huancavalica Department. Brazilian specimens come from the Jacupiranga Mine at Cajati near São Paulo in São Paulo state. Among China's sources are the Wenyuhe barite deposit in Zhushan County, Shiyan Prefecture, Hubei Province; the Danegou and Lushi mines in the Xiaoqinling Ore Belt, Sanmenxia Prefecture, Henan Province; the Gangxi barite deposit in Xinhaung County, Huaihua Prefecture, Hunan Province; the Tuchengzi mine in the Jinzhou district, Dalian Prefecture, Liaoning Province; and the Huangboshuwan deposit in Zyang County, Ankang Prefecture, Shaanxi Province.

JEWELRY & DECORATIVE USES

Barite has little use in jewelry because of its softness and brittleness. Nicely developed barite crystals, usually in blue or gold colors, are occasionally wrapped in silver wire as pendants, often for metaphysical purposes. Barite is faceted into collectors' gems as large as 12 carats. Because of its substantial density, barite has a relatively high index of refraction (1.634-1.648), slightly greater than that of such gemstones as topaz [basic aluminum fluorosilicate, $\text{Al}_2\text{SiO}_4(\text{F},\text{OH})_2$] and peridot [forsterite, magnesium silicate, Mg_2SiO_4]. Barite's substantial index of refraction imparts a lively "sparkle" to properly cut collectors' gems. In desirable or unusual colors, flawless barite collectors' gems of 10 carats sell for about \$700.

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Collectors value barite, both as individual and composite specimens, for its range of colors, well-developed crystal forms, various crystal habits, substantial density, affordability, and association in composite specimens with other interesting minerals such as calcite.

HISTORY & LORE

Barite has been known since antiquity but attracted little attention until 1603, when Italian cobbler and alchemist Vincenzo Casciarolo (vita unknown) studied unusually heavy, translucent, white stones collected at Monte Paderno near Bologna in northern Italy. Casciarolo ground these stones to a powder, which he mixed with charcoal and heated. In the dark, the powdered stone emitted an eerie, bluish glow, leading Casciarolo to believe he had discovered the legendary “philosophers’ stone” that could transmute common metals into gold. Casciarolo named the stone *lapis solaris* (“sun stone”) and showed specimens to the Italian astronomer and physicist Galileo Galilei (1564-1642). A Galileo contemporary, Giulio Cesare La Galla (1576-1624), noted in his journal that *lapis solaris* seemed to “trap” both sunlight and firelight, then release it slowly in darkness—the first recorded observation of the phenomenon of mineral phosphorescence. *Lapis solaris*, or “Bologna stone” as it became known, attracted great attention among European alchemists.

Only after the discovery of the element barium could scientists determine the composition of “Bologna stone.” In 1774, Swedish chemist Carl Wilhelm Scheele (1742-1786) suspected that a heavy oxide in calcined lime contained traces of an unidentified metallic element. French chemist Louis-Bernard Guyton de Morveau (1737-1816) named this still-unidentified element “barote,” after the Greek *barytēs*, meaning “weight.” De Morveau’s colleague, French chemist Antoine-Laurent Lavoisier (1743-1794), later known as the “father of modern chemistry,” changed this name to “baryta.” Finally, in 1803, British chemist and physicist Sir Humphry Davy (1778-1829) electrolytically reduced the molten oxide to isolate a new metal that he named “barium.” In 1837, British chemists finally identified “Bologna stone” as barium sulfate, which they formally named “baryte,” the spelling that Britain, Canada, and Australia retain today. In 1922, physicists defined barite’s atomic structure using newly developed X-ray diffraction techniques.

“Rose rock”—intergrowths of rosette-shaped barite crystals with a reddish color due to included iron-stained quartz grains—is Oklahoma’s official state rock. Barite crystals have been featured on the 7.60-ron stamp of Romania in 2010, the 7,000-dobra stamp of São Tomé e Príncipe in 2006, the 132-metacal stamp of Mozambique in 2002, and the 0.49-Belgian-franc stamp of Belgium in 1997. Modern metaphysical practitioners believe that barite helps heal the Earth, creates initiative to pursue dreams without restraint, facilitates independence, and enhances friendship, harmony, and love.

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TECHNOLOGICAL USES

Ninety 90 percent of the barite supply is used to manufacture fluids or “muds” for oil- and natural-gas-drilling operations. Drilling muds were developed in the 1920s to alleviate problems associated with rotary drilling, especially the violent “blowouts” that occurred when drills penetrated deep, high-pressure gas and oil formations. Engineers determined that drill holes filled with dense, thick fluids exerted sufficient downward, hydrostatic pressure to counter these deep-formation pressures. Barite proved to be an ideal “weighting agent” in drilling mud because of its density, inertness, insolubility, nontoxicity, availability, and low cost. Barite-based drilling muds quickly solved the blowout problem. Today, improved formulations of finely ground barite and bentonite clay maintain drill-hole stability, cool and lubricate drill bits, and flush cuttings from drill holes.

Barite is the feedstock for the production of barium chemicals and barium metal. Barium compounds, especially highly refined barite (barium sulfate), have many uses. The large size and mass of the barite molecule creates a high radio-opacity or ability to absorb X-rays and gamma rays, making barite useful in the medical and nuclear fields. Finely ground, nontoxic barite is the key ingredient in the “barium milkshakes” used in X-ray diagnosis of the human gastrointestinal tract. X-rays pass through soft tissue, but are completely absorbed by the barite-based fluid to produce clearly defined gastrointestinal-tract images. Ground barite is a standard component of radiation-shielding “heavy cements” used in radioactive-waste containers, and in the radiation-absorbing glass of older computer and television screens. When added to glass mixtures, barite produces high-refraction, “leaded” crystal that, unlike lead-oxide crystal, is nontoxic. In paints, enamels, plastics, and paper, powdered barite serves as a filler and a glossing and weighting agent. The substantial weight of playing cards is also due to barite additives.

The most important of elemental barium’s relatively few uses is as a “getter” in electronic vacuum tubes. Because highly reactive barium bonds immediately with free oxygen, a trace of the metal placed within electronic vacuum tubes eliminates residual free oxygen to significantly extend tube life. Small amounts of barium alloyed with lead improve the performance of acid-storage batteries. Elemental barium also serves as a “carrier” when working with the radioactive element radium.

Open-pit mining of huge, shallow deposits of barite-enriched sandstone ore produces 9.2 million metric tons of barite annually worldwide. Because of barite’s considerable density (specific gravity 4.3-4.6), crudely crushed ore is quickly and inexpensively concentrated by hydraulic washing to yield “primary barite,” a 95-percent-pure concentrate that sells for \$180 per metric ton. China now accounts for half the world’s barite output, followed by India and Morocco. The United States ranks fourth, producing 650,000 metric tons of barite annually from four open-pit mines in Nevada and one in Georgia.

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MINERAL FORM: THE SIX CRYSTAL SYSTEMS (PART 1)

A Club member recently asked us to explain the basics of mineral form and we welcome the opportunity to explain the terms that define mineral form. The beautiful and often elegant form of crystals, with their regular, geometric shapes and smooth, flat faces is one of the most appealing aspects of minerals, and our write-ups always provide basic crystallographic descriptions of our featured minerals.

External crystal form, which reflects a mineral's internal atomic structure, is a diagnostic feature that is very useful in identifying minerals. Mineral crystals may seem to occur in a random and seemingly infinite variety of shapes, but behind this great diversity of form there exists a strict order. Crystal structure follows rigid mathematical laws and falls into six basic groups called systems: isometric (cubic), tetragonal, hexagonal, orthorhombic, monoclinic, and triclinic.

ISOMETRIC (CUBIC): This system is characterized by three axes of symmetry, all of equal length and at right angles to each other. Isometric crystals are usually blocky in shape with many similar, symmetrical faces. Minerals that crystallize in the isometric system are usually chemically simple. Common forms are cubes, octahedrons, and dodecahedrons; familiar examples are halite [sodium chloride, NaCl], fluorite [calcium fluoride, CaF₂], and pyrite [iron disulfide, FeS₂].

TETRAGONAL: Tetragonal crystals have three axes of symmetry; two are of equal length and lie in a plane at 90 degrees, the third is longer or shorter and at a right angle to the others. Tetragonal crystals are often long, slender, and even needle-like, and usually form four-sided prisms, pyramids, and dipyrramids. Examples are rutile [titanium dioxide, TiO₂], wulfenite, [lead molybdate, PbMoO₄], and zircon [zirconium silicate, ZrSiO₄].

HEXAGONAL: The hexagonal system is the only crystal system with four axes of symmetry. Three are of equal length and lie in a common plane at 120 degrees, which creates a six-fold symmetry; the fourth is longer or shorter and at right angles to the other three. Crystals are generally prismatic or columnar with rounded triangular or rectangular cross sections. The most recognizable forms are three- or six-sided prisms, although pyramids and rhombohedrons also occur. Common examples are quartz [silicon dioxide, SiO₂], beryl [beryllium aluminum silicate, Be₃Al₂Si₆O₁₈], and elbaite [tourmaline group, basic sodium aluminum lithium borosilicate, Na(Al_{1.5}Li_{1.5})Al₆(BO₃)₃(Si₆O₁₈)(OH)₂]. The TRIGONAL system, now considered a subsystem of the hexagonal system, has three-fold, rather than six-fold, symmetry. Minerals in the trigonal subsystem include calcite [calcium carbonate, CaCO₃], rhodochrosite [manganese carbonate, MnCO₃], and hematite [iron oxide, Fe₂O₃].

ORTHORHOMBIC: The orthorhombic system is characterized by three unequal axes, all at right angles to each other. Crystals are short and stubby with diamond-shaped or rectangular cross sections. Common forms are four-sided prisms, pyramids, and pinacoids (open forms with two parallel faces). Minerals with complex chemistries or complex bonding arrangements often form

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orthorhombic crystals. Examples are wavellite [basic hydrous aluminum fluorophosphate, $[\text{Al}_3(\text{PO}_4)_2(\text{OH},\text{F})_3 \cdot 3\text{H}_2\text{O}]$], topaz [basic aluminum fluorosilicate, $\text{AlSiO}_4(\text{F},\text{OH})_2$], and adamite [basic zinc arsenate, $\text{Zn}_2(\text{AsO}_4)(\text{OH})$].

MONOCLINIC: The monoclinic system has three axes of unequal length, two in a plane at right angles, and the third inclined to the plane of the other two. Crystals are usually stubby with tilted, matching faces at opposite ends suggesting distorted rectangles or orthorhombic crystals that are distorted in one direction. Characteristic forms are prisms and pinacoids. Examples are creedite [basic hydrous calcium aluminum fluorosulfate, $\text{Ca}_3\text{Al}_2(\text{SO}_4)(\text{OH})_2 \cdot 2\text{H}_2\text{O}$], realgar [arsenic sulfide, As_4S_4], and azurite [basic copper carbonate, $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$].

TRICLINIC: Crystals that fall into the triclinic system have three axes of different lengths, none perpendicular to the others. Because of its very low symmetry, triclinic crystal forms are restricted mostly to pinacoids that have no right angles on face edges. Triclinic crystal forms are often poorly developed and flattened with sharp edges and thin cross sections. Examples include microcline [feldspar group, potassium aluminum silicate, KAlSi_3O_8], turquoise [basic hydrous copper aluminum phosphate, $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$], and rhodonite [calcium manganese silicate, $\text{CaMn}_4\text{Si}_5\text{O}_{15}$].

These general descriptions of crystals in each of the six crystal systems are ideal. Almost all crystal shapes, however, are modified to greater or lesser degrees. As an example, the ideal, or “classic,” shape of the quartz crystal is a hexagonal prism with a six-sided, pointed termination. This ideal shape may not exist in nature; virtually all quartz crystals exhibit some modification and distortion caused by varying chemical and physical conditions that occur during the crystal-growth process.

Modifications of the ideal crystal form are known as habits, which are described by such terms as prismatic, drusy, and fibrous. Aggregates of crystals have their own habits, such as micaceous, radiating, and botryoidal. In the special section of next month’s write-up, we will discuss the terms that describe crystal habits and aggregate habits.

ABOUT OUR SPECIMENS

Our barite specimens are from a classic locality for blue barite—the Chalk Cliffs near Stoneham in Weld County in northeastern Colorado. Located at the junction of Colorado routes 14 and 17, Stoneham is 125 highway miles northeast of Denver and 28 miles south of the Nebraska state line. The nearest town of any size is Sterling, 25 miles to the east on Interstate 76. Stoneham, an unincorporated crossroads settlement, is located at an elevation of 4,500 feet on the gently rolling high plains near Pawnee National Grassland. The collecting site, a low-lying escarpment known as the Chalk Cliffs, is four miles north-northeast of Stoneham.

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The local geology began forming 25 million years ago during the Oligocene Epoch, when intense volcanic activity to the southwest produced dense clouds of ash. This ash, which carried elevated levels of barium mineralization, settled in layers and with other sediments formed the White River Group of Oligocene shale. Erosion later reduced the surface, but the Chalk Cliffs remained as an isolated remnant of the once-overlying Oligocene shale. Groundwater percolated downward through the shale, dissolving calcium and barium mineralization, which it redeposited as crystals of calcite and barite within seams of the lower shale strata. Some of the shale then altered into montmorillonite clay (a group of basic, hydrated clays containing calcium, sodium, magnesium, aluminum, and iron). The barite crystals, because of their insolubility in water, were not altered. Today, the Chalk Cliffs are a badlands area of steep, rapidly eroding bluffs and deep gullies with exposed layers of soft shale and clay with seams containing crystals of yellow calcite and blue barite.

The most productive section of the 20-acre collecting area is the western edge of the Chalk Cliffs. The crystal-filled seams and pockets within the shale and clay layers range in length from mere inches to more than 10 feet. Most of the barite crystals are an inch or two in length; exceptional specimens have measured more than eight inches. The barite is often associated with drusy, white-and-yellow calcite. Stoneham barite crystals are typically transparent, well developed, terminated, and often doubly terminated. In some specimens, blue barite crystals project upward from a drusy-calcite base. The barite crystals are usually white or pale blue and occur in clusters. The blue color is attributed to color centers (see “Composition & Structure”) that formed when radiation from traces of radium deformed the crystal lattice. The blue of the thicker crystals is comparable to the delicate color of fine aquamarine, the blue, gem variety of beryl [beryllium aluminum silicate, $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$].

Barite crystals were first reported at the Chalk Cliffs by railroad workers in the late 1870s who found large quantities of blue barite crystals scattered about the surface. The Chalk Cliffs have since been a popular collecting area for more than a century, and limited quantities of specimens have periodically appeared on specimen markets. By the 1950s, Stoneham was recognized as one of the top barite localities in the United States. But quantities of specimens only became available after commercial collectors began working the site with mechanical equipment in the 1990s. Excavating to a depth of more than 10 feet, these collectors made superb recoveries that confirmed Stoneham’s reputation as a classic, blue-barite site. Commercial collectors return periodically to gather specimens.

As you examine your specimen of blue barite, note first its delicate blue color which is due to color centers that formed from exposure to natural geophysical radiation. Note also the unusual density of the specimen. Barite has a specific gravity of 4.3-4.6, meaning that it is nearly twice as dense as quartz. You can easily detect barite’s unusual density simply by “hefting” your specimen in your hand. Some barite specimens may also small areas of white or yellow-white calcite.

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