

## November 2006 Mineral of the Month: Hemimorphite

This month's mineral is named for its most unusual property—hemimorphism, the tendency to show two different crystal habits on the same crystal. Our specimens were collected at the Wenshan Mine at the Dulong Tin-Zinc Deposit in Yunnan Province of the People's Republic of China, acclaimed as the world's premier source of blue, botryoidal hemimorphite.

### PHYSICAL PROPERTIES

Chemistry:  $Zn_4Si_2O_7(OH)_2 \cdot H_2O$  Basic Hydrated Zinc Silicate (Hydrated Zinc Silicate Hydroxide), often containing some copper and iron.

Class: Silicates

Subclass: Sorosilicates (Double-Tetrahedral Silicates)

Group: Hemimorphite

Crystal System: Orthorhombic

Crystal Habit: Usually as flat, elongated, bladed crystals or botryoidal crusts. Blades are vertically striated and form fan-shaped aggregates or coxcomb groups; botryoidal crusts often show rough crystal terminations that form ridged structures. Crystals are hemimorphic and exhibit different crystal habits at opposite ends, one a typical pyramidal termination, the other with slightly domed, pedion (geometrically unrelated) faces. Also massive, granular, and stalactitic. Twinning uncommon.

Color: Colorless, white, yellow, blue, or green. Less commonly reddish or brown.

Luster: Vitreous in larger crystals; duller in botryoidal and other compact forms.

Transparency: Transparent to translucent

Streak: Colorless

Cleavage: Perfect in one direction

Fracture: Uneven to subconchoidal, brittle

Hardness: 4.5-5.0

Specific Gravity: 3.4-3.5

Luminescence: Occasionally fluoresces blue under shortwave ultraviolet light.

Refractive Index: 1.614-1.636

Distinctive Features and Tests: General field indicators are crystal habit, color, density, and luster. Often confused with botryoidal forms of smithsonite [zinc carbonate,  $ZnCO_3$ ] and prehnite [basic calcium aluminum silicate,  $Ca_2Al_2Si_3O_{10}(OH)_2$ ], but hemimorphite is lighter than smithsonite and heavier than prehnite. Smithsonite effervesces in cold hydrochloric acid, while hemimorphite does not.

Dana Classification Number: 56.1.2.1

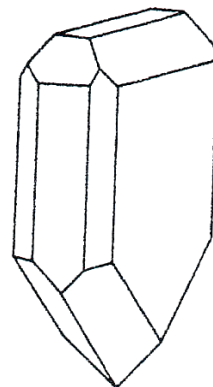


Figure 1. Hemimorphite crystal.

### NAME

The name of this month's mineral, which is correctly pronounced hemm-ee-MORF-ite, derives from its root words "hemi-," from the Greek *hemi*, or "half," and "morph," from the Greek *morphe*, meaning "form." The combined meaning is "half-form," referring to the mineral's hemimorphism, or tendency to form asymmetrical opposite terminations. Hemimorphite has also been known as "calamine," "calamina," "daviesite," "electric calamine," "emimorph," "galmei," "Geminer," "Kieselzinkerz," "Kieselzinkspath," "hemimorphit," "wagite," "hydrowillemitite," "zincglas," "zinc silicate," and "maggot-ore."

### COMPOSITION

The specimen you received this month could hardly look more different from those we sent when we first featured hemimorphite in October 2000! Back then, we sent specimens from the Santa Eulalia mining

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district, Chihuahua, Mexico, one of the world's great specimen-producing areas. Our pieces consisted of diverging sprays of white crystals on an earthy brown matrix, an outstanding contrast. Now we have these beautiful blue botryoidal specimens from half a world away!

From our 1999 write-up under *Composition*: "We are all familiar with the concept of symmetry, defined as similarity of form or arrangement on either side of a dividing line or plane, or correspondence of opposite parts in size, shape, and position. Humans are living examples of symmetry, with our symmetrical eyes, ears, arms, legs, etc. Well-formed crystals are often highly symmetrical, such as the near-perfect pyrite cubes we sent earlier this year with identical faces found on directly opposite sides of the crystal, evidence of a center of symmetry. This wonderful symmetry is a result of the internal atomic arrangement." Hemimorphite lacks such a center of symmetry, which gives it unusual properties, as explained on page 4.

But first the basics. Hemimorphite's chemical formula  $Zn_4Si_2O_7(OH)_2 \cdot H_2O$  identifies it as a basic hydrous zinc silicate containing the elements zinc (Zn), silicon (Si), oxygen (O), and hydrogen (H). The molecular weight of hemimorphite consists of 54.29 percent zinc, 11.66 percent silicon, 33.21 percent oxygen, and 0.84 percent hydrogen. All molecules achieve stability when the cumulative electrical charge of the cations (positively charged ions) equals that of the anions (negatively charged ions). In hemimorphite, the +8 charge of four zinc cations ( $Zn^{2+}$ ) is balanced by the collective -8 charge provided by the silica radical ( $Si_2O_7$ )<sup>6-</sup> and two hydroxyl ions (OH)<sup>1-</sup> in the compound anion.

Before considering structure, let's first establish hemimorphite's place among the silicate minerals. Silicates, the largest and most abundant class of minerals, form when silicon and oxygen combine with one or more metals. The fundamental silicate structural unit, the silica tetrahedron [ $(SiO_4)^{4-}$ ], consists of four equally spaced oxygen ions ( $O^{2-}$ ) that surround a silicon ion ( $Si^{4+}$ ) and form the four corners of a tetrahedron (a four-faced polyhedron). In silicate minerals, silica anions and metal cations link together like polymers (repeating chains) to form seven different structures: independent-tetrahedral silicates (nesosilicates); double-tetrahedral silicates (sorosilicates); framework silicates (tectosilicates); single- and double-chain silicates (inosilicates); ring silicates (cyclosilicates); and sheet silicates (phyllosilicates). These classifications are based on the number of shared oxygen ions per silica tetrahedron. Silica tetrahedrons may share from none to as many as all four oxygen ions with adjacent tetrahedra. The specific type of tetrahedral arrangement largely determines the characteristics of silicate minerals.

Hemimorphite is a double-tetrahedral silicate or sorosilicate (the Greek *soro* means "group"). Double-tetrahedral silicates form when a silica tetrahedron shares one oxygen ion ( $O^{2-}$ ) with an adjacent silica tetrahedron. In this arrangement, two silica tetrahedra ( $SiO_4$ )<sup>4-</sup> share a single oxygen ion to form a ( $Si_2O_7$ )<sup>6-</sup> radical (radicals are groups of atoms that act as an entity in chemical reactions). The ( $Si_2O_7$ )<sup>6-</sup> radical is the core component of both the hemimorphite molecule and crystal lattice. Within the ( $Si_2O_7$ )<sup>6-</sup> radical, the single shared oxygen is electrically neutral, while the other six each carry a -1 charge. This radical forms a stable molecule by bonding ionically with four zinc ions ( $Zn^{2+}$ ) and two hydroxyl ions (OH)<sup>1-</sup>.

Within the hemimorphite lattice, the double-silicate tetrahedra do not join directly, but are instead linked together by  $[ZnO_3(OH)]^{5-}$  tetrahedra, each consisting of a zinc ion surrounded by three oxygen ions and one hydroxyl ion. These zinc-based tetrahedra share oxygen ions with the double-tetrahedra silicate ions to form a three-dimensional network of tetrahedral structures with channels that accommodate water molecules. Check out <http://www.webmineral.com/data/Hemimorphite.shtml> to see a movable diagram.

As indicated by the " $\cdot H_2O$ " in its chemical formula  $Zn_4Si_2O_7(OH)_2 \cdot H_2O$ , hemimorphite is a hydrous (or hydrated) mineral, meaning that it has an attached molecule of water ( $H_2O$ ) called "water of hydration." Water molecules consist of a large oxygen ion ( $O^{2-}$ ) and two tiny, closely grouped hydrogen ions ( $H^{1+}$ ).

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Although they are electrically neutral, their two grouped hydrogen ions retain a small positive charge that imparts polarity. The large oxygen ion that dominates the opposite side of the molecule retains a small negative charge. Water molecules thus act as tiny dipolar magnets that attach themselves to certain other molecules to create hydrous compounds. Because they are electrically neutral, attached water molecules do not alter the electrical balance of the parent molecule.

The hemimorphite lattice is held together by a combination of strong covalent bonding, weaker ionic bonding, and very weak hydrogen bonding. Because its zinc ions are completely shielded by oxygen and hydroxyl ions, hemimorphite lacks metallic bonding and thus exhibits no metallic properties. Of the three structural planes within the lattice structure, two are dominated by covalent bonding and one by weaker ionic bonding. Hemimorphite's perfect, one-directional cleavage occurs along the plane with the greatest degree of ionic bonding. But because covalent bonding predominates within the overall lattice, hemimorphite is relatively hard at Mohs 4.5-5.0. Close molecular packing within the lattice, together with zinc's relatively high atomic weight (65.39), account for hemimorphite's moderately high density (specific gravity 3.4-3.5).

The Dana mineral-classification number of 56.1.2.1 establishes hemimorphite as a sorosilicate with  $(\text{Si}_2\text{O}_7)^{6-}$  silica groups with oxygen, hydroxyl, or fluorine cations and attached water molecules (56). Hemimorphite is subclassified (1) as having a four-coordination cation, which is seen in its four-zinc cation. Finally, hemimorphite belongs to the hemimorphite group (2) as the first (1) and only member.

Hemimorphite is an allochromatic or "other-colored" mineral, meaning its color is due to trace amounts of nonessential elements that act as chromophores (color-causing agents). Pure hemimorphite is colorless or white, but its broad range of colors is caused by such nonessential elements as copper and iron. Trace amounts of cupric copper ( $\text{Cu}^{2+}$ ) substituting for zinc ions in the lattice produce the blue color in our specimens. Interestingly, blue hemimorphite occurs exclusively in botryoidal form because of the manner in which the copper deforms the crystal lattice.

As a secondary mineral, hemimorphite forms from the weathering of sphalerite [zinc sulfide,  $\text{ZnS}$ ] in the near-surface oxidation zones of skarns (see "About Our Specimens") and disseminated hydrothermal replacement deposits in calcareous (limestone) strata. It also forms when silica-rich solutions alter smithsonite [zinc carbonate,  $\text{ZnCO}_3$ ]. Hemimorphite formation requires low-temperature conditions and a basic chemical environment. Common mineral associations include gypsum [hydrous calcium sulfate,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ], hematite [iron oxide,  $\text{Fe}_2\text{O}_3$ ], calcite [calcium carbonate,  $\text{CaCO}_3$ ], smithsonite [zinc carbonate,  $\text{ZnCO}_3$ ], anglesite [lead sulfate,  $\text{PbSO}_4$ ], cerussite [lead carbonate,  $\text{PbCO}_3$ ], and aurichalcite [basic zinc copper carbonate,  $(\text{Zn,Cu})_5(\text{CO}_3)_2(\text{OH})_6$ ]. Hemimorphite sometimes forms pseudomorphs after both calcite and smithsonite.

### *COLLECTING LOCALITIES*

Although not abundant, hemimorphite is widely distributed and occurs at most oxidized or partially oxidized zinc deposits. Our specimens were collected at a site noted for fine, blue botryoidal hemimorphite—the Wenshan zinc mine near Wenshan in Yunnan Province, People's Republic of China. Another Chinese hemimorphite source is the Ningdu zinc mine at Ningdu in Jiangxi Province.

In Australia, hemimorphite occurs at the Kintore open pit at Broken Hill in New South Wales, the Mt. Isa-Cloncurry mining complex in Queensland, and the zinc-lead-silver deposits at Kununurra and Carlton Hill in Western Australia. In Italy, specimens have been found at the Seddas Moddizzia, San Giovanni, and Mosua mines at Iglesias, Sardinia. In the United Kingdom, hemimorphite occurs (continues on page 5)

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### ***HEMIMORPHISM***

Like many complex minerals, hemimorphite crystallizes in the orthorhombic system, which is characterized by crystals with three mutually perpendicular axes of different lengths. The most unusual aspect of hemimorphite's crystallography is its hemimorphism, one of the mineral kingdom's more unusual phenomena. In hemimorphic crystals, the ends or poles of the central crystallographic axis are not symmetrical. Although hemimorphite crystals maintain their basic orthorhombic structure throughout, the same crystals exhibit different termination habits.

Hemimorphism results from abnormal crystal growth. The crystallization process begins when a minute crystal, called a seed crystal, forms from solution. Crystals grow as the seed crystal accumulates more of the same mineral constituents from its fluid environment. Growth progresses from the base to the top termination. At the completion of growth, most mineral crystals exhibit the same habit throughout the crystal. Crystals that exhibit different habits are called hemimorphic. Hemimorphism sometimes occurs when the chemical compositions of mineral fluids change during crystal growth, and the introduction of nonessential elements distorts the growing crystal lattices to create different termination habits.

But in hemimorphite and a few other minerals, hemimorphism is an inherent part of crystal-lattice growth that is likely caused by internal stresses that accumulate during the growth process. Remember that the hemimorphite lattice consists of  $[\text{ZnO}_3(\text{OH})]^{5-}$  tetrahedra that share oxygen ions with  $(\text{Si}_2\text{O}_7)^{6-}$  double-silica tetrahedra. Both the zinc-based tetrahedra and the double-silica tetrahedra are directionally aligned, with parallel bases and apices oriented in the same direction. But as the lattice grows, accumulating stresses alter this uniform alignment so that when growth is complete, the habit at the top termination differs from that at the base termination, as seen in the ideal crystal represented in Figure 1 on page 1. In hemimorphite, hemimorphism occurs in all crystal habits, including botryoidal. But unless both terminations are visible, the hemimorphism cannot be seen. Thus, hemimorphism can be observed only in doubly terminated crystals or on specimens in which crystal clusters have opposing orientations.

Several other minerals exhibit hemimorphism, but none as clearly as hemimorphite. One of these is tourmaline, a complex group of basic aluminum boron silicates with the general formula  $\text{Na}(\text{Mg},\text{Fe})_3\text{Al}_6(\text{BO}_3)_3(\text{Si}_6\text{O}_{18})(\text{OH},\text{F})_4$ . Others include zincite [zinc manganese oxide,  $(\text{ZnMn})\text{O}$ ], greenockite [cadmium sulfide,  $\text{CdS}$ ], and wurtzite [zinc iron sulfide,  $(\text{ZnFe})\text{S}$ ].

Hemimorphism is related to the phenomena of pyroelectricity and piezoelectricity in which heating or mechanical stress generate electrical potentials on crystal faces. Pyroelectric and piezoelectric crystals are thus able to directly convert thermal or mechanical energy to electrical energy. All have interlocked, three-dimensional structures, rigidity, and great spatial stability (little expansion or contraction when heated). When heated, pyroelectric crystals do not expand; instead, the thermal energy displaces ions from their normal positions in the crystal lattice. In piezoelectric crystals, mechanical stress also displaces ions from their normal positions, rather than deforming the crystal. The accumulating effects of ionic displacement throughout the crystal lattice create opposing and easily measurable electrical potentials on certain crystal faces. Hemimorphite has unusually strong pyroelectrical and piezoelectrical properties because its inherent hemimorphic (asymmetrical) nature greatly accentuates the degree of ionic displacement throughout the lattice.

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(Continued from page 3) at Leadhills in Dumfries, Scotland, and in England at the Bayle Hill Mine in the Alston-Moor district and the Roughton Gill Mine at Roughton Gill in Cumbria. In Slovenia, the Banská Štiavnica Mine in the Banská Štiavnica district at Banskobystrický Kraj yields nice specimens. Hemimorphite is also collected at the mineral's type locality, the Baita mining district at Rézbánya, Bihor, Romania. And in Spain, colorless crystals occur in the numerous small lead-zinc mines in the Picos de Europa Mountains of the northern provinces of Asturias and Cantabria.

The finest North American hemimorphite specimens, including colorless, transparent, gem-quality crystals, come from Mexico, notably from Durango at the Ojuelo Mine at Mapimí, the Congreso-Leon Mine at Casas Grandes, and from Chihuahua at the Potosí and San Antonio mines in the Santa Eulalia (Aguiles Serdan) district. This latter locality furnished the fine specimens we sent back in October 2000.

In the United States, the best hemimorphite specimens come from the Summit Mine in the Lone Mountain district of Broadwater County, Montana. Hemimorphite also occurs in New Mexico at the Stephenson-Bennett Mine in the Organ Mountains of Doña Ana County, in Socorro County at the Blanchard Mine in the Hansonburg district, and at the Anchor and Graphic mines in the Magdalena district. Numerous mines in the Goodsprings district of Clark County, Nevada, and the Leadville district of Lake County, Colorado, have produced specimens. In Idaho, hemimorphite is found in the Bunker Hill and Sullivan mines at Kellogg in the Coeur d'Alene district of Shoshone County. Moving east, other hemimorphite sources include the Aurora and Lone Elm mines in the Tri-State Mining District of Jasper County, Missouri, and the old mines at Ogdenburg and Franklin in the Franklin district of Sussex County, New Jersey.

### *JEWELRY & DECORATIVE USES*

Hemimorphite's brittleness and only moderate hardness (Mohs 4.5-5.0), along with its perfect, one-directional cleavage and a maze of hairline fractures that make faceting difficult, limit its use as a gemstone. Colorless, transparent crystals are occasionally cut into collectors' gems of three carats or less. Hemimorphite's most important gem use is as cabochons, beads, and tumbled rough shapes fashioned from blue massive or botryoidal forms. Hemimorphite cabochons and "free forms" from 7 to as many as 30 carats retail for about \$100 to \$200. Polished blue hemimorphite is very similar in appearance to gem forms of turquoise [basic hydrous copper aluminum phosphate,  $\text{CuAl}_6(\text{PO}_4)_4(\text{OH})_8 \cdot 4\text{H}_2\text{O}$ ] smithsonite [zinc carbonate,  $\text{ZnCO}_3$ ], and Larimar, the beautiful variety of pectolite [ $\text{NaCa}_2\text{Si}_3\text{O}_8(\text{OH})$ ] recently discovered in the Dominican Republic. Hemimorphite intended for gem use is usually treated with epoxy solutions to enhance strength, the transparency of colorless crystals, and color intensity of massive and botryoidal forms. Occasionally, designers of matrix-specimen jewelry fashion small crystal clusters on matrix or botryoidal blue hemimorphite into delicate, brittle freeform shapes for use in pendants.

For both study and display purposes, hemimorphite is popular among mineral collectors for its two distinct habits, hemimorphic properties, and scarcity of good specimens.

### *HISTORY & LORE*

From our October 2000 write-up: "More than three thousand years ago, the Phoenicians were mining zinc in the Laurium district of southern Greece to alloy with copper in the making of bronze. Hemimorphite was known in Roman times, when Roman writer Pliny called it *Galmei*, while other ancient writers called it *Cadmia*. Later, German miners called it *Kieselzinkerz*, a name many no doubt are sorry did not stick. Miners from Cornwall, England, many of who emigrated to mines all over the world, called all zinc ore calamine, a term perhaps derived from *Galmei*, or perhaps a corruption of *Cadmia*, or perhaps the Latin *Calamus*, meaning 'reed,' in allusion to a stalactitic crystal habit."

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Yes, hemimorphite has been known since antiquity, but until the mid-1800s it was confused with smithsonite [zinc carbonate,  $ZnCO_3$ , our April 2001 mineral], which has a similar blue botryoidal form and mineralogical occurrence. For many centuries, smithsonite and hemimorphite were considered to be a single species called “calamine.” The first suspicions that “calamine” might be two distinct minerals arose during early investigations of pyroelectricity. Both French mineralogist René Just Haüy (1743-1822) and English chemist James Smithson (1766-1829, for whom smithsonite was later named) noted that while certain “calamine” specimens exhibited strong pyroelectrical properties, others did not.

Although smithsonite was formally described as a distinct mineral in 1832, “calamine” remained a mineralogical puzzle. In 1853, German geologist and mineralogist Gustav Adolph Kenngott (1818-1897) unofficially renamed “calamine” hemimorphite, after its hemimorphic properties. Then in 1868, American clergyman and mineral dealer Ebenezer Seymour (1801-1879) described the mineral scientifically after studying specimens from the Baita mining district at Rézbánya, Bihor, Romania, which would later become the type locality. That same year, New Jersey geologist George H. Cook (vita uncertain) provided another name for the mineral—“electric calamine,” after its pyroelectrical properties. In 1895, yet another researcher renamed the mineral “hydrowillemite,” believing that it was a hydrous form of willemite (zinc silicate,  $Zn_2SiO_4$ ).

By that time, growing industrial demand for brass (a copper-zinc alloy) had spurred demand for zinc. Hemimorphite, which contains 54.2 percent zinc, became an important zinc ore in North America and Europe. Miners at the New Jersey Zinc Company mines in Ogdensburg and Franklin, New Jersey, gave hemimorphite the popular name of “maggot ore,” because its botryoidal surface was reminiscent of a mass of maggots. But by the early 1900s, after the shallow hemimorphite deposits were exhausted and zinc miners had turned to large, deep deposits of sphalerite [zinc sulfide,  $ZnS$ ], hemimorphite was no longer an important ore.

The old name “calamine” remained in widespread use until the 1930s, when mineralogists positively determined hemimorphite’s chemical composition and formally accepted its current name. X-ray diffraction studies finally defined hemimorphite’s atomic structure in the 1960s.

Hemimorphite, together with smithsonite, has long been the chemical base of the “calamine lotions” used to treat various skin conditions. Modern calamine lotion is a mixture of zinc oxide ( $ZnO$ ) with about 0.5% iron oxide ( $Fe_2O_3$ ) in a mineral-oil base, and is used as an antipruritic (anti-itching) to treat sunburn, eczema, rashes, and insect bites and stings, as a mild antiseptic to prevent infections that can be caused by scratching the affected area, and to dry weeping or oozing blisters and acne abscesses. Early physicians used hemimorphite to treat ulcers and blood problems. According to modern metaphysical beliefs, hemimorphite enhances self-esteem and self-respect, facilitates personal evolution, protects against malice, and brings joy and creativity to life.

### *TECHNOLOGICAL USES*

For centuries, hemimorphite was an important ore of zinc. Limited quantities of hemimorphite are still mined in China and other parts of the world today. Modern uses for zinc include corrosion-resistant galvanic coatings for steel, the manufacture of brass, and the fabrication of battery casings. Zinc compounds are valuable as pigments. Ten million metric tons of zinc are now mined each year. The leading producers are China, Peru, and Australia. Zinc ingots currently sell for about \$1 per pound.

Zinc is an essential trace element in the human body. Foods rich in zinc include beef, lamb, pork, turkey, chicken, lobster, salmon, crab, clams, oysters, brown rice, peas, lentils, Lima beans, yogurt, and whole

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wheat bread. Modern “calamine lotions,” which contain synthetic zinc hydroxy-carbonates and -silicates, are essentially the same as those once made from hemimorphite and smithsonite.

### *ABOUT OUR SPECIMENS*

Our hemimorphite specimens were collected at the Wenshan Mine at the town of Dulong near the city of Wenshan, Wenshan (Wenshan Zhuang) Autonomous Prefecture, Yunnan Province, in the People's Republic of China. Located in south-central China, Yunnan Province borders the Socialist Republic of Viet Nam, Laos (Lao People's Democratic Republic), and Myanmar (Union of Burma). Yunnan has a long mining history and is today a major source of nonferrous metals, notably tin and zinc. The province's rich mineralization, mountainous terrain, and complex geology are all due to extensive uplifting and faulting resulting from tectonic stresses generated in early Tertiary time by the collision of the Indian Plate with the Eurasian Plate.

The combined open-pit and underground workings of the Wenshan zinc mine are located at an elevation of 1,600 feet in a subtropical climate just 30 miles north of the Vietnamese border. The mine exploits a part of the Dulong skarn deposit. In its mineralogical usage, the term “skarn” refers to a broad range of metamorphic rock types consisting mainly of such calcium-silicate minerals as those of the garnet and pyroxene groups. In the context of economic geology, the term refers to deposits of skarn-type metamorphic rock containing high concentrations of valuable minerals. Skarns are often important sources of tungsten, copper, iron, gold, molybdenum, lead, zinc, and tin. Skarns form from regional or contact metamorphism or hydrothermal alteration of pre-existing rock near igneous intrusions and major fault systems.

Classic skarn formation involves high-temperature contact metamorphism that results when silicate-rich (granitic or rhyolitic) magma intrudes such calcium-rich sedimentary rocks as limestone or dolomite. The hot magma both recrystallizes (alters) the adjacent calcareous rock (contact metamorphism) and introduces new mineral constituents (metasomatism), notably silica, which combines with the calcareous rock to form calcium-silicate minerals. Skarns form in three stages. First, the heat of intruding magma metamorphoses the existing rock. Second, following crystallization of the magma, a metasomatic hydrothermal phase introduces dissolved metals that precipitate as sulfide minerals. Third, another alteration phase caused by circulating groundwater occurs during the final cooling stage. Along with garnet-group minerals and such pyroxene-group minerals as diopside [calcium magnesium silicate,  $\text{CaMgSi}_2\text{O}_6$ ] and enstatite [magnesium silicate,  $\text{Mg}_2\text{SiO}_6$ ], skarn minerals include quartz [silicon dioxide,  $\text{SiO}_2$ ], calcite [calcium carbonate,  $\text{CaCO}_3$ ], epidote [basic calcium aluminum iron silicate,  $\text{Ca}_2\text{Al}_2(\text{Fe,Al})\text{Si}_3\text{O}_{12}(\text{OH})$ ], vesuvianite [basic calcium aluminum magnesium iron fluorosilicate,  $\text{Ca}_{19}(\text{Al,Mg,Fe})_{13}\text{Si}_{18}\text{O}_{68}(\text{O,OH,F})_{10}$ ], and the plagioclase-feldspar minerals albite [sodium aluminum silicate,  $\text{NaAlSi}_3\text{O}_8$ ] and anorthite [calcium aluminum silicate,  $\text{CaAl}_2\text{Si}_2\text{O}_8$ ]. Skarns often are sources of fine mineral specimens.

The Dulong (the name is that of an indigenous ethnic minority group in southern Yunnan) Tin-Zinc Deposit at Wenshan is a classic skarn. Its host rock originated as marine sediments laid down some 560 million years ago in mid-Cambrian time. The heat and pressure of deep burial later metamorphosed the original limestone and shale into a stratigraphic sequence of schist and marble known as the Tianpeng Group. Some 50 million years ago, granitic magma intruded this metamorphic rock to form a mineralized skarn rich in sphalerite (zinc sulfide,  $\text{ZnS}$ ) and cassiterite (tin oxide,  $\text{SnO}_2$ ). After surface erosion eventually exposed the upper section of the skarn, the combined effects of atmosphere and water oxidized the upper sections of the sulfides, releasing zinc from sphalerite and creating the conditions under which it could combine with silicon, oxygen, and hydrogen to form our lovely specimens.

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For centuries, the Dulong deposit has provided limited amounts of tin to manufacture bronze, a copper-tin alloy. Modern mining for zinc and tin began in the 1950s, when the original small open-pit and shallow underground workings were consolidated into the Wenshan Mine. Since the 1980s, the mine has produced about 1,400 tons of ore per day, shipping sphalerite concentrates and cassiterite concentrates to zinc and tin smelters at Gejiu, 110 miles to the west. The Wenshan concentrates also contain chalcopyrite [copper iron sulfide,  $\text{CuFeS}_2$ ], stannite [copper iron tin sulfide,  $\text{Cu}_2\text{FeSnS}_4$ ], and chalcocite [copper sulfide,  $\text{Cu}_2\text{S}$ ]. Along with zinc and tin, these concentrates also yield small quantities of copper, silver, cadmium, and indium.

It is uncertain whether the Wenshan Mine produced mineral specimens prior to the late 1980s. The first fine, blue botryoidal hemimorphite specimens from Wenshan seem to have reached western markets in 1990 and 1991, where they were acclaimed as the finest of their type ever seen. Similar specimens were again found at Wenshan in 1999. Miners encountered a third occurrence of collector-quality, blue botryoidal hemimorphite—the source of our specimens—in 2004.

Because the Wenshan Mine is neither large nor modern, the Dulong Tin-Zinc Deposit has hardly been scratched by today's mining standards. The overall grade and size of the deposit were determined only in the 1990s following a modern exploration program that included 300,000 feet (56 miles!) of core drilling. These cores revealed a large skarn approximately 1,000 feet thick, 2,000 feet wide, and 12,000 feet (2.3 miles) in length. Tin-zinc mineralization is concentrated in 40 horizontal, stratiform structures called "lenses," each of which are hundreds of feet long. The Chinese National Reserve Committee, the government agency that compiles mineral-resource data, pegs Dulong's proven (core-drilled) ore reserves at 47 million metric tons of ore grading 5.12 percent zinc and 0.56 percent tin. Indicated and inferred reserves double these numbers and make Dulong China's third largest tin-zinc deposit. A consortium consisting of the Canadian junior mineral-exploration company Barytex and several Chinese resource-development companies that hold the mineral rights will soon develop a major-open pit mine at Dulong that will produce 10,000 tons of ore per day.

Our specimens are particularly pleasing to the eye both for their color and the bubbly, flowing botryoidal form. As mentioned, the sky-blue color can rival the finest turquoise and Larimar, and we do occasionally see freeform cabochons cut from this material offered for sale at shows. Copper partially replacing zinc in the crystal lattice is the cause of the pretty blue color, the copper also deforming the crystal structure so that copper-containing hemimorphite is found only in the botryoidal habit. Our specimens also sparkle in bright light, the light reflecting off the myriad small crystal faces, some of which are visible under magnification. As we always do, we passed a number of specimens under both short- and long-wave ultraviolet light but noticed no reaction.

We are especially happy to be able to present such a colorful mineral with such fascinating properties!

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