

# Mineral of the Month Club February 2017

## CALCITE var. NODULES

This month we are featuring a nodular form of calcite, or calcium carbonate, from the Huanggang Mine in the Autonomous Region of Inner Mongolia, China. Our write-up discusses calcite's mineralogy and lore; our special section explains how China became the world's leading source of mineral specimens.

### OVERVIEW

### PHYSICAL PROPERTIES

Chemistry:  $\text{CaCO}_3$  Calcium Carbonate

Class: Carbonates

Subclass: Anhydrous Carbonates

Group: Calcite

Crystal System: Hexagonal System (Trigonal Subsystem)

Crystal Habits: Usually as rhombohedrons, scalenohedrons, and prisms; also in tabular, acicular, massive, granular, compact, stalactitic, stalagmitic, oolitic, nodular, and earthy forms; twinning common. Crystal habits are numerous and often exhibit trigonal and pseudo-hexagonal shapes.

Color: White, gray, yellow, red, green, blue, brown, and near-black; also colorless.

Luster: Vitreous to dull

Transparency: Transparent to translucent; sometimes opaque.

Streak: White

Cleavage: Crystals exhibit perfect, three-directional cleavage to form rhombohedrons; cleavage surfaces do not coincide with crystal faces.

Fracture and Tenacity: Usually irregular, rarely conchoidal; brittle.

Hardness: 3.0

Specific Gravity: 2.7-3.0; increases slightly when additional amounts of iron are present.

Luminescence: Often fluorescent; sometimes thermoluminescent, triboluminescent, and phosphorescent.

Refractive Index: 1.486-1.658; crystals are doubly refractive (birefringent).

Distinctive Features and Tests: Best field indicators are rhombohedral crystal shape, softness, and vigorous effervescence in acids. Calcite can be confused with the polymorphic calcium-carbonate mineral aragonite, which crystallizes in the orthorhombic system.

Dana Classification Number: 14.1.1.1

**NAME:** The word "calcite," pronounced KHAL-site, stems from the Latin *calx*, referring to lime [calcium oxide,  $\text{CaO}$ ] or any white, calcareous mineral. Calcite's many variety names include "alabaster," "calcium spar," "calc marble," "calcareous spar," "dogtooth spar," and "Mexican jade." Transparent, rhombohedral calcite crystals are called "Iceland spar"; pink varieties are

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known as manganoan or cobaltoan calcite. In European mineralogical literature, calcite appears as *calcit*, *calciet*, *Kalcit*, and *calcita*.

**COMPOSITION:** Calcite, the most abundant of the 192 members of the carbonate class of minerals, is a simple carbonate consisting of 40.04 percent calcium (Ca), 12.00 percent carbon (C), and 47.96 percent oxygen (O). Calcite is an allochromatic (other-colored) mineral, meaning that its colors are not caused by its essential elements or the light-absorption characteristics of its crystal lattice, but by traces of accessory elements that create a wide range of colors. Calcite occurs in many different types of sedimentary, metamorphic, and igneous environments. Calcite and other simple carbonates crystallize in the trigonal subsystem of the hexagonal system; the basic, six-sided, external shapes of hexagonal-system crystals are multiples of the trigonal subsystem's three-fold symmetry. The trigonal subsystem is characterized by three axes of equal length with angles between them of *other* than 90 degrees. Nodular and concretionary forms of calcite develop in sedimentary rocks when acidic, calcium-rich groundwater loses its acidity and precipitates crystalline calcite. Calcite concretions and nodules can be spherical, ovoidal (egg-like), elongated, or irregular in shape, and can range in size from microscopic to several feet in diameter. They form within sediment layers soon after deposition and before the sediments have lithified. Calcite nodules are a type of concretion that develops when calcite replaces another mineral or a mass of organic material.

**COLLECTING LOCALITIES:** As an abundant mineral with numerous occurrences, calcite is collected in China, Switzerland, Romania, Slovakia, Austria, Bulgaria, France, Germany, Spain, Italy, England, Australia, Canada, Japan, South Africa, Turkey, Mexico, Argentina, Peru, Honduras, and the United States (Tennessee, Massachusetts, Colorado, Montana, Nevada, North Carolina, Idaho, Wisconsin).

**HISTORY, USES & LORE:** The many forms of calcite, including limestone and marble, have been known since antiquity. In 77 A.D. in his *Historia Naturalis*, the Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) referred to both calcite and lime as *calx*. Since then, because of its numerous and often confusing crystal habits, calcite has acquired many other names. It was not recognized as a distinct mineral species until 1845, when Austrian mineralogist Wilhelm Karl von Haidinger (1795-1871) formally assigned the name "calcite" after the Latin *calx*. The Vikings developed the first optical use for calcite nearly a millennium ago by using the birefringent Iceland spar variety to determine the sun's position on cloudy days and during the long, winter twilight of the northern latitudes. By rotating a crystal of Iceland spar in front of the eye while scanning the horizon, the transmitted, polarized light created two shadowy images. The horizontal deflection at which the darkness of these shadows equalized marked the position of the unseen sun to an accuracy of about one degree. Modern metaphysical practitioners believe that calcite crystals improve learning abilities, promote creativity and imagination, facilitate astral travel and channeling, reduce fear and stress, remove negative energies, and bring inner peace. Calcite is also considered a grounding, centering, and protective stone that aids efforts at reconciliation. Physically, calcite is thought to alleviate back pain, help in detoxification, and promote overall healing. In the forms of limestone and marble, calcite has great industrial importance. Limestone, a sedimentary rock consisting of at least 50 percent calcite, is quarried in huge quantities worldwide as dimension stone for construction, and as a

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source of calcium carbonate for the manufacture of cement. Marble, or metamorphosed limestone, is used extensively in sculpting and architecture. Calcite's use in jewelry is limited because of its softness, low index of refraction, and three-directional cleavage that makes cutting difficult. Attractively colored, translucent, massive calcite is a popular ornamental stone that is fashioned into cups, bowls, spheres, and other decorative objects.

**ABOUT OUR SPECIMENS:** Our specimens of nodular calcite were collected at the Huanggang Mine in Hexigten Banner (County) near the city of Chifeng, Chifeng Prefecture, Autonomous Region of Inner Mongolia, China. Huanggang, one of China's newest mines, is a complex consisting of seven, 2,000-foot-deep shafts that access a system of underground workings. Construction of the complex started in 2002; production began in 2008. The Huanggang ores, which yield mainly tin and iron, are part of a large skarn deposit that formed when magma intruded limestone and dolomite rock. Huanggang yielded its first mineral specimens in 2010 and has since gained international recognition as a source of fine specimens. Your specimen of nodular calcite was collected not from the Huanggang ore bodies, but from the surrounding limestone host rock. These nodules formed shortly after the original calcium-rich sediments were laid down, but before they lithified into limestone. It is likely that the decay of small masses of organic matter within the sediments provided space for the growth of tiny calcite crystals which then acted as "seeds" for the growth of additional crystals. As the organic matter continued to decay, the precipitation of additional calcite crystals eventually produced a spherical nodule.

### COMPREHENSIVE WRITE-UP

#### *COMPOSITION & STRUCTURE*

Calcite [calcium carbonate,  $\text{CaCO}_3$ ] consists of the elements calcium (Ca), carbon (C), and oxygen (O). Its molecular weight is made up of 40.04 percent calcium, 12.00 percent carbon, and 47.96 percent oxygen. Calcite is the most abundant of the 192 members of the carbonate class of minerals, in which a metal or metals combine with carbon and oxygen. As in all molecules, those of calcite consist of positively charged cations and negatively charged anions. In the calcite molecule, the cation is a single, divalent calcium ion  $\text{Ca}^{2+}$ ; the anion is the carbonate radical  $(\text{CO}_3)^{2-}$ . Radicals are groups of atoms of different elements that act as entities in chemical reactions. The carbonate radical, the fundamental structural unit of all carbonate minerals, has a flat, triangular shape with three equidistant oxygen ions  $3\text{O}^{2-}$  surrounding, and covalently bonded to, shared electrons to a central carbon ion  $\text{C}^{4+}$ . Carbonate minerals form when negatively charged carbonate radicals bond ionically to positively charged metal ions. The +4 charge of the carbon ion and the collective -6 charge of the three oxygen ions give the carbonate radical a total -2 charge. This -2 anionic charge balances the +2 cationic charge to provide the calcite molecule with electrical stability.

As a simple carbonate, calcite contains only a single metal cation. Simple carbonates crystallize in the trigonal (or rhombohedral) subsystem of the hexagonal system. The basic six-sided, external shape of hexagonal-system crystals is a multiple of the trigonal subsystem's three-fold

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symmetry. Simple carbonate minerals usually exhibit the three-fold, trigonal symmetry that reflects the triangular shape of the carbonate radical. The trigonal subsystem is characterized by three axes of equal length with angles between them of *other* than 90 degrees. The basic trigonal shape is the rhombohedron, a six-sided polygon with parallelogram-shaped sides. Because of the many possible variations of this basic form, calcite has more than 300 habits and 800 sub-habits and shapes, and exhibits four types of twinning.

Calcite's crystal structure is often compared to that of halite [sodium chloride, NaCl]. Halite crystallizes in the cubic (isometric) system, always in a cubic habit with perfect, three-directional, right-angle cleavage. The carbonate radicals in the calcite lattice occupy the same positions as the chlorine ions in the halite lattice. But the triangular shape of the carbonate radicals distorts the calcite lattice along one axis. Like halite, calcite therefore has perfect, three-directional cleavage. But while halite cleaves into cubes, calcite cleaves into rhombohedrons.

In the calcite crystal lattice, the carbon and oxygen ions within the carbonate radical are bound by strong covalent bonding, while the calcium ions are joined to the carbonate radicals by much weaker ionic bonding. Within the calcite lattice, six oxygen ions completely shield each calcium ion, explaining why calcite exhibits no metallic properties. The relatively weak ionic bonding between the calcium ions and the carbonate radicals accounts for calcite's minimal hardness of Mohs 3.0. Despite its close atomic packing, calcite has a low specific gravity of 2.7-3.0, only a bit higher than that of quartz [silicon dioxide, SiO<sub>2</sub>]. Calcite's low density is due to the relatively low atomic weights of its essential components calcium (40.08), carbon (12.01), and oxygen (16.00). Calcite's diagnostic effervescence in acids is caused by the weak ionic bonding between its calcium ions and its carbonate radicals. Using hydrochloric acid (HCl) as an example, calcite effervesces when the acid's highly reactive chlorine ions (Cl<sup>1-</sup>) break calcite's weak ionic bonds and replace its carbonate radicals. This reaction is expressed by the formula  $\text{CaCO}_3 + 2\text{HCl} = \text{CaCl}_2$  (calcium chloride) + H<sub>2</sub>O (water) + CO<sub>2</sub> (carbon dioxide). The subsequent, rapid release of carbon-dioxide gas creates the diagnostic bubbles of effervescence.

Calcite is an abundant mineral that comprises an estimated four percent of the weight of the Earth's crust. It forms in many mineralogical environments, most often in shallow conditions where carbonic acid (H<sub>2</sub>CO<sub>3</sub>) reacts with various metal salts. Carbonic acid forms when atmospheric carbon dioxide (CO<sub>2</sub>) dissolves in water (H<sub>2</sub>O) according to the formula  $\text{H}_2\text{O} + \text{CO}_2 = \text{H}_2\text{CO}_3$ . Under proper conditions of temperature, pressure, and chemistry, free metal ions then bond ionically with the acid's carbonate radicals to form carbonate minerals. This reaction commonly occurs in chemical-sedimentary environments to create limestone, a marine sedimentary rock containing at least 50 percent calcite. Calcite also occurs in nepheline-syenite pegmatites, metamorphic rocks, basaltic volcanic rocks, high- and low-temperature hydrothermal veins, disseminated replacement deposits, and carbonatites (carbonate-rich igneous rocks).

Calcite forms nodules and concretions in sedimentary rocks when acidic, calcium-rich groundwater loses its acidity and precipitates crystalline calcite. Concretions, a word derived from the Latin *concreescere*, meaning "to grow together," are volumes of sedimentary rock in which mineral precipitates have displaced the surrounding sediments or filled the pores between sediment grains. Concretions can be spherical, ovoidal (egg-like), elongated, or irregular in

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shape, and can range in size from microscopic to many feet in diameter. They form within sediment layers soon after deposition and before the sediments have lithified. Concretions, which are most common in such sedimentary rocks as shale, siltstone, and sandstone, develop from mineral precipitation around a nucleus. Nodules (from the Latin *nodus* or “knot”) are a type of concretion that forms when a mineral replaces another mineral or a mass of organic material.

Calcite is a polymorphic mineral and one of three natural forms of calcium carbonate. The other calcium-carbonate polymorphs are aragonite and the rare mineral vaterite. Although these three minerals share identical chemistries, calcite crystallizes in the trigonal subsystem of the hexagonal system, aragonite in the orthorhombic system, and vaterite in the hexagonal system.

Calcite is an allochromatic (other-colored) mineral in which colors are caused by traces of accessory elements. Although pure calcite is colorless or white, traces of manganese create pink manganoan calcite, while traces of cobalt create purplish cobaltoan calcite. In these minerals, manganese and cobalt distort the crystal lattice to alter its color-absorption and color-reflection characteristics. Some calcite colors are due to inclusions of particulate elements or minerals. As examples, yellow calcite contains microscopic particles of elemental sulfur, black calcite contains tiny particles of elemental carbon, and orange and red calcite is included with tiny particles of hematite [iron oxide,  $\text{Fe}_2\text{O}_3$ ].

The Dana mineral-classification number 14.1.1.1 identifies calcite as a simple, anhydrous carbonate (14) with the general formula  $\text{A}^{2+}\text{CO}_3$ , in which “ $\text{A}^{2+}$ ” represents divalent ions of calcium, magnesium, iron, manganese, cobalt, zinc, nickel, or cadmium. The subclassification (1) defines calcite as crystallizing in the trigonal subsystem of the hexagonal system. Calcite is then assigned to the calcite group (1) as the first (1) of eight members. Familiar calcite-group members, which differ only in their cationic chemistries, include magnesite [magnesium carbonate,  $\text{MgCO}_3$ ], siderite [iron carbonate,  $\text{FeCO}_3$ ], rhodochrosite [manganese carbonate,  $\text{MnCO}_3$ ], and smithsonite [zinc carbonate,  $\text{ZnCO}_3$ ].

### COLLECTING LOCALITIES

Our specimens of nodular calcite were collected at the Huanggang Mine in Hexigten Banner (County) near the city of Chifeng, Chifeng Prefecture, Autonomous Region of Inner Mongolia, China. Another notable Chinese calcite locality is the Manaoshan Mine in the Dongpo ore field near Chenzhou, Chenzhou Prefecture, Hunan Province.

In Europe, calcite is collected at the Gonzen Mine at Sargans, St. Gallen, Switzerland; the Cavnic and Boldut mines at Cavnic, Maramures County, Romania; the Banská Štiavnica district mines in Banská Bystrica Region, Slovakia; the Martis and Felixbau mines at Hüttenberg, Freisach-Hüttenberg area, Carinthia, Austria; the Stevanof Mine at Zlatograd, Smolyan Oblast', Bulgaria; the Rivet Quarry near Tarn, Midi-Pyrénées, France; the Sieben Gots Mine in the Freiburg District, Erzgebirge, Saxony, Germany; Sierra de Aracina, Huelva, Andalusia, Spain; and the Scrove Mine at Reppia, Graveglia Valley, Genova Province, Liguria, Italy. England's

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sources include the Botallack Mine at Botallack, St. Just District, Cornwall; and the Bigrigg Mine at Bigrigg in the West Cumberland Iron Field, Cumbria.

Other localities include the Broken Hill mines in Yancowinna County, New South Wales, Australia; the Sulphurets district mines near the Iskut River, Skeena Mining Division, British Columbia, Canada; the Toyoguchi Mine at Yamagata, Iwate Prefecture, Tohoku Region, Honshu Island, Japan; the Wessel Mine at Hotazel in the Kalahari Manganese Field, Northern Cape Province, South Africa; and the Dokuztepe iron-manganese deposit at Ceyhan, Adana Province, Mediterranean Region, Turkey.

Mexican specimens come from the Ojuela Mine at Mapimí in the Mapimí district, Durango; and the mines of the Santa Eulalia district at Aquiles Serdán and the Gibraltar Mine at Naica, both in Chihuahua. Other Latin American sources are the Farallón Negro Mine at Farallón Negro, Belén Department, Catamarca, Argentina; and the Mochito Mine at El Mocho, Santa Barbara Department, Honduras. Peruvian specimens come from the Casapalca Mine at Casapalca, Huarochiri Province, Lima Department; and the Pachapaqui district mines at Pachapaqui, Bolognesi Province, Ancash Department.

In the United States, calcite is collected at the Elmwood Mine at Carthage, Smith County, Tennessee; the Lane Quarry at Northfield, Franklin County, Massachusetts; the Rico Argentine Mine at Rico in Dolores County and the Idarado Mine at Telluride in San Miguel County, both in Colorado; the Alice Mine at Walkerville in the Butte district, Silver Bow County, Montana; the North Aurora Mine at Treasure Hill in the White Pine district, White Pine County, Nevada; the Bald Knob deposit near Sparta, Allegheny County, North Carolina; the Friday Mine in the Westview district, Boise County, Idaho; and the Montreal, Jupiter, Bourne, and Moore mines in the Gogebic Iron Range, Iron County, Wisconsin.

### *JEWELRY & DECORATIVE USES*

With its minimal hardness of Mohs 3.0, low index of refraction of 1.486-1.658, and perfect, three-directional cleavage that complicates cutting, crystalline calcite's use in jewelry is very limited. Attractively colored, crystalline and massive forms of calcite are sometimes wire-wrapped as pendants. Massive calcite is fashioned into beads and drilled for use in necklaces. Massive calcite is also popular as a decorative stone that is sold as "onyx," "Mexican onyx," and "alabaster." Because of its softness, massive calcite can be quickly and inexpensively carved by mechanical means into ashtrays, chess pieces, jewelry boxes, spheres, bookends, figurines, paperweights, and other decorative objects like "candle cups." These are made from translucent, massive calcite in yellow, white, orange, and red colors and transmit light in a warm glow from internal candle flames. A diagnostic feature of calcite is its rapid reaction with acids to create a vigorous effervescence (see "Composition & Structure"). This reaction is widely used to "finish" decorative objects and specimens of massive calcite. After shaping with wheels and saws, the calcite is immersed briefly in dilute hydrochloric acid (HCl) to dissolve a thin, surface layer. This inexpensive process enhances translucency, intensifies color, and creates an irregular, glassy-smooth, lustrous surface, while eliminating the need for costly, mechanical polishing.



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## *HISTORY & LORE*

Because of its abundance and often shallow occurrence, various forms of calcite were known to many ancient cultures worldwide. But despite its simple chemical composition, calcite's numerous crystal habits confused early mineralogists. Calcite was named *calx*, meaning "lime" [calcium oxide, CaO] or any white, calcareous mineral in 77 A.D. by the Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) in his *Historia Naturalis*. Many ancient cultures carved massive calcite into decorative and utilitarian objects.

The Vikings developed the first optical application for calcite nearly a millennium ago. Many historians believe that the "sunstone" mentioned in Icelandic texts dating to 1250 A.D. refers to the Iceland spar variety of calcite. It is known that the Vikings used these birefringent calcite crystals, which have been recovered from Viking archaeological sites, to determine the sun's position on cloudy days and during the long, winter twilight of the northern latitudes. By rotating Iceland spar in front of the eye while scanning the horizon, the transmitted, polarized light created two shadowy images. The horizontal deflection at which the darkness of these shadows equalized marked the unseen sun's position to an accuracy of about one degree. In 2013, Iceland spar was recovered along with bronze navigational instruments from the wreck of a 1597 British warship. Historians believe this recovery proves that the Vikings and other Europeans used calcite "sunstone" as a navigational aid even after the introduction of the magnetic compass.

In 1845, Austrian mineralogist Wilhelm Karl von Haidinger (1795-1871) recognized calcite's many varieties as those of a single mineral species which he named "calcite" after the Latin *calx*.

Modern metaphysical practitioners believe that calcite crystals improve learning abilities, promote creativity and imagination, facilitate astral travel and channeling, reduce fear and stress, remove negative energies, and bring inner peace. Calcite crystals are also considered a grounding, centering, and protective stone that aids efforts at reconciliation. Physically, calcite is thought to alleviate back pain, help in detoxification, and promote overall healing.

Calcite has appeared on the 10-manat postage stamp of Azerbaijan in 1994; the 5-leva stamp of Bulgaria in 1995; the 150-peso stamp of Chile in 1985; the 1125-franc stamp of the Comoros Islands in 1998; the 4-franc stamp of France in 1986; the 90-tyiyn stamp of Kyrgyzstan in 1994; and the 50-krónur stamp of Iceland in 1998.

## *CHINA'S MINERAL-SPECIMEN INDUSTRY*

Since the Mineral of the Month Club was founded almost 21 years ago, China has supplied our Mineral of the Month specimens. 24 times. This number is surpassed only by Mexico, which has supplied 26 of our previous Minerals of the Month. It is interesting to compare these two nations as sources of mineral specimens. Mexico has been a major source of specimens for 70 years,

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China for only 25 years—a difference that reflects the remarkable, and recent, growth of China's mining industry. In fact, since the early 1990s, China has been the world's leading source of both mineral specimens and of industrial metals and minerals.

As late as the mid-1970s, China was supplying few mineral specimens. China at that time had relatively few mines and virtually no ties to international specimen markets. Then in the late 1970s, the government announced plans to modernize the nation and dramatically accelerate its economic progress. A key element of this plan was the rapid development of coal, metal, and nonmetal mineral resources. To boost production as quickly and inexpensively as possible, the government ordered the immediate expansion of existing mines. Within a decade, the combined output of hundreds of small, old were being pushed to increase mineral production.

Small mines generally yield more mineral specimens than large mines. That's because large mines tend to exploit low-grade, disseminated mineral deposits in which specimens are not abundant. These large mines are highly mechanized mines and employ large-scale blasting, ore-loading, and haulage methods that destroy many mineral specimens; these mines also operate on tight production schedules and rarely allow specimen collecting to interfere with operations. Small mines, conversely, usually exploit high-grade, vein-type deposits that of provide many specimens. They are also much more amenable to specimen collecting. Because small mining operations rely on manual labor, both miners and managers are able to visually inspect most of the ore and waste rock. And since these workers earn lower wages, collecting mineral specimens is a welcome opportunity to generate additional income.

China's current metal-mining industry is often compared to that of the United States as it existed more than a century ago. During the late 19<sup>th</sup> and early 20<sup>th</sup> centuries, the mining industry in the western United States consisted of hundreds of small, underground mines in which miners manually worked shallow, oxidized, and often very rich, vein-type and replacement-type deposits. Many of these yielded large numbers of beautiful and unusual mineral specimens. Unfortunately, untold numbers of specimens were crushed and destroyed, because collector markets that would have made them valuable simply did not exist. After 1900, however, the emergence of such markets created a demand for mineral specimens. Only after prices soared did American miners begin collecting and selling large numbers of fine specimens, some of which are now major museum exhibits.

Conversely, China's small metal mines reached their peak of production in the 1990s, a time when international demand for mineral specimens already existed. Miners therefore began collecting huge numbers of fine specimens and selling them to waiting Chinese dealers, buyers, and exporters. As prices for Chinese specimens increased, American and European specimen dealers began visiting China to purchase specimens from Chinese middlemen or directly from the miners themselves. A Chinese mineral-collecting culture quickly developed that included miners and mine managers, and both Chinese and foreign buyers. At that point, China began to surpass such traditional specimen suppliers as Mexico, India, Morocco, Peru, and Brazil. And today it is still the world's leading source of mineral specimens.



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But China's mining industry is currently again in transition. The Chinese government, which tightly controls both nationalized and privatized industries, realizes that its hundreds of small mines are inefficient. The government now believes, and international mineral economists agree, that the future of China's mining industry lies not in continuing to maximize production at many old mines, but rather in developing large, modern, highly mechanized operations that exploit large, lower-grade mineral deposits.

Since the 1980s, the government's mineral-exploration program has identified many such low-grade mineral deposits that are suitable for mechanized, open-pit mining. Accordingly, the government has ordered the development of these large deposits and has simultaneously closed many small mines. As these small mines cease production, the supply of Chinese mineral specimens has begun to decrease.

While dealers and collectors are concerned about the future supply of Chinese mineral specimens, they do not expect a radical change anytime soon. Yet while China continues to develop low-grade ore deposits, the established specimen-collecting culture among miners and mine managers remains firmly in place. A good example of a modern Chinese mine is the Huanggang Mine, the source of this month's specimens of nodular calcite (see "About Our Specimens"). Although Huanggang is a modern, mechanized, underground mine with a rigid production schedule, its mines and managers have devised clever approaches to specimen collecting that do not compromise production. The bottom is that China is expected to continue as a leading source of fine mineral specimens for the foreseeable future, although not quite on the scale of the past two decades.

### *TECHNOLOGICAL USES*

Calcite, mainly in the form of limestone and marble, has enormous industrial importance. Limestone, a sedimentary rock consisting of at least 50 percent calcite, is quarried worldwide by the millions of tons for use as dimension stone for construction, and also as a source of calcium carbonate to convert into calcium silicate for the manufacture of cement. Marble, or metamorphosed limestone, is used extensively in architecture and as a sculpting medium. The transparent Iceland spar variety of birefringent calcite was formerly used in such optical instruments as range finders and bombsights.

### *ABOUT OUR SPECIMENS*

Our specimens of nodular calcite are from the Huanggang Mine in Hexigten Banner (County) near the city of Chifeng, Chifeng Prefecture, Autonomous Region of Inner Mongolia, China. The Autonomous Region of Inner Mongolia, one of China's 33 provincial-level, administrative divisions, is located in north-central China and borders the independent nation of Mongolia to the north. The Autonomous Region of Inner Mongolia (which appears on many maps as *Nei Mongol Zizhiqu*) is roughly twice the size of the American state of Texas and has a population of 24 million.

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The Huanggang Mine, one of China's newest mines, is located at approximately 43° 40' north latitude and 117° 30' east longitude in the low, forested mountains of Huanggangliang National Forest Park. The mine is 350 miles north of the Chinese capital of Beijing and is reached by an eight-hour drive over a modern highway. The Huanggang Mine complex consists of seven, 2,000-foot-deep shafts, each serving a system of underground levels. Construction of the mine began in 2002; production started in 2008. Huanggang produces mainly tin and iron at a rate of 15,000 tons of ore per day.

The Huanggang ores are part of a large skarn deposit. Skarns, which often host economic minerals, are created when magma intrudes formations of limestone or dolomite rock. Limestone is a sedimentary rock consisting primarily of calcite; dolomite rock is a sedimentary rock consisting mainly of the mineral dolomite [calcium magnesium carbonate,  $\text{CaMg}(\text{CO}_3)_2$ ]. Heat and pressure associated with magmatic intrusions initially caused metamorphism where magma contacted the host rock. Associated solutions then circulated through this altered rock, reacting with the carbonates in the limestone and dolomite rock to create many unusual minerals. The host rock supplied calcium, magnesium, and carbon dioxide, while the magma provided silicon, aluminum, and iron, as well as a number of rare and unusual elements. Skarns are characterized by such silicate minerals as vesuvianite [basic calcium aluminum magnesium iron oxyfluorosilicate,  $\text{Ca}_{19}(\text{Ca,Mg,Al})_{13}\text{Si}_{18}\text{O}_{68}(\text{O,OH,F})_{10}$ ], wollastonite [calcium silicate,  $\text{CaSiO}_3$ ], diopside [calcium magnesium silicate,  $\text{CaMgSi}_2\text{O}_6$ ], and tremolite [basic calcium magnesium silicate,  $\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$ ].

The Huanggang skarn formed about 100 million years ago during the mid-Cretaceous Period when orthoclase-rich, granitic magma penetrated the 260-million-year-old Dashizai and Huanggangliang limestone-dolomite formations. The resulting mineralized, and now largely oxidized, skarn is 12 miles long and 1 mile wide. The important ore minerals are magnetite [ferrous-ferric iron oxide,  $\text{Fe}^{2+}\text{Fe}^{3+}_2\text{O}_4$ ] and cassiterite [tin oxide,  $\text{SnO}_2$ ], which occur along the igneous-sedimentary contact zones in brecciated masses, veins, and disseminated bodies. Huanggang geologists have identified 185 individual ore bodies. Huanggang's complex mineralization includes low grades of molybdenum, lead, zinc, copper, and gold, all of which may eventually have economic value. Accessory minerals include andradite [garnet group, calcium iron silicate,  $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$ ], grossular [garnet group, calcium aluminum silicate,  $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$ ], diopside [calcium magnesium silicate,  $\text{CaMgSi}_2\text{O}_6$ ], quartz [silicon dioxide,  $\text{SiO}_2$ ], calcite, fluorite [calcium fluoride,  $\text{CaF}_2$ ], pyrite [iron disulfide,  $\text{FeS}_2$ ], and arsenopyrite [iron arsenic sulfide,  $\text{FeAsS}$ ].

The Huanggang Mine yielded its first specimens in 2010 and is now recognized as a classic locality for such minerals as reddish-purple, cubic fluorite; greenish-black ilvaite [basic calcium iron oxysilicate,  $\text{CaFe}_2\text{O}(\text{Si}_2\text{O}_7)(\text{OH})$ ]; pink manganoan calcite, green andradite; hedenbergite [calcium iron silicate,  $\text{CaFeSi}_2\text{O}_6$ ]; löllingite [iron arsenide,  $\text{FeAs}_2$ ]; and chlorite-included, green quartz. Huanggang also yields fine specimens of the aquamarine variety of beryl [beryllium aluminum silicate,  $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$ ], a mineral that is unusual in skarn deposits. The variety and quality of Huanggang mineral specimens compare favorably with those from the classic skarn locality at Dal'negorsk, Russia.

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As you examine your specimen, note first its generally spherical shape, which is typical of calcite nodules. Your nodule consists of an aggregate of rhombohedral crystals with smooth, lustrous, trapezoidal faces that appear as “skewed” rectangles with parallel opposite edges. These nodules formed not in the Huanggang ore bodies, but in the surrounding limestone host rock after the original, calcium-rich sediments were deposited, but before they lithified into limestone. Geologists believe that small masses of organic matter within these sediments decayed to provide space for the growth of tiny calcite crystals, which acted as “seeds” for the growth of other calcite crystals. As the organic matter continued to decay, the formation of additional calcite crystals eventually produced a spherical nodule. These calcite nodules were recovered from the limestone through which miners drove drifts to access the Huanggang ore bodies. Our specimens were collected through a cooperative, profit-sharing arrangement between miners and mine managers that does not compromise production schedules.

References: *Dana's New Mineralogy*, Eighth Edition, Richard Gaines, Catherine Skinner, et al, Wiley-Interscience, 1997; *Encyclopedia of Minerals*, Second Edition, William Roberts, Thomas Campbell, Jr., and George Rapp, Van Nostrand Reinhold Company, 1990; *2014 Fleischer's Glossary of Mineral Species*, Malcolm E. Back, The Mineralogical Record, Inc.; *Mineralogy*, John Sinkankas, Springer-Verlag, 1993; *Manual of Mineralogy*, Cornelius Hurlbut and Cornelia Klein, Twenty-first Edition, John Wiley & Sons, 1995; *Gemstones of the World*, Walter Schumann, Sterling Publishing Company, 2013; *Simon & Schuster's Guide to Gems and Precious Stones*, Cipiani, Borrelli, and Lyman, Simon & Schuster Fireside Books, 1999; *The Complete Guide to Rocks & Minerals*, John Farndon, Hermes House, 2007; “Connoisseur's Choice: Fluorite, Part 2, Huanggang Mine, Inner Mongolia, China,” Paul W. Powhat, *Rocks & Minerals*, May-June 2013; *Fine Minerals of China*, Guangua Liu, AAA Minerals AG, 2006; “The Mineral Industry of China,” Pui-Kwan Tse, *2014 Minerals Yearbook*, United States Geological Survey.

