

October 2012 Mineral of the Month: Calcite

CALCITE (var. MANGANOAN)

This month we are featuring the manganoan variety of calcite from a manganese-iron mine in China. Our write-up explains calcite's mineralogy and the origin of the delicate pink color of the manganoan variety, while providing a look at China's booming mining industry.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: CaCO_3 Calcium Carbonate (Manganoan variety always contains significant amounts of manganese.)

Class: Carbonates

Subclass: Anhydrous Carbonates

Group: Calcite

Crystal System: Hexagonal (Trigonal)

Crystal Habits: Commonly as rhombohedrons, scalenohedrons, and prisms; also tabular, acicular, granular, compact, stalactitic, stalagmitic, oolitic, and earthy; twinning common. Crystal habits are extremely varied and exhibit many trigonal or pseudo-hexagonal shapes.

Color: Manganoan calcite is always some shade of pink or rose.

Luster: Vitreous to dull

Transparency: Transparent to translucent

Streak: White

Cleavage: Perfect in three direction to form rhombohedrons (cleavage surfaces do not coincide with crystal faces).

Fracture: Conchoidal (rarely observed)

Hardness: 3.0

Specific Gravity: 2.70-3.0, varies with amount of manganese present.

Luminescence: Usually fluorescent; often thermoluminescent, triboluminescent, and phosphorescent.

Refractive Index: 1.486-1.658

Distinctive Features and Tests: Best field indicators are rhombohedral crystal shapes, softness, and vigorous effervescence in all acids. Calcite can be confused with the polymorphic calcium carbonate mineral aragonite, which lacks calcite's three-directional, rhombohedral cleavage. Optical tests are often necessary to differentiate calcite from pink varieties of dolomite [calcium magnesium carbonate, $\text{CaMg}(\text{CO}_3)_2$]. Manganoan calcite always has a diagnostic pink color.

Dana Classification Number: 14.1.1.1

NAME: The word "calcite," pronounced KHAL-site, is derived from the Greek *chalix*, meaning "lime" or any white, calcareous mineral. "Manganoan," pronounced man-ga-NO-an, refers to the presence of the accessory element manganese. Manganoan calcite has also been known as "calcimangite," "calcite-rhodochrosite," "manganocalcite," "manganiferous calcite," "spartaite,"

“rhodocalcite,” “pink calcite,” and “pink spar.” In European mineralogical literature, manganoan calcite appears as *Manganocalcit*, *calciorhodochrosita*, and *manganocalcita*.

COMPOSITION: The term “manganoan calcite” does not refer to an individual species, but to a variety of the mineral calcite. Calcite is by far the most abundant of the 192 members of the carbonate class of minerals. Calcite is a simple carbonate that consists of the elements calcium (Ca), carbon (C), and oxygen (O) in the proportions of 40.04 percent calcium, 12.00 percent carbon, and 47.96 percent oxygen. As an allochromatic (other colored) mineral, calcite colors are not caused by its essential elements or the nature of its crystal structure, but by traces of accessory elements that create a wide range of pale colors. When pure or nearly pure, calcite is colorless or white. The distinctive pink color of manganoan calcite is due to the presence of manganese. This creates a continuous, graded solid-solution series between the minerals calcite and rhodochrosite. When calcium makes up more than 50 percent of the total cationic weight, the mineral is calcite; when manganese makes up more than 50 percent of the total cationic weight, the mineral is rhodochrosite. Calcite forms in many mineralogical environments, most commonly in shallow sedimentary environments. 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). When calcite forms in a mineralogical environment that is rich in manganese, it always develops as manganoan calcite.

COLLECTING LOCALITIES: Manganoan calcite is found in China, Romania, Slovakia, Austria, Bulgaria, France, Germany, England, Spain, Italy, Switzerland, Russia, Argentina, Mexico, Peru, Australia, Canada, Japan, Morocco, South Africa, Turkey, and Honduras. Sources in the United States are found in Arizona, Colorado, Idaho, Montana, Nevada, North Carolina, Utah, and Wisconsin.

HISTORY, USES & LORE: Although calcite has been known since antiquity, its many confusing crystal habits precluded its recognition as a distinct mineral species until 1845. Manganoan calcite was recognized as a variety of calcite in the early 1900s. Calcite has very limited use in jewelry because of its softness, low index of refraction, and perfect, three-directional cleavage that makes cutting difficult. Calcite specimens are widely sought by mineral collectors for their remarkable variety of crystal habits and colors, high degree of crystal development, and, in composite specimens, interesting combinations with other minerals. Because of its attractive pink colors, the manganoan variety is among the most widely collected forms of calcite. Medieval physicians prescribed potions of both pink manganoan calcite and red rhodochrosite to remedy ailments of the blood. Modern metaphysical practitioners value manganoan calcite as a calming stone that fills the heart with both universal love and self-love; heals inner-child hurts; relieves anxiety, stress, and tension; and overcomes fears, especially those of nightmares. Because of its purported ability to amplify energy, manganoan calcite is used as a “Reiki stone” in the Japanese Reiki system of energy healing and therapy to reduce stress and promote relaxation.

ABOUT OUR SPECIMENS: Our specimens of manganoan calcite were collected at the Manaoshan Mine in the Dongpo ore field near Chenzhou, Chenzhou Prefecture, Hunan Province, in the People’s Republic of China. The Manaoshan Mine, which is 270 miles north-northwest of

the coastal city of Hong Kong, is an underground, multimetal mine in the Dongpo ore field, a richly mineralized area where a dozen major mines produce manganese, iron, lead, bismuth, silver, tin, tungsten, and molybdenum. During the Devonian Period some 400 million years ago, a shallow sea laid down sediments that eventually lithified into strata of limestone and siltstone and were later intruded by magma. Associated mineral-rich, hydrothermal solutions then deposited various metal sulfides in complex systems of veins and lenses. These mineralized strata were metamorphosed by heat and pressure, then later exposed by erosion. Finally, contact with groundwater and atmospheric oxygen altered the sulfides into the oxidized manganese- and iron-ore minerals that are mined today. In 2006, Manaoshan miners developed a lower production level and discovered ore veins that contained vugs filled with manganoan calcite in pleasing pink colors. Mine management authorizes “collection teams” of miners who gather commercial quantities of manganoan calcite specimens in a profit-sharing arrangement. These specimens are passed along through a network of Chinese dealers and are exported to international markets. The production life of Manaoshan as an underground operation is estimated at 12 years. Proposed conversion to an open-pit mining operation could extend mine life by an additional 20 years.

COMPREHENSIVE WRITE-UP

COMPOSITION

Before discussing the manganoan variety of calcite, it helps to look first at the basics of carbonate minerals and calcite itself. “Calcite” is the formal, mineralogical name for the trigonal form of calcium carbonate. The term “manganoan calcite” does not refer to an individual species, but to a variety of calcite. Calcite is by far the most abundant of the 192 members of the carbonate class of minerals. Calcite is a simple carbonate that consists of the elements calcium (Ca), carbon (C), and oxygen (O) in the proportions of 40.04 percent calcium, 12.00 percent carbon, and 47.96 percent oxygen.

In carbonate minerals, metallic elements are combined with 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 basic structural unit of all carbonate minerals, has a flat, triangular shape. Within this triangle, a central carbon ion (C^{4+}) is covalently bound by shared electrons to three equidistant oxygen ions (3O^{2-}). The +4 charge of the carbon ion C^{4+} and the collective -6 charge of the three oxygen ions 3O^{2-} provide the carbonate radical with a total -2 charge. Carbonate minerals form when negatively charged carbonate radicals bond ionically to positively charged metal ions. Calcite is a simple carbonate mineral, meaning that it consists of a single metal and a single carbonate radical. The calcite molecule, like all molecules, consists of a positively charged cation and a negatively charged anion. The calcite cation is a single, divalent calcium ion Ca^{2+} , while the calcite anion is a single carbonate radical $(\text{CO}_3)^{2-}$. The +2 cationic charge balances the -2 anionic charge to provide the calcite molecule with electrical stability.

The triangular shape of the carbonate radical is reflected in the three-fold, crystalline symmetry of most carbonate minerals. Calcite and most other simple carbonates crystallize in the hexagonal system, the characteristic, six-sided, external shape of which is a multiple of three-

fold symmetry. (In chemically complex carbonates, this basic structure is distorted, which explains why complex carbonates tend to crystallize in either the orthorhombic or monoclinic systems.) To be technically correct, calcite and most simple carbonates actually crystallize in the trigonal (or rhombohedral) system, a subdivision of the hexagonal system, which is characterized by three axes of equal length with angles between them of *other* than 90 degrees. The basic shape of the trigonal subdivision is the rhombohedron, a six-sided polygon with parallelogram sides. But because of the large number of possible variations of this basic structure, calcite actually has more than 800 distinct sub-habits and shapes, and exhibits four major types of twinning.

The calcite crystal lattice is often compared with that halite [sodium chloride, NaCl], which crystallizes in the cubic system. Halite almost always exhibits a cubic habit and has perfect cleavage in three directions that are always at right angles. The carbonate radicals in the calcite lattice occupy exactly 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. Calcite therefore has perfect cleavage in three directions, but *never* at right angles. This is the reason that halite always cleaves into perfect cubes, while calcite always cleaves into perfect rhombohedrons.

Within the calcite crystal lattice, each calcium ion is completely surrounded by six oxygen ions of the carbonate radicals, which explains why calcite exhibits no metallic properties at all. The relatively weak ionic bonding between the calcium ions and the carbonate radicals in the crystal lattice accounts for calcite's softness of only Mohs 3.0. Calcite's low specific gravity of 2.71, only a bit higher than that of quartz [silicon dioxide, SiO₂], is due to close atomic packing and the relatively low atomic weights of its essential components calcium (40.08), carbon (12.01), and oxygen (16.00). One of calcite's most important diagnostic features—its vigorous effervescence in acids—is also due to weak ionic bonding. Using hydrochloric acid (HCl) as an example, calcite effervesces when the acid's highly reactive chlorine ions (Cl¹⁻) break the ionic bonds and replace calcite's carbonate radicals. This reaction proceeds according to the formula $\text{CaCO}_3 + 2\text{HCl} = \text{CaCl}_2$ (calcium chloride) + H₂O (water) + CO₂ (carbon dioxide). The rapid release of carbon-dioxide gas creates the diagnostic bubbles of effervescence.

Calcite forms in many mineralogical environments, most commonly in shallow environments where carbonic acid (H₂CO₃) reacts with various metal salts. Carbonic acid forms when atmospheric carbon dioxide (CO₂) dissolves in water (H₂O) 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 can then bond ionically with carbonate ions from the carbonic acid to form carbonate minerals. This is especially common in chemical-sedimentary environments and results in the formation of limestone, a marine sedimentary rock consisting primarily of 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). When calcite forms in a mineralogical environment that is rich in manganese, it almost always develops in the form of manganoan calcite.

Calcite is a polymorphic (actually trimorphic) mineral that is one of the three natural forms of calcium carbonate. Along with calcite, these include aragonite and the rare mineral vaterite.

Although these three minerals have identical chemistries, calcite crystallizes in the trigonal system, aragonite in the orthorhombic system, and vaterite in the hexagonal system.

As an allochromatic (other-colored) mineral, calcite's colors are not caused by its essential elements or the nature of its crystal structure, but by traces of accessory elements that can create a wide range of pale colors. When pure or nearly pure, calcite is colorless or white. The distinctive pink color of manganoan calcite is caused by the presence of manganese (Mn) and is part of an interesting chromophoric relationship between calcite and rhodochrosite [manganese carbonate, MnCO_3]:

Calcite	calcium carbonate	CaCO_3	colorless when pure
Rhodochrosite	manganese carbonate	MnCO_3	intense red when pure

Both calcite and rhodochrosite are simple carbonates that crystallize in the trigonal system and differ only in their cationic chemistry. Both the calcium ion Ca^{2+} in calcite and the manganese ion Mn^{2+} in rhodochrosite have a divalent charge and a generally similar ionic radius. These similarities make possible the easy cationic substitution of manganese for calcium in calcite and calcium for manganese in rhodochrosite. This creates a continuous, graded solid-solution series between calcite and rhodochrosite that is sometimes expressed by the formula $(\text{Ca},\text{Mn})\text{CO}_3$. When calcium makes up more than 50 percent of the total cationic weight, the mineral is calcite; when manganese makes up more than 50 percent of the total cationic weight, the mineral is rhodochrosite. Manganoan calcite forms when a sufficient number of manganese ions replace the calcium ions in calcite to create a pink color. On the other end of this solid-solution scale, when a sufficient number of calcium ions replace the manganese ions in rhodochrosite, the intense red of pure rhodochrosite becomes tempered to pink and the mineral is described as “pink rhodochrosite.” About 10 percent of the calcium ions in calcite must be replaced by manganese ions to impart the noticeable pink color of manganoan calcite.

The Dana mineral-classification number 14.1.1.1 first identifies calcite as a simple, anhydrous carbonate (14) with the general formula A^{2+}CO_3 , in which “ A^{2+} ” can be divalent ions of calcium, magnesium, iron, manganese, cobalt, zinc, nickel, or cadmium. The subclassification (1) defines calcite as crystallizing in the trigonal system. Calcite is then assigned to the calcite group (1) as the first (1) of eight members. Other familiar members of the calcite group, which vary only in their cationic chemistry, include magnesite [magnesium carbonate, MgCO_3], siderite [iron carbonate, FeCO_3], rhodochrosite [manganese carbonate, MnCO_3], and smithsonite [zinc carbonate, ZnCO_3].

COLLECTING LOCALITIES

While calcite is abundant and found worldwide, the manganoan variety is uncommon and has relatively few collecting localities. Our specimens were collected at the Manaoshan Mine in the Dongpo ore field near Chenzhou, Chenzhou Prefecture, Hunan Province, China. Other Chinese sources include the Tuanshangou Mine, Huangpi District, Wuhan Prefecture, Hubai Province; and the Jiaodingshan manganese-cobalt deposit, Hanyuan County, Ya'an Prefecture, Sichuan Province.

In Europe, manganoan calcite occurs at the Cavnic and Boldut mines at Cavnic, Maramures County, Romania; the Banská Štiavnica district mines in Banská Štiavnica County, 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 Seben Gots Mine in the Freiberg District, Erzgebirge, Saxony, Germany; the Botallack Mine, Botallack, St. Just District, Cornwall, England; Sierra de Aracina, Huelva, Andalusia, Spain; the Scrove Mine at Reppia in the Graveglia Valley, Genova Province, Liguria, Italy; and the Gonzen Mine at Sargans, St. Gallen, Switzerland.

Other sources include the Usa manganese deposit, Kuznetsk-Alatau Range, Transbaikalia, Eastern-Siberian Region, Russia; the Farallón Negro Mine at Farallón Negro, Belén Department, Catamarca, Argentina; the Gibraltar Mine, Naica, Chihuahua, Mexico; the Casapalca Mine at Casapalca in Huarochiri Province in Lima Department, and the Pachapaqui district mines at Pachapaqui in Bolognesi Province in Ancash Department, both in Peru; 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 Idikei manganese deposit in Azilal Province, Tadmor-Azilal Region, Morocco; the Wessel Mine at Hotazel in the Kalahari manganese field, Northern Cape Province, South Africa; the Dokuztepe iron-manganese deposit at Ceyhan, Adana Province, Mediterranean Region, Turkey; and the El Mochito Mine at El Mochito, Santa Barbara Department, Honduras.

In the United States, manganoan calcite is collected at the Chloride Mine in the Silver district of the Trigo Mountains, La Paz County, Arizona; the Rico Argentine Mine at Rico in Dolores County, and the Idarado Mine at Telluride in San Miguel County, both in Colorado; the Friday Mine in the Westview district, Boise County, Idaho; 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 at Bald Knob near Sparta, Alleghany County, North Carolina; the Deer Trail Mine in the Mount Baldy district, Piute County, Utah; and the Montreal, Jupiter, Bourne, and Moore mines in the Gogebic Iron Range, Iron County, Wisconsin.

JEWELRY AND DECORATIVE USES

Calcite has very limited use in jewelry because of its softness (Mohs 3.0), low index of refraction (1.486-1.658), and perfect, three-directional cleavage that makes cutting very difficult. Nevertheless, rough calcite crystals, especially those of manganoan calcite with its pleasing pink colors, are sometimes wrapped in silver wire for wear as pendants. Calcite is occasionally cut into collectors' gems as large as 20 carats. Despite calcite's abundance and affordability, collectors' gems can be quite costly because of the difficulty in cutting. Some gem cutters estimate that 90 percent of all the rough calcite crystals they attempt to facet are lost through cleavage separation.

Massive calcite is the primary mineral component of a banded, calcareous form of onyx known as “Mexican onyx” that is fashioned into decorative objects such as ashtrays, snuffboxes, spheres, and paperweights. Calcite is also the primary mineral component of marble, the metamorphosed or recrystallized form of limestone. To most sculptors, marble is the most beautiful of all natural sculpting mediums. Marble is also fashioned into many decorative objects, including figurines, tabletops, and bookends. The rare and costly types of pink marble consist of recrystallized manganoan calcite.

Calcite specimens are widely sought by mineral collectors for their remarkable variety of crystal habits and colors, high degree of crystal development, and, in composite specimens, interesting combinations with other minerals. Because of its attractive pink colors, the manganoan variety is among the most widely collected forms of calcite.

HISTORY AND LORE

In its many forms that include limestone and marble, calcite has been known since antiquity. Because of its many confusing crystal habits, calcite was not recognized as a distinct mineral species until 1845, when it was formally named by Austrian mineralogist Wilhelm Karl von Hardinger (1795-1871). Manganoan calcite was recognized as a variety of calcite in the early 1900s after study of specimens collected from the Banská Štiavnica district mines, Banská Štiavnica County, Banská Bystrica Region, Slovakia. The crystal structure of manganoan calcite was determined by X-ray diffraction in 1926 and found to be virtually identical to that of pure calcite. The actual division between manganoan calcite and rhodochrosite in the intermediate grades of the calcite-rhodochrosite solid-solution series (see “Composition”) was established in the 1970s when mineralogists agreed that calcite would contain more than 50 percent calcium in cationic weight and rhodochrosite would contain more than 50 percent manganese in cationic weight.

Medieval physicians prescribed potions of both pink manganoan calcite and red rhodochrosite to remedy ailments of the blood. Modern metaphysical practitioners consider manganoan calcite to be a calming stone that fills the heart with both universal love and self-love; heals inner-child hurts; relieves anxiety, stress, and tension; and overcomes fears, especially those of nightmares. Because of its purported ability to amplify energy, manganoan calcite is used as “Reiki stone” in the Japanese Reiki system of energy healing and therapy to reduce stress and promote relaxation.

Manganoan calcite was featured on the 500-franc postage stamp of Mali in 1976.

THE MINING INDUSTRY OF CHINA

Our manganoan calcite specimens are among the many fine mineral specimens now coming from the People’s Republic of China. The availability and variety of mineral specimens that reach collectors’ markets have always been, for the most part, tied to commercial mining operations. It is no coincidence that most specimens available on today’s market are from such

nations as China, Peru, Mexico, Australia, the United States and others with well-developed or rapidly expanding mining industries.

As a relative newcomer to this list, China has only been a major source of mineral specimens since the 1980s, the same decade that it earned recognition as a major mining nation. Previously, with the exception of coal and iron production for domestic use, China's mining industry was fragmented, obsolescent, and inefficient. Most of this vast nation had never even been properly explored for minerals, and certainly not with modern mineral-exploration techniques. Another problem was the poor system of roads and railroads that made many mineral-rich areas inaccessible. In terms of mineral-resource exploration and development, China was in the same basic position in the 1970s that the United States had been in a century earlier. Then, the huge mineral resources of the United States were still largely unknown. But government incentives, largely provided through the Mining Law of 1872, resulted in a rush of mineral discoveries that accelerated the building of roads and railroads and rapidly populated many previously unsettled areas. Most importantly, the booming mine production that followed was a vital factor in helping the United States become a world power just a few decades later.

When the Chinese government embarked on its “Four Modernizations” program (agriculture, science and technology, industry, and defense) in 1978, mineral-resource exploration and mine development were priorities. By encouraging foreign investment, rewarding mineral discovery, subsidizing mine development, and legalizing small-scale, quasi-capitalistic, private enterprise, mineral exploration boomed. Results beyond all expectations proved that China was exceedingly rich in commercial concentrations of minerals. But of the hundreds of new mines that were developed, most were small and, unfortunately, poorly regulated and exceedingly dangerous. Nevertheless, sharply increased mineral production became a keystone of the rapidly growing Chinese economy. The source of our specimens, the Manaoshan Mine (see “About Our Specimens”), was developed during this period. It began as a group of very small underground mines in the 1970s. During the 1980s, a national mine-consolidation program phased out many small mines in favor of larger, more efficient operations. The Manaoshan Mine, a medium-sized underground mine began that production in 1989 subsequently became a significant source of manganese and iron.

During the 1990s, the Chinese mining industry continued to explore for new deposits, develop new mines, and consolidate and expand existing mines to increase both efficiency and production. By the early 2000s, China had become the world's largest, overall source of metal and nonmetal ores, a position it continues to hold today. China now leads the world in annual mine production of many major mineral commodities, including gold, aluminum, barite, bismuth, fluorspar, gold, graphite, iron, lead, magnesium, manganese, phosphate rock, rare-earth metals, tin, tungsten, and zinc. No mineral resource reflects the recent growth of the Chinese mining industry better than gold. Chinese gold production has nearly tripled in just the last decade. In 2007, China became the leader in world gold production. In 2011, China produced an estimated 12 million troy ounces (385 metric tons) of gold—about 16 percent of the world's total. And its output continues to rise today.

Thanks to its many mines that produce a wide variety of ore minerals, China is also providing a huge number and variety of specimens that are greatly impacting mineral collecting worldwide.

This recent availability of Chinese specimens, often of minerals with new and unusual crystal habits, colors, and composite combinations, has helped to generate new interest in mineral collecting, attract new collectors, create excitement at gem-and-mineral shows, and enhance many museum exhibits. Some of the fine Chinese specimens now reaching the markets include gem-quality aquamarine [blue gem variety of beryl, beryllium aluminum silicate, $\text{Be}_3\text{Al}_2\text{Si}_6\text{O}_{18}$]; well-developed, twinned crystals of bournotite [lead copper antimony sulfide, PbCuSbS_3]; lustrous, jet-black cassiterite [tin oxide, SnO_2]; bright-green plates of pyromorphite [lead chlorophosphate, $\text{Pb}_5(\text{PO}_4)_3\text{Cl}$]; spectacular, disc-shaped, crystals of rhodochrosite with a soft, yet rich, red color; bright-orange mimetite [lead chloroarsenate, $\text{Pb}_5(\text{AsO}_4)_3\text{Cl}$]; large, butterfly twins of colorless calcite; radiating clusters of kermesite [antimony oxysulfide, $\text{Sb}_2\text{S}_2\text{O}$]; deep-blue azurite [basic copper carbonate, $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$]; lustrous, green brochanite [basic copper sulfate, $\text{Cu}_4\text{SO}_4(\text{OH})_6$]; beautiful, dihypramidal crystals of red scheelite [calcium tungstate, CaWO_4]; and our Mineral of the Month, pink manganoc calcite.

Future supplies of Chinese mineral specimens will, of course, depend upon the future of the Chinese mining industry itself. The trend of industry development is clearly toward fewer, but much larger, mines. The mineral-exploration programs of the 1970s and 1980s have delineated many large, low-grade mineral deposits that are suitable for mechanized, high-volume, open-pit mining; these promise to become China's mineral sources for the future. Such large, low-grade deposits provide larger quantities of mineral resources, but always yield far fewer mineral specimens. So it seems that we may be witnessing the golden age of China's mineral-specimen productivity right now.

TECHNOLOGICAL USES

In the form of limestone, calcite is of great industrial importance. Limestone, a sedimentary rock consisting of at least 50 percent calcite, is quarried worldwide by the millions of tons both as dimension stone for construction and as a source of calcium for the conversion to calcium silicates for the manufacture of cement. Marble, a metamorphosed form of limestone, is used extensively in sculpting and architecture. Although manganoc calcite has no specific technological uses, it has served as the model for its own laboratory synthesis. Mineralogists have developed optical methods for measuring the intensity and purity of the pink color in manganoc calcite to determine its manganese content.

ABOUT OUR SPECIMENS

Our specimens of manganoc calcite were collected at the Manaoshan Mine in the Dongpo ore field near Chenzhou, Chenzhou Prefecture, Hunan Province, in the People's Republic of China. Hunan Province is located in south-central China. Chenzhou Prefecture covers some 7,000 square miles in the southernmost part of Hunan and is about the size of the state of New Jersey. The city of Chenzhou, the administrative center of Chenzhou Prefecture, is 270 miles north-northwest of the coastal city of Hong Kong. Chenzhou, population 300,000, has a diversified economy based on agriculture, mining, metallurgical processing, and light manufacturing. At an elevation of 1,100 feet, Chenzhou has a warm, humid, semitropical climate.

The Manaoshan Mine is a multimetal mine in the Dongpo ore field, a richly mineralized, polymetallic area where more than a dozen major mines produce manganese, iron, lead, bismuth, silver, tin, tungsten, and molybdenum. The complex, regional geology originated with sediments that were laid down by a shallow sea during the Devonian Period some 400 million years ago. After deep burial, these sediments eventually became lithified into massive strata of limestone and siltstone. During the Triassic Period some 200 million years ago, tectonic stresses fractured these limestone-siltstone strata which were then intruded by magma. Accompanying mineral-rich, hydrothermal solutions deposited various metal sulfides in complex systems of veins and lenses. Later, these mineralized strata were metamorphosed by heat and pressure. In the last step of this long geological sequence, uplifting accelerated surface erosion that exposed these altered, mineralized layers to the action of groundwater and atmospheric oxygen which oxidized the sulfide minerals.

These shallow, oxidized, mineralized zones were first studied in the 1970s and became known as the Dongpo ore field. The first generation of small mines produced manganese-iron and lead-silver ores. In the 1980s, a national mineral-resource development program ordered extensive core-drilling in the area (see “The Mining Industry of China”) to accurately delineate the ore bodies to plan the development of a larger manganese-iron mine. This became the Manaoshan Mine, the source of our specimens, which began production in 1989.

Manaoshan is an underground mine that is accessed by large horizontal adits. Mining is performed on four internal levels that follow horizontally oriented, vein-type deposits. A workforce of 150 miners conducts conventional drilling and blasting, then moves ore and waste with a fleet of diesel-powered, rubber-tired haulage trams. The primary manganese-ore minerals are pyrolusite [manganese dioxide, MnO_2] and romanèchite [hydrous barium manganese oxide, $(\text{Ba}, \text{H}_2\text{O})_2(\text{Mn}_2)_2\text{O}_{10}$]. The primary iron-ore mineral is magnetite [iron oxide, Fe_3O_4]; a secondary iron ore is limonite, a mixture of various iron hydroxides. Gangue minerals include calcite, dolomite [calcium magnesium carbonate, CaMgCO_3], galena [lead sulfide, PbS], pyrite [iron disulfide, FeS_2], and goethite [basic iron oxide, $\text{FeO}(\text{OH})$]. Quartz [silicon dioxide, SiO_2] is present in both microcrystalline (chalcedonic) and macrocrystalline forms. The production life of Manaoshan as an underground operation is estimated at 12 years. But geologists and engineers are studying the feasibility of converting the mine into an open pit. Cheaper open-pit mining would make it possible to mine the large volume of lower-grade manganese-iron ores that are present in the deposit. Conversion to an open-pit mining operation could extend mine life by an additional 15-20 years.

Although Manaoshan had produced specimens of pyrite and quartz, it was not considered an important specimen source until 2006, when miners developed a new, lower production level and discovered ore veins that contained vugs filled with manganoan calcite in pleasing pink colors. Geologists believe that this manganoan calcite developed late in the oxidation process and was the last mineral to form in the deposit. The calcite-rich, limestone host rock provided an abundance of calcium ions, while the manganese ore provided a source of manganese ions. Acidic groundwater (see “Composition”) transported calcium and manganese ions and, in the temperatures and pressures within the vugs of the lower ore veins, precipitated these ions out of solution as manganoan calcite.

Miners began recovering these manganoan calcite specimens in 2006 and selling them to mineral collectors and dealers in the nearby city of Chenzhou. As demand for the manganoan calcite specimens increased, Manaoshan management took steps to control the collecting process, an arrangement that is common in many Chinese mines. Unauthorized collecting was prohibited, while selected “collection teams” were allowed to gather commercial quantities of specimens in a profit-sharing arrangement. Management then sells these specimens to Chenzhou dealers, who pass them on to dealers in Changsha, Hunan’s bustling provincial capital 180 miles to the north. From Changsha, the specimens are exported to international markets.

As you examine your specimen, note first its delicate, subtle pink color that indicates a manganese content of about 10 percent, meaning that 10 percent of the calcium ions have been replaced by manganese ions (see “Composition”). Your specimen is a section of a larger, composite crystal that had lined a vug wall in a manganese-iron ore vein. The interior of the specimen, which formed first, is composed of massive calcite with no visible crystal structure. Looking at the base, or exposed cross section, of the crystal, you may see the circular pattern that developed as the crystal grew. The interior “rings” formed first, and the outer sections last. The color difference in these growth rings indicates that different amounts of manganese were present in solution during various growth phases. The surface of the specimen is composed of small, individual crystals of spiky, “dogtooth” calcite, which is one of calcite’s predominant habits. The moderate “heft” of the specimen in your hand indicates a specific gravity of about 2.75, meaning its density is slightly more than that of quartz (specific gravity 2.65). Your specimen is an unusual variety of calcite that was recovered as a by-product of China’s booming mining industry.

References: *Dana’s New Mineralogy*, Eighth Edition; *Encyclopedia of Minerals*, Second Edition, Roberts, et al, Van Nostrand Reinhold Company; *2008 Fleischer’s Glossary of Mineralogical Species*, Malcolm E. Back and Joseph A. Mandarino, The Mineralogical Record, Inc.; *Mineralogy*, John Sinkankas, Van Nostrand Reinhold Company; *Gemstone and Mineral Data Book*, John Sinkankas, Geoscience Press; *The Complete Guide to Rocks & Minerals*, John Farndon, Hermes House, 2007; *Gemstones of the World*, Walter Schumann, Sterling Publishing Company; *Fine Minerals of China*, Guangua Liu, AAA Minerals AG, 2006; “Geology and Genesis of the Iron-Manganese Polymetallic Deposit at Manaoshan, Hunan Province,” G. Q. Tang, *Regional Economic Geology of China*, Geological Publishing House, Beijing, 1985; “The Origin of Color in Minerals,” Kurt Nassau, *American Mineralogist*, Volume 63, 1978; “The Mineral Industry of China,” Pui-Kwan Tse, *2010 Minerals Yearbook*, United States Geological Survey.

Mineral of the Month Club

37-14 61 Street

Woodside, N.Y 11377

800-941-5594

www.mineralofthemonthclub.org