

September 2002 Mineral of the Month: Conichalcite

Our featured mineral comes from the most famous mining district in Mexico, first worked for silver ore by the Spanish conquerors more than four hundred years ago. The write-up will examine this mineral with its unique composition and color.

PHYSICAL PROPERTIES

Chemistry: $\text{CaCu}^{2+}(\text{AsO}_4)(\text{OH})$ Calcium Copper Arsenate Hydroxide (or Basic Calcium Copper Arsenate)

Class: Phosphates Subclass: Arsenates Group: Adelite

Crystal System: Orthorhombic

Crystal Habits: Crystals rare, equant to short prismatic; as compact crusts and reniform masses, sometimes radiating; botryoidal coatings; also massive consisting of uniformly indistinguishable crystals

Color: Usually grass green, sometimes yellowish green, occasionally bluish green

Luster: Vitreous to greasy

Transparency: Transparent and subtransparent to translucent

Streak: Light green

Refractive Index: 1.73-1.84

Cleavage: None

Fracture: Uneven; brittle

Hardness: 4.5

Specific Gravity: 4.33

Luminescence: None

Distinctive Features and Tests: Best field marks are the vivid, grass-green color which is somewhat distinctive among green minerals; relatively high density; lack of fluorescence; and occurrence only in oxidized zones of copper-rich mineralization

Dana Classification Number: 41.5.1.2

NAME

The name conichalcite derives from the Greek words *konis*, meaning “powder,” and *chalx*, or “lime,” in reference to its common occurrence in powder-like crusts and to its basic, or lime-like, chemical properties. Its correct pronunciation is cone-eh-CAL-site. In the past, conichalcite has also been informally known as “higginsite.”

COMPOSITION

As is evident by its chemical formula $\text{CaCu}^{2+}(\text{AsO}_4)(\text{OH})$, conichalcite consists of the elements calcium (Ca) and copper (Cu), both with ionic +2 charges, drawn to the combined -3 charge of the arsenate (AsO_4) radical and the -1 charge of the hydroxyl (OH) radical. In terms of atomic weight, each molecule of conichalcite consists of 15.44 percent calcium, 24.48 percent copper, 28.87 percent arsenic, 0.39 percent hydrogen, and 30.82 percent oxygen.

Within the phosphate class of minerals, the arsenate subclass and to a lesser extent the vanadate subclass mirror the true phosphates in structure, ionic charge, diversity, and physical properties. Well-known members of the phosphates mineral class that we have featured in the Club include variscite (April 2000), olivenite (January 1999), adamite (May 1998), apatite (October 1998), pyromorphite (July 2002), and one we would love to feature, turquoise, while the best known member of the vanadate subclass,

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vanadinite, we featured in November 2001. The primary difference is chemical in nature, with the arsenate (AsO_4)⁻³ or vanadate (VO_4)⁻³ radicals replacing the phosphate (PO_4)⁻³ radical. These radicals have roughly the same ionic sizes and easily substitute for each other to form solid-solution series. (Solid-solution series occur when two or more structurally similar minerals interchange components within their chemistries without significantly altering their crystal structures.) Many solid-solution series exist between minerals that contain the phosphate radical and those that contain the arsenate or vanadate radical as their principal anions.

ADELITE GROUP MINERALS

Orthorhombic arsenates and vanadates of general formula $\text{AB}^{2+}(\text{XO}_4)(\text{OH})$, A = Ca, Pb; B^{2+} = Co, Cu, Fe, Mg, Ni, Zn; X = As^{5+} , V^{5+}

<u>Mineral</u>	<u>Formula</u>	<u>Notes</u>
Adelite	$\text{CaMg}(\text{AsO}_4)(\text{OH})$	Named in 1804 from the Greek word for <i>indistinct</i> , as it forms primarily as masses
Austinite	$\text{CaZn}(\text{AsO}_4)(\text{OH})$	Zinc end member of conichalcite-austinite series
Calciovolborthite	$\text{CaCu}(\text{VO}_4)(\text{OH})$	In need of further study, series with conichalcite
Cobaltaustinite	$\text{Ca}(\text{Co}, \text{Cu}^{2+})(\text{AsO}_4)(\text{OH})$	Possible complete series with conichalcite
Conichalcite	$\text{CaCu}^{2+}(\text{AsO}_4)(\text{OH})$	
Duftite	$\text{PbCu}(\text{AsO}_4)(\text{OH})$	Named in 1920 for G. Duft, director of mines at Tsumeb
Gabrielsonite	$\text{PbFe}^{2+}(\text{AsO}_4)(\text{OH})$	Named in 1967 for Swedish mineralogist Olof Erick Gabrielson
Nickelaustinite	$\text{Ca}(\text{Ni}, \text{Zn})(\text{AsO}_4)(\text{OH})$	Named in 1987 for composition and relationship to austinite
Tangeite	$\text{CaCuVO}_4(\text{OH})$	

Among the most notable of these solid solution series is the conichalcite-calciovolborthite series. As seen in the box above, calciovolborthite [$\text{CaCu}(\text{VO}_4)(\text{OH})$] is calcium copper vanadate hydroxide and the vanadium-rich end member of the series, while conichalcite is the arsenic-rich end member. Both end members of this series are similar in color and crystal habit. Fluorescence can be a distinguishing feature:

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calciovolborthite tends to fluoresce, while conichalcite does not. (The *Fleischer's Glossary of Mineral Species 1999* indicates more study is needed on the rare mineral calciovolborthite.).

Conichalcite also forms a number of solid-solution series which exhibit cationic exchange. It is one of the end members in a series with cobaltaustinite $[\text{Ca}(\text{Co}, \text{Cu}^{2+})(\text{AsO}_4)(\text{OH})]$, in which cobalt replaces copper. Another solid solution series occurs with austinite $[\text{CaZn}(\text{AsO}_4)(\text{OH})]$, in which zinc replaces copper. In plumbian conichalcite, lead replaces some of the copper.

COLLECTING LOCALITIES

Conichalcite is a secondary copper mineral that almost always develops in the zone of alteration (oxidation) in hydrothermal replacement deposits where oxygen-rich groundwater has reacted with lower metallic sulfides to produce a broad variety of brightly colored minerals. Conichalcite is often associated with linarite $[\text{PbCu}(\text{SO}_4)(\text{OH})_2]$, the basic copper carbonates azurite and malachite, and limonite $[\text{FeO}(\text{OH})_n \cdot \text{H}_2\text{O}]$, a mixture of hydrated iron oxides. Bright green conichalcite is often encrusted onto limonitic rocks with red to yellow colors producing eye-catching composite specimens. Inclusions of perfect, orthorhombic green prisms within clear calcite crystals have been reported from several localities.

Fine specimens of conichalcite have come from the copper-rich areas of the American Southwest, where notable sources include numerous mines at Bisbee and Ajo, Arizona; in Utah in the Tintic District of Juab County and the Gold Hill District of Toole County; in Nevada at the Rhyolite Pass District in Mineral County, the Pyramid District in Washoe County, Good Springs in Clark County, and the Empire-Nevada Mine near Yerington in Lyon County; and in New Mexico in the Organ District in Doña Ana County and the Victorio District in Luna County. Conichalcite has also recently been identified at Sterling Hill, New Jersey, where it occurs in association with a variety of carbonate minerals.

Tsumeb, Namibia, has also been a steady source of many excellent specimens in which conichalcite often appears in combination with willemite, dolomite, and yellow mimetite. Other composite specimens from Tsumeb feature nicely colored conichalcite crystals measuring 3-4 millimeters in length clustered on reddish-black, massive cuprite. The type locality for conichalcite, Hinojosa del Duque, Córdoba, Spain, continues to produce specimens which are typically characterized by bright green crystalline coatings on reddish limonite. The lead-silver-copper-zinc mines at Broken Hill, New South Wales, Australia, also yield colorful specimens of conichalcite.

JEWELRY & DECORATIVE USES

Despite its attractive, sometimes peridot-like green color and moderately high refractive index, conichalcite's relative softness, brittleness, and tendency to form only small crystals has precluded use as a gemstone.

HISTORY & LORE

Conichalcite was discovered and first described by German mineralogist August Johann Friedrich Breithaupt (1791-1873) in 1849 after studying specimens from Hinojosa del Duque, Córdoba, in Andalusia, Spain. For the next 80 years, conichalcite was considered a rare mineral found only at its discovery locality. But in the early 1930s, fine specimens of conichalcite were recognized in copper mines at Bisbee, Arizona. Since then, conichalcite has been identified at dozens of oxidized, copper-rich mineral deposits and copper-ore bodies around the world.

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Metaphysicists believe that wearing or touching clusters of conichalcite crystals enhances communication and personal powers, and brings heart and intellect together. They also believe that conichalcite stimulates intuition, imagination, and adaptability, and is especially effective in preparing the mind for meditation as it deflects concerns with the physical world.

TECHNOLOGICAL USES

Because of its intimate occurrence with other copper minerals in shallow, readily accessible, oxidized ore zones, conichalcite has served, probably inadvertently, as a minor ore of copper, being mined and smelted along with far larger quantities of such oxidized copper ores as azurite $[\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2]$, malachite [both $\text{Cu}_2\text{CO}_3(\text{OH})_2$], and cuprite (Cu_2O).

In alternative medicine, powdered conichalcite, because of its copper and arsenic components, was once used as an effective treatment for psoriasis and certain related skin ailments.

Conichalcite has seen long, but limited, use as an earth-green pigment. During the 19th and early 20th centuries, it was sometimes confused with synthetic "Schweinfurt green" and "emerald green" pigments. Conichalcite is still available today from specialty suppliers as a traditional green pigment.

Although conichalcite is not considered an ore of arsenic, lots of arsenic has been mined for commercial purposes in the Mapimí district, as we will see. Despite being highly poisonous to humans, arsenic has many useful purposes: it is used in glass manufacturing to eliminate a green color caused by iron-compound impurities in the glass, and is added to lead to harden it. Arsenic is also used in insecticides, as a semiconductor when mixed with other elements, and of course in poison gases for military use. Before the discovery of penicillin, arsenic was used to treat certain sexually-transmitted diseases.

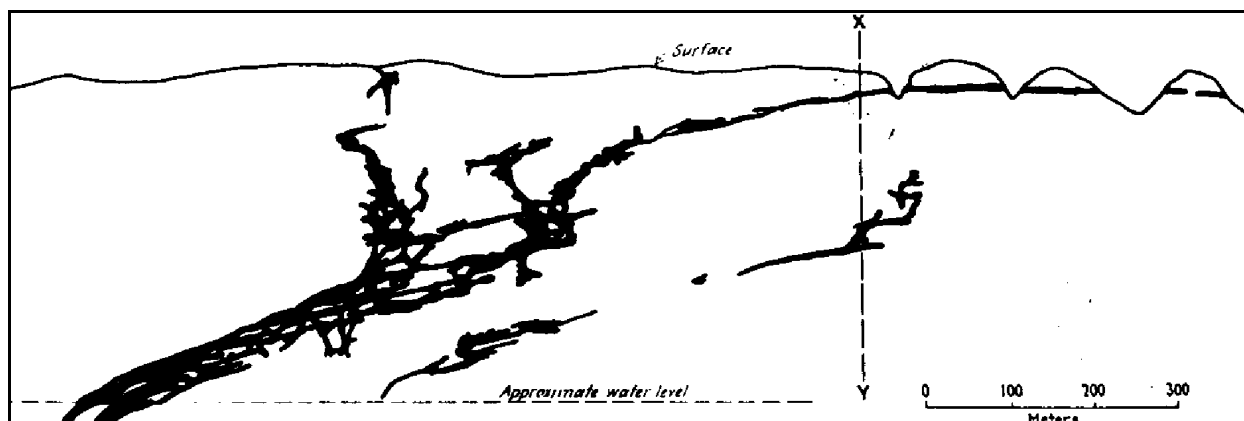
ABOUT OUR SPECIMENS

Our brightly colored specimens come from Mapimí, in the northeastern part of the Mexican state of Durango, just below the state of Chihuahua. The mining district there, known as the Bufo de Mapimí, is actually about 6 miles southeast of the town of Mapimí with its population of about 2000, which reached 20,000 during its mining heyday in the late 1800's and early 1900's. Silver mining began here under Spanish rule, in 1598. The Spaniards named the mine "Hojuela," meaning "leaf-like," because they saw what looked like leaves (hojas) in the ores, and somewhere along the way, the "H" was lost. Over the centuries, 216 mines and shafts were developed in the region, eventually producing more than 6,000,000 kilograms of silver, 49,000 kilograms of gold, 271,000 kilograms of lead, and 158,000 kilograms of arsenic.

The Ojuela mine, or *Mina Ojuela*, has been worked since at least 1800 for its unique, complex arsenical silver-lead ore. In 1910, the builders of the Brooklyn Bridge were brought in to construct a suspension bridge to connect the Ojuela mine across a steep, narrow canyon to the Socavón mine. The bridge became known simply as the "Great Bridge." (The owner of the construction company, W.A. Roebling, was a gem collector who later gave his collection to the Smithsonian.) Some years ago, the bridge was partially damaged in a fire, but has now been restored so that foot traffic is possible. By 1940, the main shaft of the Ojuela mine, known as *Tiro Norte*, had reached 2,601 feet deep, and huge pumps were used to move 6,000 gallons of water per minute to keep the lower levels dry. Ore was broken by hand and sent by train to Mapimí for smelting. *Mina Ojuela* eventually came to have six major shafts and hundreds of small shafts and adits with more than 250 miles of underground workings, all carefully named and mapped.

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A cross-section view of one of the Mapimi mining district ore bodies, showing the irregular chimney and veins typical of the area. Drawing copyright 1926 by Engineering and Mining Journal/Peñoles, from *Minerals of Mexico* by William D. Panczer

The ore bodies so long exploited in the Mapimí district are found as veins (in Spanish, mantos) and **chimneys**, which are cylindrical, more or less vertical ore bodies, as seen in the drawing. There are seven huge chimneys of varying metal and mineral content in the district, with most reaching a depth of more than 900 meters, and perhaps much greater. The ore bodies were formed through limestone replacement. The oxidation zone, where secondary minerals like malachite, azurite, and our featured mineral are found, reaches down about 1700 feet and ends at the water table, as we might expect. It is the presence of so much arsenic in the area that sets the stage for the formation of our grass-green basic calcium copper arsenate specimens. Of course, Mina Ojuela is best known for the world's finest specimens of adamite, as noted in the August 1947 *The Mineralogist*: "The spectacular crystallizations of adamite . . . are from the noted Ojuela Mine, Mapimí, Durango, Mexico . . . Recently a small pocket of adamite was encountered in the workings. The mineral was not previously found at this locality and the specimens are notable for their splendor, beauty and crystallization." It goes on to relate how many museums and collectors were adding wonderful specimens to their collections. Fine adamite specimens continue to emerge from the mine, and we were happy to be able to feature this highly fluorescent mineral in our Club in May 1998.

The grass-green color of our specimens is unusual and the contrast against the earthy brown goethite and limonite matrix makes for a pretty combination. Our specimens consist mainly of crusts and coatings of conichalcite, and we may have to be satisfied with such, as conichalcite crystals with visible faces are extremely rare. Some of our specimens have pretty calcite crystals as well, a common association at Mina Ojuela, along with malachite, austinite, mimetite, and goethite and limonite. No fluorescence was seen on our specimens, even in the normally fluorescent calcite that graced some specimens. We are glad to have been able to feature a second mineral from *Mina Ojuela*, especially one with conichalcite's fascinating properties. It is doubtful we will feature more from this outstanding locality, but we can hope!

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