

December 2007 Mineral of the Month: Vanadinite

In 1894, U.S.G.S. geologist William F. Hillebrand donated specimens of extraordinarily colorful, large, well-formed vanadinite to the U.S. National Museum of Natural History (Smithsonian Institution). The locality information he provided was the "Romaldo Pachecos claim, Silver District, Yuma County, Arizona." The whereabouts of this claim has been a mystery to collectors ever since, perhaps until now . . .

PHYSICAL PROPERTIES

Chemistry: $\text{Pb}_5(\text{VO}_4)_3\text{Cl}$ Lead Chlorovanadate

Class: Phosphates, Arsenates, and Vanadates

Group: Pyromorphite

Crystal System: Hexagonal

Crystal Habits: Usually small, prismatic crystals with hexagonal cross sections that are sometimes hopper-shaped or hollow (skeletal); also fibrous, incrusting, compact, globular, and nodular.

Color: Ruby-red, orange-red, orange, orange-brown, yellow, and brown; individual crystals are occasionally multicolored.

Luster: Adamantine, resinous

Transparency: Transparent to translucent

Streak: Pale yellow to light brownish-yellow

Cleavage: None

Fracture: Uneven to subconchoidal

Hardness: 3.0

Specific Gravity: 6.7-7.2

Luminescence: None

Refractive Index: 2.35-2.412

Distinctive Features and Tests: Best field marks are red color, bright luster, softness, and hexagonal form.

Pyromorphite [lead chlorophosphate, $\text{Pb}_5(\text{PO}_4)_3\text{Cl}$] and mimetite [lead chloroarsenate,

$\text{Pb}_5(\text{AsO}_4)_3\text{Cl}$] have similar physical properties but are usually green and yellow respectively.

Bright-red crocoite [lead chromate, PbCrO_4] crystals are striated.

Dana Classification Number: 41.8.4.3



Figure 1. Vanadinite crystal.

NAME

Vanadinite, pronounced vah-NADE-in-ite, is named for vanadium, one of its elemental components, whose name origin is described in the special section on vanadium. Vanadinite has also been known as "brown lead," "johnstonite," "lead vanadate," "vanadium lead," and "red vanadium lead." An arsenic-rich variety is called "endlichite." European mineralogists refer to vanadinite as "vanadinit" and "vanadinita."

COMPOSITION

Vanadinite now joins the list of elite minerals that we have featured twice, a list that includes cavansite, kyanite, apophyllite, azurite, crocoite, calcite, epidote, sulfur, rhodochrosite, orpiment, aragonite, celestine, dolomite, gypsum, actinolite, and hematite. Fluorite and apatite we have featured three times, pyrite four times, and we have featured several of the quartz varieties, and several members of the garnet, tourmaline, and mica groups. The first time we featured vanadinite was back in November 2001, when we sent excellent specimens from the ACF Mine, Mibladen, Midelt, Khénifra Province, Morocco. Richard and our son Keenan were driving to Denver that year when 9/11 occurred—Cheryl's flight to Denver was subsequently cancelled in the aftermath—and on September 12 saw a Moroccan dealer with a large lot of vanadinite, but was too upset to make a deal to get additional specimens.

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Vanadinite's chemical formula identifies its elemental components as lead (Pb), vanadium (V), oxygen (O), and chlorine (Cl). The molecular weight of vanadinite is made up of 73.15 percent lead, 13.56 percent oxygen, 10.79 percent vanadium, and 2.50 percent chlorine. All molecules consist of cations (positively charged ions) and anions (negatively charged ions). Anions often take the form of radicals, which are groups of atoms that act as entities in chemical reactions. In vanadinite, the cation consists of five lead ions $[5\text{Pb}^{2+}]$ with a collective charge of +10. Vanadinite's compound anion is made up of three vanadate radicals $[3(\text{VO}_4)^{3-}]$ and a chlorine ion $[\text{Cl}^{1-}]$. The collective anionic charge of -10 balances the cationic charge of +10 to provide the vanadinite molecule with electrical stability.

Vanadinite is one of nearly 300 members of the Phosphates, Arsenates, and Vanadates class of minerals. The basic building blocks of this class are the phosphate radical $[(\text{PO}_4)^{3-}]$, the arsenate radical $[(\text{AsO}_4)^{3-}]$, and the vanadate radical $[(\text{VO}_4)^{3-}]$. All form tetrahedral structures with four oxygen ions surrounding the ion of a metal or semi-metal (vanadium is a metal; arsenic and phosphorus are semi-metals). In the vanadate radical $[(\text{VO}_4)^{3-}]$, four oxygen ions $[4\text{O}^{2-}]$ surround and covalently bond to a vanadium ion $[\text{V}^{5+}]$. The resulting -3 charge is distributed evenly over the four oxygen ions, enabling the vanadate radical to bond ionically with many metal ions.

In vanadinite, three vanadate radicals $[3(\text{VO}_4)^{3-}]$ bond ionically to five lead ions $[5\text{Pb}^{2+}]$ to form the intermediate, octahedral-shaped, lead-vanadate radical $[\text{Pb}_5(\text{VO}_4)_3]^{1-}$. In the spaces between these octahedra, chlorine ions bond ionically to every fifth lead ion to complete the molecule and provide electrical balance. Each vanadinite structural unit therefore consists of a chlorine ion surrounded by six lead ions, with one of these lead ions being provided by an adjacent molecule. This arrangement of six lead ions establishes vanadinite's basic hexagonal crystal form. Because vanadate radicals shield the lead ions, and oxygen ions within the radicals shield the vanadium ions, vanadinite exhibits no metallic properties.

Within the vanadinite crystal lattice, strong, electron-sharing, covalent bonding is limited largely to the vanadate radical. Much weaker ionic bonding, which joins the lead ions to the vanadate radicals and the chlorine ions to the lead ions, dominates throughout the lattice and explains vanadinite's softness (Mohs 3.0) and brittleness. And because ionic bonding exerts strength equally in all directions, vanadinite has no cleavage planes. Vanadinite has one of the highest densities (specific gravity 6.7-7.2) of all transparent-to-translucent minerals. Vanadinite's high density is due to lead (atomic weight 207.2), which accounts for 73.15 percent of its molecular weight.

The Dana mineral classification number 41.8.4.3 first identifies vanadinite as an anhydrous phosphate, arsenate, or vanadate containing a hydroxyl or halogen ion (41). The subclassification (8) then defines it by the general formula $\text{A}_5(\text{XO}_4)_3\text{Z}_q$, in which "A" is a divalent metal ion, "XO" is a phosphate, arsenate, or vanadate radical, and "Z" is a hydroxyl ion $[(\text{OH})^{1-}]$ or a halogen ion. Halogens fall under group VII A of the periodic table of elements and include fluorine (F), chlorine (Cl), bromine (Br), iodine (I), and astatine (At). The "q" notation refers to a variable quantity. Finally, vanadinite is a member of the pyromorphite group (4) as the third (3) of three members.

These three pyromorphite-group members all share close mineralogical relationships:

Pyromorphite lead chlorophosphate $\text{Pb}_5(\text{PO}_4)_3\text{Cl}$ (hexagonal)

Mimetite lead chloroarsenate $\text{Pb}_5(\text{AsO}_4)_3\text{Cl}$ (monoclinic)

Vanadinite lead chlorovanadate $\text{Pb}_5(\text{VO}_4)_3\text{Cl}$ (hexagonal)

Their formulas vary only in the anionic phosphate, arsenate, and vanadate radicals. With similar electrical charges and ionic radii, these radicals easily substitute for each other, enabling pyromorphite, mimetite,

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and vanadinite to form mutual, graded, solid-solution series. Because of the nearly identical ionic radii of the vanadate and phosphate radicals, vanadinite and pyromorphite are isomorphic, that is, they have identical crystal structures despite their differing chemical compositions. In these solid-solution series, species identity is determined by the radical that predominates in weight. Vanadinite also undergoes a lesser degree of cationic substitution, in which calcium ions [Ca^{2+}] substitute for lead [Pb^{2+}] ions. Because of this ease of cationic and anionic substitution, vanadinite rarely, if ever, occurs in pure form. These three share other properties that make them especially desirable to collectors: bright color and luster, and small but sharp, well-formed crystals. Pyromorphite, which we featured in July 2002 from a new find in China, is usually bright green, and occasionally brown, yellow or orange, while mimetite, which we have yet to feature but hope to when a new strike is made, is usually bright yellow, and sometimes yellow-brown, brown, or orange.

Vanadinite is an idiochromatic (self-colored) mineral in which color is created by its essential elemental components or because of the nature of its crystal structure. The basic, ruby-red color of vanadinite is created by its vanadate radicals, which cause the lattice to absorb the entire lower end of the visible spectrum and thus to reflect only light in the red wavelengths. Frequent cationic and anionic substitution, along with the presence of other impurities, alter the light-absorption properties of the lattice to impart a range of colors from ruby-red to brown. Chemical variations in the crystallizing solutions can also create multi-coloration, with reds and browns appearing in the same crystal.

Vanadinite is an uncommon secondary mineral that develops almost exclusively in the alteration zones of massive hydrothermal replacement and vein deposits. It is a product of the oxidation of primary lead minerals and forms mainly in arid climates in environments with restricted circulation of acidic groundwater. Vanadinite is often associated with galena [lead sulfide, PbS], barite [barium sulfate, BaSO_4], calcite [calcium carbonate, CaCO_3], and wulfenite [lead molybdate, PbMoO_4].

COLLECTING LOCALITIES

Although vanadinite is an uncommon mineral, it is widely distributed and occurs in many localities. However, well-developed specimens larger than one-half inch in size are almost always found in shallow deposits in arid climates. Our specimens were collected at a classic vanadinite locality—the Pure Potential Mine (also known as the North Geronimo Mine) in the Silver Mining District in the Trigo Mountains of La Paz County, Arizona. Both these locality names, “Pure Potential Mine” and “North Geronimo Mine,” identify the same claim. It has been known as North Geronimo for decades, but when it was reclaimed in 1994, the Pure Potential name was used. Mindat.org calls it “Pure Potential,” while the *Mineralogical Record* calls it “North Geronimo.” So we put both names on our labels, and are using them interchangeably in the write-up. Could this perhaps be the locality of the long lost Romaldo Pachecos claim?

Arizona is by far the leading source of vanadinite specimens in the United States, with upwards of forty productive mines. including the Apache Vanadium Mine in the Globe-Miami district in Gila County, the Old Yuma Mine at Jaynes in the Amole district in Pima County, the J. C. Holmes Mine in Temporal Gulch near Patagonia in the Patagonia Mountains in Santa Cruz County, and the Mammoth-St. Anthony Mine at Tiger in the Mammoth district in Pinal County.

Other notable vanadinite sources in the United States are the Carlin Gold Mine in the Lynn district and the Gold Quarry Mine in the Maggie Creek district, both in Eureka County, Nevada; the Groundhog Mine at Vanadium in the Central Mining District in Grant County, New Mexico; the Dukes, Lonestar, and Purple Sage mines in the Indio Mountains of Hudspeth County, Texas; the El Dorado Mine near Indio in Riverside County, California; and the Spokane Mine at Iron Mountain in Custer County, South Dakota.

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In Mexico, vanadinite specimens are found at the type locality at Zimapán in Hidalgo. Other notable Mexican sources include Villa Ahumada in the Sierra Los Lamentos district, and the San Carlos Mine at San Carlos near Manuel Benavides, both in Chihuahua.

Fine specimens are found in Australia at the Iron Monarch open pit in the Middleback Range on the Eyre Peninsula in South Australia; in Chile at La Presidenta Mine at San Antonio in Copiapó Province in the Antofagasta Region; in Argentina at the Río Agrio Mine at Neuquen, Picunches Department; in Scotland at the Belton Grain vein at Wanlockhead in the Leadhills-Wanlockhead district in Dumfriesshire; in England at the Old Pots Gill and Brandy Gill mines at Caldbeck Fells in Cumbria; and in Austria at the Alt-Stefanie Mine at Heiligengeist in the Bleiberg district of Carinthia.

Africa has produced many fine vanadinite specimens, notably from the Kabwe Mine (Broken Hill Mine) at Kabwe in the Central Province of Zambia, and the Abenab Mine at Grootfontein in the Grootfontein district in the Otjozondjupa Region of Namibia. The best African specimens have come from two mines in the Meknès-Tafilalet Region of Morocco: the Kwal Mine at Miblanene in Khénifra Province, and the Four Man Mine at Taouz in El Rachidia Province.

JEWELRY & DECORATIVE USES

Despite its attractive red and orange colors, vanadinite is much too soft (Mohs 3.0), too difficult to polish, and too brittle to serve as a gemstone. However, its bright colors coupled with the rarity of good specimens have long made vanadinite one of the most collectible of all minerals for both study and display purposes, and one of the most valuable.

HISTORY & LORE

Spanish naturalist and mineralogist Andrés Manuel del Río (1764-1849) was first to realize that vanadinite was a new mineral. Working in Mexico City in 1801, del Río studied specimens from Zimapán, Hidalgo, that he called “brown lead.” He correctly deduced that these specimens contained a previously undiscovered metallic element that he named “panchromium,” then later renamed “erythronium.” However, French chemist Hippolyte Victor Collett-Desotils (vita uncertain) contested del Río’s conclusion, claiming that “erythronium” was merely a form of chromium and that “brown lead” was actually lead chromate [crocoite, PbCrO_4]. Del Río withdrew his claim and “brown lead” was forgotten. The confirmed identification of vanadium as a new element in 1830 (see “About Vanadium”) refocused attention on del Río’s “brown lead,” which was formally named “vanadinite” in 1838.

Vanadinite was the only source of vanadium until metallurgists succeeded in extracting the metal from vanadiferous magnetite [iron (ferrous-ferric) iron oxide, $\text{Fe}^{2+}\text{Fe}_{23+}\text{O}_4$] iron ores in 1870. Researchers used X-ray diffraction methods to determine the atomic structure of vanadinite in 1926.

Modern metaphysical practitioners believe that vanadinite helps to bring emotional sensitivity to analytically minded people who tend to over-intellectualize their feelings. They also believe it enhances sensitivity in general, helps to clear confusion and feelings of purposelessness, and assists in grounding and centering.

TECHNOLOGICAL USES

Vanadinite, once the only known ore of vanadium, has also served as a minor ore of lead.

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VANADIUM

Vanadium, the namesake for vanadinite, was actually “discovered” three times by three different researchers. The first, as explained previously, was Spanish mineralogist Andrés Manuel del Río who, in 1801, proposed the existence of a new metal in specimens of “brown lead.” In 1830, German chemist and mineralogist Friedrich Karl Wöhler (1800-1882) reexamined “brown lead” to confirm del Río’s original claim of a new metal. But when Wöhler made his discovery, he was soon to become a “fluorine martyr,” a researcher who had compromised his health by inhaling hydrogen-fluoride gas generated in the course of studying the mineral fluorite [calcium fluoride, CaF_2]. (“Fluorine martyrs” are explained in our “Fluorite” write-up in October 2007.) Seriously ill, Wöhler could not publish his findings and thus was not credited for co-discovering the new element.

In 1831, Swedish chemist Nils Gabriel Sefström (1787-1845), working independently of Wöhler, experimented with ores from Sweden’s Taberg iron mine and produced an oxide that contained a previously unidentified metallic element. From this oxide, Sefström also produced several other brightly colored red and yellow compounds. Although he failed to isolate the new element, he nevertheless named it “vanadium,” after Vanadis, the Norse goddess of beauty, in reference to its colorful compounds.

In 1867, Sir Henry Enfield Roscoe (1835-1915), a professor of chemistry at Britain’s Owens College (now the University of Manchester), finally succeeded in isolating elemental vanadium by reducing vanadium chloride. One of the transition metals, vanadium is a relatively soft, ductile, silver-white metal with good structural strength and chemical resistance. With an atomic mass of 50.94, it is a bit less dense than iron, but has a considerably higher melting point. When first isolated, vanadium was considered rare (it actually ranks 19th among the elements in crustal abundance and is a bit more abundant than nickel) and was obtained only in small quantities from vanadinite or as a by-product of processing certain iron ores.

Initially, vanadium was a laboratory curiosity without any practical uses. But in the late 1890s, French metallurgists found that adding 0.1 to 5.0 percent vanadium to steel refined the grain of the steel matrix and enhanced its tensile strength, toughness, ductility, and corrosion resistance, and also combined with the carbon present to form carbides that hardened the steel. As industrial demand for vanadium increased, the first primary vanadium mine opened in Peru in 1901, exploiting a large deposit of patrónite [vanadium sulfide, $\text{V}(\text{S}_2)_2$]. Several years later, carnotite [hydrous potassium uranium vanadate, $\text{K}_2(\text{UO}_2)_2(\text{VO}_4)_2 \cdot 3\text{H}_2\text{O}$] became another source of vanadium.

But many steelmakers, especially those in the United States, resisted using the unfamiliar alloying metal. That changed after 1910, however, when American industrialist Henry Ford (1863-1947), searching for new materials for his early automobiles, happened to inspect a European racing car that crashed at the newly opened Indianapolis Motor Speedway. The impact of the crash had demolished the car’s engine and bent or fractured virtually every chassis or power-train component. The single exception was the undamaged crankshaft, which Ford learned consisted of a new Swedish steel that was alloyed with vanadium. After investigating the properties of vanadium alloys, Ford began specifying them for critical parts in his own automotive power trains. Vanadium-steels eventually went into 15 million Model Ts, clearly demonstrating to American steelmakers the great value of the new alloys.

Today, vanadium-steel alloys are used to manufacture large-diameter pipeline sections, high-speed tool steels, and girders for bridges and high-rise buildings. Vanadium-chrome steels are the preferred alloys

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for automotive suspension springs, transmission gears, and high-stress engine components. In the form of lightweight, heat-resistant vanadium-aluminum-titanium alloys, vanadium is vital to the aerospace and aviation industries for the manufacture of high-performance jet and rocket engines. Vanadium dioxide, the metal's most important compound, is a catalyst for the production of sulfuric acid and maleic anhydride, the latter a feedstock for manufacturing polyester resins and fiberglass. Vanadium dioxide is also used in the huge "load-leveling" batteries that maximize the efficiency of commercial power grids and rechargeable lithium batteries for clocks, watches, cameras, and computers.

Most vanadium is no longer obtained from mines, but recovered as a by-product of processing vanadiferous iron and titanium ores, slags, and petroleum residues. Some 1.7 million pounds of vanadium are used worldwide each year, with 85 percent going into alloys. In its oxide form, one pound of vanadium is currently worth \$3.20.

ABOUT OUR SPECIMENS

As mentioned in "Collecting Localities," our specimens come from a classic vanadinite locality—the Pure Potential Mine (a.k.a. the North Geronimo Mine) in the Silver Mining District in the Trigo Mountains of La Paz County, Arizona. The Pure Potential Mine has an interesting history in that, as a specimen source, it has been overshadowed for more than a century by another famous mine, the nearby Red Cloud. The Pure Potential has recently emerged as a classic locality and now appears to be the "lost" mine that once provided superb vanadinite specimens to the Smithsonian Institution more than a century ago.

The Pure Potential Mine and the Silver Mining District are located in a remote and rugged part of southwestern Arizona some 30 air miles due north of the city of Yuma, as seen in the map on Figure 2. It occupies a narrow section of land administrated by the U.S. Bureau of Land Management that lies between the U.S. Army's Yuma Proving Ground one mile to the east and the Cibola National Wildlife Refuge on the Colorado River five miles to the west. The local topography is typical basin-and-range, with long valleys and basins separated by such low, north-south-trending mountain ranges as the Trigo Mountains. At an elevation of 750 feet, the Silver Mining District lies within the ecological province of the hot, arid, Upper Sonoran Desert where the sparse vegetation is largely limited to cholla, ocotillo, and barrel cactus.

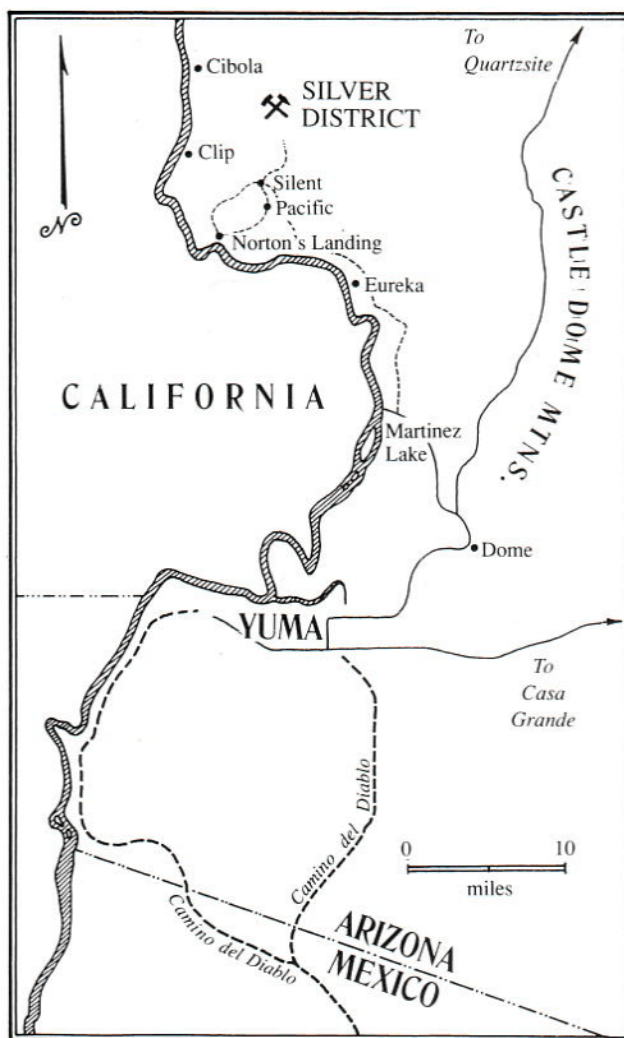


Figure 2. Location map, courtesy of Mineralogical Record, used by permission.

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Prospectors discovered the district's silver-lead ores along a highly mineralized fault in 1863, but the area's remoteness and the inability to mill or ship ores prevented its immediate development. Additional claims were filed in 1878 and miners formally established the Silver Mining District a year later. The event that finally spurred mine development was the 1882 completion of the Southern Pacific Railroad linking southern Arizona Territory with El Paso to the east and Los Angeles to the west. The Southern Pacific Railroad passed through Yuma, which became the closest shipping point for the Silver Mining District. The district was served by mule-drawn, heavy freight wagons that hauled high-grade silver ore south over 45 miles of rough trail to Yuma, returning with mining equipment and supplies.

The Silver Mining District reached its peak in the 1880s, when it produced 240,000 troy ounces of silver and 2,000 tons of lead worth about \$250,000. Ore grades varied somewhat among the district mines, but an average ton of ore contained eight troy ounces of silver and six percent lead (about 120 pounds of lead per ton). The richest mines were the Red Cloud, Red Cloud No. 1, and Red Cloud Extension mines. Other producers included the North and South Geronimo, Pacific, Black Rock, Melissa, Cochise, Black Eagle No.2, R. C. Frac, Papago, and Lone Star State mines, as seen in Figure 3. These were all small underground mines with shafts no deeper than 300 feet. From the shafts, miners drove narrow, lateral drifts to search for pockets and veins of high-grade ore, which they extracted by stoping methods. By 1890, the district's shallow, high-grade, argentiferous (containing silver)-galena and secondary-argentiferous-lead ores were largely exhausted and production declined sharply.

By then, geologists had learned that the genesis of the district's mineralization had begun some 20 million years ago when tectonic stresses generated by the grinding of the North American Plate over the edge of the Pacific Plate uplifted much of what is now the American Southwest. These stresses activated existing fault systems, resulting in block displacement that created the basin-and-range topography. Within what would become the Silver Mining District, the basement rock consisted of volcanic rhyolite overlying older formations of monzonite and quartz monzonite. As tectonic stresses activated the major local fault, now known as the Red Cloud Fault, the monzonite block displaced upward relative to the rhyolite. This brought the monzonite, on the west side of the fault, into direct contact with the rhyolite on the east side.

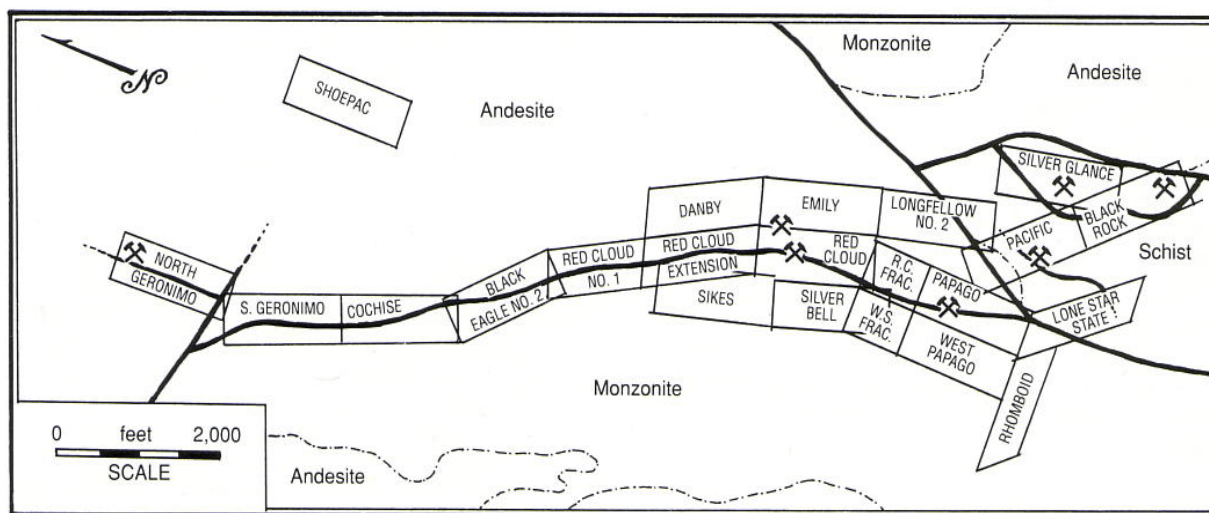


Figure 3. Claims along the Red Cloud Fault, courtesy of *Mineralogical Record*, used by permission.

During this displacement, metal-rich hydrothermal solutions surged through the fault and emplaced

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epithermal vein mineralization in the form of argentiferous galena [lead sulfide, PbS , containing varying amounts of silver] and other primary minerals of zinc, iron, and molybdenum. Erosion eventually reduced the surface, bringing groundwater and atmospheric oxygen into contact with the mineralized fault. As acidic groundwater percolated downward through the fault, oxidation altered much of the galena to anglesite [lead sulfate, PbSO_4], cerussite [lead carbonate, PbCO_3], and massicot [lead oxide, PbO]. Argentiferous galena and its argentiferous alteration minerals were the ores of the Silver Mining District.

Although the district was never a major source of silver and lead, it did have two minerals that would bring it enduring fame—red vanadinite and orange-red wulfenite [lead molybdate, PbMoO_4]. In the complex alteration process that created these secondary minerals, acidic groundwater dissolved small amounts of vanadium mineralization from the adjoining body of monzonite, then percolated downward into the fault. After contacting lead ions, this groundwater filled voids and seams within the fault where vanadinite crystallized out of solution. In a similar process, acidic groundwater dissolved molybdenum and lead minerals from the mineralized fault itself, depositing them as wulfenite onto the walls of lower cavities.

The greatest abundance of these colorful secondary minerals is found in two mines: wulfenite in the Red Cloud and vanadinite in the North Geronimo. Both mines are located directly on the Red Cloud Fault, the North Geronimo being only 1.8 miles north of the Red Cloud. By 1885, the Red Cloud Mine was supplying fine wulfenite crystals to the A. E. Foote Mineral Company of Philadelphia, Pennsylvania, a leading national supplier of mineral specimens. The district also gained fame for its vanadinite specimens. This was the time period when United States Geological Survey geologist William F. Hildebrand (1853-1925) donated a flat of superb vanadinite specimens, with crystals as large as one inch, to the Smithsonian Institution, starting the legend of the “Romaldo Pachecos” mine in the Silver Mining District.

The 1893 silver-market collapse was the final nail in the coffin of the Silver Mining District. In later decades, miners occasionally attempted to reopen old workings and rework mine waste for silver, but with poor results. Fortunately, in 1938, the legendary, professional mineral collector Edwin J. “Ed” Over (1903-1963), of Colorado Springs, Colorado, worked the Red Cloud Mine, recovering many beautiful wulfenite crystals. In the 1950s, serious Arizona collectors began working the Red Cloud Mine and, despite the harsh conditions, made impressive wulfenite recoveries. No records exist of any collecting at the North Geronimo Mine.

In 1982, a realignment of counties placed the Silver Mining District, previously part of Yuma County, in newly created La Paz County. This has since led to some confusion in source notations of specimens from the Silver Mining District. Then in the late 1980s, two factors renewed interest in the district's specimen potential—sharply rising prices for fine wulfenite and vanadinite specimens, and suspicion that the North Geronimo Mine was actually the lost Romaldo Pachecos Mine. But while collectors did recover brilliant-red, beautifully formed vanadinite crystals from the North Geronimo, they were considerably smaller than the 1894 specimens in the Smithsonian collection, casting doubts that the lost Romaldo Pachecos mine had been rediscovered.

Commercial collectors returned to the North Geronimo Mine in 1994, reclaiming the property under the new name of the Pure Potential Mine. This renaming has also led to confusion in the creation of mineral labels. At this time, the mine had a 25-foot-deep shaft connecting to a declined tunnel that went to a depth of 70 feet. Short lateral drifts extended on both sides of the 25-foot and 70-foot levels. Although work was difficult, collectors found many vanadinite-filled pockets and veins along the decline and the 70-foot-level drifts, recovering more than 150 flats of fine vanadinite specimens. Some individual crystals measured nearly one inch, convincing most experts that the Pure Potential is indeed the lost Romaldo Pachecos Mine! The mine was reopened again in 2000 by the Golden, Colorado-based Collector's Edge, one of the

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nation's foremost commercial-collecting organizations. Collector's Edge experts worked the Pure Potential for three successive winter seasons, during which they recovered our vanadinite specimens. They were not able to recover enough specimens to show a profit for the efforts--the costs of mining in the United States are so high that it is difficult to turn a profit unless a lot of exceptional material is produced. Though perhaps not financially rewarding, their efforts had proven to be a bonanza for us! And thanks to these fine specimens and others collected during the past 20 years, the Pure Potential Mine/North Geronimo Mine is now recognized as the leading vanadinite source in the United States and one of the top sources in the world--and the mystery of the Romaldo Pacheco claim has been solved after 100 years!



Figure 4. Headframe at the Pure Potential Mine. All photos courtesy on Collector's Edge Minerals.

Most striking of course is the bright orange-red color of the crystals. Though most crystals are very small, with our loupe we can see the 6-sided barrel shape and the flat terminations seen in the ideal crystal drawing in Figure 1. Minute calcite crystals are sometimes encountered, and other minerals found here are fluorite, mimetite, quartz, and wulfenite. We will enjoy adding these colorful specimens to our collections, and studying them will remind us of their fascinating history!



Figure 5. Adit at Pure Potential Mine.

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Mineral of the Month Club 1770 Orville Avenue Cambria, CA 93428

1-800-941-5594 www.mineralofthemonthclub.org