

June 2007 Mineral of the Month: Epidote

In July 1997, when we had about 125 members, we featured fine specimens of excellent epidote from a new find, some 14,000 feet above sea level in the Andes Mountains of Peru. Nearly ten years later, we are again proud to present even better specimens from the same locality, along with a highly informative write-up, twice as long as what we sent to Club members then. Read on and enjoy!

PHYSICAL PROPERTIES

Chemistry: $\text{Ca}_2\text{Al}_2(\text{Fe}^{3+},\text{Al})\text{Si}_3\text{O}_{12}(\text{OH})$ Calcium Aluminum Iron Silicate Hydroxide (Basic Calcium Aluminum Iron Silicate)

Class: Silicates

Subclass: Sorosilicates (Double-Tetrahedral Silicates)

Group: Epidote

Crystal System: Monoclinic

Crystal Habits: Usually as thick, tabular crystals or long, slender prismatic crystals that are typically well-developed and terminated by two sloping faces; often deeply striated (grooved); also massive, columnar, divergent, acicular, radial, and granular. Twinning common.

Color: Yellowish-green to greenish-black and brownish-black, often pistachio green; less frequently pink, gray, black, and yellow.

Luster: Vitreous; pearly on cleavage surfaces.

Transparency: Transparent to translucent; rarely opaque.

Streak: Colorless to gray

Cleavage: Perfect in one direction

Fracture: Uneven

Hardness: 6.0-7.0

Specific Gravity: 3.3-3.6

Luminescence: None

Refractive Index: 1.715-1.797

Distinctive Features and Tests: Best field marks are pistachio-green to dark, greenish-black color, grooved crystals, and perfect, one-directional cleavage.

Dana Classification Number: 58.2.1a.7

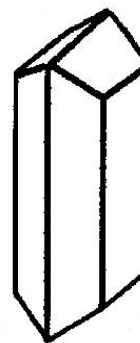


Figure 1. Epidote crystal.

NAME

The name of this month's mineral is correctly pronounced EH-peh-dote. The name stems from the French *épidote* which, in turn, derives from the Greek *epididonai*, literally "to give more," a reference of uncertain meaning (see "History & Lore"). European mineralogists refer to epidote as "epidotita" and "epidotit." Former names for epidote include "acanticonone," "acanticonite," "allochite," "bucklandite," "delphinite," "ferriepidote," "iron epidote," "epidosite," "epidotite," "pistazite," "puschkinite," "selphinite," and "epithallite."

COMPOSITION

Epidote, chemical formula $\text{Ca}_2\text{Al}_2(\text{Fe}^{3+},\text{Al})\text{Si}_3\text{O}_{12}(\text{OH})$, contains the elements calcium (Ca), aluminum (Al), iron (Fe), silicon (Si), oxygen (O), and hydrogen (H). By weight, epidote consists of 15.44 percent calcium, 3.90 percent aluminum, 24.20 percent iron, 16.22 percent silicon, 0.19 percent hydrogen, and 40.05 percent oxygen.

The complex epidote molecule $\text{Ca}_2\text{Al}_2(\text{Fe}^{3+},\text{Al})\text{Si}_3\text{O}_{12}(\text{OH})$ has three cations (positively charged ions) and two anions (negatively charged ions). Its compound cation consists of two calcium ions (2Ca^{2+}) and two

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aluminum ions (2Al^{3+}), along with the substitution unit ($\text{Fe}^{3+},\text{Al}^{3+}$). In substitution units, two elements freely replace each other. In epidote, the interchangeable ions are iron (ferric, Fe^{3+}) and aluminum (Al^{3+}), and the ($\text{Fe}^{3+},\text{Al}^{3+}$) substitution unit contributes a +3 charge to the compound cation. Thus, the epidote cation, with the +4 charge of its two calcium ions (2Ca^{2+}), the +6 charge of its two aluminum ions (2Al^{3+}), and the +3 charge of its iron-aluminum substitution unit, has a collective +13 charge. Epidote's compound anion has two radicals (groups of atoms that act as an entity in chemical reactions). One is the silicate radical (Si_3O_{12})¹²⁻, which has three silicon ions (3Si^{4+}), twelve oxygen ions (12O^{2-}), and a net -12 charge; the other is the hydroxyl ion (OH^{-1}) with its one hydrogen ion (H^{1+}), one oxygen ion (O^{2-}), and a combined net -1 charge. This collective -13 anionic charge balances the +13 cationic charge to provide the epidote molecule with electrical stability.

Epidote is a member of the silicates, the largest and most abundant class of minerals. Silicates are combinations of silicon and oxygen with one or more metals. The basic silicate structural unit is the silica tetrahedron (SiO_4)⁴⁻, in which a silicon ion is surrounded by four equally spaced oxygen ions positioned at the corners of a tetrahedron (a four-faced polyhedron). In silicate minerals, silica anions and metal cations join together like polymers (repeating chains) to form seven types of structures: independent tetrahedral silicates (nesosilicates); framework silicates (tectosilicates); single- and double-chain silicates (inosilicates); ring silicates (cyclosilicates); sheet silicates (phyllosilicates); and double tetrahedral silicates (sorosilicates).

Epidote is a sorosilicate or double-tetrahedral silicate, a group in which some silica tetrahedra (SiO_4)⁴⁻ share one oxygen ion with adjacent tetrahedra to form (Si_2O_7)⁶⁻ groups. These groups act as complex negative ions that are held together by positively charged metal ions positioned between them. Hydroxyl ions [$(\text{OH})^{-1}$] occupy the interstitial spaces to balance the remaining positive charge. In the rigid sorosilicate crystal lattices, each silica tetrahedron is bonded both covalently and ionically to metal ions to form a repeating, three-dimensional structure. Strong covalent bonding with shared electrons predominates, making epidote quite hard (Mohs 6.0-7.0). This hardness is directional, being greatest along the two planes of greatest covalent bonding. The third plane with less covalent bonding is the softest and exhibits one-directional, perfect cleavage and parallel surface striations. Although classified as a sorosilicate or double-tetrahedral silicate, epidote actually contains both double silica tetrahedra (Si_2O_7)⁶⁻ and independent silica tetrahedra (SiO_4)⁴⁻. To reflect this double-tetrahedral structure, epidote's chemical formula is sometimes written as $\text{Ca}_2\text{Fe}(\text{Al}_2\text{O})(\text{Si}_2\text{O}_7)(\text{SiO}_4)(\text{OH})$.

As an idiochromatic or self-colored mineral, epidote's basic green color is due to the presence of iron. But because the amount of iron varies with the degree of substitution for aluminum, epidote's color actually ranges from yellowish-green to black, with darker colors reflecting increasing amounts of iron. These variations in the amount of iron also account for epidote's broad specific-gravity range (3.3 to 3.6). Epidote is strongly pleochroic, meaning its colors change as it is viewed along different optical axes, a phenomenon caused by variations in the type of light absorption within doubly refractive crystals. The crystals of certain tetragonal, hexagonal, and trigonal minerals are dichroic and exhibit two main colors, while the crystals of certain triclinic, monoclinic, and orthorhombic crystals are trichroic and exhibit three main colors. Pleochroism can be weak, definite, or strong. Epidote has strong trichroism, with colors shifting between yellow, green, and brown as the crystal is rotated.

Because it forms from common elements in several environments over a wide range of temperatures and pressures, epidote is by far the most common sorosilicate. It occurs with albite [sodium aluminum silicate, $\text{NaAlSi}_3\text{O}_8$] and andalusite [aluminum silicate, Al_2SiO_5] in granite pegmatites, and with calcite [calcium carbonate, CaCO_3] and zeolite minerals [a group of hydrous complex silicates] in cavities of basalt and other volcanic rocks. Small epidote crystals often form from residual gases or solutions in the shrinkage seams of granite. However, most epidote forms as a secondary mineral through metamorphism and

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alteration. It occurs with chlorite [a group of hydrous magnesium iron aluminum silicates] and actinolite [basic calcium magnesium iron silicate, $\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$] in hornfels and greenstone of contact metamorphic rocks, and with hornblende [a group of hydrous calcium sodium potassium iron magnesium aluminum silicates], the garnet-group mineral almandine [iron aluminum silicate, $\text{FeAl}_2(\text{SiO}_4)_2$], and actinolite in regional metamorphic rocks. It is very common where igneous bodies contact calcium-rich metamorphic and sedimentary rocks. Massive and granular varieties of epidote are especially abundant, with well-developed crystals less common. Massive epidote can be so locally abundant that it imparts a green color to rocks. "Epidosite" refers to a rock composed of quartz and epidote, while "unakite" is a granitic rock consisting of green epidote, pink orthoclase [potassium aluminum silicate, KAlSi_3O_8], and white quartz [silicon dioxide, SiO_2]. (Epidosite and unakite are not formal mineral names).

The Dana mineral classification number 58.2.1a.7 identifies epidote as a sorosilicate with insular, mixed, single, or larger tetrahedral groups (58). The subclassification (2) next defines it as containing silica tetrahedrons with six-oxygen coordination or higher, which is seen in epidote's $(\text{Si}_3\text{O}_{12})^{12-}$ cation. Epidote is then assigned to the epidote subgroup (1a) as the seventh (7) of 19 members. The epidote-group minerals are all complex and contain both single and double silica tetrahedrons. The group-member clinozoisite [basic calcium aluminum silicate, $\text{Ca}_2\text{Al}_3\text{Si}_3\text{O}_{12}(\text{OH})$] forms a complete solid-solution series with epidote. Solid-solution series are created by cationic or anionic substitution. In the clinozoisite-epidote series, iron (ferrous, Fe^{2+}) substitutes for the trivalent aluminum ion Al^{3+} . Clinozoisite contains little or no iron and is colorless to light yellowish-green; epidote, which contains greater amounts of iron, is yellowish-green to nearly black.

COLLECTING LOCALITIES

Our epidote specimens come from the Rosario Mabel Mine, near the small village of Pampa Blanca (meaning "White Prairie,") Castrovirreyna Province, Huancavelica Department, Peru (see "About Our Specimens.") Brazil supplies dark epidote crystals on quartz from Capelinha in Minas Gerais and thick, terminated crystals from the Vereda do Meio Mine at Lajes in Rio Grande do Norte. Fan-like sprays of prismatic epidote are collected at the Kari-Kari Mine near Potosí in Potosí Department, Bolivia. In Mexico, epidote specimens occur at Santa Roselía at Mulegé in Baja California Sur, and at the Fomento and Rosa mines at Los Gavilanes in Baja California Norte.

In Austria, fine epidote specimens occur at the Knappenwand Mine at Untersulzbachtel in the Hohe Tauern Mountains of Salzburg, and at Langinger Spitze Mountain at Gertusk in the Saualpe Mountains of Carinthia. In France, epidote is collected at its type locality at Bourg d'Oisans near Isère in Rhône-Alpes. In Italy, epidote occurs in Torino, Piedmont, at the Suela, Locatelli, and Montecatina quarries at Mt. Comoscio and the Traversella and Tomaine quarries in the Chiusella Valley. Norwegian epidote is found at the Damåsen Mine at Konnerud in Buskerud. In Spain, epidote is collected at Olvera Olphite near Cádiz in Andalusia, and at the Nueva Vizcaya, Monchi, and La Judía mines at Badajuz, Extremadura.

Russian specimens come from the Pouyva Mine at Tyumenskaya Oblast' in the Western Siberian Region and Dal'negorsk at Primorskiy in the Far Eastern Region. Large, dark-green epidote crystals are collected at the Daskasan cobalt-iron deposit at Daskasan, Azerbaijan. Japanese specimens are found at the Fuka Mine, Takahashi, Chugoku Region, Honshu Island. Epidote also occurs in the Masherbrum and Haramosh Mountains near the Shigar River Valley in the Gilgit District of northern Pakistan. Pakistani epidote is considered the world's finest, but Rosario Mabel epidote demands a rethinking of that opinion!

In Australia, epidote specimens occur at the Parabarana Mine at Mount Fitton in the Flinders Ranges of South Australia; at the Mount Mary, Kong, and Carrara mines in the Hartz Ranges of the Northern

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Territory; and at the Aga Khan Mine at Cue in Cue Shire in Western Australia. Africa also provides epidote specimens, notably from Bendoukou, Sandaré district, Kayes Region, Mali. Here the epidote forms as much thicker and darker crystals than ours this month, and often serves as a resting place for the gorgeous apple-green botryoidal balls of prehnite [$\text{Ca}_2\text{Al}_2\text{Si}_3\text{O}_{10}(\text{OH})_2$, calcium aluminum silicate hydroxide] that we featured in September 2005. In Kenya, specimens are found at the Olkario Volcano in Hell's Gate National Park in the Rift Valley Province. Epidote has two important sources in Namibia: Tubusis in the Omaruru District of the Erongo Region, where our August 2003 black tourmaline came from, and the Abenab Mine in the Grootfontein District of the Otjozondjuba Region. In South Africa, specimens come from the Messina and Artonvilla mines in the Messina District of Limpopo Province.

In the United States, epidote is collected at the Hilltop Mine in the California Mining District near Benson, Arizona; numerous mines in the Greenhorn tungsten-mining district of Kern County, California; the Seven Devils Mining District in Adams County, Idaho; the Hazel Quarry at Meers in Comanche County, Oklahoma; the Iron Crown, Andalusite, and Green Talc mines in the Fitting District of Mineral County, Nevada; and Timber Butte in the Boulder Batholith area of Silver Bow County, Montana. In Colorado, epidote specimens occur at three primary sites: the Calumet Mine in the Turret Mining District of Chaffee County; the Idarado Mine at Telluride in San Miguel County; and the Cripple Creek district mines in Teller County. New Mexico has two notable sites: the San Pedro Mine in the New Placers district in Santa Fe County, and the Harding Mine in the Harding district near Taos in Taos County. In Arkansas, specimens are collected at the Mauney, Diamond Corp., and Arkansas mines at Murfreesboro in Pike County.

East of the Mississippi River, epidote is found in Virginia at the Gossan, Iron Ridge, and Chestnut Yard mines at Fries in the Gossan lead-mining district in Carroll County; in New York at the Rossie lead mine at Rossie in St. Lawrence County; in Maryland at the Mountain View Mine at Union Bridge in Carroll County; in Maine at Hall's Quarry at Mount Desert in Hancock County; and in Connecticut at the Roncari Quarry at East Granby in Hartford County.

Canadian specimens come from the Marmoraton Mine in Marmorata Township in Hasting County and the Craigmont Mine at Raglan Township in Renfrew County, both in Ontario. The Uni-Mix and Poudrette quarries at Mont Saint-Hilaire in Rouville County, Québec, also provide epidote specimens.

JEWELRY & DECORATIVE USES

Despite epidote's appreciable hardness (Mohs 6.0-7.0) and relatively high refractive index (1.715-1.797), it is not faceted for jewelry use because its color is too similar to that of dark peridot, the gem variety of forsterite [magnesium silicate, Mg_2SiO_4]. Transparent crystals in the lighter, pistachio-green colors are faceted into collectors' gems of about four or five carats in weight. Massive epidote is fashioned into cabochons. Fibrous inclusions in both crystalline and massive epidote sometimes produce chatoyancy (cat's-eye effect). Massive epidote is also fashioned into two- or three-inch spheres and figurines.

A metamorphosed granitic rock composed primarily of green epidote, pink orthoclase, and white quartz is marketed as "unakite." Named for the Unaka Range, a sub-range of the Appalachians in Virginia, Tennessee, and North Carolina where it is found, unakite is more popular as a gemstone than epidote itself. With its mottled pinks and greens, unakite is fashioned into cabochons, spheres, and figurines. Unakite is the official state stone of Virginia.

From our July 1997 Epidote write-up: *Other members of the epidote mineral group are often used and much prized in jewelry. Pink zoisite [$\text{Ca}_2\text{Al}_3\text{Si}_3\text{O}_{12}(\text{OH})$, calcium aluminum silicate hydroxide] is also known as "thulite" and is sometimes cut into cabochons and beads. (The name "thulite" [not an approved mineral*

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name] comes from “Thule,” an ancient name for Norway. “Zoisite” comes from Baron von Zois, who supplied samples of the mineral when it was first described in the 19th century.) Rubies were found in green zoisite matrix in Africa, and for many years the ruby was extracted and the zoisite discarded, but recently, cutters and carvers have recognized the beauty of the green zoisite and are making striking cabochons and carvings from it, often with small ruby crystals still visible in it! In 1967, a prospector named Manuel d’Souza was looking for sapphires in Tanzania, Africa. While there, he discovered exquisite blue zoisite crystals, which were subsequently faceted and given the name “Tanzanite” by Tiffany and Co, in New York. This beautiful blue/purple gemstone is highly valued because of its pleochroism, showing blue when viewed from one direction, and purple from another. Most tanzanite gemstones today have been heat treated to enhance the color.

Individual crystals and composite specimens of epidote are valued by mineral collectors for study and display purposes. Epidote crystals in intimate association with calcite [calcium carbonate, CaCO₃] are often prepared for display with hydrochloric acid (HCl). Hydrochloric acid does not affect the epidote, but dissolves the calcite to expose perfect, individual epidote crystals.

HISTORY & LORE

Scientists initially confused epidote with both actinolite [Ca₂(Mg,Fe)₅Si₈O₂₂(OH)₂, basic calcium magnesium iron silicate,] and schorl [NaFe₃Al₆(BO₃)₃(Si₆O₁₈)(OH)₄, basic sodium iron aluminum borosilicate]. But in 1801, after studying specimens collected at Bourg d’Oisans near Isère in Rhône-Alpes, France, French mineralogist and father of modern crystallography René-Just Haüy (1743-1822) determined that epidote was actually a new mineral species. Haüy’s intent in choosing the name “epidote” remains uncertain. Mineralogists originally believed that epidote’s Greek meaning “to give more” referred to an enlargement of one side of the crystal in some specimens. Many mineralogists today believe that Haüy referred instead to expanding the list of known minerals.

Differentiating the epidote-group minerals became much easier in 1820 after German mineralogist Christian Samuel Weiss (1780-1856), a pioneer in the field of systematic crystallography, compiled the first complete index of crystal faces on monoclinic epidote. Nevertheless, in 1822, Haüy himself confused epidote with zoisite. The precise relationships of the epidote-group minerals remained unclear until 1954 when Japanese mineralogist and crystallographer Tei-Ichi Ito (1898-1980) determined epidote’s correct atomic arrangement and demonstrated that it contained both single and double silica tetrahedra. Systematic studies by the contemporary American mineralogist Wayne A. Dollase finally confirmed the crystal-chemical relationships of the epidote-group minerals in 1970.

In the past, epidote was used medicinally as a general tonic, thought to improve overall physical well-being. To modern metaphysical practitioners, epidote is associated with transformation and evolution and is thought of as a stone of empowerment and fulfillment.

Epidote was featured on the 10-manat stamp of Azerbaijan in 1994 and the 1.00-franc stamp of the French Southern and Antarctic territories in 1999.

TECHNOLOGICAL USES

Apart from minor use as a semiprecious gemstone, epidote has no commercial applications. However, it is valuable in petrology (the study of rocks) as a clue to origin. The ratio of epidote and prehnite [basic calcium aluminum silicate, Ca₂Al₂Si₃O₁₀(OH)₂] present in certain rocks indicates the conditions under which these rocks formed.

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PERU: A MINERAL-COLLECTING HISTORY

It is not surprising that Peru, with its highly-mineralized mining districts, numerous types of metal ores, hundreds of mines, and long mining history, is a leading source of mineral specimens. Yet Peruvian specimens have become available only in the past few decades. Mining in what is now Peru dates to about 1500 B.C., when pre-Incan cultures began working rich gold placers. When the Spanish arrived in 1533 A.D., the then-dominant Incan culture mined gold, silver, copper, and tin. Initially, the Spanish were concerned only with looting gold from Incan cities. But when they began prospecting and mining decades later, the important metals turned out to be silver and mercury. Spanish prospectors discovered the enormous silver deposit at Potosí in 1545. By 1590, Potosí was producing two million troy ounces of silver per year! In 1559 at Huancavelica, the Spanish discovered large deposits of mercury, a metal needed for the amalgamation recovery of gold and silver. Other major silver discoveries followed at Hualgoyoc, Huallanca, Castrovirreyna, Huancapeti, and Cerro de Pasco. By 1630, Spain's Peruvian mines were turning out five million troy ounces of silver per year. Metal mining declined after Peru attained independence in 1821, when government instability and was compounded the difficulties of mining in the high Andes. Mineral exploration and mine production finally picked up again in the 1890s when Peru legalized foreign mine ownership.

Only recently have Peruvian miners become aware of the existence of collector markets and of the substantial value of fine mineral specimens. For centuries, all Peruvian mineral specimens, despite rarity or aesthetic qualities, had routinely gone to the crushers—heartbreaking to think about. But that changed in the 1970s, when rising prices for silver, gold, copper, lead, and zinc began stimulating Peru's lethargic mining industry. As mine production increased, mine dumps filled with large quantities of pyrite [iron disulfide, FeS₂]. Although much occurred as bright, superbly developed crystals, pyrite nevertheless was considered as a worthless gangue mineral!

But a Peruvian entrepreneur found that he could sell pyrite specimens to foreign visitors and middle-class Peruvian citizens in the marketplaces and plazas of the capital city of Lima. By the mid-1970s, dozens of pyrite marketers, called piriteros, were buying pyrite specimens from the mines and selling them for a profit in Lima. Some even exported pyrite to foreign dealers to sell on world collector markets. By 1977, hundreds of piriteros were earning their living by buying and selling pyrite specimens. That same year, world-class rhodochrosite [manganese carbonate, MnCO₃] specimens were found at mines in Pasto Bueno. (The excellent specimens we featured in June 2004 as our 100th mineral came from Uchucchacua Mine, Oyon Province, Lima Department, Peru.) After these spectacular specimens appeared on the world markets, collectors and dealers descended on Peru. Every Peruvian miner then realized that setting aside fine mineral specimens could bring them secondary income. We were privileged to feature exceptional clusters of pyrite from the Huanzala mine in Huanuco Department, Peru, in October 2003.

By the 1980s, Peru had become a huge source of superb specimens of pyrite, rhodochrosite, quartz, barite [barium sulfate, BaSO₄], galena [lead sulfide, PbS], sphalerite [zinc sulfide, ZnS], and other collectible minerals. But in 1988, sagging metal prices and political unrest began curtailing both mine production and specimen output. Today, soaring metal prices and more liberal mining-privatization laws have revived the Peruvian mining industry. Peru now mines nearly 100 million troy ounces of silver per year, ranking second in world production. Peru also ranks second in production of zinc, third in tin and copper, and fourth in lead and molybdenum. With large reserves of silver, lead, zinc, copper, and tin ores, Peru is continuing to attract foreign investment to fund mineral exploration and mine development. The future availability of mineral specimens, however, is somewhat uncertain. Mines are now much more tightly controlled and many companies are prohibiting miners from collecting specimens because it interferes with ore production. Nevertheless, many dealers are confident that Peru's miners will find ways to continue to provide them with good supplies of fine mineral specimens.

ABOUT OUR SPECIMENS

Our epidote specimens were collected at the Rosario Mabel Mine in the Castrovirreyna (cahs-troh-vee-RAY-nah) District of Castrovirreyna Province in Huancavelica Department, Peru. Located on South America's western coast, the Republic of Peru is bounded by the Pacific Ocean to the west, Ecuador and

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Colombia to the north, Brazil and Bolivia to the east, and Chile to the south. With an area of 496,000 square miles, Peru is nearly as large as the state of Alaska. Although Peru has coastal plains in the west and jungle lowlands on the east, its topography is dominated by the Andes Mountains. The nation is divided into 25 administrative districts or departments. Huancavelica Department, located in south-central Peru, is roughly 150 miles southeast of the capital city of Lima. Among Huancavelica Department's seven provinces is Castrovirreyna, which covers 1,544 square miles of rugged mountains. The provincial capital of Castrovirreyna, population 4,500, is located in a mountain basin at the lofty elevation of 13,500 feet.

Even higher is the nearby Castrovirreyna mining district, which is bisected by the Continental Divide and has 18 peaks above 15,500 feet in elevation. Geologists believe that the district was mineralized some 20 million years ago when magma rose through sedimentary basement rock. Some of this magma extruded to create the present volcanic topography and near-surface country rock of andesite, dacite, and rhyolite. After the remaining magma solidified at depth as an igneous intrusion, associated mineral-rich, hydrothermal solutions moved upward into faults and fissures in the overlying volcanic rock to form complex, vein-type deposits rich in silver and lead and with lesser amounts of zinc, copper, and gold. Spanish prospectors discovered this mineralization in 1590 and developed numerous small silver mines. Although these mines initially yielded large quantities of silver, they were depleted by 1650.



Figure 2. Climbing up to epidote locality.

Serious mining did not resume at Castrovirreyna until 1946. And production did not become significant until the 1970s, after modern mineral exploration methods had delineated new vein systems at depth. Today, four major district mines, the Caudalosa, Candelaria, San Genaro, and the Carman-Lira, exploit three silver-lead-copper-zinc vein systems. The district also has a dozen smaller mines, including the Reliquias, Dorito, San Pablo, Madona, and Rosario Mabel. The four larger mines have concentration mills and accept ores from the smaller operations on a weight-and-grade toll basis.



Figure 3. View from near Rosario Mabel mine.

The veins in the Castrovirreyna district are from one to ten feet thick and mineralogically similar. Because they formed in at least three separate emplacement phases, their mineralization is quite complex. Quartz is the main gangue mineral. The wide variety of ore minerals includes such sulfosalts as proustite [silver arsenic sulfide, Ag_3AsS_3], enargite [copper arsenic sulfide, Cu_3AsS_4], tetrahedrite [copper iron zinc antimony arsenic sulfide, $\text{Cu}_6\text{Cu}_4(\text{Fe,Zn})_2(\text{Sb,As})_4\text{S}_{13}$], our July 1999 featured mineral, from the Casapalca District, Peru],

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boulangerite [lead antimony sulfide, $\text{Pb}_5\text{Sb}_4\text{S}_{11}$], bournonite [lead copper antimony sulfide, PbCuSbS_3] and pyrargyrite [silver antimony sulfide, Ag_3SbS_3]. Among the other ore minerals are wire silver [native silver, Ag], argentiferous galena [silver-bearing lead sulfide, PbS], sphalerite [zinc sulfide, ZnS], stibnite [antimony sulfide, Sb_2S_3], and chalcopyrite [copper iron sulfide, CuFeS_2], our November 2003 featured mineral, from the Huaron Mining District, San Jose de Huayllay District, Cerro de Pasco, Alcides Carrión Province, Pasco Department, Peru.] Accessory minerals include calcite [calcium carbonate, CaCO_3], pyrite, barite [barium sulfate, BaSO_4], and rhodochrosite [manganese carbonate, MnCO_3].

The Rosario Mabel Mine opened in the late 1970s, with the elevation of its portal just above 14,000 feet. The mine produces silver and lead along with by-product amounts of copper and zinc and was not originally known for mineral specimens. But in 1995, underground miners reached a highly metamorphosed area where a granitic intrusion contacts calcium-rich rock to find epidote filling the fissures in the lime-silicate contact rock. The epidote occurred in well-developed radial sprays and individual crystals as long as three inches! Associated minerals included quartz, calcite, and reddish-brown crystals of the garnet-group mineral andradite [calcium iron silicate, $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$]. These specimens, including several two-foot-wide pieces with sheaves of green epidote prisms on white quartz that sold for many thousands of dollars, received much attention in the European specimen markets in 1996. The March-April 1997 issue of the *Mineralogical Record* said about this find: "Epidote from the fantastic find at the Rosario Mabel mine near Castrovirreyna, Peru, was everywhere at the Munich show this year. Many great single fans of epidote . . . would grace any collector's cabinet." As epidote fever spread to the U.S., the *Mineralogical Record* said later in the year: "The typical habit is as long, subparallel sprays of bright, thin crystals (though not so thin as to fail to show good terminations with visible twinning planes)." Indeed, a special issue of the *MR* (July-August 1997) was devoted entirely to Mines and Minerals of Peru!

The Rosario Mabel Mine was sold in 1999 and renamed La Flor del Peru II, a name change that is sure to cause some confusion if new mineral finds are labeled with the new name—we'll have to remember both names. The mine continues to produce silver ore and is an occasional supplier of mineral specimens.

It is easy to see why collectors are so enthusiastic about these epidotes—the long thin crystal forms; the attractive fan-shaped habit; the excellent, 2-sided, wedge-shaped terminations; and the lovely luster as light reflects off the individual crystals. A few of our pieces contain small quartz or feldspar crystals nestled among the epidote crystals. When we first featured this fascinating mineral nearly ten years ago, it was quite a challenge to describe many of its interesting properties, but we have learned a lot in the interim. And if anything, our appreciation for this marvelous mineral has only increased!

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