

August 2010 Mineral of the Month: Vesuvianite

This month we are pleased to feature vesuvianite, a complex silicate from a classic locality—Canada's Jeffrey asbestos mine. Our write-up explains the unusual metamorphic origin of vesuvianite and its use as a gemstone, along with the facts and fiction surrounding asbestos and the rich history of what was once the world's largest asbestos mine.

OVERVIEW

PHYSICAL PROPERTIES

Chemistry: $\text{Ca}_{19}(\text{Al},\text{Mg},\text{Fe})_{13}\text{Si}_{18}\text{O}_{68}(\text{O},\text{OH},\text{F})_{10}$ Basic Calcium Aluminum Magnesium Iron Oxyfluorosilicate (Calcium Aluminum Magnesium Iron Oxyfluorosilicate Hydroxide), often containing copper, beryllium, chromium, manganese, and boron.

Class: Silicates

Subclass: Sorosilicates (Double-Tetrahedral Silicates)

Group: Vesuvianite

Crystal System: Tetragonal

Crystal Habits: Usually as short, prismatic crystals with square cross sections; occasionally long prismatic; also columnar, granular, massive, and compact.

Color: Brown, amber, reddish-brown, sherry, purple, violet, blue-green, yellow, yellowish-green, and green; occasionally colorless, white, and blue; often exhibits prominent color zoning.

Luster: Vitreous to resinous

Transparency: Transparent to translucent

Streak: White

Refractive Index: 1.700-1.721

Cleavage: Poor in one direction, indistinct in two others

Fracture: Subconchoidal, brittle

Hardness: 6.5

Specific Gravity: 3.3-3.5

Luminescence: None

Distinctive Features and Tests: Translucent, green vesuvianite can be confused with jade, but it is harder and more dense than either jadeite [sodium iron aluminum silicate, $\text{Na}(\text{Al},\text{Fe})\text{Si}_2\text{O}_6$] or nephrite (a variety of the actinolite-tremolite solid-solution series of basic calcium magnesium iron silicate composition). Vesuvianite can also appear similar to certain color varieties of zircon [zirconium silicate, ZrSiO_4], but unlike zircon it is not fluorescent.

Dana Classification Number: 58.2.4.1.1

NAME Vesuvianite, pronounced veh-SOO-vee-ahn-ite, is named for its type locality at Vesuvio (Mt. Vesuvius) in Campania, Italy. The alternative name "idocrase," which usually refers to gem forms of vesuvianite, stems from the Greek words *eidos*, meaning "form," and *krasis*, "mixture," alluding to its crystal habits that are similar to those of many other minerals. "Californite" (not a formal mineral name) is a massive green form of vesuvianite; "cyprine" is a blue, compact variety; "egeran" is a yellowish-green variety; and "fluorvesuvianite" is a yellowish, fluorine-rich variety. Other names for vesuvianite include "genevite," "jevreinovite," "vesuviana," "volcanic chrysotile," and "pyramidal garnet." In European mineralogical literature, vesuvianite appears as *Vesuvian*, *vesuvianita*, and *vesuvianiet*.

COMPOSITION: Vesuvianite now joins the list of minerals we have twice featured, both times sending you specimens from the same locality—it must be the delicate, lovely colors that have such a powerful effect on us! March 2000 was the first time, from this prolific locality, the Jeffrey Mine, near the town of Asbestos, Québec, Canada. And just like ten years ago, we are marveling at the pastel colors and amazing crystals!

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Vesuvianite contains the elements calcium (Ca), aluminum (Al), magnesium (Mg), iron (Fe), silicon (Si), oxygen (O), hydrogen (H), and fluorine (F). Its molecular weight consists of approximately 27 percent calcium, 8 percent aluminum, 3 percent magnesium, 3 percent iron, 17 percent silicon, 40 percent oxygen, and 1 percent each of hydrogen and fluorine. Vesuvianite is a member of the silicates, which consist of silicon and oxygen combined with one or more metals. The basic silicate structure is the silica tetrahedron (SiO_4)⁴⁻, in which four equally spaced oxygen ions (4O^{2-}) surrounding a silicon ion (Si^{4+}) are positioned at the four corners of a tetrahedron (a four-faced polyhedron). Vesuvianite is a double-tetrahedral silicate or sorosilicate, in which a silica tetrahedron shares one of its oxygen ions (O^{2-}) with an adjacent tetrahedron. As an allochromatic mineral, vesuvianite's colors are caused by trace amounts of non-essential elements that act as chromophores (color-causing agents). When nearly pure, vesuvianite is colorless or white, but such nonessential elements as copper, beryllium, chromium, manganese, and boron create a broad range of colors. Excessive amounts of the essential element iron also affect vesuvianite's color. Vesuvianite colors are therefore often caused by a combination of chromophoric effects. Browns, greens, and yellows are caused by excess iron, blues by copper, violets and purples by manganese, and greens by chromium. Vesuvianite is an uncommon mineral that forms primarily through metamorphism.

COLLECTING LOCALITIES: Although widely distributed, vesuvianite is an uncommon mineral with relatively few collecting sites. Notable localities are in Québec, Canada; Coahuila, Mexico; Rio Grande do Norte, Brazil; and Castrovirreyna Province, Peru. Other sources are in Italy, Austria, Switzerland, Sweden, Russia, Pakistan, Japan, China, Kenya, and Namibia. Important collecting sites in the United States are in California, Arizona, Idaho, Washington, Nevada, Texas, Arkansas, and New Hampshire.

HISTORY, LORE, & USES: Vesuvianite was identified as a distinct mineral species in 1795. The alternate name "idocrase" was used interchangeably until 1888, when mineralogists formally confirmed the original name "vesuvianite." Transparent vesuvianite is faceted into collectors' gems; translucent forms are cut into cabochons for use in jewelry. According to metaphysical practitioners, vesuvianite crystals promote loyalty, cooperation and courage, while helping to dispel negative thoughts, anger, depression, and fear. Vesuvianite has no technological uses.

ABOUT OUR SPECIMENS: Our specimens are from the Jeffrey Mine in Asbestos, Les Sources Regional County Municipality, Québec, Canada. The Jeffrey Mine and the town of Asbestos are located in south-central Quebec 70 miles east of Montreal and 50 miles north of the Vermont border. The Jeffrey Mine exploits a large deposit of serpentinite, a dense, fine-grained, light-green metamorphic rock consisting largely of the asbestos-group mineral antigorite. This deposit was opened in 1890 and, as worldwide demand for asbestos increased in the early 1900s, the mine was mechanized to boost production. During World War II, the Jeffrey Mine, then owned by the Johns-Manville Corporation, became the world's largest asbestos mine. In 1949, the mine was the site of Canada's most bitter and violent labor strike. By 1973, the Jeffrey Mine had developed into a 7,000-foot-wide, 350-foot-deep open pit that produced 200,000 tons of asbestos fiber each year. But production then fell steadily as global asbestos consumption declined in the face of asbestos-related health concerns. Since 2002, the mine has worked on a part-time basis and is likely to be closed. Our specimens were obtained from miners over the last few years and are likely some of the last specimens ever to come from the Jeffrey Mine.

10 YEARS AGO IN OUR CLUB: Dravite (tourmaline), Serra Branca (pegmatite), Pedra Lavrada (closest town), Paraiba, Brazil. These were well-formed crystals, black in color, in a gray matrix, and the first of two times we have featured dravite, the second being as translucent root-beer-brown crystals from Myanmar (formerly Burma) in August 2004. Despite Brazil's tremendous mineral wealth, we have not featured too many of its minerals—we rarely have the opportunity to pick up large lots! Still, we have featured its tourmaline twice, along with lepidolite, muscovite, citrine, quartz, agate—quite a few, but we'd like more!

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COMPREHENSIVE WRITE-UP

COMPOSITION

The chemical formula $\text{Ca}_{19}(\text{Al},\text{Mg},\text{Fe})_{13}\text{Si}_{18}\text{O}_{68}(\text{O},\text{OH},\text{F})_{10}$ identifies vesuvianite as a basic calcium aluminum magnesium iron oxyfluorosilicate containing the elements calcium (Ca), aluminum (Al), magnesium (Mg), iron (Fe), silicon (Si), oxygen (O), hydrogen (H), and fluorine (F). Vesuvianite's molecular weight consists of approximately 27 percent calcium, 8 percent aluminum, 3 percent magnesium, 3 percent iron, 17 percent silicon, 40 percent oxygen, and 1 percent each of hydrogen and fluorine. Because of the quantitative variability of elements in vesuvianite's compound cation and anion, we cannot provide precise proportions. All molecules achieve stability when the cumulative electrical charge of the cations (positively charged ions) equals that of the anions (negatively charged ions). In vesuvianite, the compound cation $[\text{Ca}_{19}(\text{Al},\text{Mg},\text{Fe})_{13}]^{100+}$ has an approximate electrical charge of +100, while the compound anion $[\text{Si}_{18}\text{O}_{68}(\text{O},\text{OH},\text{F})_{10}]^{100-}$ has an approximate electrical charge of -100. In this formula, the proportions of the elements within parentheses and separated by commas in both the compound cation and anion are variable. As the electrical charge of the cation increases or decreases, the electrical charge of the anion increases or decreases proportionally to maintain electrical stability within the vesuvianite molecule.

Vesuvianite is a member of the silicates, the largest and most abundant class of minerals, in which silicon and oxygen are combined with one or more metals. The basic structure of all silicates is the silica tetrahedron (SiO_4^{4-}), which consists of four equally spaced oxygen ions (4O^{2-}) surrounding a silicon ion (Si^{4+}) and positioned at the four corners of a tetrahedron (a four-faced polyhedron). In silicate minerals, silica anions and metal cations link together like polymers (repeating chains) to form seven different structures: framework silicates (tectosilicates); single- and double-chain silicates (inosilicates); ring silicates (cyclosilicates); sheet silicates (phyllosilicates); independent-tetrahedral silicates (nesosilicates); and double-tetrahedral silicates (sorosilicates).

Vesuvianite is a double-tetrahedral silicate or sorosilicate. Double-tetrahedral silicates form when a silica tetrahedron shares one of its oxygen ions (O^{2-}) with an adjacent tetrahedron. In this arrangement, two silica tetrahedra (2SiO_4^{4-}) share this single oxygen ion to form the $(\text{Si}_2\text{O}_7)^{6-}$ radical. The $(\text{Si}_2\text{O}_7)^{6-}$ radical is the core component of the vesuvianite molecule and its crystal lattice. Within this radical, the single shared oxygen is electrically neutral, while the other six each carry a -1 charge. The general elemental proportions of the $(\text{Si}_2\text{O}_7)^{6-}$ radical are reflected in vesuvianite's $(\text{Si}_{18}\text{O}_{68})^{64-}$ radical. These double-tetrahedral $(\text{Si}_2\text{O}_7)^{6-}$ units are insular, meaning that they are not directly connected. Within the vesuvianite lattice, they are linked together only by mutual ionic bonding to metal ions. The $(\text{Si}_{18}\text{O}_{68})^{64-}$ radical begins to form a stable molecule when the negatively charged oxygen ions within its double-tetrahedra bond ionically with 19 calcium ions and 13 aluminum-magnesium-iron cationic radicals to build a three-dimensional structure. Because this partially completed molecule $[\text{Ca}_{19}(\text{Al},\text{Mg},\text{Fe})_{13}\text{Si}_{18}\text{O}_{68}]^{40+}$ with its +40 charge is electrically unstable, it attracts and bonds ionically with a sufficient number of negatively charged oxygen (O^{2-}), hydroxyl (OH^{-1}), and fluorine (F^{-1}) ions to achieve stability. These oxygen, hydroxyl and fluorine ions are positioned within channels in the complex silica chains.

Despite a considerable amount of weak ionic bonding, the vesuvianite lattice is dominated by strong covalent bonding between the shared oxygen ions within its double-tetrahedral units to account for a substantial hardness of Mohs 6.5. Omnidirectional bonding throughout the three-dimensional lattice structure produces no pronounced cleavage planes. Because the silica tetrahedra completely shield the metal ions, vesuvianite exhibits no metallic properties. Close atomic packing accounts for vesuvianite's moderately high density (specific gravity 3.3-3.5).

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As an allochromatic or “other-colored” mineral, vesuvianite’s colors are due to excessive amounts of the essential element iron and trace amounts of nonessential elements that act as chromophores (color-causing agents). In the rare cases when vesuvianite is nearly pure, it is colorless or white. But excessive amounts of iron create browns, greens, and yellows. Traces of such nonessential elements as copper, beryllium, chromium, manganese, and boron create a range of colors. Blue colors are caused by copper, violets and purples by manganese, and greens by chromium.

Vesuvianite is an uncommon mineral that forms primarily through metamorphic processes. It occurs with grossular [garnet group, calcium aluminum silicate, $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$], wollastonite [calcium silicate, CaSiO_3], and calcite [calcium carbonate, CaCO_3] in fine-grained silicate metamorphic rocks (hornfels); with chromite [iron chromium oxide, FeCr_2O_4] and magnetite [iron oxide, Fe_3O_4] in serpentinite of hydrothermal metamorphic rocks; and with wollastonite, andradite [garnet group, calcium iron silicate, $\text{Ca}_3\text{Fe}_2(\text{SiO}_4)_3$], and diopside [calcium magnesium silicate, $\text{CaMgSi}_2\text{O}_6$] in carbonatites (carbonate-rich igneous rocks).

The Dana mineral-classification number 58.2.4.1 first establishes vesuvianite as a sorosilicate with insular (unconnected) silica groups (58). It then subclassifies vesuvianite (2) as an insular sorosilicate with oxygen coordinations of four or greater (the vesuvianite oxygen coordination is seven, as seen in its double-tetrahedral $(\text{Si}_2\text{O}_7)^{6-}$ structure). Finally, vesuvianite is assigned to the vesuvianite group (4) as the first (1) of three members. The other vesuvianite-group members are wiluite [basic calcium aluminum magnesium iron titanium oxyborosilicate, $\text{Ca}_{19}(\text{Al},\text{Mg},\text{Fe},\text{Ti})_{13}(\text{B},\text{Al})_5(\text{Si}_{18}\text{O}_{68}(\text{O},\text{OH})_{10})$] and manganvesuvianite [basic calcium manganese aluminum iron magnesium silicate, $\text{Ca}_{19}\text{Mn}(\text{Al},\text{Mn},\text{Fe})_{10}(\text{Mg},\text{Mn})_2(\text{Si}_{18}\text{O}_{68}(\text{OH})_9)$].

COLLECTING LOCALITIES

Although widely distributed, vesuvianite is an uncommon mineral with relatively few important collecting sites. The following list includes only those localities known for gem-quality, collectible, or mineralogically notable specimens. Our specimens are from the Jeffrey Mine at Asbestos, Les Sources Regional County Municipality, Quebec, Canada. Other sources in Quebec are the Maple Leaf, Montreal Chrome Pit, Lake Asbestos Mine, and British Canadian Nos. 1 and 2 mines near Thetford Mines in Chaudière-Appalaches Regional County Municipality. Mexican specimens come from the Sierra de la Cruz mines, Sierra Mojada, Coahuila; Brazilian vesuvianite is collected at the Bola do Laje Mine at Currais Novos in the Borborema Mineral Province, Rio Grande do Norte; Peruvian specimens come from the Flor de Peru I claim at Pampa Blanca, Castrovirreyna District, Castrovirreyna Province.

In Italy, vesuvianite occurs at its type locality at Vesuvio (Mt. Vesuvius) in Campania, and the Toscopomici Quarry, Pitigliano, Grosseto. Other European sources include the Wollanig marble quarry in the Afritz Mountains near Villach, Carinthia, Austria; the upper Cerboia Valley, Albo County, Romania; Piz Lunghin in the Bregaglia Valley near Casaccio, Grischun, Switzerland; and the Långban mines at Filipstad and the Jakobsberg Mine at Nordmark, both in Värmland, Sweden. Russian sources are the Lupikko Mine in the Pitkyakanta district, Karelia Republic, Northern Region; and the Yoko-Dovyrensky Massif near Lake Baikal in Irkutskaya Oblast', Eastern-Siberian Region. Pakistani specimens come from Alchuri in the Skarov district of the Shigar Valley, Balistan, Northern Areas. A notable Japanese locality is Mt. Ohsa at Ohsa-cho, Okayama Prefecture, Chugoku Region, Honshu Island. Gem-quality vesuvianite is collected at the Fushan iron deposit in Xingtai County, Xingtai Prefecture, Hebei Province, China. Africa’s two important vesuvianite localities are the Kaiado district in Rift Valley Province, Kenya; and the Kombat Mine at Kombat in the Grootfontein district, Otjozondjupa Region, Namibia.

In the United States, vesuvianite occurs in California at Shepherd Canyon in the Crystal Dome district of Inyo County; the Havilan skarn deposit in the Clear Creek district of Kern County; and at Happy Camp on

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Indian Creek in Siskiyou County. The “californite” massive green variety is collected at the Pulga deposit on the North Fork of the Feather River in Butte County, California. Other sources in the western United States are the Blaisdell marble deposit in the Gila Mountains, Yuma County, Arizona; the Warm Springs district in Blaine County and the Wildhorse Mine in the Alto district in Custer County, both in Idaho; the Pipestone Mine at Bald Mountain in Jefferson County, Montana; Rattlesnake Mountain near Wellpinit, Washington; the Indian Queen Mine in the Buena Vista district, Mineral County, Nevada; and the Marble Canyon Mine near Apache Peak in Brewster County and Babyhead Mountain in Llano County, both in Texas. Vesuvianite is also found in Arkansas at the Kimzey quarries at Magnet Cove in Hot Spring County; in Connecticut at the Hazen Quarry at Haddam, Middlesex County; in Maine at the Sanford vesuvianite locality at Sanford, York County; in New Hampshire at Joppa Hill near Amherst in Hillsborough County; in Vermont at the Belvedere quarries at Lowell and Eden on the Orleans-Lamoille county line; and in Pennsylvania at the Williams Quarry in Easton in Northampton County

JEWELRY & DECORATIVE USES

Vesuvianite has only limited popularity as a gemstone because it lacks a single, distinctive color. Vesuvianite gems are similar in appearance to peridot [Mg_2SiO_4], smoky quartz [SiO_2], certain color varieties of zircon [$ZrSiO_4$], and other gemstones. Vesuvianite gems are quite brilliant due to their relatively high refractive index of 1.700-1.721 which approaches that of the corundum gemstones ruby and sapphire. Transparent vesuvianite—often referred to as “idocrase” in the gem trade—is cut into collector gems as large as 10 carats, usually in brownish-yellow, amber, or green colors. Ten-carat gems sell for about \$300 and make attractive and unusual display pieces; one-carat gems sell for about \$100. Transparent vesuvianite is rarely faceted for jewelry use because it is too soft (Mohs 6.5) to endure regular wear. Prices of vesuvianite collector gems vary widely and are dependent upon degree of transparency, absence of prominent inclusions, and minimal color zoning.

Massive, translucent, green vesuvianite was discovered in California in 1900 and came to the attention of America’s first gemologist, George Frederick Kunz (1856-1928), who named it “californite” (not a formal mineralogical name) and publicized its similarity to green jade. Californite later acquired such alternative names as “American jade,” “California jade,” and “vesuvianite jade.” Interestingly, some modern gemologists believe that vesuvianite might have gained more gemological prestige had Kunz popularized it as a beautiful stone in its own right and not as a jade simulant. Californite and other translucent forms of vesuvianite are fashioned into cabochons, beads, and free-form pieces for wear in jewelry.

Because they are uncommon, well-developed crystals of vesuvianite, both as individual and composite specimens, are popular among mineral collectors for study and display purposes.

HISTORY & LORE

Vesuvianite, which had been known since antiquity, was identified as a distinct mineral species in 1795 when German mineralogist Abraham Gottlieb Werner (1747-1817) discovered crystals within metamorphosed limestone blocks that had been trapped within lava on the slopes of Mt. Vesuvius in Campania, Italy. Werner named this new mineral “vesuvianite” after the discovery site. Four years later, the French mineralogist and crystallographer René Just Haüy (1743-1822) suggested the new mineral should instead be named “idocrase,” from the Greek *eidos*, meaning “form,” and *krasis*, “mixture,” because its crystal habits were similar to those of other minerals. Both names were used interchangeably until 1888, when mineralogists confirmed the original name “vesuvianite.” Nevertheless, “idocrase” has endured and now generally refers to the gem forms of vesuvianite. Mineralogists determined the atomic structure of vesuvianite using X-ray diffraction methods in 1929.

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TECHNOLOGICAL USES

Apart from serving as the model for its own synthesis, vesuvianite has no technological uses.

ASBESTOS: FACT AND FICTION

*Our vesuvianite specimens were collected at the Jeffrey Mine, once the world's largest asbestos mine, in Asbestos, Quebec, Canada. The town's name, Asbestos, reflects the former economic importance of regional asbestos mining. Asbestos, referring to the mineral resource, has two connotations. One is as an extraordinarily useful material that has been manufactured into thousands of industrial and consumer products. The other is as a proven carcinogen (cancer-causing agent) that is linked to asbestosis, mesothelioma, and various forms of lung cancer. Since the 1970s, asbestos has become shrouded in controversy that includes a mix of both fact and fiction. Because our vesuvianite specimens were collected at an asbestos mine, we have an opportunity to discuss asbestos. **Be assured that vesuvianite, which is not an asbestos-group mineral, poses no health risks whatsoever.***

From the standpoint of mineral economics, few materials have ever risen as high—and fallen as low—as asbestos. Just 40 years ago, asbestos was one of the most widely used industrial minerals. Its soft, flexible, fire-resistant fibers were perfectly suited for the manufacture of everything from home-insulation panels, fire-retardant fabrics, and automotive brake shoes and clutch plates to filters for gas masks, ventilation systems and even cigarettes, along with thousands of other uses. But in the 1970s, after medical researchers had dispelled all doubt about whether asbestos particles were carcinogenic, many nations banned or restricted the use of asbestos. As a result, very little asbestos is now used in industrial and consumer products.

The term “asbestos” is not a formal mineralogical name, but a generic industrial term for a group of fibrous minerals. Our modern word stems from the Greek asbestos, meaning “inextinguishable” or “indestructible,” referring to the material's nonflammable and nonreactive properties. Asbestos-group minerals are divided into two closely related classes: amphiboles and serpentines.

Amphibole asbestos: *The amphibole-asbestos group includes four amphibole minerals, all dark, basic, rock-forming silicates that crystallize in the monoclinic system in flexible, fibrous habits:*

Actinolite [basic calcium iron magnesium silicate, $\text{Ca}_2(\text{Mg,Fe})_5\text{Si}_8\text{O}_{22}(\text{OH})_2$]

Tremolite [basic calcium magnesium silicate, $\text{Ca}_2\text{Mg}_5\text{Si}_8\text{O}_{22}(\text{OH})_2$], also called “amosite” and “brown asbestos.”

Anthophyllite [basic magnesium silicate, $\text{Mg}_2\text{Si}_8\text{O}_{22}(\text{OH})_2$]

Crocidolite: a fibrous variety of the mineral riebeckite [basic sodium iron silicate, $\text{Na}_2\text{Fe}_3\text{Si}_8\text{O}_{22}(\text{OH})_2$], called “blue asbestos.”

Serpentine Asbestos: *Serpentine asbestos consists of a mix of several greenish-yellow, chemically simple, basic amphibole minerals of the serpentine subgroup that crystallize in the monoclinic system, often in flexible, fibrous habits. The most important type of serpentine asbestos is chrysotile, a mix of serpentine minerals consisting primarily of fibrous antigorite [basic magnesium silicate, $\text{Mg}_3\text{Si}_2\text{O}_5(\text{OH})_4$].*

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The two commercially important types of amphibole asbestos are tremolite (“brown asbestos”) and crocidolite (“blue asbestos”). Because it has strong, stiff fibers, amphibole asbestos is the greatest threat to human health. Chrysotile, the commercial form of serpentine asbestos, differs considerably in texture. Its fibers are softer and more biodegradable; although still hazardous, they do not damage lung tissues as readily as amphibole asbestos. Chrysotile makes up 95 percent of all the asbestos used worldwide during the past century.

The utilitarian history of asbestos dates to the ancient Egyptians and Persians who wove asbestos funerary cloth. Archaeologists have found that asbestos was used in Scandinavia in ceramics and as a chink material for log structures as early as 3000 B.C. By 400 B.C., the Greeks were using asbestos wicks in the “eternal flames” of the Acropolis. Later, medieval European alchemists called asbestos “salamandra,” believing that it was the petrified skin, feathers, and crests of mythical, fire-resistant birds and salamanders. Medieval knights used asbestos to insulate their suits of armor. Because some forms of asbestos are wood-like in appearance, unscrupulous medieval merchants sometimes fashioned them into crosses, selling them as pieces of the “True Cross” and citing their inflammability as “proof” of authenticity.

By the early 1800s, asbestos was serving as a durable fiber for the manufacture of fire-retardant tablecloths, flags, garments, and protective wear for firefighters. Over centuries, asbestos has acquired such alternative names as “incombustible linen,” “feathered alum,” “rock floss,” and “mountain leather.”

Asbestos became a major industrial mineral after 1860 when Henry Ward Johns, a New York City building contractor, combined asbestos fiber, tar, and manila paper to make flame-resistant tar paper for roofing use. Johns’ tar paper was a huge success at a time when chimney sparks frequently touched off roof fires. As the manufacture of asbestos-based construction products developed into a booming industry, Johns’ business evolved into the Johns-Manville Corporation.

During World War II, asbestos fibers were made into a variety of military items from fireproof cords for parachute flares and flame-insulation panels for aircraft fuel tanks and engines. By the 1950s, asbestos shingles and tar paper and asbestos-cement pipes had become standard in newly constructed houses. Food and beverage companies purified their products with asbestos filters, while surgeons used asbestos fibers for sutures. Asbestos particles and fibers even served as mild abrasives and fillers in toothpaste and as glittering, artificial Christmas “snow.” By 1973, the United States alone was consuming more than one million tons of asbestos annually. But by then, medical researchers had finally provided undeniable proof of the ailments that stemmed from the inhalation of asbestos dust and particles.

Awareness of asbestos-related health problems had actually been documented 2,000 years earlier, when Roman scholar Pliny the Elder (Gaius Plinius Secundus, A.D. 23-79) noted the unusually short life spans of slaves who had worked in asbestos quarries. By 1897, European physicians had attributed the emaciation and various pulmonary ailments common among asbestos workers to long-term inhalation of asbestos particles. North American and European insurance companies soon limited medical coverage of asbestos workers. In 1928, doctors formally assigned the name “asbestosis” to the debilitating and often fatal scarring of lung tissues caused by the inhalation of asbestos particles. Partly because many asbestos-mining, -milling, and -manufacturing companies concealed the growing knowledge of asbestos-related health hazards from workers and consumers, asbestos use increased until the early 1970s when researchers confirmed that large numbers of asbestos-industry workers had developed debilitating or fatal cases of asbestosis, mesothelioma, or lung cancer. Asbestos use then began a sharp decline. Today, asbestos use in North America and Europe has declined by 97 percent since 1973.

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During the 1980s, many misconceptions emerged about the nature of asbestos hazards, including the ideas that asbestos minerals and products were “poisonous to the touch” and asbestos-related pulmonary afflictions were somehow contagious. But the detrimental health effects of asbestos are caused exclusively by the prolonged inhalation of asbestos dust and fibers and thus are limited almost exclusively to those working in asbestos-mining, -milling, -manufacturing, -construction, and -demolition environments. Asbestos mineral specimens, in normal conditions of display and storage, pose no health hazards at all.

The negative connotations surrounding the word “asbestos” continue, however, as reflected by a hotly debated issue in the town of Asbestos, Quebec. Asbestos residents, most of whom had long been proud of their asbestos-mining heritage, now fear that their town’s name is discouraging tourism and economic development. Accordingly, some have proposed renaming their town Trois-Lacs (Three Lakes) in the hope that a new name might bring a better future.

ABOUT OUR SPECIMENS

Our specimens were collected at the Jeffrey Mine at Asbestos, Les Sources Regional County Municipality, Quebec, Canada. The Jeffrey Mine and the town of Asbestos are located in south-central Quebec, 70 miles east of Montreal and 50 miles north of the Vermont border. This area of low, rocky hills and sparse pine forest has an elevation of about 1,200 feet and marks the northern limit of the Appalachian Mountain chain. Most of the approximately 6,000 residents of Asbestos are culturally mixed and speak both English and French.

The local asbestos deposits are examples of metamorphism by serpentinization. The original country rock of mafic (silica-poor, iron- and magnesium-rich) and ultramafic rocks such as peridotite formed from the slow crystallization of magma at mid-ocean ridges at the boundary of tectonic plates when the region was submerged beneath an ancient sea. Peridotite is a medium-grained igneous rock rich in such olivine-group minerals as forsterite [magnesium silicate, Mg_2SiO_4] and fayalite [iron silicate, Fe_2SiO_4]; pyroxene-group minerals such as augite [calcium sodium magnesium iron titanium aluminosilicate, $(Ca,Na)(Mg,Al,Fe,Ti)(Si,Al)_2O_6$]; and amphibole minerals including the hornblende group of basic complex silicates. (We featured peridot in December 2003, and will put its write-up on our web site along with the other sample write-ups found there so you can read up on it if you wish. We are working on featuring augite from Africa in the future.)

During the Paleozoic Era some 500 million years ago, crustal stresses accompanying tectonic collisions uplifted much of present-day eastern North America. Later, crustal deformation associated with the Appalachian Mountain uplift increased temperatures within the original peridotite to initiate serpentinization. Serpentinization is a low-temperature, metamorphic process involving heat and water in which mafic and ultramafic rocks are oxidized and hydrolyzed to form serpentinite. Serpentinite is a dense, fine-grained metamorphic rock with a light-greenish color that consists largely of antigorite [chrysotile asbestos, basic magnesium silicate, $Mg_3Si_2O_5(OH)_4$]; brucite [magnesium hydroxide, $Mg(OH)_2$]; the chlorite-group minerals of basic magnesium iron aluminum oxysilicates; magnesite [magnesium carbonate, $MgCO_3$]; magnetite [iron oxide, Fe_3O_4]; talc [basic magnesium silicate, $Mg_3Si_4O_{10}(OH)_2$]; and grossular [garnet-group, calcium aluminum silicate, $Ca_3Al_2(SiO_4)_3$].

Intensive glacial scouring during the geologically recent Pleistocene ice ages exposed the metamorphosed rock as serpentinite laced with lighter-colored antigorite veins. Early settlers were unable to identify this mineralization, but in 1881, a visiting Welsh miner inspected the exposed veins on a rocky hillside known as Webb’s Ledge and correctly identified it as chrysotile asbestos. In 1890, local farmer

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J. H. Jeffrey began mining the deposit, paying the landowner a \$10 royalty on each ton of asbestos fiber mined and sacked. Within five years, production had risen from one ton to seven tons per day. As worldwide demand for asbestos increased in the early 1900s, the mine became mechanized and increased its production. The small, adjacent town that grew to serve the miners was appropriately named Asbestos. During World War II, the Jeffrey Mine, then owned by the Johns-Manville Corporation, became the world's largest asbestos mine and was a vital source of asbestos for the Allied war effort.

In 1949, the Jeffrey Mine was the site of the most bitter and most violent labor strike in Canadian history. In February 1949, miners walked off the job demanding the elimination of hazardous asbestos dust (see "Asbestos: Fact and Fiction") from their workplaces, wage increases, and the establishment of a social-security fund, demands that were all considered radical in post-war Quebec. When mine owners and supervisors, most of whom were English-speaking, rejected these demands, the strike escalated to intimidation, widespread violence and destruction of property, the use of scab labor, and the barricading of roads and railroads. The strike soon grew from a battle between labor unions and mine owners to confrontations between French and English speakers and between the Catholic Church and the Quebec government. Although strikers gained little during the four-month-long walkout, wages and working conditions did improve considerably over the long term. More importantly the "Asbestos Strike of 1949" triggered social, cultural, and political upheaval that marked the beginning of what historians call "modern Quebec." Among the strike supporters was an unknown attorney and journalist named Pierre Elliot Trudeau (1919-2000). The strike launched a political career that culminated in Trudeau's two terms as Prime Minister of Canada (1968-1979, 1980-1984).

By 1970, the Jeffrey Mine had become an open pit 7,000 feet (1.3 miles) across at the rim and 350 feet deep. The town of Asbestos had been forced to relocate its downtown three times to accommodate the continued expansion of this huge pit. At its peak in 1973 with both open-pit and underground operations, the Jeffrey Mine was shipping 200,000 tons of asbestos fiber each year. But world asbestos demand then began declining sharply in the face of serious health concerns (see "Asbestos: Fact and Fiction"). The mine survived by exporting its production, while modernizing to make mining and milling safer. Since the 1980s, the entire milling process has been performed under partial-vacuum conditions that eliminate most of the hazardous asbestos dust. In 2002, the collapsing market for asbestos forced the mine into part-time production. According to our sources, current mine owners are seeking a grant from the Canadian government in order to expand the underground operations, and if the grant is not given, the mine will be closed down for good.

Since the 1950s, the Jeffrey Mine has attracted the attention of mineral collectors worldwide for its unusual suite of metamorphic minerals. Until recently, it ranked as one of Canada's most prolific specimen sources. Mineralogists have identified 110 minerals at the Jeffrey Mine and it is the type locality for two minerals: jeffreysteite [calcium beryllium silicate, $\text{Ca}_2\text{BeSi}_2\text{O}_7$], named for the mine; and spertiniite [copper hydroxide, $\text{Cu}(\text{OH})_2$], named for Francesco Spertini (1937-), the mine's former chief geologist. The mine is famed for beautiful crystals of orange, pink, and green grossular [garnet group, calcium aluminum silicate, $\text{Ca}_3\text{Al}_2(\text{SiO}_4)_3$]; vesuvianite crystals of various colors; violet crystals of manganvesuvianite [basic calcium manganese aluminum iron magnesium silicate, $\text{Ca}_{19}\text{Mn}(\text{Al},\text{Mn},\text{Fe})_{10}(\text{Mg},\text{Mn})_2(\text{Si}_{18}\text{O}_{68}(\text{OH})_9$]; white, translucent crystals of pectolite [basic sodium calcium silicate, $\text{NaCa}_2\text{Si}_3\text{O}_8(\text{OH})$]; and terminated green crystals of prehnite [basic calcium aluminum silicate, $\text{Ca}_2\text{Al}_2\text{Si}_3\text{O}_{10}(\text{OH})_2$]. We have handled small amounts of each of these over the years and can testify to their beauty, particularly vesuvianite and grossular. We would love to feature grossular garnets from Jeffrey, but they are far too rare and dear for us to get our hands on a large enough lot at a price we could afford. Still there is always hope!

With only limited production and closure seemingly imminent, the supply of mineral specimens from the Jeffrey Mine has now nearly disappeared. Professional collectors still occasionally negotiate access to the

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pit to obtain specimens, and some of the miners make specimens available to mineral dealers. The bulk of our vesuvianite specimens were purchased by a Canadian mineral dealer directly from the miners at Jeffrey, collected during the last few years. Evidently, there is a large vein of massive vesuvianite in a section of the pit, a vein roughly fifteen feet wide, ten feet high, and sixty feet long, about the size of three houses! Small vesuvianite crystals are found on the massive material, and these are the pieces most sought by collectors, and are what we sent to Gold- and Silver-level members. Occasionally, small clusters with crystals up to a quarter inch are collected, and these are most desirable, the habit we made available to Platinum-level members this month. Single crystals up to one inch long are sometimes found, too. Almost all the larger crystals are light green in color. We have some of these larger single crystals and groups of smaller crystals for any Club members who would like one.

In examining your specimen (ideally with a magnifying glass or loupe), note first that the individual crystals within the crystal cluster exhibit the square cross section and short-prismatic shape typical of vesuvianite. Some crystals have six or eight termination facets. Note, too, the bright, vitreous (glass-like) luster on the smooth crystal faces. Crystal colors are mostly green. Some crystals will appear entirely purple or green, while others will exhibit both colors. In Jeffrey Mine vesuvianite specimens, purple is caused by small amounts of the accessory element manganese, while green is due to excessive amounts of the essential element iron. Color zoning, common in vesuvianite, may be readily apparent in your specimen.



Figure 1. Vesuvianite crystal group.

While rotating the specimen slowly under magnification, observe how the colors (both purple and green) are often not evenly distributed within the crystals. These features can be seen in the specimen in Figure 1, a typical Gold-level specimen that is actually about 1.25" across. (A specimen the size of the photo would be worth hundreds!) The purple and green colors, vitreous luster, short-prismatic shape, and prominent color zoning are all typical of vesuvianite specimens from one of Canada's classic mineral localities—the Jeffrey Mine.

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