May 2014 Mineral of the Month

MICROCLINE var. AMAZONITE

This month we are featuring the amazonite variety of microcline. Our specimens were collected in Colorado and our write-up explains this green-blue gemstone's mineralogy and lore, as well as its current celebrity on The Weather Channel's popular television reality show *Prospectors*.

OVERVIEW

PHYSICAL PROPERTIES:

Chemistry: $KAlSi_30_8$ Potassium Aluminum Silicate (Potassium Aluminosilicate) Often containing small amounts of lead, iron, and sodium.
Class: Silicates
Subclass: Tectosilicates (Framework Silicates)
Group: Feldspars
Subgroup: Alkali Feldspars (K-Feldspars, Potassium Feldspars, Potash Feldspars)
Crystal System: Triclinic
Crystal Habits: Usually as single, equant prisms with generally square or rectangular cross sections, also tabular; often blocky; twinning common; also occurs in granular forms and cleavage masses, and as disseminated, irregular grains. Often exhibits lattice (perthitic) intergrowth with other feldspar minerals.
Color: Pale-to-intense green to bluish-green, occasionally yellow-green; often streaked with white.
Luster: Vitreous
Transparency: Translucent to opaque, rarely transparent.
Streak: White
Cleavage: Perfect in one direction, good in two others.
Fracture: Uneven
Hardness: 6.0-6.5
Specific Gravity: 2.56
Luminescence: None
Refractive Index: 1.518-1.525
Distinctive Features and Tests: Distinctive, green-to-bluish-green colors; hardness slightly less than that of quartz; vitreous luster; tendency to cleave into rhombohedrons; and occurrence in granite pegmatites in association with quartz [silicon dioxide, SiO_2] and albite [sodium aluminum silicate, $NaAlSi_3O_8$]. Amazonite is the only green-to-bluish-green feldspar mineral. Can be confused with turquoise, which occurs in a different mineralogical environment.
Dana Classification Number: 76.1.1.5

NAME: The name "microcline," pronounced MY-crow-kline, stems from the Greek words *mikros*, meaning "small," and *klinein*, meaning "leaning" or "sloped" and alluding to cleavage angles that are slightly inclined from 90 degrees. Microcline is also known as "potash feldspar." "Ferruginous microcline" is an iron-bearing, orange-brown variety. In European mineralogical literature, microcline appears as *microklin* and *microclina*. The variety name "amazonite," pronounced AM-ah-zahn-ite, combines the word "Amazon" with the suffix "-ite," meaning "stone." Alternative names include "Amazon stone," "green microcline," "green feldspar," "green spar," and "green stone." In European mineralogical literature, amazonite appears as *amazonit* and *amazonita*.

COMPOSITION & STRUCTURE: Amazonite, chemical formula $KAlSi_30_8$, is a variety of the feldspar-group mineral microcline. The molecular weight of microcline is made up of 14.04 percent potassium, 9.69 percent aluminum, 30.28 percent silicon, and 45.99 percent oxygen. Microcline is a member of the silicates, the largest of all mineral groups. Silicon and oxygen, the essential elements in all silicate minerals, are the most abundant elements in the Earth's crust and form more than 2,000 silicate minerals that comprise 75 percent of the total crustal weight. As an allochromatic (other-colored) mineral, microcline's colors are due to traces of nonessential elements called chromophores. Pure microcline is colorless or white. The distinctive green-to-bluish-green colors of amazonite are caused by a combination of lead and structural water together with the effects of geochemical radiation. Current research indicates that iron also plays a role in creating amazonite's green-to-bluish-green colors. The amazonite variety of microcline occurs almost exclusively in granite pegmatites.

COLLECTING LOCALITIES: Although microcline is abundant, the amazonite variety is rare and few localities produce fine specimens. The primary amazonite source in the United States is Colorado's Pikes Peak Batholith region. Amazonite also occurs in Pennsylvania, Nevada, Massachusetts, and Virginia. Worldwide, amazonite is collected in Austria, France, Germany, Norway, Russia, Brazil, Australia, Japan, Ethiopia, Madagascar, Mozambique, South Africa, and Myanmar.

HISTORY, LORE & USES: Amazonite beads, inlay, and carved objects have been found in 3,000-year-old tombs from Egypt to central Russia. Various ancient cultures attributed talismanic powers to amazonite pendants and carvings. Mineralogists recognized microcline as a feldspar-mineral species in the 1830s. The amazonite variety was then known as "Amazon stone," with the context of the word "Amazon" attributed variously to the Amazon River, the reflection of jungle canopies along the Amazon River, a native Amazon Basin culture that traded green-blue beads, and a race of female warriors of Greek mythology who offered gifts of green stones. To modern metaphysical practitioners, amazonite is a "hope stone" that inspires hope and increases personal confidence. Microcline and other feldspar minerals have been mined for centuries, initially for use in glassmaking. Today, finely ground feldspar is used in container glass, ceramics, and tiles, as a filler material in the manufacture of paper and glossy cardboards, and as the abrasive in household scouring powders. Because of its rarity, amazonite has no technological uses, but it does serve as an attractive gemstone. Because it is usually opaque, amazonite is cut into cabochons or flat inlay pieces, or fashioned into beads. Amazonite gems are mounted in silver for wear as pendants, necklaces, and bracelets. Amazonite is also carved into spheres and small figurines. Amazonite specimens, both as individual crystals and as composite specimens, the latter in association with albite and smoky quartz, are popular mineral collectibles.

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ABOUT OUR SPECIMENS: Our amazonite specimens were collected at the Smoky Hawk Mine in central Colorado's Crystal Peak area, which is a short distance north of Florissant in northwest Teller County. This area marks the western edge of the Pikes Peak Batholith, a 60-mile-long intrusion of coarse, pinkish Pikes Peak granite that covers 1,200 square miles of Douglas, Fremont, El Paso, Park, and Teller counties. The granite of the Pikes Peak Batholith contains numerous pegmatite pockets that are sometimes filled with crystals of amazonite, topaz, and smoky quartz. The batholith formed more than one billion years ago as a deep, granitic intrusion that cooled very slowly to solidify into coarsely textured granite with many pegmatite pockets. Anglo prospectors discovered amazonite at Crystal Peak during or immediately following the Pikes Peak gold rush of 1858-1859, and commercial collecting had begun by 1865. In the 1880s, when "crystal tours" were an important part of the local economy, gemologist George Frederick Kunz (1856-1932) wrote extensively about Crystal Peak amazonite in his annual gemstone reports for the United States Geological Survey. Within the Pikes Peak Batholith, amazonite occurs in subterranean or partially exposed in situ pockets, collapsed in situ pockets, and alluvial concentrations. Colorado amazonite mining has recently received international attention via the reality television show *Prospectors* that debuted on The Weather Channel in March 2013. *Prospectors* documents the challenges and rewards of independent gemstone miners who search for crystals of amazonite, smoky quartz, topaz, and the aquamarine variety of beryl. The show is popular for its drama, spectacular scenery, and explanations of mining and gemstone-recovery techniques. Your amazonite specimen was recovered by the same miners who appear on *Prospectors*.

COMPREHENSIVE WRITE-UP

COMPOSITION & STRUCTURE

Amazonite is a color variety of the feldspar-group mineral microcline. Microcline's chemical formula $KAlSi_30_8$ identifies its elemental components as potassium (K), aluminum (Al), silicon (Si), and oxygen (O). Microcline's molecular weight is made up of 14.04 percent potassium, 9.69 percent aluminum, 30.28 percent silicon, and 45.99 percent oxygen. Microcline is a member of the silicates, the largest of all mineral groups. Silicon and oxygen, essential elements in all silicates, are the most abundant elements in the Earth's crust and form more than 2,000 silicate minerals that comprise 75 percent of the total crustal weight.

The structural foundation of all silicate minerals is the silica tetrahedron $(SiO_4)^{4-}$, in which a silicon ion is surrounded by four equally spaced oxygen ions that are positioned at the corners of a tetrahedron (a four-faced polyhedron). In all silicates, silica anions bond with metal cations in repeating chains to form seven types of structures: independent tetrahedral silicates (nesosilicates); double tetrahedral silicates (sorosilicates); single- and double-chain silicates (inosilicates); ring silicates (cyclosilicates); sheet silicates (phyllosilicates); and framework silicates (tectosilicates). Microcline is a framework silicate or tectosilicate, in which each tetrahedron shares all four oxygen ions with adjacent tetrahedra to form framework structures that extend indefinitely in three dimensions.

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All molecules consist of positively charged cations and negatively charged anions, and molecular stability requires a balance of their electrical charges. Microcline's double cation consists of a potassium ion K^{1+} and an aluminum ion Al^{3+}, with a collective cationic charge of +4. Microcline's anion is the silicate radical $(Si_3O_8)^{4-}$. Radicals are groups of two or more elements that act as a single chemical entity. The $(Si_3O_8)^{4-}$ radical consists of three silicon ions ($3Si^{4+}$) and eight oxygen ions ($8O^{2-}$). The -4 anionic charge balances the +4 cationic charge to provide molecular stability.

Because aluminum ions Al^{3+} are stable within silica tetrahedra, they can sometimes replace certain silicon ions. This introduction of aluminum ions creates many mineralogical possibilities. When an aluminum ion replaces a silicon ion within a silica tetrahedron, it creates a negative electrical charge. To reestablish electrical stability, the resulting aluminum-silicate radical $(AlSi_3O_8)^{1-}$ must accept another positively charged ion. Positively charged ions with suitable radii to fit between the tetrahedra include potassium (K^{1+}), sodium (Na^{1+}), and calcium (Ca^{2+}). In the framework silicates, the partial replacement of silicon ions by aluminum ions and the subsequent ionic bonding of potassium, sodium, or calcium ions create the aluminosilicate minerals of the feldspar group.

The feldspars fall into two subgroups: alkali feldspars and plagioclase feldspars (see "The Feldspars: Industrial Commodities to Gemstones"). Alkali feldspars have the same or similar chemical compositions, but their crystal structures vary with the temperature at which they formed and their subsequent rate of cooling. Microcline and orthoclase, both alkali feldspars, are polymorphic, meaning that they have identical chemistries but different crystal structures. Both microcline and orthoclase are potassium aluminum silicates with the formula $KAlSi_3O_8$. But because they form at different temperatures, orthoclase crystallizes in the monoclinic system and microcline in the triclinic system. Despite this structural difference, microcline and orthoclase can be positively distinguished only by optical examination of thin sections under polarizing microscopes. The green-to-greenish-blue colors of amazonite occur only in microcline and not in orthoclase (or any other feldspar mineral), apparently because the monoclinic structure of orthoclase does not accommodate lead ions.

In microcline, the electrical imbalance created when aluminum ions replace silicon ions is satisfied by the ionic bonding of a potassium ion K^{1+}. Potassium ions occupy spaces between the tetrahedra in a three-dimensional structure that explains microcline's uneven fracture. The plane of weak ionic bonding has perfect cleavage, while the other two planes, both dominated by stronger covalent bonding, exhibit good cleavage. The strong, oxygen-oxygen covalent bonding that dominates throughout the lattice accounts for microcline's considerable hardness of Mohs 6.0-6.5, which is just slightly less than that of quartz (7.0). Microcline's relatively low specific gravity of 2.56, somewhat less than that of quartz (2.65), is due to loose atomic packing that creates large spaces between the tetrahedra. Microcline rarely forms crystals that are smaller than one-half inch and, in fact, may form the largest of all mineral crystals. In the 1970s, a Russian source yielded a mass of microcline with single-crystal characteristics that weighed an estimated 2,000 tons.

The Dana mineral-classification number 76.1.1.5 first identifies microcline as a tectosilicate with an aluminum-silicon framework structure (76). The subclassification (1) defines it as an alkali feldspar. Microcline is then assigned to the orthoclase group (1) which includes alkali feldspars containing potassium, sodium, or barium, as the fifth (5) of eight members. Other group members are orthoclase [potassium aluminum silicate, $KAlSi_3O_8$], sanidine [potassium sodium aluminum silicate, $(K,Na)AlSi_3O_8$], hyalophane [potassium barium aluminum silicate, $(K,Ba)AlSi_3O_8$], and anorthoclase [sodium potassium aluminum silicate, $(Na,K)AlSi_3O_8$].

As an allochromatic (other-colored) mineral, microcline's colors are due to traces of nonessential elements. Pure microcline is colorless or white, but traces of iron produce off-white, pale-yellow, and salmon hues. Higher iron levels create the more intense, orange-brown colors of ferruginous microcline. Amazonite's distinctive green-to-bluish-green colors are produced by a combination of lead, structural water (water bonded within the crystal lattice), and the effects of geochemical radiation. The natural radioactive decay of the isotope potassium-40 oxidizes the divalent lead ion Pb^{2+} into trivalent lead Pb^{3+}; it also produces hydroxyl radicals $(OH)^{1-}$ from the structural water that displace oxygen ions to create vacant lattice positions. These vacant positions, called "color centers," then trap the trivalent lead ions, causing the microcline lattice to absorb the red end of the spectrum, while reflecting the greens and blues that we perceive in amazonite. Current research indicates that the ferrous iron Fe^{2+} may also contribute to amazonite's green-to-bluish-green colors.

Feldspars are essential components of virtually all silica-rich, igneous and metamorphic rocks. Microcline is especially common in granite pegmatites and hornfels (fine-grained silicate rocks) of contact and regional metamorphic rocks. The amazonite variety of microcline occurs exclusively in granite pegmatites. Pegmatites, which are bodies of very coarse-grained granite, form when residual magma—the last magma to solidify—retains heat and cools very slowly. Rather than quickly "freezing" into fine-grained granite, residual magma crystallizes on a fractional, or mineral-by-mineral, basis to form pods, lenses, pockets, and irregular dikes. As residual magma, which is often enriched with accessory or rare minerals, slowly solidifies, gases sometimes create vugs, or mariolitic cavities, that provide space for the growth of large, well-developed crystals. Amazonite derives its traces of chromophoric lead from metal-enriched, residual magma.

Crystals of microcline (and amazonite) are often intergrown with other feldspar minerals such as albite [sodium aluminum silicate, $NaAlSi_3O_8$]. At crystallization temperatures, most feldspars are completely soluble. But because cooling decreases solubility, feldspar minerals sometimes exsolve (separate by solid diffusion) after crystallization. The sodium ions aggregate in bands along certain crystallographic axes, where they replace potassium ions to form single crystals with alternating bands of green-blue microcline (amazonite) and white albite. If microcline predominates in volume, the crystal is called perthite; if albite occupies the greater volume, it is called antiperthite ("perthite" and "antiperthite" are not formal mineral names). In amazonite, this perthitic effect creates an attractive white streaking that accents the basic green-blue color.

COLLECTING LOCALITIES

While microcline is abundant, its amazonite variety is rare, with few localities yielding fine specimens. Our specimens are from the major source of amazonite in the United States—central

Colorado's Pikes Peak Batholith. Localities within the batholith region include the Crystal Peak area of Teller and Park counties; the Devil's Head and Pine Creek pegmatite areas in Douglas County; the Cheyenne District and the Pikes Peak and Crystal Park areas in El Paso County; and Harris Park and Lake George in Park County. Other localities in the United States are the Poor House Quarry, West Bradford Township, Chester County, Pennsylvania; the Zapot Pegmatite in the Fitting District, Mineral County, Nevada; the feldspar quarries at Rockport, Beverly, and Gloucester, Essex County, Massachusetts; and the Morefield Mine at Winterham in Amelia County, the Amelia Mine at Amelia in Amelia County, and the Burley Prospect at Roseland in Amherst County, all in Virginia.

European amazonite is collected in Austria at Gradischkogel Mountain at St. Vinzenz in Carinthia and at the Pack pegmatite in the Packalpe Mountains, Styria; in France at Vizzalona Mountain, Vivanio, Corsica; in Germany at the Ossling and Dubring quarries at Kamenz, Saxony; and in Norway at the Landsverk feldspar quarry at Landsverk, Akershus. Russian specimens come from the Danburitovaya and Etyka pegmatites in Chitinsilaya Oblast and the Tazheranskii Massif in Irkutskaya Oblast', both in the Eastern Siberian Region; and from Kanozero on the Kola Peninsula, Murmansk Oblast', Northern Region.

Brazilian amazonite is collected at the Velha Mine at Tenente Ananias, Rio Grande do Norte; and the Santa Maria do Itabera Mine at Itabera and the Fazenda Mine at Ferros, both in Minas Gerais. In Australia, amazonite occurs at the Cararra Mine in the Harts Range, Northern Territory; and the Pinnacles Mine at Broken Hill, New South Wales. Japanese specimens come from the Tadachi quarries in Nagano Prefecture, Honshu Island. African sources include the Konso and Kenticha areas of Sidamo Province, Ethiopia; the Ankazobe pegmatite field, Antananarvio Province, Madagascar; the Alto Ligonha pegmatite field, Alta Ligonha, Zambesia Province, Mozambique; the feldspar quarries at Kakamas and Bushmanland, Northern Cape Province, South Africa; and the Sakangyi pegmatites, Mogok Township, Pyin-Oo-Lwin District, Mandalay Division, Myanmar.

JEWELRY & DECORATIVE USES

With its considerable hardness, ability to take a fine polish, and range of attractive, green-to-greenish-blue colors, amazonite is a popular gemstone. Because of its opacity or semitranslucency, it is cut into cabochons or flat inlay pieces, or fashioned into beads. Amazonite gems are mounted in silver for wear as pendants, necklaces, and bracelets. In recent decades, amazonite has gained popularity in southwestern-style, silver jewelry as an alternative to turquoise, a gemstone that it closely resembles in appearance. Unlike turquoise, amazonite is not color-enhanced or otherwise treated. Amazonite is also carved into an array of spheres and small figurines. Most gem-quality amazonite used in beads, inlays, and decorative objects comes from Russia or Colorado.

Amazonite specimens, both as individual crystals and composite specimens in association with albite and smoky quartz are popular among mineral collectors. The most desirable specimens have short, prismatic crystals with intense, clean green-to-greenish-blue colors, sharp crystal edges, and a bright, vitreous luster. Adding to collector interest, amazonite specimens from different localities can vary considerably in color, structure, degree of white streaking, and mineralogical associations.

HISTORY & LORE

Amazonite beads inlay pieces, and carved objects have been found in 3,000-year-old tombs from Egypt to central Russia. Various ancient cultures attributed talismanic powers to amazonite pendants and carvings. Medieval physicians prescribed powdered amazonite to treat skin and eye ailments and to enhance the condition of the skin. Historical writings have long confused amazonite with turquoise and jade. Mineralogical understanding of amazonite began in the 1790s, when scientists recognized certain feldspars as members of a general mineral group. Mineralogists recognized orthoclase and microcline as distinct feldspar-mineral species in the 1830s. Further understanding of feldspar mineralogy came with the introduction of X-ray diffraction and advanced spectrographic analysis methods in the 1920s.

In the early 1800s, amazonite was known as “Amazon stone.” The context of the word “Amazon” has been variously attributed to the Amazon River, the reflection of jungle canopies along the Amazon River, a native Amazon Basin culture that traded green-blue beads, and a race of female warriors in Greek mythology who offered gifts of green stones. German mineralogist Johann Friedrich August Breithaupt (1791-1873) named the amazonite variety of microcline in 1847, supposedly after a vague type locality in Brazil’s Amazon Basin. This name apparently saw little use until the systematic mining of Colorado’s sources in the 1860s and 1870s, after which amazonite gained great popularity as a gemstone (see “About Our Specimens”).

To modern metaphysical practitioners, amazonite is a “hope stone” that inspires hope and increases personal confidence. Amazonite, an alternative birthstone for December, has appeared on the one-franc French Southwest Antarctic Territories stamp of 1996, the 150-shilling stamp of Kenya of 1977, and the 150-shilling stamp of Uganda of 1988.

TECHNOLOGICAL USES

Feldspar minerals have been mined at least since Roman times, initially for use in glassmaking. Today, finely ground feldspar is used in container glass (bottles, jars, etc.), ceramics, and tiles, and as a filler material in the manufacture of paper and glossy cardboards. In glassmaking, feldspar provides silica and acts as a flux to lower the melting point of the glass mix. Powdered feldspar is the abrasive in household scouring powders. Because its hardness (Mohs 6.0-6.5) is less than that of most types of glass, feldspar-based scouring powders clean glass without scratching it. Industrial-grade feldspars now cost about $60 per ton. Worldwide, an estimated 15 million metric tons of feldspar are mined each year. The United States annually mines 650,000 metric tons of feldspar worth about $40 million.

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THE FELDSPARS: INDUSTRIAL COMMODITIES TO GEMSTONES

Feldspars are a group of abundant and closely related aluminosilicate minerals. The name "feldspar" stems from the German *Feld*, or "field," and the Old German *Spath* (or spar), referring to any lustrous, cleavable mineral. The literal translation of "field spar" (or "fieldstone") alludes to the tendency of the feldspars to weather into soil-building clays. Because all feldspars have a Mohs hardness of 6.0-6.5 and a vitreous luster, any glassy mineral that is slightly softer than quartz and has a roughly similar density is likely to be a feldspar. There are 19 feldspar minerals that, as explained in "Composition & Structure," fall into two subgroups: alkali feldspars (also known as "alkali feldspars," "potash feldspars," and "K-feldspars) and plagioclase feldspars.

The alkali feldspars have the same or similar chemical compositions, but their crystal structures vary with the temperature at which they formed and their subsequent rate of cooling. The important alkali feldspars and their crystal structures are:

Anorthoclase	$(Na,K)AlSi_3O_8$)	sodium potassium aluminum silicate	triclinic
Sanidine	$(K,Na)AlSi_3O_8$	potassium sodium aluminum silicate	monoclinic
Orthoclase	$KAlSi_3O_8$	potassium aluminum silicate	monoclinic
Microcline	$KAlSi_3O_8$	potassium aluminum silicate	triclinic

The variations in crystal structure reflect the degree of ordering of aluminum-ion and silicon-ion tetrahedral sites within the crystal lattices. Sanidine and anorthoclase, which crystallize at high temperatures and cool very rapidly, have disordered structures with a nearly random placement of aluminum and silicon ions. Orthoclase, which crystallizes at intermediate temperatures and cools slowly, has a partially ordered structure. Microcline, which crystallizes at low temperatures and cools extremely slowly, has a perfectly ordered structure with its aluminum and silicon ions occupying regular lattice positions.

The important members of the plagioclase-feldspar subgroup are albite and anorthite:

Albite	$NaAlSi_3O_8$	sodium aluminum silicate	triclinic
Anorthite	$CaAl_2Si_2O_8$	calcium aluminum silicate	triclinic

Albite and anorthite form a complete solid-solution series with four intermediate members that are classified by proportions of contained sodium and calcium. The end-member albite contains 0 to 10 percent calcium; the end-member anorthite contains 90-100 percent calcium. The four intermediate members of the albite-anorthite series, which are not recognized as distinct mineral species, include oligoclase, 10-30 percent calcium; andesine, 30-50 percent calcium; labradorite, 50-70 percent calcium; and bytownite, 70-90 percent calcium. Laboratory methods are necessary to distinguish these minerals and their intermediate phases.

Feldspars, among the most common rock-forming minerals, are important components of most rocks in the Earth's crust. Feldspar minerals weather into clays, which are a major constituent of soils and vital for water-retention. The feldspars also have many industrial applications (see "Technological Uses"), making mining and processing feldspar minerals a billion-dollar-per-year, global industry.

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Several feldspars serve as gemstones, one is arguably the "perfect" matrix in mineral specimens, and another was once the "secret ingredient" in fine Chinese porcelain.

The most familiar feldspar gemstone is this month's featured mineral—the amazonite variety of microcline (see "Jewelry & Decorative Uses"). Among the lesser known, but no less beautiful and distinctive, feldspar gemstones are:

Moonstone: "Moonstone" is a general term for several translucent feldspar species and varieties that exhibit adularescence, an optical phenomenon that produces a soft, bluish-white sheen. Adularescence is caused by layers of included crystals that diffuse reflected light. One type of moonstone is a translucent microcline that is included with layers of tiny albite crystals. Moonstone is fashioned into cabochons for wear in pendants, earrings, bracelets, and rings.

Orthoclase Gems: Transparent orthoclase crystals and crystals of the bytownite phase of the albite-anorthite solid-solution series are faceted into beautiful, champagne-colored and golden-yellow gems. Although their colors are too similar to those of other yellow gemstones to establish their own gemological identity, they make superb collectors' gems. Major museums often exhibit faceted orthoclase gems of 100 carats or more.

Labradorite: In the labradorite variety of anorthite, twinned lamellae produce a play of blue-green, metallic colors called labradorescence. Labradorite was discovered in 1770 and named for the place of its discovery in Labrador, Canada. It is collected in Canada, Finland, Russia, Madagascar, Australia, Mexico, and the United States (California). Labradorite is usually opaque and dark gray in color: its diagnostic green, blue, and gold labradorescence is due to light interference within reflections from its layered structure. Labradorite occurs mainly as phenocrysts and compact masses in silica-rich igneous rocks.

Aventurine (Sunstone): The aventurine variety of the albite-anorthite solid-solution phases is translucent and has tiny inclusions of the iron minerals hematite and goethite. These inclusions reflect light as a reddish-gold, metallic glitter that is beautifully displayed in cabochons.

Albite: Albite contributes significantly to the beauty of certain composite mineral specimens. In its crystalline or massive form, snow-white, glittering albite is considered a "perfect" matrix for such pegmatite crystals as those of the aquamarine variety of beryl and the tourmaline-mineral elbaite. In many museum-grade specimens of elbaite and aquamarine, the primary crystals contrast beautifully with a snow-white matrix of albite.

Porcelain: Feldspars have also contributed to such man-made objects of great beauty as fine Chinese porcelain, a ceramic material that is known for its delicate translucency. When Chinese porcelain first reached Europe about 1200 A.D., it was considered to be rare and was valued almost as highly as gold. The Chinese began making this porcelain around 500 A.D. by firing a mix of kaolin clay and a second, "secret ingredient." For centuries, Europeans tried but failed to replicate Chinese porcelain, sometimes coming close but never achieving success. In the 1800s, the world finally learned the secret ingredient's identity—finely powdered orthoclase, one of the most abundant feldspar minerals.

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ABOUT OUR SPECIMENS

Our amazonite specimens are from the Smoky Hawk Mine in the Crystal Peak area of central Colorado. Crystal Peak, which is only a low hill, is located several miles north of Florissant in northwest Teller County. This area, where open meadows are interspersed with rolling hills and pine forests, is about 9,000 feet in elevation. Florissant, a town of only a few hundred residents, is on U. S. Highway 24, about 12 miles northwest of 14,110-foot-high Pikes Peak—the regional landmark—and 35 miles west of the city of Colorado Springs.

Crystal Peak is located at the western edge of the Pikes Peak Batholith, a 60-mile-long intrusion of coarse, pinkish Pikes Peak granite that covers 1,200 square miles of Douglas, Fremont, El Paso, Park, and Teller counties. The Pikes Peak Batholith is known for its numerous pegmatite pockets that are often filled with crystals of amazonite, topaz [basic aluminum fluorosilicate, $Al_2SiO_4(F,OH)_2$], and smoky quartz [silicon dioxide, SiO_2]. The batholith formed more than one billion years ago as a deep, granitic intrusion. Its slow cooling is evident in its coarsely textured granite and many pegmatite pockets. Some 65 million years ago, the Laramide Orogeny, the mountain-building episode that created the Rocky Mountains, uplifted the entire region. Accelerated surface erosion then eventually exposed the Pikes Peak granite and many pegmatites.

Early Spanish and Anglo explorers observed that Native Americans, especially Utes and Arapahos, wore and traded amazonite beads that were most likely fashioned from material collected near Crystal Peak. Gold prospectors found amazonite at Crystal Peak during or immediately following the Pikes Peak gold rush of 1858-1859. By 1865, commercial collecting of amazonite and smoky quartz crystals was underway. And by the time amazonite was formally recognized as a Colorado mineral variety in 1867, the crystal-collecting area was already known variously as “Crystal Peak,” “Florissant Crystal Beds,” and “Crystal Butte.”

In 1872, the American mineralogist Dr. A. E. Foote (1846-1895), head of the Philadelphia-based Foote Mineral Company, then the nation’s largest marketer of mineral specimens, hired crews to dig amazonite and smoky quartz crystals at Crystal Peak. Foote’s substantial recoveries enabled the United States to surpass Russia as the world’s leading amazonite source. By 1880, “crystal tours” had become an important part of the local economy. In Colorado’s first fee mineral-collecting venture, a three-day collecting expedition to Crystal Peak that included horses, tents, meals, and the services of an experienced guide cost $20. During this period, gemologist George Frederick Kunz (1856-1932) wrote extensively about Crystal Peak amazonite in his gemstone reports for the United States Geological Survey’s annual *Mineral Resources* books.

Within the Pikes Peak Batholith, amazonite occurs in subterranean or partially exposed, situ pockets, collapsed in situ pockets, and alluvial concentrations. The rare, intact pockets are similar to geodes, with large, well-developed crystals of amazonite and smoky quartz protruding downward from the roof. Wall crystals are smaller and more crudely developed, while floor crystals are usually broken and cemented together with a reddish clay of albite and hematite [iron oxide, Fe_2O_3]. Much more common are collapsed pockets in decomposed granite that are filled with a jumble of often-broken crystals cemented together with albite-hematite clay. Alluvial concentrations are the remains of pockets after the surrounding granite has completely decomposed and undergone alluvial movement. Pegmatite pockets in the Crystal Peak area are rarely longer than four to six feet. The largest documented pocket, found in the early 1900s, was 15 feet long and contained $3,500 ($87,000 in 2014 dollars) worth of amazonite and smoky quartz crystals. The largest single amazonite crystal ever found at Crystal Peak measured 18 inches and was recovered during this period.

Commercial mining of amazonite and smoky-quartz, which utilized mechanical excavators to trench into decomposed granite, became a local industry and tourist attraction at Crystal Peak in the 1930s. Crystal Gem Mines, a popular fee-collecting attraction, opened in 1935 and operated continuously for 35 years. The once-rural Crystal Peak area is now zoned as rural-residential. Many pegmatites are on private land, much of which is leased to collectors, mineral clubs, or commercial miners. More than 150 gemstone-pegmatite claims are also registered on land in the adjacent Pike National Forest.

Our amazonite specimens are from the Smoky Hawk Mine, one of several Crystal Peak-area pegmatite properties claimed by Glacier Peak Mining, LLC, of Colorado Springs. In 2006, Glacier Peak joined forces with the Colorado Calumet Company, Inc., owned by Colorado mineral dealer Bryan Lees, president of The Collector's Edge, a leading international source of specimens. Both Glacier Peak and Colorado Calumet have been major sources of amazonite and smoky quartz specimens for many years. This partnership is currently the most active and productive mining group at Crystal Peak: it employs mechanical trenching equipment to dig through the weathered granite to search for in situ pegmatite pockets.

As you examine your specimen, note first its green-to-bluish-green color that is diagnostic of the amazonite variety of microcline. Your specimen has an unusually intense color; most amazonite is considerably paler. The basic color is also streaked with white, which is caused by the presence of albite [sodium aluminum silicate, $NaAlSi_3O_8$], which exsolved from the amazonite by solid diffusion after crystallization (see "Composition & Structure"). The luster, especially on cleavage surfaces, is bright and vitreous—another diagnostic feature of microcline.

Colorado amazonite mining is currently receiving national attention on the reality television show *Prospectors* that debuted on The Weather Channel in March 2013. *Prospectors* is produced by Colorado-based High Noon Entertainment and is now in its second, nine-episode season. Filmed entirely in Colorado, *Prospectors* depicts the challenges and successes of independent miners who dig for gemstones. The show has two locales: the Pikes Peak Batholith area near Florissant, where topaz, amazonite, and smoky quartz are found; and the summit area of 14,421-foot Mt. Antero, 50 miles to the west, where miners seek the aquamarine variety of beryl. The show is quite popular for its drama, personalities, spectacular mountain scenery, and explanations of gemstone-mining-and-recovery techniques. Your amazonite specimen was recovered by the same miners who appear on *Prospectors*.

References: *Dana's New Mineralogy*, Eighth Edition; *Encyclopedia of Minerals*, Second Edition, Roberts, et al, Van Nostrand Reinhold Co.; *2008 Fleischer's Glossary of Mineral Species*,

May 2014 Mineral of the Month

Joseph Mandarino and Malcolm Back, The Mineralogical Record Company; *Mineralogy*, John Sinkankas, Van Nostrand Reinhold Co.; *Manual of Mineralogy*, Cornelius Hurlbut and Cornelia Klein, Twenty-first Edition, John Wiley & Sons; *Gems and Jewelry*, Joel E. Arem, Geoscience Press, 1992; *Simon & Schuster's Guide to Gems and Precious Stone*s, Cipiani, Borelli, and Lyman, Simon & Schuster Fireside Books, 1999; *The Treasure of Crystal Peak*, H. H. Odiorne, Forum Press, 1978; "Amazonite From the Pikes Peak Batholith, Colorado," Eugene Foord and Robert Martin, *The Mineralogical Record*, November-December 1979; "A Tour of Colorado Gemstone Localities," Jack A. Murphy, *Rocks & Minerals*, July-August 2002; "Colorado Mineral Collecting Localities," Peter J. Modreski, *Rocks & Minerals,* September-October 2005; "The Cooperative Effects of Lead and Structural Water on Color Intensity of Microcline, Var. Amazonite," *MP2 Research Group Abstracts, 2002*, Rein, Simmons, Falster, et al, University of New Orleans Department of Earth and Environmental Sciences; "Colorado Amazonite," Steve Voynick, *Rock & Gem*, May 1986; "A Brief Summary of the Mineral Deposits of the Pikes Peak Batholith, Colorado," Ed Raines, *Rocks & Minerals*, September-October 2001; "Feldspar and Nephelene Syenite," Michael J. Potter, *2012 Minerals Yearbook*, United States Geological Survey.