March 2013 Mineral of the Month: Scolecite

SCOLECITE

This month we are featuring scolecite, an uncommon zeolite mineral in an unusual radiating, aggregate form from India's Deccan Traps. Our write-up explains the mineralogy of scolecite and the geology of the Deccan Traps, and provides tips on how to view your mineral specimen.

OVERVIEW

PHYSICAL PROPERTIES:

Chemistry: $Ca(Al_2Si_3O_{10})\cdot 3H_2O$ Hydrous Calcium Aluminum Silicate (Hydrous Calcium Aluminosilicate), usually containing some potassium and sodium.
Class: Silicates
Subclass: Tectosilicates
Group: Zeolites
Crystal System: Monoclinic
Crystal Habits: Usually as radiating sprays or clusters of thin, acicular crystals or hair-like fibers; crystals are often flattened, with tetragonal cross sections, lengthwise striations, and slanted terminations; also massive and as radiating aggregates of compact, hair-like crystals. Twinning common.
Color: Usually colorless, white, or gray; occasionally subtle shades of brown, pink, or yellow.
Luster: Vitreous to silky
Transparency: Transparent to translucent
Streak: White
Cleavage: Perfect in one direction
Fracture: Uneven, brittle.
Hardness: 5.0-5.5
Specific Gravity: 2.16-2.40
Luminescence: Often fluoresces yellow or brown under ultraviolet light.
Refractive Index: 1.507-1.521
Distinctive Features and Tests: Scolecite's best field-identification marks are its acicular crystal habit; vitreous-to-silky luster; very low density; slanted crystal terminations, and association with other zeolite minerals such as natrolite [hydrous sodium aluminosilicate, $Na_2(Al_2Si_3O_{10})\cdot 2H_2O$] and mesolite [hydrous sodium calcium aluminosilicate, $Na_2Ca_2(Al_6Si_9O_{30})\cdot 8H_2O$]. Laboratory tests are often needed to distinguish scolecite from certain other zeolite minerals.
Dana Classification Number: 77.1.5.5

NAME: The name "scolecite," pronounced SKO-leh-site, comes from the German *Skolezit*, which is in turn derived from the Greek *skōlēx*, meaning "worm" and alluding to the tendency of its acicular crystals to curl when heated and dehydrated. Scolecite's former names include "acicular stone," "ellegite," "lime mesotype," "calcium mesotype," and "weissian." In European mineralogical literature, scolecite appears as *Skolezit*, *scolecita*, and *espiscolecita*.

COMPOSITION: Scolecite consists of 10.22 percent calcium (Ca), 13.75 percent aluminum (Al), 21.48 percent silicon (Si), 53.01percent oxygen (O), and 1.54 percent hydrogen (H). Scolecite is one of 83 members of the zeolite-mineral group of hydrous aluminosilicates. As a hydrous mineral, scolecite has three molecules of water attached to each parent molecule. Known as "water of hydration," these attached water molecules are electrically neutral and do not affect the electrical balance of the parent molecule. Scolecite is a framework silicate or tectosilicate with a crystal lattice based on a modified aluminosilicate structure that forms long, aligned chains. These lengthy chains, which explain scolecite's long, needle-like or hair-like prisms, have a parallel arrangement and are separated by open channels that provide space for the ionic bonding of calcium ions and the hydrogen bonding of water of hydration. The hollow channels account for scolecite's very low specific gravity of 2.16-2.40 and are a structural feature of all zeolite minerals. Scolecite is a low-temperature, low-pressure mineral that forms primarily within amygdaloidal cavities of basaltic rocks in association with quartz and with other zeolite minerals.

COLLECTING LOCALITIES: The primary sources of scolecite specimens are in India and include the Panchmajal District of Gujarāt state and the Nashik, Ahmadnagar, Jalgaon, Mumbai, and Pune districts of Maharashtra state. Other sources are in Russia, South Africa, Canada, Japan, Brazil, France, Denmark, Northern Ireland, Scotland, Sweden, Iceland, England, Switzerland, Italy, Germany, Chile, Norway, and Austria. In the United States, scolecite occurs in New Mexico, Pennsylvania, Utah, Rhode Island, Oregon, New Jersey, Alaska, Arizona, California, Colorado, and Maine.

HISTORY, LORE, & USES: Scolecite was recognized as a mineral species in 1813 and received its name in 1823. Mineralogists used X-ray diffraction methods to determine its atomic structure in 1923. Scolecite has little use in jewelry because of the thinness and fragility of its acicular prisms. Massive or compact forms of scolecite are sometimes tumbled and polished for use as pendants for metaphysical purposes. Scolecite is one of the few zeolite minerals that can be faceted. But because cutting is difficult, scolecite collectors' gems are costly. Mineral collectors value scolecite both as single and composite specimens, the latter in association with quartz and other zeolite minerals. Undamaged scolecite specimens are unusual because of the difficulty in removing them intact from basaltic cavities. Due to its rarity, scolecite has only minimal use in industry. It is, however, mined in conjunction with more common zeolites. Zeolites are used to purify water and gases, catalyze petrochemical and chemical processes, remove radioactive wastes in nuclear processes, and control nutrient-release times in agricultural fertilizers. Modern metaphysical practitioners believe that scolecite promotes inner peace, deep relaxation, and meditation; facilitates both dream recall and restful sleep; and enhances the dream state.

ABOUT OUR SPECIMENS: Our scolecite specimens were collected at Pavagadh Mountain near Pavagadh, Panchmajal District, Gujarāt state, India. This region marks the northernmost limit of the Deccan Traps, one of the world's largest volcanic regions. Pavagadh Mountain is a formation consisting entirely of basalt, a fine-grained, extrusive (volcanic) igneous rock with a characteristic dark color. The basalt of the Deccan Traps contains numerous amygdules—cavities that originated as gas bubbles in the original lava. These cavities later filled with secondary minerals when alkaline groundwater percolated downward, dissolving aluminum and silica-bearing minerals in the basalt, then precipitating scolecite and other zeolite minerals. At Pavagadh Mountain, sheer cliffs nearly 1,000 feet high expose vast areas of basalt with zeolite-filled amygdules. Collecting requires little actual excavation, but is dangerous because of the steep cliffs and talus slopes. After climbing to exposed, zeolite-filled amygdules, professional collectors must utilize special techniques to extract specimens of scolecite and other zeolites—undamaged—from the tough basalt. Specimens are then shipped south to dealers in Maharashtra state for export to international markets.

COMPREHENSIVE WRITE-UP

COMPOSITION

This is the third time in 15 years we have featured scolecite as our Mineral of the Month. Each time, our specimens have come from separate localities in India and have differed greatly in appearance and crystal habit. Scolecite is one of the 83 members of the zeolite-mineral group. Zeolites are hydrous aluminum silicates with three unusual features. First, their crystal lattice has many microscopic, hollow channels that provide space for the attachment of water molecules. Second, they are able to lose and regain this “water of hydration” without altering their crystal structure. The third distinguishing feature is their ability to readily exchange metal ions. These properties combine to give zeolites many important uses in science, industry, and the manufacture of consumer products (see “Technological Uses”).

Scolecite’s chemical formula $Ca(Al_2Si_3O_{10})\cdot 3H_2O$ shows that it consists of five elements: calcium (Ca), aluminum (Al), silicon (Si), oxygen (O), and hydrogen (H). Scolecite’s molecular weight is made up of 10.22 percent calcium, 13.75 percent aluminum, 21.48 percent silicon, 53.01percent oxygen, and 1.54 percent hydrogen. To understand scolecite’s chemical formula, remember that all molecules are composed of positively charged cations and negatively charged anions. Scolecite’s simple cation consists of one calcium ion Ca^{2+} with its +2 charge. Its anion is a radical, a group of ions of different atoms that behave as a single entity in chemical reactions. Scolecite’s anion is the aluminosilicate radical $(Al_2Si_3O_{10})^{2-}$, which contains two aluminum ions $2Al^{3+}$, three silicon ions $3Si^{4+}$, and ten oxygen ions $10O^{2-}$. This aluminosilicate radical has a collective, anionic -2 charge that balances the cationic +2 charge to provide the scolecite molecule with electrical stability.

As a hydrous (or hydrated) mineral, scolecite contains attached molecules of water (H_2O) that are known as “water of hydration.” The “$\cdot 3H_2O$” in scolecite’s chemical formula indicates that three molecules of water ($3H_2O$) are attached to each scolecite molecule. These attached water molecules are electrically neutral and do not affect the electrical balance of the parent molecule. In the water molecule, two hydrogen ions are grouped together on one side of a large oxygen ion. These grouped hydrogen ions retain a small positive charge, while the opposite side of the molecule, dominated by the large oxygen ion, retains a small negative charge. This arrangement creates an electrical polarity that enables water molecules to behave as tiny dipole magnets and attach themselves to other molecules by a weak attraction called “hydrogen bonding.” In scolecite, the positive polarity of the water molecules enables them to attract the negative charges of the oxygen ions within the aluminosilicate radicals.

As a silicate mineral, scolecite is a member of the largest of all mineral classes, in which silicon and oxygen combine with one or more metals. In the basic silicate structural unit, the silica tetrahedron $(SiO_4)^{4-}$, a silicon ion is surrounded by four equally spaced oxygen ions positioned at the four corners of a tetrahedron (a four-faced polyhedron). In the silicates, silica anions and metal cations join together 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).

Scolecite is a framework silicate or tectosilicate. Its crystal lattice is based on a modified aluminosilicate structure of aligned chains in which alternate oxygen ions in each silica tetrahedra are bound to aluminum ions within their own tetrahedra or to silicon ions in adjacent tetrahedra. This arrangement creates a lengthy configuration that accounts for scolecite’s long, needle-like or hair-like prisms. Hollow channels, a diagnostic structural feature of all zeolite minerals, separate the parallel chains. These channels provide space for the ionic bonding of calcium ions and the hydrogen bonding of water molecules, and also explain scolecite’s low density (specific gravity 2.16-2.40). The channels also enable the zeolites to lose and regain water of hydration without altering their crystal structures. Additionally, they function as molecular filters that allow certain ions, atoms, and molecules to pass through, while blocking others. Since the weak ionic bonding of the metal cations within these channels is easily broken, other metal ions can easily substitute in a phenomenon called “ion exchange.”

Because strong, covalent oxygen-oxygen and oxygen-aluminum bonding predominates throughout its crystal lattice, scolecite has a substantial hardness of Mohs 5.0-5.5. Within the scolecite lattice, the distance between the aluminosilicate chains is greatest along a single plane. Very weak bonding strength along this same plane explains scolecite’s perfect, one-directional cleavage. Because scolecite crystals are rarely more than one-quarter-inch thick, this perfect, one-directional cleavage is not readily apparent. Scolecite’s diagnostic, slanted terminations are due to contact and penetration twinning.

Scolecite’s Dana mineral-classification number 77.1.5.5 places it in the tectosilicate-zeolite group (77). The subclassification (1) defines it as a zeolite. Scolecite is then assigned to the natrolite group (5) as the fifth (5) of 11 members. The metal cations of the natrolite-group minerals can be sodium, calcium, barium, strontium, or beryllium, either singularly or in or paired combinations. The two natrolite-group members most closely related to scolecite are natrolite and mesolite:

scolecite	hydrous calcium aluminosilicate	$Ca(Al_2Si_3O_{10})\cdot 3H_2O$	monoclinic
natrolite	hydrous sodium aluminosilicate	$Na_2(Al_2Si_3O_{10})\cdot 2H_2O$	orthorhombic
mesolite	hydrous sodium calcium aluminosilicate	$Na_2Ca_2(Al_6Si_9O_{30})\cdot 8H_2O$	orthorhombic

These three natrolite-group minerals are known as the “chain” or “needle” zeolites and often occur together. They are difficult to distinguish visually because of their similar colors and radiating, acicular crystal habits. Natrolite tends to form thin crystals with pyramidal terminations. Mesolite forms the thinnest crystals, while those of scolecite are the thickest and have slanted terminations.

Scolecite is a low-temperature, low-pressure mineral that occurs primarily within amygdaloidal cavities of basaltic, volcanic rocks. These cavities form as gas bubbles during the solidification of mafic (silica-deficient, iron and magnesium-rich) magmas. Percolating, alkaline groundwater deposits zeolite minerals within these cavities, often as well-developed crystals. Scolecite is usually deposited together with such other zeolite minerals as natrolite and mesolite, and also with such non-zeolite minerals as quartz [silicon dioxide, SiO_2], prehnite [basic calcium aluminosilicate, $Ca_2Al_2Si_3O_{10}(OH)_2$], and calcite [calcium carbonate, $CaCO_3$]. As the last mineral to form, scolecite typically develops atop crystals of such previously deposited zeolites as stilbite-Ca [hydrous calcium potassium sodium aluminosilicate, $(Ca_{0.5},K,Na)_9(Al_9Si_{27}O_{72})\cdot 28H_2O$], heulandite-Ca [hydrous calcium sodium potassium aluminosilicate, $(Ca_{0.5},Na,K)_9(Al_9Si_{27}O_{72})\cdot\sim 24H_2O$], and epistilbite [hydrous calcium aluminosilicate, $Ca_3(Al_6Si_{18}O_{48})\cdot 16H_2O$].

As an allochromatic (other-colored) mineral, scolecite’s narrow range of pale colors is caused by chromophoric (color-causing) impurities. When nearly pure, scolecite is colorless, white, or gray. Trace impurities of ferrous iron (Fe^{2+}) create pale brownish or yellowish hues; traces of divalent manganese (Mn^{2+}) create subtle, pinkish hues. Scolecite exhibits both pyroelectric and piezoelectric properties. Pyroelectricity (from the Greek *pyr*, or “fire”) is electrical voltage that is generated by heat; piezoelectricity (from the Greek *piezein*, “to press”) is electrical voltage that is generated by mechanical pressure. Pyroelectricity and piezoelectricity are caused when heat or mechanical pressure displaces electrons from their normal orbits, thus generating an electrical differential (voltage) across certain crystal faces.

COLLECTING LOCALITIES

The basalt formations of India’s Deccan Traps are the premier source of fine specimens of scolecite and many other zeolite minerals. Our specimens are from Pavagadh Mountain near Pavagadh, Panchmajal District, Gujarāt state, India. Other Indian sources include the Ahmadnagar, Nashik, Jalgaon, Mumbai, and Pune districts in the adjacent state of Maharashtra.

Scolecite also occurs in Dal’negorsk, Primorskiy Kray, Kamchatka Oblast’, Far-Eastern Region, Russia; the Palabora Mine at Loolekop, Limpopo Province, South Africa; Gates Mountain, Kings County, Nova Scotia, Canada; the Hokizawa quarries, Yamakita, Kanto Region, Honshu Island, Japan; the Rodaito Mine, Coquimbo, Elqui Province, Coquimbo Region, Chile; and Campos Novos, Santa Catarina, Brazil.

In Europe, scolecite is collected at the Bussiol Quarry, Puy-de-Dôme, Auvergne, France; the lava flows of Denmark’s Faeroe Islands; Lanford Lodge, Dunseverick, County Antrim, Northern Ireland; Trotternish, Isle of Skye, North West Highlands, Scotland; and the Leveäniemi Mine at

Svappavaara, Kiruna district, Lappland, Sweden. Other localities are Osfjall, Breiðdalsvik, Suður-Múlasýsia, Iceland; the Dean Quarry at St. Taeverne, Lizard Peninsula, Cornwall, England; the Forno quarries in the Bregaglia Valley, and the Arvigo gneiss quarries in the Mesolcina Valley, both in Grischun, Switzerland; the Lierskogen Quarry at Lier, Buskerud, Norway; the Fasso Valley quarries in Trento Province, Trentino-Alto Adige, Italy; the Kaiserstuhl Quarry at Kaiserstuhl, Baden-Württemberg, Germany; and the Kreuzkogel Massif, Nassfeld Valley, Hohe Tauern Mountains, Salzburg, Austria.

Scolecite localities in the United States include the Hanover-Fierro district, Grant County, New Mexico; the Station Quarry in Haverford Township, Delaware County, Pennsylvania; Clayton Peak in Wasatch County, Utah; the Dexter and Conklin quarries at Lincoln, Providence County, Rhode Island; the Edwards Lava Flow in Tillamook County, Oregon; the Prospect Park and Sowerbutt traprock quarries at Prospect Park, Passaic County, New Jersey; the Hound Island breccia formation, Kuiu Island, Sitka Borough, Alaska; the Bunker Hill district in the Galiuro Mountains, Pinal County, Arizona; the Genesee Valley copper prospects, Plumas County, and the Crestmore Quarry at Crestmore, Riverside County, both in California; Upper Slate Lake, Summit County, Colorado; and Windham, Cumberland County, Maine.

JEWELRY & DECORATIVE USES

Scolecite has limited use in jewelry because of its rarity and the fragility of its thin, acicular prisms. Massive or compact, radiating forms of scolecite are sometimes tumbled and polished for wear as pendants for metaphysical purposes. Although its brittleness and perfect, one-directional cleavage makes cutting difficult, scolecite is one of the few zeolite minerals that can be faceted into collectors' gems. These gems usually weigh less than five carats and are faceted in elongated, emerald cuts to maximize cutting retention of the thin, acicular crystals. Because of scolecite's very low density (average specific gravity 2.16-2.40), a two-carat scolecite gem is about as big as a four-carat diamond (specific gravity 3.5). Four-carat, scolecite collector gems are nearly one inch long and just one-fifth of an inch thick. Because of their rarity, difficulty in cutting, and unusual weight-dimension relationships, scolecite collectors' gems are expensive and in high demand.

Scolecite is widely collected as both single and composite specimens. Because scolecite is fragile and difficult to remove intact from basalt cavities, undamaged specimens can be difficult to find. In composite specimens, scolecite is usually associated with quartz, calcite, or other zeolite minerals. Scolecite specimens often grow atop crystals of heulandite-Ca [hydrous calcium sodium potassium aluminosilicate, $(Ca_{0.5},Na,K)_9(Al_9Si_{27}O_{72})\cdot{\sim}24H_2O$], stilbite-Ca [hydrous calcium potassium sodium aluminum silicate, $(Ca_{0.5},K,Na)_9(Al_9Si_{27}O_{72})\cdot28H_2O$] or epistilbite [hydrous calcium aluminosilicate, $Ca_3(Al_6Si_{18}O_{48})\cdot16H_2O$]. The largest-known scolecite specimen, a radiating spray of colorless, acicular crystals measuring 20 inches across and 11 inches high, is displayed at the National Museum of Natural History (Smithsonian Institution) in Washington, D.C.

HISTORY & LORE

Swedish mineralogist Axel Fredrick Cronstedt (1722-1765) pioneered the study of zeolite minerals in 1756 by identifying stilbite (now stilbite-Ca). Noting how stilbite vibrated when heat drove off its water of hydration, Cronstedt coined the word “zeolite,” literally “stone that boils,” from the Greek *zein*, meaning “to boil,” and *lithos*, or “stone.” Chemists began to distinguish between zeolite species in 1800, when German mineralogist Abraham Gottlieb Werner (1747-1817) categorized the minerals now known as scolecite, natrolite [hydrous sodium aluminosilicate, $Na_2(Al_2Si_3O_{10})\cdot 2H_2O$] and mesolite [hydrous sodium calcium aluminosilicate, $Na_2Ca_2(Al_6Si_9O_{30})\cdot 8H_2O$] as *Faserzeolithen* (fibrous zeolites). The following year, the French mineralogist and crystallographer René-Just Haüy renamed this group “mesotype” and identified its calcium-rich member. Although he did not recognize this member as a new species, he informally named it *Skolezit*, from the Greek *skōlēx*, meaning “worm,” alluding to the tendency of its long, thin crystals to curl in the dehydrating heat of a blowpipe. Researchers recognized natrolite, the sodium-rich mesotype member, as a new species in 1805. In 1813, German mineralogists Johann Nepomuk Fuchs (1774-1856) and Adolph Ferdinand Gehlen (1775-1815), working with specimens from Kaiserstuhl, Baden-Württemberg, Germany, recognized *Skolezit*, the calcium-rich mesotype member, as a new species. In 1816, mineralogists recognized the last mesotype member, a hydrous sodium calcium aluminosilicate, as a new species and named it “mesolite.”

In 1823, mineralogists anglicized the name *Skolezit* to “scolecite.” But because Fuchs and Gehlen had also studied specimens from other localities, Kaiserstuhl, Germany, could not be designated as the scolecite type locality. In the 1880s, German chemist Johann Theodor Lemberg (1842-1902) used scolecite to demonstrate the phenomenon of ion exchange. By substituting sodium for all or part of its calcium cations, he in effect convert scolecite to natrolite.

Mineralogists recognized 19 zeolite minerals by 1842, and 29 species by 1920. By the mid-1970s, they had identified 41 zeolite species and were then proposing a new species every year. Because of growing confusion about the rapidly increasing number of zeolite species, the International Mineralogical Association’s Commission on New Minerals and Mineral Names revised the zeolite-classification system in 1997. As a result of this revision, mineralogists now recognize 83 members of the zeolite-mineral group of hydrous aluminosilicates.

According to modern metaphysical beliefs, scolecite promotes inner peace, deep relaxation, and meditation; facilitates both dream recall and restful sleep; and enhances the dream state.

TECHNOLOGICAL USES

Scolecite is too uncommon to have significant industrial importance. Nevertheless, it is mined along with more abundant zeolites. The two most common natural, industrial zeolite minerals are chabazite-Ca [hydrous calcium aluminosilicate, $(Ca_2(Al_4Si_8O_{24}\cdot 13H_2O$] and clinoptilolite-Ca [calcium sodium potassium aluminosilicate, $Ca_2Na_{1.5}K(Al_{6.5}Si_{29.5}O_{72})\cdot 24H_2O$]. Each year, an estimated 3.3 million metric tons of natural zeolites are mined. China is the production leader, mining some two metric tons annually. Other major sources of natural zeolites are the

Republic of Korea, Japan, Turkey, and Jordan. The United States ranks sixth, producing 66,000 metric tons of natural zeolites annually from open-pit mines in New Mexico, California, Nevada, Idaho, Arizona, and Texas. “Run-of-the-mine” zeolites with no special processing now sell for about $170 per metric ton. Production has recently increased to help satisfy demand for the large volumes of zeolites needed to clean up Japan’s tsunami-devastated Fukushima Daiichi nuclear facility.

With their open-channel structures and ion-exchange capabilities, zeolites are well-suited for such applications as chemical and physical absorption and filtration, ion-exchange, chemical catalysis, and molecular sieving. They are used in science, industry, and agriculture to purify water and gases, catalyze petrochemical and chemical processes, remove radioactive wastes in the nuclear, medical and power-generation fields, and control nutrient-release times in agricultural fertilizers.

Scolecite and other natural zeolites have served as the chemical models for their own laboratory synthesis. More than five million metric tons of synthetic zeolites are produced each year.

VIEWING YOUR MINERAL SPECIMENS

When viewing mineral specimens, the features that first attract our eyes are color and structure. While it is easy to limit the assessment of specimens to just these two features, mineral specimens are much more complex and have many other features which, when recognized and understood, contribute to overall appreciation and enjoyment. In each of our write-ups, the final paragraph of the “About Our Specimens” section describes the various, observable features of interest for that particular mineral.

To get the most out of viewing a mineral specimen, never view it casually, when you are distracted, or in poor light. To properly view a specimen, sit at a desk or table with a good light source and the write-up for that particular mineral in front of you. Then review the write-up, particularly the specimen-description paragraph(s). Next, turn your attention to a specimen. It is critical to use an intense light source, and it can be helpful to have a loupe or magnifying glass on hand. View each specimen from every angle with both reflected and, whenever possible with transparent or translucent minerals, transmitted light. Then observe each of the following features:

Color: Every specimen has an obvious, basic color, but this color can vary significantly with reflected or transmitted light, or even with he angle of viewing relative to the crystal axes. Rotate the specimen in your hand as you study the color and note any color shifts. Many crystals will exhibit color zoning, where color intensity varies in different sections of the same crystal. Others can be multicolored, with completely different colors appearing in the same crystal.

Transparency, translucency, and opacity: These terms describe the manner in which a mineral transmits light. Transparent minerals transmit most of the light that strikes them, while translucent minerals transmit only a portion of the light. Opaque minerals reflect, but do not transmit, light. The different sections of some crystals can have very different transmission properties, such as transparent terminations and translucent bases. When viewed under an intense light source, seemingly opaque specimens sometimes reveal a surprising and colorful translucency at their thin edges—a good reason to study all specimens with a proper light source.

Luster: Luster, the manner in which light is reflected from a mineral's surface, is sometimes known as "sheen" or "gloss." Many descriptive terms for mineral luster are self-explanatory: vitreous, metallic, waxy, earthy, silky, resinous, adamantine, greasy, etc. Some minerals, notably sulfides, exhibit iridescence as rainbow-like flashes of such complementary colors as cyan, magenta, and yellow. Luster is a diagnostic feature of many minerals.

Structure: External crystal shape is determined by the geometric relationships of prismatic and termination faces and edges. Although all minerals crystallize in one of six general crystal systems, they can occur in many different habits, or modifications of these basic systems. Crystals have a geometric beauty and a mathematical complexity that is fascinating to observe. When studying crystal shape, view the crystal from all possible angles and think in terms of the crystal system of that particular mineral. Do not, however, limit your assessment of structure to external shape. In transparent crystals, look for internal inclusions of secondary minerals, as well as repeating, feathery, internal structures that often replicate the crystal's external shape. On crystal faces, look for striations, the parallel grooves that can be diagnostic for a particular species. Many specimens will have broken areas that resulted from the mining or collecting process. These areas provide an opportunity to observe cleavage, which is the tendency of some minerals to break along definite planes, and fracture, which refers to irregular breakage and is described by such terms as conchoidal, splintery, fibrous, hackly, etc.

Density: Although density, which is mathematically expressed as specific gravity and refers to weight per unit volume, can only be precisely determined using specialized equipment, simply "hefting" a specimen can often provide a general idea of density. Some minerals have very low densities, which is apparent in their light heft. Other minerals have a much greater heft, a difference that is due to chemical composition and the nature of the atomic packing within the crystal lattice.

Matrix minerals: Many mineral specimens are composites, meaning that they consist of a primary species associated with a matrix of two or more different species. While primary minerals receive the greatest attention, matrix minerals can be quite beautiful and interesting. Matrix minerals are often an indication of origin and are specific for certain mineralogical environments such as pegmatites, hydrothermal veins, basaltic cavities, etc.

No mineral specimen should ever be considered "simple." Many observable characteristics combine to create a physical complexity that is fascinating as well as educational. And fully appreciating the complexity and beauty of mineral specimens requires only a little time, and a good light source—and our write-ups.

ABOUT OUR SPECIMENS Our scolecite specimens were collected at Pavagadh Mountain near Pavagadh, Panchmajal District, Gujarāt state, in the Republic of India.

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The state of Gujarāt is located in west-central India and borders the Arabian Sea on the west, the Islamic Republic of Pakistan on the northwest, and the Indian states of Maharashtra on the south, Madhiya Pradesh on the east, and Rajasthan on the northeast. Covering 78,687 square miles, Gujarāt, population 60 million, is about the size of the state of Nebraska and is among India's most industrialized and developed states. Its capital is Gāndhīnagar; its largest city is Ahmadābād which, with a population 5.2 million, is India's seventh largest city.

The source of our specimens, Pavagadh Mountain, is in the Panchmajal District in southeastern Gujarāt about 200 miles north of the major coastal city of Mumbai (formerly Bombay) in Maharashtra state. Pavagadh is 29 miles south of the city of Vadodara, population 1.7 million. The Pavagadh area has numerous industrialized towns surrounded by agricultural areas that grow sugar, tobacco, and cotton. Pavagadh, population 20,000, is a historic and religious center that attracts many tourists and pilgrims. At an elevation of 1,500 feet, Pavagadh served as a "hill station" during British colonial times as a place where colonial administrators sought relief from the oppressive lowland heat. One of the major local attractions is Pavagadh Mountain, a steeply rising, basalt monolith that towers 1,500 feet above the surrounding plain. In 2004, Pavagadh Mountain, the site of many prehistoric ruins and early Hindu shrines and forts, became part of Chapaner-Pavagadh Archeological Park, a United Nations World Heritage Site.

Pavagadh Mountain marks the northern limit of the Deccan (DECK-kenn) Traps, one of the world's largest volcanic regions that covers 200,000 square miles (an area approaching that of the state of Texas) and includes most of Maharashtra and small areas of adjacent Gujarāt. The Deccan Traps formed from massive extrusions of magma 65 million years ago during the late Cretaceous Period. Rising through long, narrow crustal fissures and faults, this magma extruded onto the surface and spread in horizontal sheets to form basalt formations thousands of feet thick. Although the Deccan Traps contain no commercial mineral deposits, the hard, durable, dense, inert basalt itself makes a fine construction material. As the only regionally available rock, basalt serves as ballast, fill for roads and rail beds, and foundations for buildings and dams. When finely crushed, it is a gravel additive for cement. Basalt quarrying is a major industry throughout the Deccan Traps region.

Basalt, a fine-grained, extrusive (volcanic) igneous rock, forms from the solidification of magma at or near the surface. While deficient in quartz, it is rich in iron and magnesium minerals that impart its characteristic dark color. It frequently contains vesicles (cavities) that form from gas bubbles within the flowing magma. Vesicles that later become filled with such secondary minerals as quartz and zeolites are known as amygdules. Amygdules form when groundwater rich in dissolved aluminum- and silica-bearing minerals percolates downward to fill the cavities and precipitate zeolite minerals, often as well-developed crystals.

Pavagadh Mountain is the northernmost zeolite-collecting area of the Deccan Traps. It also has the oldest known regional basalt and represents the earliest stages of the massive extrusion that created the Deccan Traps. At Pavagadh Mountain, sheer cliffs nearly 1,000 feet high expose large areas of basalt and many zeolite-filled amygdules. Although collecting requires little actual excavation, it is dangerous because of the steep cliffs and talus slopes. Experienced, commercial collectors utilize special techniques to extract undamaged specimens of scolecite and other zeolites from the tough basalt. They ship these specimens south to dealers in Maharashtra state for export to international markets.

When studying your scolecite specimen, handle it carefully as its long, acicular crystals are very fragile. Our scolecite specimens appear as well-rounded, mammillary aggregates with hemispherical shapes. The interior of these aggregates is composed of radiating, colorless-to-white, very thin, acicular crystals. Their rounded surfaces are formed by the terminations of millions of tiny crystals. Clusters of individual crystals appear at the base of each aggregate. Using a loupe or magnifying glass, note that many of these crystals are colorless and transparent and show a vitreous luster. Under magnification, these crystals exhibit two of scolecite's diagnostic features—steeply slanted terminations and faint, parallel striations running lengthwise along the prisms. Despite the colorless transparency of most of these tiny, individual crystals, the hemispherical aggregates appear white and opaque. This is because the millions of crystal-face contact surfaces within the tight, compact, aggregates bend and reflect light in virtually all directions, allowing little light transmission but a great deal of reflection. Note also that the aggregates have a slight pinkish or rosy tint that is due to the trace presence of manganese.

Our specimens are composites that consist of scolecite atop a matrix of another zeolite mineral—light-tan-colored, massive heulandite-Ca [hydrous calcium sodium potassium aluminosilicate, $(Ca_{0.5},Na,K)_9(Al_9Si_{27}O_{72})\cdot{\sim}24H_2O$]. In the crystallization sequence of our specimens, heulandite formed first to cover the interior walls of a basaltic cavity. In a later, secondary crystallization event, mineral-laden groundwater with an entirely different chemistry refilled the amygdule and precipitated scolecite as radiating, hemispheric aggregates atop the heulandite. Our specimens were recovered from exposed amygdules that were generally spherical in shape, about three feet in diameter, with interior walls completely covered with crystals of scolecite and heulandite.

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