

## ***March 2008 Mineral of the Month: Stellerite***

This month's mineral, stellerite, is a rare zeolite with a decidedly international flavor. It was first found in Russia, recognized as a mineral species by a Polish mineralogist, and named for a German naturalist. Our specimens were collected in India from the Deccan Traps, one of the world's largest volcanic provinces and the source of the finest zeolite specimens.

### *PHYSICAL PROPERTIES*

Chemistry:  $\text{Ca}_4(\text{Al}_8\text{Si}_{28}\text{O}_{72}) \cdot 28\text{H}_2\text{O}$  Hydrous Calcium Aluminosilicate (Hydrous Calcium Aluminum Silicate), usually containing some sodium and potassium  
Class: Silicates  
Subclass: Tectosilicates  
Group: Zeolite  
Subgroup: Heulandite  
Crystal System: Orthorhombic  
Crystal Habits: Dipyramidal, usually spherical as radiating, rounded nodules or sheaf-like aggregates of thin, platy crystals; also massive and fibrous.  
Color: Usually colorless or white, sometimes pale hues of yellow, brown, orange, or pink  
Luster: Vitreous  
Transparency: Transparent to translucent  
Streak: White  
Refractive Index: 1.484-1.497  
Cleavage: Perfect in one direction  
Fracture: Uneven, brittle  
Hardness: 4.5  
Specific Gravity: 2.2  
Luminescence: None  
Distinctive Features and Tests: Best field marks are radiating form, thin crystals, and primary occurrence in hydrothermally metamorphosed volcanic environments. Stellerite is easily confused with the zeolite minerals stilbite-Ca  $[(\text{Ca}_{0.5}, \text{K}, \text{Na})_9(\text{Al}_9\text{Si}_{27}\text{O}_{72}) \cdot 28\text{H}_2\text{O}]$  and barrerite  $[\text{Na}_8(\text{Al}_8\text{Si}_{28}\text{O}_{72}) \cdot 26\text{H}_2\text{O}]$ . Positive differentiation between these species often requires laboratory methods.  
Dana Classification Number: 77.1.4.4

### *NAME*

Stellerite, which is named for German naturalist Georg Wilhelm Steller (1709-1746), is pronounced just as it is spelled—STELL-er-ite. Stellerite was formerly thought to have two varieties, which were referred to as "calcium stellerite" and "sodium stellerite." In contemporary European mineralogical literature, stellerite appears as "stellerit" and "stellerita."

### *COMPOSITION*

Stellerite is the fifth zeolite group mineral to be featured as our Mineral of the Month. Our other zeolites have included scolecite  $[\text{Ca}(\text{Al}_2\text{Si}_3\text{O}_{10}) \cdot 3\text{H}_2\text{O}]$  in May 1997, stilbite-Ca  $[(\text{Ca}_{0.5}, \text{K}, \text{Na})_9(\text{Al}_9\text{Si}_{27}\text{O}_{72}) \cdot 28\text{H}_2\text{O}]$  in May 1999, heulandite-Ca  $[(\text{Ca}_{0.5}, \text{Na}, \text{K})_9(\text{Al}_9\text{Si}_{27}\text{O}_{72}) \cdot 24\text{H}_2\text{O}]$  in November 2002, and thomsonite-Ca  $[\text{Ca}_2\text{Na}(\text{Al}_5\text{Si}_5\text{O}_{20}) \cdot 6\text{H}_2\text{O}]$  in November 2007. Okenite  $[\text{Ca}_5\text{Si}_9\text{O}_{23}) \cdot 9\text{H}_2\text{O}]$ , our January 1998 featured mineral, and apophyllite  $[\text{KCa}_4\text{Si}_8\text{O}_{20}(\text{F}, \text{OH}) \cdot 8\text{H}_2\text{O}]$ , our July 1996/July 2006 featured mineral, are often found with zeolite group minerals in India, so that many assume they also are zeolite minerals, but though they are closely related, they do not belong to the zeolite mineral group.

## ***March 2008 Mineral of the Month: Stellerite***

As shown by its chemical formula  $\text{Ca}_4(\text{Al}_8\text{Si}_{28}\text{O}_{72}) \cdot 28\text{H}_2\text{O}$ , stellerite contains the elements calcium (Ca), aluminum (Al), silicon (Si), oxygen (O), and hydrogen (H). Stellerite's molecular weight is made up of 5.68 percent calcium, 7.66 percent aluminum, 27.90 percent silicon, 56.76 percent oxygen, and 2.00 percent hydrogen. The cations (positively charged ions) in the stellerite molecule include four calcium ions, each with a +2 charge, and eight aluminum ions, each with a +3 charge. These provide a cumulative cationic charge of +32. The anion (negatively charged ion) in the stellerite molecule is the silicate radical  $(\text{Si}_{28}\text{O}_{72})^{32-}$ , with the -32 charge accruing from the +4 charge of each silicon ion and the -2 charge of each oxygen ion. The cumulative anionic -32 charge balances the +32 cationic charge to provide the stellerite molecule with electrical stability.

The " $\cdot 28\text{H}_2\text{O}$ " in stellerite's chemical formula means that it is a hydrous (or hydrated) mineral with 28 attached molecules of water ( $\text{H}_2\text{O}$ ). Attached water molecules are collectively called "water of hydration" and consist of electrically neutral water molecules that do not affect the electrical balance of the parent molecule. Water molecules can attach themselves to other molecules because of their unusual atomic configuration in which 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 subsequent polarity enables water molecules to function as tiny dipole magnets that attach themselves to other molecules with a weak attraction called "hydrogen bonding."

Stellerite is a member of the silicates, the largest and most abundant of all mineral classes. In the silicates, silicon and oxygen are combined with one or more metals. The basic silicate structural unit is the silica tetrahedron  $(\text{SiO}_4)^{4-}$ , in which 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).

Stellerite is a framework silicate or tectosilicate, a classification that includes such common and familiar minerals as quartz [silicon dioxide,  $\text{SiO}_2$ ] and the feldspar group of complex aluminum silicates containing potassium, calcium, and/or sodium. But the stellerite crystal lattice is actually based on a modified tectosilicate structure in which silica tetrahedra  $(\text{SiO}_4)^{4-}$  alternate with alumina tetrahedra  $(\text{AlO}_4)^{5-}$ . This arrangement is reflected in stellerite's chemical formula  $\text{Ca}_4(\text{Al}_8\text{Si}_{28}\text{O}_{72}) \cdot 28\text{H}_2\text{O}$ , which expresses the aluminum ions  $[\text{Al}^{3+}]$  as a structural part of the aluminosilicate radical  $(\text{Al}_8\text{Si}_{28}\text{O}_{72})^{32-}$ . Each stellerite molecular unit consists of 14 silica tetrahedra and 4 alumina tetrahedra. Because of its alumina tetrahedra, stellerite is more accurately described as a modified tectosilicate or an aluminosilicate.

Within the stellerite lattice, all silica and alumina tetrahedra covalently share their four oxygen ions to create a repetitive, three-dimensional structure of hollow cells separated by channels and large spaces. Because the charge of the aluminosilicate tetrahedron is -5, the stellerite molecular units carry an excess negative charge that must be balanced by additional cations. This is achieved by four calcium ions  $[4\text{Ca}^{2+}]$  that bond ionically to each molecule. The channels and spaces within and between these molecules provide space for the attachment of 28 water molecules by hydrogen bonding.

Stellerite's hollow molecular cells and intermolecular channels, which are characteristic of all zeolite minerals, account for its low specific gravity (density) of only 2.2. Its perfect one-directional cleavage is explained by the alternate layering of silica and alumina tetrahedra in sheet-like arrangements. At Mohs 4.5, stellerite is among the softest of all silicate minerals. This softness is mainly due to the considerable interionic distances within the hollow molecular units that reduce the strength of the atomic bonds.

## ***March 2008 Mineral of the Month: Stellerite***

This unique structure of zeolites provides several unusual properties. First is the ability to lose and regain water of hydration without any alteration of the crystal structure. Another is that the network of hollow spaces and channels passes certain ions, atoms, and molecules while blocking others, and thus functions as a molecular filter. Finally, the weak cationic bonding within zeolite molecules is easily broken, enabling substitution by other metal cations in a phenomenon called “ion exchange.” All these zeolite properties have many industrial applications (see “Technological Uses”).

Through complex metal-cation substitution, stellerite forms a partial solid-solution series with two other minerals, stilbite-Ca, [hydrous calcium potassium sodium aluminosilicate,  $(\text{Ca}_{0.5}\text{K},\text{Na})_9(\text{Al}_9\text{Si}_{27}\text{O}_{72})\cdot 28\text{H}_2\text{O}$ ] and barrerite [hydrous sodium aluminum silicate,  $\text{Na}_8(\text{Al}_8\text{Si}_{28}\text{O}_{72})\cdot 26\text{H}_2\text{O}$ ]. In the stilbite-Ca partial series, both potassium and sodium substitute for some of the calcium in stellerite. Because this complex substitution alters the silicate-aluminosilicate arrangement within the lattice, stilbite-Ca, unlike stellerite, crystallizes in the monoclinic system. But in the partial solid-solution series with barrerite, only sodium replaces some of stellerite’s calcium in a simpler substitution that does not alter the crystal lattice. Because both barrerite and stellerite crystallize in the orthorhombic system, they can be very difficult to distinguish.

Stellerite is a rare mineral that occurs primarily in amygdaloidal cavities of basaltic volcanic rocks. These cavities form from gas bubbles during the solidification of silica-deficient (mafic) magma. In subsequent low-grade, hydrothermal metamorphism, percolating alkaline groundwater deposits zeolite minerals, often as well-developed crystals associated with other zeolite minerals, quartz, and calcite [calcium carbonate,  $\text{CaCO}_3$ ]. Stellerite occasionally occurs with other zeolites as a cementing material in sandstones, and in bedded sedimentary deposits where percolating alkaline groundwater has altered accumulations of volcanic ash. Stellerite has also been found with other zeolites in bedded deposits formed through alkaline alteration of marine sediments.

When pure, stellerite is colorless or white. Such common impurities as sodium, potassium, strontium, barium, and magnesium do not alter this basic color. Stellerite is classified as an allochromatic (“other-colored”) mineral, meaning that color-causing impurities called chromophores can impart a range of other colors. Iron and manganese impurities create the pale yellow, brown, orange, and pink hues often seen in stellerite specimens.

The Dana mineral-classification number 77.1.4.4 identifies stellerite as a tectosilicate member of the general zeolite group (77). The subclassification (1) defines it as a true zeolite, a group of hydrous aluminosilicates that can lose and regain water of hydration without altering their crystal structures. Stellerite is then assigned to the heulandite group (4) as the 4<sup>th</sup> (4) of five member-groups. This group includes five members of the heulandite group (77.1.4.1.a-d), three members of the clinoptilolite group (77.1.4.2.a-b), two members of the stilbite group (77.1.4.3.a-b), stellerite, and barrerite (77.1.4.5)

### *COLLECTING LOCALITIES*

Although widely distributed, stellerite is rare and has few sources of fine specimens. Our specimens were collected at the Valunj basalt quarry near the city of Aurangabad in the Aurangabad district of the Maharashtra state in the Republic of India. Other sources in Maharashtra include a number of basalt quarries in the adjoining Ahmadnagar, Jalgaon, and Mumbai districts.

In Russia, stellerite is collected at the type locality on Mednyi Ostrov (Copper Island) in Komandorskije Ostrova (Commander Islands) in Kamchatka Oblast’ in the Far-Eastern Region. The Commander Islands are located off the eastern coast of the Kamchatka Peninsula. Other Russian localities are the Alabashka

## ***March 2008 Mineral of the Month: Stellerite***

pegmatite field at Yuzhakova in Sverdlovskaya Oblast', Urals Region; and Malechansk near Lake Baikal, Transbaikalia, Western-Siberian Region. In Kazakhstan, specimens are found at the Sarbai and Sokol'noye mines at Rudnyi Altai in Qostanay Oblast'. Japanese specimens come from the Seikoshi Mine at To-cho in the Shizuoka Prefecture of the Chubu Region on Honshu Island. Australian specimens are collected at Gunnedah in the Coonabarabran district and Mount Mitchell Station at Tambar Springs, both in Pottinger County, New South Wales.

European specimens come from mines at Kongsberg, Buskerud, Norway; Cape Marargui at Bosa in Oristano Province, Sardinia, Italy; La Balme Peak in the La Lauzière Massif at Savoie in Rhône-Alpes, France; Ettrigen-Bellerberg Mountain at Ettrigen in the Eifel Mountains of Rhineland-Palatinate, Germany; andesite quarries at Nadap in the Valencei Mountains in Fejér County, Hungary; and Pièce Glacier at Arolla in the Hère Valley of Valais, Switzerland.

In the United States, stellerite occurs at Chena Hot Springs near Fairbanks, North Star Borough, Alaska; the Grenville-Ellis Quarry at Mt. Desert in Hancock County, Maine; the Squaw Creek Mine in the Taylor tin district of Sierra County, New Mexico; Ritter Hot Springs at Ritter, Grant County, Oregon; the Kibblehouse Quarry at the town of Perkiomen in Montgomery County, Pennsylvania; the A. H. Smith Quarry at Mitchell in Culpepper County, Virginia; the Rock Candy No. 1 Mine in Thurston County, Washington; and the Calavera Quarry near Carlsbad in San Diego County, California. New Jersey provides fine specimens, notably from the basalt quarries at Watchung and Bernard Township in Somerset County and the Breen Quarry at Haledon in Passaic County.

### *JEWELRY & DECORATIVE USES*

Stellerite's small crystal size and relative softness preclude any jewelry use. Mineral collectors value stellerite specimens because of their rarity and unusual crystal habits for both study and display purposes.

### *HISTORY & LORE*

The scientific study of zeolite minerals dates to 1756, when Swedish mineralogist Axel Fredrick Cronstedt (1722-1765) identified the first zeolite mineral, stilbite-Ca [hydrous calcium potassium sodium aluminosilicate,  $(\text{Ca}_{0.5}\text{K,Na})_9(\text{Al}_9\text{Si}_{27}\text{O}_{72}) \cdot 28\text{H}_2\text{O}$ ]. Observing how stilbite-Ca specimens vibrated as heat drove off their water of hydration, Cronstedt created the word "zeolite," literally "stone that boils," from the Greek *zein*, meaning "to boil," and *lithos*, "stone."

Stellerite was among the first generation of zeolites to be discovered. In 1903, Józef A. Morozewicz (1865-1941), professor of mineralogy at Jagellonian University at Kraków, Poland, studied specimens that had been collected on Mednyi Ostrov (Copper Island) in Komandorskiye Ostrova (Commander Islands) in the Bering Sea in Russia's Far-Eastern Region. Morozewicz later proposed that these specimens represented a new zeolite. Stellerite was accepted as a new mineral species, at the time only the eleventh zeolite to be recognized, when Morozewicz published his findings in the bulletin of the Polish Academy of Sciences in 1909. Morozewicz named the new mineral "stellerite" in honor of German naturalist Georg Wilhelm Steller (1709-1746). Nearly two centuries earlier, Steller had sailed in the service of Russia together with Danish navigator Vitus Jonassen Bering (1680-1741) to explore Siberia's Pacific coast and adjacent areas of Alaska. Steller spent much time on Copper Island in the Commander Islands where he described more than two dozen new species of flora and fauna.

During the 1920s, researchers used X-ray diffraction to determine the atomic structure of stellerite and other known zeolites. In the late 1950s, when the International Mineralogical Association (IMA) began to

## ***March 2008 Mineral of the Month: Stellerite***

formally list and approve mineral names, stellerite was “grandfathered in” as a previously confirmed mineral species. But confusion about stellerite remained, particularly regarding a sodium-rich variety called “sodium stellerite.” In 1974, researchers finally determined that “sodium stellerite” was actually a distinct mineral species. The IMA accepted the new mineral as barrerite [hydrous sodium aluminum silicate,  $\text{Na}_8(\text{Al}_8\text{Si}_{28}\text{O}_{72}) \cdot 26\text{H}_2\text{O}$ ]. Today, stellerite and barrerite are among 83 approved zeolite minerals, a list that continues to grow.

Modern metaphysical practitioners believe that zeolite minerals temper negative energy with happiness, encourage stable connections between emotions and intellect, decrease brashness and laziness, enhance mental clarity, and to help connect with the highest levels of consciousness.

### ***X-RAY CRYSTALLOGRAPHY***

*Mineralogists determined the atomic structure of stellerite and several other zeolites in the 1920s, when the introduction of X-ray diffraction (XRD) technology and the emergence of a specialized branch of physics called X-ray crystallography were greatly advancing mineralogy. X-ray crystallography is the science of determining the arrangement of atoms within mineral crystals by observing the manner in which X rays are diffracted when passing through crystals. XRD provides three-dimensional “scatter patterns” that represent electron densities within crystal lattices. These patterns enable mineralogists to determine the precise positions of atoms and the nature of atomic bonding within the crystals.*

*French mineralogist René-Just Haüy (1743-1822) laid the foundation of modern crystallography in 1784 by proposing that crystals consist of individual tiny units arranged in orderly, repeating, internal structures that are reflected in the angles and shapes of external faces. Researchers suggested details of internal crystal structures in the 1880s, but proving their hypotheses required two landmark advancements in physics. The first came in 1895 when German physicist Wilhelm Conrad Roentgen (1845-1923) discovered X rays, a form of penetrating electromagnetic radiation with wavelengths shorter than those of visible light. The second was the emergence of quantum theory in the early 1900s, which postulated that matter consisted of atomic and subatomic particles that interacted with each other and with energy according to precise physical laws.*

*In 1912, German physicist Max Theodore Felix von Laue (1879-1960), while studying how microscopic slits called gratings diffracted visible light, learned that diffraction occurred only when the grating size corresponded closely to the wavelength of the light. Von Laue then proposed that the internal atomic planes of crystals could function as diffraction gratings, but that visible light was unsuitable for studying crystal diffraction because its wavelengths are far larger than the distances between the atomic planes of crystals. Using the very short wavelengths of X rays, von Laue demonstrated that the electrons that orbited atoms within a crystal lattice did indeed diffract or scatter X rays into spherical patterns. Just as interference in visible light produces iridescence (see our explanation of iridescence in our July 2007 write-up on “Rainbow” Pyrite), some X-ray waves canceled themselves out (destructive interference), while others became reinforced (constructive interference) and produced X-ray interference images on photographic plates. Von Laue’s experiments founded the science of X-ray crystallography and earned him the 1914 Nobel Prize in physics.*

*The father-son team of British physicists Sir William Henry Bragg (1862-1942) and Sir William Lawrence Bragg (1890-1971) carried on von Laue’s work. The Braggs expressed X-ray interference images mathematically to simplify their interpretation. William Lawrence Bragg proved that the angle of diffraction*

## ***March 2008 Mineral of the Month: Stellerite***

for specific X-ray wavelengths was governed by the distance between the atomic planes within the crystal lattice, a relationship now known as "Bragg's Law."

Although early XRD crystal-structure images were only one-dimensional, they greatly enhanced the understanding of crystallography. In 1914, the Braggs used XRD analysis to define the atomic structure of halite [sodium chloride, NaCl], fluorite [calcium fluoride, CaF<sub>2</sub>], and pyrite [iron disulfide, FeS<sub>2</sub>], and also to reveal the isometric structure of diamond [carbon, C] and the tetrahedral arrangement of its carbon-carbon bonds. Turning to more chemically and structurally complex minerals, the Braggs then used XRD to define the structure of spinel [magnesium aluminum oxide, MgAl<sub>2</sub>O<sub>4</sub>] and to explain the structural differences between the anatase and rutile polymorphs of titanium dioxide [TiO<sub>2</sub>].

Although they initially performed their XRD research with single, near-perfect mineral crystals, the Braggs quickly learned to define the crystal structures of polycrystalline samples, a technique now known as X-ray powder diffraction. In 1916, the powder-diffraction technique revealed the hexagonal structure of graphite [carbon, C] and the crystal structures of elemental iron and magnesium. For the spectacular advances in mineral crystallography made possible by XRD analysis, the Braggs received the 1916 Nobel Prize for physics, the only Nobel Prize ever won by a father-son team.

Improved computational and experimental methods soon enabled researchers to accurately deduce atomic positions in complicated two- and three-dimensional lattice arrangements. By 1924, systematic XRD studies of the silicates had defined the internal structures of the garnet-group minerals, a group of complex aluminum silicates, that had long puzzled mineralogists. From XRD analysis, mineralogists also learned that variations in silicon-oxygen ratios created changes in internal structure—an understanding that established the seven basic silicate structures. Then in 1926, XRD revealed how aluminum substitutes for silicon in certain silicates—the key to understanding the structure of zeolites and to the future identification of dozens of new zeolite minerals.

Today, the most precise and commonly used method of XRD analysis is also the oldest—single-crystal diffraction. The first step is to obtain a sample crystal having high chemical purity, a non-deformed structure with no twinning or significant internal defects, and a three-dimensional size of at least 100 micrometers (also called microns, one-millionth of a meter). Sample crystals are subjected to an intense beam of monochromatic (single wavelength) X rays which diffract into scatter patterns. As these crystals are slowly rotated, new reflection patterns appear and are recorded on sensitized electrostatic surfaces. A single data "set" produced from a one-half rotation of the crystal contains tens of thousands of individual scatter points. The voluminous data representing multiple sets are then processed by the same computerized-axial-tomography (CAT) techniques used in medical CAT and magnetic-resonance-imaging (MRI) scans.

X-ray crystallography has come a long way since the pioneering work of von Laue and the Braggs. Today, XRD-derived crystallography data for virtually every known mineral is contained in huge databases that are available to mineralogists and crystallographers around the world. And XRD-derived definitions of crystal structure are mandatory for the recognition of every new mineral species.

### ***TECHNOLOGICAL USES***

The ability to exchange metal cations and absorb and filter particulate matter makes the zeolites superb mediums for absorption, filtration, ion-exchange, chemical catalysis, and molecular sieving. Zeolites are

## March 2008 Mineral of the Month: Stellerite

regularly used to filter water and gases, catalyze petrochemical and chemical processes, remove radioactive wastes during the processing of nuclear materials, formulate “slow-nutrient-release” agricultural fertilizers, and purify medical oxygen. Two of the biggest zeolite uses are as “filtration-capture” mediums in household and commercial laundry detergents and as filtration mediums for aquariums and pools. China provides most of the five million metric tons of zeolite minerals now mined each year. Zeolites are also synthesized in large quantities.

Until the 1999 discovery in China of bedded, sedimentary, stellerite-rich zeolite deposits, stellerite had not been considered a commercial zeolite mineral. But the Chinese now mine stellerite, not for direct zeolitic uses, but as a raw material for the production of special synthetic zeolites.

### ABOUT OUR SPECIMENS

As noted, our stellerite specimens were collected at the Valunj basalt quarry near the city of Aurangabad in the Aurangabad district in the Republic of India. Aurangabad is one of the 34 administrative districts of the state of Maharashtra, which borders the Arabian Sea in west-central India. The capital of Maharashtra is the port city of Mumbai (formerly Bombay). Aurangabad, the capital of the Aurangabad district, is located about 160 miles northeast of Mumbai. With a population nearing one million, Aurangabad is one of India's fastest growing cities and a manufacturing center for silk and cotton fabrics, automotive and electronic components, and pharmaceuticals. As the gateway to the Ajanta and Ellora World Heritage historical sites, Aurangabad is also a tourism center.



Figure 1. Valunj Quarry, Aurangabad.

Geologically, Aurangabad is located near the center of the Deccan Traps, a huge volcanic province that covers most of the state of Maharashtra. Consisting of basalt formations as thick as 4,000 feet, the Deccan Traps were created 65 million years ago when enormous volumes of magma extruded onto the surface. Basalt is an extrusive (volcanic) igneous rock with little quartz, but large amounts of iron and magnesium minerals that impart a characteristic dark color. Basalt sometimes contains cavities that are filled with mineral crystals. These cavities or vesicles form from gas bubbles within the original magma as it solidifies. Vesicles, which range in size from less than an inch to many feet, are initially barren and devoid of secondary mineralization. But fissures and fractures in the basalt conduct circulating groundwater that often becomes alkaline and dissolves certain aluminum and silica-bearing minerals. Eventually, this water fills many vesicles and precipitates such minerals as quartz, calcite, and a variety of zeolites, the latter often in well-developed botryoidal, spherical, and radiating crystal forms. When filled with secondary minerals, vesicles are correctly termed *amygdules*.

Basalt, which is hard, durable, and dense, makes a fine cement additive and ballast-fill material for general construction use. Because Maharashtra has virtually no limestone, sandstone, or other types of rock resources, basalt is the only available material for construction purposes. To minimize transportation costs, basalt is quarried as near as possible to where it is needed. Like most Maharashtra districts, Aurangabad has thousands of basalt quarries of all sizes, configurations, and production levels. Many are located near the city of Aurangabad, where the rapidly growing population and economy have created record demand for basalt.



## March 2008 Mineral of the Month: Stellerite

The Deccan Traps are the world's leading source of zeolite specimens, most of which are recovered as by-products of basalt quarrying. The Valunj Quarry, the source of our stellerite specimens, is one of Aurangabad's larger, fully mechanized basalt-mining operations. Valunj quarry workers break the basalt by systematically drilling and blasting large sections of quarry walls called benches. Trucks then haul the broken rock to crushers where it is sized for specific uses. As in many Indian quarries, Valunj's managers now consider zeolite specimens to be a valuable by-product of basalt mining. Accordingly, they contract with experienced specimen miners who expertly remove valuable specimens as soon as they are exposed by quarrying operations.



**Figure 2.** A vehicle for hire, one of the chief modes of transport in India, known as an "Auto Rickshaw," in front of Valunj quarry.

Stellerite specimens were first found in the Aurangabad quarries in the early 1990s. Small quantities reached international gem-and-mineral shows in 1996, where their quality drew considerable attention among collectors, with the January-February 2003 special edition of the *Mineralogical Record* on Indian zeolites calling Aurangabad stellerites "very impressive." Because stellerite recoveries at Valunj and other Aurangabad quarries have since been sporadic and somewhat limited, the specimens continue to attract attention and are quickly purchased by collectors whenever they become available. We are happy to have made a connection with an Indian geologist/mineral dealer who has access to fine material from Indian quarries and can provide the kind of quality and quantity that we need for Club members.

Some dealers and collectors assert that they can differentiate stilbite from stellerite by examining the crystal terminations, holding that stilbite has pointed terminations while stellerite has flat terminations, an averment denied by the *Mineralogical Record*. Stellerite crystallizes in the orthorhombic system while stilbite belongs to the monoclinic group, so we might expect noticeable differences in their crystal forms--but because stilbite forms pseudo-orthorhombic crystals, X-ray diffraction testing is the only way to correctly tell them apart. Sufficient XRD analysis has been performed on Aurangabad specimens to determine that they are stellerite rather than its closely related cousin stilbite. Now that we have added stilbite and stellerite to our collections, we will focus on obtaining a large lot of barrerite so that we complete the trio!

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