

April 2006 Mineral of the Month: Cavansite

"A trove of royal-blue cavansite specimens that astonished the mineral community at the Tucson Show in 1989 was collected from a quarry in the vicinity of Wagholi village. Thousands of fine examples, the best ever seen for the species, were found there. Additional occurrences in quarries nearby have now been discovered."—Rustam Z. Kothavala, Mineralogical Record, November-December 1991.

PHYSICAL PROPERTIES

Chemistry: $\text{Ca}(\text{VO})\text{Si}_4\text{O}_{10}\cdot 4\text{H}_2\text{O}$ Hydrus Calcium Vanadium Silicate (Calcium Vanadium Silicate Hydrate), also Hydrus Calcium Vanadyl Silicate

Class: Silicates Subclass: Phyllosilicates

Group: Cavansite (Vanadium-containing Phyllosilicates)

Crystal System: Orthorhombic

Crystal Habits: Usually as isolated spherical aggregates, radiating spheres, tufts, or rosettes of crystals; less commonly as linear clusters of somewhat more distinct individual crystals; terminations pointed but not sharp; twinning rare. Almost always occurs as inclusions in, or growths on, zeolite minerals. Small crystals rarely exceed one-half inch in length.

Color: Greenish blue to deep, vivid blue and "electric" blue

Luster: Vitreous

Transparency: Transparent to translucent

Streak: Bluish-white

Cleavage: Perfect in one direction

Fracture: Conchoidal, brittle

Hardness: 3.0-4.0, varies directionally

Specific Gravity: 2.21-2.31

Luminescence: None

Refractive Index: 1.54-1.55

Distinctive Features and Tests: Best field indications are vivid blue color, secondary occurrence in vesicles or fractures of basalt or andesite, and association with zeolite minerals. Cavansite is sometimes confused with the dimorphic mineral pentagonite, as explained in *Composition*.

Dana Classification Number: 74.3.7.1

NAME

Correctly pronounced "CAV-an-site," the mnemonic ("assisting memory") name is derived from an acronym consisting of the first letters of three of its elemental components: *C*alcium, *V*ANadium, and *S*ilicon. It also appears in technical literature as the German "cavansit," and the Spanish "cavansita."

COMPOSITION

The chemical formula of cavansite, $\text{Ca}(\text{VO})\text{Si}_4\text{O}_{10}\cdot 4\text{H}_2\text{O}$, indicates that it contains five elements: calcium (Ca), vanadium (V), silicon (Si), oxygen (O), and hydrogen (H). The molecular weight of cavansite is made up of 8.88 percent calcium, 11.28 percent vanadium, 24.89 percent silicon, 53.16 percent oxygen, and 1.79 percent hydrogen. In the cavansite molecule, the compound cation, or positively charged ion, $[\text{Ca}(\text{VO})]^{4+}$, consists of a calcium ion with a +2 charge, a vanadium ion with a +4 charge, and an oxygen ion with a -2 charge. Together, these ions produce a cumulative +4 cationic charge. The compound anion, or negatively charged compound ion, $(\text{Si}_4\text{O}_{10})^{4-}$, consists of four silicon ions, each with a +4 charge, and ten oxygen ions, each with a -2 charge. Together, these ions produce a cumulative anionic charge of -4, which counters the cationic charge of +4, thus providing the cavansite molecule with electrical balance and molecular stability.

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As shown by the $\cdot 4\text{H}_2\text{O}$ in its chemical formula, $\text{Ca}(\text{VO})\text{Si}_4\text{O}_{10}\cdot 4\text{H}_2\text{O}$, cavansite is a hydrous, or hydrated, mineral, meaning that it has attached molecules of water (H_2O) called “water of hydration.” Each molecule of cavansite has four attached water molecules. In hydrous minerals, these attached water molecules do not alter the cationic-anionic electrical balance of the parent molecule. This is because the attached water consists not of individual hydrogen and oxygen ions, but of complete, electrically balanced water molecules. Within each water molecule, the collective charge of the double hydrogen cation $(2\text{H})^{2+}$ is balanced by the charge of the single oxygen anion O^{2-} . But because the two hydrogen ions are closely grouped within the molecule, rather than evenly opposed, they retain a residual positive charge. The opposite side of the water molecule, which is dominated by the large oxygen ion, retains a small negative charge. Because of this dipolar effect, water molecules behave as tiny dipolar magnets and are able to attach themselves to certain other molecules to create hydrous minerals. But before seeing how they attach to the cavansite molecule, let’s look first at the structure of cavansite itself.

Cavansite is a member of the largest and most abundant class of minerals—the silicates. Silicates are combinations of silicon with one or more metals and may or may not be hydrated. The silica tetrahedron, $(\text{SiO}_4)^{4-}$, which is the structural foundation of all silicates, consists of a silicon atom surrounded by four equally spaced oxygen atoms at the corners of a tetrahedron (a polyhedron with four faces). Silicate minerals consist of silica anions bound to metal cations and form seven distinct and complex groups that are classified by lattice structure.

One of these groups, which include cavansite, is the phyllosilicates, or “sheet” silicates. In the sheet silicates, each silica tetrahedron shares three oxygen ions with adjacent tetrahedra to create a thin, sheet-type structure that extends indefinitely in two directions. The layers themselves do not consist of continuous rows of tetrahedra, but rather of a checkerboard-like system of alternating “strips” of three tetrahedra each that are linked at their corners. This arrangement electrically satisfies three of the oxygen ions on each tetrahedron, leaving one remaining oxygen ion on the apex of each tetrahedron still with a negative charge. And this is where the water of hydration comes in. Drawn by their dipolar positive charge (opposite charges attract), water molecules fill the spaces between the apices of the silica tetrahedra, partially accommodating their remaining negative charge. These water molecules are attached only by hydrogen bonds, a very weak form of bonding created by the attraction of the faintly positive poles of water molecules to other electrons. Stacks of these complex sheets are then held together by a layer of positive metal ions which satisfy the remaining collective negative charge of the tetrahedra layers.

Phyllosilicates are subclassified structurally into two- or three-layer groups. Cavansite exhibits a typical three-layer or “2:1” structure, in which two tetrahedral layers “sandwich” an octahedral layer of metal ions or metal-radical ions (a radical is a combination of different ions that acts as a chemical entity). In cavansite, the ions in the “sandwiched” middle layer are calcium (Ca^{2+}) and vanadyl $[(\text{VO})^{2+}]$. Within these sheets, a combination of strong covalent and ionic bonding creates cohesive sheet units. But the ionic attraction *between* the three-layer sheets is so weak that the sheets slip and separate even under moderate mechanical pressure. This explains cavansite’s perfect, one-directional cleavage and its relative softness of Mohs 3.0-4.0. Cavansite’s hardness also varies directionally, being softest when scratched along the direction of the perfect cleavage plane.

The Dana classification number of 74.3.7.1 first identifies cavansite as a phyllosilicate with modulated (alternating) layers (74). The subclassification (3) next defines cavansite as a modulated phyllosilicate in which the tetrahedral layers consist of joined tetrahedral strips. Finally, cavansite is a member of a group of modulated, “joined-strip” phyllosilicates that contain vanadium (7), in which it is the first (1) of two members. The other member of this group is pentagonite (Dana number 74.3.7.2), which is a dimorph of cavansite—a mineral with the exact same chemistry but a different crystal symmetry. Cavansite is often confused with pentagonite; both have similar colors, crystallize in the orthorhombic system, occur in the

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same mineralogical environment, and form under very similar conditions. But the crystal habits of the two minerals differ considerably. Cavansite usually forms isolated spherical clusters of crystals or, less commonly, linear clusters of more distinct individual crystals that are compared in shape to a “pile of logs.” Cavansite crystals rarely have sharp terminations. On the other hand, pentagonite does not form tight spheres of crystals, but usually occurs as showy sprays of small, sharp crystals of unequal lengths. Unlike cavansite, pentagonite crystals have sharp terminations and are almost always twinned. Pentagonite also tends to be more transparent than cavansite.

Furthermore, cavansite tends to form directly atop stilbite-Ca $[(\text{Ca}_{0.5}, \text{K}, \text{Na})_9(\text{Al}_9\text{Si}_{27}\text{O}_{72}) \cdot 28\text{H}_2\text{O}]$, our May 1999 mineral], while pentagonite associates more with heulandite-Ca $[\text{Ca}_{0.5}, \text{Na}, \text{K})_9(\text{Al}_9\text{Si}_{27}\text{O}_{72}) \cdot 24\text{H}_2\text{O}]$, our November 2002 mineral]. This is most likely the result of a depositional sequence in which stilbite crystallizes first and is followed by cavansite. In subsequent depositional phases, heulandite and calcite sometimes crystallize as tiny crystals on cavansite crystals. Pentagonite crystallizes last and is often found on heulandite crystals.

As far as is known, cavansite occurs exclusively as a secondary mineral within vesicles (vugs) of basalt and andesite, both extrusive igneous rocks that form from the solidification of lava. Basalt is a basic (silica-poor) extrusive igneous rock, while andesite is a closely related rock of intermediate silica content. Vesicles form as gas bubbles in the original lava. After cooling and solidification of the lava, these gas- or fluid-filled voids provide an environment for the crystallization of secondary minerals, which can form either from the original, mineral-rich fluids trapped within the vugs or from later fluids that migrate through the rock. In this environment, cavansite (and its dimorph pentagonite) are associated with such minerals as calcite (calcium carbonate, CaCO_3), quartz (silicon dioxide, SiO_2), and especially with stilbite, heulandite, and other zeolite minerals.

Cavansite cannot be classified as a zeolite, although it appears to exhibit certain zeolitic properties. According to a recently broadened mineralogical definition, zeolites are hydrated tectosilicates (framework silicates) with structures that contain channels to accommodate attached water molecules. A key characteristic of zeolites is their ability to lose or regain water of hydration without altering their crystal structure. While cavansite is not a tectosilicate, and therefore not a zeolite, it does appear to be able to lose (through heating) at least some of its water of hydration and to regain it without altering its crystal structure. Mineralogists note that these observations are inconclusive and that much research remains to be done in this area.

Cavansite is an idiochromatic mineral, meaning that its characteristic and diagnostic deep-blue color is due to essential chemical composition and crystal structure, rather than the presence of any nonessential chromophores (coloring agents). Vanadium has four common oxidation states: V^{2+} , V^{3+} , V^{4+} , and V^{5+} . The +4 oxidation state of the vanadium (V^{4+}) in cavansite is a powerful blue pigmenting agent. In cavansite, vanadium ions within the crystal lattice create absorption characteristics that absorb all wavelengths of visible light except for a narrow band of blue, the reflectance of which is the color we perceive in cavansite. The intensity of the blue color depends upon the amount of vanadium actually present in the particular cavansite specimen. Color zoning is often apparent in cavansite crystals, and is usually seen as paler prism colors tipped by intense blue terminations.

COLLECTING LOCALITIES

Cavansite is a rare mineral with few known occurrences. The world's premier occurrence of cavansite is in a group of quarries in India's Deccan traps, vast formations of basalt that are famed as a source of often-spectacular zeolite minerals. The finest cavansite specimens come from the Wagholi Quarry, with

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specimens of somewhat lesser quality found in the neighboring Dhoot and Chavan quarries. Cavansite has also been reported from the Pashan Quarry in the nearby village of Pashan. All these quarries are located near the village of Wagholi, about 20 km northeast of the center of Pune (Poona), roughly 80 km southeast of the city of Mumbai (Bombay), in India's west-central state of Maharashtra.

Tiny crystals of cavansite are found at the mineral's type locality, a basalt road cut near the Owyhee Dam in Lake Owyhee State Park, Malheur County, in east-central Oregon, and in basalt at the Chapman Quarry near Goble, Columbia County, in northwest Oregon. (Some literature includes the Goble site as a co-type locality.) Small crystals of cavansite have also been found in Brazil in the municipal quarry at Morro Reuter in the state of Rio Grande do Sul, and in New Zealand at the Aranga Quarry near Dargaville in Northland (North Island).

JEWELRY & DECORATIVE USES

Cavansite has little jewelry or decorative uses because of its scarcity and small crystal size, although we did purchase some cabochons made from cavansite from the Indian geologist who owns the mineral rights at Wagholi and who supplied our specimens. But because of its brilliant blue color, rarity, and occurrence on white heulandite and stilbite crystals, cavansite is in great demand by collectors for its mineralogical value and as display specimens.

HISTORY & LORE

Let's go back to our April 1996 write-up on cavansite to begin our history section: "A couple named Mr. and Mrs. Leslie Perrigo were driving through Lake Owyhee State Park in eastern Oregon near the Oregon-Idaho border in the fall of 1960. They noticed a blue mineral on a large rock face that had recently been exposed by a road cut. Together with Mr. and Mrs. Frank Patterson they collected specimens and sent some to Dr. Paul Desautels of the Smithsonian National Museum, who reported that it was probably a new mineral. In February 1963, Mr. John Cowles found some in a quarry near Goble, Oregon, approximately 350 miles northwest of Lake Owyhee. In the fall of that year, Mr. Cowles presented some to Dr. Lloyd Staples for identification, and it was determined to be a new mineral!"

Cavansite and its closely related dimorph pentagonite were officially recognized as new mineral species in 1967. The specimens found at these two initial sites were of interest primarily to collectors of new/rare minerals, as the first cavansite crystals were only 0.5 to 1.0 mm in length, and .05 mm in diameter, little more than a blue splodge on a rock. Fortunately for all of us, this did not remain the case.

In 1973, Indian mineral collector/dealer Rustam Kothvala was digging through thousands of unmarked specimens belonging to a dealer in Bombay (now Mumbai), India. Kothvala eagerly obtained a few specimens with rosettes of bright blue acicular crystals on top of white stilbite crystals, but had no idea what they were or where they came from. A quick trip to Harvard University brought an identification of cavansite, and two of the original specimens stayed in their collection. Although these specimens were inferior to what would later be found, they were far superior to the original specimens found in Oregon, and the remaining specimens sold immediately. Kothvala now became determined to find the locality.

The white stilbite crystals suggested that the specimens came from the area around Pune. For fifteen years, Kothvala criss-crossed the area, "examining hundreds of quarries and thousands of specimens," as he later wrote in the *Mineralogical Record*. Unfortunately for him, he had overlooked the quarries near Wagholi! The story continues under *About Our Specimens*. Because cavansite has no technological uses, we have omitted that section of the write-up.

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Metaphysical practitioners believe that cavansite stimulates intuition, heightens awareness, enhances channeling ability, rids the mind of negative thoughts, inspires new ideas, and protects the healer during healing sessions.

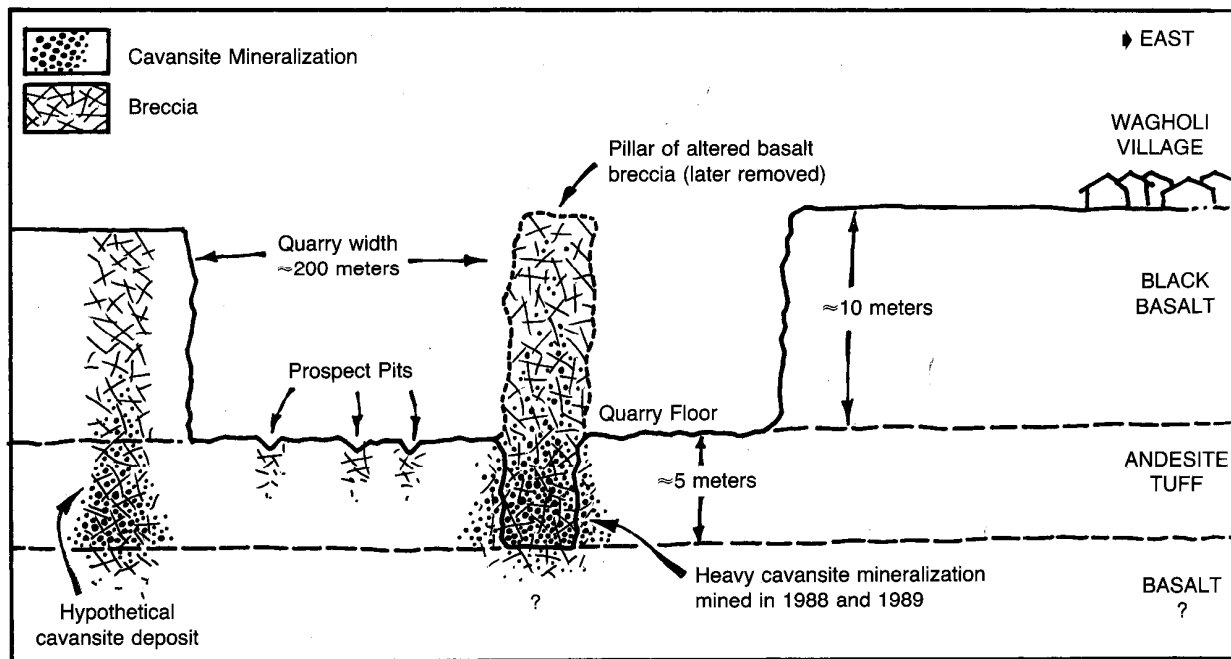


Figure 1. Schematic cross-section of Main quarry, Wagholi, showing relationship of cavansite mineralization to alteration and breccia in basalt and andesite layers (not to scale.) From the November-December 1991 Mineralogical Record, used by permission.

ABOUT OUR SPECIMENS

Quarries near Wagholi village are worked for a black basalt that is ideal for construction purposes. The basalt is about 30 feet thick, and sits atop a layer of andesite and andesite tuff, not usable for construction purposes. At the Main quarry, an area of the basalt was unusable because it had been naturally broken apart and then cemented together and chemically altered by migrating hydrothermal solutions. The quarry was expanded around it until this ignored portion stuck up as a large pillar, as sketched in Figure 1. This pillar made an ideal lookout spot for visiting government officials, who would regularly sit and survey the growing quarry, levying royalties on the quarry owner for the rock removed. To make such surveys more difficult, the owner decided that this conveniently placed pillar must go!

And so pillar removal began in 1988, and as the removal work advanced, small blue crystals began to be revealed. As the work progressed, the quality of the crystals improved, and the very best were found near the bottom, where the pillar contacted the underlying andesine layer. Specimens were quickly brought to dealers in nearby Pune, where consulting geologist Arvind Bhale and his confreres correctly identified this striking new find as the world's best cavansite!

Arrangements were quickly made, and the 1989 Tucson show saw the debut of this remarkable new

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find. Descriptions from show reports describe it as “deep blue in color, very similar to but slightly darker than copper sulfate blue” (1989 *Mineralogical Record*) and “Certainly one of the most important (and colorful!) new discoveries over the last year . . . The lironite-blue 2-cm spherical crystal aggregates on white stilbite crystals are breathtakingly beautiful, and at least two orders of magnitude better than anything ever found before. They are clearly the world’s finest cavansites” (1989 *Mineralogical Record*). (Lironite $\text{Cu}^{2+}_2\text{Al}(\text{AsO}_4)(\text{OH})_4 \cdot 4(\text{H}_2\text{O})$ is a rare sky-blue mineral first discovered in Cornwall, England, in the early 1800’s.) From what we hear, these first specimens were extremely expensive, and as new finds were made and hit the market, the prices fell greatly, which seems to be typical of new finds.

In the years since, new finds have been made at each of the quarries at Wagholi. Each time, specimens are quickly snapped up by eager collectors—no serious collection is without one or more exceptional Wagholi cavansite specimens! Ironically, the cavansite finds have become a source of problems rather than of revenue to the quarry owners. Each time a new find is made, quarry workers focus on recovering and reselling cavansite specimens instead of the normal quarrying operations. This is understandable, as just a few decent specimens sold to a local “runner” can net the quarry worker more gain than a month’s worth of backbreaking quarry work! The runners then bring the cavansite to dealers in Pune for resale.



Figure 2. Collecting cavansite at Wagholi.

Examining your specimen under magnification will prove most illuminating. Can you see the individual thin prismatic crystals that make up the cluster, and perhaps some of their customary chisel-shaped terminations? Any color-zoning? Most specimens are on a bed of clear stilbite crystals, with some specimens having larger white stilbite crystals as well, occasionally growing on or into the cavansite! With just a quick glance or under magnification, it is easy to see why collectors greatly prize this highly aesthetic mineral!

References: *Manual of Mineralogy*, Klein and Hurlbut, John Wiley & Sons; *Dana’s New Mineralogy*, Eighth Edition; *Encyclopedia of Minerals*, Second Edition, Roberts, et al, Van Nostrand Reinhold Company; *2004 Glossary of Mineralogical Species*, J. A. Mandarino and Malcolm E. Back, The Mineralogical Record, Inc.; *Mineralogy*, John Sinkankas, Van Nostrand Reinhold Company; “The Micromount Corner,” Dave Babulski, *Tips and Trips* (Georgia Mineral Society), March 2005; “Cavansite and Pentagonite: New Dimorphous Calcium Vanadium Silicate Minerals from Oregon,” L. W. Staples, H. T. Evans, Jr., and J.R. Lindsay, *American Mineralogist*, May-June 1973; “Crystal Structure of Cavansite Dehydrated at 220° C.,” R. Rinaldi, J. J. Pluth, and J. V. Smith, *Structural Crystallography and Crystal Chemistry*, June 1975; “The Crystal Structure of Cavansite and Pentagonite,” H. T. Evans, Jr., *American Mineralogist*, May-June 1973; “What’s New in Minerals,” Wendell Wilson, *The Mineralogical Record*, January-February 1977; “Cavansite from the Poona District, India,” Bill Birch, *The Mineralogical Record*, January-February 1977; “Cavansite, near Wagholi, Poona District, Maharashtra, India,” Robert B. Cook, *Rocks & Minerals*, May-June 1996; “What’s New in Minerals,” Wendell Wilson, *The Mineralogical Record*, May-June and September-October 1989; “The Wagholi Cavansite Locality near Poona, India,” Rustam Z. Kothavala, *The Mineralogical Record*, November-December 1991; “Scientists Spot Rare Gem,” *Deccan Herald* (New Delhi, India), December 19, 2005; “Let’s Get it Right: Cavansite or Pentagonite?” John S. White, *Rocks & Minerals*, July-August 2002; Cavansite from Wagholi, Claus Hedegaard, hedegaard.com.