Northwest
Micro Mineral
Study Group

MICRO PROBE

FALL, 1988

VOLUME VI Number 7

FALL MEETING AT FOREST GROVE

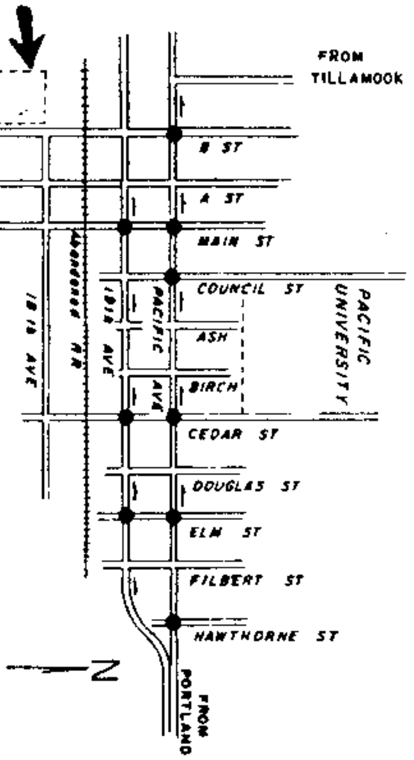
Saturday, November 5, 1988

9 am to ??

**Forest Grove Light and Power
Auditorium
1818 B Street
Forest Grove, Oregon**

There will be the usual pot-luck in the evening, plus coffee and goodies all day long.

Come prepared to have a good time.



FOREST GROVE, OREGON

Our meetings provide lots of time for looking at each other's specimens and for sharing personal experiences on a one-to-one basis. Bring your microscope and some specimens for the rest of us to admire.

Specialties of the day will include:

BIG TREE CREEK, YACOLT, WASHINGTON (featured in this issue). Bring the specimens you are not too sure of. Identified specimens will be available for purposes of comparison.

HANSEN CREEK, SNOQUALMIE CO., WASH. (to be featured in an issue next year). We are currently compiling a report on the area. Bring what you have collected so that we can make our report as complete as possible.

RITTER AREA, OREGON (to be featured in an issue next year). This will include specimens from both old and new quarries, along the road and at the hot springs, and nearby areas such as Three Mile School and locations along the North and Middle forks of the John Day River. Again, help us make our report as complete as possible by showing what you have collected.

After the Pot Luck, we will have a slide projector available, so bring slides that you would like to share with the group.

Identifying the Disordered Zeolites

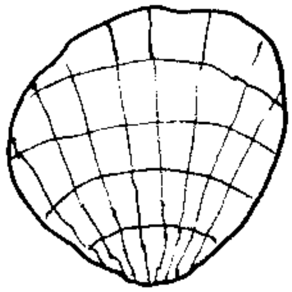
Donald Howard

The positive identification this spring of the zeolite Gonnardite (from Ritter, Oregon and from Yacolt, Washington) means that we now have two of the so-called disordered zeolites among our list of species in the Northwest: Garronite and Gonnardite. Identifying zeolites is a difficult business at best, and these species are more difficult than most. Hence, a few words to describe these two species, which may already be represented but unidentified in your collected material.

Garronite

Garronite is a disordered member of the group of minerals containing Phillipsite and Gismondine. It is fairly common at Goble, Oregon, Pete's Point, Wallowa Co., Oregon, and Capitol Peak, Thurston Co., Washington, and is one of the group of minerals identified from Big Tree Creek, Yacolt, Washington.

Most commonly, Garronite completely fills the cavities in which it forms. It often shows a pattern of radial and curving cracks, which are a good indicator when present. Material with this crack pattern often falls apart easily, especially just after it is first exposed, and care must be taken in the field to preserve it.



typical cracking pattern of Garronite

When Garronite does not completely fill the cavity, it forms a milky white mass whose spherically curved surface is covered with Phillipsite crystals, usually oriented so that many faces reflect light at the same time. Phillipsite always covers otherwise free surfaces of Garronite.

Garronite and granular, radial Phillipsite strongly resemble each other. However, because of its disordered nature, Garronite reflects x-rays in fewer directions than does Phillipsite, and therefore can be positively identified by its x-ray reflection pattern.

Gonnardite

Gonnardite is a disordered zeolite related to both Natrolite and Thomsonite. It is usually in the form of one to several spherical masses which, when broken, appear to radiate from a center. However, Thomsonite often forms the same sort of structures. In fact, the radial structures often blend from Gonnardite at the center to Thomsonite near the outside. Masses of Gonnardite that do not completely fill their cavities usually have at least a thin layer of Thomsonite on the surface.

Like Thomsonite, Gonnardite is a rather hard zeolite, often difficult to break. It generally is bluish-white in color. It resembles Thomsonite so closely that there is no easy way to distinguish them.

The x-ray diffraction pattern of Gonnardite is very similar to Natrolite (rather than Thomsonite). Natrolite normally forms needles rather than radial masses. Thus, x-rays are the best way of verifying the presence of Gonnardite.

Three other disordered zeolites, Paranatrolite, Tetranatrolite, and Gobbinsite are very similar in structure and x-ray pattern to Gonnardite. As yet, these others have not been identified from any Northwest location. The associated minerals that these blend into is usually Natrolite rather than Thomsonite.

The disordered nature of these minerals indicate that they have formed relatively quickly, thus not achieving the well-ordered structure. As growth slowed, they convert back to the more structured form appropriate to the solution composition.

Garronite is rather easy to identify in its cracked form. It was the primary solid white filling at Goble until the advent of the Tschernichite-bearing rock which contains many white, poorly ordered cavities (so poorly ordered, in fact, that they give no x-ray diffraction pattern at all). The Garronite at Yacolt is much harder to identify because it seldom shows the pattern of cracking. At Yacolt, Garronite, Gonnardite, and the granular forms of Laumontite, Scolesite, and Epistilbite all resemble each other, and careful comparison to identified specimens (or x-ray studies) will be required to separate them. Nevertheless, solid, clay-lined cavities of Gonnardite are excellent representatives of one of the less common zeolites and all such cavities should be kept for later identification.

P H O T O   C A P T I O N S

Photomicrographs (Number at lower right on front)

#135	Heulandite on Diabantite	(x40)
#142	Epistilbite twin (see figure 5, page 5 for explanation of orientation)	(x100)
#225	Cowlesite (at right) on Diabantite (at left)	(x35)

Photographs (Number on the back)

#33	Scolecite on Heulandite	(x2)
#34	Gonnardite with Smectite lining	(x5)
#35	Heulandite with Mordenite inclusions	(x10)

All specimens are from Big Tree Creek, Yacolt, Washington

All photographs and micrographs are by the editor: Donald G. Howard

EPISTILBITE

Donald G. Howard

There seems to be a great deal of confusion surrounding the minerals Stilbite and Epistilbite. Both are monoclinic zeolites that normally form twinned (often complexly twinned) crystals that, because of the twinning, appear to be orthorhombic rather than monoclinic. Each mineral has rather characteristic forms which differentiate them. The confusion comes more from the similarity in names rather than in crystal forms.

Stilbite

Stilbite is a rather common zeolite that normally forms a bladed crystal similar to that drawn in perspective in figure 1. Such crystals are often formed of eight or more twinned individuals in a complex arrangement. Because of slight misalignments, the faces of Stilbite are often curved so that a sheaf-like group results. Crystals from Goble, Oregon; Rickreall Creek Quarry, Oregon; and from locations along the Lewis River, Wash. are usually of this form.

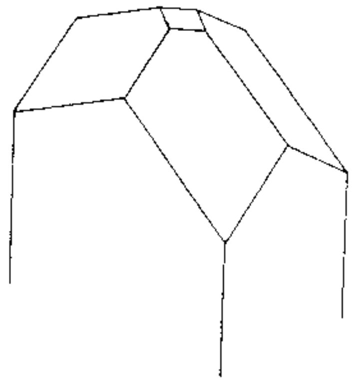


Figure 1. Typical habit for crystals of Stilbite.

A second form of Stilbite is a twin which superficially looks like a complete orthorhombic prism. This variety was originally called Epidesmine in the days before x-ray diffraction proved both forms to have an identical atomic structure. Crystal groups from the old site in Milwaukee, Oregon and recent material from Shellrock Mountain, Oregon are of this type.

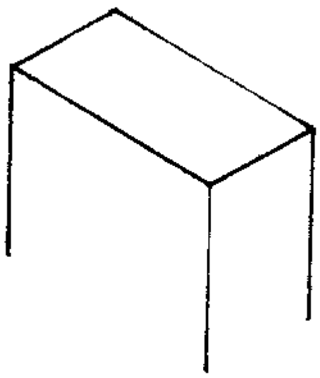


Figure 2. Shape of crystal of Stilbite variety Epidesmine.

The characteristic of stilbite is usually a blade with square cross-section, whether it has a tapered top or a flat top in the two modifications described above.

Epistilbite

Epistilbite is a different mineral with its own characteristic composition and crystal structure. The normal cross-sectional shape of Espstilbite is a diamond, as illustrated in figure 3 (top view at upper right, side view at upper left, end view at lower right, plus a perspective view). The three monoclinic monoclinic axes are shown, and the indices of the faces of the front crystal are

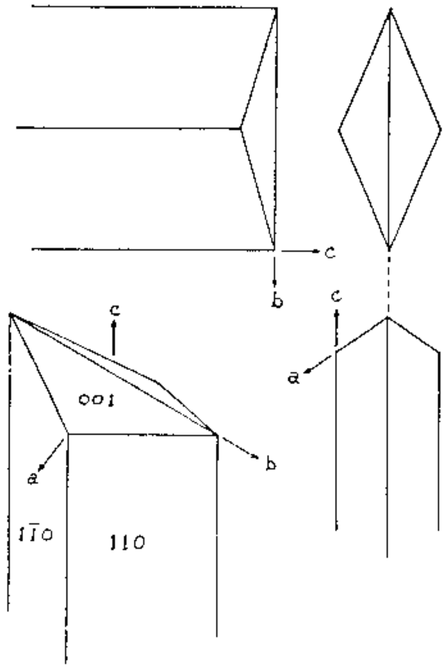


Figure 3. Simple habit of twinning in Epistilbite. The (100) twin plane is shown as a dashed line.

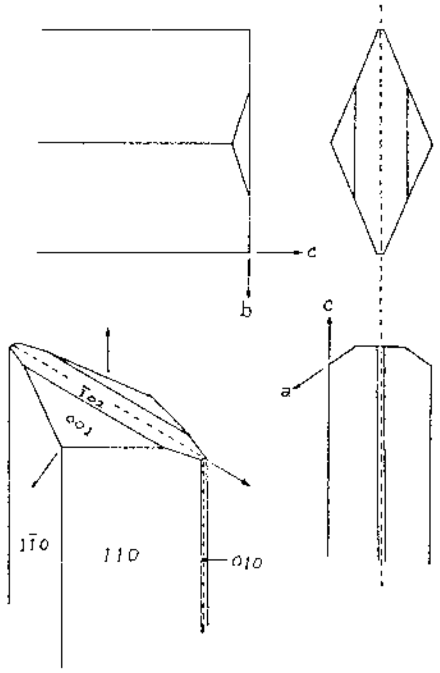


Figure 4. Epistilbite twin as in fig. 3, except with more faces present. The (100) twin plane is shown as a dashed line.

given; the rest of the crystal is a mirror image twin with the (100) face (shown as a dashed line) as the mirror plane.

In slightly more complicated crystals, (102) and (010) faces may also appear, leading to the related form shown in figure 4. This is the type of crystal that was found at Kosmos, Washington.

Both of the above forms have been found in the material from Big Tree Creek, Yacolt, Wash. In addition, very unusual bladed crystals with a complicated twinning are found at this location. These are based upon a form with a much more developed (010) face and a top termination based on (112), as shown in figure 5. Twinning now occurs, first of all, on the (010) plane, followed by subsequent twinning on the (110) plane. Such a twin is shown in photomicrograph #142. The crystal in front at right has a twin on (010) at left rear; each of these then twin on (110) to form the left front and right rear segments. A partial sketch is also shown in figure 5, where the indices of the front right crystal are given (the indices of the front left twin are shown in parenthesis).

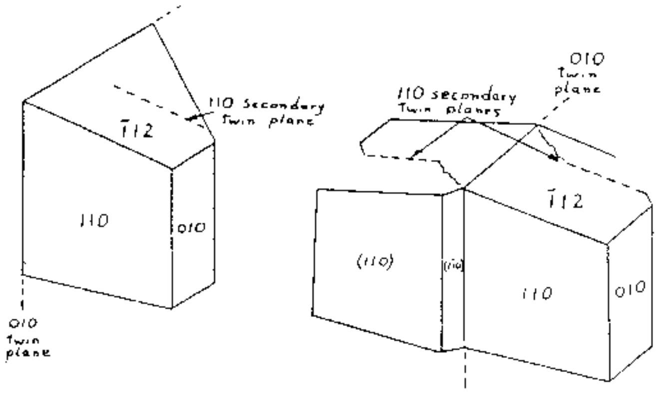


Figure 5. Epistilbite twin of the type in Micrograph #142. At left is shown the basic form. The partial sketch at right shows the orientation of the Micrograph crystal.

THE OCCURRENCE AND ORIGIN OF SILICA RICH AND SILICA POOR ZEOLITES AT BIG TREE CREEK, YACOLT, CLARK COUNTY, WASHINGTON

by

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The zeolite location generally known only as "Yacolt" is found 3.8 miles east of the railroad tracks in Yacolt, in a very shallow logging road-cut heavily overgrown by grass, trees, and moss along the north side of the valley containing Big Tree Creek. The rock is in place along the north side of the road but little collecting is done there due to the dense vegetation. During construction of the logging road, moss-covered boulders were slid off the top of the andesitic-basalt flows along with a great amount of soil and deposited along the south side of the road. When the road was first made, highly vesicular zeolite-bearing boulders were abundant along side of the road; later someone removed truck loads of zeolite-bearing rock to build a fireplace. Productive boulders are now hard to find in the soil and must be probed for with a bar or dug out with a shovel. Productive boulders are rich and everything should be taken home for closer observation.

Two hundred feet further up the road is a steep double-sided road-cut through the volcanic flows consisting of a dense flow with a few large pockets of stilbite on quartz overlain by a vesicular flow which contains rather poor specimens of colorless drusy heulandite, mesolite, scolecite, laumontite, rarely stilbite and thomsonite. The volcanic flows in the double-sided road-cut dip to the west. The upper vesicular flow dips to road-level 200 feet further to the west in the area where the excellent zeolites are found.

The most desirable minerals at Yacolt are the excellent twinned epistilbite, cowlesite attractively scattered on dark green chlorite, unusual crystal forms and colors of heulandite, and the rare zeolites garronite and gonnardite.

Each mineral found at Yacolt is described in the approximate order of crystallization, followed by observed sequences of crystallization and inferred crystallization history.

CLAYS: Three distinct types or habits of clay-chlorite minerals have been observed at Yacolt.

The first generation of clay lines all vesicles at Yacolt with a inconspicuous, thin, smooth-surfaced lining only 1 mm thick. This clay appears to be smectite and precedes all the zeolites.

The second clay-like mineral forms attractive, thick accumulations of spherical aggregates composed of mica-like plates which are transparent green, becoming opaque black with exposure to the atmosphere. This second generation green mineral is characteristic of the green vesicles and always is found on top of the early, light green smectite. XRD indicates these aggregates are chlorite.

The third and last green mineral forms only in some of the vesicles as olive-green fibrous plates always covering fresh unaltered chlorite spheres.

In the green vesicles, the thick chlorite spherical aggregates and olive-green fibrous clay are usually covered by scattered groups of cowlesite and colorless, elongated heulandite, or rarely gonnardite, garronite, thomsonite, laumontite, mordenite, chabazite, calcite, and phillipsite.

Rarely, small spherical aggregates of chlorite are found on the surface of orange or cream heulandite (filled with mordenite inclusions) often totally covered by a transparent heulandite overgrowth. Chlorite spheres are also rarely found both under and on mordenite needles later covered by either heulandite or epistilbite.

MORDENITE: At Yacolt, long thin white hair-like needles of mordenite is the first zeolite to crystallize in the colored-vesicles, usually forming on a very thin, light green, inconspicuous layer of clay. The needles usually form compact linings, only 5 mm to 10 mm long, although a few individual hairs extend several centimeters to the center of larger cavities. The mordenite cavity-lining usually is covered by a cream, orange or red heulandite or cream to orange epistilbite. Early colored heulandite is filled with mordenite inclusions and often gives the heulandite a cream coloration. Later generations of colorless heulandite which overgrows the colored heulandite is free of any mordenite inclusions. Any mordenite extending from the early heulandite must have been redissolved, since the needles all abruptly stop at the surface of the colored heulandite. When mordenite is alone in cavities or with epistilbite it was not always dissolved. All needles under or in heulandite and epistilbite are mordenite. All needles on top of heulandite or epistilbite are scolecite or mesolite.

Thin, widely scattered needles of mordenite are very rarely found in the chlorite-lined cavities, usually associated with cowlesite and epistilbite.

Rarely mordenite needles are found both on chlorite and covered by scattered chlorite spheres, indicating co-crystallizing of the two minerals.

HEULANDITE: Several different crystal forms and colors of heulandite exist at Yacolt. Heulandite is the most obvious cavity lining, forming thin bladed crystals colored red, orange, pink, cream which are <u>flattened along the b-axis</u>, often covering a white fibrous lining of mordenite. An abundance of mordenite inclusions within the heulandite often imparts a white to cream color to the heulandite. Rarely, heulandite forms a smooth-surfaced, orange to white botryoidal vesicle-lining covering mordenite needles and is followed by a shell of either parallel growth heulandite or epistilbite crystals which lays flat against the surface of the mounds.

A second generation heulandite occurs at Yacolt, widely separated in the crystallization sequence from the early colored heulandite. It forms large colorless crystals covering epistilbite, laumontite, mordenite, and colored heulandite. It overgrows and enlarges the colored, inclusion-filled heulandite, forming phantom crystals. Rarely, inclusions of dark green clay aggregates are seen on the surface of the colored heulandite which are completely covered by the transparent heulandite overgrowth. Both levyne and third generation epistilbite are found on top of the large colorless heulandite.

In the green vesicles, two generations of heulandite exist, which are very different in crystal form from those in the colored vesicles. The heulandite forms colorless prismatic crystals greatly elongated along the b-axis with a nearly-rectangular cross section and is always found on deep green, spherical chlorite aggregates. The first generation of elongated-heulandite forms single prisms or bow-tie like groups (see SEM photo). A later generation forms compact radiating hemispherical aggregates which covers both the bow-tie heulandite groups and milky-colored cowlesite aggregates. Both generations of heulandite are covered by garronite and phillipsite. The relationship between the heulandite and cowlesite is difficult to determine, for the two minerals occur side by side often, without clearly being on each other. Some single heulandite prisms have been seen extending out of a cowlesite group in which the dark clay could be seen by looking down the length of the heulandite clearly showing that the bow-tie heulandite was present before the cowlesite. Large hemispherical aggregates of transparent heulandite in contact with cowlesite show cowlesite terminations inside the transparent heulandite and also cover the bow-tie heulandite.

Colored heulandite is never found in the green vesicles and the elongated colorless heulandite is never present in the colored epistilbite-mordenite-heulandite vesicles.

COWLESITE: Attractive, isolated, radiating hemispherical aggregates of cowlesite, scattered on dark green chlorite and associated with colorless elongated heulandite, are common in the green vesicles. Nearly every chlorite-lined vesicle has a few cowlesite aggregates. The aggregates are composed of very thin, pointed, soft blades which sparkle in the light. Cowlesite never completely lines the cavities as it does at most other locations. The contrasting milky white sparkling cowlesite aggregates on the dark chlorite background makes excellent micro specimens. Milky colored aggregates of cowlesite are seen surrounding clear transparent heulandite bow-tie groups, if viewed down the elongation of the heulandite, the dark chlorite base is seen, showing that the cowlesite clearly crystallized after the bow-tie heulandite. The hemispherical heulandite aggregates, on the other hand, are clearly seen covering cowlesite and bow-tie heulandite indicating it is a later generation. Cowlesite is clearly established as crystallizing between these two distinct heulandite phases.

Radiating cowlesite groups are seen completely covered by massive garronite and by whitish thomsonite in zoned gonnardite-thomsonite masses.

Cowlesite is never found in the colored vesicles.

QUARTZ: Rarely, banded and layered chalcedony nodules are found completely filling vesicles. Very rarely colorless transparent quartz crystals are found on mordenite, orange heulandite, or banded chalcedony and is followed by stilbite. Most of these quartz and chalcedony specimens come from the dense flow which corresponds to the lower flow in the double-side road-cut.

Quartz or chalcedony is never found in the green vesicles.

EPISTILBITE: The excellent specimens of epistilbite found in the colored cavities at Yacolt are highly prized, although good specimens are scarce. Epistilbite formed at several different times; each with a considerably different habit. The first generation of epistilbite is usually colored white, cream, or orange; often filled with mordenite fibers, and forms on the colored heulandite. These crystals are found up to 10 mm long extending into the cavity with simple crystal form or it forms a botryoidal smooth surface over botryoidal colored heulandite. A parallel growth of epistilbite often occurs on the surface of the botryoidal epistilbite with the elongation of the crystals laying nearly tangentially to the smooth curved surface.

The second generation of epistilbite is colorless, overgrows the colored epistilbite to form phantoms and often completely fills the colored heulandite nodules. The centers of these nodules often have small open spaces where the epistilbite crystals failed to completely fill the nodule and terminations are present. Some of these crystals are 5 to 15 mm long. Rarely, when the epistilbite crystals did not grow too large, small zoned crystals line the cavities covering colored heulandite. When the colorless second generation epistilbite overgrew an existing simple epistilbite it merely enlarged the size of the crystal and retained it's simple crystal form. When the colorless second generation of epistilbite did not form on an existing colored epistilbite, it forms tiny flattened twins, 1 to 4 mm long, which are complexly twinned on the {110}.

Rarely, colorless second generation heulandite is found perched on first and second generation epistilbite.

Very rarely a third generation of epistilbite formed tiny colorless flat twins, under 1 mm long, on laumontite and large colorless second generation heulandite.

Levyne is a found on all generations of epistilbite at Yacolt. Everywhere else in the world the levyne and epistilbite are never found together.

All epistilbite crystals are twinned on {100} making the simple pseudo-orthorhombic forms. Very rarely they are also twinned on {110} forming what appears to be a flat blade which is actually composed of four simple crystals (see SEM photo). "V" shaped twins also occur which are formed from two flattened, twinned crystals.

Very rarely colorless aggregates of epistilbite are found in the green chlorite-lined cavities, associated with cowlesite, while thin mordenite fiber extending through the epistilbite groups. These aggregates display only the edges of the epistilbite crystals and are hard to recognize.

STILBITE: Small pointed stilbite with small flat tips are found in the double-side road-cut, on colorless heulandite and covered by small groups of thomsonite. Some very large pockets of stilbite on quartz are exposed in the cut with stilbite up to 2 cm long. Stilbite is very rarely found on heulandite in the quartz-bearing dense flow which is found near the vesicular epistilbite-cowlesite bearing rocks. One cavity was found containing 1 cm long colorless rectangular stilbite on epistilbite. Stilbite associated with other zeolites is needed to establish it's position in the crystallization history at Yacolt.

SCOLECITE: Rarely, large white coarse prisms of pure scolecite up to 7 cm long and 5 mm wide are found on red heulandite nearly completely fill the open space in the vesicles. Rarely, scolecite is covered with small colorless rhombohedra of chabazite, while small groups of laumontite are found between the scolecite prisms.

Smaller radiating needles form very attractive hemispherical groups up to 2 cm in diameter. They consist of a chalky-white lower portion of pure scolecite which become transparent colorless mesolite at the upper half of each needle. Scolecite has only been found in the colored cavities.

LAUMONTITE: In the colored-vesicles, colorless prisms of laumontite, 1 to 3 cm long, when freshly collected, in time, become milky and opaque white, split and crumble into white powder. Laumontite crystals have a single sloping termination and are often found on colored heulandite, 1st and 2nd generation epistilbite, and rarely is covered by colorless 2nd generation heulandite, tiny colorless epistilbite, levyne, thomsonite, or calcite. Laumontite appears to have formed after scolecite.

Specimens of laumontite often remain fairly stable if kept in a cool environment, such as a basement which is not heated. Remember we only have laumontite specimens on loan; they will all dehydrate and crumble in time when kept in the air, regardless of how it is "preserved". Minerals grown on laumontite will eventually crack or fall off when the laumontite dehydrates and expands.

Rarely, laumontite forms coarse colorless to milky white, radiating masses completely filling dark chlorite-lined vesicles.

GONNARDITE: Very hard, tough, fine grained, white to transparent, colorless or blue, fibrous, radiating masses of gonnardite completely fill dark clay-lined cavities or form the base of radial groups overgrown by coarser blades of thomsonite.

In partially-filled cavities the massive radial groups of gonnardite are overgrown by colorless, bladed thomsonite, which appears as chalky white, randomly oriented blades on the surface of the group. The gonnardite-thomsonite groups are found alone in dark chlorite-lined vesicles or covering cowlesite and heulandite, and rarely is itself covered by chabazite.

Garronite is found covering pure gonnardite aggregates without any thomsonite overgrowth, indicating thomsonite overgrew gonnardite at a later time. The surface of the fine-grained, gray to bluish, concentric layered pure gonnardite hemispheres are smooth due to its being composed of very small crystals, but is rarely exposed because of a garronite or thomsonite overgrowths.

The thomsonite portion of the gonnardite-thomsonite aggregates clearly overgrows cowlesite although cowlesite has never been seen directly associated with the gonnardite portion. Gonnardite covers bow-tie heulandite.

In the colored vesicles, small white-bladed thomsonite aggregates radiate from a fine grained gonnardite base are rarely found on orange heulandite, epistilbite, or laumontite and covered by mesolite and chabazite.

GARRONITE: Translucent, white, grainy, sugary masses of garronite, 1 to 2 cm in diameter, without the typical conchoidal parting, completely fills many of the green chlorite-lined cavities, clearly covering colorless, radial heulandite, cowlesite, and gonnardite. Rarely, when garronite is present in incompletely filled dark green chlorite lined cavites, it is always covered by coarse, parallel aggregates of phillipsite. The larger the faces on the phillipsite overgrowth, the smaller the amount of underlaying garronite.

PHILLIPSITE: Milky-white phillipsite is rare at Yacolt. It forms 1 to 2 cm diameter aggregates, composed of primarily of pyramidal faces, covering white massive garronite in green chlorite-lined vesicles. Isolated pseudo-dodecahedra of phillipsite were found on colorless, elongated heulandite and chlorite in one cavity, resembling the morphology of paulingite although the presence of striated faces and milky-zoned interior is typical of phillipsite.

Small white spherical pseudo-dodecahedra aggregates of phillipsite, only 1 to 2 mm, in diameter are rarely found on epistilbite in the colored-cavities.

LEVYNE: Only a few specimens of thin colorless hexagonal levyne crystals have been found, usually on epistilbite. Tiny colorless levyne and flat 3rd generation epistilbite have been found on white laumontite prisms in orange heulandite-lined cavities. One vesicle lined only by the light green clay contained an abundance of twinned epistilbite covered by a single, large levyne crystal which was coated by a very thin milky-white offretite overgrowth.

Levyne, a low silica zeolite, is usually never found at locations containing quartz or high silica zeolites such as epistilbite.

OFFRETITE: Only a few specimens show a very thin, milky-white offretite-overgrowth on the {0001} of levyne crystals.

ANALCIME: Tiny, colorless, transparent trapezoheodra of analcime, under 1 mm in diameter, are found covering both dark green chlorite spheres and cowlesite in only one small vesicle. Until additional specimens of analcime is found, it's relationship to the other zeolites is unknown.

THOMSONITE: Small white hemispheres, 1 to 2 mm in diameter, composed of randomly-oriented or radiating groups of bladed thomsonite on fine-grained gonnardite, are very rarely present on heulandite or epistilbite in the colored-pockets. One thomsonite group was clearly found on the side prism face of laumontite, indicating it was one of the later minerals to crystallize. Hair-like needles of mesolite are found extending from some thomsonite groups, both minerals covered by chabazite and calcite. Thomsonite hemispheres are also found on heulandite and stilbite in the double-sided road-cut.

In the green cavities, thomsonite occurs as chalky white, randomly oriented blades on the surface of the zoned aggregates which consist primarily of white to bluish, fine-grained gonnardite at the base alternating with zones of the thomsonite as the surface of the aggregate is approached. Thomsonite is is also found on smooth-surfaced gonnardite hemispheres which completely fill the vesicles.

Two tiny bundles of colorless, transparent, exceptionally long bladed crystals resembling chisel-shaped thomsonite in crystal form, were found in one cavity, on dark green chlorite, associated with only cowlesite. These are probably thomsonite.

MESOLITE: Very thin hair-like needles of pure mesolite, covered by chabazite and calcite, are found extending from white aggregates of gonnardite-thomsonite blades. Attractive radiating groups of zoned needles, with the upper half mesolite and lower half scolecite are found on colored heulandite. Mesolite appears to have formed at a much later time than the scolecite; clearly after 2nd generation heulandite, laumontite, gonnardite, thomsonite while scolecite formed before laumontite and the 2nd generation heulandite.

CHABAZITE: Small colorless rhombohedra of chabazite, 1 to 8 mm in diameter, are found on scolecite, mesolite, gonnardite-thomsonite, laumontite, epistilbite, and heulandite in the colored-vesicles.

Chabazite is rarely found on green chlorite. One sample shows colorless transparent rhombohedra of chabazite clearly on cowlesite and chlorite.

CALCITE: Calcite is not abundant in any of the cavities but sporadically occurs throughout the deposit. It is rarely found on all the zeolites, placing it at end of the crystallization sequence.

OBSERVED SEQUENCES OF CRYSTALLIZATION:

GREEN CLAY-CHLORITE LINED VESICLES:

*heulandite is always colorless and elongated in b direction
*a smooth light green clay precedes the dark chlorite

clay > chlorite > heulandite (common)
clay > chlorite > heulandite > calcite (8 samples)
clay > chlorite > calcite (6 samples)
clay > chlorite > garronite (massive) (common)
clay > chlorite > cowlesite (common)
clay > chlorite > bow-tie heulandite > cowlesite (5 samples)
clay > chlorite > bow-tie heulandite > cowlesite > radiating heulandite (3 samples)
clay > chlorite > cowlesite > calcite (5 samples)
clay > chlorite > chabazite (3 samples)
clay > chlorite > cowlesite > garronite (4 samples)
clay > chlorite > cowlesite > chabazite (1 sample)
clay > chlorite > cowlesite > analcime (1 sample)
clay > chlorite > mordenite >? cowlesite > epistilbite (1 sample)
clay > chlorite > cowlesite > heulandite > garronite > phillipsite (3 samples)

clay > chlorite > heulandite > garronite (massive) (5 samples)
clay > chlorite > gonnardite (9 samples)
clay > chlorite > gonnardite > garronite (2 samples)
clay > chlorite > gonnardite > gonnardite-thomsonite (8 samples)
clay > chlorite > cowlesite > gonnardite-thomsonite > thomsonite (6 samples)
clay > chlorite > gonnardite-thomsonite > thomsonite > chabazite (1 sample)
clay > chlorite > mordenite > clay (2 samples)
clay > mordenite > chlorite (1 sample)
clay > chlorite > mordenite > chlorite (4 samples)
clay > chlorite > laumontite (5 samples)

****

COLORED VESICLES

* absence of cowlesite
* a light green thin smooth clay precedes all the zeolites
* rarely presence of minor chlorite

clay > orange heulandite > laumontite > thomsonite (1 sample)
clay > red heulandite > scolecite > mesolite > chabazite (2 samples)
clay > red heulandite > scolecite > mesolite > calcite (1 sample)
clay > orange heulandite > laumontite > chabazite (3 samples)
clay > orange heulandite > laumontite > epistilbite-levyne (1 sample)
clay > cream heulandite > stilbite > thomsonite (1 sample)
clay > red heulandite > scolecite > mesolite (7 samples)
clay > orange heulandite > orange epistilbite > colorless heulandite (2 samples)
clay > mordenite > white heulandite > colorless heulandite (common)
clay > mordenite > orange heulandite > epistilbite > colorless heulandite > chabazite (3 samples)
clay > mordenite > orange heulandite > epistilbite > stilbite (1 sample)
clay > mordenite > orange heulandite > epistilbite > colorless heulandite > phillipsite > chabazite (3 samples)
clay > mordenite > orange heulandite > gonnardite > thomsonite > chabazite > calcite (4 samples)
clay > mordenite > orange heulandite > epistilbite > gonnardite > thomsonite > chabazite > calcite (3 samples)
clay > mordenite > orange heulandite > laumontite > colorless heulandite > levyne (2 samples)
clay > mordenite > orange heulandite > epistilbite > colorless heulandite > drusy epistilbite (1 sample)
clay > orange heulandite > colorless epistilbite > levyne (5 samples)
clay > orange heulandite > cream-orange epistilbite (common)
clay > colorless heulandite > chabazite (5 samples)
clay > orange heulandite > laumontite (common)
clay > orange heulandite > chlorite (4 samples)
clay > mordenite > cream heulandite > chlorite > clear heulandite (3 samples)
clay > epistilbite > levyne > offretite (6 samples)
clay > chlorite > epistilbite > levyne (4 samples)
clay > epistilbite > chabazite (8 sample)

clay > red heulandite > scolecite > laumontite > chabazite (1 sample)
clay > mordenite > quartz (6 samples)
clay > mordenite > quartz > stilbite (2 samples)
clay > chalcedony > quartz (4 samples)
clay > mordenite > orange heulandite > chalcedonly > quartz (6 samples)

GENERALIZED SEQUENCE OF CRYSTALLIZATION:

Green vesicles: clay 1 > chlorite > clay 2 > mordenite > bow-tie heulandite > cowlesite > radial heulandite > gonnardite? > garronite-phillipsite > thomsonite > chabazite > calcite.

Epistilbite and laumontite are present in the green vesicles but relationship to other minerals is unclear. Epistilbite postdates mordenite. Judging from the position of epistilbite and laumontite in the colored vesicles both minerals occur between the two generation of heulandite therefore at nearly the same time as cowlesite. Analcime postdates cowlesite.

Colored vesicles: clay 1 > mordenite > colored heulandite > chlorite > chalcedony > quartz > epistilbite > scolecite > laumontite > colorless heulandite > stilbite > epistilbite-levyne > gonnardite > phillipseite > thomsonite > mesolite > chabazite > calcite.

Highly generallized combined sequence: light green clay > chlorite-mordenite > fibrous clay > heulandite (colored or bow-tie) > cowlesite > chalcedony > quartz >? epistilbite > scolecite > laumontite > clear or radial heulandite >? stilbite > epistilbite-levyne >? gonnardite > garronsite-phillipsite >? thomsonite > mesolite > chabazite > calcite.

ORIGIN OF THE ZEOLITES AT BIG TREE CREEK, YACOLT.

There are two distinct groups of minerals present at Big Tree Creek which normally are not found together. One is a low silica group characterized by cowlesite-heulandite-garronite-phillipsite which are found in the dark green vesicles and the other is a medium to high silica group characterized by mordenite-heulandite-epistilbite in the colored vesicles.

Low silica zeolites having a Si/Al ratio from under 2.00 are typical of the minerals found in olivine basalts at Spray; Beech Creek; Oak fork of the Clackamas River all in Oregon; and many locations in Icland and Ireland. The minerals present are generally mesolite, natrolite, scolecite, levyne, offretite, gismondine, cowlesite, thomsonite, garronite, phillipsite, and gonnardite.

Medium silica zeolites having a Si/Al ratio from 2.00 to 3.50 are typical of tholeiitic basalt at Skookumchuck Dam; Kosmos; Mossyrock Dam; Lewis River in Washington; and Dallas, Oregon. Typical zeolites are heulandite, stilbite, mordenite, QUARTZ, epistilbite, laumontite and the Ca-silicates, okenite, gyrolite, apophyllite, tacharanite, and tobermorite.

High silica zeolites having a Si/Al ratio from 3.50 to 7.00 are typical of silica rich basalts, rhyolite, and andesite at locations such as Cape Lookout; Agate Beach; Richardsons Ranch in Oregon; and Altoona, Washington. Typical minerals are dachiardite, ferrierite, mordenite, QUARTZ, erionite, high-silica heulandite (=clinoptilolite).

Some zeolites like phillipsite and analcime can occur in many different environments and some medium silica zeolites such as stilbite and heulandite occur in very limited amounts in low silica enviornments at Spray and Beech Creek. Often two adjacent flows with considerably different composition or density can occur on top of each other, each producing radically different mineral assemblages such as the hard dense flows at Ritter, Goble, and Skookumchuck Dam. One flow produces medium silica zeolites while the adjacent flow produces primarily low silica zeolites.

It is very unusual to find adjacent vesicles in the same rock producing low silica zeolites in one and medium to high silica zeolites in vesicles only a few centimeters way. This is the case at Yacolt.

Since the vesicles are found next to each other, factors such as differences in temperature, pressure, and fluid composition, rock composition, and density can be considered constant in all the vesicles in a small area of rock studied. In the green cavities alot of clay-chlorite is produce which removes the Mg and Fe and leaves a Ca-Al-Si rich solution which produces colorless Ca-rich zeolites. Iron which colors most zeolites is removed from solution by crystallization the Fe-Mg rich clay-chlorite.

In the colored vesicles very little clay formed therefore some Fe remained in solution and colored the zeolites at the beinging of crystalliztion (early heulandite and epistilbite only) with all the later zeolites being colorless or white.

The factor which might have determined if the vesicle would crystallize clay-chlorite and low-silica zeolites verses sparse clay and high-silica zeolites and quartz is the pH of the solution. A slightly higher pH (more basic) favors the low-silica zeolites while lower pH (more acidic) favors formation of high-silica zeolites and quartz.

I wish to thank Jim Babcock of Vancouver who first discovered the Yacolt zeolite location, Vi Frazer, who was the guide to the site, and Don Howard who tested numerous specimens by XRD, made SEM photos, and reviewed this paper.

N O T I C E

Annual Dues are $ 6.00 per mailing address.

If you did not pay your dues for 1988 at the Spring meeting in Raymond and cannot attend the Fall meeting in Forest Grove, please send your dues to the editor to insure that you will get your future issues of the Microprobe on time.

Donald G. Howard
356 S.E. 44 th Ave.
Portland, Oregon 97215

LOCATION: BIG TREE CREEK, YACOLT, CLARK CO., WASHINGTON

Date: 8-20-88

```
-------------------------------------------------------------
MINERAL:  first to crystallize >------ last to crystallize->
-------------------------------------------------------------
CLAY            -  -
CHLORITE        --
MORDENITE        ---
HEULANDITE            -       -
COWLESITE              --
QUARTZ                    -
EPISTILBITE            --     . -
STILBITE                   -
SCOLECITE                   -
LAUMONTITE                    -
GONNARDITE                        -
GARRONITE                            -
PHILLIPSITE                             -
LEVYNE                                     -
OFFRETITE                                   -
ANALCIME                                     -
THOMSONITE                                     -
MESOLITE                                           -
CHABAZITE                                               -
CALCITE                                                      -
-------------------------------------------------------------
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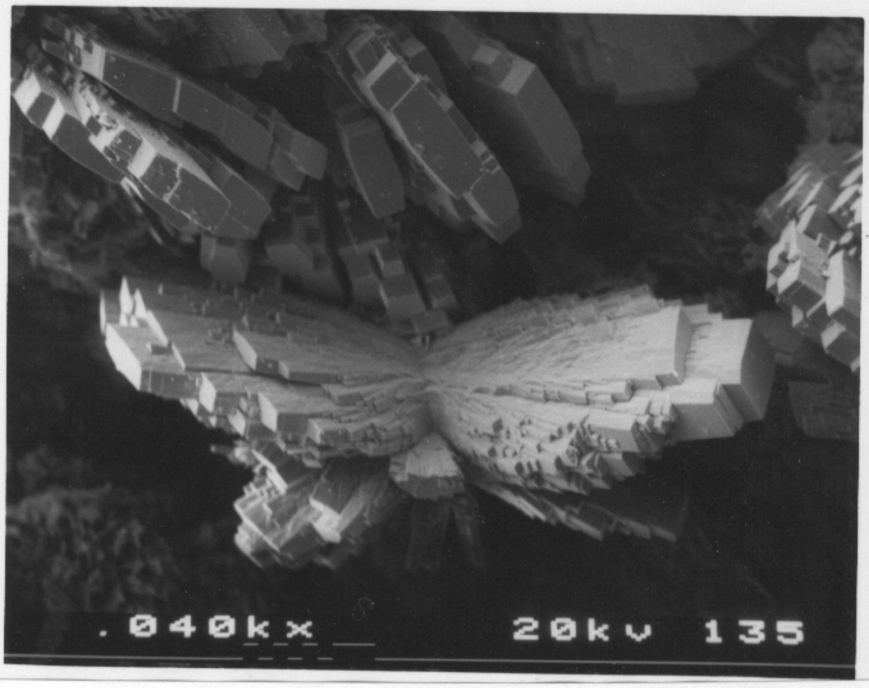
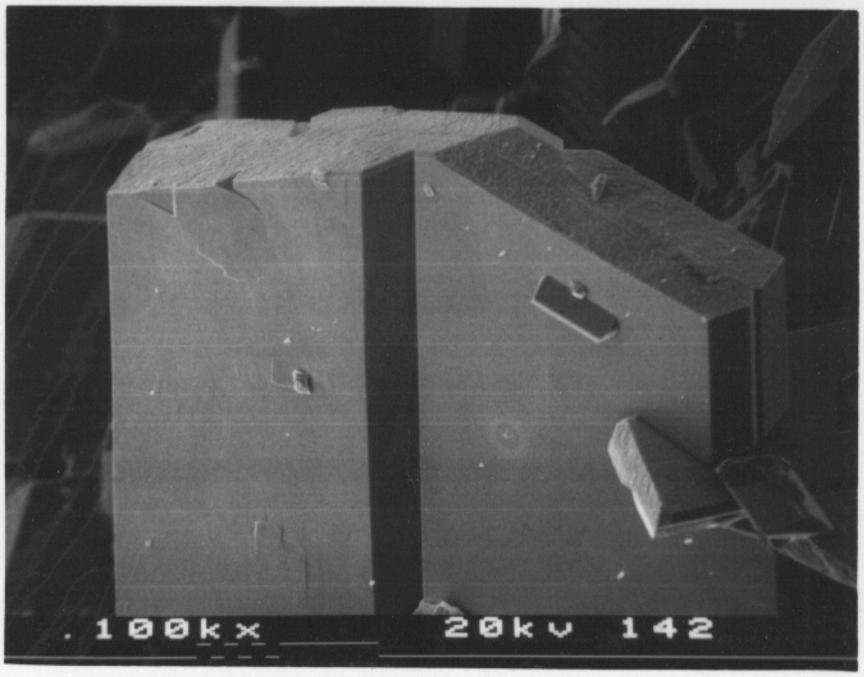
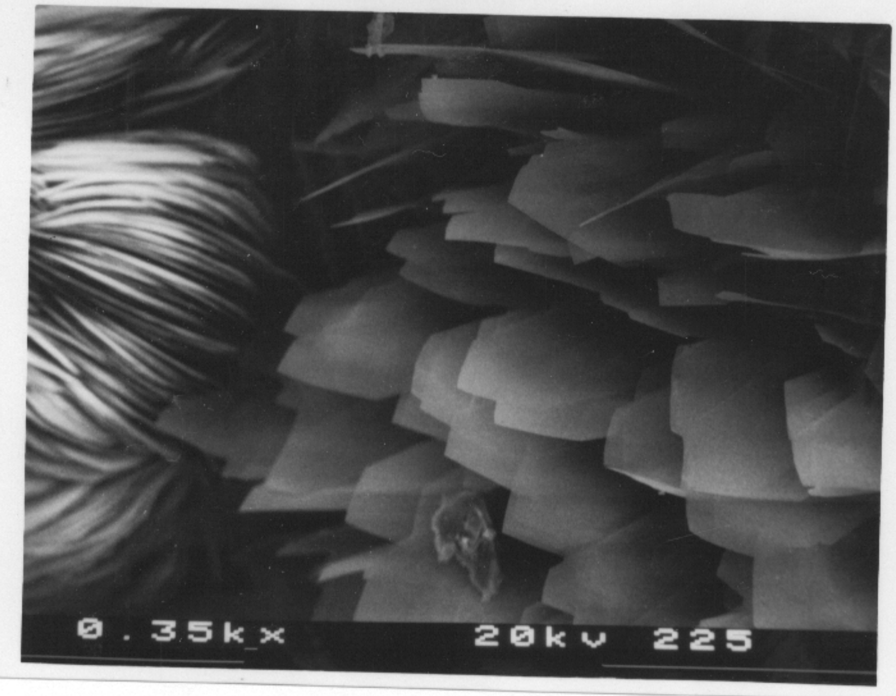


#135 – HEULANDITE – BIG TREE CREEK, YACOLT, WASHINGTON – 40X

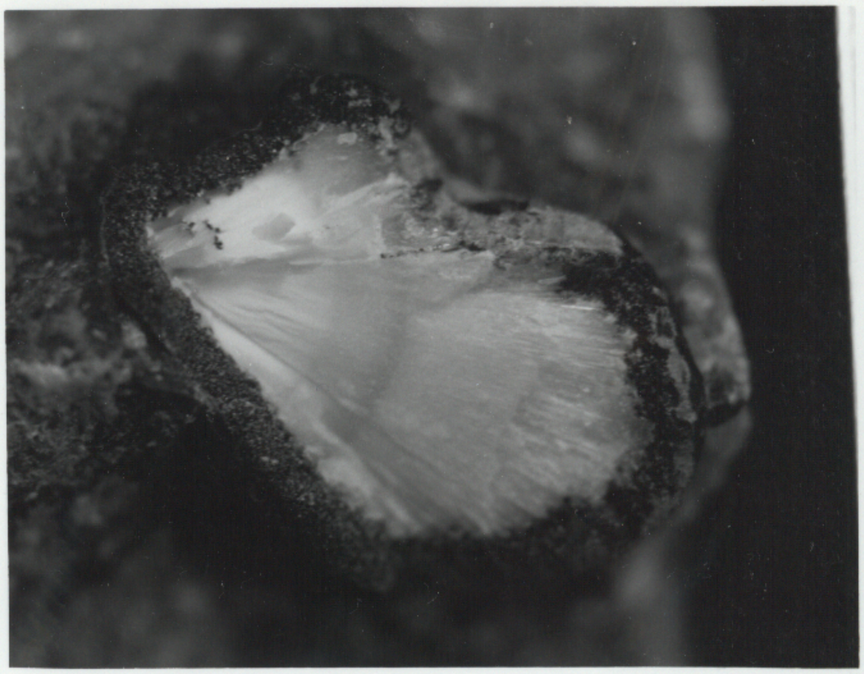


#142 – EPISTILBITE – BIG TREE CREEK, YACOLT, WASHINGTON – 100X



#225 – COWLESITE – BIG TREE CREEK, YACOLT, WASHINGTON – 35X

#33 – SCOLECITE – BIG TREE CREEK, YACOLT, WASHINGTON – 2X



#34 – GONNARDITE – BIG TREE CREEK, YACOLT, WASHINGTON – 5X

#35 – HEULANDITE, MORDENITE – BIG TREE CREEK, YACOLT, WASHINGTON – 10X