Northwest

Micro Mineral

Study Group

MICRO PROBE

FALL, 1990 VOLUME VII Number 2

FALL MEETING ---- VANCOUVER, WASHINGTON

November 10, 1990 10 am to 10 pm

Clark County P. U. D. Building
1200 Ft. Vancouver Way

Time once again for a day of fun and fellowship, of trading rocks and stories, of looking at the newest finds of each of us. Come with microscopes and plan to share with each other. Material from the John Day River and from Goble will be available for those who were not able to collect there.

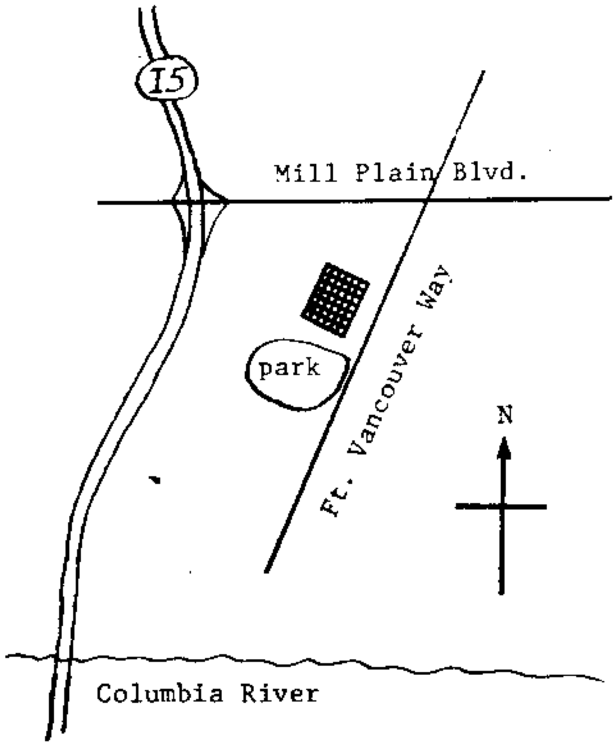
Short business meeting at 2 pm to plan activities for the coming year, plus an exchange of information on collecting localities in the Northwest.

Pot Luck Dinner around 6 pm. Bring a salad, hot dish, or dessert plus plate, cup, tableware.

Bring slides to show after dinner.

We will plan, depending on weather and on collecting conditions to go to the Goble area on Sunday. More information at the meeting as well as the article inside this issue.

Easy to reach -- approximately 2 miles north of the Interstate Bridge on I5. Take the Mill Plain Blvd. exit and go east to the first intersection. Turn right onto Ft. Vancouver Way. The PUD building is on the right. Ample parking at the south end of the building,where the Auditorium is located.



Minerals of the GOLDEN HORN Batholith -- Part II

The Rare Earth Fluorocarbonates

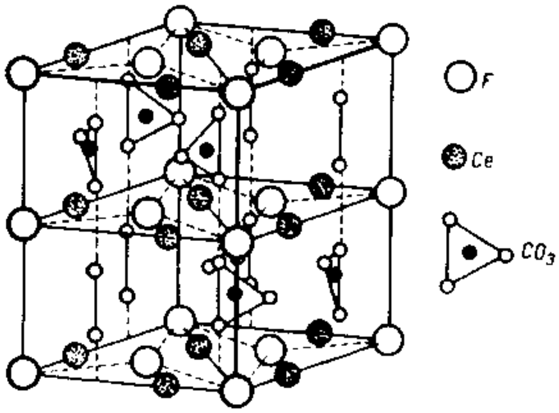
Donald G. Howard

A series of minerals of very similar structure and composition are to be found among the minerals at Washington Pass. The two "end-members" of this group are Bastnaesite and Vaterite. The compositional scheme of the group looks something like:

Bastnaesite	$Ce\ CO_3\ (F,OH)$	a=7.18	c=9.83
Parisite	$Ca\ Ce_2\ (CO_3)_3\ F_2$	a=7.18	c=84.1
Roentgenite	$Ca_2\ Ce_3\ (CO_3)_5\ F_3$	a=7.13	c=69.4
Synchysite	$Ca\ Ce\ (CO_3)_2\ F$	a=7.11	c=54.7
Vaterite	$Ca\ CO_3$	a=7.16	c=16.98

Vaterite is a "trimorph" (three different crystal structures with identical chemical composition) with Calcite and Aragonite.

All of the above minerals are hexagonal in structure, with a layered structure. The unit cell for Bastnaesite is shown at right. It is composed of sheets of cerium and fluorine atoms that are held together by the carbonate ions, which interestingly enough are standing on edge. The structure of Vaterite is just the same, with the calcium atoms occupying the position of the cerium atoms, the fluorine atoms being absent. The other three minerals listed above are "mixtures" of the two extremes, with layers of cerium and fluorine alternating with layers of calcium in an appropriate proportion to make the correct general formula. The alternating of layers is what makes the c-dimension of these intermediate species so large.



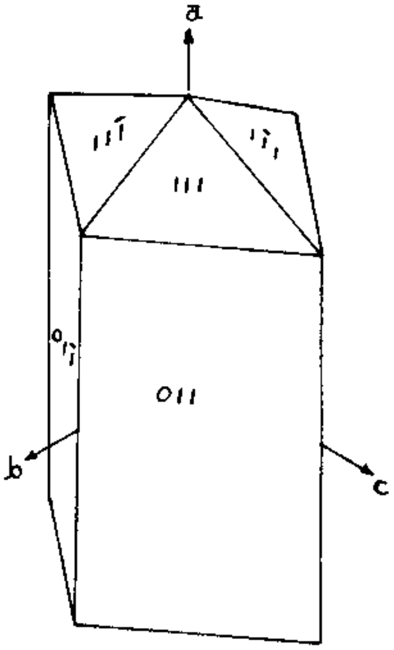
The atomic structure of the mineral Bastnaesite.

In general occurrence, these minerals have a wide variety of forms, with a number of complex crystal faces. At Washington Pass, however, the basic form of each mineral is quite simple: tabular, with a simple hexagonal prism and flat c-face. The color is a cream or pale tan, with some of the Bastnaesite being reddish on the outside.

PARISITE has been found as tiny, thin hexagonal flakes intimately associated with anatase, as shown in micrograph #470. This was in rock of the "border granite" type, which contained in addition clinochlore, siderite, zircon, and gadolinite. Too little material was present for x-ray diffraction studies; identification was based on the ratio of calcium to rare earth elements determined by x-ray fluorescence.

SYNCHYSITE has been found as scattered, slightly larger and thicker individual hexagonal prisms in the same general rock as the parisite. Again, too little material was found to allow x-ray diffraction determination. Micrograph #475 shows a group of smaller crystals clustered around a larger synchysite.

GADOLINITE of quite a different habit and color is found in the same border granite phase, closely associated with clinochlore. These crystals are white in color and possess a pearly luster. The (011) prism faces still predominate, but the termination consists of a first-order pyramid (111) rather than the flat a-face as described in the previous issue. Another difference is that the faces are rather rough, particularly those of the prism (011). Crystals of this type often form in radiating clusters. They are very hard to see against a background of white minerals, such as microcline and quartz.



Terminated form of Gadolinite

BASTNAESITE seldom occurs by itself, but rather is always associated with another of the fluorocarbonates, probably synchysite, which is the first mineral to form. Later minerals grow epitaxially on the first. In micrograph #479, the inner hexagonal crystal is synchysite. During growth, the solution was probably enriched in calcium, growing another layer that was nearly pure vaterite. Finally, a reduction to low calcium concentration produced an outer layer of bastnaesite that is very low in calcium. The low calcium solutions also served to disolve away the calcium-rich middle region, leaving the hexagonal annular gap characteristic of many of the synchysite-bastnaesite intergrowths at Washington Pass. Some of the bastnaesite crystals are hollow hexagonal shells, with the entire center missing. Bastnaesite occurs in both granite phases, but is mostly found in the arfvedsonite granite associated with fluorite, chevkinite, okanoganite, etc.

Zeolite Associates -- APOPHYLLITE

Donald G. Howard

In previous issues of the Microprobe we have featured articles on various zeolite minerals. In this issue, we present the mineral Apophyllite, a common associate of the zeolites. Apophyllite is not a zeolite because it contains no aluminum, though it does contain considerable water. The chemical formula is

$$K\,Ca_4\,(H_2O)_8\,(Si_4O_{10})_2F$$

Sodium can partially replace the potassium and hydroxyl can partially replace the fluorine in the crystal lattice.

In the structure, the silicon are as usual surrounded by four oxygen atoms that form a tetrahedron. These tetrahedra are joined together to form sheets, with the vertices of the tetrahedra alternating in direction. The potassium, surrounded by water molecules, and the fluorine, surrounded by calcium atoms, lie between the layers and serve to hold them together. The unit cell is actually two layers thick, making the c-direction of the tetragonal unit cell considerable longer than the a-direction. (a=9.02, c=15.8)

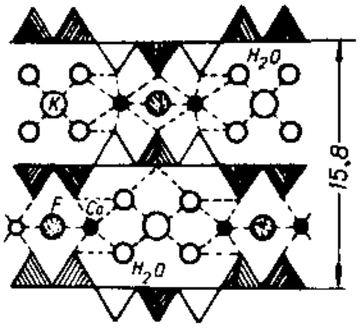
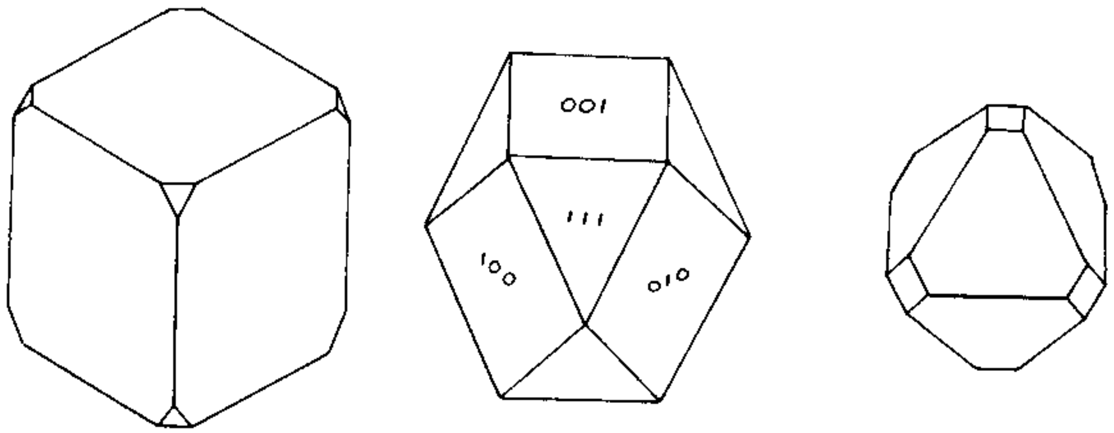


Figure 1
The structure of apophyllite, as projected on the (110) plane.

The structure of apophyllite, with layers perpendicular to the c-axis, leads to a perfect cleavage on the (001) plane. In addition, cracks and imperfections on this plane often produce crystals with bands throughout running perpendicular to the c-axis. Completely clear crystals are rather rare.

The fact that the unit cell is considerably taller than it is wide does not mean that crystals will also be of this shape. The final dimensions depend more upon how many blocks are piled in each direction than on the shape of the blocks. Both elongated (longer in the c-direction) and tabular (thin in the c-direction) occur in nature. The usual form of apophyllite is approximately a cube, with the prism (100) faces often striated vertically (that is, with striations parallel to the c-axis). The c-face (001) is sometimes roughened, and often has a pearly luster.

Probably some of the most spectacular specimens of apophyllite are those with large clear cubes on green prehnite from Fairfax Quarry, Centerville, Virginia. Almost all crystals are simple cubes, with occassionally a corner beveled by the addition



i ii iii

Figure 2. The normal habit of apophyllite, showing the basic cube with increasing amounts of modification by the pyramid.

of pyramidal (111) faces. Magnificent specimens of apophyllite from India generally show similarly shaped crystals, though often with more pronounced beveling, associated with various zeolites.

Various locations in the Northwest show crystals with even more pyramidal development. Opaque white crystals on thomsonite from Pete's Point, Wallowa Co., Oregon have the prism and pyramid faces almost equally developed, as shown in figure 2ii. The Neer Road site at Goble, Oregon has produced opaque white crystals, associated with stilbite and chabazite, where the pyramid faces almost completely dominate, as in figure 2iii. Many of the specimens from the Neer Road site are in radiating groups that often entirely fill their cavity. Complicated groups and elongated individuals with unusual faces that have recently been collected near Jaquish Road, Goble are described in the next article.

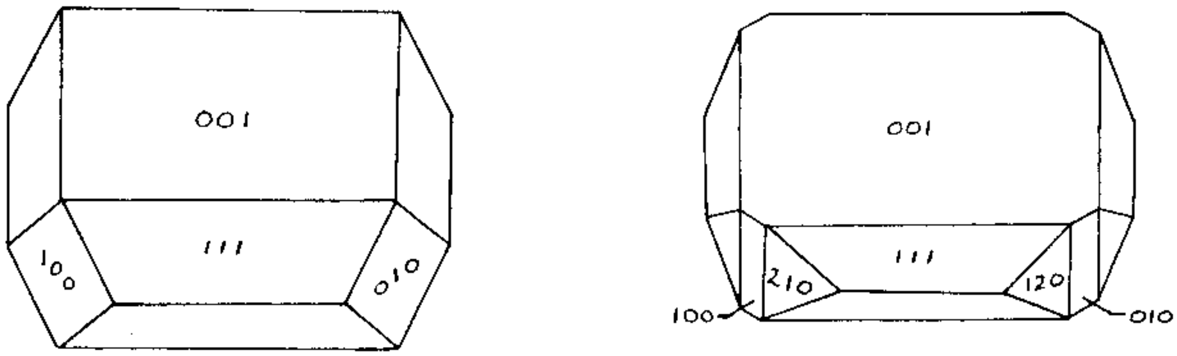


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Figure 3. Tabular forms of apophyllite. The crystal at left shows pyramidal development approximately the same as the crystal shown in figure 2iii. In the crystal at right, small (120) faces are also present.

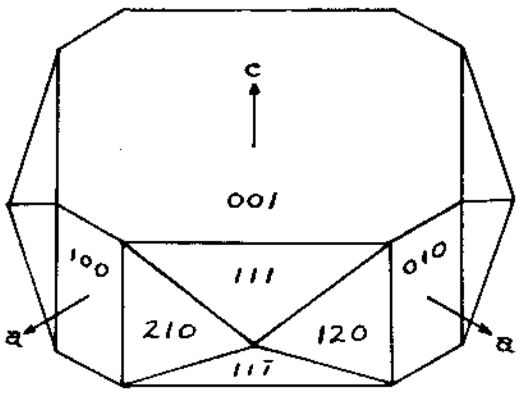
Crystals with a tabular habit are more common in the zeolite localities of Grant Co., Oregon (Stony Creek, Ritter, Monument, Big Bend). Specimens from the hard-rock upper portion of the New Ritter Quarry, associated with phillipsite, gyrolite, and tobermorite, have a tabular form primarily showing pyramid and c-face, as shown in figure 3i. These crystals often show a "sandwich" effect, where a brown outer layer on each c-face encloses otherwise clear crystal.

Crystals from Stony Creek, North Fork John Day River (Microprobe, Vol. VI, #8) show in addition a small set of higher order prism faces (120) modifying the edges of the tablets, as shown in micrograph #037. Associations here include phillipsite, mesolite, gyrolite, and tacharanite.

A few specimens from the quarry at Monument show an even more developed (120), as shown in figure 4. Such crystals appear almost round when viewed from the top, as the diagram suggests. This habit at Monument seems to be limited to crystals forming on an underlying layer of phillipsite. Apophyllite forming on the usual layer of analcime at Monument have a cubic habit with only a trace of beveling at the corners. Thus, we see that the chemical environemnt in which a crystal grows can affect the importance of the various faces on its surface.

Extremely thin, tabular crystal of apophyllite occur on occassion, such as the very thin wafers associated with the thick natrolite crystals from Hurunui Gorge, New Zealand.

And apophyllite is not limited to zeolite occurrances; it also is found as a late mineral in pegmatites, and as an occassional accessory mineral in ore deposits, such as the coppers on the Michigan peninsula.



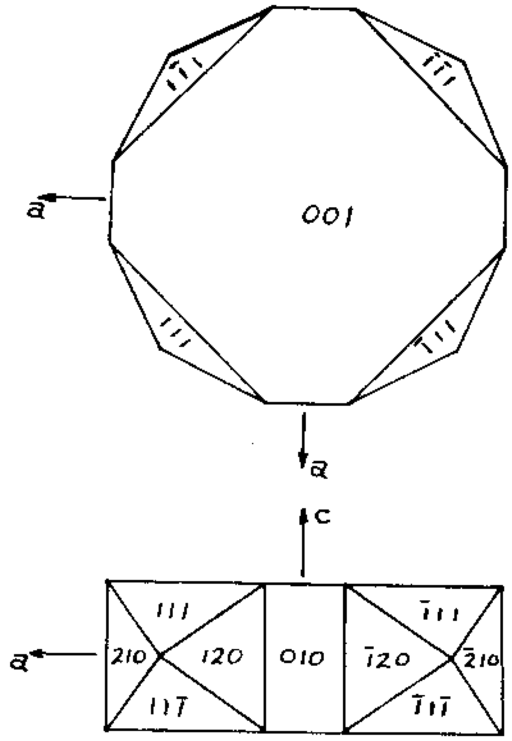


Figure 4. Tabular crystal of apophyllite, showing almost equal development of the (111) and the (120) faces.

ZEOLITES FROM THE JAQUISH ROAD CUT, GOBLE, COLUMBIA COUNTY, OREGON

by
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Spectacular zeolite specimens were found during construction of the Jaquish Road cut, 0.1 mile south of Goble, on Highway 30. Collecting was possible for a very short period of time during widening of the road which was started and completed during the month of August of 1990. The first week of quarrying was high on the cliff face in a greenish-gray basalt which contained a few vesicular areas but was primarily a massive flow. A few cavities lined with unimpressive drusy heulandite, thomsonite, chabazite, copper minerals, or matted mordenite were found but nothing noteworthy. Mordenite-line cavities were dominate. Blasting each day exposed new material which the road crew rapidly removed and buried for road fill near the Trojan Nuclear Power Plant, north of Goble. Collecting was allowed each day only after the crew left (6:00 pm) and all day on weekends. Unfortunately most of the zeolite-bearing rock was removed and buried too quickly to be collected.

By the second week, the north end of the quarry had intersected a red breccia zone which had formed when a gritty ash layer on the top of one flow was covered by a another basalt flow, baking the ash to a brick red color and became mixed with brecciated basalt at the base of the flow. This red breccia produced most of the fabulous thomsonite-mesolite-chabazite balls. Continued work intersecting the red breccia produced an abundance of spectacular display and micro sized crystals.

Local mineral collectors and rockhounds visited the site every night and saved as much as possible in the short period before dark. For those of us who had to travel longer distances to reach the site, weekends were just too far apart and most of the specimens were lost during a weeks work. Not every day was productive. Some days only the grayish-green rock remained with little more than a few mordenite cavities. When blasting was in the red breccia zone, some days would produce an abundance of specimens with each day yielding slightly different material. Some days produced smooth marble-sized thomsonite balls. The next day larger complex thomsonite-chabazite balls or unusual thomsonite-mesolite-chabazite aggregates were found.

The basalt flows dip 10^{o} to 15^{o} to the southwest. The mineralized red breccia zone now seen high on the north end of the present road cut nearly reaches road level at the south end (Fig. 1). The northern half of the exposed red breccia zone produced most of the fine thomsonite-mesolite-chabazite specimens while the southern half was not brecciated and did not produce specimens. A second red ash layer (not brecciated) present at the base of the road cut at the north end did not produce specimens because it lacked cavities.

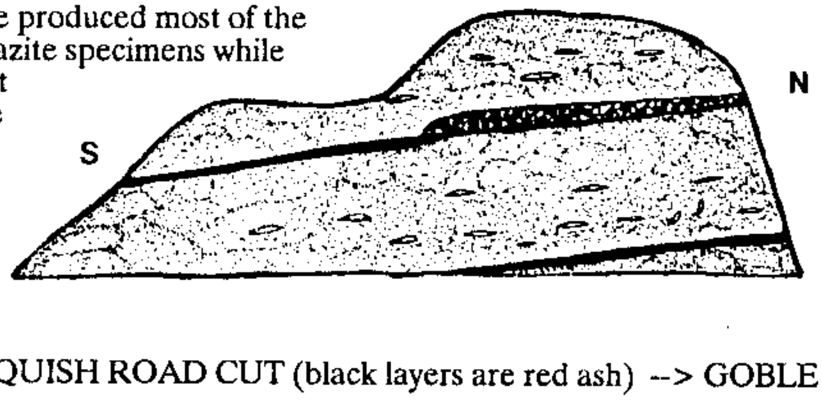


Figure 1 JAQUISH ROAD CUT (black layers are red ash) --> GOBLE

A cold water surface spring is found just north of the road cut and probably was the source of the water found in the cavities but was not the source of mineralization. The zeolites probably formed while the basalt, buried deep in the ground, was subjected to hydrothermal water between 70^{o} to 120^{o} C and later up lifted to its present position.

Specimens can still be collected in the boulders dumped south of the intersection of Jaquish Road with Highway 30 and along the new road fill near the Trojan Nuclear Power Plant. Considerably more rock is needed to complete the road fill, therefore more road cuts are expected in the Goble area with the cliffs at the intersection of Neer Road and Highway 30 being the most likely site.

Minerals present at the Jaquish Road cut are listed in the approximate order of abundance: heulandite, stilbite, clay, mordenite, thomsonite, chabazite, mesolite, calcite, apophyllite, copper, okenite, and analcime.

Order of crystallization in low silica cavities:

Clay > copper > heulandite > stilbite > colorless-thomsonite > white-thomsonite > mesolite > white-thomsonite > copper alteration > (chabazite-thomsonite) > calcite

heulandite > apophyllite > (colorless thomsonite-chabazite-colorless thomsonite)

heulandite > analcime > colorless and white thomsonite-chabazite

Order of crystallization in high silica cavities:

clay > mordenite > apophyllite

clay > okenite > apophyllite

chalcedony > apophyllite-chalcedony

clay > heulandite > mordenite > apophyllite > okenite > apophyllite

clay > heulandite > mordenite > chalcedony > mordenite

clay > heulandite > golden calcite > mordenite > apophyllite

MINERALIZATION IN THE LOW SILICA CAVITIES:

CLAY was responsible for the greenish color in most of the cavities in the grayish-green vesicular rock but was absent on the red breccia, therefore cavities without a clay lining appeared red due to transmission of the color of the red rock through the colorless drusy heulandite.

COPPER rarely formed small 1 to 2 mm bright crude faceted crystals on the clay or red breccia and usually was covered by drusy heulandite. Some copper crystals extended beyond the heulandite druse and were usually altered black. Rarely, copper was covered by thomsonite, chabazite, or calcite. Although the copper crystallized at about the same time in the crystallization sequence as the copper at Neer Road, the copper at that locality formed thin foil like sheets rather than thick faceted crystals. A few mordenite-lined cavities were preceded by layers of sugary massive heulandite, up to 5 cm thick, in which copper foil sheets up to 15 mm long were intergrown.

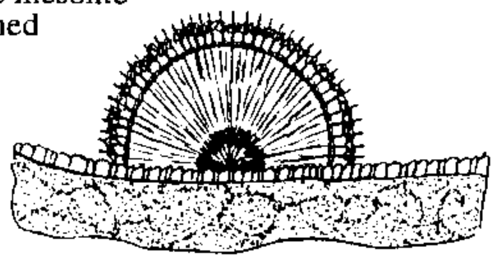
HEULANDITE lined most of the cavities in both the green vesicular basalt and red breccia zone (although not obvious in the mordenite and okenite cavities). Unimpressive tiny colorless drusy crystals flattened on the b-axis which line the cavities are typical of the Goble area. Some had a red or green appearance due to the green clay or red rock underneath. Native copper crystals occasionally were seen under the heulandite also extend from the clay base out of and above the heulandite druse. Very rarely tube-like cavities, 5 cm in diameter and over 25 cm long were found in the grayish-green rock, lined with 1 cm long, rather thick, light-greenish heulandite.

STILBITE was very common in the red breccia zone but scarce in the green vesicular rock. All the crystals were colorless, very lustrous, pointed individual blades, up to 1 cm long, with a tiny flat tip. Stilbite was usually scattered on the drusy heulandite and often heavily covered with small colorless rhombohedra of chabazite. One large 60 cm cavity in the grayish-green rock contained chabazite up to 15 mm across on the stilbite. Fan-like aggregates and bow-tie aggregates were not present.

ANALCIME was found in only a few cavities. It formed colorless, transparent, trapezohedra, up to 8 mm in diameter, on drusy heulandite and was covered with chabazite and thomsonite.

THOMSONITE at the Jaquish Road cut developed into a wide variety of habits and produced exceptional micro specimens and some of the worlds finest cabinet specimens of that mineral. Several generations of thomsonite growth occurred in the red breccia cavities, starting with development of colorless transparent, radial, near smooth-surfaced balls, a few mm to 12 mm in diameter. Continued growth of thomsonite in some cavities produced a white thomsonite overgrowth on the colorless core, resulting in ball-like aggregates 2 to 4 cm in diameter. At this stage some of the thomsonite balls were overgrown by mesolite needles followed by a drusy chabazite which resulted in a complex thomsonite-mesolite-chabazite ball, 2 to 5 cm in diameter (Fig. 2). In cavities where mesolite did not crystallize on the thomsonite, chabazite formed a solid crust over the thomsonite ball producing spectacular sugary-appearing balls scattered on the red breccia. These specimens of thomsonite are some of the finest and largest in the world.

A very late generation of white curly thomsonite fibers formed on the surface of some of the thomsonite balls, grew from the sides of mesolite needles like branches of a tree, and formed coral-like mounds scattered on drusy heulandite and stilbite.



THOMSONITE-MESOLITE-CHABAZITE BALL on drusy heulandite
Figure 2

Crystallization of the thomsonite proceeded to different stages in different areas of the road cut. Some areas only produced smooth marble-like thomsonite balls, other areas larger aggregate balls composed of several generations of thomsonite covered by drusy chabazite were dominate, while in some areas the more complex balls composed of several generations of thomsonite, mesolite, and chabazite were present.

Most of the thomsonite was found in the red breccia zone although some smooth surfaced gray thomsonite was found in the grayish-green vesicular rock.

MESOLITE formed long, thin, straight, colorless needles extending from the surface of nearly smooth thomsonite balls. The mesolite needles were generally only 5 to 10 mm long, although some up to 2 cm were seen. Chabazite often encrusted the mesolite with a few scattered rhombohedra or a solid hard covering on top of or between the needles to form a thomsonite-mesolite-chabazite aggregate ball which ranged from 2 cm to 5 cm in diameter. White branching thomsonite crystals often extended from the sides of straight mesolite crystals to form tree-like growths.

Often the thin mesolite needles were too dirty from exposure to dust in the quarry operation or from collecting to make attractive specimens. Some of the specimens could be cleaned with compressed air or water but many were beyond normal cleaning techniques and extreme cleaning measures were employed. When all else failed to clean the mesolite, a high pressure stream of water was used along with a tooth brush to completely remove the dirty mesolite hair and exposure a well protected complete chabazite encrusted thomsonite ball below the hair. This method produced very attractive thomsonite-chabazite display specimens that otherwise would have been thrown away.

COPPER ALTERATION produced a dark black coating on most of the exposed copper crystals and made greenish (malachite) and bluish (chrysocolla) stains on the zeolites. Some of the colored stains are seen under chabazite rhombohedra. A black flat branching metallic mineral, which may only be altered copper crystals, is rarely found on some heulandite, thomsonite, and mesolite.

CHABAZITE formed simple, colorless, transparent rhombohedra, very commonly covering stilbite, heulandite, thomsonite, and mesolite either as scattered crystals or heavy solid crusts. Most of the chabazite rhombohedra were under 1 mm but a few cavities contained rhombohedra up to 15 mm across. These were very attractive when perched on stilbite blades and became the "icing on the cake" when encrusting the mesolite and thomsonite balls. In some cavities a few scattered chabazite crystals were colored golden-yellow, green, or even blue due to some copper alteration under the chabazite. Rarely tiny, smooth, colorless thomsonite balls cover chabazite rhombohedra.

CALCITE formed tiny colorless crystals, usually under 1 mm long, scattered with chabazite on mesolite needles or other zeolites. Rarely did it make attractive specimens of its own. In the grayish-green breccia zone above the lowest red ash layer, attractive deep amber colored rhombohedra of calcite, commonly up to 12 mm, with a few reaching 5 cm were found.

MINERALIZATION IN THE HIGH SILICA CAVITIES:

MORDENITE was common in many large elongated cavities, often 20 to 80 cm long and 12 to 30 cm high, in the grayish-green rock but was absent in the red breccia zone. Mordenite was never found with thomsonite, mesolite, stilbite, chabazite. The cavities were lined with snow-white, matted thin cotton-like needles, which if straight would have been over 2.5 cm long, covering irregular rock fragments making attractive snow-white mounds, which if they had not been matted, would have been spectacular specimens. Normally, these cavities would have been dry but the presence of a nearby spring saturated the rock with water and did not allow the rock to slowly loose water and dry out the cavities. These thin delicate needles will tolerate water under static conditions when it crystallizes from stagnate water in a sealed cavity but rapid movement of the water filled cavity during blasting and moving of the boulders matted the hair-like needles. If the water filled mordenite cavities slowly become dry without movement (natural conditions) the hair becomes stiff and good undamaged specimens result. The spectacular mordenite specimens collected by John Cowles in the 1960's were from dry cavities in a quarry 2 miles further south on highway 30. This was not the case at the Jaquish Road cut for water would often run out of newly opened mordenite cavities and exposed ones would already be matted. Even matted mordenite can make interesting specimens when snow-white and covering interestingly shaped rock fragments. When collecting matted mordenite hair, try to keep it as clean as possible. When at home very gently run water over the mordenite to remove dirt and rock fragments and let dry for several days. Do not brush, rub, or use pressurized water, for that will remove the mordenite, unless that is what you want to do.

A few mordenite cavities contained the normal matted white needles covered with attractive undamaged pin-cushion like white okenite balls, up to 15 mm in diameter, delicately perched on top of the mordenite lining. Only of few of these balls survived due to the mud, water, and matting during attempts to collect it. Other mordenite-lined cavities contained tiny, tough, white okenite balls which formed a crust over the mordenite needles.

Mordenite is easily confused with okenite. Both minerals form white needles and were associated with apophyllite. Mordenite characteristically formed soft white fur-like matted linings which would easily separate from the cavity while okenite formed tough, rubbery, masses or flexible silky needles which are very durable and appear hard. Both optics and X-ray patterns distinguish the two minerals.

About 25% of the mordenite cavities were covered by tiny apophyllite crystals, suspended on the needles or forming a thick layer at the base of the mordenite. These cavities, when "petted" had a gritty feel while those without apophyllite were soft. Running your hand over the mordenite-lined cavities quickly revealed which cavities were worth removing. The pure mordenite cavities were often too dirty to be saved but those with apophyllite produced very good micro crystals when the dirty mordenite hair was washed off with pressurized water. Rice-grain like quartz which is often found on mordenite hair was not found at the Jaquish Road cut.

OKENITE was found in several pockets, the largest was approximately 50 cm in diameter, in the grayish-green rock and was lined with 3.5 cm mounds of translucent, rubbery, white, massive, radiating fibers covered by short, 3 to 5 mm long, colorless flexible needles (exactly like the Bombay, India okenite). The other side of the cavity (probably the roof of the cavity) contained small colorless apophyllite crystals forming a 10 mm layer on randomly growing okenite fibers or suspended individuals on the okenite fibers. A smaller pocket also contained 3 cm okenite balls but were covered with a solid shell of apophyllite.

One of the most unusual finds at the Jaquish Road cut was the attractive silky-white pin-cushion like okenite balls which ranged from tiny 1 mm radiating groups of needles to 15 mm diameter balls delicately perched on matted mordenite in cavities, up to 10 x 20 x 35 cm. These okenite pin-cushions were very tough and durable but difficult to remove, clean, and trim on the matrix because the mordenite lining usually fell apart and left only single pin-cushions of okenite. Okenite on mordenite has never been reported anywhere else in the world. These two minerals look remarkable alike in these cavities and can be easily mistaken for mordenite. Okenite which was in remarkably good condition does not collapse in water and because it is very tough and flexible, dirt and debris can be blown off with a strong stream of pressured air. Pressurized water should only be used as last resort, for it will remove the thin needles on the surface of the rubbery okenite ball.

APOPHYLLITE crystals, often with a very unusual crystal form, were found on both mordenite and okenite in the grayish-green rock. In many of the mordenite cavities, apophyllite formed a 10 mm layer of 1 to 5 mm long, double terminated colorless crystals on the white mordenite needles. The crystals were elongated along the c-axis, with dominate pyramidal termination and nearly rounded prism faces, probably as a result of intergrowth of {100},{010}, and {110} prism faces. Some of these rounded apophyllite crystals would have fan-like growths of tiny apophyllite crystals extending from the {100} and {010} faces at both ends of the crystal. Other cavities contained apophyllite with the {110} prism dominate terminated with {111} and {001} which is similar to the morphology of natrolite (Fig. 3a). Many of the apophyllite crystals were composed of an unusual combination of dominate {10·10·1} where the {110} face normally is found in combination with tiny {100} and {010} and the standard {111} and {001} termination (Fig. 3b & 3c). Larger apophyllite crystals and aggregates, up to 3 cm across, had the normal apophyllite morphology with {100}, {010}, {111} and {001} (Fig. 4a & 4b) and often were mistaken for quartz crystals.

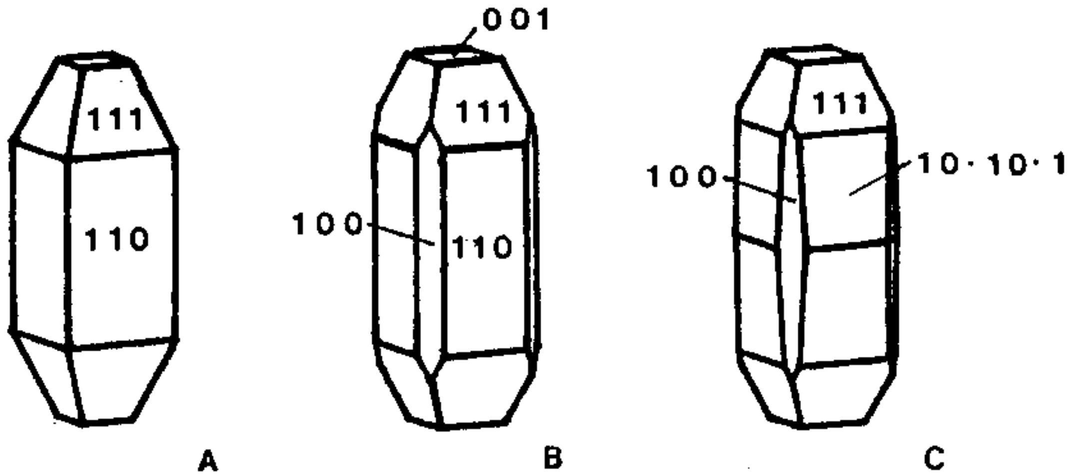


Figure 3 UNUSUAL APOPHYLLITE MORPHOLOGY

In some cavities apophyllite with the normal morphology (seen in Figure 4b) formed a shell over okenite balls. A few flattened cavities (20 x 7 x 30 cm) were lined with highly lustrous colorless apophyllite, up to 3 cm long, which looked very similar to that found at Poona, India. One cavity (30 x 40 x 7 cm) contained tiny smooth gray thomsonite spheres covering 15 mm long colorless apophyllite crystals. A very unusual cavity (described under chalcedony) contained altered white apophyllite which co-crystallized with the chalcedony.

CHALCEDONY nodules with weak colorless banding were found, up to 12 cm in diameter, rarely in the grayish-green rock. A thin white botryoidal layer of chalcedony rarely was found on drusy heulandite and mordenite while followed by more mordenite. Terminated quartz crystals were found in one cavity.

One exceptional chalcedony pocket (15 x 30 x 100 cm) was encountered, lined with 4 cm of bluish-gray botryoidal chalcedony which formed 5 to 7 cm mounds studded with 15 mm wide creamy-white flat-topped apophyllite crystals (Fig. 5). The two minerals appeared to have co-crystallized, for many of the apophyllite crystals had decomposed and left a tapering square cavity extending down into the chalcedony.

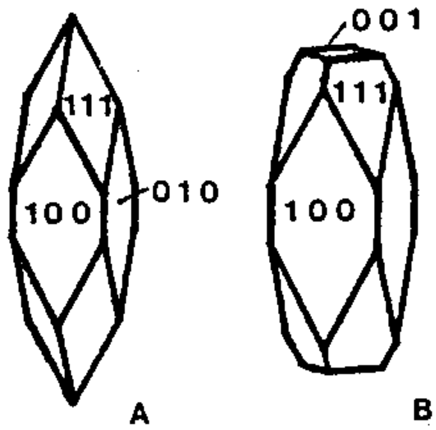


Figure 4 NORMAL APOPHYLLITE MORPHOLOGY

ORIGIN:

Two different environments were present for zeolite crystallization at the Jaquish Road cut. One consisted of a very porous open channel system where water could easily flow (the red breccia zone) and the other was a static condition where water could only very slowly migrate (vesicular grayish-green rock). The cavities in the breccia zone were dry during collecting, indicating that water was easily removed just by quarrying the rock. In the grayish-green rock both large and small cavities were usually still full of water even several weeks after removal. Minerals in the red breccia zone did not contain a clay lining while those in the grayish-green rock did. The minerals deposited in the red breccia zone probably were deposited

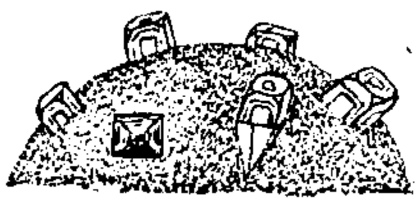


Figure 5 APOPHYLLLITE ON CHALCEDONY

from solutions which were derived from somewhere else in the hydrothermal system as hot mineral-ladened water rapidly circulated through the system of openings in the rock. In this situation, the Fe, Mg, Al, and Si from alteration of pyroxene, olivine, and glass is carried way and not deposited as clay minerals. The silica content which is highest during the initial alteration of basaltic glass is diluted as well. The result is low silica zeolites starting first with heulandite and stilbite (moderate silica content) proceeding to thomsonite, mesolite, and chabazite which are low in silica.

In the greenish-gray rock where the water could not migrate, the ions derived from alteration of olivine, pyroxene, and glass were concentrated in cavities near where they occurred. Since Fe, Mg, Al, and Si were not diluted from massive circulation of water, clay minerals first formed which removed the Fe, Mg, and reduced the amount of Al and Si. These cavities were much richer in silica than those in the breccia zone; therefore the silica-rich minerals mordenite, okenite, and apophyllite (the last two silicates contain no Al at all) crystallized, while in less concentrated cavities lower silica zeolites heulandite, stilbite, thomsonite, and chabazite formed.

This situation is very similar to the mineralization at Neer Road which produced tschernichite and boggsite (both with a high silica content and associated with okenite and chalcedony) in the very dense rock and the commoner species (lower in silica) abundantly in the adjacent vesicular rock.

SPECIMENS COLLECTED FROM THE JAQUISH ROAD CUT WILL BE ON DISPLAY AT THE NOVEMBER 10TH MEETING.

SLIDES SHOWING THE COLLECTING AND MINERALS FROM JAQUISH ROAD CUT WILL BE PRESENTED.

FREE ROCK CONTAINING MICRO CRYSTALS FROM JAQUISH ROAD CUT WILL BE PRESENT.

OTHER SPECIMENS WILL BE AVAILABLE FOR TRADE AND PURCHASE.

IF THERE IS ACTIVITY AT ANY OF THE ROAD CUTS NEAR GOBLE DURING THE MEETING, WE WILL HAVE A FIELD TRIP TO THAT SITE ON SUNDAY.

Zeolites at BIG BEND, KIMBERLEY, OREGON

D. G. Howard

Grant County, Oregon contains some of the best areas for collecting zeolites in the state. These sites are all along the Middle and North forks of the John Day River, and they all are remarkably similar in the suite of minerals that appear. The locations already described are along the upper portion of the North Fork in the northeastern corner of Grant County, especially the site near Stony Creek which was the location of our June field trip. The mineralogy of the Stony Creek location was the subject of an article in the Spring, 1989 issue of the Microprobe (vol. VI, no. 8, pp 10-13).

The location described in this article is on the lower reaches of the North Fork on the western edge of Grant County. Big Bend is a campground about 3 miles east of Kimberley on the road that leads to Monument.The road runs along the north bank of the river, and the campground is on a wide flat between the road and the river. There are a few picnic tables set up under scattered juniper trees, and restroom facilities have been erected, but there is no water supply, and therefore no fees are charged for the use of the campsites.

The collecting site is immediately to the east of the campground turnoff along the north side of the road. At this point the road is cut from a basalt cliff along the river. The cliff is perhaps 30 or 40 meters high. The upper portion is composed entirely of a non-vesicular basalt that shatters into angular fragments. It is black with rusty stains on the surfaces. The bottom of this flow is 3 or 4 meters above road level. The upper portion of the next flow is very vesicular, beginning with a region of small (1 centimeter or less) cavities densely packed near the flow interface. Between this point and road level, the cavities become larger, generally several centimeters in diameter, and they are only a few centimeters apart. This region is very thoroughly mineralized, with all vesicles filled with zeolites.

Collecting at the site is rather difficult. The exposed wall rises sharply only a few feet off the pavement, so care must be taken to keep a sharp lookout for cars and trucks. The rock is not easy to break, and requires much hammering in an awkward position to split chunks loose. The rock is fractured, and large pieces can be dropped with perseverence. These are generally filled with many good specimens when they are broken. The color and texture of the basalt is almost identical to that collected at Stony Creek, and the suite of minerals present is very similar in species, form, and relative abundances to that location (with the exception that gmelinite has not yet been found).

The series of crystallization seems to have led to three types of cavity fillings. The most common seems to have started with a base layer of analcime, and these are generally filled almost completely with thomsonite and mesolite. The analcime continues to crystalize, so that the bases of the thomsonite-mesolite sprays are usually well embedded. Only very rarely do these cavities have the later minerals gyrolite and apophyllite. The sequence order here appears to be:

analcime > thomsonite > mesolite > analcime > (gyrolite, apophyllite)

Almost equally common are cavities where the base mineral is phillipsite, and (very like the Stony Creek material) this is followed by the white tacharanite, and by well-developed groups of gyrolite and individuals of apophyllite. Vermiculite and calcite are late minerals. The sequence is:

phillipsite > tacharanite > gyrolite > apophyllite, chabazite > vermiculite > calcite

A few cavities appear to have a base layer of chabazite of a very complicated twin structure (phacolite). Apophyllite is the only common subsequent mineral. A few specimens show crystals of phillipsite (white rather than the normal clear) which may pre-ceed the chabazite. This sequence is therefore:

(phillipsite) > chabazite(phacolite) > apophyllite

Very little clay is present beneath the zeolites.

MINERALS PRESENT:

ANALCIME appears to be the first zeolite, particularly in vesicles near the top of the flow. In some of the larger cavities, the individual crystals may be several millimeters in size, but they are grown together in a crystal crust so that good specimens are not usually obtained. The crystals are glassy, but whiteness below and within somewhat spoils the appearance. The form is the normal trisoctahedron, but it is often considerably distorted.

THOMSONITE forms radial sprays of flat blades. Small cavities from the top of the flow near the interface show these blades very nicely if there is not a large overgrowth of mesolite. In larger cavities, the thomsonite phase is usually seen as white radiating regions embedded in the later growth of analcime.

MESOLITE continues outward from bases of thomsonite to form sprays of needles that are often several centimeters long. However, the needles are often intergrown and tend to nearly fill many of the vesicles. Furthermore, the mesolite-analcime cavities are often large and are difficult to remove intact. Occassionally, isolated sprays, or cavities where the needles are not too dense produce excellent specimens. The abundance of mesolite at this location is probably its major difference from Stony Creek.

PHILLIPSITE occurs as cavity linings in many of the larger vesicles. Mesolite never seems to occur in cavities with phillipsite. The crystals are generally very clear and may be quite large (up to several millimeters). The habit is simple prism and pyramid (psuedo-tetragonal) which in reality is made up of fourling twins, as shown in the diagram. The more complex twins do not seem to be present. A few crystals associated with chabazite are opaque white and appear heavily etched. This location is probably currently producing the best phillipsite specimens in Oregon.

TACHARANITE occurs as small masses of opaque white, porcelain-like material on top of the phillipsite. Linings of tacharanite of the type seen at Stony Creek do not seem to occur at Big Bend.

GYROLITE forms small rosettes on top of the phillipsite and tacharanite. Larger rosettes contain thicker blades in parallel growth habit, often with a roughly hexagonal outline, and have a clear, glassy appearance. Later growths are composed of very thin blades randomly oriented, and are somewhat more tan in color; these later growths are often fragile and can be easily destroyed during washing.

CHABAZITE is not very abundant at Big Bend. It occassionally forms small, clear rhombohedrons on top of the gyrolite. More often it is the base mineral forming very complex twins (phacolite) similar to those seen at Stony Creek, but without any hexagonal prism (gmelinite) on the interior. These crystals are more similar in form to the cyclic twins found at the Nicolai Road quarry at Goble.

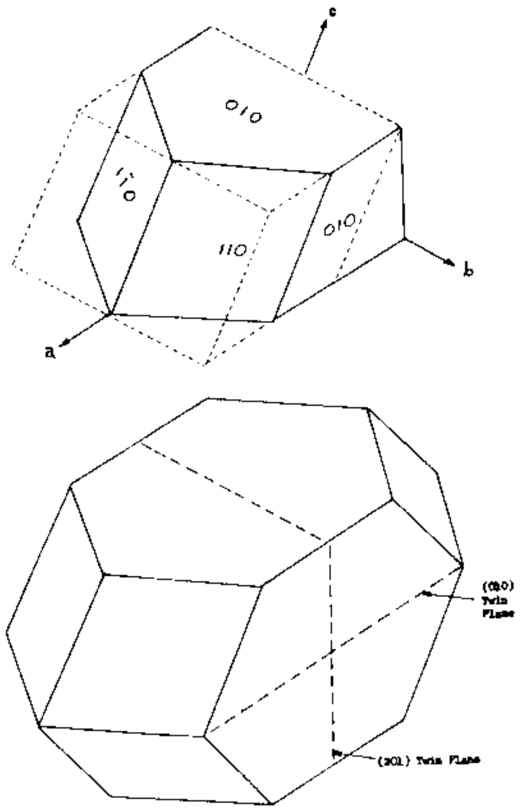
APOPHYLLITE is a late mineral, forming square prisms with small bevelled edges (see page 5, fig. 2i). The crystals are usually tabular in habit, and show internal banding parallel to the c-face. These crystals sometimes show a "sandwich" effect, with golden brown layers on the external c-faces and a colorless interior. Individual crystals are usually scattered but sometimes grow into an almost continuous crust. Unlike the other locations, the apophyllite does not seem to grow in cavities with mesolite; the only crystal found with mesolite inclusions was heavily weathered to an opaque white. It showed considerably more developed pyramid faces.

VERMICULITE is a very interesting late mineral. At Big Bend it is seen almost exclusively in the phillipsite-gyrolite cavities. It forms clay-like masses that are grayer than the tacharanite and gyrolite, and that have a somewhat pearly luster. The material is not particularly attractive on specimens but is not easy to remove.

CALCITE is quite rare at Big Bend. Generally it forms as tiny granular spots on the phillipsite crystals. These will not wash off, but can be removed rather quickly by a short dip in dilute acid. Occassionally, calcite crystals of an earlier origin are seen embedded in the primary analcime.

"SIMPLE" HABIT OF PHILLIPSITE

Crystals of phillipsite appear to be tetragonal but are really monoclinic. The upper diagram shows the monoclinic unit cell (dashed lines) about one of the four individuals making up a twin. The lower diagram shows how this individual, reflected downward in the (010) and backward in the (201) planes forms a complete fourling. Crystals from Big Bend are all of this type.



ADDITIONS TO THE MINERAL LISTS OF PREVIOUSLY REPORTED LOCATIONS AS A RESULT OF THE FIELD TRIPS THIS SUMMER:

STONY CREEK, NORTH FORK, JOHN DAY RIVER

Several cavities of LEVYNE were found. Most were without the white coating of offretite. Crystals were glassy, thickened, and intergrown. Associated minerals were not observed.

A small cavity of gmelinite of a very different habit was found: elongated along the c-axis with a smooth, well-developed c-face. The prism faces are irregular and heavily striated horizontally (parallel to the c-face).

SUNDAY CREEK, NORTH FORK, SNOQUALMIE RIVER

Several cavities filled with calcite were found. Upon etching in acetic acid, it was found that they contained tiny crystals of STILBITE (variety epidesmine) and CHABAZITE (simple rhombohedra) growing on the adularia crystal surfaces.

Examination of the site shows that the stream boulders are washing out of the stream bank from glacial deposits. It is therefore unlikely that the source of the mineralized primary rock can be located.

S. E. M. Micrographs accompanying this issue
(Photo number is on the front at lower right.)

From: the Golden Horn, Washington Pass, Okanogan Co., Washington
#470 Anatase on Parisite (x310)
Tiny black tetragonal rods of anatase growing on cream-colored hexagonal platelets of parisite

#475 Synchysite (x100)
Synchysite crystals seem to be considerably larger and thicker than the parisite.

#479 Bastnaesite-Synchysite on Microcline (x 80)
The inner part of the hexagonal rod is synchysite. The gap represents a region (probably calcium-rich) that later disolved away. The outside rim is bastnaesite, with almost no calcuim detectable.

From: Stony Creek, North Fork, John Day River, Grant Co., Oregon
#037 Apophyllite on Mesolite on Phillipsite (x 19)
Tabular crystal clearly showing the (210) face on either side of the (100). See page 5, figure 3ii.

From: Jaquish Road, Goble, Columbia Co., Oregon
#020 Apophyllite on Mordenite (x 75)
Crystal elongated along the c-axis, with (110) face clearly showing between the (100) faces.
See page 12, figure 3B.

#035 Chabazite on Thomsonite (x 50)
Simple rhombohedron growing on the tortuous twisty thomsonite, which at this magnification proves to be series of flat, thin crystal laths growing into each other.

From: Neer Road, Goble, Columbia Co., Oregon
#609 Tschernichite (x 50)
An unusual cyclic twin.

From: Pollena, Mt. Somma-Vesuvius, Italy
#009 Montesommaite (x200)
Another new zeolite mineral! And although it looks just like tschernichite, it has a lower silica content and different internal structure. The nearly tetragonal crystals are glassy clear. Chemical formula is:

$$K_9 Al_9 Si_{23} O_{64} \cdot 10 H_2O$$

The mineral has been approved and submitted to Am. Min. for publication in the near future.

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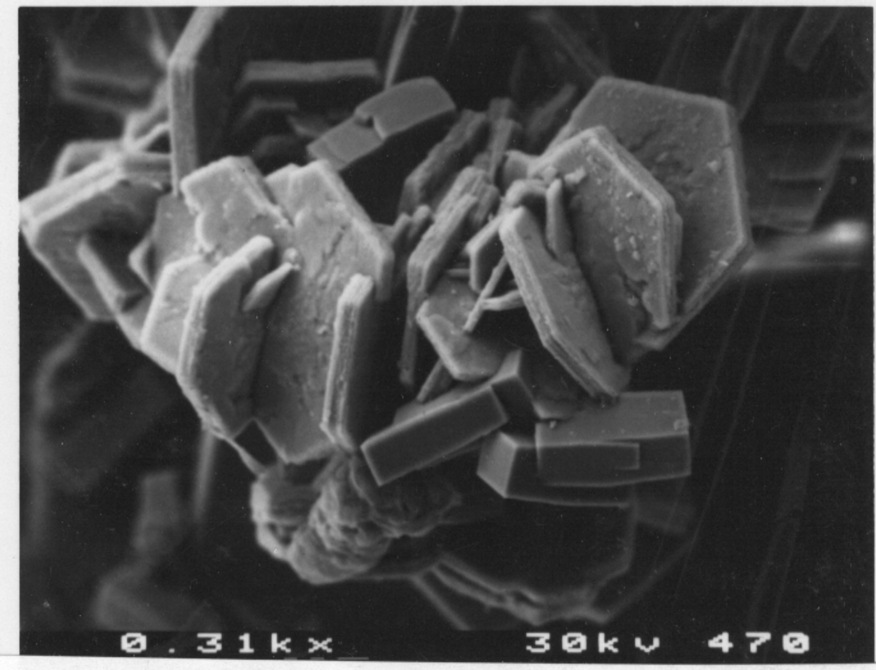
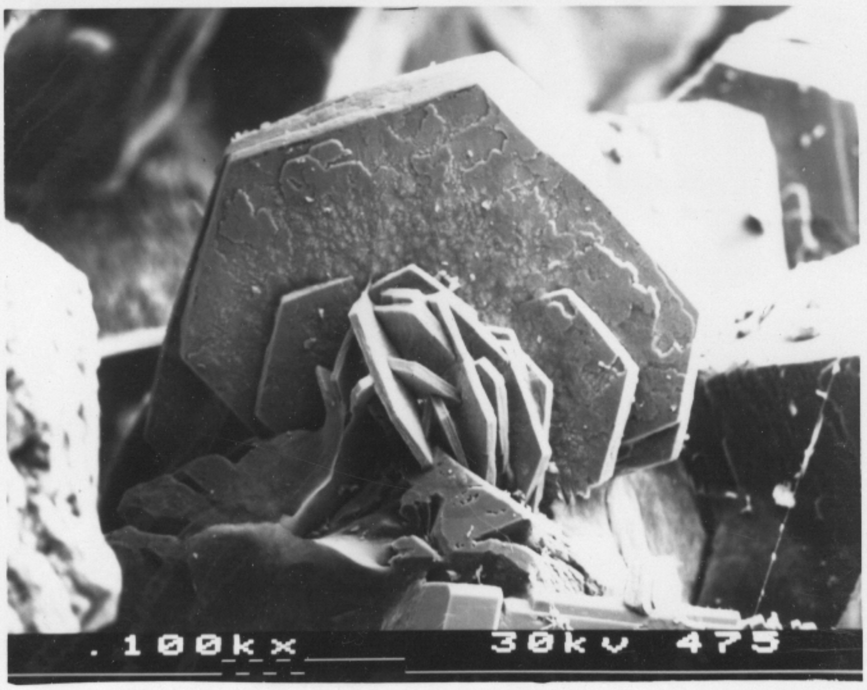
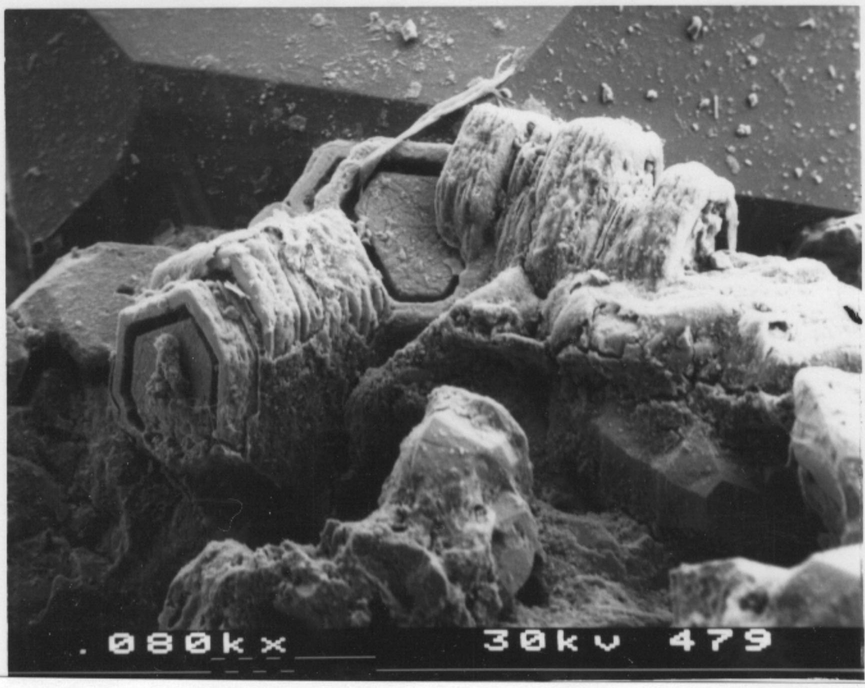


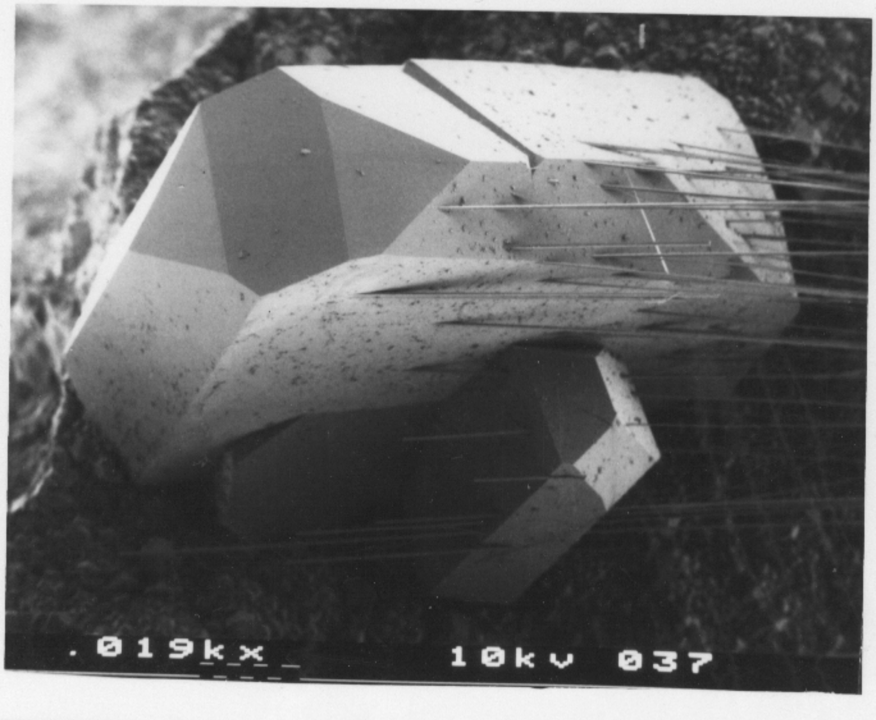
#470 – ANATASE, PARISITE – GOLDEN HORN BATHOLITH, WASHINGTON PASS, OKANOGAN CO., WASHINGTON – 310X



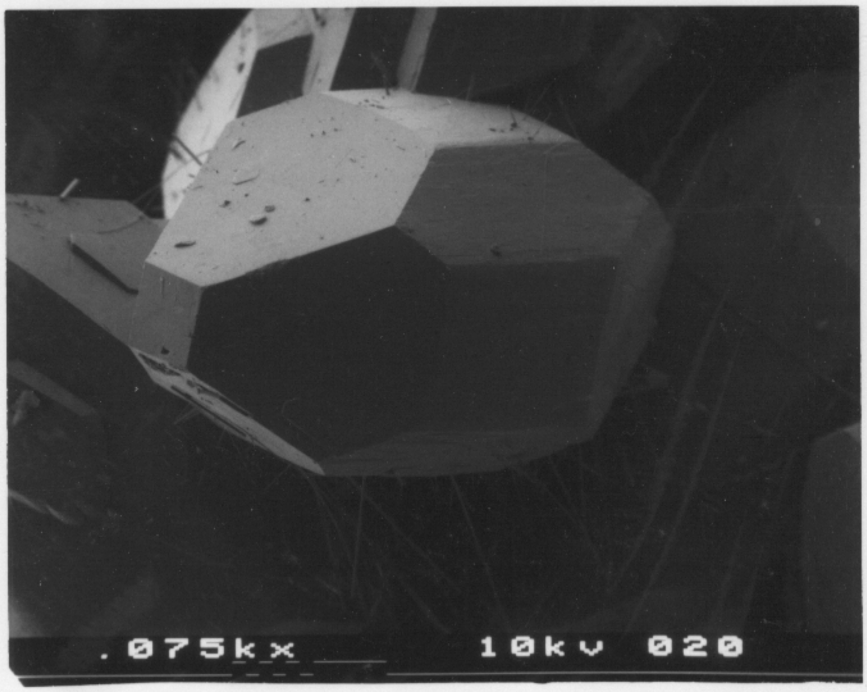
#475 – SYNCHYSITE – GOLDEN HORN BATHOLITH, WASHINGTON PASS, OKANOGAN COUNTY, WASHINGTON – 100X



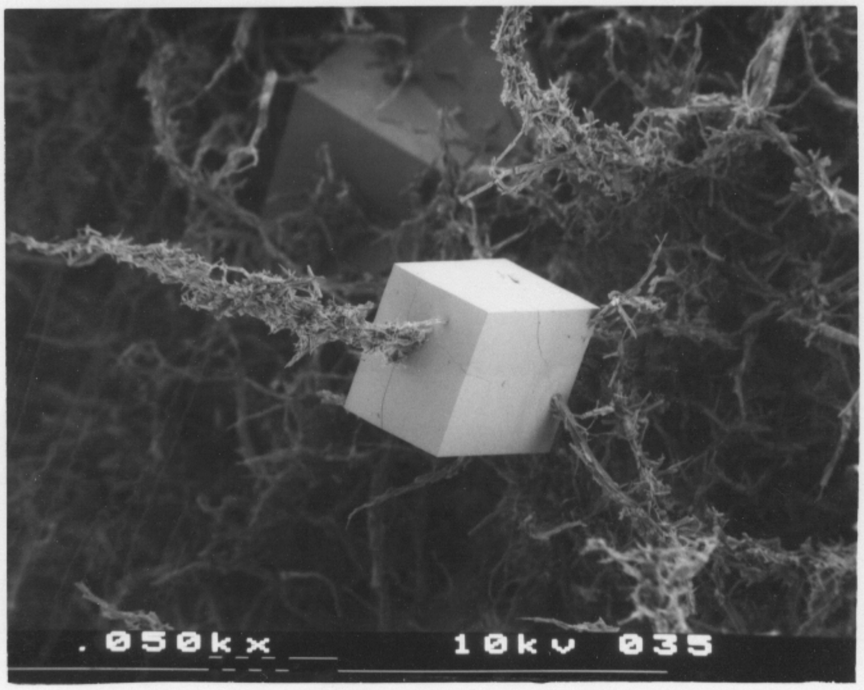
#479 – BASTNAESITE , SYNCHYSITE – GOLDEN HORN BATHOLITH, WASHINGTON PASS, OKANOGAN CO., WA – 80X



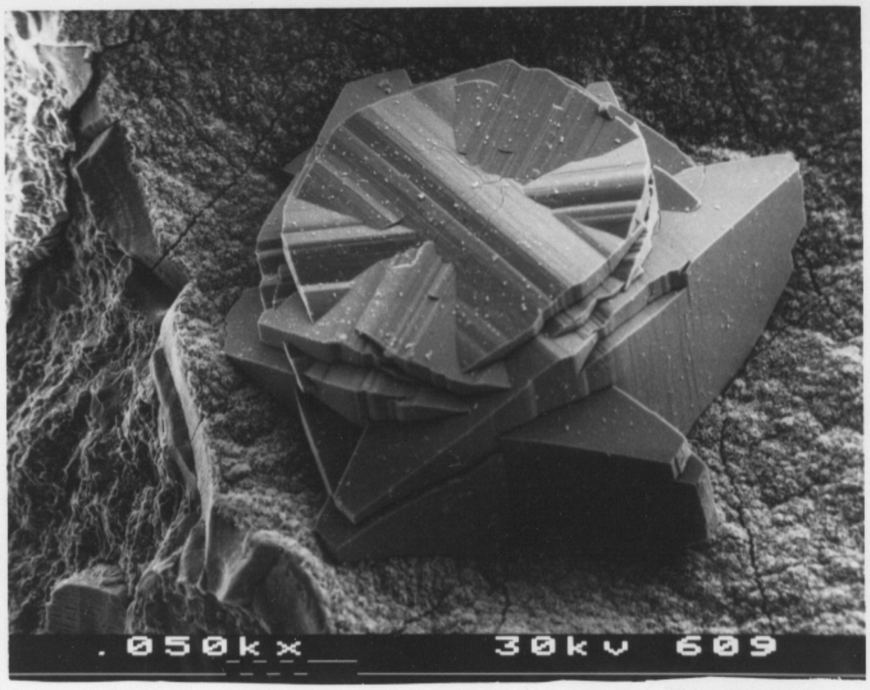
#037 – APOPHYLLITE, MESOLITE – STONY CREEK, NORTH FORK JOHN DAY, GRANT COUNTY, OREGON – 19X



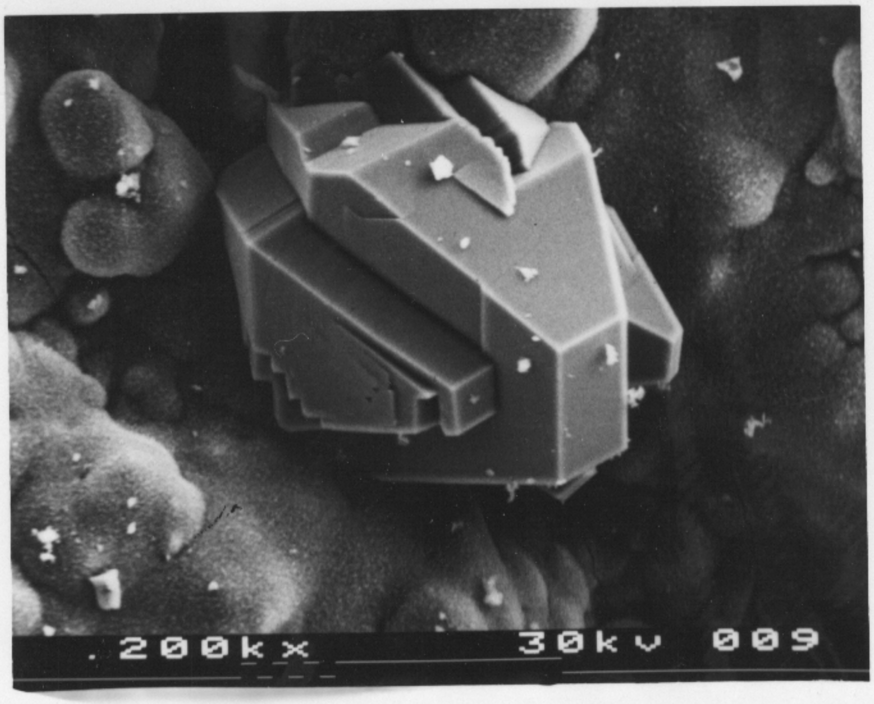
#020 – APOPHYLLITE, MORDENITE, JAQUISH ROAD, GOBLE, COLUMBIA COUNTY, OREGON – 75X



#035 – CHABAZITE, THOMSONITE – JAQUISH ROAD, GOBLE, COLUMBIA COUNTY, OREGON – 50X



#609 – TSCHERNICHITE – NEER ROAD, GOBLE, COLUMBIA COUNTY, OREGON – 50X



#009 – MONTESOMMAITE – POLLENA, MT. SOMMA, MT. VESUVIUS, ITALY – 200X