

Northwest
Micro Mineral
Study Group



MICRO PROBE

FALL, 1995

VOLUME VIII, Number 2

FALL MEETINGVANCOUVER, WASHINGTON

November 11, 1995

9:30 am to 6:30 pm

**Clark County P. U. D. Building
1200 Fort Vancouver Way
Vancouver, Washington**

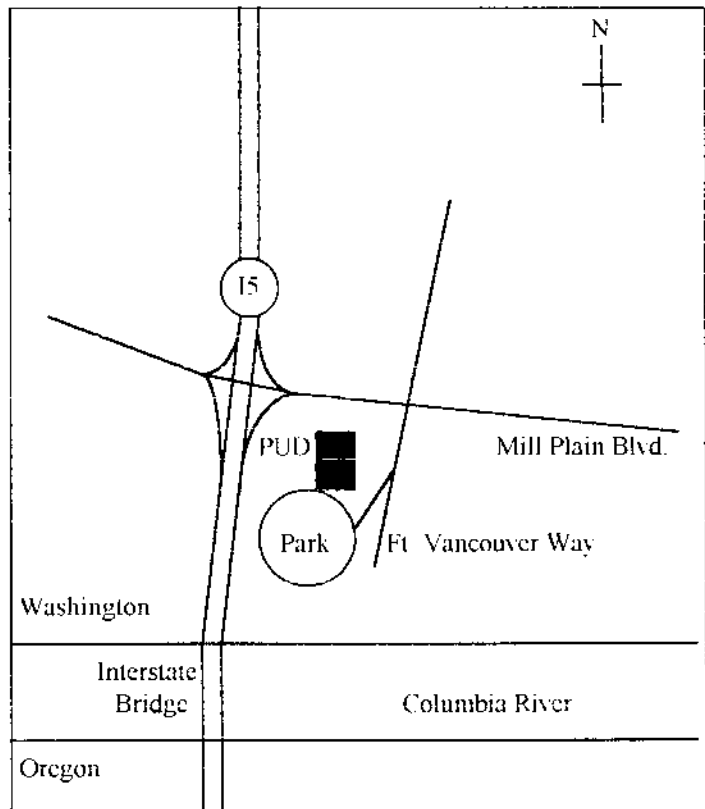
Come share your new finds and acquisition from another summer of collecting. Bring your microscopes and some material to share with others that can be put out on the free table. Good material will be available from Lucin, Utah as well as the locations in Oregon and Washington described in this issue.

During the afternoon, after a very brief business meeting, we will be discussing new collecting areas. Rudy Tschernich and Don Howard will be showing slides of Oceanside, the Wheeler County locations, and the White King Mine. If you have slides of your own summer collecting, bring them to share with the group.

The kitchen area is available as usual and we will provide lemonade, coffee, popcorn, etc. There will be a snack table, so bring snacks to share with others during the day. However, there will be

NO POTLUCK DINNER

in the evening. This scheme worked well this spring and we intend to continue it.



EDITORIAL

In the last issue, we mentioned that there was some problem with the interpretation of the rules of using the Clark County PUD facilities. Their rules specify that there not be "any form of private gain" by an individual. We have explained our policy as follows:

We provide a service to those collectors who are not able to go into the field to collect. Individuals provide specimens for sale at a nominal cost to cover the expenses incurred in collecting and transporting the material.

There is therefore no intent to make a profit off of the sale of such specimens.

Based on this understanding, the management has agreed that we can continue providing specimens under these circumstances. We have emphasized that most of the material provided is free of charge (the free table), and that most of us trade material rather than buy it. The specimens provided at nominal cost are primarily for those who do not have the opportunity to collect material that they could use for the purpose of trade.

It is our intent to continue to emphasize the Free Table, and to make as much of the material as possible available on that basis.

We have been notified that there will be some inconvenience at our next meeting caused by remodeling to the auditorium.

Don Howard	<i>President</i>
Genie Howard	<i>Treasurer</i>

THE MICROPROBE	Northwest Micromineral Study Group
Annual Dues: \$15. per mailing address	

Changes to the Roster

Mr. Robert Barrell
3115 Fernan Hill Rd.
Coeur D'Alene, ID 83814

Mr. & Mrs. Gerald Jungles
10431 W. Ruth Ave.
Peoria, AZ 85345
(602)974-4590

Ms. Elaine M. Sole
188-02 89th Ave.
Hollis, NY 11423-1906

Mr. Bob Campbell
37-1750 Pacific Way
Kamloops, B.C. V2F 2K8 Canada
(604) 374-3822

Mr. Brendon Laurs
407 Marview Lane
Solana Beach, CA 92075
(619)755-3044

Mr. Patrick Starnes
3424 Liberty Rd. South
Salem, OR 97302

Mrs. Margaret Gross
15463 Villa Sierra Rd.
Valley Center, Ca 92082
(619) 749-8854

Mr. & Mrs. Daniel Feathers Marsh
P.O. Box 37
Gold Bar, WA 98251

Mr. & Mrs. Bob White
2 Summit Ave.
Redlands, CA 92373
(909)798-3635

Mr. William Henderson, Jr.
47 Robin Ridge Dr.
Madison, CT 06443
(203)254-0489

Mr. Tim Rose
4352 Golf Dr.
Livermore, CA 94550
(510)455-5626

Mr. Tad Wolgamott
P.O. Box 875
Columbia, CA 95310
(209)532-5060

FIGURE CAPTIONS

Micrograph Number is in the upper left corner on the back of the print.

- # 6 **Metavariscite with Variscite** (x 55)
Utahlite Claim, Lucin, Box Elder Co., Utah
 A penetration twin on the (101) plane (see diagram, page 6). Notice the striation lines parallel to the *a*-axis. The small prismatic crystals about the base are variscite.
- # 7 **Variscite** (x150)
Utahlite Claim, Lucin, Box Elder Co., Utah
 An individual, slightly etched crystal viewed down almost parallel to the *a*-axis
- # 8 **Minyulite** (x450)
Utahlite Claim, Lucin, Box Elder Co., Utah
 The terminations of these acicular orthorhombic crystals are quite complex.
- # 9 **Natrolite and Thomsonite** (x 12)
Lower Kahler Creek, Spray, Wheeler Co., Oregon
 An open spray of needles, several of which are noticeably curved.
- # 10 **Natrolite and Thomsonite** (x 70)
Lower Kahler Creek, Spray, Wheeler Co., Oregon
 One of the natrolite arches, showing the tendency of straight crystals to grow off tangent to the central curved crystal. The blades at lower left are thomsonite.
- # 11 **Pyrite and Stilbite on Heulandite** (x 16)
Valley Landfill Pit, Coffin Butte, Benton Co., Oregon
 The pyrite is composed of numerous, somewhat misaligned segments typical of the crystals from this location. The zeolites are all very clear.
- # 12 **Yugawaralite on Heulandite** (x 60)
Wolf Point Quarry, Cowlitz Co., Washington
 A thin doubly-terminated crystal. The actual faces present varies considerably from one crystal to the next. See the diagrams on page 23.
- # 13 **Quartz** (x 60)
Mill Creek Quarry, Buell, Polk Co., Oregon
 A single crystal with a rhombohedral termination and tapering sides due to numerous growth steps, shown here as horizontal striations.

PHOTO CREDITS

All Micrographs:		<i>Donald Howard</i>
Specimens:	#6, 7 & 8	<i>Joe Marty</i>
	#11	<i>Mike Sunde</i>
	#12	<i>Rudy Tschernich</i>
	#9, 10 & 13	<i>Donald Howard</i>

**Minerals of the Uthlite Claim
(Edison and Bird Mine)
Lucin, Box Elder County, Utah**

Joe Marty
3457 E. Silver Oak Road
Salt Lake City, Utah 84108
and
Donald G. Howard

Introduction

The presence of phosphate minerals in northwestern Utah has been known since 1905. In 1909, Frank Edison and Edward Bird located claims on Uthlite Hill (Edison and Bird mine) and produced variscite until 1910. Now the location is known as the Uthlite claim. This locality is important because of lapidary grade variscite and well-formed microcrystals of metavariscite. Reports of wulfenite crystals occurring on variscite (personal communication, Richard W. Thomssen) enticed Joe Marty to explore the location together with Jim McGlasson. The number of mineral species occurring at this location is limited, but interesting. Currently, one small oval open pit has been developed for the mining of lapidary material. To the north of this pit is a small variscite prospect.

The area is located 3.8 miles north of Lucin, in Box Elder County, Utah, about an hours drive north of Wendover, Utah. The road to Uthlite Hill (at Grouse Creek junction) is 8.7 miles east of the Utah-Nevada border on state highway 30 or about 18 miles north east of Montello, Nevada. Next, after traveling 1.9 miles to the south, there is a gate and road on the west side of the road that will take you to the top of the hill and to the claim (1.1 miles from the gate).

Geology

The Uthlite claim is situated in the Permian Rex Chert Formation which is composed of dolomite, limestone, quartzite, chert, and siltstone. The host rock is heavily brecciated in the vicinity of the mineral occurrence. In addition, prominent northwest-striking, high-angle faulting is evident in the open pit. These structural events provided good permeability for fluids carrying phosphate ions from the underlying Meade Peak Formation (related to the Phosphoria Formation). Although the exact mode of mineral deposition is uncertain, nearby igneous bodies may have provided the heat and solutions necessary for mineral deposition (typical of epithermal systems). These solutions cemented and replaced brecciated rocks with variscite and silica.

Mineralogy

Initially, hydrothermal solutions were probably acidic and rich in aluminum, calcium and phosphate. The source of the phosphate was probably the underlying phosphate beds while aluminum and calcium may have come from the wallrocks. The first crystals to form were variscite and metavariscite. As aluminum concentrations decreased, apatite crystals formed. As phosphate replaced limestone, the pH also increased (less acid). Minyulite appears to have formed coincident with the final phases of apatite formation. In some of the open spaces, cementing or filling was incomplete, allowing for the crystallization of euhedral crystals of metavariscite, variscite, apatite, minyulite, quartz, and several unknowns.

The minerals described below were collected in March, 1993 by Joe Marty and Jim McGlasson while on a field trip to the open pit with the owner Dave Penney.

Apatite, (?Hydroxylapatite?), $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$, occurs as white, opaque, prismatic, euhedral to subhedral crystals up to 3 mm. Many of the crystals coalesce to form botryoidal masses and on rare occasion crystals are attached to the surface of variscite crystals. Some of the crystals form as small acicular bundles and powdery masses. The apatite may represent hydroxylapatite, however, detailed chemical analysis is not available at this time (personal communication, Eugene Foord, USGS). Small tabular crystals of apatite occur to the north of the claim in a small variscite prospect.

Crandallite, $\text{CaAl}_3(\text{PO}_4)_2(\text{OH})_5 \cdot \text{H}_2\text{O}$, is rare and occurs as yellow masses which may represent a late stage alteration product of variscite. One spot on the east wall produced small crandallite crystals pseudomorphed after twined metavariscite crystals.

Jarosite, $\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$, occurs in an outcrop a short distance northeast of the main pit as yellow, translucent, platy crystals up to 0.6 mm, associated with small, clear apatite crystals (personal communication, Mel Cannon).

Metavariscite, $\text{AlPO}_4 \cdot 2 \text{H}_2\text{O}$, is abundant and forms colorless to light green euhedral bladed crystals to 2.0 mm. Metavariscite may be seen perched on massive variscite or with variscite crystals attached to prism faces, and frequently forms flat prisms and less commonly V shaped twins. This location is the type locality for metavariscite.

The mineral is monoclinic, but the β angle is so close to 90° that for the purposes of discussing habit, it may be considered orthorhombic. The crystals tend to be thin in the b direction and elongated in the a direction, with striations on the (010) face parallel to the a axis. The blades have beveled edges formed by (110) and (011). Twinning occurs as contact twins on the (101) plane. The double twin shown in Micrograph #6 appears to be a penetration twin, since there is no prominent plane perpendicular to (101). (The (301) is about 3° off, too far to explain the near-perfect parallel orientation.)

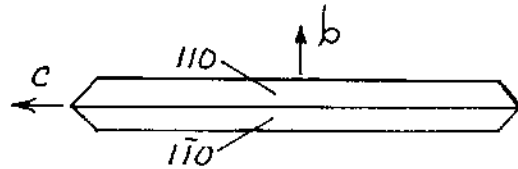
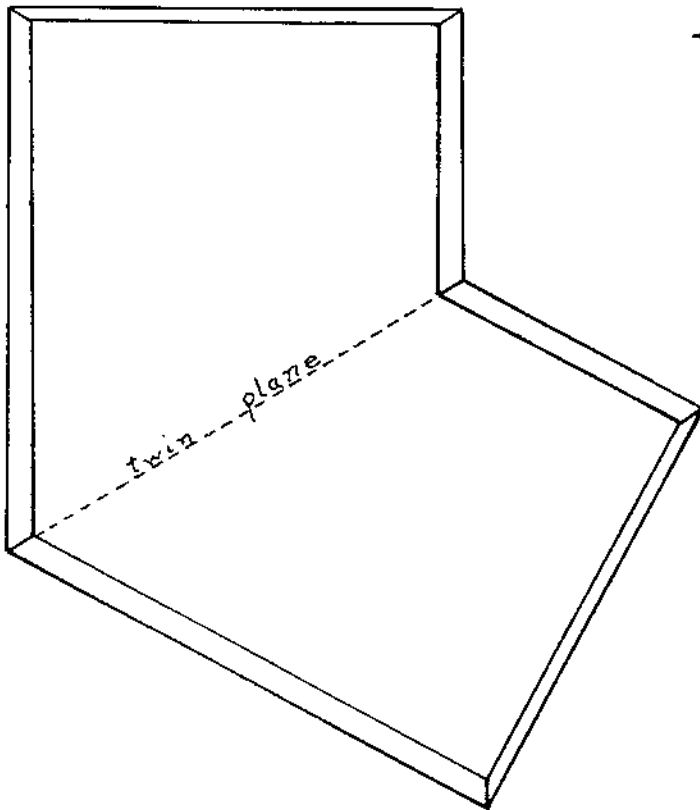
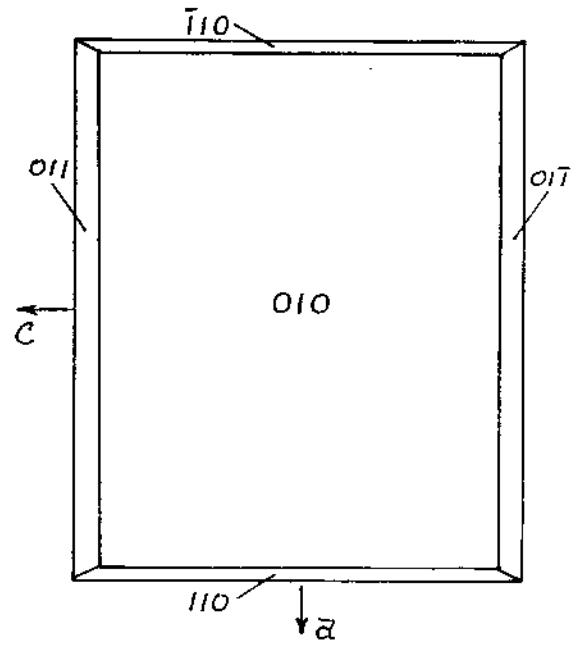
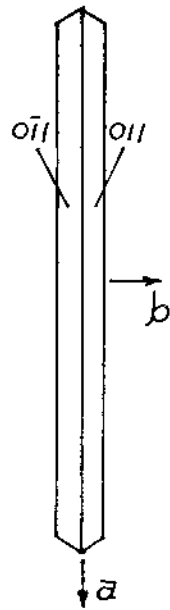
Monoclinic

$$a = 5.15 \text{ \AA}$$

$$b = 9.45 \text{ \AA}$$

$$c = 8.45 \text{ \AA}$$

$$\beta \approx 90^\circ$$

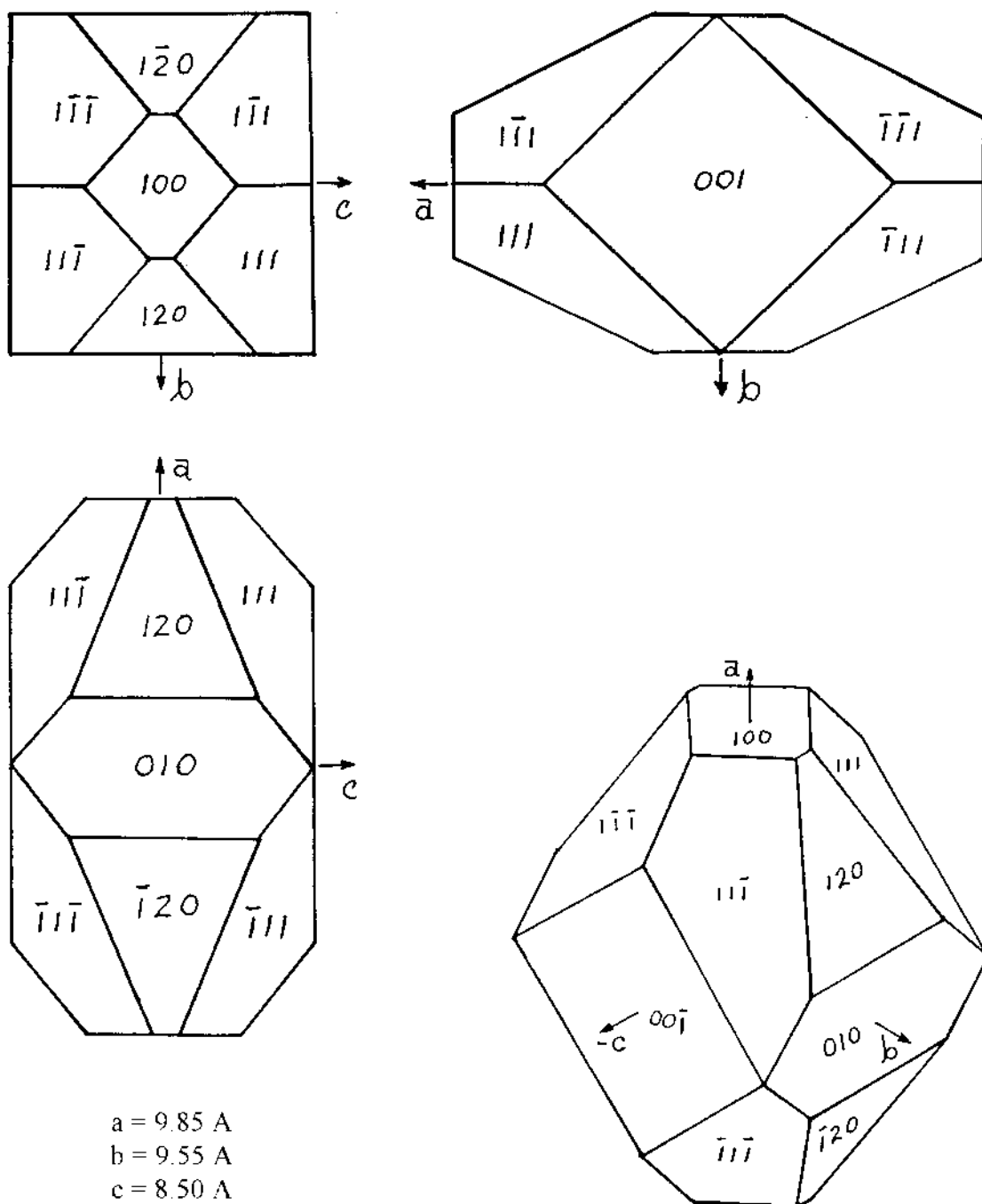


Habit of Metavariscite

Lucin, Utah

Crystals are elongated along a and thinned along b , with bevelled edges

The pair at left are twinned on the (101) plane. See Micrograph #7.



Habit of Variscite Crystals, Lucin, Utah

Equant orthorhombic prism and octahedron, with modifying faces
 Compare with Micrograph #7.

Variscite, $\text{AlPO}_4 \cdot 2 \text{H}_2\text{O}$, is very abundant and occurs principally as massive material with local colorless to green poorly formed dipyramidal crystals up to 0.5 mm. Rarely, very well-formed crystals can be found, some of which may be observed perched on metavariscite crystals. In one area of the pit numerous green balls or spheres of variscite occur up to 3 mm in diameter. The green coloration is likely due to low concentrations of vanadium and chromium. SEM-EDS examination of similar material from Clay Canyon showed the presence of traces of vanadium and chromium (Shaller, 1912 & 1916, also found vanadium and chromium traces to be present.)

Much of the massive variscite typically has a concentric texture and is therefore desirable for lapidary purposes. The nomenclature for variscite has changed since the original description. The material that was originally called variscite has now been shown to be metavariscite. Also, the material that was originally called lucinite has been definitively shown to be variscite. In addition, peganite was shown to be the same species as variscite and thus the name peganite has been discarded.

Variscite is an orthorhombic mineral. At Lucin, the crystals are equant, as opposed to the bladed metavariscite. They are primarily octahedral in habit, the (111) faces being most well developed in all the crystals. Corners are truncated with prism faces, with the (001) best developed. The presence of (120) faces on each side limits the development of the (010) faces. A small (100) face is usually present. Micrograph #7 depicts such an individual crystal. Micrograph #6 shows a number of such crystals clustered about the base of the metavariscite blade.

Minyulite, $\text{KAl}_2(\text{PO}_4)_2(\text{OH},\text{F})\text{H}_2\text{O}$, occurs as translucent colorless to faintly green prismatic crystals up to 2 mm in length. Several aggregates of long prismatic crystals were found that were very aesthetic. The crystals were limited to one small pocket or zone in an area which is now inaccessible. It was identified by X-ray diffraction and SEM-EDS methods by Eugene Foord, USGS. This is approximately the 8th known occurrence for minyulite.

The crystals are orthorhombic. They appear to be acicular, elongated parallel to the *c* direction. The terminations, as shown in Micrograph #8, are quite complex. Since most of the published structural work has been done on material from the original occurrence in Western Australia where the mineral was mainly in fibrous arrays, no work appears to have been done as yet on the morphology of this mineral. It warrants further examination.

Quartz, SiO_2 , probably "secondary" crystals, up to 3 mm occur in cavities with variscite and metavariscite crystals. The majority of quartz is cryptocrystalline.

Unknown # 1, very rare, is closely associated with apatite and minyulite, occurs as white acicular needles to 1.0 mm, and resembles wavellite. Identification is pending.

Unknown # 2, is very rare, somewhat resembles leucophosphite, and occurs as black to brown 0.2 mm "blobs" on fracture surfaces. Identification may not be possible due to the limited quantity and size of the material.

Phosphosiderite, *wardite* and *strengite* have been reported to occur at this locality but were not confirmed.

Discussion

The dump at the Uthlite claim will undoubtedly continue to provide interesting crystals for the mineral collector. The potential exists for other minerals to be found and described. However, the economic future for continued mining of variscite for lapidary purposes is uncertain. At the present time access to the bottom of the small open pit with equipment is becoming more difficult and this may limit future mining and diminish the potential for mineral collecting. After discussions with the BLM, the claim owner is considering filling in the open pit.

Other related phosphate deposits include Clay Canyon, Utah; Amatrice Hill, Utah; unspecified localities between Park Valley, Utah, and Snowville, Utah (Hansel Mountains); Saint George, Utah; and Island Park, Idaho. Variscite is known to occur at all of the above localities in or near Paleozoic phosphatic limestones. Metavariscite crystals are known to occur at the Uthlite claim and at Island Park.

The Utah deposits have been investigated by the Utah Geological Survey for scandium potential because scandium is roughly equal in value to gold and the United States supplies are nearly non-existent. Scandium is a trivalent trace element that is a minor constituent present in hundreds of minerals. In aluminum phosphate minerals (scandium-bearing) scandium is very common and forms complexes with the phosphate ion (PO₄). With scandium-bearing minerals, scandium is not the sole cation. However, at the Clay Canyon variscite deposit, the mineral kolbeckite contains scandium as the sole cation and is one of the rare scandium minerals.

Further research now suggests that wulfenite may have occurred on variscite at the Empire mine (Tecoma Hill # 18 mine) below Tecoma Hill in Regulator Canyon which is just a short distance to the east of the Tecoma Hill Mine # 11 mine. This district is about 10 miles southwest of the Uthlite claim on the Utah-Nevada border.

Claim Status

Permission to collect must be obtained from Dave Penney, in Beaver, Utah (801-438-5522), who has the lease on the claim. Dave will have a few attractive miniature pieces of metavariscite for sale that range in price from \$10 to \$50 at the Tucson Show, Holiday Inn Hollidome, Room 250 (Penney's Gemstones).

Acknowledgments

We wish to thank Dr. Eugene Foord with the USGS in Denver, Colorado, for help in the identifications of the minerals, and Dave Penney, who allowed us access to his claim.

Bibliography

1. Thomssen, R. W., 1991. Forgotten phosphates of Fairfield. *Lapidary Journal* Vol 45. 46-53.
2. Shubat, M. A., 1988. Scandium-Bearing aluminum phosphate deposits of Utah. *Utah Geological and Mineral Survey Report of Investigation*. 209.
3. Foster, M.D., Schaller, W. T., 1966. Cause of colors in wavellite from Dug Hill Arkansas. *The American Mineralogist*. Vol 51. 422-428.
4. Larsen, S. E., Schaller, W. T., 1925. The identity of variscite and peganite and the dimorphous form, metavariscite. *The American Mineralogist*. Vol 10. 23-28.
5. McConnell, D., 1925. Clinobarrandite and the isodimorphous series, variscite-metavariscite. *The American Mineralogist*. Vol 25. 719-725.
6. Doelling, H.H., et al., 1980. *Geology and mineral resources of Box Elder County, Utah*. Utah Geological and Mineral Survey. Bulletin 115., 251 p.
7. Miller, D. M., 1985. *Geologic map of the Lucin quadrangle, Box Elder County, Utah*. Utah Geological and Mineral Survey. Map 78.
8. Frondel, C., Ito, J.I., and Montgomery, A., 1968. Scandium content of some aluminum phosphates. *American Mineralogist*. Vol 53., 1223-1231.
9. Larsen, B.S. and Shannon, E.V. (1930) *Mineralogy of the phosphate nodules from near Fairfield, Utah*. *American Mineralogist*. Vol 15., 307-337.
10. Larsen, B.S. and Montgomery, A. (1940) *Sterrettite, a new mineral from Fairfield, Utah*. *American Mineralogist*. Vol 25., 513-518.
11. Montgomery, A.(1970) [Various parts in *Rocks and Minerals*]

part 1	pg 667-674
part 2	pg 739-745
part 3	pg 3-9
part 4	pg 75-80.

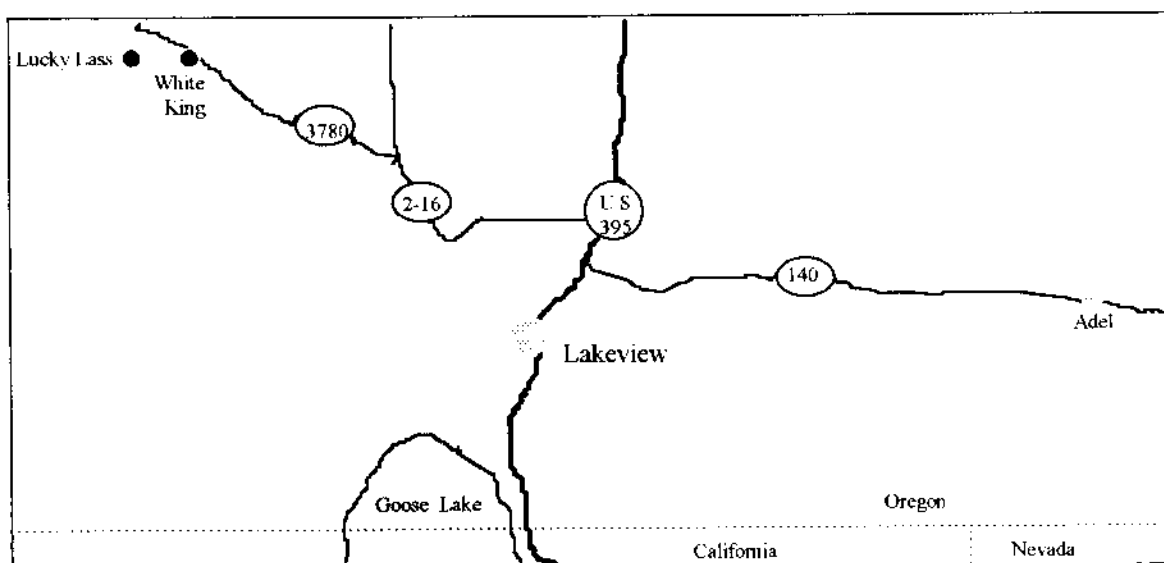
WHITE KING MINE LAKEVIEW, LAKE COUNTY, OREGON

Donald G. Howard

During the 1950's, traces of uranium were discovered about 15 miles north west of Lakeview, Oregon. Two mines were established in the area. Uranium ore was obtained from one of the mines, the Lucky Lady Mine. This appears to have been from ore pipes present at that location. At the other location, the White King Mine, traces of uranium were found, but despite extensive earth moving, no mineable ore body was found. The mineral containing the uranium was metaheinrichite, at that time a new mineral found there and in Germany in the central Black Forest region. The paper describing this new mineral was published in 1958 by Gross, Corey, Mitchell and Walenta (Am. Min. **43**, pg 1134-1143.), naming the White King Mine as one of the type localities of this new mineral.

The White King Mine is now designated as a toxic cleanup site under the control of the Forest Service, and is being studied to see the extent of the problem and determine how best to deal with the problems. Since this will probably mean the removal of this mine as a collecting site in the next few years, now seems an appropriate time to report the status of collecting.

The mine lies in a meadow that is a part of the upper drainage of Auger Creek which flows generally southward to join other creeks in the area to flow past Lakeview into Goose Lake. The meadow can be reached by Forest Service road #3780. The site is fenced and the gate locked, so permission to collect would have to be obtained through the Forest Service District Office just north of Lakeview.



The metaheinrichite at the White King occurs as yellow platelets in a light gray, altered, silicified rhyolite tuff along fracture lines and in tiny vugs. Small amounts of massive realgar and radial wheels of dark stibnite also are present in this rock. In the process of searching for an ore body, large quantities of this material were scooped out of the hillside and dumped in two large piles in the meadow below. These pale-colored dumps in the midst of a very green meadow are clearly visible from the Forest Service road. The large excavation left behind has filled with water to form a pretty, deep blue lake behind the white dumps.

The major clean-up problem, interestingly enough, is not radioactivity. It seems that the lake is very acid -- with a pH between 3 and 4 -- and has a sizable concentration of dissolved arsenic. The material that forms the dump has continued to alter, changing into a pale gray clay, so that very few solid pieces of rock are present anywhere on the dump. The walls of the open pit slope steeply down into the very acid lake, making the actual mine site a difficult and hazardous place to collect. Thus, very little collectable material remains at the site. The minerals obviously leach out easily into the water, so that with no likelihood of fresh material being exposed, collecting at this site, even apart from the cleanup efforts, would probably be at an end.

Metaheinrichite is a hydrated barium uranyl arsenate. Structurally, it is placed in the meta-autunite group, which together with the autunite group is sometimes referred to as the uranium micas. Structurally, all are tetragonal minerals and normally form as thin plates perpendicular to the c-axis. Chemically, the members are all phosphates or arsenates containing UO_2 groups and another positive ion that is usually divalent. They form as sheets of atoms held together by water molecules -- normally 8 for the meta-autunite structure and 12 for the autunite structure. The water is of the type referred to as *zeolitic*, in that it can easily be lost through evaporation. For this reason, by the time the material has been exposed for any length of time, or has been put into a collection, it has probably dehydrated down to the meta-autunite type. The accompanying table shows the currently identified and named members of the two groups, and their relationship to each other.

Metaheinrichite at the White King Mine forms as very thin, tetragonal platelets in clusters and sprays primarily along the cracks in the altered rhyolite. It is very fluorescent, and therefore stands out from the whitish matrix much more strongly in sunlight than it does in artificial light. Because the seams are thin and not very open, most of the blades are clustered laying down to form shiny patches. Only occasionally is there enough room for standing crystals to be present, and these are so thin and fragile that it is seldom possible to identify complete crystals exhibiting tetragonal symmetry.

MINERALS OF THE AUTUNITE AND META-AUTUNITE GROUPS

	PHOSPHATES	ARSENATES
Ca	autunite $\text{Ca}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 10-12 \text{H}_2\text{O}$ meta-autunite $\text{Ca}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 2-6 \text{H}_2\text{O}$	uranospinite $\text{Ca}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 10 \text{H}_2\text{O}$ meta-uranospinite $\text{Ca}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 8 \text{H}_2\text{O}$
Ba	uranocircite $\text{Ba}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 12 \text{H}_2\text{O}$ meta-uranocircite $\text{Ba}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 8 \text{H}_2\text{O}$	heinrichite $\text{Ba}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 10-12 \text{H}_2\text{O}$ metaheinrichite $\text{Ba}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 8 \text{H}_2\text{O}$
Mg	saleeite $\text{Mg}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 10 \text{H}_2\text{O}$	novacekite $\text{Mg}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 12 \text{H}_2\text{O}$ metanovacekite $\text{Mg}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 4-8 \text{H}_2\text{O}$
Cu	torbernite $\text{Cu}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 8-12 \text{H}_2\text{O}$ metatorbernite $\text{Cu}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 8 \text{H}_2\text{O}$	zeunerite $\text{Cu}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 10-16 \text{H}_2\text{O}$ metazeunerite $\text{Cu}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 8 \text{H}_2\text{O}$
Fe	Bassetite $\text{Fe}(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 8 \text{H}_2\text{O}$	kahlerite $\text{Fe}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 10-12 \text{H}_2\text{O}$ metakahlerite $\text{Fe}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 8 \text{H}_2\text{O}$
Co		metakirchheimerite $\text{Co}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 8 \text{H}_2\text{O}$
Mn	Fritzscheite $\text{Mn}(\text{UO}_2)_2((\text{P},\text{V})\text{O}_4)_2 \cdot 10 \text{H}_2\text{O}$	
Zn		metalodevite $\text{Zn}(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 10 \text{H}_2\text{O}$
K ₂	meta-ankoleite $\text{K}_2(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 6 \text{H}_2\text{O}$	abemathyite $\text{K}_2(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 8 \text{H}_2\text{O}$
Na ₂	sodium autunite $\text{Na}_2(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 8 \text{H}_2\text{O}$	sodium uranospinite $(\text{Na}_2, \text{Ca})(\text{UO}_2)_2(\text{AsO}_4)_2 \cdot 5 \text{H}_2\text{O}$
H Al	Sabugalite $\text{H Al}(\text{UO}_2)_4(\text{PO}_4)_4 \cdot 16 \text{H}_2\text{O}$	
NH ₄	uramphite $(\text{NH}_4)_2(\text{UO}_2)_2(\text{PO}_4)_2 \cdot 6 \text{H}_2\text{O}$	
other		Troegerite $(\text{UO}_2)_3(\text{AsO}_4)_2 \cdot 12 \text{H}_2\text{O}$

MINERALS OF THE ROAD CUTTING, DON HILL, TASMANIA

Brian and Beryl Carney

20 Stanley St., Ulverstone, Tasmania, Australia. 7315

During June, 1986, a road gang of the Tasmanian Department of Main Roads was engaged in widening the Bass Highway on the Don Hill, 6 km west of Devonport and just north of the present railway overpass. The work involved excavations into the foot of Don Hill, about 20 meters above sea level and 300 meters inland, where a bed of Tertiary Basalt was exposed. The site is now covered by the roadway. The cutting itself extended for about 400 meters along the highway and was up to 50 meters wide. Excavation work was quite shallow -- no more than 3 meters -- and most of the material was collected from the northern end of the workings. There is evidence that the basalt beds extend on to the beach area from where zeolites have been collected, but these are water-stained.

The movements of the land masses and the intrusion of dolerite that occurred during the Jurassic Period set the basic framework for the future geological developments of the North West Coast. The faulting and joint system resulted in the development of river valleys and steep scarps that still dominate Tasmania's landscape. The earth movements continued into the Tertiary Period and during this time Bass Strait was formed, thus separating Tasmania completely from the Australian mainland. The fractures that had been formed in the surface themselves became the avenues for change when very large quantities of basaltic lava were channeled through them, generally flowing quietly and over a long period of time. These basalt flows on the North West caused some change to the coastline as the lava filled the deeper parts of the old valleys and often extended below sea level. The area where the road cutting was made was probably on part of an old shore platform formed at the foot of a cliff of Tertiary basalt.

Because of the small size of the crystals contained in the cavities, it seems likely that the lava was quite slow in cooling and that, in this area anyway, the effect of sudden cooling by the sea was minimal. Some of the 'plates' of minerals observed indicated that the cavities were as large as perhaps 2 meters across; cavities that were studied ranged up to about 40 centimeters across and were always lined with phillipsite and coated with a carbonate -- siderite, calcite or aragonite. The smaller cavities were generally quite close together throughout the basalt and contained natrolite, phillipsite, chabazite, thomsonite, gonnardite, siderite, aragonite, calcite, chalcedony, pyrite, hyalite and clay minerals.

Most of the cavities that were found were lined with phillipsite and followed by a coating of clay minerals; on this has formed either calcite/siderite or chabazite. The majority of the others were lined with montmorillonite followed by the formation of chabazite crystals. Some of the cavities were filled with solid aragonite or clay material. In the softer base material which seemed to be either a compacted clay or weathered basalt were nodules of chalcedony lined inside with siderite layers which broke fairly easily from the matrix.

It seems that the zeolites were formed at two distinct stages in history and were followed by other stages during which clay and, later, the carbonates were formed. During the first zeolite stage, phillipsite formed radiating transparent prisms followed by larger blocky phillipsite crystals on the radial aggregates. At about the same time in a few other cavities colorless to white radial groups of gonnardite crystallized. It is likely that a great deal of time, perhaps millions of years, then passed, during which some alteration began to occur in the original crystals. The second zeolite stage occurred when a hydrothermal solution of a different composition and pH replaced the first solution. Natrolite, chabazite and clay minerals crystallized on the pre-existing zeolites and partially altered or totally dissolved some of the phillipsite and gonnardite. This also resulted in phillipsite being etched away or replaced by clay, and gonnardite being turned white or yellow or being replaced by clay. Another long period of time may have passed again before a carbon-rich solution filled the cavities and covered the zeolites with calcite, aragonite, siderite and chalcedony.

THE ZEOLITES

Chabazite: Chabazite is the second most abundant and widespread of the zeolites to form. It has been found in two major habits:

1. As simple rhombohedrons. Single crystals were small, up to 3mm. Some showed sets of intersecting striations on exposed faces; some had perfectly smooth faces, and some had modifications with small $(01\bar{1}2)$ faces. Most of the crystals of this habit formed as twins, either as penetration twins rotated 60° around the c -axis or as multiple twinning on $(10\bar{1}1)$ faces, some of which are most complex. Most of these crystals were water-clear, although some yellowish transparent specimens were found.
2. As lens-shaped 'phacolite' twins. Most of the chabazite crystals formed twins and about half of these exhibited the typical 'phacolite' form. These were usually small and yellowish.

Gonnardite/Natrolite: A number of cavities are lined with what appears to be aggregates of gonnardite and natrolite. Colorless transparent needles up to 2mm long extend from a compact white, cream or yellow-green gonnardite. The amount of each species varies in different cavities from mostly gonnardite to mostly natrolite. The gonnardite is soft and altered in most cavities and many have been altered, replaced or coated with clay from later hydrothermal solutions. Clay spheres and rarely chabazite are seen on top of natrolite needles.

Natrolite: Very few specimens of natrolite were found apart from the gonnardite/natrolite aggregates. These crystals were relatively small (up to 5mm) and were found lining or filling small cavities. Most of the natrolite found was whitish due to deterioration, although some smaller specimens showed no evidence of alteration, being fresh and transparent. On some specimens, white natrolite groups were covered with hollow siderite hemispheres. Natrolite was not found in association with other minerals apart from those mentioned.

Phillipsite: This was the most common of the zeolites at this locality, having been formed early and lining most of the cavities. As linings, the crystals formed as radiating groups usually of even size, and were then coated with thin layers of creamish or greyish siderite, or clay material; on this usually formed chabazite and siderite. In some specimens the phillipsite crystals appeared white, cream or yellowish, and are sometimes skeletonized, probably caused during the later clay-forming phase. Sometimes these skeletonized crystals are found in cavities with water-clear chabazite, and some specimens show spaces between the clear chabazite crystals from which the phillipsites were etched away completely. Water-clear twinned crystals appear to be of the Perier, Marburg and Stemple forms. The Perier twinning is of the simple form without re-entrants; the Marburg twinning shows re-entrant twinning on (010) faces, and the Stemple twinning is composed of Perier twins.

Thomsonite: In one cavity measuring 5x3mm tiny hemispheres of smooth, translucent thomsonite were found stacked on each other. Issuing from the surface of the hemispheres were tiny needle crystals of a similar color. No other minerals were with them.

OTHER MINERALS

Aragonite: Aragonite was found in a very small area, and unfortunately most of it was broken by the excavations. However, some perfectly clear pseudohexagonal crystals up to 60mm were collected (most of these were separated from the matrix). Massed twinned crystals up to 100mm in circumference were tinted brown, white or pinkish. Botryoidal calcite coated the base of some of the crystals. Some clear or white fans up to 50mm long were found in cavities. Parallel bands of clear and white aragonite were layered between basalt seams.

Calcite: The most common form of this mineral occurs as a build-up of very thin, sequential layers on siderite, aragonite, other forms of calcite, natrolite and phillipsite, and are translucent to opaque in various shades of cream, yellow and brown. It was found also in the form of clubs coating a white, soft core of a carbonate material. On these forms it seems that the calcite coating was itself coated with a layer of tiny clear rhombohedral calcite crystals. Small golden, glassy scalenohedral crystals were not common, and most of these were coated with an opaque layer of paler calcite.

Hyalite: On the surface of a small cavity was hyalite, which was coated with flecks of siderite.

Clay minerals: These clay minerals were formed very early and are found sometimes coating phillipsite or lining cavities; on some specimens, chabazite was found having formed just after the clay. It was also found as tiny groups of spheres on chabazite and natrolite crystals. The colors were cream, grey, blue and green-brown.

Chalcedony: Small spheres of translucent chalcedony were found on siderite and as 'fills' between siderite hemispheres within some of the larger cavities. In the latter case, layering similar to agate was noticed.

Pyrite: Tiny octahedra of pyrite, some quite iridescent, were found sprinkled on phillipsite and siderite

Siderite: Siderite occurs as light- to dark-brown hemispheres up to 3cm across forming directly on the basalt and sometimes on clay minerals. It seems also to have formed layers (probably with calcite) in domes that sometimes cover phillipsite and chabazite groups and sometime are mounted directly on the basalt.

Acknowledgment:

Appreciation is expressed for the help and encouragement received from Rudy Tschernich (Washington, U.S.A.) and for the mass of 'surplus' material from the locality donated by Don Broadfield of Ulverstone.

LOWER KAHLER CREEK, SPRAY, WHEELER COUNTY, OREGON

Donald G. Howard and Rudy Tschernich

A number of zeolites and associated minerals occur in a road cut along State Highway 19 (and 207) about 1.4 miles west of the town of Spray. This is just east of the place where Kahler Creek empties into the John Day River. Since the upper part of Kahler Creek passes the zeolite location north of Spray (usually referred to as Burnt Cabin Creek, a tributary of Kahler Creek), we have chosen to call this location *Lower* Kahler Creek.

Zeolites occur for a considerable distance along the road. Indeed, they have been traced vertically to the top of the ridge that separates this stretch of river from the town of Spray. The basalts along the road cut lie only about 20 feet above the gray sediments of the John Day Formation. Commonly, the zeolite-rich rock in this region is to be found at the base of the flows just above the John Day Formation.

At the west end of the cut (about 100 yards west of MP 89) is found a large cavity (4 feet wide, 1 foot high, 6 feet deep) lined with small flat-topped stilbite, rhombohedral chabazite, and thin needles of mesolite. The rest of the cut to the east contains a quite different suite of minerals -- primarily analcime, natrolite, thomsonite and calcite with minor amounts of phillipsite and chabazite. It is this region which is of primary interest.

Most of the fibrous zeolites of Wheeler and Grant Counties are mesolite. The primary exceptions to this are the quarry at Monument and the road cut at Lower Kahler Creek. Natrolite normally forms very straight, inflexible needles (as at Monument). However, many of the needles at this new location are bent or arched, so that bunches of needles often straggle out like a badly-cared-for paintbrush. Curved needles and arches have been described from near Flinders Beach, Victoria, Australia by Henderson and Garland (*Min. Record* 17, pg 377-379, 1986), and have been observed at a few Northwest locations such as the Rainier Quarry. The suggested explanation of how such curved needles form is that they start out as very fine, hairlike crystals that are thin enough to be flexible, and are bent at that time by natural conditions, such as fluid flow or surface tension. Continued growth occurs by lateral accretion until the crystals are thicker and permanently curved. Internal strain caused by deformation of the crystal lattice then tends to cause further growth to occur tangentially, so that the arches formed are a series of straight crystals oriented similarly to the base crystal but growing off tangentially. Almost all of the crystals from Flinders Beach are of this type. Some such arches have been found at Lower Kahler Creek, such as that shown in Micrograph #10, but many of the natrolite crystals form individual bent needles with no evident tangential growth. Micrograph #9 illustrates at least two of this type of bent natrolites.

Another abundant zeolite mineral at this site is thomsonite. There appear to be at least three generations present. The first generation forms small fine-grained compact masses on or between analcime trapezohedra. The second generation forms somewhat coarser blades extending in bundles from the fine-grained thomsonite core. In a few cavities, the first generation has been dissolved away by etching to leave a hollow core. The third generation is most abundant, forming much larger blades. These crystals are often very well formed, and may be mounted on the natrolite that has formed out of the second generation clusters. The larger blades also tend to form in piles with random orientation. Though smaller than the blades from Whipple Quarry, they nevertheless make very attractive specimens.

The basalt in some places contains iron-rich pockets that have oxidized to a rich red. Cavities in the vicinity may show red natrolite needles due to an accumulation of material on their surfaces. The iron, however, seems to preferentially stain the third generation thomsonite, so that rich red blades can sometimes be found in the cavities around the iron-rich regions. Colored cavities are more red rather than the usual orangish color iron imparts to zeolites such as the stilbite at Mill Creek and the heulandite at Yacolt.

Considerable loose material lies around the base of the rock face and is well worth working through. The material containing the red stains is a softer rock that probably lies under the rubble in place. The cliff face itself is concave and rather dangerous at present, so care must be taken while collecting at this location.

The minerals present (in approximate chronological order) are:

Analcime is usually first to form, and appears to continue crystallizing throughout zeolite formation. Crystals tend to be scattered, colorless trapezohedra. Some of the first to form show signs of etching on their faces. Later generations, such as those that formed at the same time as generation three thomsonite, are tiny, water-clear, and usually scattered on the other minerals.

Thomsonite, at least the first two generations, seems to have followed the analcime. They often coat part or all of the earlier crystals as well as grow in the spaces between them.

Natrolite often grows in bunches from the second generation thomsonite. The crystals are clear and have pyramidal terminations. They are often scattered in haphazard directions, and grow off of each other producing branching. Many of the needles are curved. Some cavities contain only a few scattered needles while others are densely filled.

Calcite is occasionally present as a late mineral. Crystals tend to be complex and poorly formed. They vary in color from colorless through yellowish white to amber. Natural faces are much rougher than cleavage faces, and often show hairlike crystals of natrolite emerging.

Phillipsite and **chabazite** were found only in one boulder, associated with analcime, natrolite and calcite. The phillipsite formed a drusy lining on which analcime crystals grew. The chabazite is the twinned variety phacolite. It tended to be highly etched, and covered by tiny late-generation analcime trapezohedra. Etched chabazite crystals display interesting growth hillocks (from dissolution) on the surfaces of large flat faces and are highly corroded along the edges. Only shards of some chabazites remain.

Observed sequences of crystallization:

analcime>thomsonite 1&2>natrolite>thomsonite 3 - analcime>calcite
 analcime>thomsonite 1>thomsonite 2>analcime>thomsonite 3>analcime
 phillipsite>analcime>chabazite>analcime>(etching)>natrolite>calcite
 thomsonite 2&3>natrolite-analcime>calcite

Possible general sequence:

phillipsite>analcime>thomsonite 1>thomsonite 2>analcime>natrolite>analcime>calcite

VALLEY LANDFILL PIT, COFFIN BUTTE, BENTON COUNTY, OREGON

Donald G. Howard and Mike Sunde

A major garbage disposal experiment is underway at Coffin Butte, in the northern edge of Benton County, Oregon. The garbage is loaded into pits that when full are covered with plastic sheet that is held down with a layer of crushed rock. Pipes inserted into the decaying material will then tap the methane gas that is produced by decay for use in generating energy. Bit by bit, the hill near Coffin Butte is being torn down to be converted into covering material for the project. Most of this rock is flinty, solid material with no chance of mineralization. However, at one point, an underground streambed was uncovered where interesting mineralization had occurred. It is the purpose of this article to describe the mineralization of the material collected from the vicinity of this streambed.

The base rock is very black and flinty; it breaks only with difficulty. However, the action of the underground stream caused pieces to break off naturally, and many of these pieces were coated, often on all sides, with pyrite, calcite, heulandite, stilbite, apophyllite and clay. Mineralized surfaces were often many inches in diameter. The order of formation seems to be as follows:

Pyrite appears to be the earliest mineral to form. Cubes up to half a centimeter on a side often thickly coat surfaces. Each cube is generally composed of a number of slightly misaligned members that give the whole structure a rather irregular, haphazard overall appearance as if the faces were somewhat curved or wavy (see Micrograph # 11). Not all surfaces are heavily covered; samples coated with subsequent minerals (zeolites) sometimes show only a few scattered pyrite cubes among the other crystals.

Calcite was also an occasional early mineral. This generation is clear and very nearly cubic in shape. When covered with the subsequent clay layer, it is hard to distinguish from the coated pyrite.

Clay appears to have followed the pyrite. This was an inky black, fairly thick layer with a very velvety texture. It stuck tightly to the matrix rock, but apparently not so well to the pyrite, so that it came loose from the pyrite cubes. Specimens of shiny pyrite on a velvety black base are very attractive. The dark clay continued to co-form into the period of crystallization of the earliest zeolites.

Heulandite was the first zeolite to form. The crystals are small, glassy clear, and of the normal coffin-shape. They occasionally have tufts of black clay scattered over them. Heulandite may cover the earlier pyrite and calcite where the black clay is still intact; it does not appear to have formed directly on any of the metallic pyrite faces, indicating that the clay broke loose at a time well after mineralization had ceased.

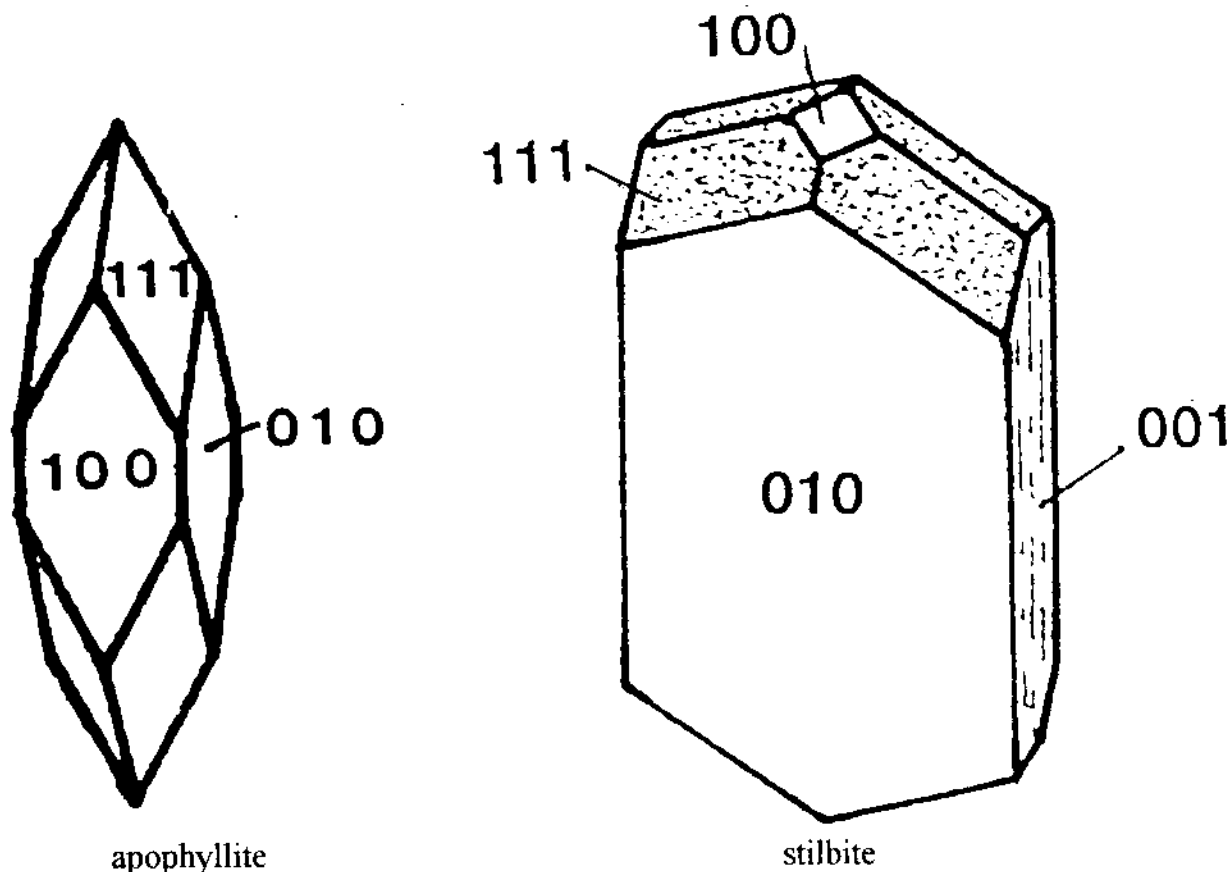
Stilbite is the next zeolite that formed, also as very clear crystals. The stilbite is in thin, pointed blades of the normal habit. These are sometimes widely scattered, and at other times thickly coat surfaces. The stilbite is often coated in turn by a light-colored late-generation of clay.

Apophyllite appears to have formed next. These are tiny, water clear crystals that are easily missed during casual inspection. The crystals are elongated along the c direction, so that they appear sharply pointed with no c-face at all. Prism (100) and pyramidal (111) faces are the only ones present.

Clay again formed late in the sequence, tending to coat the earlier clear crystals. This clay is a light tan color and appears micaceous. Unfortunately, it gives many of the best formed zeolite specimens a rather dirty appearance.

Calcite formed again at the end of mineralization. These crystals are clear with fine-grained matte surfaces and are generally rhombohedral in shape, often in complex intergrown groups. Some very large crystals several inches across have been found.

Since there is a good deal of turnover in the operation, the site must be considered rather chancy for collecting at any given time. Further excavation of the region may turn up other subsurface watercourses that may contain interesting mineralization.



YUGAWARALITE -- a rare zeolite from Wolf Point, Cowlitz County, Washington

by
Rudy W. Tschernich

Yugawaralite, a rare calcium zeolite, is found in only a few localities in the world, principally in India, Iceland, Italy, and Japan. Until this year yugawaralite had been found in the Pacific Northwest only in one cavity at Yellow Lake, Olalla, British Columbia. On May 7, 1995 during the North West Micro Mineral Study Group field trip three cavities containing yugawaralite were found in several scattered loose boulders in the 200/237 Road Quarry, near Wolf Point, Cowlitz County, Washington. For information on other minerals in this quarry see the Micro Probe, V 7, No. 10, pp 2-10. At Wolf Point yugawaralite forms colorless to white flat crystals, generally 1 to 2 mm long with one that is 6 mm long, that resemble thin pointed stilbite or thin flattened heulandite (Figs. 1 -5). The asymmetrical termination of yugawaralite is distinctive (Figs. 1 & 2). It is glassy, has very poor cleavage and no pearly luster. Yugawaralite can be easily distinguished from stilbite and heulandite by its lack of cleavage but is very difficult to distinguish from all the other colorless to white zeolites in the field. Yugawaralite has a broad $b\{010\}$ face with many faceted faces on the edges $\{100\}$, $\{120\}$, $\{110\}$, $\{011\}$, $\{001\}$, $\{111\}$, and $\{1\bar{1}1\}$ (Figs. 1-5). Double terminated crystals are rare at most localities but are common at Wolf Point. Some crystals are composed of a combinations of faces that resemble an orthorhombic crystal (Fig. 5).

The following is a description of four rather unique specimens plus group of similar specimens that were found in one chunk of rock.

The first crystals of yugawaralite were found by Lanny Ream on a small loose chunk of altered iron stained basalt along the north edge of the quarry. The rock appears to be similar to rock that makes up an altered basalt knob situated at the northeast corner of the quarry. The basalt knob contains numerous cavities and veins lined with heulandite, stilbite, laumontite, and quartz as well as smaller amounts of epistilbite, mordenite, and scolecite. The yugawaralite crystals are in an open space in a white vein cutting the rock. The vein is lined with long, thin, white mordenite needles that are completely covered by heulandite crystals up to 6 mm long. On the heulandite are several thin, colorless, transparent, glasslike yugawaralite crystals, up to 6 mm long, 3 mm wide, and 0.5 mm thick with an orthorhombic crystal form (Fig. 5). These crystals are the largest yugawaralite crystals found in the quarry. The minerals in the yugawaralite cavity crystallized in the order: mordenite > heulandite > yugawaralite. Other veins in the altered basalt knob contain mordenite covered by heulandite but are covered with quartz crystals.

A second specimen of yugawaralite was found by Randy Becker in the center of a massive chunk of basalt along the northern edge of the quarry. It also appears to be from the altered basalt knob. This cavity was 2 inches across and lined with colorless sceptered quartz crystals, up to 10 mm long, thick white to colorless stilbite, colorless heulandite, and tiny colorless yugawaralite crystals one millimeter long. Heulandite first formed in the cavity and was covered with long prisms of quartz. Tiny rice-grainlike quartz crystals and the yugawaralite co-crystallized on the heulandite and larger quartz crystals. Stilbite followed by calcite formed after the quartz-yugawaralite phase. Probably much later,

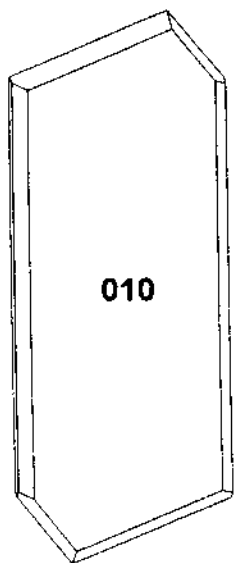


Fig. 1
Side view

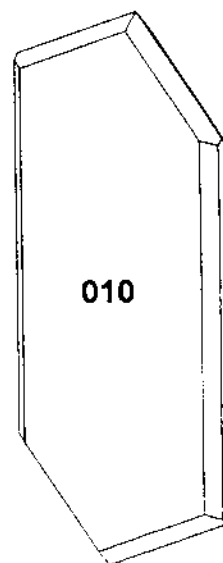


Fig. 2
Side view

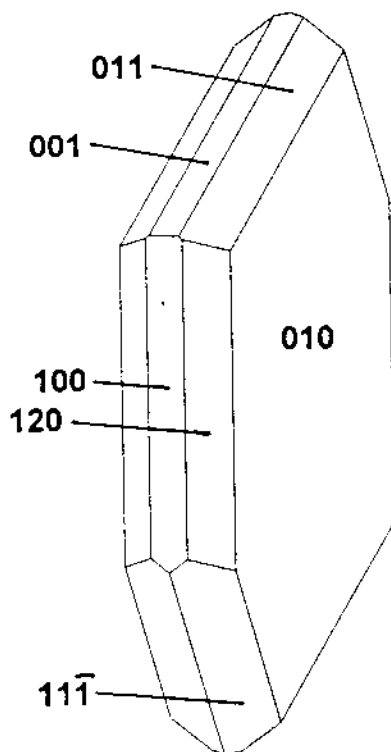


Fig. 3
Common forms

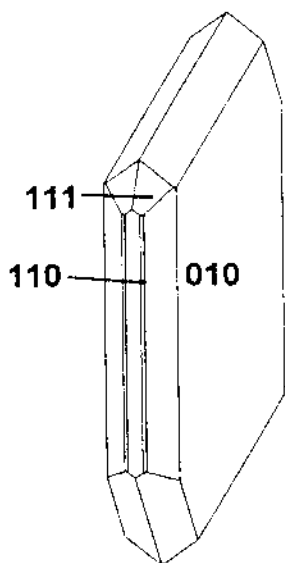


Fig. 4
Complex forms

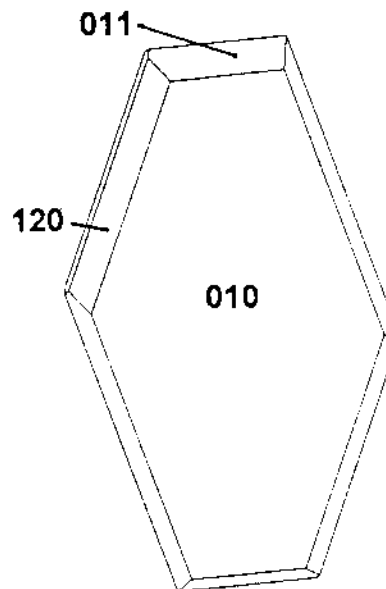


Fig. 5
Tilted crystal

during weathering of the rock, a dark brown manganese oxide coated some of the minerals. The minerals in this cavity crystallized in the order: heulandite > quartz prisms > yugawaralite-rice-grain quartz > stilbite > calcite.

Two yugawaralite-lined cavities were found in a dark black vesicular boulder over the north bank of the 200 road north of the quarry. This rock consists of numerous rounded smooth-walled vesicles lined with clay, scolecite, and laumontite and is typical of the rock that commonly produces the good scolecite specimens in this quarry. This particular rock also contained an abundance of levyne, epistilbite, and calcite. The first cavity containing yugawaralite in this rock was found by Randy Becker. It is one of the best specimens of yugawaralite found in the quarry. It consists of an abundance of milky-white to colorless pointed yugawaralite crystals, up to 2 mm long, covered with colorless dodecahedra of phillipsite, rhombohedra of chabazite, and white laumontite. The minerals crystallized in the order: yugawaralite > phillipsite > chabazite > laumontite. A second cavity later found by the author in the remains of the same rock contains tiny colorless yugawaralite crystals, up to 3 mm long, on heulandite. Stilbite and calcite clearly cover both the yugawaralite and heulandite. The minerals in this cavity crystallized in the order: heulandite > yugawaralite > stilbite > calcite.

On June 12, 1995 yugawaralite was found by the author lining small irregular cavities and veinlets in a loose chunk of soft, altered, greenish rock on the boulder pile in the quarry. Nearly all the cavities in this rock contain tiny colorless yugawaralite blades, up to 2 mm long, with white laumontite prisms. A few cavities also contain thin white mordenite needles, white etched analcime trapezohedra, colorless heulandite, white scolecite needles, and colorless chabazite rhombohedra associated with the yugawaralite. The mordenite needles first formed in some of the cavities followed by frosted yugawaralite crystals. Very rarely white analcime crystals are found between the frosted yugawaralite crystals. Rhombohedral calcite crystals covered the early-formed mordenite-yugawaralite-analcime in a few cavities and was followed by heulandite. A second generation of yugawaralite then formed tiny double terminated crystals on the heulandite and enlarged any yugawaralite crystals not already covered by heulandite or calcite. This second generation of yugawaralite forms brilliant, lustrous crystals occasionally containing phantoms of the early generation. In a few cavities colorless rectangular stilbite crystals cover the second generation yugawaralite. Laumontite is commonly found on all of the other zeolites. Drusy colorless chabazite crystals cover the second generation yugawaralite and laumontite in some cavities. At a much later time the calcite was partly or totally dissolved away revealing the mordenite, frosted yugawaralite and analcime, leaving a rhombohedral hole under the heulandite, late formed yugawaralite, and chabazite. The minerals that had been covered with calcite are covered with a reddish to maroon colored manganese oxide while crystals not covered by the calcite are clean and brilliant. Vitamin C rapidly removes the manganese oxide from the zeolites without harming them. The minerals in these cavities appear to have crystallized in the order: mordenite > yugawaralite > analcime > calcite > heulandite > yugawaralite > stilbite > scolecite > laumontite > chabazite > dissolution of the calcite. The combined sequence of crystallization in the yugawaralite-cavities from different parts of the quarry appear to be in the order: mordenite > yugawaralite > analcime > calcite > heulandite > quartz-yugawaralite-quartz > stilbite > scolecite > phillipsite > laumontite > chabazite > calcite.

Footnote: During the first week of July the 200/237 Road Quarry was blasted. The lake in the upper level of the quarry was drained and a large pile of highly broken up rock was left in the lower level of the quarry along with a large previous pile of rock. Most of the blasted rock was barren. Some contained veins of laumontite while the rock on the west side of the pile did contain vesicles lined with zeolites. By the middle of August all the loose rock had been removed from both piles of rock and used to surface logging roads. A few new boulders containing laumontite remain in the quarry and some vesicular rock is still present on the west side of the quarry but in general the quarry was cleaned out. The southern wall in the lower level of the quarry is barren. No cavities. No sign of white zeolites. The blast produced very few specimens and did more harm to the site than good.

ERIONITE from Wolf Point, Cowlitz County, Washington

by

Rudy W. Tschernich

Erionite was first found in the 200/237 Road Quarry, near Wolf Point, Cowlitz County, Washington on May 13, 1995 in a boulder containing numerous tiny round 1 to 2 millimeter vesicles and rarely elongated cavities up to 10 mm long. The erionite forms tiny, one-millimeter-long, silky, yellowish-white bundles of needles directly on the cavity walls or on lustrous pyrite cubes. Colorless transparent stilbite, heulandite, or levyne always completely covers the erionite needles and appears yellow-colored due to the color of the erionite crystals being transmitted through the colorless minerals. The stilbite crystals form a very thin parallel growth over the erionite needles. Blocky heulandite crystals cover erionite in other cavities. The most interesting erionite specimens are those that are covered by levyne. The levyne forms colorless plates and parallel growths, usually with the {0001} face showing, over the erionite. Unusual sets of levyne crystals are found covering scattered curved-ended bundles of erionite needles. The epitaxial nature of the two minerals require that the c-axis of the two minerals to be in alignment. Since the c-axis of the erionite bundle is radiating the levyne crystals that cover them also try to radiate and in so doing form an oriented cluster of levyne crystals that all reflect light of hexagonal or triangular c-faces in a curved pattern that matches the curved erionite bundle beneath. Additional levyne that grew in the cavities that was not directly in contact with the erionite is oriented in random directions. The minerals in the erionite cavities appear to have crystallized in the order: pyrite > erionite > heulandite > stilbite > levyne > calcite with no clay preceding the zeolites.

ERIONITE and ASSOCIATED MINERALS FROM OCEANSIDE, TILLAMOOK COUNTY, OREGON

by
Rudy W. Tschernich

Miocene volcanics rocks that are part of the Columbia River Basalt Group account for most of the spectacular headlands, cliffs, seastacks and arches found along the northern Oregon coast that extend from Tillamook Head (south of Seaside) in the north to Yaquina Head near Agate Beach in the south.

The headlands at Yaquina Head, Cape Lookout, and Cape Meares including the area near Oceanside, are the remnants of ancient volcanic islands that first flowed from fissures into an ancient sea 16 million years ago to form breccia and pillow lava. They were later covered with massive surface basalt flows and fragmental debris when the islands rose above the sea 14 million years ago. These rocks are equivalent in composition and age to the Grand Rhonde basalt so common in eastern Oregon and Washington. The rock is a silica-rich tholeiitic basalt near andesite in composition with areas that are full of vesicles lined with zeolites, calcite, chalcedony, and clay. Silica-rich zeolites such as erionite, silica-rich heulandite (= clinoptilolite), mordenite, and dachiardite along with lower silica zeolites phillipsite and chabazite are found on the clay. Erosion of this rock produces most of the agate found on Oregon beaches.

Zeolites were first collected in these rocks at a quarry near Cape Lookout in 1961 by John Cowles. Work in the early 1970's by the author produced excellent specimens of erionite, dachiardite, heulandite, and other minerals from Cape Lookout and Yaquina Head. At Yaquina Head one boulder was found by the author that contained spectacular balls of erionite that resembled "fish eggs" (See color photos C-5, C-7, C-12 in *Zeolites of the World*). The area at Oceanside was explored at that time but was not extensively worked since it appeared to contain only weathered and stained heulandite, mordenite, and erionite similar to the clean, fresh zeolites found in the quarries at Cape Lookout and Yaquina Head. In the spring of 1995 that Aaron Weiting brought to my attention some spectacular green erionite balls similar to those found at Yaquina Head that he had found in boulders on Tunnel Beach and Short Beach. This report deals with the occurrence of the zeolites in the Oceanside area which includes the beaches and cliffs extending from Oceanside in the south to Cape Meares in the north (see map).

In the north, zeolites are found in rounded beach basalt that has eroded from the nearby cliffs along Short Beach, just south of Cape Meares. To reach the site, proceed from Oceanside, along the Three Caped Road, 1.1 miles to 3.5 mile post and park at the low point along the road. Short Creek drains a small lake east of the road down to the beach on the west side of the road. A steep trail along the creek leads to the rocky beach below. If you miss the parking spot, 100 feet north of the creek, Radar Road turns to the west. Further up the road an active barren quarry is located along the road 0.6 miles from the creek. Erionite, heulandite, mordenite, chabazite, phillipsite, chalcedony, and pyrite are found in the beach rock near the base of the trail and around the basalt cliffs to the south. A basalt hill or sea stack just off shore from the base of the trail is filled with colorless chalcedony nodules. Boulders to the far north along the beach nearest Cape Meares contain an abundance of heulandite, mordenite, calcite, and chalcedony.

South of Short Beach, beyond the rocky cliffs, is an unnamed beach I will call Isolation Beach because it is very difficult to reach even with minus tides. Both ends of this beach are protected by cliffs allowing access to the beach only for a short time at very low tides. Although zeolites probably are present, an extreme danger of being stranded by the incoming tides exists.

The best zeolite collecting is in the seacliffs and boulders along the beach north of the tunnel leading through the basalt headland (Maxwell Point) at the town of Oceanside. To reach this area park at the Oceanside Beach parking lot and walk 1/4 mile north along the beach to the base of the basalt headland. Notice the well exposed pillow basalt at the base of the cliff. The best zeolites are found in a flow just above the pillow basalt. At low tide you can walk around the headland but you must remember that you can be quickly cut off by the water and the cliffs are too steep to climb. At high tide the water extends all the way to the base of the cliffs along Tunnel Beach. A 120 foot tunnel was dug through Maxwell Point above the high tide line to allow access and retreat during high tide but unfortunately a rock and mud slide from faulted and brecciated rock above the tunnel covered the southern entrance. Although still officially closed, the tunnel has been partly dug out. The first 15 feet of the tunnel is only 2 feet high and requires an unpleasant crawl but from then on it becomes its normal cramped 5 feet high. Always keep your head down. I normally use the tunnel to reach the beach and cliffs a couple of hours after high tide. I then do my collecting, trimming, and wrapping of the zeolites and wait for low tide (positive one foot or lower) to pack out the rock. The beach next to Maxwell Point changes daily. At times the sand has been eroded away and a deep water-filled trench is present near the base of the cliff making it impractical to walk around the point unless you have a minus 2 or greater tide. Other times the sand is piled high near the base of the cliff and you can easily walk around even at a (positive one foot) low tide. Check a tide table before collecting in this area. Dragging a full pack of rocks and tools through the tunnel is no fun at all.

Once you reach the beach you can start looking for rounded vesicular beach boulders that contain cavities lined with white minerals. Exposed cavities have been sand blasted and any exposed crystals are damaged. A 4 to 6 pound hammer is required to break the rock for it is very hard and brittle. Collecting in the cliffs is recommended and can be very productive but for the greatest variety of species the boulders are best. On my first collecting trip to this area I found a 300 lb. boulder partly buried in the sand that showed radiating groups of erionite up to 15 mm across on its surface. I proceeded to break it up and with darkness and high tide approaching, packed out what I could through the tunnel. I left about 50 lb. of broken up rock which contained nice erionite balls and the remaining large 150 lb. boulder for the next morning when a low minus 2.8 tide would allow me to use the packboard to remove the remaining rock around the cliffs. Arriving at 6:30 am, the next day I quickly made my way to where I had left my treasure. It was gone! Mother Nature had played a dirty trick. Not a trace of the big boulder remained. Just a nice thick layer of sand. After some searching I found a few scattered pieces I had broken off the boulder but even one night of rolling in the surf partly rounded the rock and sand blasted any exposed crystals. I learned my lesson. Never leave specimens on the beach. The 150 lb. boulder was never found. It's the one that got away. The wave action does have its

way of cleaning the beach. After a days work barring rock from the cliffs and breaking them up the next tide will remove them making it look as if no one had been there.

The most abundant zeolites are silica-rich heulandite, mordenite, and erionite while chabazite and phillipsite are scarce. Dachardite that was previously reported from area was found to be only white groups of erionite. Pyrite and gryolite are also present. The minerals crystallized in the order: black clay > pyrite > chalcedony crust and hemispheres > green erionite > white erionite > heulandite-mordenite-heulandite > chalcedony > phillipsite-chabazite > calcite.

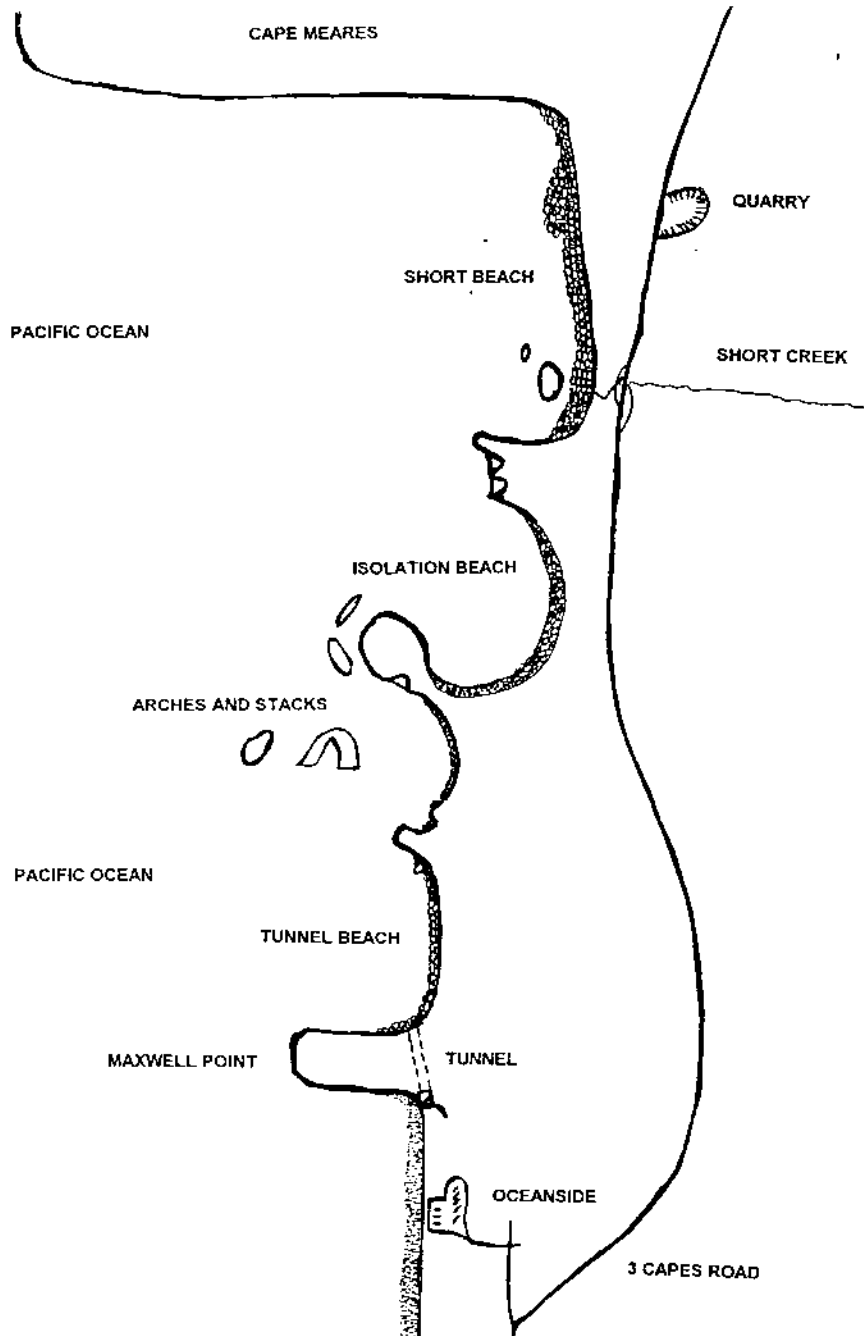
A thin colorless crust of chalcedony or scattered, colorless, dull-surfaced hemispheres of chalcedony cover the clay-lined walls in most cavities. In many of the cavities brilliant pyrite cubes can be seen between the clay and the transparent chalcedony crust. Erionite, mordenite, and heulandite are found on the chalcedony. The first zeolite to crystallize is erionite. In it's early stages of growth, the erionite formed radiating groups of long colorless prisms or needles that combine into smooth-surfaced, lustrous, compact hemispheres, up to 10 mm across. Many of these erionite hemispheres are filled with clay inclusions that impart very attractive shades of lemon yellow, light yellow-green, dark green, and golden brown color. Following the early compact colored erionite hemisphere phase, erionite formed silky white bundles and radiating fans, up to 15 mm long, either growing on the chalcedony hemispheres or extending the size of the early-formed colored erionite hemispheres. When the colored hemispheres are overgrown with the white generation of erionite, the surface of the aggregate is no longer smooth and lustrous due to different rates of growth for each needle. The irregular surface appears milky or frosted. In some cavities the thin white needles of erionite have used the hemispheres of chalcedony as nucleation sites and formed spikes on the chalcedony balls. Some of the erionite also forms flared bundles of needles that are wider at their termination than at their base. Continued growth of the erionite completely covers the chalcedony. The white erionite needles are silky white when viewed on their sides but are dark when viewed down the end of the group of needles. They resemble a bundles of fiber optic filaments. A simple hexagonal prism is not often observed due to the small size of individual needles and irregular twinning of the prisms. The brilliant green balls of erionite hemispheres are particularly attractive when surrounded with the silky white erionite needles.

After the two phases of erionite growth, mordenite crystallized. It formed tiny short white needles, only 1 or 2 millimeters long, covering the exposed chalcedony crust and chalcedony hemispheres. It also totally encrusts many of the white fan-like groups of erionite but for some unknown reason does not crystallize on the compact smooth-surfaced erionite. Mordenite also forms snow-white aggregates that resemble tiny cotton balls, only a few millimeters across, and usually cover the white erionite needles.

Colorless to light-green blocky silica-rich heulandite crystals, up to 3 mm long, often form attractive aggregates, up to 10 mm across, and are commonly associated with small white mounds of mordenite needles. Most of the heulandite crystallized after the mordenite. The color white of the mordenite clearly seen through the colorless heulandite; however, some of the heulandite crystals contain a dark center that indicates it started crystallization before the mordenite.

Colorless rhombohedra of chabazite, up to 8 mm across, are rarely found lining some cavities or covers erionite. Blocky colorless phillipsite crystals, up to 3 mm long, are found

on erionite in few cavities. Filiform or octahedral pyrite is very rarely found on the zeolites. A few cavities contain thin, white, micaceous, hexagonal plates and aggregates of gyrolite on the erionite. In addition to the thin crust of chalcedony that predates zeolite crystallization, colorless spheres of chalcedony cover erionite, mordenite, and heulandite and completely fills some cavities. Colorless chalcedony commonly fills cavities that do not contain zeolites. When weathered from the basalt this chalcedony becomes the beach agate commonly found in this area.



MILL CREEK QUARRY, BUELL, POLK COUNTY, OREGON

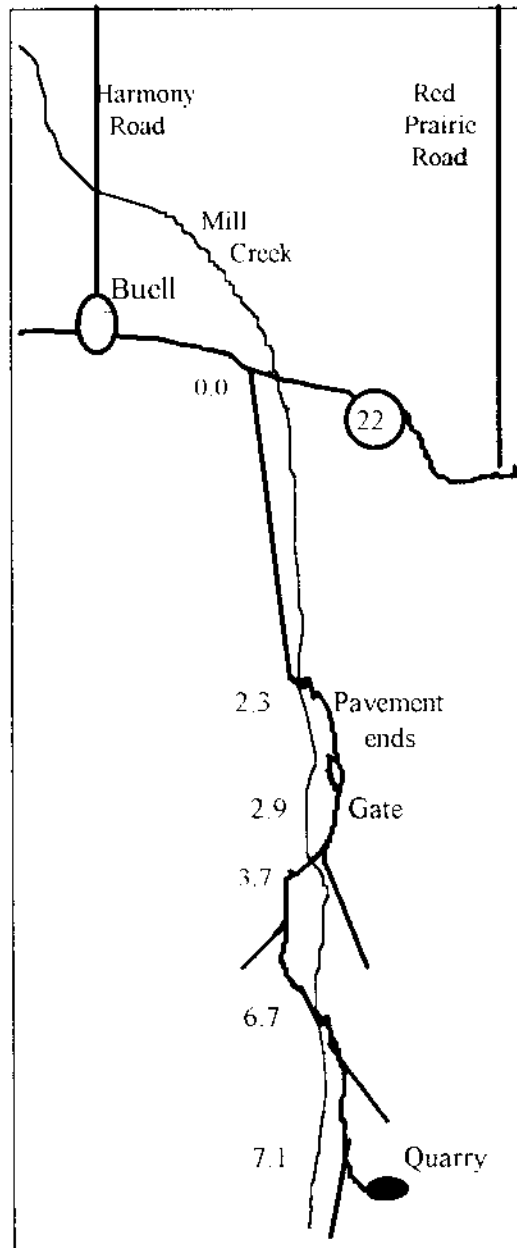
Donald G. Howard

The Quarry on Mill Creek has been a popular collecting spot for a number of years. During the early 1980's, the Northwest Micromineral Study Group had a field trip to the location. In the intervening years, Willamette Industries has continued to use the quarry on a limited basis, so that the amount of exposed rock has increased. With the continued exposure, the collecting has actually improved.

The intersection that is called Buell on the map is located about 10 miles south of Sheridan, in the northernmost part of Polk County, Oregon. State Highway 22 crosses Mill Creek just east of Buell. Mill Creek Road goes up the west side of the creek initially. It is well marked because of a county picnic ground.

The road is paved for a little over 2 miles, providing access to the picnic area. Shortly beyond that point, the road becomes the mainline logging road for Willamette Industries. At that point there is a turn-around area and a yellow gate, which is normally open. The mainline continues along the creek, crossing it twice before reaching the access road to the quarry, which branches off to the left approximately 7 miles from the turnoff from highway 22. There is a locked yellow gate on the beginning of the access road, but plenty of room to park. The quarry is only about 1/4 mile up the access road through a stand of timber that has not yet been cut.

The original collecting area is still present at the front of the quarry. It is in a brownish, altered rock. Although numerous zeolite cavities occur in this rock, most are almost completely filled, and much of the stilbite filling them is pale to white. This band of altered rock continues eastward into the newer, deeper part of the quarry, where a blacker, much harder basalt is exposed beneath the altered layer. The altered layer continues to



have considerable evidence of mineralization, but the stilbite continues down into the upper zone of the darker rock. Here the cavities are only partially filled, and the stilbite has an excellent orange color. Good cavities seem to run in pockets.

The best specimens from Mill Creek Quarry are those with clusters of glassy quartz perched upon the bright orange stilbite. A few cavities have calcite crystals as well or instead of the quartz. The variety of minerals present is very small, but outstanding specimens can be obtained up to an inch or more in diameter. The cavities are clearly elongated, with many being about as big around and as long as a finger. Such elongated cavities usually result when there is flow in the basalt during the degassing that forms the cavities.

Minerals present, in the approximate order of formation:

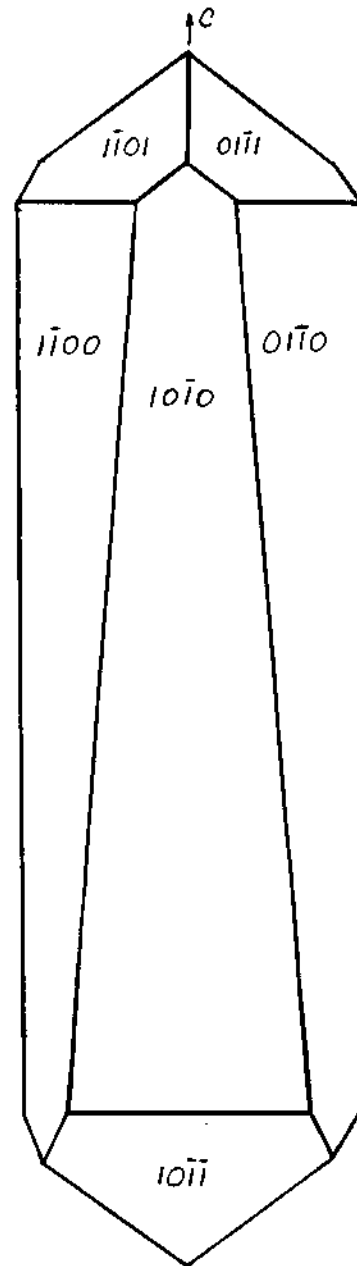
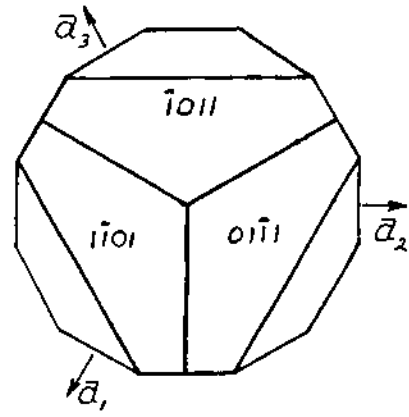
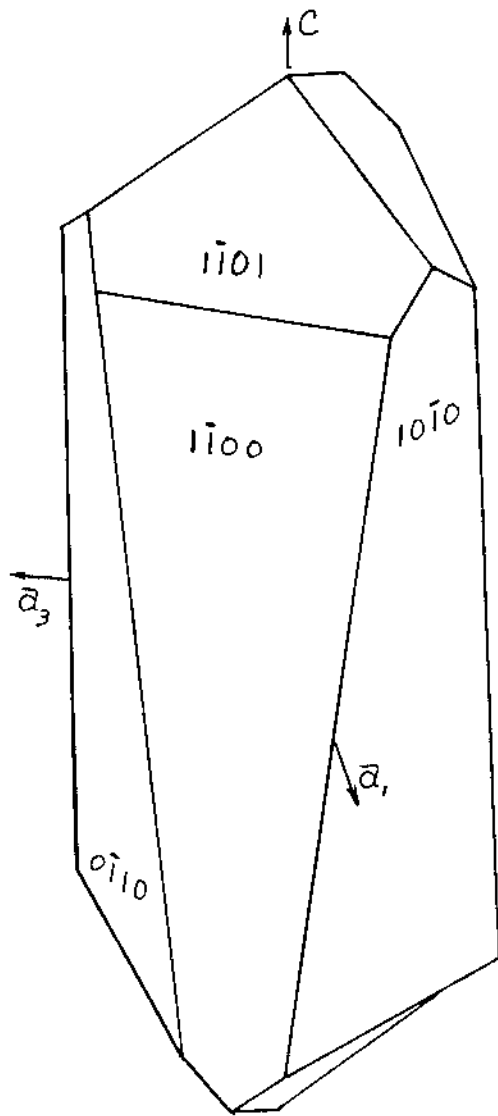
Stilbite is the only zeolite present in this quarry. The earliest material to form was colored a bright orange by iron impurities. Later formation was paler, grading to white. The orange crystals tend to be quite clear and transparent, with no evidence of other zeolite inclusions. A clear, colorless layer may form the outside of most of the larger crystals. The whiter material tend to be much less clear, tending to milkiness. In shape, the crystals are the standard form of pointed terminations at the end of thin prisms. The stilbite alone makes attractive specimens because of the intense color.

Quartz was a later mineral that formed upon the stilbite. The quartz appears to have begun as glassy masses with a radiating structure. Such masses often exhibit a surface of very rough, fine points. Very often one or more larger crystals grow out of the top of these masses. In the case of groups, one crystal is usually larger than the rest, and the whole set shows parallel orientation. An occasional scepter has been found.

The terminations of the quartz are in the form of a pyramid of only three sides. The prism beneath starts out below the termination with three of the sides much better developed than the others. However, the sides tend to be somewhat rough and taper, so that the three well-developed sides narrow, and the poorly developed sides grow wider until at the bottom they dominate. Since most of the crystals radiate out from their base, the other termination is only occasionally visible; it is most easily studied in the scepters. These show that the other termination is also three-sided, but twisted 60° from the termination at the top end. These crystals clearly show that quartz is a rhombohedral mineral rather than a true hexagonal one.

Clinochlore is present in some of the cavities. The iron present has often been oxidized so that the material has a dark, rusty appearance, and the layers are often exfoliated due to dehydration. This material is more of an annoyance than an attractive asset in specimens. Sometimes very tiny calcite crystals can be seen growing out from between the spreading layers of the exfoliated clinochlore.

Calcite appears to be the last mineral to form. Crystals are in the form of rather steeply pointed rhombohedrons, some simple and some with numerous beveled edges and corners. Calcites in the fresher, darker rock are clear with smooth faces. In the more altered rock, the calcite tends to show etching on the surfaces. Calcite is much less common than quartz in the cavities.



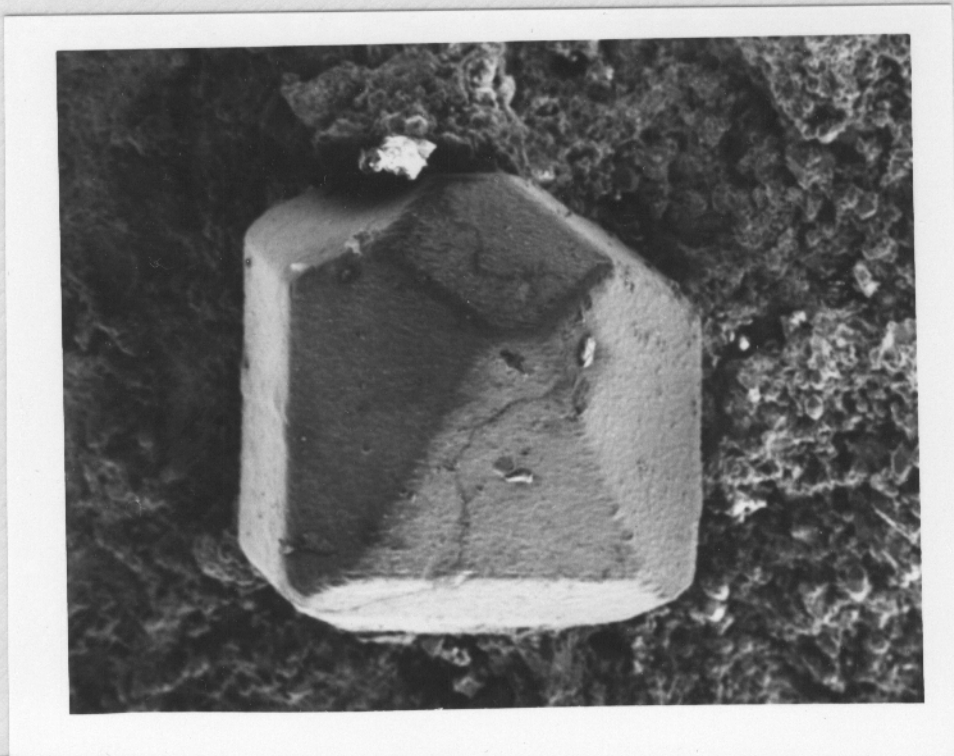
**Quartz Crystal
Mill Creek Quarry**

The lower symmetry than usually seen in quartz clearly indicates the rhombohedral habit of the mineral

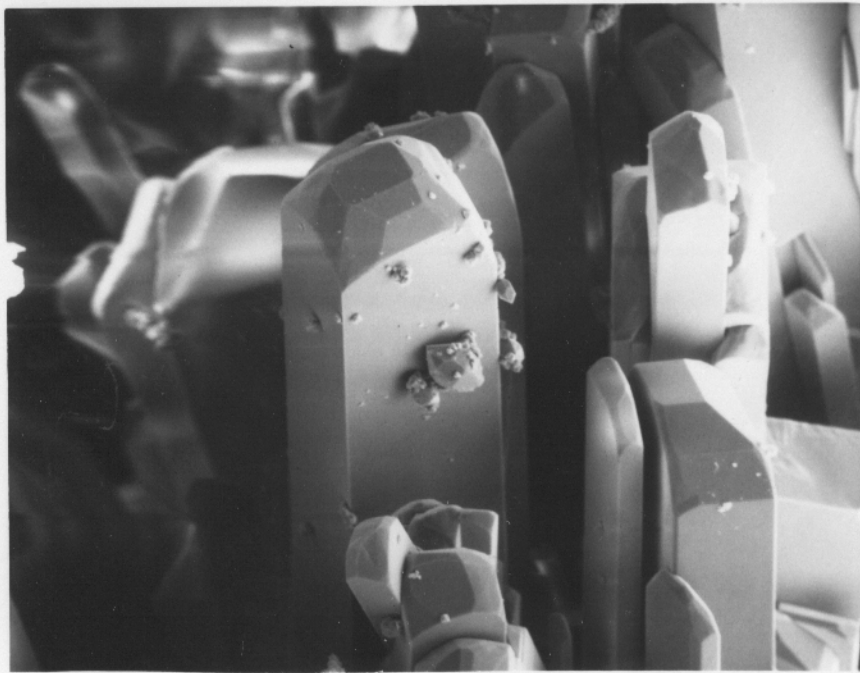
Compare to Micrograph #8.



#6 - METAVARISCITE, VARISCITE - UTAHLITE CLAIM, LUCIN, BOX ELDER COUNTY, UTAH - 55X



#7 - VARISCITE - UTAHLITE CLAIM, LUCIN, BOX ELDER COUNTY, UTAH - 150X



#8 - MINYULITE - UTAHLITE CLAIM, LUCIN, BOX ELDER COUNTY, UTAH - 450X



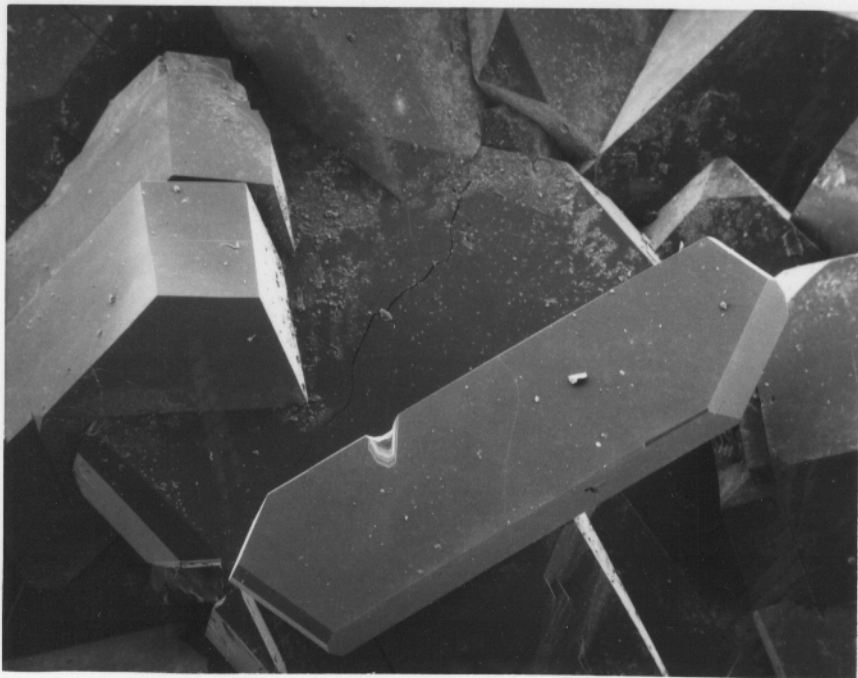
#9 - NATROLITE, THOMSONITE - LOWER KAHLER CREEK, SPRAY, WHEELER COUNTY, OREGON - 12X



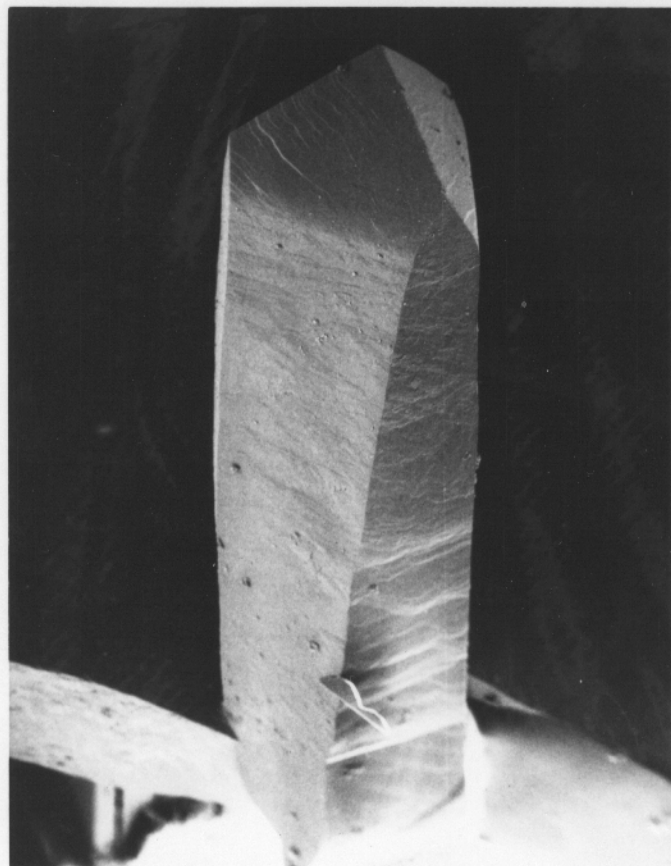
#10 - NATROLITE, THOMSONITE - LOWER KAHLER CREEK, SPRAY, WHEELER COUNTY, OREGON - 70X



#11 - PYRITE, STILBITE, HEULANDITE - VALLEY LANDFILL, COFFIN BUTTE, BENTON COUNTY, OREGON - 16X



#12 - YUGAWARALITE, HEULANDITE - WOLF POINT QUARRY, COWLITZ COUNTY, WASHINGTON - 60X



#13 - QUARTZ - MILL CREEK QUARRY, BUELL, POLK COUNTY, OREGON - 60X