

Northwest
Micro Mineral
Study Group



MICRO PROBE

SPRING, 1997

VOLUME VIII, Number 5

SPRING MEETINGVANCOUVER, WASHINGTON

May 3, 1997

9:30 am to 6:30 pm

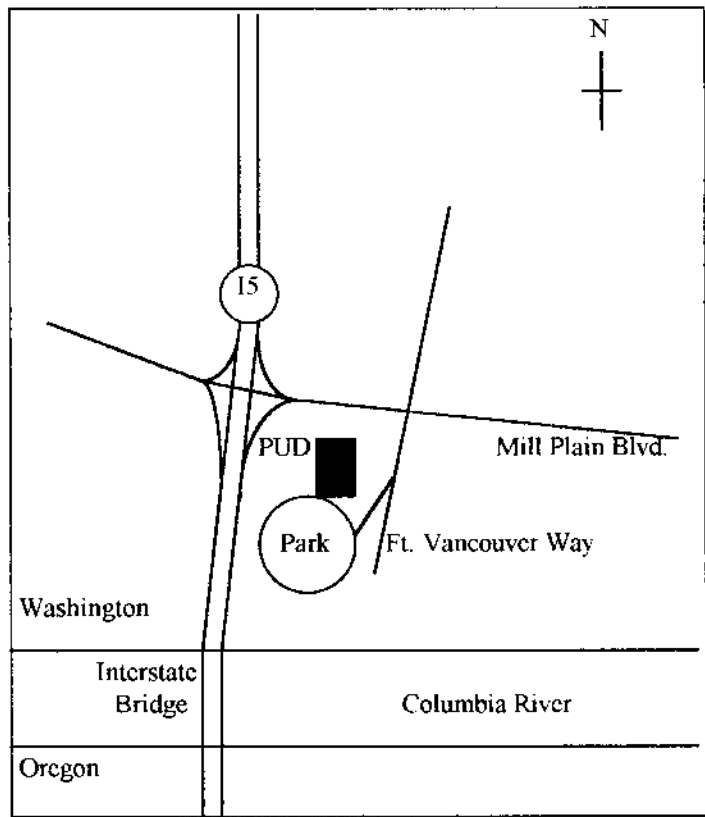
**Clark County P. U. D. Building
1200 Fort Vancouver Way
Vancouver, Washington**

The Fort Vancouver facilities are our regular home once again. Bring your microscopes and something for the free table to share with others, as well as your special new finds and your unknowns to be identified. We will have our usual brief business meeting in the afternoon, to be followed by our update session to find out what localities are actively producing material and are good bets for collecting trips. Weather permitting, we will plan an outing for Sunday at that time. No special speaker has been planned, but if you have slides of mineral specimens or collecting localities that you would like to share, bring them along; we will have a projector and screen waiting. There should be ample time to enjoy looking at each other's special pieces, and swapping information about collecting.

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 for lunch and during the day. However, there will be

NO POTLUCK DINNER

in the evening. Restaurants are available in the local area.



MINERALS OF THE CANWOOD CONSTRUCTION SITE, AGOURA HILLS, CALIFORNIA

Fred DeVito

INTRODUCTION

During the latter part of 1984 and the beginning of 1985, the Heller Construction Company of Westlake, California leveled a small hill on a 14 acre site for a commercial complex. The location is in Agoura Hills (formerly called Agoura) in the extreme western part of Los Angeles County about 3 miles from the Ventura County line (See figure 1 below.). The old Kanan Road Quarry, which produced much clinoptilolite and ferrierite during the 1960-1970 time period, is about 2.5 miles to the south. At the Canwood site 150,000 cubic yards of overburden were bulldozed off the surface and 100,000 cubic yards of rock were blasted and either removed or graded to make room for the Canwood Business Center. After the leveling more blasting took place for the trenching needed for pipelines. All of the rock removed from the site was taken to several fill sites in the Agoura Hills area, and mineral collectors can still find minerals in some of them today.

The blasting methods at Canwood consisted of vertical drilling to 12 feet and packing the holes with slow release, low vibration explosives because of the nearby homes. The explosive charge would fracture the rock and bulldozers would push it up into large piles where trucks could haul it away. Unfortunately, this method of rock removal makes it difficult to accurately determine the geological and mineralogical relationships.

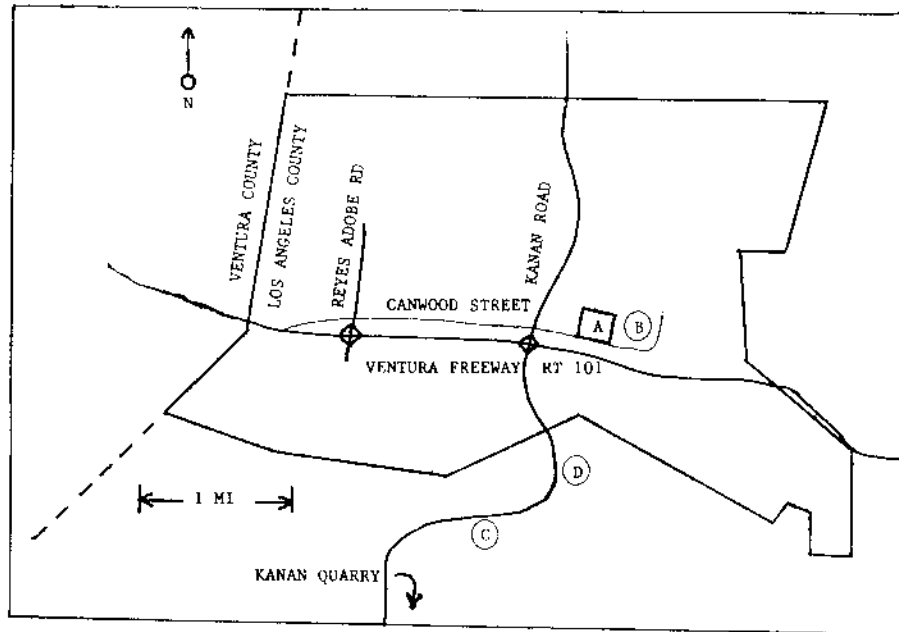


Figure 1. Map of the city of Agoura Hills, Los Angeles County, California

- A. Canwood Site, now the Canwood Business Center
- B. Rock Dump form the Canwood Site: Phillipsite-rich andesite. Now covered over..
- C. Rock Dump form the Canwood Site: Andesite containing zeolites. Open to collecting.
- D. Rock Dump form the Canwood Site: Andesite containing calcite, quartz, pyrite. Open.

GEOLOGY

The rocks in the Agoura Hills area are part of the Conejo Volcanics of middle Miocene age, and consist of brecciated marine basalts and andesites on a siltstone, clay and sandy shale base. Alternating andesite breccias and basalt breccias with mudflow breccias, flows, and pillow breccias are common (*Yerkes*). The rock exposed at the old Kanan Road Quarry is a brecciated porphyritic andesite, composed of microphenocrysts of plagioclase and hypersthene set in a glass-rich groundmass. The mineralization occurs in voids in saponite-covered calcite cementing the brecciated fragments. The early precipitation of calcite probably allowed the silica-rich and alkali-rich zeolites to crystallize from water percolating through the breccia (*Wise, Nokleberg & Kokinos*). The geology and mineralogy of the old Kanan Road Quarry is nearly identical to that of zone 2 at the Canwood site (see figure 2). The one exception is the increased number of zeolite species present at Canwood.

The Canwood site appears to be a series of andesite flows, as shown in figure 2, beginning with an intermediate volcanic tuff containing considerable glass which was devitrified and altered to clays and zeolites (zone 3 in figure 2) (*R. W. Thomssen, Pers. Comm.*). The andesite tuff was subsequently covered with a gray-black brecciated glass-rich porphyritic andesite (zone 2 in figure 2). The last flow, a dark dense glass-rich brecciated basaltic andesite, contained large pockets of quartz and calcite, but was devoid of zeolites. This rock, designated zone 1, made up about 60-70% of the rock at the Canwood site. The decrease in the influence of activity of water on the andesites can be seen going from zone 3 > zone 2 > zone 1.

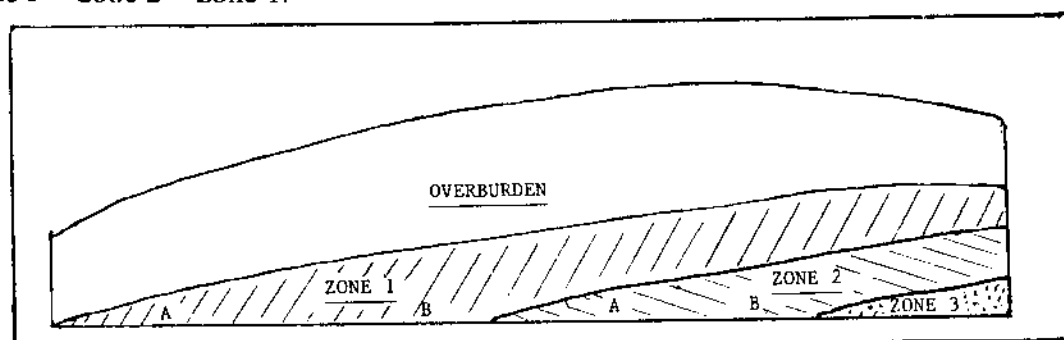


Figure 2. Canwood Site looking north at the exposure excavated. Blasting and rock removal was from west to east (left to right). Approximate horizontal distance is 500 feet. Vertical distance is exaggerated.

Zone 1 : Dark dense glassy andesite, with large calcite pockets. No zeolites. Last flow.

Zone 2 : Brecciated porphyritic andesite, with much glass and many zeolites.

Zone 3 : Andesitic tuff that is phillipsite and offretite rich. The first lava flow.

MINERALOGY

The Canwood site has produced over 23 different mineral species, including at least 8 different zeolites. Many of these species had not been found in the Agoura area before, and one (offretite) had not been reported from California prior to the Agoura find. Equally surprising is the number of Agoura species that have not been found at Canwood. Barite was very common at the Kanan Road Quarry in association with ferrierite and clinoptilolite, and yet was never found in the similar environment at Canwood. Cristobalite and celadonite on

mordenite were common at the Reyes Adobe site a mile up the road, and yet cristobalite has not been found at Canwood, and celadonite is considered rare. Other Agoura area minerals not found at Canwood are gyrolite, prehnite, natrolite and thomsonite, although the latter two species prefer a less siliceous environment and basalt does not appear at Canwood.

An interesting feature of the Canwood zeolites in zone 2B is the melted appearance of some of the crystals, with many occurring in the same cavity with perfect, sharp, euhedral crystals of the same species. The crystals in the center of the growth are euhedral and at right angles to the matrix, but become flat and prostrate parallel to the matrix, and then become formless like opal, creating a glassy coating less than 1 mm thick around the perimeter. This condition occurs with some of the analcime, clinoptilolite, chabazite, dachiardite and ferrierite, and may be due to slower cooling toward the center of the mass.

Mineralogical changes from west to east (zones 1 - 2 & 3) and their approximate crystallization sequences are as follows:

Zone 1A - Calcite-quartz-opal-pyrite in large cavities

Zone 1B - As above with much more pyrite, plus siderite and hematite (turgite).

Zone 2A - (Calcite-saponite-clinoptilolite & ferrierite-mordenite-opal) (phillipsite-analcime)

Zone 2B - As above with dachiardite & chabazite forming with clinoptilolite & ferrierite.

Zone 3 - Phillipsite-offretite-calcite-smectite.

ANALCIME Analcime is the most common zeolite at Canwood and occurs in all zeolite areas as sharp, clear, trapezohedral crystals. Many crystals also display cube faces. The best analcime occurs in zone 2 as clear crystal groups and individual crystals to 4 mm on dense white mats of minute intergrown phillipsite crystals. The analcime is so clear that without reflection from the faces only the phillipsite is obvious. Some of the analcime exhibits a melted appearance and coats the phillipsite in an opal-like manner. Analcime also occurs in zone 2 with clinoptilolite and prismatic phillipsite on yellow calcite in veins in breccia. Analcime is of limited occurrence in zone 3 in the phillipsite-offretite vesicles.

APOPHYLLITE Small white bipyramidal crystals occur in zone 2A. The crystals appear to have been replaced by silica and are found with analcime. Although apophyllite is common in the basalts south of Agoura, it would have to be considered rare at Canwood.

ALBITE Minute flat albite crystals coat many of the amygdaloidal cavities in the andesite. Most albite has been covered by successive mineralization.

ARAGONITE Transparent to white radiating sprays of sharp crystals, resembling a zeolite, have been found in zone 3. These coat fractures in the harder parts of the tuff. The aragonite forms directly on the dark andesite, making a striking contrast.

CALCITE Unquestionably the most common mineral at Canwood, calcite is one of the first minerals to form, and in some cases, also the last. It is common in all zones except zone 3. **Zone 1** - Calcite occurs as steep rhombohedral crystals to 3 cm that have prominent triangular (m) faces. The crystals are yellow in color, and form on intergrown quartz crystals in gas pockets up to 3 feet across. Calcite also occurs commonly as yellow pseudo-cubic rhombs with clear, doubly-terminated quartz crystals perched at 45° on the tops of the rhombs. In

some pockets the yellow rhombs have clear lenticular calcite covering their tops. These make very showy specimens. In zone 1A, deep orange scalenohedral crystals to 5 mm are found with pyrite crystals.

Zone 2A & 2B - Scalenohedral calcite crystals covered with black saponite are the matrix for the majority of the zeolites in these zones. In the saponite-free area yellow calcite makes an attractive matrix for phillipsite, analcime and clinoptilolite. Calcite also occurs with pink phillipsite and pyrite as gray-white scalenohedrons that have been replaced by chalcedony.

CELADONITE This species would have to be considered uncommon at Canwood, although it is very common in other Agoura area andesites. At Canwood it occurs in zone 1 as sea-green micaceous coatings in amygdoidal cavities as the first mineral to form, followed by chalcedony and siderite. It also occurs as closely packed green needles coating saponite, occasionally with sphalerite, and sometimes as a replacement of a mineral resembling tridymite.

CHABAZITE In zone 2B, clusters of clear, colorless, intergrown, twinned, rhombic chabazite to 8 mm are moderately common, associated with ferrierite, clinoptilolite, dachiardite, mordenite, chalcedony and opal on a black saponite matrix. The crystals closely resemble willhendersonite but were determined to be chabazite. Chabazite occurs in another part of zone 2B as clusters of crystals to 5 mm with calcite and pyrite on a glassy andesitic breccia.

CLINOPTILOLITE Sharp crystals to 8 mm showing flat, striated b-faces (010) are quite common in zone 2A, with calcite, analcime and philipsite. In zone 2B, clinoptilolite occurs very commonly as clear, well-developed crystals to 6 mm in association with ferrierite, dachiardite and mordenite on a black saponite matrix. Some specimens grade from euhedral crystals to opal-like coatings (as described in the mineralogy section of this report). A cross-section of this habit is shown in figure 3.

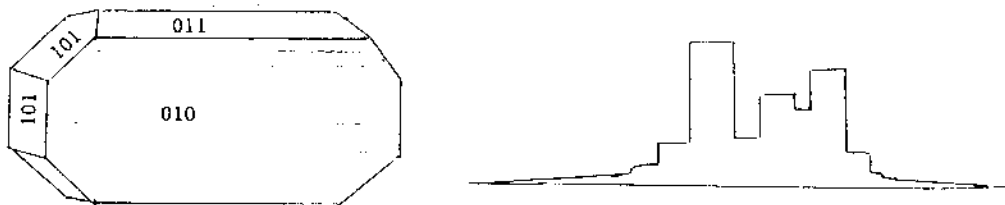


Figure 3 Clinoptilolite, showing the thin tabular habit (at left) similar to photograph #17. (right) Crystal group cross-section showing the glassy, formless edges.

DACHIARDITE Dachiardite is found only in zone 2B, mainly as gray-white translucent brush-like crystal groups associated with ferrierite, clinoptilolite, mordenite, chabazite, pyrite and occasionally sphalerite and saponite-covered calcite. Dachiardite also forms as radiating brushes, single and double sheaves, and bladed masses of crystals (see figure 4). The morphology is very similar to that of the Altoona, Washington dachiardite. Very showy

combinations of white sprays of dachiardite with white radiating ferrierite and filamentous mordenite on black saponite are not uncommon (see photograph 18). On several specimens, mordenite forms nests in which the brush-like sprays of dachiardite sit. On one dachiardite and clinoptilolite specimen there are about 36 dachiardite brushes on a square inch of surface area. Lath-like crystals are also common, with some showing bowties and some grouped together in a random arrangement.

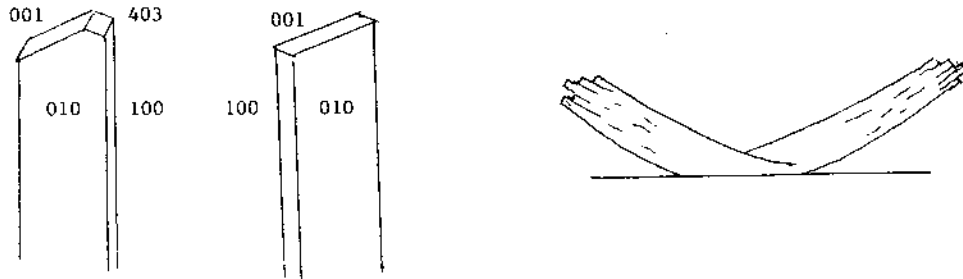


Figure 4 Dachiardite morphology (after Tschernich)
left and center: Usual forms *right:* lath-like bowtie, showing terminal development.
 These were common at Canwood, as were brush-like bowties.

FERRIERITE White radiating balls of thin crystals of ferrierite on a black saponite matrix are very common in zones 2A and 2B. The balls are up to 5 mm in diameter, and form botryoidal groups up to 2 cm across (see photograph #19). Ferrierite also forms bowties as well as crystals laying flat on the saponite matrix that resemble hydromagnesite (see the left diagram in figure 5). Attractive examples of ferrierite bowties partially to completely covered with balls of opal and blue chalcedony are also common. Below the base of the zone 3 andesite, white fibers in the siltstone were determined to be ferrierite. Unlike the ferrierite from the old Kanan Road Quarry, the Canwood ferrierite fluoresces and phosphoresces a bright pale blue under both short-wave and long-wave ultraviolet light. Approximately 100 specimens were checked from different parts of zones 2A and 2B, and every one had the same response and intensity. The fluorescent activator has not been determined as yet. Small groups of very thin, white, bladed crystals of the monoclinic variety of ferrierite are found with mordenite in zone 2B.

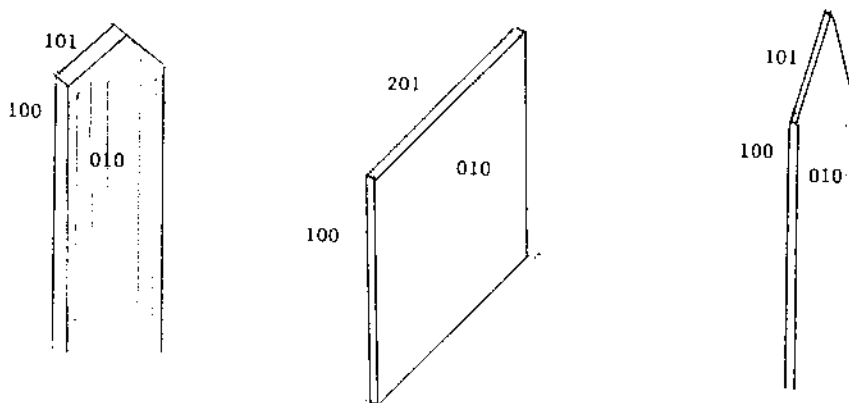


Figure 5 Ferrierite.
left: common bladed form *center:* unusual monoclinic form (Tschernich)
right: Acicular form found in the ball-like clusters of crystals.

GOETHITE Small reddish-black sprays and spheres of goethite occur in zone 1A with balls of opal and quartz crystals on yellow intergrown calcite rhombohedra. Goethite is not common at Canwood, although it is very common at the nearby Reyes Adobe site.

GYPSUM Clear, brilliant, well-formed selenite crystals occur with limonite, jarosite and hisingerite on altered andesite near the clay-siltstone base. Large masses of crude selenite crystals to 8 inches across are common in the siltstone.

HEMATITE the variety turgite is very common in zone 1B, forming brilliant, iridescent masses on pyrite-rich calcite veins. The turgite forms masses up to a foot across and is very conspicuous from 50 to 100 feet away.

HISINGERITE and JAROSITE *See Gypsum.*

MORDENITE In zones 2A and particularly zone 2B, mordenite forms as white, hair-like sprays and masses and as cottony balls on black saponite with dachiardite, ferrierite, clinoptilolite and minute pyrite crystals. Mordenite occurs commonly with very well crystallized ferrierite as fuzzy, twisted, stalactitic groups on saponite.

OFFRETITE Offretite occurs only in the zone 3 tuff vesicles as simple, elongated, hexagonal prisms and closely-packed radiating groups of prisms, always showing the (0001) pinacoid. (See photograph #20.) The offretite occurs on clear, colorless to pale pink phillipsite crystals in association with grape-like, acicular clusters of a smectite-group mineral, and rarely with analcime and orange scalenohedral calcite. It is common as solid radiating fillings in voids in the tuff. An unusual feature of some of the Canwood offretite is the bundles of fine, parallel, hexagonal crystals formed into composite hexagonal crystal groups. Some of the bundles also show differing rates of growth of the individual crystals along the (c) axis (see figure 6). Some of the hexagonal prisms continue to diminish until they form a point. Offretite analyses indicate no erionite intergrowth.

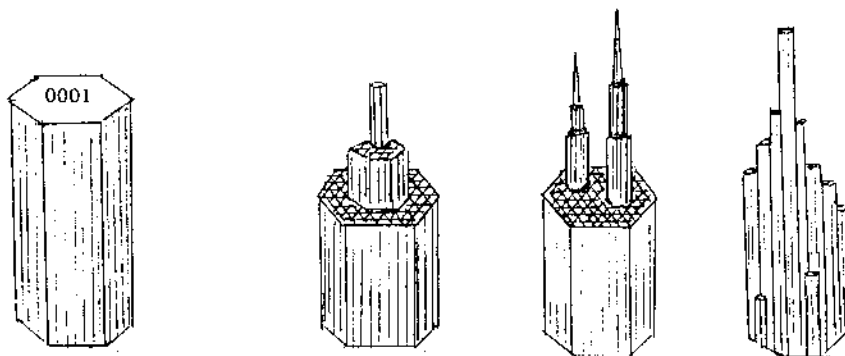


Figure 6 Offretite habits.

left: Simple hexagonal form - common at Canwood.

right: Three figures showing the bundles of crystals, extension along the c-axis, and diminishing crystal growth.

All of the habits at right are not uncommon.

PHILLIPSITE Although phillipsite has not been reported from the Agoura area before, it is very common at the Canwood site, occurring in several zones and in several different habits (see figure 7).

Zone 2A - Deep pink pseudododecahedral crystals and ball-like groups of crystals, up to 5 mm, resembling garnet, are found in small calcite-filled cavities. The calcite was etched away with acid to expose the phillipsite, along with pyrite crystals and scalenohedral calcite crystals that have been replaced by chalcedony. At another zone 2A occurrence, the phillipsite crystals themselves have been replaced by blue chalcedony and then covered by clinoptilolite, mordenite and opal. The pink phillipsite in zone 2A resembles the harmotome that was found south of Agoura, but SEM analysis shows very little barium in the Canwood crystals. Another zone 2A occurrence is as white masses of intergrown crystals (60x magnification) coating cavities and voids up to 3 inches across. The phillipsite in turn is covered by sharp, clear analcime crystals. A significant occurrence of phillipsite in zone 2A is as very sharp, clear to white, elongated, prismatic crystals and radiating crystal groups, to 3 mm, found on yellow calcite rhombohedra with clear analcime and clinoptilolite (see photograph #21). This occurrence is in calcite seams between breccia blocks. The seams are up to 8 inches long and 1/2 inch wide, and the phillipsite is found in open cavities in the calcite.

Zone 2B - Clear to white equant crystals on andesite in small cavities free from clay, silica or calcite are found sparingly in this area.

Zone 3 - Pale pink, intergrown, equant crystals covering the walls of voids are very common in the andesitic tuff. The phillipsite was followed in formation by offretite and clusters of spherical smectite.

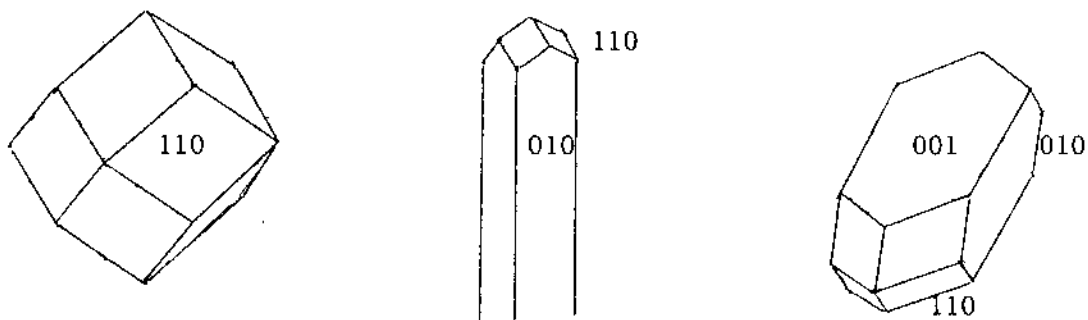


Figure 7 Phillipsite (*morphology from Tschernich*)

left: pink crystals, zone 2A. center: vein phillipsite, zone 2A
right: crystals from zones 2B and 3.

PYRITE Pyrite is common in all zones, particularly zone 1B, where it is found in large masses in calcite associated with siderite, turgite, chalcedony and possibly marcasite. It is also common in zones 1A and 1B as very sharp pyritohedra on calcite. Brilliant pyritohedra on clinoptilolite with mordenite have been found in zone 2A. In zone 2B, the pyrite occurs as small cubic crystals in and on saponite with clinoptilolite, ferrierite, dachiardite and occasionally sphalerite.

QUARTZ Quartz is very common in zone 1A as crystals, up to 15 mm in size, with calcite in pockets to 3 feet across. It also forms small, doubly terminated crystals on yellow calcite rhombs. Skeletal crystals and remnants occur in zone 1B with clear, colorless opal and blue chalcedony. Here chalcedony is common as coatings on the andesite up to 1/2 inch thick and several feet across. Pale blue 'mushrooms' and 'fingers' of chalcedony are also common on calcite in this zone. Zones 2A and 2B produced opal and blue chalcedony with ferrierite, clinoptilolite, dachiardite and mordenite. Quartz, in any form, is very unusual in zone 3.

SIDERITE Pale brown, translucent, short, sheaf-like crystal groups to 5 mm occur in chalcedony and in saponite. It is not uncommon in zone 1A.

SAPONITE The smectite group is very common at Canwood, with ferroan-saponite the most common member by far. Zone 1 quartz cavities were lined first by celadonite followed by chalcedony, siderite, saponite and finally quartz. In zone 2, it commonly formed on the calcite but preceded the zeolites. Found occasionally, but not common at Canwood, is the mixed-layer ferroan-saponite/chlorite that was so common at the Reyes Adobe site (*Bill Wise, pers. comm.*). White, pseudo-hexagonal montmorillonite crystals on calcite were encountered in zone 1A. In zone 3, another smectite member occurs as gray-white spherical clusters on phillipsite and offretite.

SPHALERITE Brilliant reddish-brown to deep amber crystals exhibiting many forms are common in zones 1 and 2, particularly in zone 2B, where it is associated with the zeolites clinoptilolite, mordenite, ferrierite, dachiardite and chabazite on black saponite in a heavily brecciated area (see photograph #22). It also occurs in zone 2B on a crystallized greenish-black mixed-layer ferroan-saponite/chlorite matrix. One of the most unusual sphalerite habits, although common at Canwood, is the very thin, clear, yellow-brown, pseudo-hexagonal crystals in zone 2A cavities with gray-white smectite (probably montmorillonite), calcite, pyrite and occasionally clinoptilolite. Yellow, hemimorphic crystals, found on saponite in zone 2B, have been found to contain 3% cadmium.

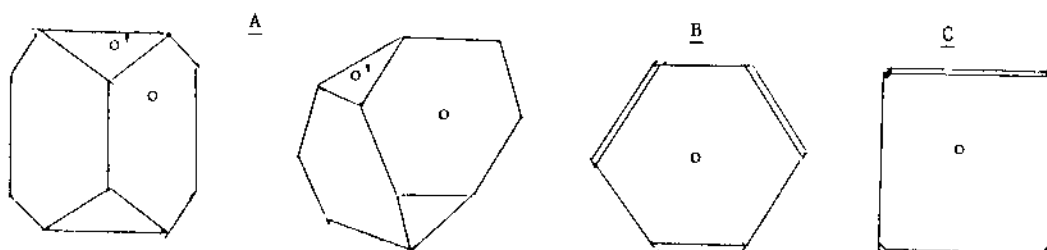


figure 8 Sphalerite from the Canwood site. (*Goldschmidt designations*)

- A. Common forms on iron-rich clays
- B. Common form on iron-deficient clays
- C. Unusual habit found on iron-deficient clays

ACKNOWLEDGMENTS

My thanks go to Dr. William Wise of the University of California, Santa Barbara, for his work using optical methods, x-ray diffraction and SEM analysis in the determination of the following Canwood site minerals: Chabazite, dachiardite, offretite, phillipsite, siderite, and the pseudo-hexagonal sphalerite. My thanks also go to Robert Housley of Pasadena, California for his x-ray work and SEM determinations of the stalactitic mordenite, the high-cadmium sphalerite and the monoclinic ferrierite.

BIBLIOGRAPHY

1. R. Tschernich, *Zeolites of the World*, Geoscience Press, 1992.
 2. R.F. Yerkes & R.H. Campbell, *Stratigraphic Nomenclature of the Central Santa Monica Mountains, Los Angeles County, California*, USGS Bulletin 1457-E, 1979.
 3. F. DeVito, *Microscop*, Bull. of the Mineralogical Soc. of So. Calif., Jan. 1985.
 4. W. Wise, W. Nokleberg & M. Kokinos, *Clinoptilolite and Ferrierite from Agoura, California*, Am. Min. **54**, may-June, 1969.
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COMPLEX MINERALOGY IN MIAROLITIC CAVITIES AT LENNOX CREEK, NORTH FORK OF THE SNOQUALIME RIVER, NORTH BEND, KING COUNTY, WASHINGTON

Rudy W. Tschernich
526 Avenue A
Snohomish, Washington

and

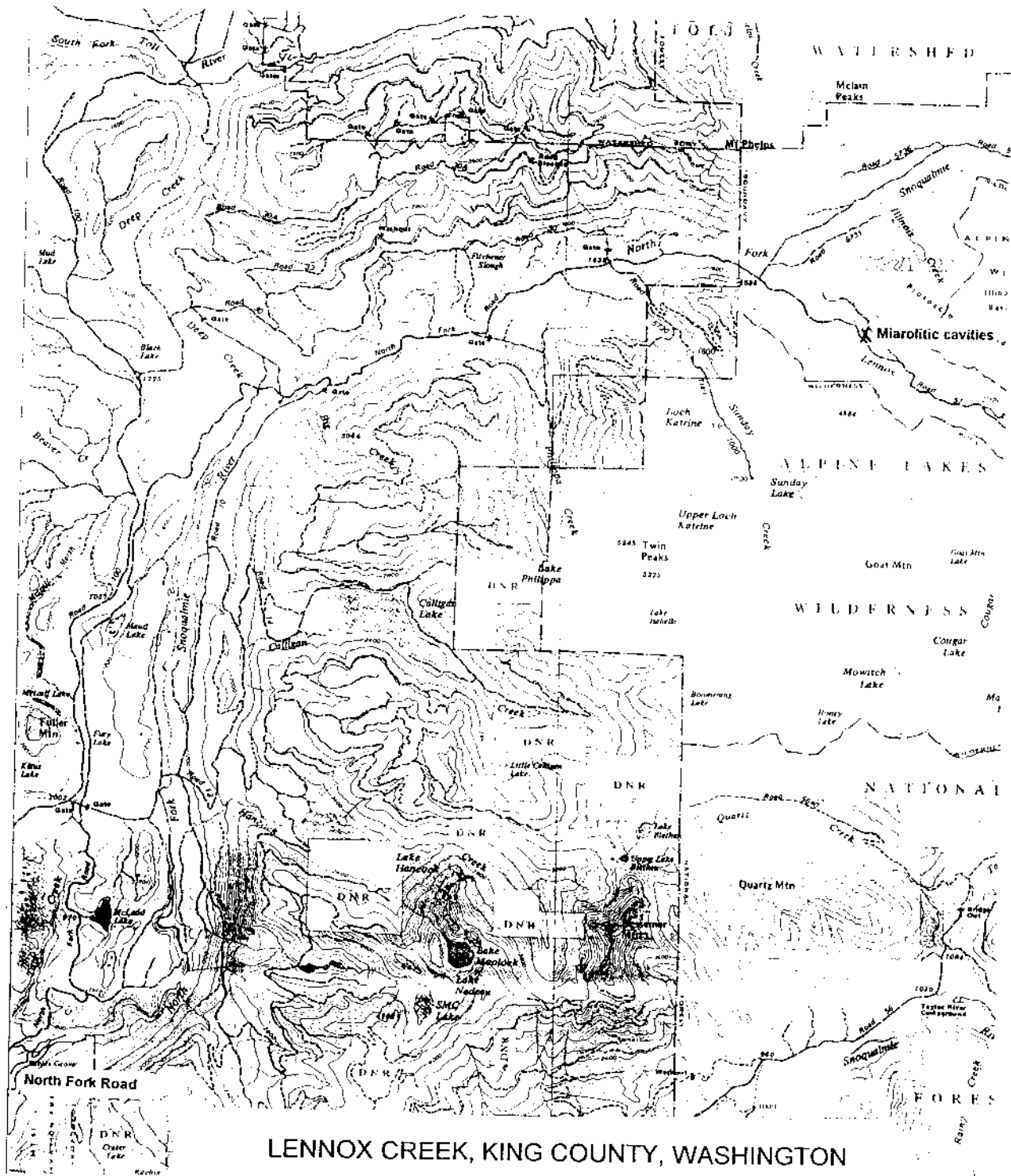
Randy Becker
14415 Sleepy Hollow Road
Lake Stevens, Washington

LOCALITY DESCRIPTION

Unusually complex miarolitic cavities that contain zeolites have been found in a localized area in along Lennox Creek, on the North Fork of the Snoqualime River, in the central Cascade Range, King County, Washington. The pockets are located on the east side of Lennox Creek 0.6 miles beyond the bridge that crosses the creek. The site can be reached from Snoqualime Falls by taking the Mill Pond Road, adjacent to the bridge crossing the Snoqualime River, for 1.5 miles, then turning left on the Reing Road. Keep to the right following the river for 2 miles to 428 Ave. SE. Turn left and follow the road 1.5 miles to the junction of North Fork Road and Ernies Grove Road. Set your mileage to zero at this point. Follow the North Fork Road passing through a steel gate at 0.4 miles, later passing by gate 10 at 3.7 miles, and the first bridge at 9 miles. The major bridge crossing the North fork of the Snoqualmie River is found at 10 miles, and a new cement bridge crossing Lennox Creek at 15.3 miles. Follow Forest Service Road 57 to the right up Lennox Creek for 0.5 miles to a large sloping rock exposure on your left. The site is located at about 1600 feet N 47° 39' 24" W 121° 34' 27" or center of NE 1/4 sec 18 T25N R10E. The pocket area is in the middle of this exposure extending from below road level to about 5 feet above the road. The rock and pockets are wet and covered with moss and ferns that make them look ancient.

COLLECTING HISTORY

A series of five or more interconnected miarolitic cavities have been found in a fine-grained hornblende-biotite syenite at the base of a high rock exposure on the east side of the road. The first cavity was found by Bart Cannon in 1965, on one of his first mineral collecting trips, when he was 15 years old. The remaining hole is an egg-shaped cavity 7 inches across and about 4 feet above road level. This cavity was reported to contain white stilbite crystals, up to 3/4 inch long, on quartz and natrolite (Cannon, 1975) although the needles were later found to be scolecite (Tschernich, 1992). The description of this pocket lured other collectors to investigate the area. In 1986 Randy Becker found the second cavity, 4 feet lower than the Cannon pocket, right at road level. This 12 inch rounded cavity contained a predominance of stilbite and scolecite on a complex intergrowth of tourmaline, feldspar, clinocllore, minor quartz, and an abundance of accessory minerals. Contents of a third rounded cavity, 18 inches to the right of the Becker pocket, might have been removed by an unknown collector. In 1991 John Lindell found a fracture zone extending from the Becker pocket downward for another 2 to 3 feet below road level that exposed two more miarolitic cavities. The fracture zone dips to the west parallel to jointing that is widespread in the syenite and may intersect all the previously found miarolitic cavities. The openings in the fractures pinched down to a few inches across and then opened into miarolitic cavities up to 8 inches by 12 inches and 4 inches wide. Tourmaline and calcite were only found in the larger pockets. The narrow flat areas of the fracture zone between miarolitic cavities contain a crust of scolecite-apophyllite-stilbite directly on quartz crystals or the smooth, flat, syenite rock-surface. Evidence of a disturbance in the cavities is seen when plates of scolecite-covered minerals



LENNOX CREEK, KING COUNTY, WASHINGTON

were detached from the walls of the rock and quartz crystals so that laumontite and stilbite could crystallize in the newly-formed spaces.

The rock surrounding the pocket area is a uniform medium-grained hornblende-biotite syenite. As the rim of the miarolitic cavities is approached the amount of dark minerals decreases, the biotite becomes chlorite, and the size of quartz and feldspar increases until at the rim of the pocket a layer of intergrown quartz, feldspar and chlorite is 1 to 2 inches thick. Alteration of the primary feldspar and chlorite and reaction with the exotic elements in the primary solutions produced the secondary minerals rutile, ilmenite, tourmaline, clinocllore, adularia, and white mica. In some cavities the primary feldspar was totally removed leaving resistant, granular, subhedral quartz grains and terminated quartz crystals. In some of the miarolitic cavities long greenish-black tourmaline crystallized on the quartz-feldspar and extended well into the open space of the cavity. Calcite and white mica appear to be the last secondary minerals to form from the original solutions in the miarolitic cavity. Fracturing of the rock appears to have taken place sometime after the primary and secondary minerals formed. Hydrothermal solutions then filled the cavities and deposited zeolites on the minerals in the miarolitic cavities and on flat fracture surfaces.

MINERALOGY IN ORDER OF CRYSTALLIZATION

PRIMARY MINERALS

Feldspar, quartz and chlorite co-crystallized along the rim of the cavities and project into the pocket.

FELDSPAR (plagioclase) forms highly-corroded, skeletal, blocky, white to cream-colored crystals, 1 to 2 mm in diameter, that are often intergrown with quartz. Well-formed wedge-shaped adularia crystals that formed as a result of the alteration of the primary crystals are found on the corroded plagioclase crystals.

QUARTZ forms colorless, transparent, terminated crystals, up to 6 mm long, and anhedral grains intergrown with corroded feldspar that are commonly completely covered by tourmaline, white mica, and scolecite in the Lindell pocket. Green chlorite plates and rarely inclusions of rutile are found included within the granular quartz. Masses of granular quartz several inches thick were found in some miarolitic cavities while others contained only traces of quartz. A disturbance in the cavities caused the terminated quartz crystals to detach from the white mica-scolecite overgrowth, leaving hollow casts with shapes of quartz-crystal-faces inside. Rarely laumontite crystals are found protruding into these quartz-shaped spaces. Quartz was scarce in the Becker pocket.

CHLORITE forms attractive, green, flat, hexagonal plates, up to 1 cm in diameter, intergrown with the primary feldspar and quartz. the thin plates are commonly included within corroded feldspar. Alteration of thick green chlorite crystals produces hollow crystals that are golden brown in color and filled with rutile needles.

PYRITE or **CHALCOPYRITE** blebs with complex faces that are golden yellow when broken are rarely present with scolecite in the Becker cavity.

SECONDARY MINERALIZATION

Alteration of the primary minerals formed rutile, ilmenite, titanite, adularia, clinochlore, tourmaline, white mica, and calcite in a general overlapping sequence rather than in a distinct progressive sequence. Tourmaline and white mica were common in the Lindell and Becker pockets while rutile, ilmenite, titanite, adularia, and clinochlore were abundant only in the Becker pocket.

CLINOCHLORE forms attractive rounded, dark green to black, ball-like crystals, up to 1 mm across, on the surface of the feldspar and flat plates of chlorite.

RUTILE forms tiny golden needles and reticulated sheets that are often covered with dark green clinochlore crystals and cream-colored corroded feldspar. Rutile needles are seen as inclusions in both corroded feldspar and quartz. Rutile is found on the surface and in the core of altered chlorite plates and as reticulated sheets, up to 10 mm across, covering blades of ilmenite.

ILMENITE rarely forms thin, opaque, black plates, with a brilliant luster and black streak, on corroded feldspar. Some of the ilmenite plates are partially to totally covered with very thin golden rutile crystals and adularia that form sandwich-like complex alternating layers.

TOURMALINE forms thin, dark-green needles, a few millimeters long, and thicker compound crystals, up to an inch long, that appear black. They occur on quartz and corroded feldspar and are covered by white mica, scolecite, or calcite. Some tourmaline needles, less than 1 cm long, are color-zoned from brown at the base to light green and blue near the termination. Groups of small greenish-blue tourmaline needles are found on corroded feldspar crystals. Rarely titanite is present on the tourmaline.

ADULARIA forms translucent to transparent, 1 mm wedge-shaped crystals on corroded cream-colored feldspar. Some adularia crystals contain inclusions of black tourmaline needles and green chlorite plates. Rounded chlorite crystals are often found on adularia. Parallel growths of adularia crystals cover some plate of reticulated rutile/ilmenite.

CALCITE forms colorless to white corroded rhombohedra and fragments, up to 2 inches on an edge, that enclose blackish-green tourmaline and green clinochlore. White mica covers exposed tourmaline and parts of the calcite. Partly etched calcite masses and hollow calcite-crystal-shaped cavities are common.

BROWN ALTERED BLEBS with a dark brownish-black glassy core and reddish-brown earthy outer shell that may have been chalcopryrite or pyrite have been found in the Becker pocket. Green stains and green needles of malachite are concentrated near the brown, rounded masses.

MALACHITE forms tiny bundles of green needles in only two samples in the Becker pocket.

WHITE MICA-LIKE MINERAL possibly illite, sercite, or hydromuscovite forms spheres, under 1-millimeter in diameter, and crusts, 1 to 2 mm thick, composed of thin plates with high luster on the cleavage surfaces. It commonly occurs on quartz, tourmaline, chlorite, calcite and all of the other early-formed minerals in all the pockets. Its presence marks the end of the primary mineralization and predates the zeolite mineralization in the cavities.

ZEOLITE STAGE

Fracturing of the rock followed by hydrothermal fluid deposited an abundance of scolecite and stilbite in all of the pockets along with small amounts of apophyllite, laumontite, heulandite, and chabazite in only a few pockets.

SCOLECITE forms a colorless to white crust composed of flattened needles, generally 5 to 10 mm long, on white mica, quartz, feldspar, tourmaline, and other primary minerals in all the pockets. The scolecite needles are covered with layers of blocky corroded apophyllite and stilbite blades. Thin white needles of scolecite are also scattered on the primary and secondary pocket minerals and in some areas forms a colorless to bluish solid mass that cements the early-formed minerals together.

LAUMONTITE forms simple white prisms, up to 5 mm long, on scolecite, corroded feldspar and tourmaline crystals. It is a common mineral in both the largermiarolitic cavities and on the wall rock in the fractured areas. Laumontite prisms are rarely covered by stilbite and apophyllite. White mica-covered molds where quartz crystals once had been contain laumontite crystals on the inside of the molds.

APOPHYLLITE forms highly etched and altered blocky crystals, elongated along the c-axis, on scolecite and is covered by stilbite only in the Lindell pocket. The mineral is difficult to identify because only corroded grains remain. The remaining fragments display good basal cleavage and square cross section with smaller second order prism faces. The crystals are striated with the elongation of the crystal which is common when second order prism faces are present on apophyllite. Evidence of some pyramidal faces can be found which with a small c-face made up the termination. Washing of the specimens often leaves a gap between the scolecite and stilbite where the apophyllite had formed.

STILBITE forms a crust of colorless, intergrown, pointed blades, commonly 3 to 5 mm long, on scolecite and apophyllite and is found scattered in dissolution cavities between quartz grains in the rock. The largest crystals, up to 3/4 inch long, were collected in the Cannon pocket (Cannon, 1975).

HEULANDITE very rarely forms isolated, 5-mm long, colorless crystals on corroded feldspar and clinocllore. It is associated with thin cream-colored scolecite needles.

CHABAZITE very rarely forms colorless simple rhombohedra, up to 5 mm across, on corroded feldspar, clinocllore, and thin cream-colored scolecite needles.

SUMMARY:

ROCK FORMING PHASE followed by **EARLY MIAROLITIC CAVITY PHASE:**

(feldspar-hornblende-biotite)

(feldspar > quartz > clinocllore)

LATE MIAROLITIC CAVITY MINERALS

(quartz > ilmenite-rutile plates > adularia-titanite > tourmaline > titanite > calcite > white mica)

ZEOLITE PHASE

(heulandite > scolecite > laumontite > apophyllite > stilbite)

chabazite only on scolecite

OBSERVED SEQUENCE OF CRYSTALLIZATION IN THE MIAROLITIC CAVITY

quartz > chlorite > feldspar

rutile > chlorite > adularia

rutile > white blocky feldspar > colorless adularia

ilmenite > altered feldspar

corroded blocky feldspar > bluish tourmaline

chlorite > ilmenite

chlorite > clinocllore balls > adularia

chlorite > adularia > clinocllore

chlorite > titanite

clinocllore ball > light green tourmaline

clinocllore > white mica

clinocllore > massive scolecite

adularia > clinocllore

altered feldspar > adularia

altered spar > chlorite plates-adularia > clinocllore balls

rutile > adularia > white mica

REFERENCES:

Cannon, B. (1975) Minerals of Washington. Cordillera, Mercer Island, Washington.

Tschernich, R.W. (1992) Zeolites of the World. Geoscience Press, Inc., Phoenix, Arizona.

**FIRST OCCURRENCE OF APOPHYLLITE AND MESOLITE
AT THE 200/237 ROAD QUARRY, WOLF POINT,
COWLITZ COUNTY, WASHINGTON**

During a NWMMSG field trip on May 5, 1996 a single cavity, 2 inches across, was found in the west wall of the upper level of the quarry at Wolf Point that contained pointed colorless apophyllite crystals, up to 15 mm long. This is the first occurrence of this mineral at the Wolf Point Quarry. It occurs on a parallel growth of heulandite and white prisms of laumontite. Most of the crystals appeared blocky with large "c" face and small triangular corners, although most of these crystals appear to have been cleaved during removal. Smaller crystals on the same specimens displayed large pyramidal faces, small prism faces, and no "c" face which is probably the morphology of the larger crystals as well. The minerals in the apophyllite-cavity crystallized in the order: heulandite > laumontite > calcite > apophyllite > calcite.

Scolecite, laumontite, and traces of mordenite make up most of the fibrous zeolites in the quarry. Several cavities have now been found in the boulder pile in the center of the upper level of the quarry that contained mesolite. It forms coarse, colorless, straight needles, up to 12 mm long, often with tiny, white, matted, hair-like terminations, similar to an artist paint brush. Optics of these needles indicates that they are pure mesolite. Further testing of other cavities that contain scolecite showed that some of the thin needles are a combination of both mesolite and scolecite with scolecite making up 90% of the needle. The needles in the pure mesolite cavities can not be distinguished from scolecite in the field. They must be tested. The only clue is the mineral association. The mesolite was found on rather short thick yugawaralite crystals and are covered by rhombohedra of chabazite.

During this same trip several unusually good yugawaralite specimens were found in the west wall of the upper level of the quarry and in the talus at the base of the wall. The best was an angular cavity, 5 inches long, 1.5 inches thick, and 3 inches wide that contained an abundance of sceptered quartz and large yugawaralite crystals, one being 15 mm long. Stilbite and calcite were also present. These cavities appear to have developed along fractures in the rock rather than as vesicles. A problem developed from this type of formation for when the specimens were trimmed, they tend to break right through the cavity making it hard to save a good sized specimen. Minerals in the new yugawaralite-cavity crystallized in the order: yugawaralite > frosted quartz > clear quartz > rice grain quartz > green clay > calcite > stilbite

During a later trip to this quarry Jocelyn Thornton and Don Howard found more of the very unusual cyclic 8-ling epistilbite but unfortunately did not know it until they reached home and could not longer remember which rock the samples were taken.

This quarry still has great potential for unusually minerals and needs much more work.

LIMITATIONS OF IDENTIFYING ZEOLITES
WHY NO ONE WILL TELL YOU EXACTLY WHICH IS WHICH

Donald G. Howard

The fuzzy little white crystals in the basalts can be very confusing. Some come in very characteristically shaped crystals and we can say with a cursory look what mineral is probably present. Some come in such a variety of forms that it takes years of experience to recognize them all. For those that are seldom encountered, we take them to one of the experts for identification. And sometimes we get an immediate answer and are satisfied. Sometimes we do not.

What goes into the identification of the more difficult ones? Chemical tests are seldom of much value, since all zeolites are made of more or less the same elements -- aluminum, silicon, and some combination of alkali and alkali earth elements. Very careful quantitative tests are necessary to detect differences, and these types of tests are expensive and time consuming. The most practical tests usually are one of two types: structural determination by x-ray diffraction and optical tests in a polarizing microscope. But these two types of tests are not always sufficient to differentiate between certain established mineral names that we encounter while collecting the zeolite family. The purpose of this note is to describe these related minerals, and explain what is involved in separating them.

Natrolite family

X-ray diffraction is incapable of easily seeing differences between natrolite, mesolite and scolecite. All three of these minerals have the same basic lattice structure. They differ chemically in possessing entirely sodium (natrolite), calcium (scolecite), or a 50/50 mixture of the two elements (mesolite).

Fortunately, when calcium substitutes for sodium in this lattice, a small distortion occurs in the structure. Although this is too small to see easily as a shift in the position of the x-ray diffraction peaks, it causes enough change to the optical properties to clearly differentiate the three minerals. This group is therefore always studied optically in polarized light.

A number of disordered members of this group have been named. These include gonnardite, tetranatrolite and paranatrolite. The x-ray patterns for these disordered forms do not differ enough from the ordered minerals to be distinguished except under very special circumstances. Mainly, the peak intensities and widths differ somewhat, and these changes are generally masked by sample preparation, especially when less than ideal samples are under study. Gonnardite and tetranatrolite differ mainly in sodium-calcium ratio (which unlike the ordered minerals can be of any value). They can sometimes be differentiated optically, but the refractive indices overlap and identification is not certain. Paranatrolite is a water-rich variety that can be distinguished optically only when fresh (before it has dehydrated); otherwise it is identical to the other disordered species.

Erionite-Offretite

Erionite and offretite are two minerals closely related to levyne, and are often found growing on levyne blades, though they do occur as separate crystals or crystal clusters. They are often intergrown with each other. Their physical appearance is in general the same.

Offretite is the calcium-rich member and erionite tends to be more potassium-rich. The unit cell for erionite is twice as large as for offretite, and it therefore has more x-ray reflection angles. However, these additional reflections are rather weak, and may be obtained only with a very good sample. If the two minerals are at all intergrown, the resulting pattern will resemble erionite. Therefore, separating them using x-ray diffraction is not reliable.

In general, erionite has lower refractive indices than offretite, and the two minerals can be separated optically. However, the ranges overlap slightly, so in some cases even this means is not reliable.

Overgrowths on levyne seldom make good samples for structural study. At localities in the USA, the overgrowth has generally been identified as offretite, while in some European localities it is generally called erionite. In actuality, what is present is probably an intergrowth of both minerals.

Merlinoite-Phillipsite

Recent work on the zeolites associated with the montesommaite from Mt. Vesuvius in Italy has indicated that merlinoite is commonly present. Now clear twinned crystals are available in addition to the earlier merlinoite that was primarily in the form of finely crystalline crusts. Merlinoite forms the same core-bit twins as phillipsite. In fact, the morphology of the two minerals is identical, so that visual differentiation is impossible.

X-ray diffraction is not much help. The two minerals differ only in a shift of part of the unit cell with respect to the rest. As a result, the two minerals can (and often do) intergrow. The pattern of x-ray peaks are nearly identical in positions. The pattern for merlinoite has recently been worked out, and the documentation on pure material is good. The documentation of phillipsite is older, dating before the advent of merlinoite as a separate species, and is therefore possibly contaminated by intergrowths. Better x-ray data for pure phillipsite would be needed before any hope of separating them by qualitative x-ray diffraction.

In this case, the optical properties are virtually identical, so they can not be differentiated using a polarizing microscope, either. The chemical composition of both minerals is very nearly the same as well. Differentiating these two minerals is a difficult job that requires the best of technical equipment. It is well beyond the ability of most technical people, let alone even advanced collectors.

Gismondine, and its disordered relative garronite, possess related x-ray patterns, but they have considerably fewer reflections, so they can be easily separated from phillipsite/merlinoite and from each other. Gobbinsite is the sodium-rich equivalent of garronite (which is calcium-rich) and has an identical x-ray pattern. The sodium tends to

lower the refractive index below that of garronite, and can therefore probably be differentiated.

Chabazite Group

Chabazite is one of those minerals that can form in a variety of forms due to its often complex twinning. The x-ray pattern for chabazite, herschelite, and willhendersonite are identical (with the exception that herschelite often shows some intergrowth of gmelinite). The chemistry and optical properties also range over the same values. Willhendersonite is supposed to be an ordered chabazite. Herschelite generally is a name reserved for a bladed form that resembles levyne but has a chabazite-like x-ray pattern. Because there seems to be no way to define these three minerals uniquely, they are lumped together in *Zeolites of the World* under the heading of chabazite.

Analcime

Analcime, in disordered form, is a cubic mineral. Ordered forms can be tetragonal, orthorhombic, monoclinic or triclinic depending on the nature of the ordering. The distortions are too small to be picked up easily in normal x-ray diffraction. Fortunately, separate names have not been assigned to the various ordered forms in this case. Wairakite and pollucite have the same structure as analcime and are therefore not identifiable by x-rays. The refractive indices are somewhat different, but tend to border on each other, so optical differentiation is difficult. Here, chemistry forms the basis for differentiation. Analcime is a sodium zeolite. Wairakite is calcium rich, so the presence of large concentrations of calcium (identifiable by x-ray fluorescent spectroscopy in an electron microscope study) serves to identify it. Pollucite is lithium rich and must be verified by other chemical tests, since lithium cannot be detected by x-ray fluorescence. Both wairakite and pollucite are quite rare compared to the relatively common zeolite analcime.

In each of these cases, a new find of one of these groups are impossible to differentiate by the field collector. Unless independent work has been done to identify which mineral is present, they should be classified as:

- natrolite group
- erionite/offretite
- phillipsite
- chabazite
- analcime

FIGURE CAPTIONS

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

- #17 **Clinoptilolite with Calcite** (x 12)
Canwood Mall, Agoura Hills, Los Angeles Co., California
 Clear crystal flattened along the b-axis, from zone 2A.
- #18 **Dachiardite with Mordenite** (x 12)
Canwood Mall, Agoura Hills, Los Angeles Co., California
 Sprays of bladed crystals from zone 2B.
- #19 **Ferrierite** (x 12)
Canwood Mall, Agoura Hills, Los Angeles Co., California
 Balls of bladed crystals from zone 2B, that fluoresce and phosphoresce pale blue..
- #20 **Offretite** (x 25)
Canwood Mall, Agoura Hills, Los Angeles Co., California
 Clear hexagonal rods with flat terminations nearly filling a cavity, from zone 3.
- #21 **Phillipsite on Analcime** (x 12)
Canwood Mall, Agoura Hills, Los Angeles Co., California
 White prismatic crystal groups on water-clear analcime trapezohedra, from zone 2A.
- #22 **Sphalerite and Dachiardite on Saponite** (x 10)
Canwood Mall, Agoura Hills, Los Angeles Co., California
 From zone 2B. Extreme color contrast makes photography difficult.
- #23 **Clinoptilolite on a tan clay matrix** (x 33)
Washington Pass, Okanogan Co., Washington
 It was bound to happen eventually! This is the first verified zeolite mineral from Washington Pass, found by Lanny Ream and Randy Becker. It came from a boulder along the road described as a biotite granite deficient in arfvedsonite.

Micrograph Number is in the lower right corner on the front of the print.

- #234 **Merlinoite** (x 160)
Monte Somma, Vesuvius, Napoli, Italy
 A parallel growth of 4 crystals, each a drill-bit fourling. Like phillipsite, merlinoite tends to crack in vacuum during preparation for the electron microscope. Though somewhat fractured now, the crystals started out glassy-clear and sharp. They occur with calcite and montesommaite.

PHOTO CREDITS

Photographs #17 through 22
 Micrographs #23 and 234

Fred DeVito
Donald Howard

In Memory of Norman Steele, Jr.

Norman Steele's gentle spirit and willingness to pitch in and help will be sorely missed in the Northwest Micromineral Study Group. Norm was a charter member and served as president and editor of the *Microprobe* after Bob Hagglund and before Don Howard. He was the one who initiated the inclusion of picture prints to go along with the text articles, and he spent many hours taking the photographs and printing pictures. Norm will always be remembered by his willingness to help when something was needed. He attended many of the early NWMMSG field trips, the first being to Kamloops Lake for ferrierite. At that time, there was no road on the north side of the lake; therefore we had to take a boat 5 miles across the lake from Savona to the collecting site. Norm brought his boat from Seattle to Kamloops and spent most of the day ferrying us back and forth across the lake. Norm also belonged to many other mineral clubs in the Northwest, including the Boeing Rock and Gem Club, Faceters Guild, the Seattle Museum Group, and Friends of Mineralogy. He will be long remembered for the superb series of Faceting Design books which he produced. Norm passed away on January 31 and was laid to rest at Washelli on February 8, 1997.

In Memory of Helen Rice

Helen Rice, mother of Sharleen Harvey, also passed away on February 4, 1997. Helen held all of the offices in the Oregon Agate and Mineral Society, and was past president of the American Federation of Mineralogical Societies. She started mineral collecting in 1938, and with her husband Richard produced one of the finest mineral collections in the Northwest. Helen and Richard recently founded the Rice Northwest Museum of Rocks and Minerals at Hillsboro, Oregon. It is hoped this museum will grow into a fine regional mineral museum that can preserve the finest mineral specimens found in the Northwest. Specimens and collections can now be donated to the museum.

THE MICROPROBE

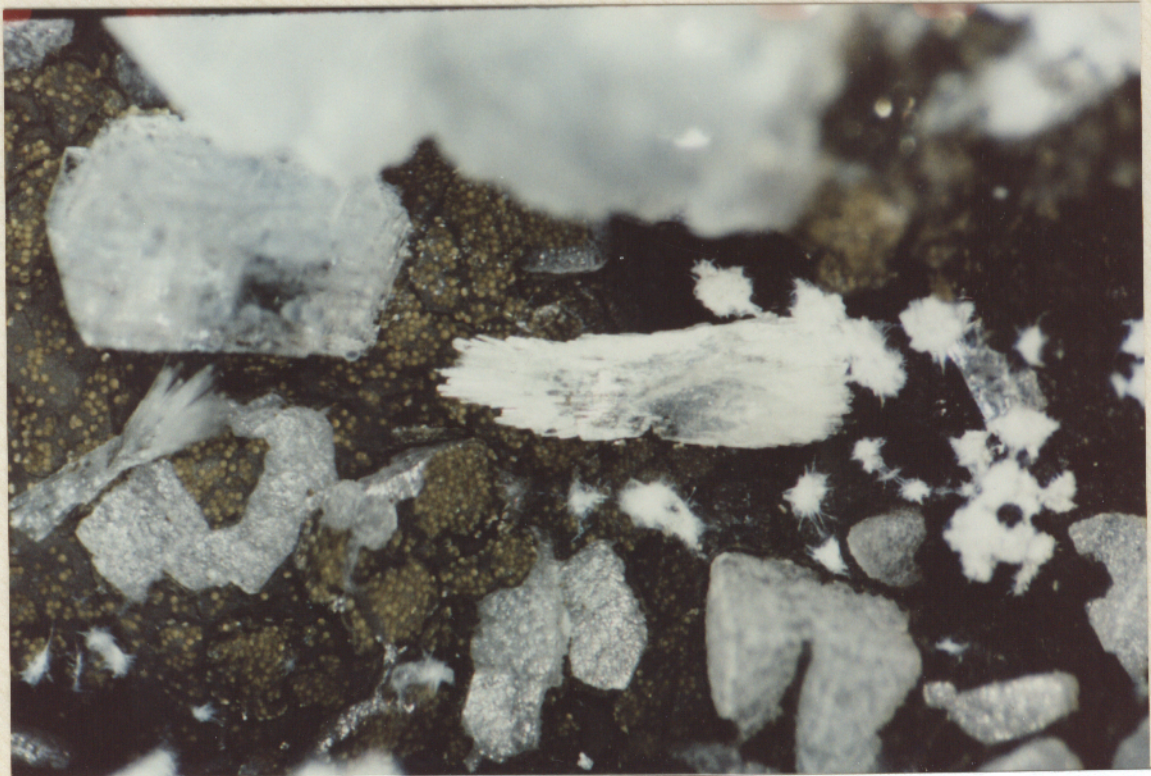
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#17 - CLINOPTILOLITE, CALCITE - CANWOOD MALL, AOURA HILLS, LOS ANGELES COUNTY, CALIFORNIA - 12X



#18 - DACHIARDITE, MORDENITE - CANWOOD MALL, AGOURA HILLS, LOS ANGELES COUNTY, CALIFORNIA 0 12X



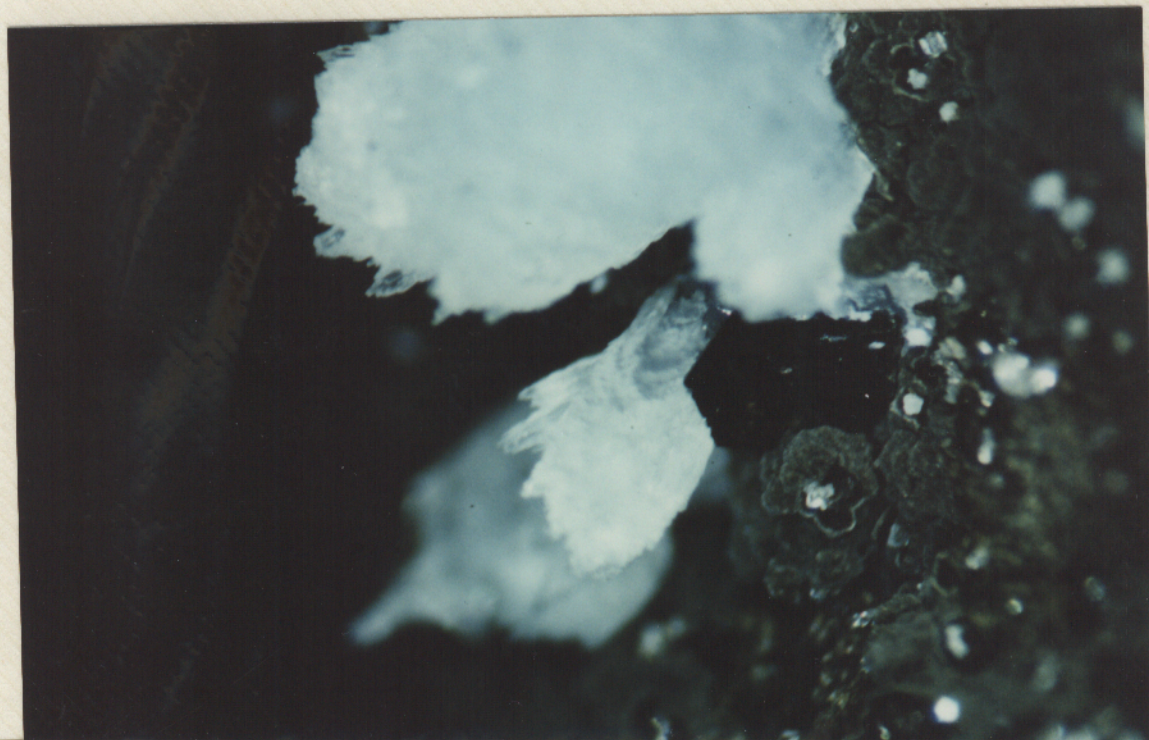
#19 - FERRIERITE - CANWOOD MALL, AGOURA HILLS, LOS ANGELES COUNTY, CALIFORNIA - 12X



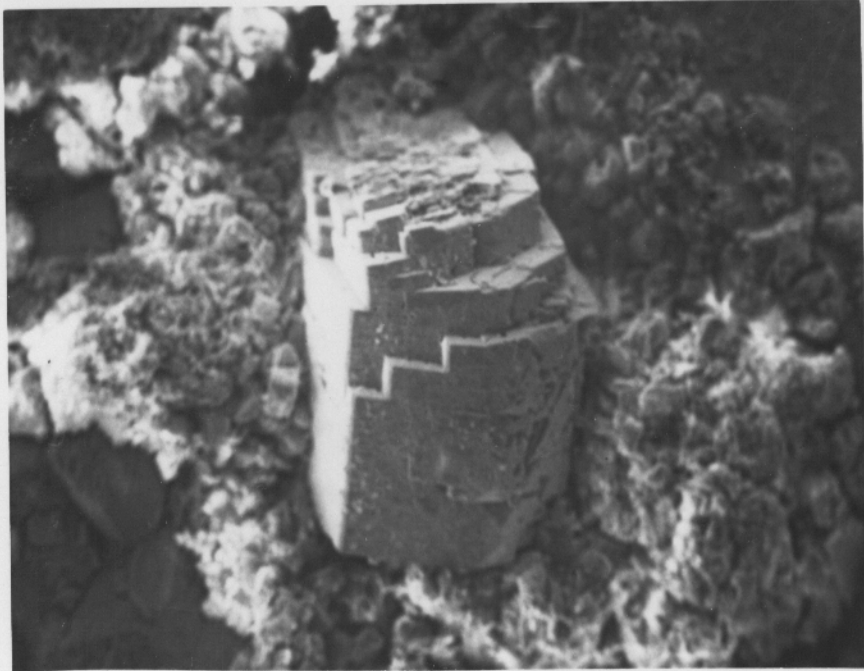
#20 - OFFRETITE - CANWOOD MALL, AGOURA HILLS, LOS ANGELES COUNTY, CALIFORNIA - 25X



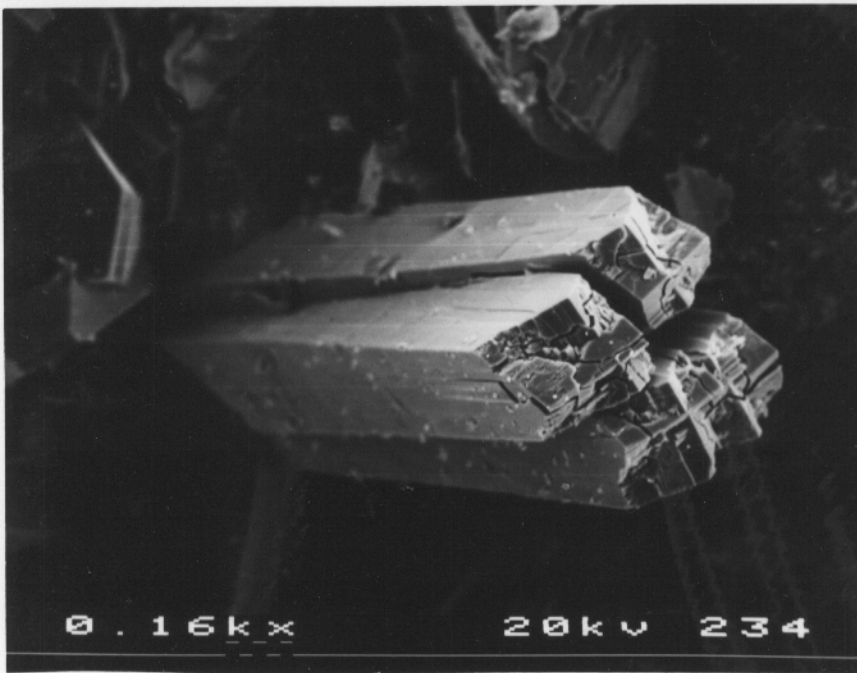
#21 - PHILLIPSITE, ANALCIME - CANWOOD MALL, AGOURA HILLS, LOS ANGELES COUNTY, CALIFORNIA - 10X



#22 - SPHALERITE, DACHIARDITE, SAPONITE - CANWOOD MALL, AGOURA HILLS, LOS ANGELES CO., CALIFORNIA - 10X



#23 - CLINOPTILOLITE - WASHINGTON PASS, OKANOGAN COUNTY, WASHINGTON - 33X



#234 - MERLINOITE - MONTE SOMMA, VESUVIUS, NAPOLI, ITALY - 160X