

Northwest  
Micro Mineral  
Study Group



# MICRO PROBE

FALL, 1991

VOLUME VII Number 4

FALL MEETING ---- VANCOUVER, WASHINGTON

November 2, 1991

10 am to 10 pm

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

Bring your microscopes and we will all spend another day of fun and sharing, trading both specimens and stories. Bring some good material for the give-away table so everyone will be able to take home a new treasure.

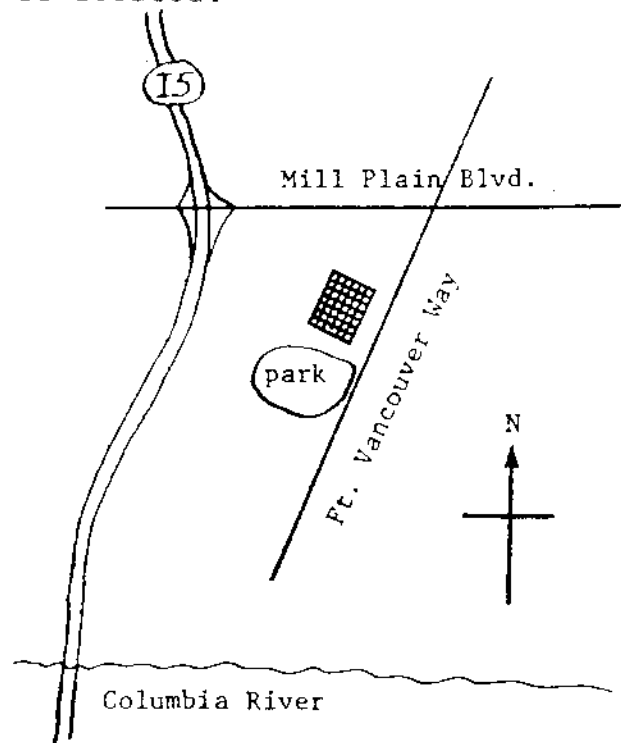
There will be a short business meeting at 1:30 pm, to be followed by our usual exchange of information on the status of collecting sites.

Don Howard will give the afternoon talk on "The Scanning Electron Microscope, how it works, what it can and cannot do in mineral identification".

Pot Luck Dinner around 6 pm. Bring a salad, hot dish, or dessert.

Also, bring slides to show.

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



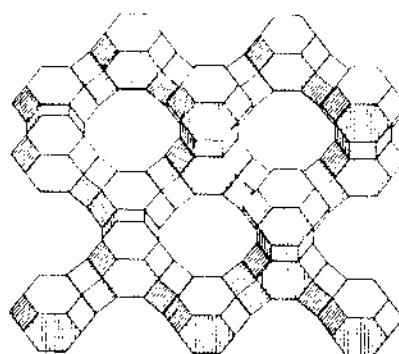
## THE CUBIC ZEOLITES

Donald G. Howard

In previous issues of the Microprobe, we have featured various articles on the identification of selected groups of the zeolite group. In this issue we focus on those of cubic structure. Zeolites, being composed of complex spatial arrangements of silica-alumina frameworks, generally have rather complex symmetry, so there are really only four that display cubic symmetry, and two of them are closely related structurally.

FAUJASITE  $(\text{Na}_2, \text{Ca})_7 \text{Al}_{14} \text{Si}_{34} \text{O}_{96} \cdot 64\text{H}_2\text{O}$ ;  $a = 24.65 \text{ \AA}$

The internal structure of this rather rare zeolite is composed of cubo-octahedral "cages" connected together tetrahedrally by short hexagonal prisms, as shown in the diagram at right. This leads to rather large open channels along the [110] directions. The cations and water molecules occupy sites within the cavities, and because the cavities and channels are so large, ion exchange with a wide range of other cations is possible, making faujasite of considerable importance as an ion exchange medium. The very open structure also makes faujasite an important support structure for catalysts, since the large channel size will accommodate reasonably large organic molecules in vapor form. Faujasite is therefore a prime support system for catalytic "cracking in the manufacture of gasoline. Since it is so rare, most of the material so used is synthesized artificially in the laboratory.

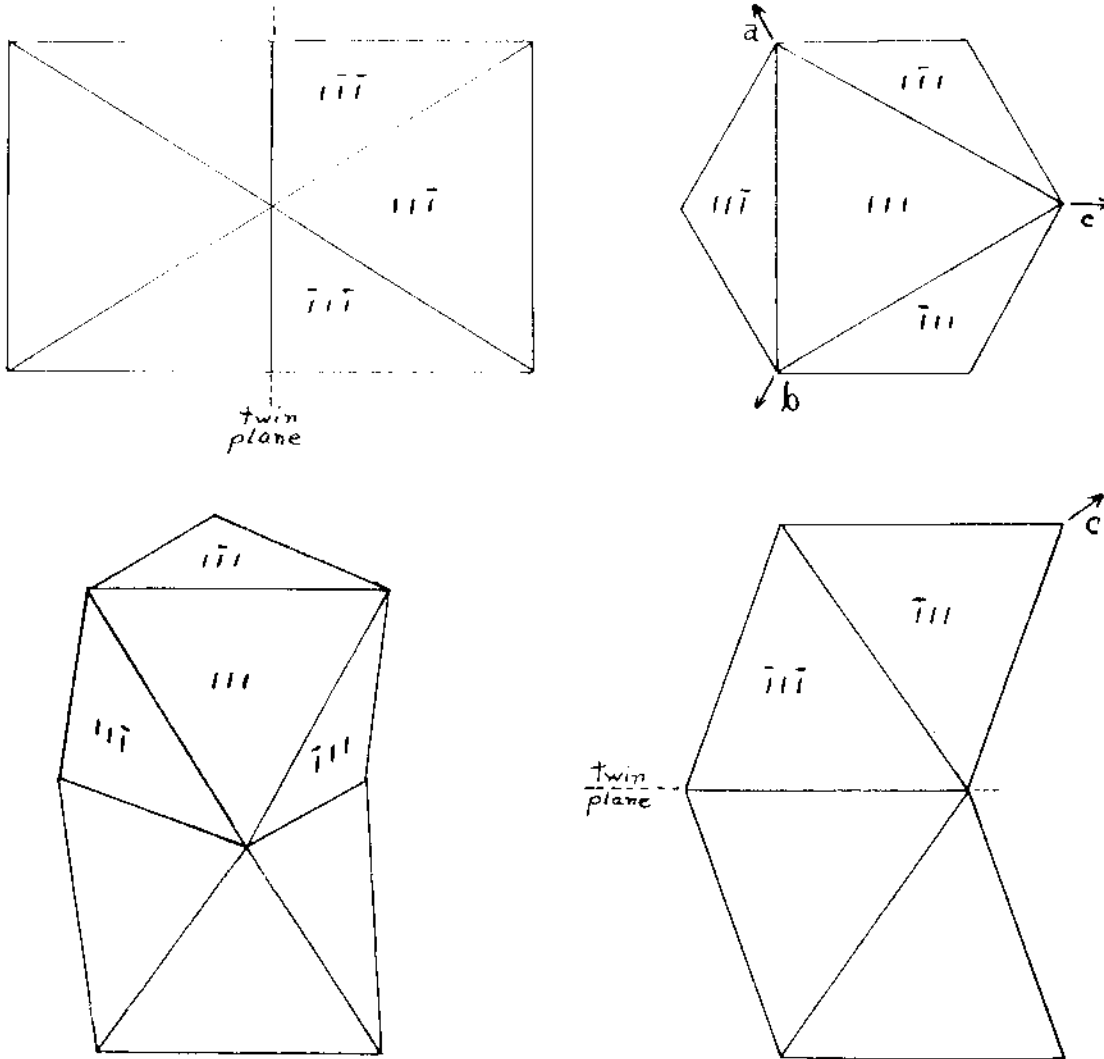


View of the internal structure of faujasite as viewed along the [110] direction. The corner of each polyhedron is the center of a  $(\text{Si}, \text{Al})\text{O}_4$  tetrahedron.

Of the cubic zeolites, faujasite forms crystals whose external form is the simplest. Crystals are in the form of simple octahedra without other faces modifying the corners.

Twinning is rather unusual in such a high-symmetry system, but is possible on a plane that is not a mirror plane. The face of the octahedron, [111], is such a face, and the resulting "spinel twin" is observed for this material. It is a reflection of the fact that coordination on the microscopic level is tetrahedral rather than octahedral. Twins occur in simple pairs, and might appear to have trigonal symmetry if it were not for the reentrant angles, which are always a sure sign of a twin.

Faujasite was first reported from Sasbach, Germany. There is also a location in San Bernardino Co., California, but it has not yet been found in the Pacific Northwest.



"Spinel Twin" of Faujasite. The view at upper right is looking along the (111) direction perpendicular to the top face of the octahedron, which is the twin plane.

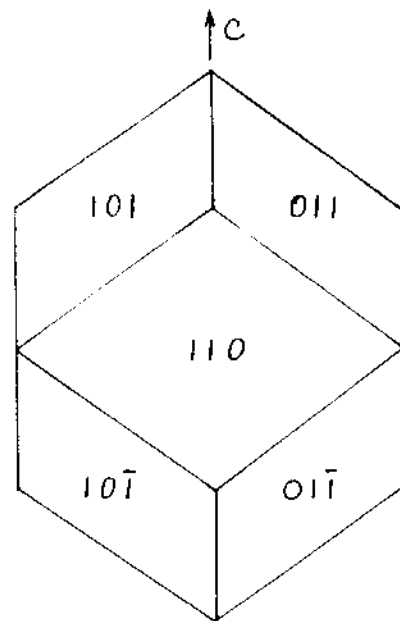
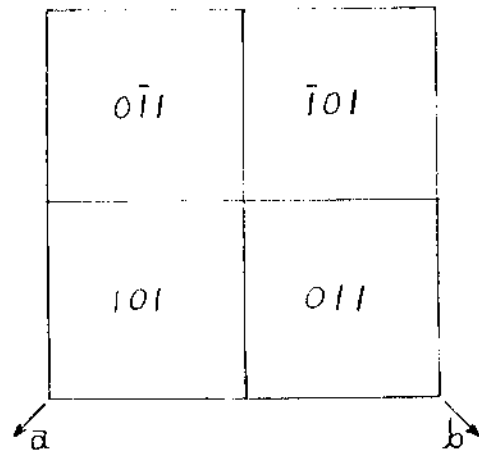
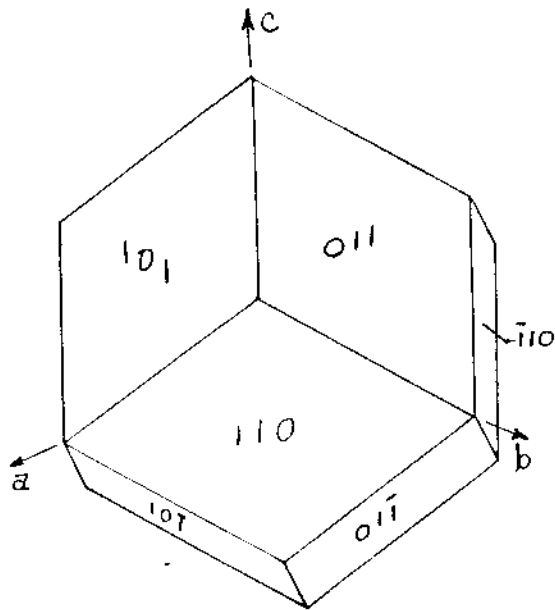
PAULINGITE  $(K_2, Ca, Na_2, Ba)_5 Al_{10} Si_{32} O_{84} \cdot 34-44 H_2 O$  ;  $a = 35.10 \text{ \AA}$

The internal positions of the various atoms in paulingite has not yet been determined. Of all the zeolites, it has the largest unit cell. The variability of the water content is probably related to the substitution of divalent ions (Ca, Ba, etc.) for monovalent ions.

The external form of all paulingite crystals is that of the dodecahedron. The crystals are usually clear, sharp, and simple, but occasionally forms with small truncations of the corners (by cube faces {100}) or minor bevelling of the edges (by trapezohedral faces {112}) are observed. Crystals often form drusies, and therefore grow into each other, but there does not seem to be any tendency toward twinning.

Paulingite was first found in the float material at Rock Island Dam in Washington, but the source of the rock containing the zeolites at that location has not been found, and very little of the material remains. Most of the paulingite has come from the site at Three Mile School, Grant Co., Oregon, where the mineral is very abundant locally and can still be easily collected. Paulingite is also found in several sites around Monte Lake, British Columbia, and recently has been found in Northern Ireland.

The simple dodecahedron, unmodified. This is the normal shape for crystals of Paulingite.

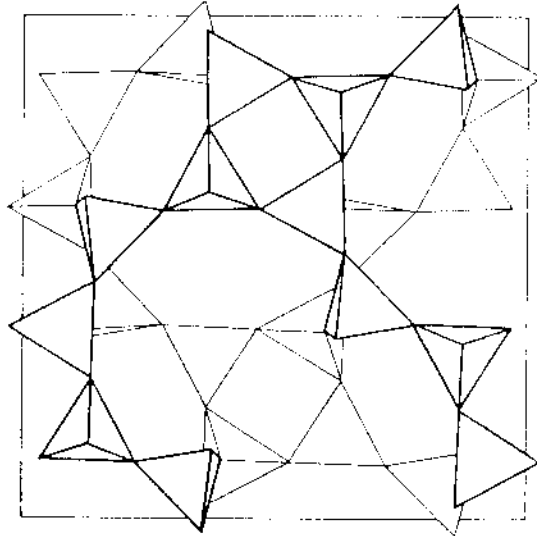


ANALCIME	Na Al Si <sub>2</sub> O <sub>6</sub> • H <sub>2</sub> O	;	a = 13.7 Å
WAIRAKITE	Ca Al <sub>2</sub> Si <sub>4</sub> O <sub>12</sub> • 2 H <sub>2</sub> O	;	a = 13.7 Å

These two zeolites are probably the end members of a series, though it is not clear whether all intermediate compositions can occur. Another series extends from analcime toward the cesium end member Pollucite, but water of crystallization is lost as the cesium concentration increases, so that Pollucite has no water of hydration and is therefore not properly a zeolite.

All three minerals have the same internal structure, and it is far simpler than the other cubic zeolites. The analcime unit cell contains 16 of the above formula units. The (Al,Si) O<sub>4</sub> tetrahedra are linked corner-to-corner (as shown in the diagram at right) to form rings of six tetrahedra and rings of four tetrahedra.

The six-membered rings form channels parallel to the [111] directions that do not intersect, and it is in these channels that the water molecules are located. Since the channels do not interconnect (as they do in structures such as faujasite and boggsite), they may become easily blocked, so the structure is not a particularly good one for ion exchange applications or for a catalyst support.



Structure of the aluminosilicate framework for analcime, showing 4- and 6-membered rings of tetrahedra, projected on the (100) plane.

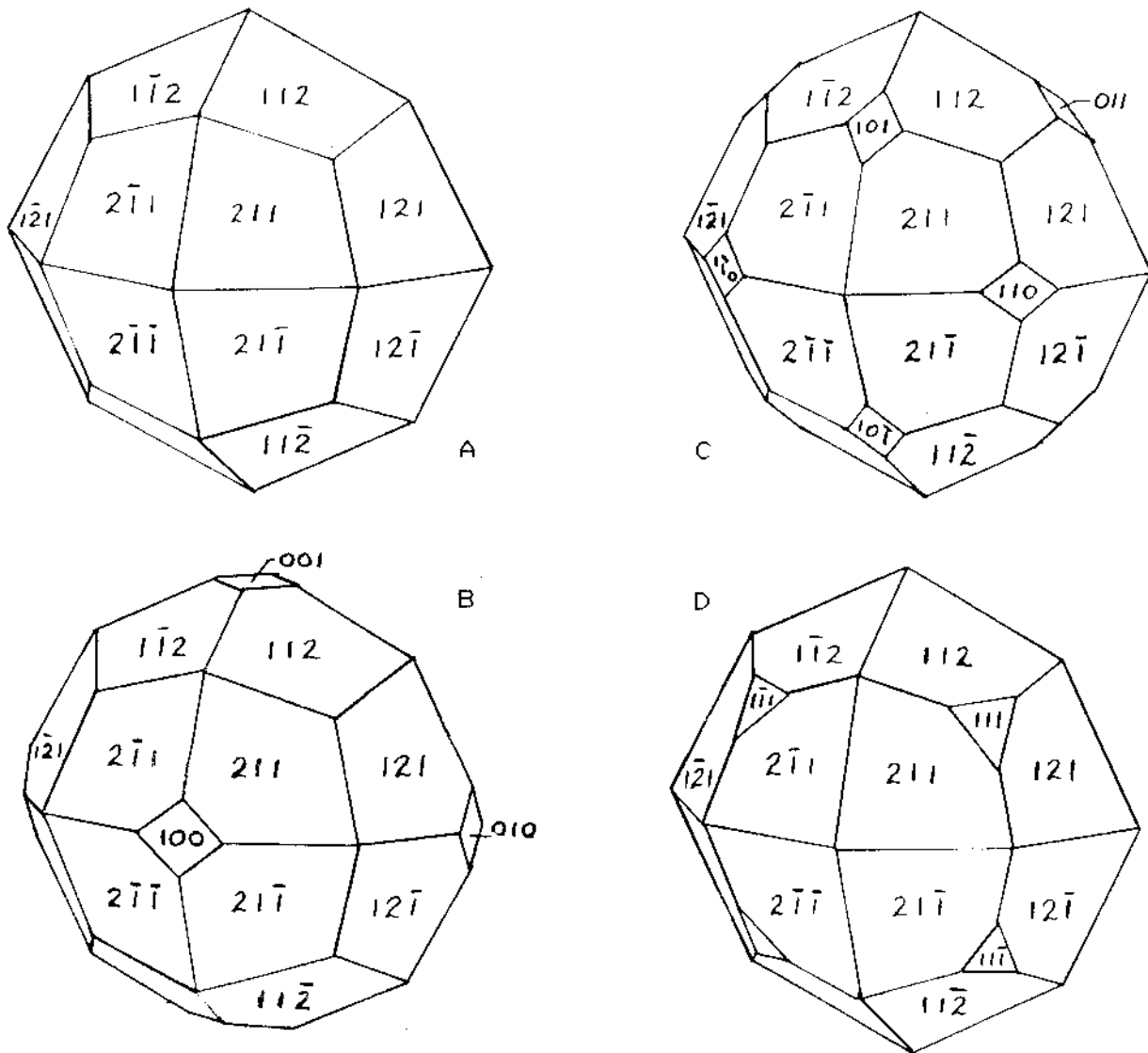
There are 24 of the smaller four-membered rings, and it is at these locations that the sodium ions are located. Since there are a total of only 16 such ions in analcime, only two-thirds of these positions are occupied, a condition which should break the cubic symmetry. It appears that, if the analcime crystal forms slowly enough that the occupied sites are ordered, the symmetry is indeed lower than cubic, and depending on exactly which cells are left empty, the crystals may actually be tetragonal, orthorhombic, or even monoclinic. The tendency in such systems is to twin rather heavily. Thus one finds analcime in radiating clusters of crystals, and in complex rounded groups. The analcime that occurs at Goble, Oregon is largely of this type. If the crystals grow faster so that the sites are randomly occupied, then the cubic form is obtained, and there is little tendency to twin. Most of the locations in eastern Oregon are of this type.

The normal form of analcime is the trapezohedron (trisoctahedron) in which three {112} faces appear on each of

6.

the eight octahedral faces to make a total of twenty four. Normally, only this dominant set of faces are present, but occasionally corners may be modified by either the cube faces {100}, the dodecahedral faces {110}, or the octahedral faces {111}, or possibly some combination of two or even all three forms. Only very rarely do any of these modifications become the dominant faces, and even then the trapezohedral faces will still be present to some extent.

Analcime and Wairakite (and Pollucite) can only be identified by chemical tests to establish which cations are present within the framework. The crystal forms are identical and cannot be used for identification purposes among members. Even x-ray diffraction cannot differentiate the members because the structures are identical internally.



The trapezohedron, the basic form of analcime and wairakite.

- (a) unmodified
- (b) truncated by the cube {100}
- (c) truncated by the dodecahedron {110}
- (d) truncated by the octahedron {111}

Thus we see there are only three cubic structures of zeolites. A few other minerals can masquerade as cubic, such as chabazite, whose rhombohedral form is that of a slightly distorted cube. However, since none of the three cubic zeolites normally form cubes, clear cubes will always warrant a closer inspection to see if the angles may be a few degrees off. Calcite can also form rhombs, but again they will not have right angle edges, and a drop of dilute acid will serve to sort out calcite. At least one location -- Yellow Lake -- has small octahedrons of fluorite associated with the zeolites that could be confused with faujasite. Those sorts of rare occurrences will still require the services of a specialist to test them out.

At least with cubic zeolites you have a fighting chance to identify them yourself.

---

## GARNET, EPIDOTE, AND HEDENBERGITE FROM CLARK COUNTY, WASHINGTON

Milton R. Marks

A small quarry or borrow pit on Rawson Micro Road (Road L 1510) about 15 miles northeast of Orchards in Clark County, Washington contains several silicate minerals in quartz seams in what appears to be andesite country rock.

The collecting site is an excavated outcrop approximately 75' by 100' just off Rawson Micro Road. Although the last 4 or 5 miles of the road is dirt and gravel, in June, 1991 it was easily passable in a passenger car. There is ample room to park next to the outcrop.

The mineral-bearing seams of up to 1.5 inches wide are nearly vertical and parallel, and are spaced around 18 inches apart. The main components of the seams are white to grayish quartz and pale green epidote. Garnet crystals occur within voids in the seams, along with a fibrous or needle-like pyroxene mineral.

The country rock is quite durable and requires a selection of chisels, points, pry bars, and sledges. There are also a large number of boulders present which contain seams.

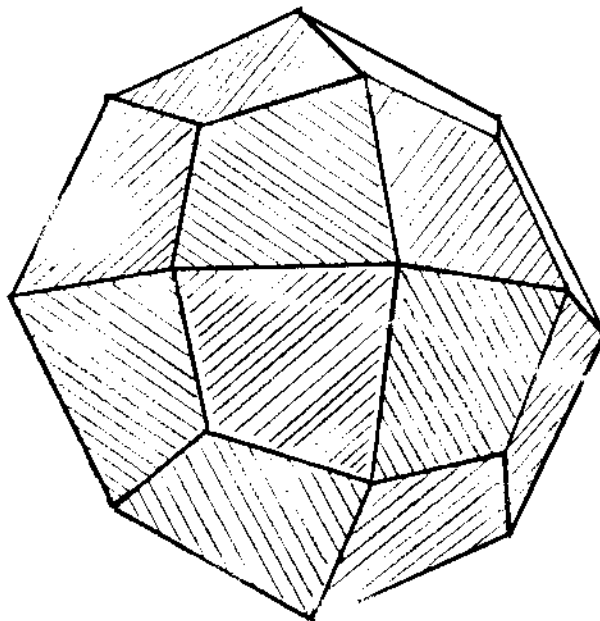
QUARTZ - white to grayish granular, is the primary component of the seams, and probably the earliest mineral to form. Prismatic clear crystals up to about 1 inch occur singly and in groups.

EPIDOTE - occurs as pale green crystals mostly mixed with the quartz, but also present as distinct crystals. The faces are often rounded and irregular.

HEDENBERGITE - occurs as mats and sprays of flattened needles. In color they vary from pale green to dark brown (the latter iron stained). Though they look very similar to the diopside found elsewhere, analysis shows that even the pale green needles have a considerable iron content and therefore are probably the iron-rich member, hedenbergite.

ANDRADITE - occurs as euhedral crystals, sometimes impaled on the needles of hedenbergite. They are honey to deep reddish brown in color, mostly opaque but occasionally translucent to nearly transparent. The clearest crystals are those that occur on quartz crystals. The basic form is trapezohedral, but the faces are usually striated parallel to the intersection with the dodecahedral faces {110}. Again, the iron content runs rather high, indicating in the solid solution between andradite and grossular that they are probably slightly on the side of andradite.

The striations may very possibly be due to etching rather than growth features. This would be consistent with the rounded appearance of the epidote.



Form of the Andradite from Rawson Rd., indicating the direction of striations.

Other minerals observed or reported:

PYRITE - a quarter-inch crystal surrounded by a shell of limonite

ILMENITE (?) - one sub-metalline, black, wedge-shaped micro

CALCITE - as irregular masses in the seams

Reference: Jon Gladwell, "Crystals & Minerals Vol II"



## ZEOLITES FROM THE PRICE CREEK QUARRIES, KINGS VALLEY, BENTON COUNTY, OREGON

by  
Rudy W. Tschernich  
526 Avenue A  
Snohomish, Washington 98290

Zeolites are abundant in black marine Eocene pillow basalt in several quarries near Price Creek, southeast of Kings Valley, Benton County, Oregon. The most productive quarry is located on the southern ridge and is known as the Price Creek Quarry (= DEK Quarry).

To reach the quarry, from the Kings Valley General Store, travel south on Highway 223 for 2 miles, turn east on the Price Creek Road and drive until you reach a locked gate. If you have a key, proceed one mile, turn right and cross Price Creek. Follow this road for 1.3 miles, to the mountain top and the quarry, keeping to the left at all intersections. Vehicles with low clearance should not attempt this road.

The zeolites are found in the large central cavities in the pillows and the more restricted interstitial cavities between pillows.

**ANALCIME** is the most common and most spectacular mineral found in the quarries. It forms transparent colorless trapezohedra, up to 4 cm in diameter, which lose water and turn milky-white when removed from the damp rock. A few crystals were found up to 7 cm (3 inches) in diameter. The best analcime crystals were found in large cavities in the center of the cavities. Analcime in interstitial cavities commonly have grown completely across the space and become intergrown.

**NATROLITE** forms colorless sprays of thin needles, up to 5 cm long, generally extending from white thomsonite blades. Natrolite is much less abundant than analcime in these quarries.

**THOMSONITE** commonly forms inconspicuous aggregates composed of radiating white blades, up to 2 cm long, that are totally covered by natrolite needles and analcime. Rarely white bladed thomsonite is not covered by other minerals.

**LAUMONTITE** forms small transparent colorless prisms, up to 8 mm long, which lose water and turn white after exposure to the dry air. Laumontite is found on analcime, natrolite, and thomsonite.

**CHABAZITE** forms colorless to white highly striated penetration twinned rhombohedra, up to 15 mm across, that are covered by analcime.

**STILBITE** forms colorless flat-topped prisms, up to 2 cm long, that turn white from a loss of water when exposed to the air.

**APOPHYLLITE** commonly forms colorless pointed dipyramids, up to 4 cm long. A few crystals with a light yellow or green coloration have been found.

**CALCITE** commonly forms colorless, cream, and yellow rhombohedra, up to 5 cm across, with a few crystals up to 10 cm (4 inches) in diameter.

**PYRITE** is found on the surface of the rock but not on the zeolites.

**CLAY** forms a black lining which precedes zeolite crystallization in all the cavities.

## ZEOLITES FROM THE OAKVILLE QUARRY, OAKVILLE, GRAYS HARBOR COUNTY, WASHINGTON

by  
Rudy W. Tschernich  
526 Avenue A  
Snohomish, Washington 98290

Zeolites are common in vesicular Eocene basalt in the Oakville Quarry, along Highway 12, 0.5 mile northwest of Oakville, Grays Harbor County, Washington. The locality was brought to my attention by Gloria and Terry Cook in 1991. The quarry is now filled with water and has little productive rock exposed. Fortunately several very large boulder piles are present that are a good source of specimens. Cavities range from 5 mm to 5 cm in diameter. A lot of nonvesicular basalt is also present. Selection of boulders that have the largest cavities is most rewarding. The boulder piles are being hauled away or are being consumed by a crusher. Collecting should be done before the locality becomes extinct. Good specimens are not abundant but with time and effort some very interesting microcrystals can be found. The boulders in the piles move easily; therefore, be careful when climbing on them or breaking the rock. The rock breaks easily.

**PHILLIPSITE** commonly forms light yellow, to cream-colored blocky, lustrous, pointed crystals, up to 4 mm long, that line many of the cavities. Cream-colored radial aggregates of phillipsite, up to 15 mm in diameter, are also present. In some boulders the phillipsite is altered to a crumbly yellowish-white powder. Fresh phillipsite crystals make excellent specimens. Chabazite, natrolite, analcime, and calcite are found on the phillipsite.

**NATROLITE** commonly forms attractive, transparent, colorless, radiating groups composed of thin needles, up to 2 cm long, on analcime. Natrolite also forms a completely white overgrowth, up to 5 mm thick, on the surface of thomsonite hemispheres. Rarely, a second generation of small, colorless analcime trapezohedra and white bladed thomsonite occur on the natrolite needles.

**ANALCIME** commonly forms transparent, colorless, or light yellow trapezohedra, up to 5 mm across. Analcime is found on phillipsite, chabazite, and gmelinite and is covered by natrolite, white thomsonite, and calcite. A late phase of analcime crystallization is rarely found on the natrolite needles in a few cavities.

**THOMSONITE** rarely forms zoned, colorless to milky-white, radiating hemispheres, up to 8 mm in diameter, with a few reaching 2 cm in diameter. All of the thomsonite hemispheres are covered by a white overgrowth of natrolite needles, 1 to 5 mm thick. Tiny white blades of thomsonite formed at a later time scattered on some of the natrolite needles.

**CALCITE** forms attractive cream-colored or golden rhombohedra, commonly 3 mm across, although some crystals, up to 1 cm across, do occur on many of the zeolites. Tiny cream-colored rhombohedra also crystallized in some cavities before the zeolites.

**CHABAZITE** rarely forms colorless, light orange, or yellow twinned phacolite crystals, 3 to 10 mm in diameter. The dominant, lens-like, curved surface of the phacolite twins appears frosted due to numerous minute rhombohedra. Some phacolite crystals are overgrown with a smooth-surfaced, thin shell of gmelinite. Analcime is frequently found on the chabazite.

**GMELINITE** rarely forms colorless to light orange, partial overgrowths on the surface of some chabazite crystals and complete overgrowths in other cavities. Gmelinite-chabazite crystals are rarely over 5 mm in diameter. The gmelinite can be distinguished by the smooth flat pyramidal faces and the presence of a {0001} pinacoid.

**CLAY** forms a thin, black, velvety cavity-lining that precedes zeolite crystallization.

The minerals crystallized in the order: calcite > radial thomsonite > phillipsite > chabazite > gmelinite > analcime > natrolite > analcime > white thomsonite > natrolite > calcite.

Natrolite, analcime, and calcite are common in many of the marine Eocene basalt localities in western Washington. The sodium needed for these zeolites is derived from the sodium in seawater trapped in the glass when it cooled under the ocean. Later alteration of the glass released the sodium and some potassium into the zeolite forming solution. The presence of the calcium-sodium-rich zeolites; thomsonite, chabazite, and gmelinite associated with the sodium-rich zeolites; natrolite and analcime is unusual and makes a more interesting suite of minerals. The only similar occurrence in Washington has been at Mt. Solo, Longview. The presence of the potassium-rich zeolite, phillipsite, with sodium-rich minerals is not common. Potassium can be incorporated into the structure of chabazite but not into gmelinite. Potassium in the solution promotes the growth of chabazite. When gmelinite is found at localities that contain a potassium mineral, such as phillipsite, it is always intergrown with chabazite. The overgrowth of gmelinite on chabazite is not easy to recognize in the field. Collect all the specimens that appear to be chabazite variety phacolite and carefully observe the surface characteristics with your microscope at home. The phacolite crystal will be curved and rough while the gmelinite portion will be smooth and lustrous. Some phacolite crystals have only patches of gmelinite on the surface. Others are completely covered.

## ERIONITE FROM THE TYPE LOCALITY

by  
Rudy W. Tschernich  
526 Avenue A  
Snohomish, Washington

A white woolly massive mineral was found in rhyolite-tuff near Durkee, Oregon by E. Porter Emerson in 1897. Specimens were sent to the mineral museum at Harvard University, where in 1898, Arthur S. Eakle described and named the mineral erionite after the Greek word for wool because of its woolly appearance. When the mineral was first described, it was thought to be orthorhombic. Much later, when well formed needles of the same mineral were discovered at other localities, it was found to be hexagonal.

The type locality for erionite is located in a small open pit mine, along Swayzee Creek, 1.7 miles east of Interstate 84 exit 330, south of Durkee, Baker County, Oregon. The open pit was mined for fire opal, in 1897. Two pits are found along the north side of the road. Zeolites were found only in the lower pit nearest the road. Zeolites are very rare in vesicles and seams in rock that make up the dumps on both sides of the road.

The woolly erionite occurs in a brownish-gray, welded, rhyolite, Tertiary tuff that is covered by volcanic ash deposits. Although unknown to Eakle in 1898, the overlying ash had been altered to minute crystals of erionite. The woolly erionite and opal very rarely occur in scarce vesicles and seams parallel to the flowage of the welded tuff. Woolly erionite feels soft and is tough and flexible like asbestos. When the rock is broken the white tufts, which completely fill the cavities, adhere to the cavity lining and pull out to form curly white fibers. Woolly erionite masses are rarely over 2 cm wide. A few cavities in the same rock contain thin, colorless, hexagonal erionite needles, the form that is common for erionite at other localities. In one area of the pit a spherulitic phase of the tuff produced small hollow thundereggs that are lined with colorless heulandite crystals. Erionite is extremely rare at this locality. Several hours of breaking rock may produce only a couple of tiny specimens.

Only two other localities in the world produce woolly erionite. One is near Pass Valley, northwest of Savona, British Columbia, Canada and the other is at Reese River, near Austin, Churchill County, Nevada.

Colorless to white fibrous needles of erionite have also been found with heulandite in vesicular basalt 2.5 miles from Interstate 84 exit 327, on the Manning Creek Road, north of Swayzee Creek.

## ZEOLITES AND ASSOCIATED MINERALS NEAR OXBOW DAM, BAKER COUNTY, OREGON

by  
Rudy W. Tschernich  
526 Avenue A  
Snohomish, Washington 98290

Zeolites are abundant in a section of Miocene olivine basalt near Oxbow Dam, Baker County, Oregon. These flows are near the base of the thick Miocene basalt flows that make up much of eastern Oregon and Washington. The flows near Oxbow Dam are approximately the same age as the zeolite-bearing flows in the Monument-Kimberly-Spray-Ritter areas that are some of our better known zeolite localities. The collecting site is located about 1 mile south from the Idaho Power Camp Ground on the road leading to Oxbow Dam. Zeolites are found in a 100 yard long section along the road that consists of pillow lava, breccia, and vesicular portions covered by large basalt columns. Zeolites are found in cavities in the centers of pillows, in cavities between pillows and breccia fragments, and in vesicles up to 2 feet in diameter. Much rock has already been barred loose. Be careful of overhanging rock. Removing the zeolite-bearing rock from underneath 50 foot columns can be hazardous to your health.

**CLAY** at this locality is very abundant in most of the larger cavities. It forms loosely piled light green spheres, 0.5 mm in diameter, that fill up the lower part of many of the cavities. In some of the cavities the clay portion is 15 cm thick or more. Heulandite, stilbite, and rarely chabazite have grown within the clay and take their green color from the numerous clay inclusions found in the crystals. Zeolites that formed shells over the surface of the clay portion are colorless.

**HEULANDITE** is the most common zeolite at this locality. It forms blocky colorless crystals, up to 1 cm long, although most of the crystals are only 2 to 5 mm across. Small heulandite crystals frequently have formed within the clay portion of the cavities and are green in color from the clay that is included within the heulandite crystal. Colorless crusts of heulandite crystals also cover the clay portion of the cavity with the underside of the crust containing well formed crystals that extended into the clay and are filled with green clay spheres. Colorless heulandite crystals cover white mordenite needles and commonly are associated with stilbite and thomsonite-mesolite aggregates.

**STILBITE** forms colorless flat-topped rectangular crystals, up to 1 cm long, with triangular corners, that are associated with heulandite and calcite on green clay. Rarely, stilbite crystals extend into the clay portion of the cavities and are filled with green clay inclusions. Stilbite also forms radial groups and even lustrous smooth surfaced hemispheres, up to 15 mm in diameter.

**MORDENITE** forms thin white hair-like needles, up to 5 mm long, covering the walls and forming stalactite-like growths up to 10 cm long, in a few cavities. Some of these cavities reach 60 cm (2 feet) in diameter. Colorless heulandite crystals commonly cover the mordenite. Much of the mordenite is covered with a sooty black manganese oxide that can be removed with a vitamin C (ascorbic acid) solution but the resulting mordenite becomes matted and makes poor specimens.

**CHABAZITE** is not common at this locality but when present makes very nice specimens. Chabazite forms colorless, cream-colored, and light orange rhombohedra, up to 4 cm across. It is frequently associated with thomsonite-mesolite aggregates and drusy heulandite. One exceptional pocket produced well formed, green, penetration twinned chabazite crystals, up to 4 cm across, that were filled with clay inclusions. A few cavities contained colorless chabazite variety phacolite, up to 3 cm in diameter, associated with yellow thomsonite-mesolite hemispheres.

**THOMSONITE** is rare at this locality and has been found in only one small area. Several cavities, up to 30 cm in diameter, were lined with colorless to white compact radial thomsonite blades, up to 3 cm in diameter, covered with short thin yellow mesolite needles and associated with cream-colored chabazite and green clay. The variety of colors and crystal forms of the minerals make these specimens very desirable.

**MESOLITE** forms short thin colorless needles, 2 to 5 mm long, covering the surface of white thomsonite hemispheres, up to 3 cm in diameter. The mesolite is commonly colored yellow or orange from iron oxide and is associated with chabazite, heulandite, and clay.

**PHILLIPSITE** very rarely forms complex white aggregates, up to 2 cm in diameter on drusy heulandite.

**ARAGONITE** is abundant in a silica-rich area of the deposit. It forms colorless rectangular prisms or hexagonal twins, up to 15 cm long. Most of the aragonite has been replaced or coated by heulandite, chalcedony, or both minerals.

**CHALCEDONY** forms colorless to white coatings over aragonite crystals in cavities up to 30 cm in diameter in the silica-rich area of the deposit. Radial groups of stilbite and aggregates of heulandite are the only zeolites present in this area.

**CALCITE** commonly forms small colorless to light yellow pointed crystals associated with most of the other minerals.

**ORDER OF CRYSTALLIZATION:** The minerals have been observed to crystallize in the order: clay > aragonite > chalcedony > mordenite > heulandite > stilbite > thomsonite > chabazite > mesolite > calcite. The order in which the minerals crystallized appears to have been controlled by a simple decrease in silica content in the solution.

## Zeolite Associates -- TOBERMORITE AND TACHARANITE

Donald G. Howard

A number of zeolite locations, particularly those in Grant Co., Oregon, show a chalk-white mineral that is sometimes identified as Tacharanite and sometimes as Tobermorite. These minerals are not zeolites but often occur with them. Both minerals have a layered structure much like the clays, and do not form visible crystals. There are, however, some important differences between these minerals and the clays.

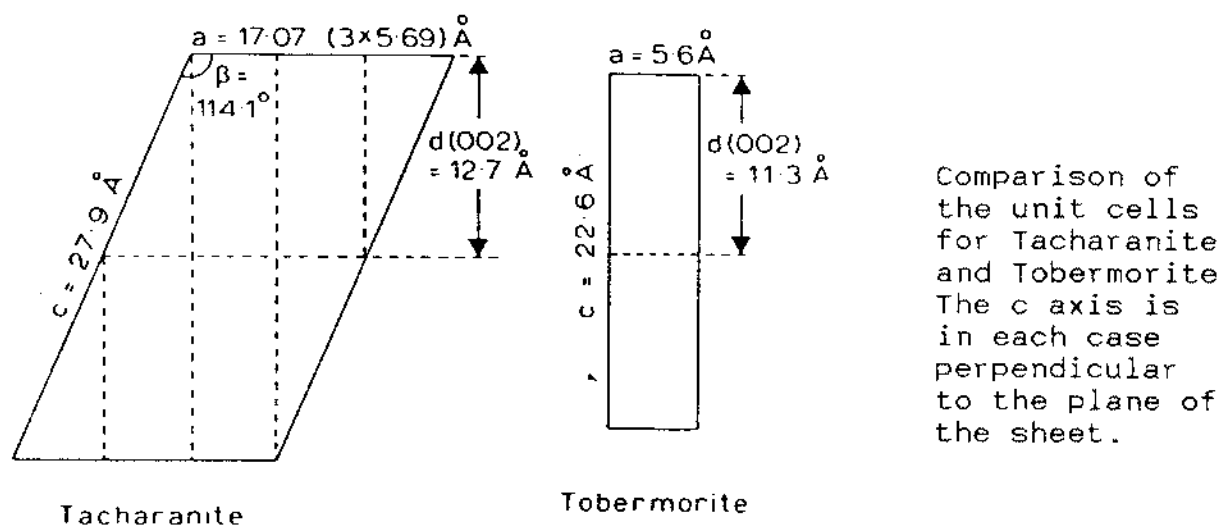
First of all, there is a difference in composition. Smectite clays, the kind that usually form in basalts, are primarily basic magnesium silicates, with iron substituting for a part of the magnesium. They are therefore usually green, or if oxidized, rusty orange or brown. The source of the magnesium is generally glasses and olivine phenocrysts in the basalt that are quickly broken down by ground water, so that they tend to form very early and usually line the cavities before zeolites begin to form.

Tobermorite  $\text{Ca}_5\text{Si}_6\text{O}_{16}(\text{OH})_2 \cdot 4\text{H}_2\text{O}$  is a basic calcium silicate. The source of the calcium and silica are going to be the same as for the zeolites, so it will tend to form along midway in the sequence of crystallization. The absence of aluminum is the feature that distinguishes it from zeolites. It will form when the aluminum concentration is too low for zeolite formation. Similar, aluminum deficient minerals that form with zeolites are gyrolite and okenite, which are also basic calcium silicates without aluminum.

Tacharanite is approximately  $\text{Ca}_{12}\text{Al}_2\text{Si}_{18}\text{O}_{69}\text{H}_{36}$ . Aluminum appears to be a minor but essential constituent. The ratio of alumina to silica is about half that of what is found in most zeolites. This appears to be a mineral that forms at moderate aluminum concentrations, and therefore is the more likely zeolite associate.

Secondly, there are structural differences. Both Tobermorite and Tacharanite have a structure in the plane of the layers that is about 7.3 Å by 5.6 Å in size, though in Tacharanite the second cell dimension is actually tripled. The distance between each layer is also different. In fact, Tobermorite is a name given to three different cells, one with a layer separation of 9.3 Å, one with 11.3 Å, and a third with 14.0 Å. (The three differ presumably by the amount of waters of hydration.) In all three cases the layers are stacked directly above each other, so Tobermorite is orthorhombic.

The interlayer separation for Tacharanite is slightly larger, and the layers are offset to give a monoclinic structure. The cells of the two structures are compared in the following diagram.



Actual crystals as such of either mineral have never been found. Structural studies were done on tiny fragments separated from the mass and examined in the transmission electron microscope. There is no way to separate these two minerals except by x-ray diffraction studies, which can identify which unit cell is present.

Tacharanite was originally reported from Scotland, and has since been found in Germany as well as the Pacific Northwest. The material from the North Fork of the John Day River, from Kimberley, and from the old original quarry at Ritter have been positively identified as Tacharanite. Only the recent material found in the new quarry at Ritter has proven to be the 11.3 Å form of Tobermorite.

#### ODD ZEOLITE ASSOCIATES -- Yellow Lake, British Columbia

Donald G. Howard

One of the oddest zeolite occurrences is found on the north shore of Yellow Lake, a small lake near the summit of the section of Canadian Route 3 between Keremeos and Penticton at the very southern edge of British Columbia.

The rock appears to be a trachyte, light in color, with phenocrysts of olivine, biotite, and magnetite. Amygdules occur, up to several centimeters in size, which are lined with various zeolites, depending on vertical position in the deposit. Near road level, most of the larger cavities are filled with thomsonite of a very odd, blocky habit. Smaller cavities often contain analcime.

Vertical seams intersect much of the deposit, and these, too, contain zeolites. An orangish heulandite with a very pointed, assymmetric habit was followed by clear, well-formed prisms of brewsterite. Openings in the seams are often lined with lovely brewsterite, and this is the mineral that is usually collected at this site.

The presence of faulting and mineralized seams indicates that the area must have experienced an upwelling of hot mineralized waters. The solutions must have been very rich in strontium to have formed so much brewsterite. Indeed, some of the other zeolites, such as the heulandite and thomsonite, contain considerable concentrations of strontium -- that could possibly account for the very unusual crystal forms observed. The solutions also contained fluorine, vanadium, and some of the rare earth elements.

Fluorite crystals, clear, colorless, with octahedral habit, are found mounted upon brewsterite. In fact, they are often embedded in the surface layer of the brewsterite (see micrograph #005). Thus, both the strontium aluminum silicate and the calcium fluoride were forming from solution in the latter stages of the formation of the brewsterite. Fluorite is not a common associate of zeolites.

Even odder is the appearance of Wakefieldite (Ce) a rare-earth vanadate. This has been found on the brewsterite and on analcime in cavities adjacent to the brewsterite vein. The crystals are so dark a red that they appear black. Their structure is identical to that of zircon, which is tetragonal. Crystals are usually prisms with second-order faces, and either a flat basal termination, or rarely a second-order pyramid (see micrograph #007). Though the fluorite and wakefieldite have not been found together, they occur in the same vein within a short distance of each other. The fluorine may have had an important role in transporting the rare earth elements.

Recent microprobe analysis has shown that the chemical composition of the wakefieldite is:

component	weight percentage	
	center	edge
V <sub>2</sub> O <sub>5</sub>	34.7 ±.5	33.2 ±.3
Ce <sub>2</sub> O <sub>3</sub>	32.6 ±.3	38.1 ±.3
La <sub>2</sub> O <sub>3</sub>	24.8 ±.4	15.5 ±.6
Nd <sub>2</sub> O <sub>3</sub>	4.8 ±.1	7.4 ±.3
Sm <sub>2</sub> O <sub>3</sub>	0.4 ±.1	0.6 ±.1
	<hr/>	<hr/>
totals:	97.3 ±.6	94.8 ±.8

The totals are less than 100%, presumably because of low concentrations of the other rare earths, which were not included in the analysis. No iron, manganese, or niobium was found. Expressed in formula notation, we would have:



Centers: (Ce<sub>0.52</sub> La<sub>0.40</sub> Nd<sub>0.07</sub> Sm<sub>0.01</sub>) V<sub>1.06</sub> O<sub>4.00</sub>

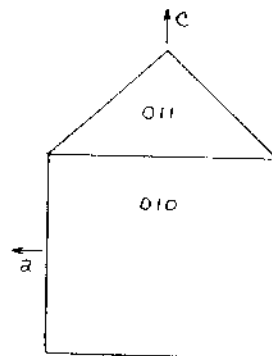
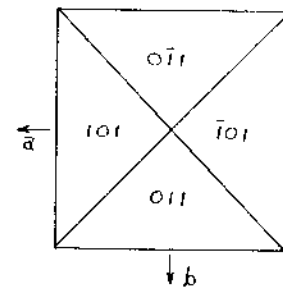
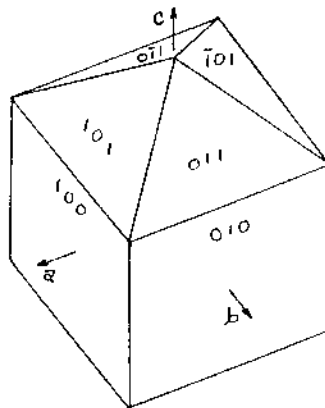
Edges: (Ce<sub>0.63</sub> La<sub>0.26</sub> Nd<sub>0.12</sub> Sm<sub>0.01</sub>) V<sub>0.99</sub> O<sub>4.00</sub>

The composition is rather unusual, because most minerals that contain rare earths and crystallize with the zircon structure favor the heavy members of the lanthanide series, while these crystals are almost exclusively the light members. There is a decrease in the lanthanum and a corresponding increase in the heavier rare earths at the very end of formation, as displayed in the altered composition for the outermost exposed edges.

This is the third occurrence reported for wakefieldite. It was originally identified and named from a feldspar quarry in Quebec, Canada, where it occurred in microscopic crystals embedded in feldspar. The original mineral wakefieldite (Y) contained little of the rare earths. The second occurrence was observed in museum specimens that had been previously collected at a lead mine in Zaire (originally named Kusuite after the mine). It was in gossan associated with lead and copper minerals, including vanadates such as vanadinite, mottramite, and descloisite (a much more likely chemical environment). This mineral contained primarily cerium, but with considerable replacement in the cerium site by lead.

Yellow Lake is the first known occurrence of wakefieldite in a zeolite environment. Wakefieldite was preceded by heulandite, analcime, and brewsterite; probably coformed with fluorite; and was followed by laumontite and calcite. Wakefieldite is quite rare at Yellow Lake, and only a few specimens have so far been found.

The typical habit for crystal of Wakefieldite at Yellow Lake, B.C.



## PROVIDING STORAGE SPACE

Donald G. Howard

Sooner or later, we all seem to have the same problem: we cannot find a particular specimen that we want to show to someone, or that we want to take to a meeting. Organizing a collection is often a distraction from the pleasure of adding new specimens to our collections. Simply finding space to put things in a way they do not "disappear" is often a real challenge.

Though I collect specimens in a variety of sizes, I find that the most common container I use to house pieces is the "perky" box -- 1 3/8" on a side. A good field trip, or an interesting trade with another collector will generally generate one or two dozen mounted specimens that I intend to keep for my collection, with maybe as many more mounted that I intend to give or trade with other collectors. The numbers can mount up fast, and the available storage space quickly is used up and overflows.

To help ease the problem, I have developed a small case that is about the right size to sit on a bookshelf. Each case will accommodate 40 "perky" boxes, grouped 8 to a shelf for easy retrieval. A selection of such cases allow one to sort and store specimens as to location, mineral, crystal system, or any other way you may have to order your collection. The cases sit on the shelf all sorted, ready to go with you to the next micromounters meeting.

Such cases are in fact not hard to construct, so I thought that I would pass on the plans, plus some tips on construction, in this issue of the Microprobe.

Construction is easiest if you have access to a small electric table saw to cut out the pieces. Both the half-inch plywood and the 1/8" acrylic plastic will cut very nicely with a fine-tooths saw, such as a plywood blade. The grooves are best cut with a blade that makes a cut slightly larger than 1/8" -- most general purpose blades are this wide, and the carbide-tipped blades are especially nice for making smooth grooves of this width.

## MATERIALS:

The cases themselves are made of half-inch plywood. I prefer the kind with one finished side so that the outside will look nice, and I pick through the available lumber to find a piece that is clear. Since the individual pieces are small, odds and ends of plywood, if available, work very well and can be profitably used up in this way. A full 4' by 8' sheet will contain enough lumber to make about 20 cases.

The 1/8 inch thick acrylic plastic sheet can be purchased at a plastics supply house. I buy mine at Tap Plastic (39 th and SE Division St.) in Portland because it is convenient and because they have a "scrap bin" of pieces cut off other projects available at a very reasonable price. If you go through such a bin, make sure to check for the proper thickness, and make sure the scraps are clear and have a smooth surface. It is a good idea to have the sizes of the pieces necessary with you so that you can only take suitable scraps.

#### CUTTING AND ASSEMBLING THE CASE:

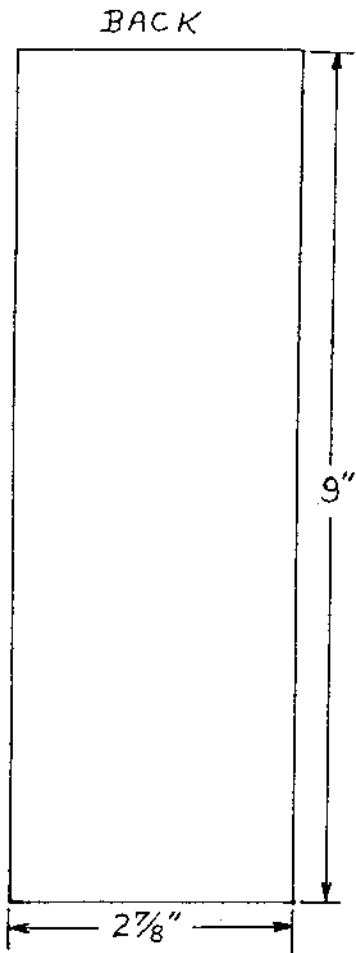
I generally set up my saw to make all cuts of similar size at the same time. This is particularly important with the 2 7/8" cuts so that the case fits tightly together. Also, I try to cut the back slightly short so that the sides will lap over top and bottom just a bit, making it easier to sand down the outside after the case is assembled.

Once all the pieces are cut out, the saw needs to be reset so that it will just cut into the wood about 5/32" deep. The five grooves can then be cut in the poorer quality side of the 7 1/4" by 10" pieces. I also run a similar groove up the side I intend to be the front, so that in the finished case the drawers will go in all the way and leave the front flush. Notice that this requires the two sides to be mirror images of each other, with grooves cut on opposite edges with respect to the five cross-grooves.

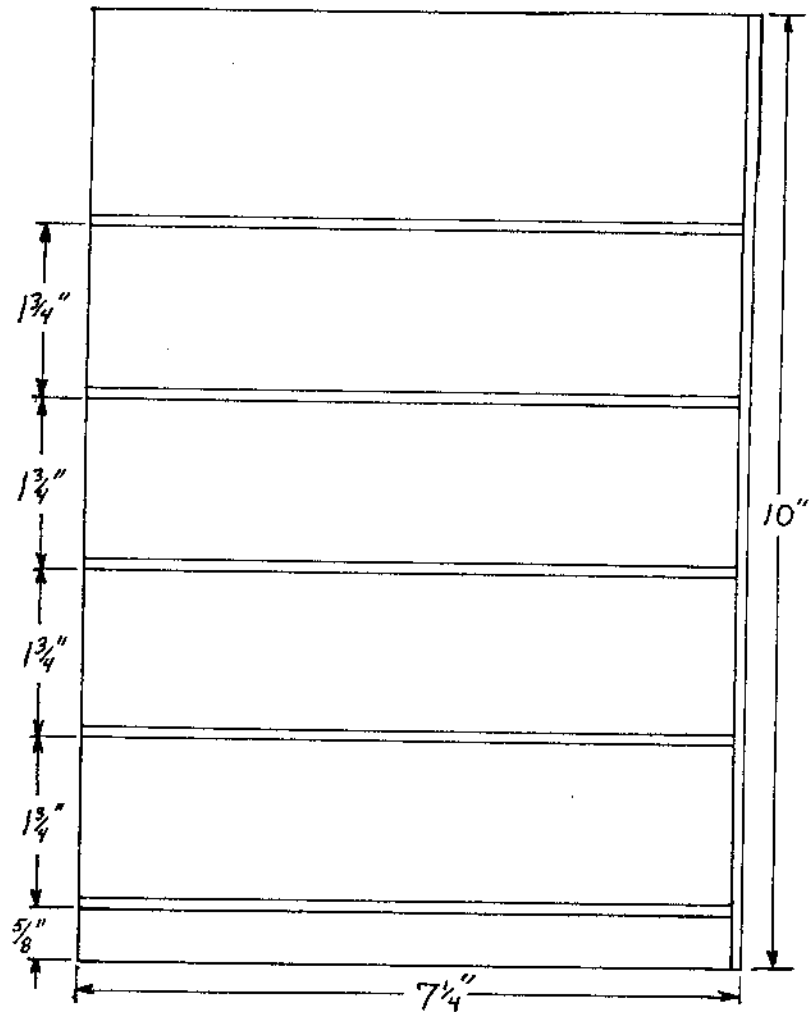
After cutting, I give all the inner surfaces of the wood a coat of white primer paint, and allow it to dry thoroughly. This will make the boxes white on the inside. Because the boxes are rather narrow, it is awkward to reach in after assembly with a brush to paint the inner surface.

To assemble the case, I use both glue (Elmer's) and wire brads (about 1" long). Starting with the top, spread glue on one long edge, and nail the top of one side to it. Let the top overlap just a little, so that you can sand it down later for a good flush fit. Next spread glue on the edge at top and one side of the back, and nail the side with the top attached to it. Also put a brad down through the top to keep everything tight and in line. Next spread glue on the side and rear edges of the bottom and nail this in place. Again, a brad in through the bottom will keep everything in line. Finally, turn the assembly over, spread glue along the remaining edge, and nail the other side on. Again, the alignment at the top is most important, with a slight lap to be finished down later.

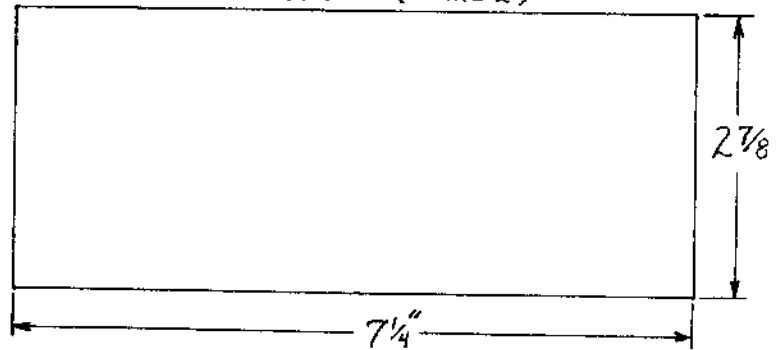
Set the completed box aside so the glue will dry thoroughly. Wood putty can be used to fill any exposed voids in the ply around the edges, and the extra pieces of 1/8" groove on the front at top and bottom. Once the wood putty is set, the case can be sanded smooth and even, given a coat of primer, and painted whatever color you desire.



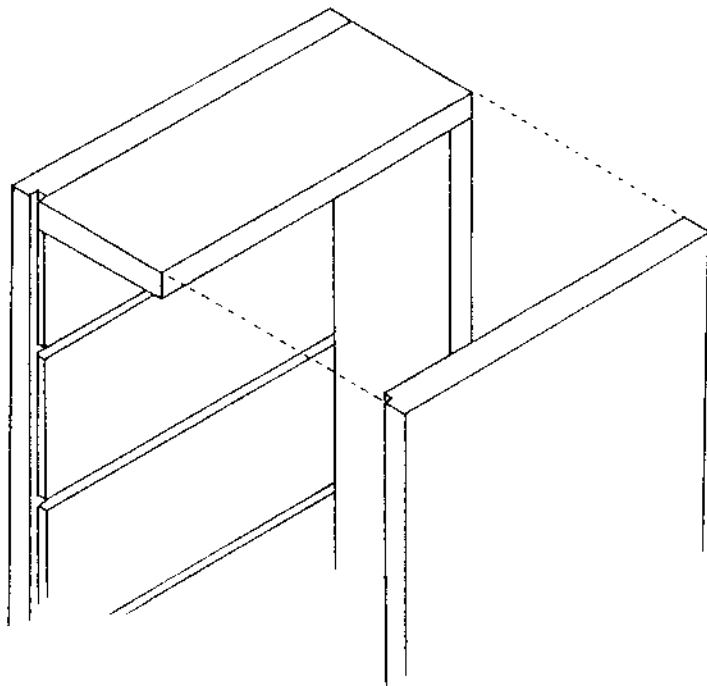
SIDE (make 2)



TOP & BOTTOM (make 2)



Layout of the five pieces to be cut from  $\frac{1}{2}$ " plywood. Note that the two side pieces must have the groove (shown on the far right side) cut on opposite sides for the two pieces.



Assembly detail of the  
plywood case unit.

If you make many of these, as I have done, you may want them all the same color, but I prefer having each painted a different shade to make it easy to tell them apart. The best way to do this is to get small cans of a variety of colors and mix them yourself in small amounts in little glass jars left over from the kitchen. Mixing a very little color into white paint will give very pretty pastels. Be sure that you mix enough to give at least two coats so the color will be uniform. Also, make sure the paints are compatible (ie., both oil base or both water base, for example). This is a fun

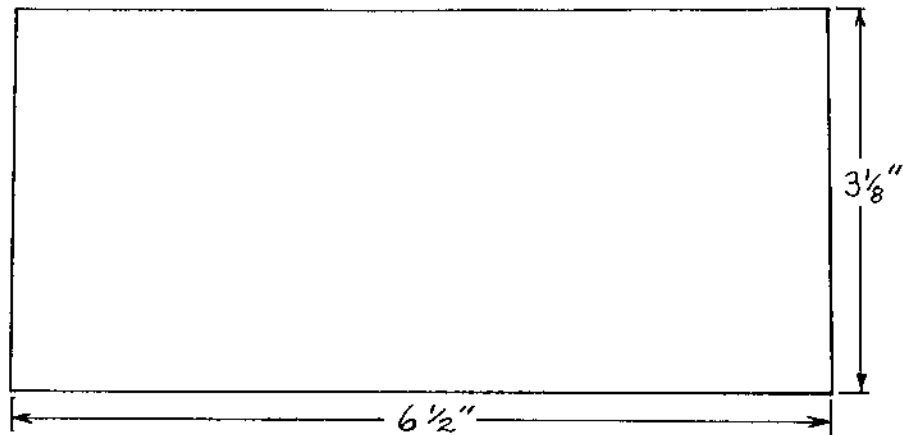
part of the operation, and the color that results will often be a surprise. And if you do not like it after it dries, then mix a new shade and paint it over the top.

#### CUTTING AND ASSEMBLING THE DRAWERS

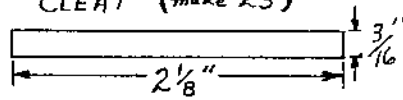
Always leave the paper covering on an acrylic sheet until they are cut to final size. If cutting on a table saw, set the guard at the proper width and run the pieces through. If you cut the plastic by hand saw (such as a hack saw or other fine-toothed saw), the paper makes a convenient medium on which to draw out the lines to cut with a pencil. After cutting, the edges often need smoothing with a file or sand paper, even if cut on a table saw. The paper can be peeled off after each piece is properly shaped and smoothed.

Acrylic is fastened together with acrylic cement, which is a clear fluid (available at plastic supply stores) that will partially dissolve the surface of the plastic, and which evaporates quickly. This fluid should be applied in small amounts to the interface where two sheets to be glued are held tightly together. The ideal instrument to apply the fluid to the crack between the two pieces is a hypodermic syringe. Disposable ones with metal needles and plastic bodies can be purchased at a drug store -- but they are truly not reuseable: since the solvent quickly attacks the plastic body, they soon refuse to slide smoothly. I use a syringe whose body is made of glass (also obtained from a drug store) that has survived many gluing sessions. The metal needle is removeable, and can be used over and over until it gets plugged with something (and that does not happen often).

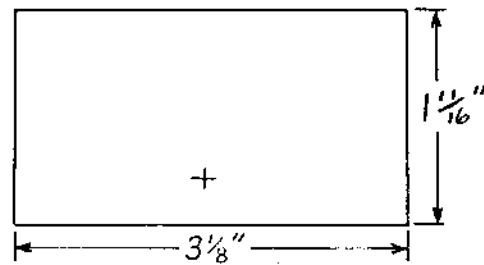
DRAWER (make 5)



CLEAT (make 25)

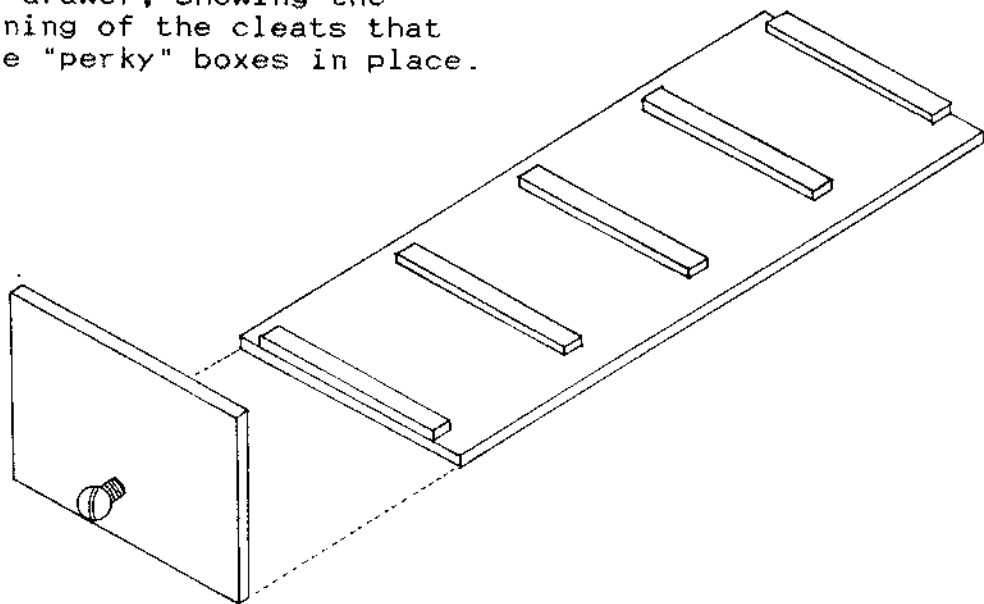


FRONT (make 5)



Layout of the pieces  
to be cut from  $\frac{1}{8}''$   
clear acrylic sheet.

Assembly drawing of a finished  
plastic drawer, showing the  
positioning of the cleats that  
hold the "perky" boxes in place.



Take all the paper off of the cut pieces and make sure all edges are smooth. Then, starting with the base, position one of the cleats flush against one end (this end will be the front), hold it firmly in place, and with the needle add just enough fluid cement to completely wet the space between the two pieces of plastic. Be careful not to "spill" extra fluid on surfaces; because it tends to cloud wherever it hits -- if you do "spill" some, wipe it off immediately. Continue to hold the two pieces together in place for twenty or thirty seconds until they are beginning to "set". Then set them aside for a few minutes to allow the solvent to evaporate and the bond to harden. I tend to do the above procedure to each of the five shelf pieces at once, then go on to the next step for all five. This gives sufficient drying time between operations.

At some point it is useful to cut from thin cardboard a "spacer" to help position the cleats. This should be 1 3/8" wide, just the size of one of the "perky" boxes. Place this spacer against the first cleat, position a new cleat against its other side and hold firmly. Remove the cardboard and wet the contact with cement, hold briefly, and put aside to harden. In this way cement a total of five cleats to each bottom piece.

The front is put on the same way. If you kept the first cleat just flush, the front should fit on smoothly and be perpendicular to the base. If there is a slight offset, you may need to file or sand the end smooth and perpendicular. While holding the two pieces together, needle in just enough cement to completely wet the interface. The bottom of the front should be just flush with the bottom of the base. You may need to hold this joint a little longer to make sure that it does not come apart or slip before setting.

#### DRAWER HANDLES

You need something on each drawer to help pull it out of the case. I actually turn little plastic knobs from 1/2" acrylic rod and glue them in place with the same acrylic cement. Assuming that you do not have access to a small lathe as I have, I make the following suggestions:

1. Drill a #29 hole in the front of the drawer at the proper place and tap an 8-32 thread into it with a hand-held tap. You can then screw an 8-32 machine screw (3/8" or 1/2" long) into the hole. If it is not tight, wetting slightly with acrylic cement should set it in place.
2. Knobs could be made by cutting discs of plastic from stock rod. One could use either one short length of 1/2" stock, or a "sandwich" of a 1/2" disc on top of a smaller disc.
3. Knobs do not have to be round. A small piece of the 1/8" acrylic sheet could be cut (say 1/2" by 1/2") and cemented edgewise to the front of the drawer.

Be inventive. Part of the fun is to create a unique and distinctive system to store your most precious specimens.

## CAPTIONS FOR THE MICROGRAPHS IN THIS ISSUE

Note: Photo number is on the front at lower right.  
Micrograph credits: Donald G. Howard

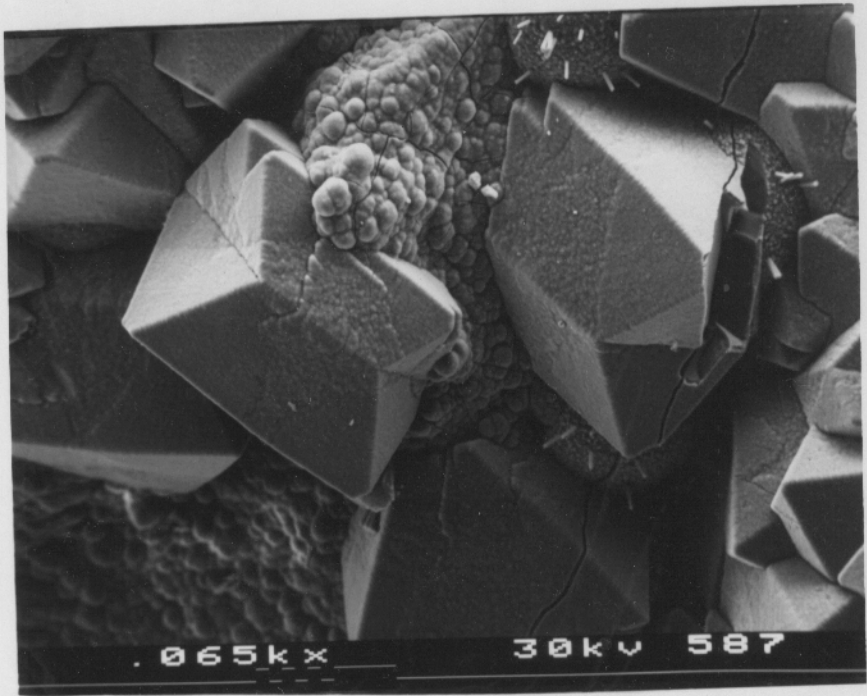
- #587 Faujasite and Erionite on clay (x 65)  
Kaiserstuhl, Sasbach, Germany  
Spinel twins. Most faujasite from this location  
is covered with a thin layer of opal.
- #041 Paulingite (x 66)  
Three Mile School, Grant Co., Oregon  
Scattered dodecahedrons on a smectite base.
- #746 Analcime (x125)  
Magheramore Quarry, Northern Ireland  
Crystal shows a well-developed cube face {100} in  
addition to the normal trapezohedral faces {112}.
- #056 Wairakite (x 28)  
Wairaki, New Zealand  
Trapexohedrons, with small modifications of both the  
cube {100} and the dodecahedron {110} at the corners.
- #006 Andradite (x 75)  
Rawson Micro Rd., Clark Co., Washington  
Trapezohedrons with faces heavily striated parallel  
to the intersection with the dodecahedral {110} faces.  
The striations could be a growth feature, but are more  
likely generated during etching by later solutions.
- #005 Fluorite on Brewsterite (x 40)  
Yellow Lake, Olalla, British Columbia  
Here the fluorite octahedra are clearly embedded in  
the prisms of brewsterite. Fluorite crystals are at  
the left and right edges of the brewsterite cluster.
- #007 Wakefieldite (Ce) on Brewsterite (x125)  
Yellow Lake, Olalla, British Columbia  
Second-order prism with second-order pyramid

THE MICROPROBE --- Published twice each year by the  
Northwest Micromineral Study Group

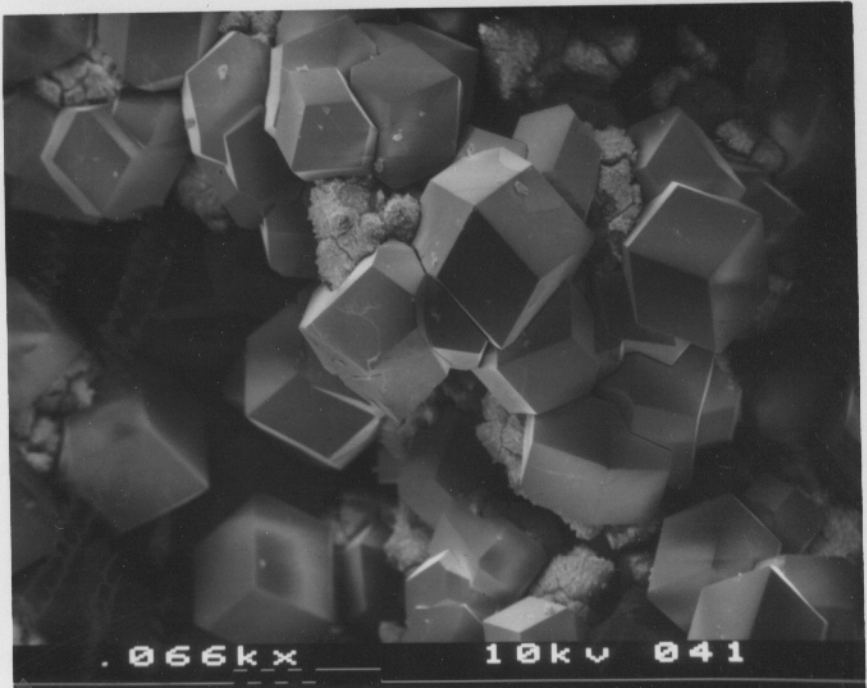
Yearly membership subscription rate: \$10

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

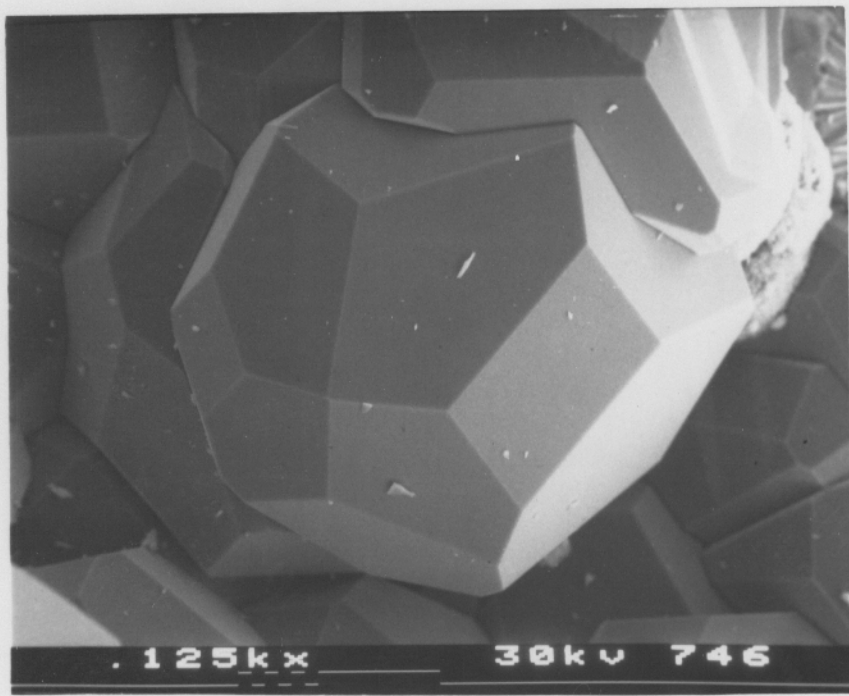




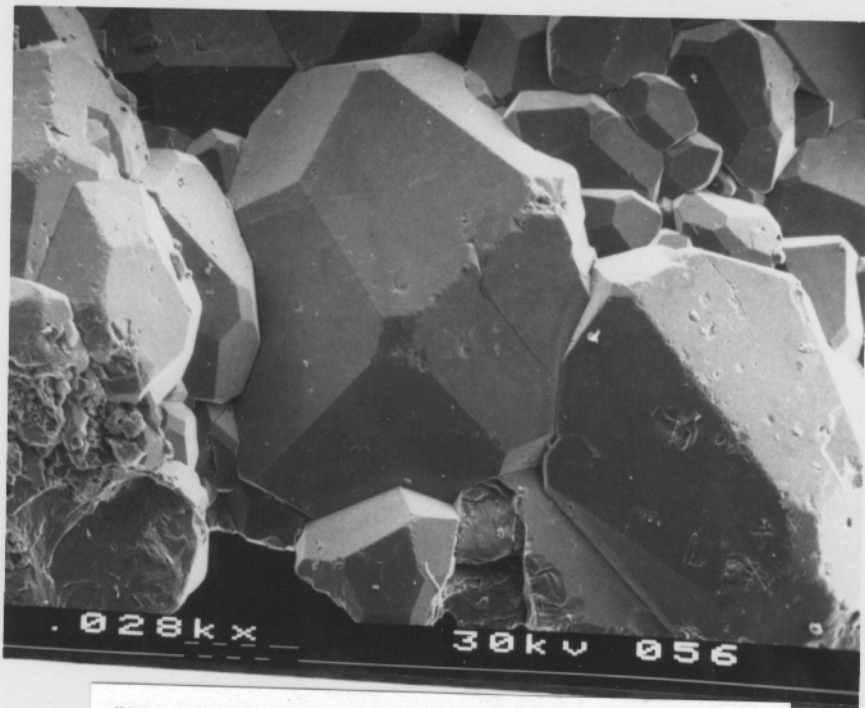
#586 - FAUJASITE, ERIONITE - KAISERSTUHL, SASBACH, GERMANY - 65X



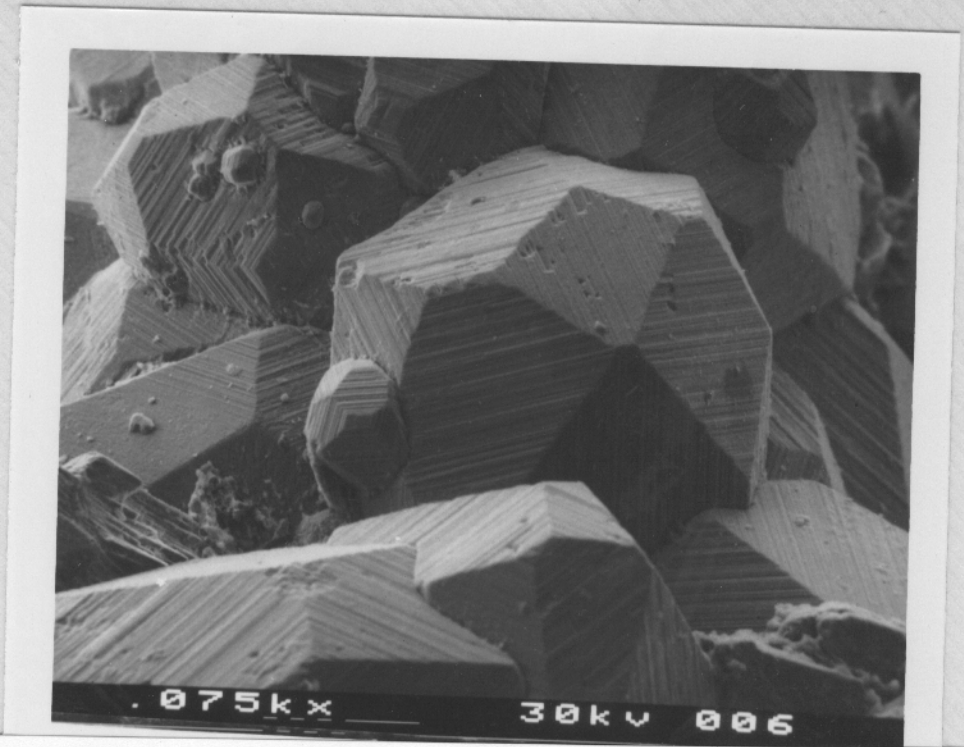
#041 - PAULINGITE - THREE MILE SCHOOL, GRANT COUNTY, OREGON - 66X



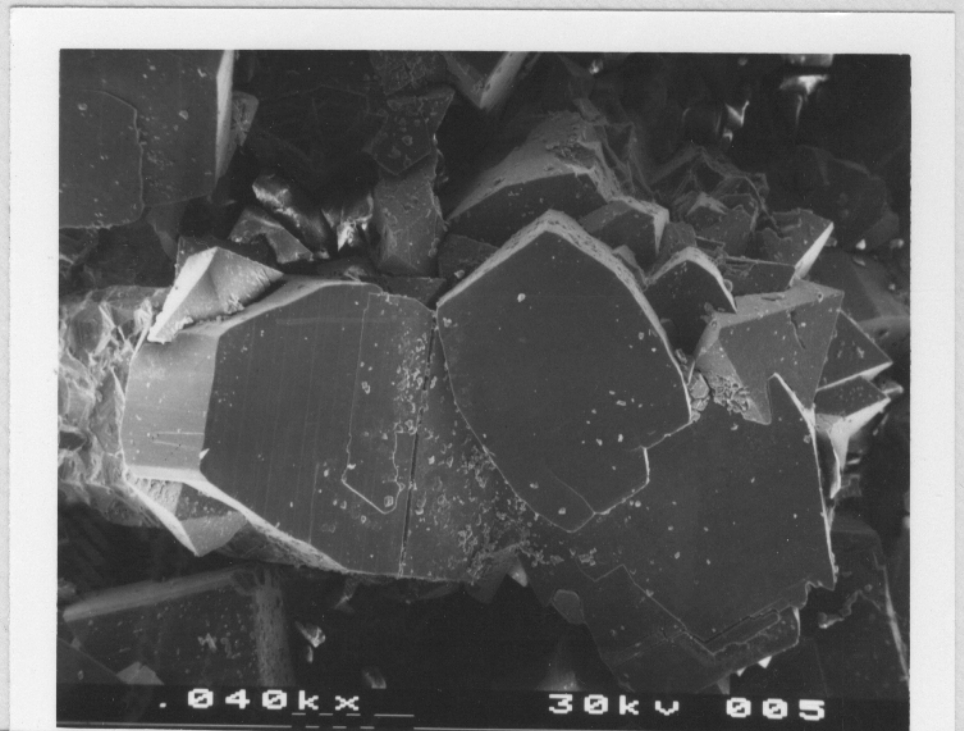
#746 - ANALCIME - MAGHERAMORE QUARRY, NORTHERN IRELAND - 125X



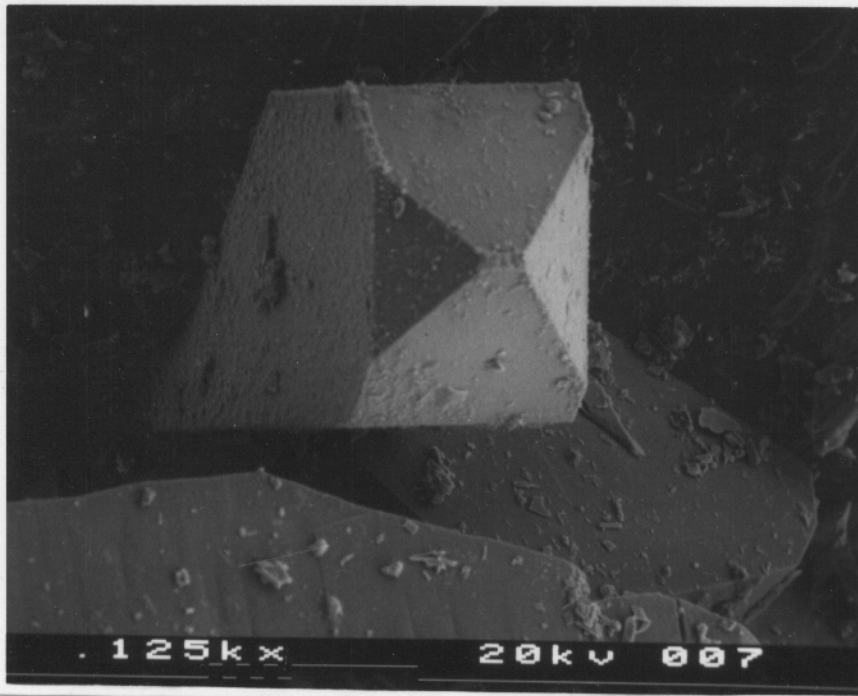
#056 - WAIRAKITE - WAIRAKI, NEW ZEALAND - 28X



#006 - ANDRADITE - RAWSON MICRO ROAD, CLARK COUNTY, WASHINGTON - 75X



#005 - FLUORITE, BREWSTERITE - YELLOW LAKE, OLALLA, BRITISH COLUMBIA, CANADA - 40X



#007 - WAKEFIELDITE-(Ce), BREWSTERITE - YELLOW LAKE, OLALLA, BRITISH COLUMBIA, CANADA - 125X