Northwest
Micro Mineral
Study Group

MICRO PROBE

SPRING, 1995 VOLUME VIII, Number 1

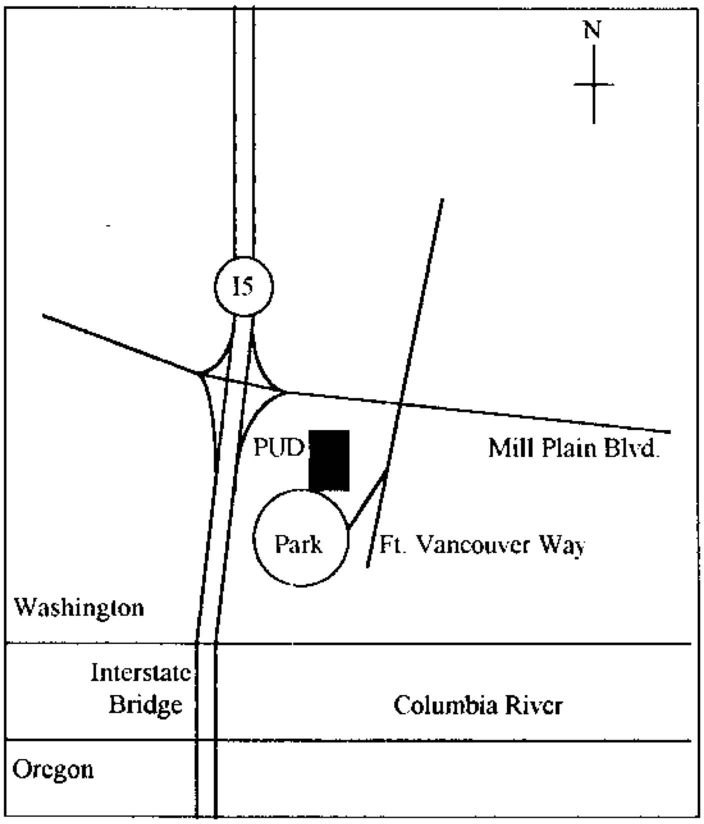
SPRING MEETING . .. . .VANCOUVER, WASHINGTON

May 6, 1995 9:30 am to 6:30 pm

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

Come join us for a day of good fun and fellowship about mineral collecting. Bring your microscopes and specimens to share with others, particularly those you are unsure about and would like a fresh opinion. Also bring some material to share with others that can be put out on the free table During the afternoon, after a very brief business meeting, we will be discussing and looking at slides of new collecting areas in Oregon and Washington. This will include detailed information about the Wolf Point Quarry, which (weather permitting) we will be planning to visit on Sunday. There will also be information on new zeolite locations in Eastern Oregon. In addition, Russ Boggs will be showing slides and talking about his trip to the Kola Peninsula last summer.

The kitchen area is available as usual and we will provide coffee, popcorn, etc. There will be a snack table, so bring snacks to share with others during the day. However, there will be ***NO POTLUCK DINNER*** in the evening. This is only one of several changes agreed upon last fall. For a more complete explanation, please see page 2 of this issue.



EDITORIAL

Once again we begin a new volume of the *Microprobe*. Our Group is steadily growing, and with growth and changing times comes the need to make some changes.

The first of these involves a change in dues. The property tax limitation in Oregon has put pressure on Portland State University to the point that the supplies necessary to produce the S.E.M. micrographs may not be available in the future. At the meeting last fall, the membership felt strongly that we as a group should be covering *all* of our expenses, especially the film needed for the S.E.M. and the chemicals used in printing the photographs that have become such an important part of our publication. That, together with rising postal rates, prompted a motion to raise the dues to $15 per year that was unanimously adopted. So,

Your dues for 1995 will be $15.

As a result of a new bookkeeping program, we are now able to send out a statement of each members account with this issue. Everyone, with the exception of honorary members, will receive a statement indicating the date to which your dues have been paid. We hope that this will make it easier to bring your dues up to date. Dues may be paid at the Spring Meeting; if you are unable to attend, please remit $10 for 1993 , $10 for 1994, and $15 for 1995. Our policy has been to cease sending additional copies of the *Microprobe* to people whose dues are more than two years in arrears.

We also enclose a new roster with this issue to make our membership current, especially since the area codes for many telephone numbers in the state of Washington have changed. Please check your entry as to accuracy, and let us know if any errors are present so they can be corrected. Also, we are missing a number of telephone numbers. In the event of a planned function (meeting, field trip) that must be rescheduled at the last minute, the only way we have of contacting people is via telephone. If you wish your number included in the next roster printing, please make sure that we know what it is.

Finally, we have felt it appropriate to discontinue the potluck dinner after meetings. It was a necessary feature when we met in Raymond and most people were staying overnight; with the meetings in Vancouver, most people are interested in starting home early, and the number actually staying for the potluck has steadily dwindled. So instead, we are going to try something new: a **SNACK TABLE** during meetings. The club will provide the usual: coffee, tea, and herb tea. In addition we intend to have lemonade and popcorn. We invite you to bring finger food (chips, dips, pickles, fruit, cookies, etc.) to share with others. There will be plates and eating utensils available. The kitchen will be there for anyone who wishes to use it to prepare other things for their own lunch. Whatever else, we want to provide good fellowship and an agreeable afternoon.

Due to a room scheduling conflict, our fall meeting will be *November 11*, the *second* Saturday in November. Please mark your calendar. The rules regarding the use of the Community Room specify that there not be "*any form of private gain*" by an individual, so we need to discuss discontinuing the *sale* of minerals, and emphasize the free table and the trading of minerals only within the confines of the auditorium.

Don Howard *President*
Genie Howard *Treasurer*

Zeolite Associates --- MOTUKOREAITE and HYDROTALCITE

Donald G. Howard

These two minerals are not represented as yet in occurrences in the Pacific Northwest, but they are well worth keeping in mind when examining specimens from new locations. Both minerals are carbonates that form late in the sequence of crystallization. They could be easily overlooked in the "crud" that we sometimes dissolve away in acid.

Motukoreaite is a fairly recent mineral (1977). It was reported as a white, clay-like cement in beach rock and basaltic tuffs from Brown's Island, within Waitemata Harbor, Auckland, New Zealand. The mineral was named for the island, whose native Maori name is Motukorea. The material was a fine-grained, greenish-white porcelaineous mass gluing sand, pebbles, and small rocks together. Individual crystals could only be resolved under high magnification, and were seldom much larger than 3 microns. Electron micrographs revealed them to form as thin hexagonal plates. Chemically, the material is a hydrated basic carbonate sulfate of magnesium, aluminum and sodium:

$$Na_2Mg_{38}Al_{24}(CO_3)_{13}(SO_4)_8(OH)_{108}\cdot 56H_2O$$

No zeolites are reported from this occurrence.

Subsequently, much better crystallized material has been found at the Stradner Kogel Quarry, Wilhelmsdorf, Feldbach, Steiermark, Austria. Motukoreaite is generally in clusters mounted on a drusy lining of wellsite (a barium-rich phillipsite). They sometimes coat calcite crystals growing on the wellsite. Individual clusters, which strongly resemble gyrolite, are typically about 1 millimeter in diameter. The interlacing hexagonal blades of which they are composed are about the same diameter, but are very thin. The color of the mineral from this quarry is very white, and has a lustrous, waxy appearance when the balls are broken. As can be seen in Micrograph #074 , the clusters often display a roughly hexagonal outline.

A second unusual zeolite associate occurring in this quarry is hydrotalcite. The name for this mineral, which has been known for many years, is misleading, since it is *not* a hydrated modification of talc. In fact, it is not a silicate at all, but rather a hydrated basic carbonate of magnesium and aluminum: $Mg_6Al_2(CO_3)(OH)_{16}\cdot 4H_2O$. The structure is thought to involve brucite-like layers. Like the above mineral, it is believed to be a hexagonal (or possible trigonal) mineral.

Hydrotalcite also forms small (less than 1 millimeter) blobs on wellsite and on the calcite that grows on top of the wellsite. In color, they are dead white with a matte surface and no discernible structure.

Hydrotalcite is closely related to the mineral manasseite, differing in that the former has a c-dimension three times that of the latter. To date, no crystals large enough have been found of either mineral to do a structure determination using x-rays.

ZEOLITES FROM CLARKSTON, WHITMAN COUNTY, EASTERN WASHINGTON

Rudy W. Tschernich
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Snohomish, Washington 98290

Zeolites are rarely found at the surface of the Miocene Columbia River basalt in eastern Washington, although deep test wells drilled through 2 miles of basalt at the Rattlesnake Hills near Hanford found the zeolites heulandite, mordenite, and laumontite in cavities below 1200 feet. In eastern Washington erosion has not cut deep enough to expose the zeolite-bearing flows; therefore, extraordinary events are required to expose the deeper flows and bring the zeolites to the surface. Such an event occurred in the Clarkston/Lewston area on the Washington/Idaho border (Fig. 1). The first flows of the Columbia River Basalt Group, call the Imnaha basalt, flowed into the Clarkston area 17.3 to 16.5 million years ago over an irregular erosional surface. The Imnaha basalt is an olivine basalt similar in chemical composition to the Picture Gorge basalt found around Spray and Ritter in central Oregon. Both rock units are well known for their abundance of low-silica zeolites. Between 16.5 to 14 million years ago the most massive series of basalt flows on the face of the earth occurred. This group, the Grande Ronde basalt, is composed of silica-rich basalt called a tholeiite and makes up 87% of the Columbia River Basalt Group. It covered the Imnaha basalt in the Clarkston area but due to the weight of several thousand feet of basalt flows, the area sagged to form a broad, low angle syncline. Later deformation broke one limb of the syncline to form a steep reverse fault and an anticline known as the Lewiston structure. Up lift along the fault has displaced the Uniontown Plateau, 2000 feet above the Lewiston Basin (where the towns of Clarkston and Lewiston are located) and exposed the lower flows of the Grande Ronde and Imnaha basalt where zeolites are present.

In the field the Imnaha basalt is a medium to coarse grained, porphyritic rock that is generally less resistant to weathering than the Grande Ronde basalt; therefore, outcrops of Imnaha basalt are more rounded, sloping, and crumbly than those of the overlying Grande Ronde basalt. The Grand Ronde basalt is a hard fine-grained rock that forms cliffs, columns, and in some places is highly vesicular.

When traveling on highway 12 on the southside of the Snake River west of Clarkston the impressive highly tilted basalt flows of the Gaging Station Anticline are seen on the north side of the river surrounded by nearly horizontal flows. Most of the zeolites are found in flows that dip easterly up to 55°

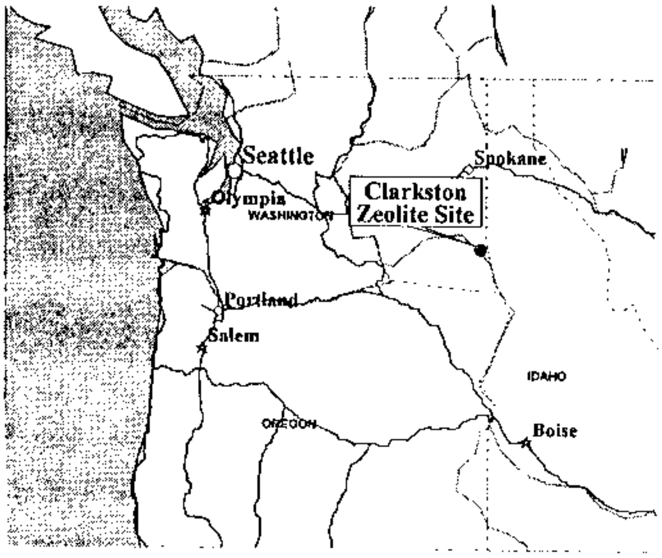


FIGURE 1: Clarkston, Washington

although a mile to the west the dip is only around 5° to the west.

After crossing the Snake River on the bridge west of Clarkston, follow state highway 193 (Wawawai River Road) until the rock exposures are found along the road (Fig. 2).

Highly vesicular Grande Ronde basalt, 3.6 miles west of the Clarkston bridge, contains heulandite is found in about 5% of the cavities. The remaining cavities are barren. Vesicles in partly liquid volcanic rocks are elongated or streched in the direction that the flow is moving and when solidified preseve a rough indication of level at that time. These cavities now strike N80°W and dip 43° south from present day horizontal. Flat white platforms and floors that are composed of various minerals that settled to the base of the cavities during crystallization appear to be aligned with present day horizontal.

Further down the road at 4.5 mile point and directly across the Snake River from the Gaging Station, highly vesicular Grande Ronde basalt is exposed. Heulandite lines nearly all the cavities. Platforms of chalcedony that cover the heulandite are abundant. At this site the platforms strike N48°E and dip 58°S. At the western end of this site colorless phillipsite prisms form radiating hemispheres that line some of the cavities and are found both on heulandite and covered by heulandite. Colorless to white multifaceted calcite crystals are found on heulandite and phillipsite. Erionite has not been

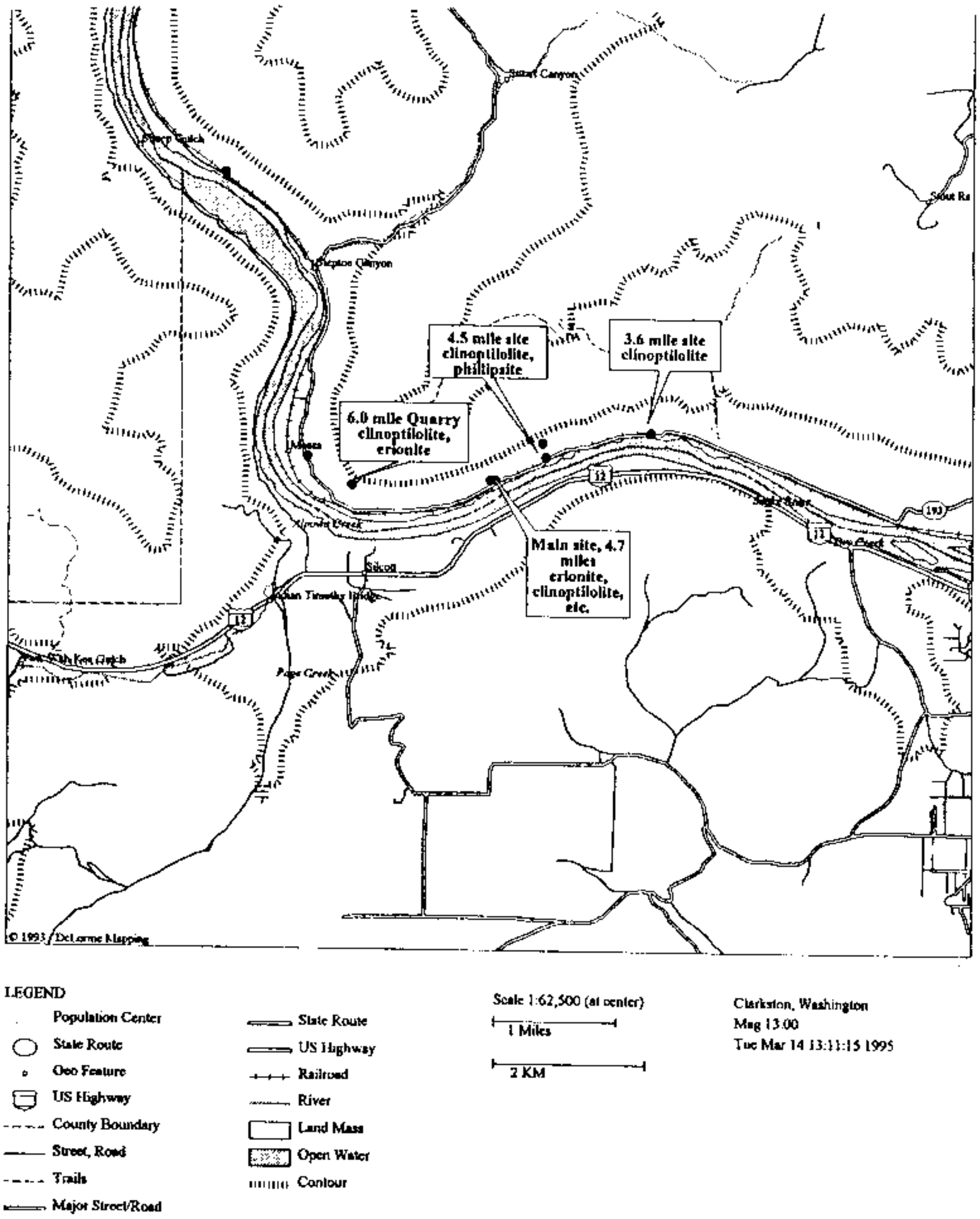


FIGURE 2: Zeolite sites near Clarkston, Washington

observed. A quarry located above this roadcut is out of sight from the road. It contains additional exposures zeolites.

The main collecting site is located 4.7 miles from the bridge and is a geologically complex area that not only represents the contact between the Imnaha and Grande Ronde basalt but the two rock units are separated by a vertical dike that consists of horizontal columns that have only their ends exposed. The dike rock contains widely scattered cavities, up to 8 cm across, in the columns that are lined with colorless to white, rough-surfaced, blocky apophyllite crystals, up to 10 mm in diameter.These crystals consist of large pyramidal faces, small prism faces, and are terminated by a c-face. The apophyllite has grown on colorless heulandite crystals. The western 1/3 of the site is soft altered Imnaha basalt that contains numerous weathered veins. These veins are lined with thin colorless to cream-colored mesolite needles (some with natrolite terminations); 1 mm colorless rhombohedra of chabazite; colorless radiating prisms of phillipsite (some covered with chalcedony), and rarely laumontite, analcime, stilbite, heulandite, and calcite. The eastern 1/3 of the site is hard Grande Ronde basalt that contains scattered vesicles lined with heulandite, erionite, and chalcedony with traces of phillipsite, pyrite, and calcite. The flows strike N35°E and dip 70°S while platforms measured in place have a nearly east-west strike and dip 43°S. It was at this site that Lanny Ream found the unusual wedge shaped heulandite and the white erionite needles on black clay.

The area west of the main collecting site (4.0 to 5.1 miles) contains exposures of highly altered Imnaha basalt with numerous altered veins that once contained zeolites.

At the 6.0 mile point (directly across from the 131 river mile marker) more Grande Ronde basalt is encountered along the road and in another quarry on the side hill. In the upper level of the quarry vesicular rock contains an abundance of heulandite with chalcedony, quartz, and a trace of erionite needles.

Continuing west further up the road past the sign for Moses (a railroad siding) traces of heulandite and chalcedony are found in vesicular Grand Ronde basalt. Traces of heulandite have been found in road cuts of Grand Ronde basalt for 10 miles along the road, to a point where the road crosses the railroad tracks.

The following is a description of the minerals found in the cavities.

ERIONITE crystallized at least three different times at the Clarkston locality. The first generation of erionite formed thin, straight, colorless needles on drusy heulandite. Rarely tiny heulandite crystals occur on the straight erionite needles. Orange-red spheres of clay are commonly on the first generation erionite.

A second generation of erionite formed white tufts and compound groups of coarse needles that are always on a black clay cavity lining. In some black clay-lined cavities, white layers and hemispherical balls of chalcedony act as nucleation points for the coarse white groups of erionite needles to crystallize. When viewed with the SEM single crystals of this type of erionite are seen to have a single {0001} termination but do not have simple hexagonal prism faces. The prisms are highly striated and twinned (see SEM photo). In these cavities phillipsite or heulandite are very rarely present with the erionite. When present the coarse erionite needles are clearly on top of blocky phillipsite prisms. Large blocky heulandite crystals clearly cover the course white erionite needles in the black cavities. These cavities do not contain platforms; therefore, the relationship of the coarse erionite to the platforms can not be easily determined. A lack of clay on the coarse white erionite needles indicates it formed late in the cavities.

The third generation of erionite formed thin, straight, white needles between radiating groups of coarse erionite needles in the black clay-lined cavities. Erionite also forms radiating tufts of very thin needles on drusy heulandite and on the last formed platform in the cavities. This period probably equals the third generation of thin straight needles in the black cavities. These needles often mat together into clumps or form a platform at the base of a cavity. Some cavities contain a drusy lining of heulandite covered by a rubbery asbestos-like mass of erionite needles. These masses often pull away from the heulandite to form a pure white lump of erionite. When pulled apart, these lumps resemble the curly erionite from the type locality at Durkee, Oregon.

HEULANDITE is very common in the cavities and probably formed several different generations that were widely separated in time. It forms granular intergrown layers (confirmed by optics) that make up the first platforms or floors in some of the cavities. Heulandite commonly forms a drusy lining composed of colorless transparent bladed crystals flattened on the b-axis on which other minerals crystallize. Rarely large blocky colorless crystals of heulandite, up to 5 mm long, are found scattered on an early formed chalcedony or clay. Very rarely large blocky heulandite crystals cover coarse white erionite needles. The chemistry of the heulandite has not been checked although crystals of this morphology, mineral association, and rock type is usually the silica-rich variety clinoptilolite.

In one small area at the east end of the main deposit, unusual wedge-shaped heulandite crystals (confirmed by X-ray diffraction) are found in a few cavities only a few millimeters away from normal bladed heulandite crystals. These wedge-shaped crystals consist of a broad {010} face at the termination that tapers with $\{4\bar{1}0\}$ and $\{0\bar{1}\bar{4}\}$ faces to a point at the other end (see D. Howard, V 7, No. 9, p 19 (1994) of the Micro Probe). Even rarer are double-terminated twinned wedges that resemble bow-ties when they meet at each others point or vertex (see SEM photo). The crystals appear to be twinned on the {010} plane. A few cavities contain the wedge-shaped heulandite enclosing single erionite needles. Other cavities show a mat of thin third generation erionite needles covering the wedge-shaped heulandite crystals. The wedge-shaped crystals all appear delicately attached to a crust of heulandite and appear to have formed late in the crystallization sequence.

CHALCEDONY crystallized throughout the mineralization in the cavities. In some cavities it covers the early-formed heulandite and in other cavities it is covered by heulandite. In a few cavities chalcedony is the dominant mineral.

OPAL forms milky-white masses completely filling the cavity or it forms a flat floor that is covered by chalcedony. In the Moses area fire opal has been found in a few cavities in a side canyon above the road (Randy Becker, personal communication).

PHILLIPSITE has been found in only a couple of cavities at the main site. It forms colorless blocky crystals covered with coarse white erionite. Rarely, tiny chabazite crystals are found on top of the phillipsite. At the 4.5 mile site radiating groups of colorless, milky-white, or light yellow phillipsite prisms are commonly found on heulandite. Some samples have a second generation of heulandite that enlarged the original heulandite crystals and covered or partly covered the phillipsite hemispheres. Later the phillipsite dissolved leaving hollow hemispheres under the heulandite.

CHABAZITE rarely forms tiny, colorless, stepped rhombohedra on blocky phillipsite at the main site.

PYRITE rarely forms tiny stepped octahedra, a few millimeters across, on heulandite at the main site.

CLAY in cavities that contain the second generation erionite needles is black. It lines the cavities but is never found on the second generation white erionite needles. In most of the other cavities the clay is a deep reddish-amber color and takes on the appearance of transparent glassy common opal. Tiny red spheres of clay are found on some of the heulandite and first generation erionite needles. The red clay makes up many of the platforms, some crystallizing before the major heulandite generation and several crystallizing later.

FLOORS AND PLATFORMS

When we observe minerals in a cavity we often try to determine the sequence that the minerals crystallized by distinguishing which mineral formed on top of another. We rarely are able to tell how long it took for those minerals to crystallize or if they crystallized in a short period of time with one mineral crystallizing right after the other or if they crystallized at several different widely separated times.

The relationship between platforms or flat floors formed by the rapid crystallization and settling of small crystals (due to gravity) and the faulting and folding of the rocks in the Clarkston area allows us to grasp the amount of time that it took between events seen in the cavities. Most of the cavities have a drusy lining of crystals on the walls and do not have a flat floor. Some cavities have one or two floors (Figs. 3 & 4), a few have up to 6

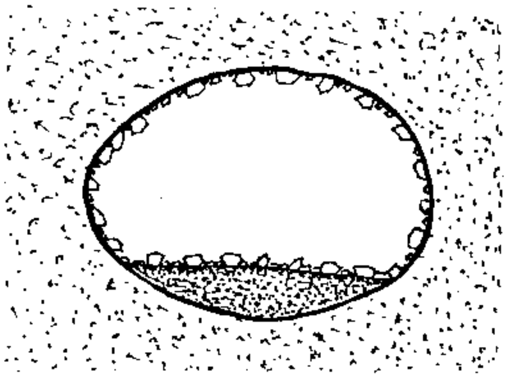


FIGURE 3: Single floor cavity with zeolites.

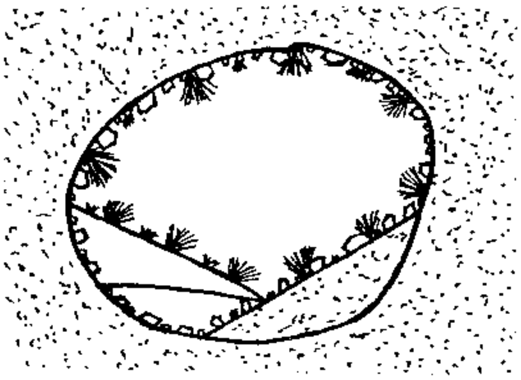


FIGURE 4: Trifloored cavity with zeolites.

floors that are inclined to each other (Fig. 5). A single platform or floor has been found at many zeolite localities in the Northwest and has been used to indicate level when the minerals crystallized. If the floor is parallel to the elongation of the vesicles, it can be assumed that the zeolites crystallized before any tipping or folding of the flows. If the floor is tipped at an angle repective to the elongation of the vesicles, then the zeolites formed after the folding or tipping of the flows. The relationship of the cavity floor to present day level can also be measured. At the Clarkston zeolite sites we have the unique opportunity to observe the crystallization of the zeolites in cavities with several floors and their relationship to a highly folded basalt. Only a few cavities contain well preserved multiple floors since those composed of clay usually fall apart during removal. Cavities that contain chalcedony, red clay, and zeolites offer the best opportunity to study the different stages of inclined floors because the intermediate floors of chalcedony are more resistant than the fragile clay floors and the chalcedony faithfully preserves many small crystallization stages better than does the clay.

The first floor in the cavities is usually is composed of different colored layers of white opal, cream, brown, and red clay, cream-colored to colorless granular heulandite, and blue-gray chalcedony (Fig. 3). Later floors are composed of red glassy clay and colorless, white, and gray chalcedony inclined at angles of 26°, 30°, 37°, 39°, and 45° (Figs. 5) from the first floor. The last floor often is covered with drusy heulandite and tufts of cream to white erionite fibers. Tapering of some layers, particularly the last clay layer and some intermediate layers, indicates crystallization continued during movement of the rock. Intermediate inclined clay floors are hard to detect and preserve because they fall apart during collecting and trimming. Large heulandite crystals often form on the first floor and last floors while tufts of erionite are common on the last floor. Erionite formed early in the cavities is covered with red clay. Erionite form late in the cavites is on top of the clay.

From these observations and the sequence of crystallization of the zeolites in the cavities, it can be inferred that the zeolites started crystallization while the basalt flows were still horizontal, before faulting and deformation started. Crystallization continued in steps with intervals of hundreds, thousands, or millions of years as the fault and fold slowly moved, lifting the blocks, 2000 feet relative to each other, and tipping the flows in the anticline. The events are preserved by the sequential change of angles in the floors.

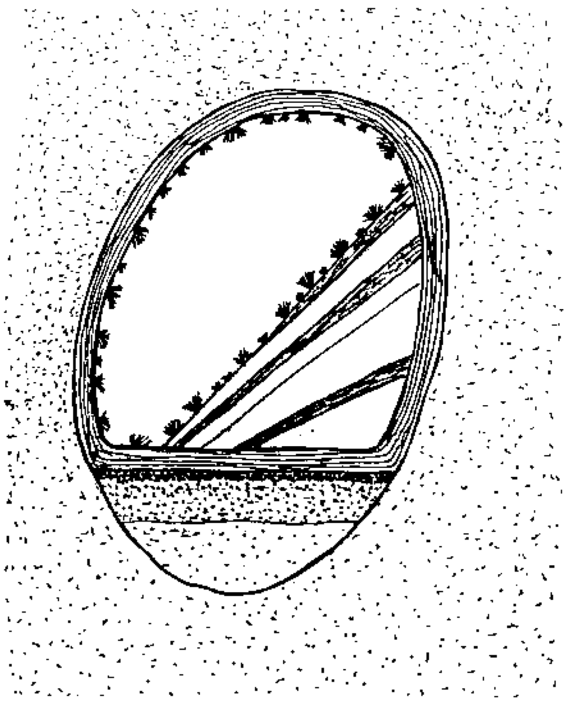


FIGURE 5: Multifloored cavity with layers of chalcedony, clay, and zeolites.

Finally, crystallization of more zeolites after deformation, produced the last floor which matches the present day horizontal position and enlarged some crystals that originally formed thousands of years earlier.

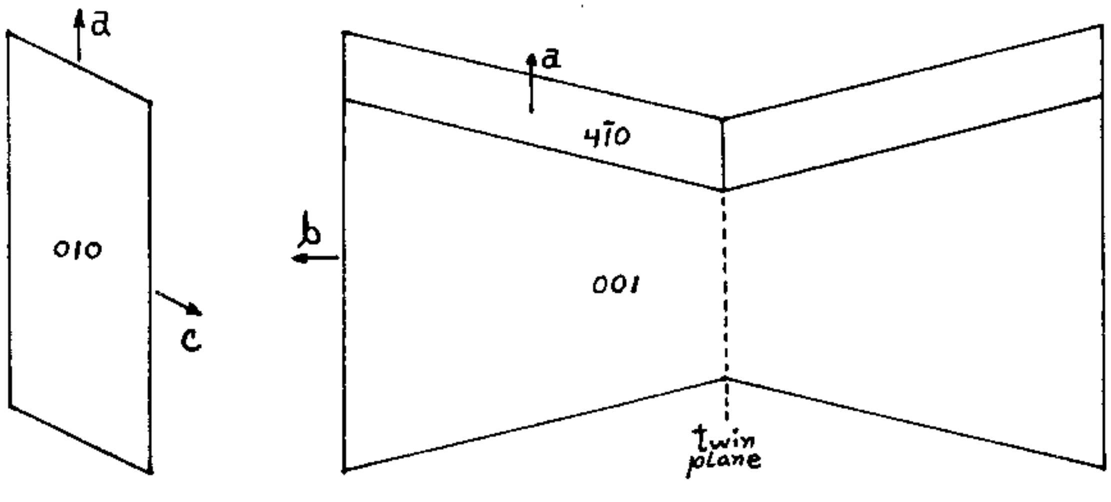
OBSERVED SEQUENCES:

heulandite > chalcedony layer > heulandite
wedge-shaped heulandite > white erionite
heulandite > pyrite
black clay > phillipsite > coarse erionite
chalcedony > coarse erionite
heulandite > straight erionite > clay spheres
last clay floor > heulandite > erionite tufts
chalcedony > coarse erionite > fine erionite
black clay > coarse erionite > heulandite
heulandite > phillipsite > heulandite
phillipsite > chabazite

TIME LINE:

CLAY -------- ----------------- -------- ------- 45°
HEULANDITE --------- ----- 45°
CHALCEDONY --
ERIONITE -- single -----------coarse ------ tuffs
PHILLIPSITE -----
CHABAZITE ----
PYRITE --

Although the rare zeolite paulingite has not be found at Clarkston, the presence of a tholeiitic basalt that contains heulandite, phillipsite, erionite, and chalcedony is characteristic of paulingite localities. A careful search for paulingite should be conducted at this site.



"Bowtie" twin of heulandite, Clarkston, Washington

Wedge-shaped Heulandite: a Logical Inconsistency

Donald G. Howard

The heulandite crystals from Clarkston, Washington described in the previous article, and in some detail in the ***Microprobe***, VII #9, page 19, present serious crystallographic problems. The material has been examined using x-ray diffraction in a Gadolfi Camera, and gives a classic pattern identical to heulandite. However, the symmetry class normally given for heulandite is prismatic class -- the highest symmetry consistent with a monoclinic crystal. The space group that represents this class is given as C2/m. In order to explain the problem, let us first discuss what this symbol means.

A monoclinic crystal is one in which the three principle axes are not all perpendicular. In particular, the angle that is *not* 90° is called β and is traditionally taken to be the angle between the a- and c-axes. The other pairs of axes are at 90°. For heulandite, the unit cell has the following parameters:

a = 17.6 A
b = 17.9 A $\beta = 116.4°$
c = 7.4 A

The "2" in the symbol above means that there is a two-fold rotation axis -- that is, an axis for which the crystal is unchanged after a rotation of 180°. The only such axis in the monoclinic system must be the b-axis, so there is no ambiguity in the symbol. The "2/m" means further that there is a symmetry plane perpendicular to the two-fold axis. This then must be the (010) plane. A symmetry plane means that if that plane were a mirror, the crystal would look identical when reflected in the mirror.

The heulandite crystals from Clarkston do indeed have the two-fold rotational symmetry about the b-axis, but they lack the mirror symmetry in the (010) plane. If they possessed this symmetry, they would be fat in the middle and taper in *both directions*. Said another way, they should possess (410) and (014) faces as well as $(4\bar{1}0)$ and $(0\bar{1}4)$ faces (see the diagram below and the one in vol. VII, #9, page 19).

Moreover, a crystal cannot twin on a plane of mirror symmetry. For twinning to occur, the structure must look *different* when reflected in the twinning plane. Two of the crystals shown in Micrograph #026 are clearly twinned on the (010) plane to form the bowtie pair as illustrated on the previous page. To our knowledge, twinning has never been observed in heulandite before.

Something is radically wrong. These crystals seem to belong to the sphenoidal subclass of the monoclinic system, denoted by C2. Either the symmetry class of heulandite that has been accepted for years is wrong, or these crystals are different in some subtle way from heulandite. Much more work will be needed in the future to resolve this dilemma.

MINERALS OF THE SPIDER MINE, HONEYCOMB HILLS, JUAB COUNTY, UTAH

Joe Marty *and* **Donald G. Howard**

The spider Mine is situated on the south flank of a small rhyolite knob at the north end of the Honeycomb Hills, which are located in west-central Utah. The mine is less than an hour's drive west of the Thomas Range. The Honeycomb Hills are best described as a topaz-rich rhyolite dome which erupted about 5 million years ago. Rhyolite phenocrysts consist of quartz, sanidine, oglioclase, biotite and topaz. Nash* has described accessory phases occurring as microphenocrysts or inclusions in biotite and topaz including magnetite, fluorite, zircon, thorite, monazite, fluocerite, and the niobates columbite, fergusonite, and ishikawaite.

The Spider Mine is a small adit that was developed during the uranium boom. There is no record of commercial production. There is very little in the literature regarding the mineralogy of this mine. Earlier studies may not be correct regarding the mineralogy. The minerals being described here were recently collected within 10 feet of the portal to the mine, primarily in fracture fillings in the rhyolite. The fracture seems were rather difficult to work because of the toughness of the rhyolite Help in the identification of the minerals was provided by Dr. Eugene Foord of the USGS in Denver, Colorado.

Minerals Present

TRIDYMITE $Si O_2$

tends to be the base mineral, forming directly on the pale gray rhyolite. It occurs as subhedral or euhedral blue platy crystals to 1 millimeter.

THOMSENOLITE $Na Ca Al F_6 \cdot H_2O$

occurs as colorless tapered prismatic or tabular crystals, often several millimeters in length. Prismatic crystals are elongated along the c-axis. In the unit cell, the a- and b-axes are almost identical in size, with the c-axis nearly three times as long. The crystals are monoclinic, however, rather than tetragonal, with the c-axis inclined about 6.5° from being perpendicular to the other two. This leads to slightly distorted prisms. The principle faces present are {110}, {111} and {111}, as shown in the diagram on the next page. In actual crystals, the prism faces tend to be rather curved due to alternating sections of {110} and {111}. The resulting surfaces therefore show prominent striations parallel to (001), the intersection of these two classes of faces. Crystals of this type in a variety of orientations are depicted in Micrograph #392.

BOLTWOODITE $(H_3O)\,K\,(UO_2)\,(SiO_4)$

is a monoclinic uranium mineral that generally occurs as sprays of slender, bright yellow needles up to about 2 millimeters in length. They are generally mounted on and often sprout from the thomsenolite crystals. Unlike most uranium minerals, boltwoodite does not fluoresce under ultraviolet illumination.

Meta-AUTUNITE $Ca\,(UO_2)_2\,(PO_4)_2 \cdot 2\text{-}6\,H_2O$

occurs as thin tabular yellow tetragonal plates 0.5 to 2 millimeters on a side. Under ultraviolet illumination, the plates fluoresce a bright yellow-green.

GOETHITE α - Fe O (OH)

is often present as black coatings on the fracture seems that are productive.

REFERENCES;

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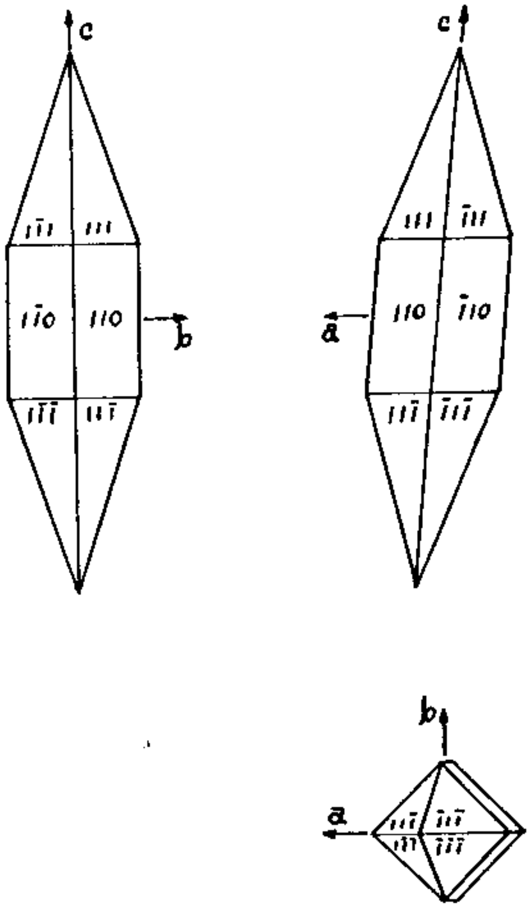

The Crystal habit
of Thomsenolite

monoclinic
a = 5.58 A
b = 5.51 A
c = 16.13 A
β = 96.5°

Elongated along c with
striations parallel to (001)

Cavansite from the Jaquish Road Cut, Goble, Columbia County, Oregon

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The spectacular zeolite specimens produced from Jaquish Road cut on Highway 30 have resulted in the locality being recognized as one of the classic Oregon mineral localities. Specimens can still be found in the boulder piles behind the roadcut and to the south of the Jaquish road intersection though it is becoming increasingly difficult to find worthwhile material. Heavy sledge and bar work coupled with plenty of patience are required to find most of the remaining good specimens.

In the fall of 1993 a series of small unusual cavities were found in a boulder from the upper red breccia zone. The boulder measured about 2.5m x 1.3m x 1.0m and sat about 10m south of the Jaquish road intersection. The cavities occurred in a zone about 5cm x 5cm x 5cm and are unusual in that they have a white cavity lining and phantomed calcite crystals. Small blue clusters of cavansite crystals were noted though they were originally interpreted as some of the copper minerals common to the Goble area. While examining the calcite crystals under the microscope, minute crystal faces were observed on the cavansite crystals. The crystals are small enough that details were difficult to observe under a 40x optical microscope so the specimens waited for the opportunity to be studied with more powerful analytical equipment.

The small cavity system appeared to consist of several zones in which mineralogy varies somewhat. The best clusters of cavansite crystals, up to 0.5mm, occur in a small series of cavities to one side of the cavansite bearing zone in which the white cavity lining is the thickest. Towards the middle of the zone, the crystals occur in greater quantities, but the crystals are much smaller, completely invisible to the naked eye, and easily missed under a 40x optical microscope. At the other end of the zone, where the white cavity lining is the thinnest, no cavansite crystals have yet been observed. The crystallization in the cavities began as per normal low silica cavities from the Jaquish road cut with clay forming, then copper followed by heulandite. The white cavity lining completely coats the heulandite crystals giving the cavities a botryoidal appearance. Under the SEM, however, the material appears irregular and somewhat porous, possibly from being etched. Attempts to identify the white lining have been inconclusive though X-Ray data has suggested heulandite or thomsonite.

In the zone with the largest cavansite clusters and the thickest white lining, cavansite forms rather typical groups of crystals radiating from a central point. Though the crystals radiate, they also tend to be oriented such that they form kind of a fan with the b-axes pointing in roughly the same direction. Occurring with the cavansite crystals are reddish brown rhombohedral calcite crystals in singles up to 1.0mm and clusters to 3.0mm. The crystals tend to be golden to amber on the inside with only the outer 0.1mm actually a reddish brown. The reddish brown calcite fluoresces yellow under short wave ultraviolet light and orange under long wave with the edges of the crystals glowing the brightest when viewed under a microscope.

In the middle zone, the white lining thins to about 0.1mm and vaguely shows the shape of the underlying heulandite crystals. The cavansite forms radiating clusters of crystals as well as "bow-ties," suggesting that the crystals may have begun to form in solution and continued growing after attaching themselves to the cavity walls. The crystals tend to be more slender and vary in length more than in larger specimens. In a couple of cases, minute cavansite crystals are found on the surface of calcite crystals, partially overgrown by the calcite. Calcite crystals are golden in color and smaller with singles up to 0.7mm and clusters to 2.0mm. Fluorescence tends to be paler with the color under the long wave lamp closer to a yellow than an orange. Associated with the cavansite is an as yet unidentified mineral which forms wedge-shaped eight sided prisms with flat terminations. The crystals are similar to crystals of laumontite in figure 353, p. 275, *Zeolites of the World*, by Rudy W. Tschernich. All the faces are smooth except the faces corresponding to the 010 and $0\bar{1}0$ faces of laumontite which are invariably striated on the unknown.

In the zone where the white lining is the thinnest, no cavansite crystals have yet been noted, however, crystals too small to be easily observed may be present. The white lining is very thin, less than 0.05mm, and allows the structure of the underlying heulandite to be easily seen. Calcite ranges from clear to golden to dark reddish brown with most of the crystals showing phantoms, usually a darker phantom inside a lighter crystal. In a couple of instances, almost clear rhombohedral crystals show dark reddish brown scanelohedral phantoms within. Exposed copper crystals tend to be blackish or iridescent and in a few cases, the calcite has overgrown the native copper. Few of the calcite crystals or clusters exceed 1.0mm.

Cavansite apears to have formed in a small series of cavities from which the cavansite forming fluid moved away in a roughly linear fashion. This is suggested by the decreasing thickness of the white lining and the decreasing size of the cavansite. On the other side of the main cavansite cavities are normal low silica cavities with drusy heulandite, native copper, white thomsonite, and chabazite. So far, this is the only known occurrence of cavansite at the Jaquish Road cut. Any specimens with a white cavity lining over heulandite should be examined more closely, looking for blue minerals which may at first appear to be copper minerals.

Acknowledgements: Thanks to Don Howard for information regarding analysis of the white cavity lining. Thanks especially to Erik Sanchez for the opportunity to spend many hours using his SEM. The specimens were originally identified when the presence of vanadium was confirmed using his EDAX.

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at the Clark Co. PUD on Ft. Vancouver Way, Vancouver, Washington

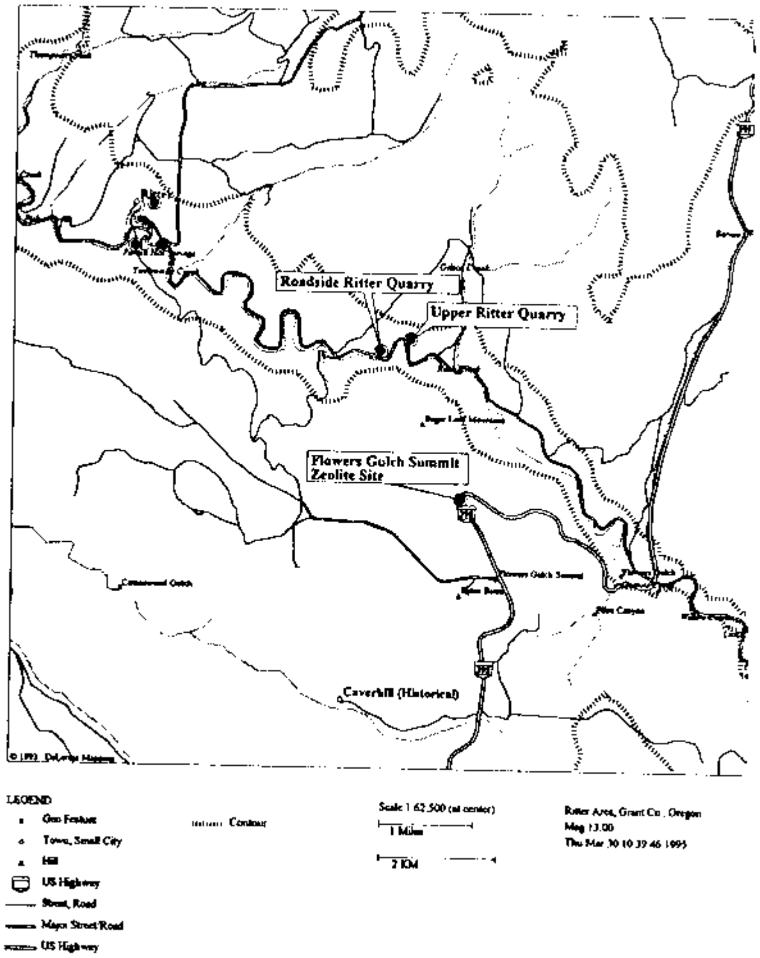
FLOWERS GULCH SUMMIT, RITTER, GRANT COUNTY, OREGON

Donald G. Howard *and* Rudy W. Tschernich

New collecting areas are hard to come by as a rule, and that is why it is such a pleasure to report a new one. Grant and Wheeler Counties in central Oregon probably contain the greatest concentration of zeolite locations in the Northwest, and each one added contributes another spot to include in a spring or summer collecting trip.

Flowers Gulch Summit is the name on the map for the highest elevation along US 395 as it proceeds north from the town of Long Creek toward the Middle Fork of the John Day River and the turnoff to Ritter Hot Springs. The summit itself is the point at which the access road to the Ritter Butte fire lookout branches off to the west. The collecting spot is about a mile north of the actual summit, where the road makes a sweeping turn to begin the long descent down to the bridge across the Middle Fork of the John Day River. At that point, the road passes through a road cut exposing rock on both sides of the highway. Wide shoulders at that point make parking easy. The highway department appears to sweep these shoulders clean quite often, so it is necessary to work into the cut itself to get collectable material.

The locality is actually only about two miles due south of the Upper Ritter Quarry, but it is about 1000 feet higher in elevation. Unlike most of the collecting spots along the various forks of the John Day River, which are only slightly above river level, this location is along a ridgetop. Most of the mineralized basalts of this region are in the very lowest flows of the Columbia River Basalt; for instance, just east of the Upper Ritter Quarry, the underlying John Day Formation and granite beneath is exposed. The granite and metamorphic rock exposed continues most of the way up the grade on the south side of the river, so in spite of the large difference in elevation, this is probably still material that comprises the lowest layers of the Columbia River Basalt. A vertical



Map of the Ritter Area

fault is known to run from Threemile School directly through Ritter Hot Springs and east through the Upper Ritter Quarry and on up the Middle Fork of the John Day River. Upthrust on the south side of this fault probably accounts for the large offset in elevation.

What is interesting about the road cut near Flowers Gulch Summit is that it appears to be a basalt breccia, with fragments one to several feet in diameter. The various fragments vary from dark gray-black to a relatively light gray, through a rusty brownish to ones definitely reddish in color. They also vary in the density and size of the cavities, from very porous with millimeter holes to ones with cavities several inches long. The various fragments are apparently a sampling of a number of older flows, with differences not only in color and texture, but also in chemical composition. This results in the different fragments having different suites of zeolite minerals present.

Zeolites are present and can be collected on both sides of the road. The east side, however, is the deeper cut and therefore exposes lower regions of the strata. Chabazite seems to be the most common mineral present, as rhombohedral crystals completely lining pockets. Other minerals, however, are also present. It is necessary to prospect around through a number of fragments to be able to sample all that this deposit may contain. To date, only a few hours have been spent investigating the deposit, so that only a few interesting fragments have been studied in detail. The following is a summary of the minerals thus far observed, ordered as if there were a common sequence of formation, which considering the varied nature of the individual fragments may be an incorrect view.

Minerals Present

CLAY Most of the cavities show a lining of brownish black clay, varying from very thin to layers of several millimeters. The thicker layers are generally located on one side of the cavity only. In a number of the cavities, contorted filaments of clay twist upward from the surface. These growths are often coated by later minerals, especially thomsonite.

LEVYNE Thin blades of levyne have been found at one end of one of the fragments. These are similar in form to the levyne blades from Beech Creek. The levyne has a whitish appearance because of a thin overgrowth of ***OFFRETITE.*** Although the blades seem to have formed on the dark clay, exposed clay areas later were covered with a thin layer of a bluish gray clay, giving the samples an altogether different appearance than the white-on-black-appearance of the Beech Creek material. The lighter clay appears to have formed after the offretite layer was completed. One sample shows clear rhombohedral crystals of chabazite growing on top of the levyne/offretite.

PHILLIPSITE There appears to be at least two generations of phillipsite. The first forms as tiny water-clear simple (Morvenite twin) crystals scattered individually about on the dark clay base. These crystals appear very dark to black against the bluish-gray clay that has formed over the exposed clay surfaces around them. Many of these cavities have scattered chabazite as clear interpenetrating groups of rhombohedra growing on the phillipsite and lighter clay.

Some cavities show a complete drusy lining of tiny clear phillipsite crystals, upon which chabazite grow, both as interpenetrating rhombohedra and as complexly twinned phacolite.

CLAY A second generation of clay, a steely bluish-gray color, often forms a thin layer over the earlier darker clay. in cavities where levyne/offretite or phillipsite had already formed, this surrounds those zeolites but does not seem to coat or cover them. It may represent a chemical alteration of the uppermost layer of the exposed darker clay by mineralizing solutions.

THOMSONITE Several fragments have yielded thomsonite of varying appearance. One fragment contained numerous irregular cavities lined with lustrous balls of a light brownish color, often growing in strings on the clay fingers beneath. The brownish thomsonite completely covers the walls of these cavities. This thomsonite appears to have preceded the bluish-gray clay layer; the brown clay beneath it is usually very thin. The only mineral observed on top of this brownish thomsonite is todorokite.

In other cavities, the thomsonite is glassy clear, forming crusts of overlapping spheres. Scattered clear chabazite rhombohedrons are often growing on this material, with the crystals appearing to be partially embedded, as if the two minerals were co-crystallizing, at least in the later stages of thomsonite formation.

A third form of thomsonite is milky white. Again, this form has been seen to overgrow the clay fingers to form contorted rods. On these specimens, the chabazite definitely penetrates down into (and possibly through) the thomsonite layer.

These may represent three different generations of thomsonite, or they may simply be the result of formation in different fragments where the chemical environment is somewhat different.

PHILLIPSITE A second generation of phillipsite is observed growing on top of the white thomsonite. These crystals tend to be somewhat larger, cloudy, and usually tend toward cruciform crystals.

CHABAZITE By far the most common mineral present is chabazite. In many of the fragments it is the only mineral present, thickly lining the walls of the vesicles. These crystals are basically rhombohedral with much interpenetration of individuals.

Scattered interpenetrating groups of rhombohedral crystals have been observed growing on levyne/offretite and phillipsite, particularly where the bluish-gray clay layer is present. These crystals are water clear, and the gray clay can clearly be seen beneath them.

Similar scattered groups grow on thomsonite, usually embedded to some degree down into the surface, but only very occasionally reaching the clay layer underneath.

Similar groups have been observed growing on drusy phillipsite linings. Complexly twinned individuals (variety Phacolite) have also been observed on the drusy phillipsite.

TODOROKITE The manganese oxide mineral todorokite has been observed as porous blobs with a metallic luster sitting on top of the light brown thomsonite balls. The observance of a single dendrite on the surface of a rhombohedron of chabazite suggests that the formation of manganese minerals occurred rather late in the sequence. X-ray fluorescent analysis confirms the presence of a small concentration of calcium into the manganese oxide. The formula for todorokite is usually given as $(Mn^{+2}, Ca, Mg)\ Mn_3^{+4}\ O_7 \cdot H_2O$.

CALCITE Cloudy white euhedral crystals of calcite have been observed on top of the chabazite. These crystals have very rough rounded prism faces, but sharp flattened three-fold terminations of what must be the rhombohedral faces. Calcite does not seem to be a common mineral in this rock.

* * *

The complex nature of a basalt breccia, with different minerals in various fragments, makes this deposit of particular interest. It certainly warrants much more work to fully characterize the variety of minerals and mineral associations present. Its very easy accessibility, and the ease with which pieces can be broken out, make this an ideal spot to spend some time collecting. We believe a little effort will be well rewarded.

UPDATE on the RITTER QUARRY, GRANT COUNTY, OREGON

Donald G. Howard

For many years the quarries along the road from US 395 to Ritter Hot Springs has been a choice location for zeolite collecting. The original quarry, now referred to as the Roadside Quarry, produced excellent specimens of a variety of zeolites and zeolite associates This quarry and the minerals from it were described in the ***Microprobe***, Vol. VII, #8, pg 8-11. Weathering, together with no fresh exposures, has in time made collecting of quality specimens from this quarry increasingly difficult.

In the early 1980's, the newer quarry, now referred to as the Upper Ritter Quarry, was constructed to provide gravel for the county roads of the area. This was a much larger quarry, and enormous heaps of crushed rock were piled between the quarry and the road to Ritter Hot Springs. This quarry, with a similar suite of zeolites and zeolite associates, have been described in the ***Microprobe***, Vol. VII, #8, pg 12-17.

Extensive road work during the last two years used up almost all of the stockpiles of crushed rock, so the quarry was re-activated in September, 1994, blasted even larger, and restocked with huge piles of crushed rock. Normally, this would mean that considerable new exposures would be available for collecting. However, the basalt that makes the best road base is the hard upper flow, and the recent blasting was almost exclusively into this hard flinty layer. Although there are secondary minerals present in this layer, there are relatively few vesicles present. Moreover, the variety of minerals in this zone is quite limited.

The more productive, softer basalt, with a much greater variety of minerals, lies beneath the hard layer, extending at most 6 to 10 feet above the quarry floor. The central area projecting out into the base of the quarry, was largely undisturbed by the new blasting. This is the area where beautiful specimens of thomsonite and mesolite, and some cowlesite have been found. The collecting area is still intact, but generally covered by a layer of dirt and debris a couple of feet thick. Continued collecting will require some work to remove this overburden.

In the course of processing the shattered rock into gravel, several large boulders were encountered, probably bigger than the crusher could comfortably handle, These were shoved around behind the projection of softer rock and left. In examining these boulders last fall, we found one that is worthy of note. The chunk was perhaps 6 by 4 by 2 feet in size, and was filled with irregular voids that were all lined with a golden brown ***calcite*** in crusts of rhombohedral crystals, the individuals being about 1 millimeter on a side. The cavities ranged from 1 to 10 centimeters in size, and were throughout the boulder. What made the specimens spectacular was that individual white crystals of zeolites were scattered about on top of the darker calcite The most abundant of these was ***phillipsite*** as white crystals up to 3 millimeters across and 10 millimeters long. Also present were white wheels and balls of ***thomsonite*** up to about 5 millimeters in diameter, with surfaces marked by the parallel growth of the individual crystal blades. Where phillipsite and thomsonite came into contact, the thomsonite was clearly on top.

Clear ***chabazite*** crystals to about 3 millimeters were often scattered about on the calcite as well. Generally the individuals show interpenetrating rhombohedrons. These appear to have formed after the phillipsite and thomsonite. One particularly large cavity showed all three of the above minerals, and in addition half a dozen snow-white balls of ***gonnardite*** up to about 3 millimeters in diameter. The gonnardite appears to have formed after the phillipsite but before the thomsonite. In most of these specimens, the zeolites cover only a small fraction of the calcite surface. The calcite crystals often show signs of surface etching. The base rock is the relatively soft, black basalt characteristic of the lower flow. In places in the base rock, very small vesicles and clusters of vesicles (generally only a few millimeters in diameter at most) are lined with snowy white ***cowlesite***.

This quarry should currently be considered a prime collecting spot. More work needs to be done on the various boulders that have been left. The very productive rock in the center of the quarry is available for further collecting after some shovel work to clear away debris. This quarry has produced some outstanding specimens and should remain productive for many years to come.

FIGURE CAPTIONS

Photograph Number in the lower right corner or on the back upper left corner.

#074 Motukoreaite on Wellsite (x60)

Stradner Kogel Quarry, Wilhelmsdorf, Feldbach, Steiermark, Austria

White, waxy clusters of hexagonal platelets, growing like cabbages on a drusy base of Wellsite (a barium-rich phillipsite)

#084 Erionite on Chalcedony (x70)

Clarkston, Whitman Co., Washington

Bundles of snow-white needles growing from a chalcedony base with a texture like cauliflower. The surrounding light material is the clay base lining the cavity.

#088 Erionite (x700)

Clarkston, Whitman Co., Washington

A close-up showing the flat c-face terminations and the irregular cross-section of the individual erionite needles. Twinning has completely obscured any hexagonal outline.

#026 Heulandite (x 55)

Clarkston, Whitman Co., Washington

A group of the strange, tapered crystals, including two that appear to be twinned on the (010) into a bowtie shape. Further parallel growths are present on one of the twins.

#392 **Boltwoodite on Thomsenolite** (x110)

Spider Mine, Honeycomb Hills, Juab Co., Utah

Tufts of bright lemon-yellow Boltwoodite needles growing from the ends and surfaces of clear, tapered, striated prisms of Thomsenolite, on a background of pale gray rhyolite.

1 **Cavansite** (x640)

Jaquish Road, Goble, Columbia Co., Oregon

A radiating spray of bright blue needles of cavansite. The identity of the prismatic crystal is not known.

2 **Cavansite** (x160)

Jaquish Road, Goble, Columbia Co., Oregon

Another group of slightly larger crystals, showing the wedge-shape terminations that are characteristic of cavansite. The botryoidal white material upon which it is growing appears to be a fine-grained zeolite mixture, primarily composed of heulandite.

3 **Levyne with Offretite overgrowth** (x 4)

Flowers Gulch Summit, Grant Co., Oregon

Thin hexagonal platelets with stepped edges. The crystals are very similar in appearance to those found at the Beech Creek Quarry, but the clay background is a bluish-gray rather than the black of Beech Creek specimens.

4 **Chabazite on Phillipsite** (x10)

Flowers Gulch Summit, Grant Co., Oregon

Glassy clusters of interpenetrating rhombohedrons of Chabazite. The smaller, water-clear crystals of Phillipsite appear dark because of the darker clay they grew upon. The bluish-gray clay formed between the Phillipsite and the Chabazite.

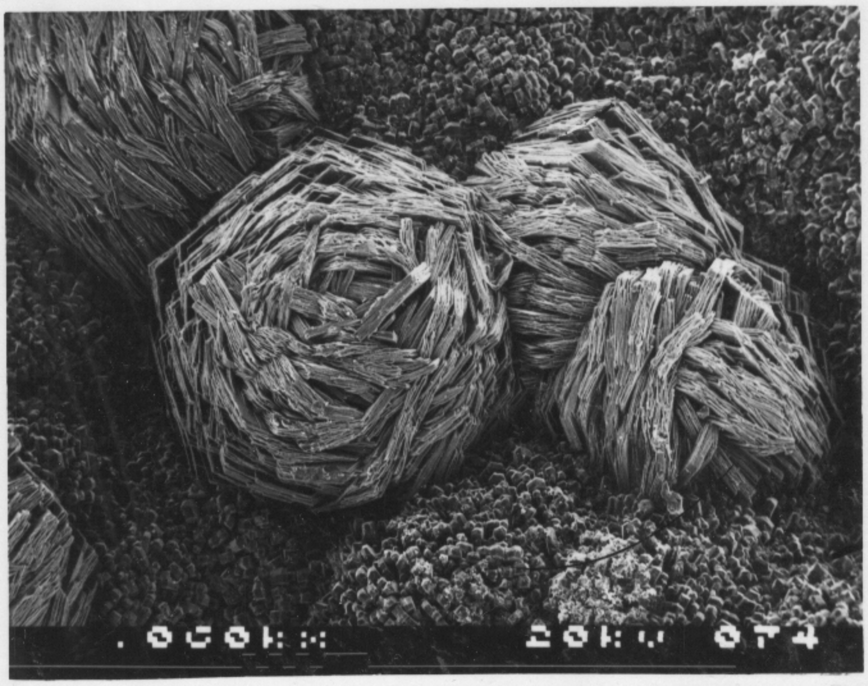
5 **Phillipsite on Calcite** (x 4)

Upper Ritter Quarry, Grant Co., Oregon

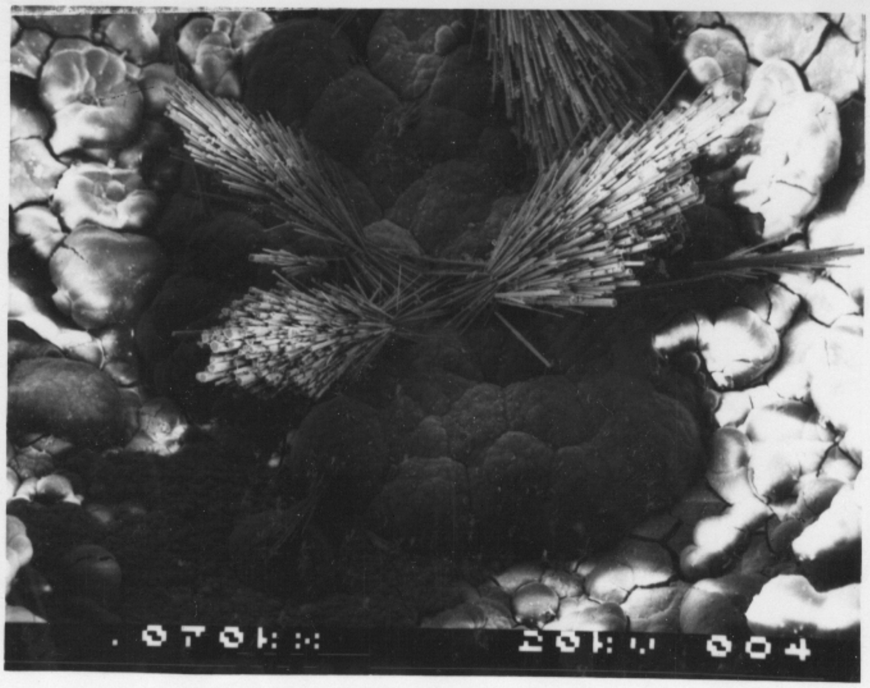
Scattered prisms of white Phillipsite on a background of rhombohedral Calcite crystals.

PHOTO CREDITS

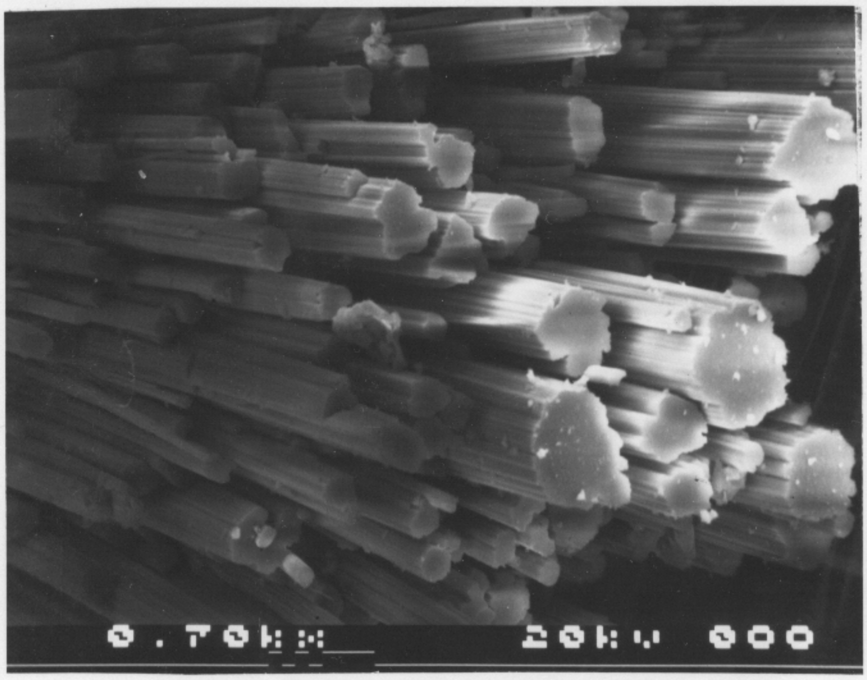
Micrographs # 1 and #2 :
Picture and specimen: *Aaron Wieting* and *Erik Sanchez*
All other Micrographs and Photographs:
Picture: *Donald G. Howard*
Specimens: :
#074 *Walter Postl*, Steiermarkisches Landesmuseum, Graz, Austria
#084 & 088 *Rudy Tschernich*
#026 *Lanny Reem*
#392 *Joe Marty*
#3, 4, 5 *Donald Howard*



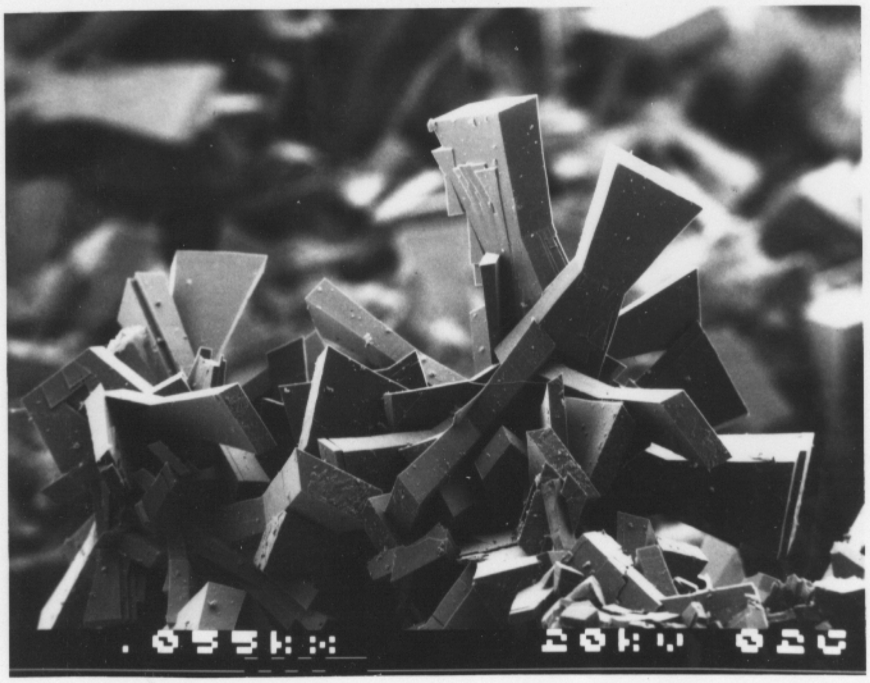
#074 – MOTUKOREAITE, WELLSITE – STRADNER KOGEL QUARRY, WILHELMSDORF, FELDBACH, AUSTRIA – 60X



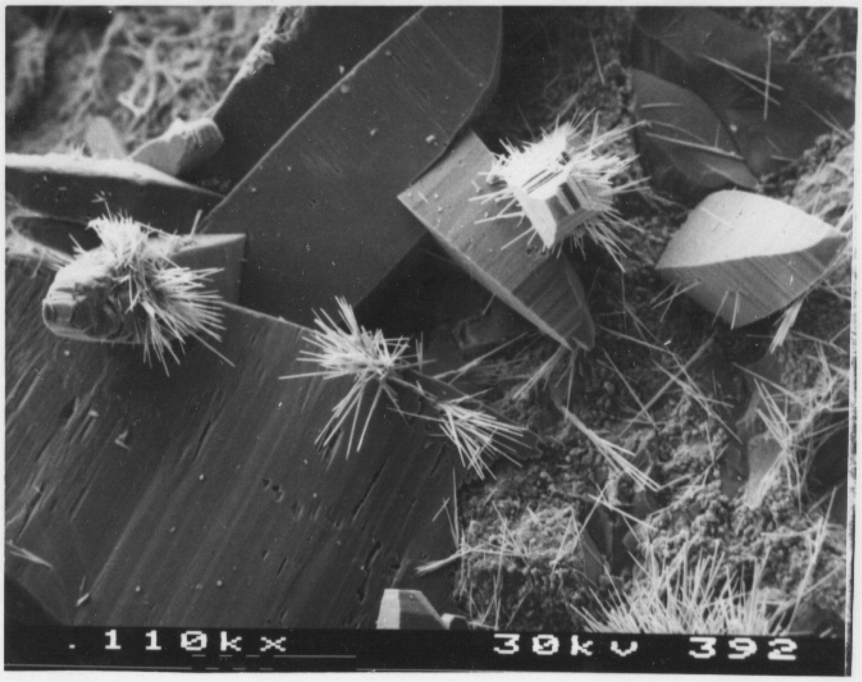
#084 – ERIONITE – CLARKSTON, WHITMAN COUNTY, WASHINGTON – 70X



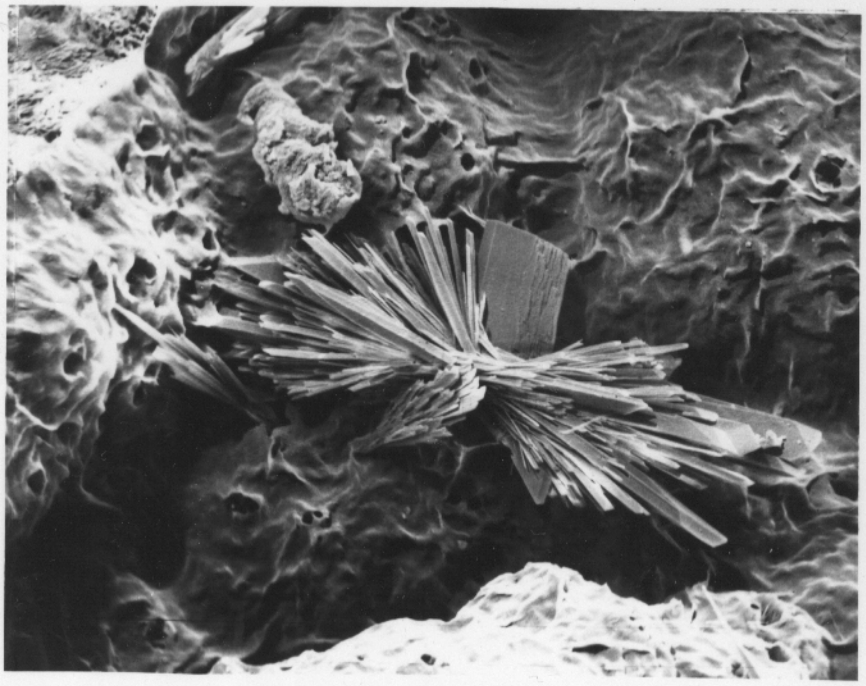
#088 – ERIONITE – CLARKSTON, WHITMAN COUNTY, WASHINGTON – 700X



#26 – HEULANDITE – CLARKSTON, WHITMAN COUNTY, WASHINGTON – 55X



#392 – BOLTWOODITE, THOMSENOLITE – SPIDER MINE, HONEYCOMB HILLS, JUAB COUNTY, UTAH – 110X



#1 – CAVANSITE – JAQUISH ROAD, GOBLE, COLUMBIA COUNTY, OREGON – 640X

#2 – CAVANSITE – JAQUISH ROAD, GOBLE, COLUMBIA COUNTY, OREGON – 160X

#3 – LEVYNE, OFFRETITE – FLOWERS GULCH SUMMIT, GRANT COUNTY, OREGON – 4X

#4 – CHABAZITE, PHILLIPSITE – FLOWERS GULCH SUMMIT, GRANT COUNTY, OREGON – 10X

#5 – PHILLIPSITE, CALCITE – UPPER RITTER QUARRY, GRANT COUNTY, OREGON – 4X