

Northwest
Micro Mineral
Study Group



MICRO PROBE

FALL, 2001

VOLUME IX, Number 4

FALL MEETINGVANCOUVER, WASHINGTON

November 3, 2001

9:30 am to 6:30 pm

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

Once again we have a day to talk rocks and share collecting stories. Microscopes are a must as usual, and don't forget to bring your extra material for the give-away table so that others will have treasures to look over and take home.

Morning:

Bob Smith will talk and show slides of collecting along Elk Creek, South Dakota.

Afternoon:

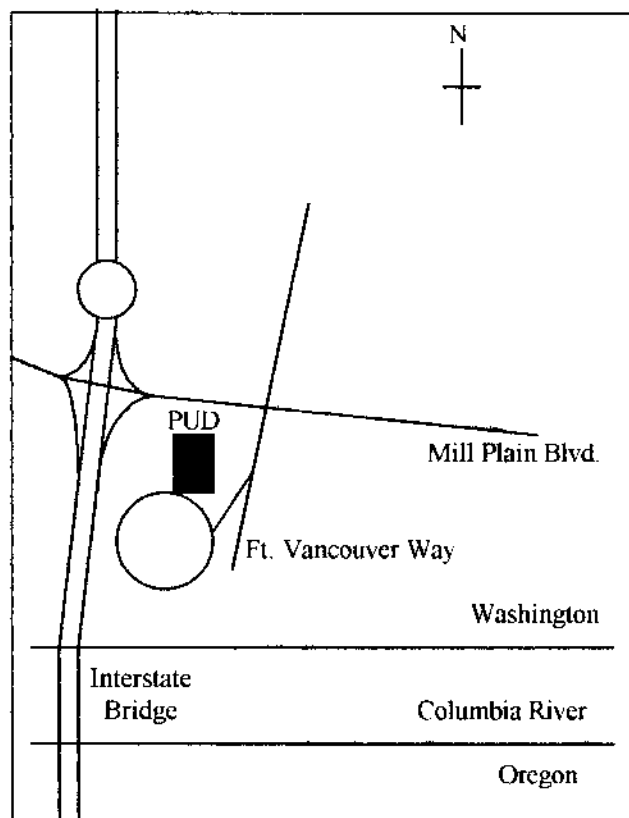
We will have a short business meeting and our usual review of the collecting status of locations in the Northwest.

Don Howard will talk and show slides of Osidian Cliffs, Lane Co., Oregon.

Anyone who has slides to share with the group should bring them along to show at this time.

The kitchen area is available as usual and we will provide lemonade, coffee, hot water, etc. There will be a snack table, so bring makings for lunch and we will plan to have a sort of "pot luck" at noontime.

Restaurants are available in the local area. Some of us will plan to eat dinner together, so please plan to join us.



PRESIDENT'S COMMENTS: Results of the Membership Questionnaire

Two things are clear from the little questionnaire I circulated at the Spring meeting. The first is that there are many very good ideas secreted among the membership of the NWMMSG. The second is that, by and large, the members are willing to help the organization in many ways. These findings are very positive for the future of the club. I would like to distill some of the ideas I found in the poll so that the membership can consider them (and other ideas) for future action.

First, there were a number of good ideas about the programs of the club. Everyone bemoans the decline in collecting areas. This leads to the thought that we should have more (and more varied) field trips. This would require more volunteers to plan and lead the trips. So far there has been a small number of very active leaders who have led successful trips over the years. Now, more members need to move into this leadership area.

There was general happiness with the meeting programs on collecting sites in the northwest. This fits the general satisfaction with the way the club has been organized over the past decades. However, some interesting ideas were mentioned:

A number of folks suggested that some topics of general educational value be offered. These included topics such as crystallography, mineral chemistry, paragenesis, etc. This would require the research and presentation of a topic in some detail. It is clear that this would demand much from the members, but it is also clear that it would expand the experience of all members (and guests).

A number of people noted that we could take on some special projects. Some of these projects might be the completion of the northwest location registers (such as an Oregon site guide). This has been a controversial topic over the years, but maybe it is time to approach it with new concepts. One thing was clear. Many felt that this could be done best in cooperation with other groups in the area, such as Friends of Mineralogy or the Federation.

A few other ideas included setting up a Web site for the club. And the thought of setting up a listing or clearing-house for trading minerals both within the group and with others around the country and the world. This could be done through interactions with similar organizations around the country and the world.

One thing that was not brought up, but that is very important, is contributions to the *Microprobe*. Many of the ideas of field trips and programs lend themselves to articles for the 'probe. Every member should seriously consider contributing to the newsletter. It is the organ that helps to hold our club together. The contributions need not be long nor professional. It can be an experience such as a field trip or a visit to a show or display. *[Editors note: The article need not be in final form. Indeed, it may be no more than notes or an outline. The editor would be more than pleased to work with anyone who has a good idea.]*

Everyone showed an interest in helping the organization in many ways. Some volunteered time on projects, and some even suggested that they might be willing to help in the leadership of the club. I was very pleased to see this attitude. One interesting idea about the leadership was brought forward: to elect a vice president who would act as a president elect and would move into the presidency for the next term. This is the way

many of the professional societies operate. It has many good aspects. There is always a leader in the wings to take over. And it gives the next president some time to learn the job. Often the vice president (or president elect) has a role, such as programs chairman or the like. Usually the groups that use this process have a somewhat larger membership, but it is something to which we should give some thought.

Another idea we should give thought to is the possibility of using some of the club funds (we are in pretty good shape financially) to bring in speakers from the outside to present programs. These presentations would be great for the members of the club and would bring in outsiders who might eventually join. Other thoughts along this line include inviting guests into the meetings from young people's organizations and schools, etc.

There were many good ideas in the poll, and I am sure there are as many great ideas still out in the membership. You don't need a questionnaire to give us benefit of your ideas. Just pass them on to me or one of the other officers of the club.

Finally, I would like to note that one reason that people have not been rushing to change the club is the general feeling of satisfaction with the way the organization has been run for many years. I can safely say that this has been the best organized of all the clubs with which I have been associated. A big vote of thanks is due to Don and Genie Howard for the years of great leadership. And of course a big thanks to the soul of the club: Rudy Tschernich. And finally a vote of appreciation to all of the members past and present who have developed and led the NWMMSG over the years.

One thing is clear from the questionnaire: that the future of the NWMMSG is good and positive.

Bob Smith

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Donald G. Howard, Editor
356 S. E. 44th Avenue
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e-mail: pogoette@mindspring.com

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IN MEMORY OF RAYMOND SCHNEIDER

1909 - 2001

Ray was born October 30, 1909, in Portland, where he attended school, later graduating from Benson Polytechnic High School. He and his older brother, Tony, became rock collectors in the 1930's. Their earliest interests were in lapidary materials. They collected at many locations in the Willamette Valley, central and eastern Oregon, southern Washington, and northern Nevada.

In 1933, Ray became a charter member of the Oregon Agate and Mineral Society. He was the first editor of the "Oregon Rockhound Bulletin" and later was president.

Ray served in World War II as an aircraft mechanic in the U.S. Army Air Force. Part of his service time was spent in Ohio, where he collected minerals at such locations as Clay Center.

After the war, Ray worked as an aviation mechanic at McClellan Air Force Base in Sacramento, California. At that time, he was a member of the Sacramento Mineral Society, the Valley Rock Rustlers, and the El Dorado County Gem and Mineral Society in Placerville. Being so close to the "Mother Lode", he spent many hours collecting all types of quartz crystals and other minerals from the many mining areas. Ray's collecting was not limited to those areas, as he also collected in such locations as San Benito County, Death Valley, and Crestmore Quarry. While living in Sacramento, he exhibited his minerals and gems at shows throughout the state. He also judged at many shows and fairs.

In 1975, Ray retired and returned to Portland, where he again became active in his former clubs. Shortly before his return, the northwest chapter of the Friends of Mineralogy was formed. He became one of the earliest members of that organization, and also of the newly-formed Northwest Micromineral Study Group. Ray's interests and activities are too numerous to fully list, but they include being a Charter member of the Mount Hood Rock Club, the Oregon Archeological Society (first secretary), Oregon Geological Society, and the Portland Stamp Club. He was also a founding member of the Oregon Museum of Science and Industry. He was also named as the first honorary member of the Taiwan Mineral Society in Taipei, recognizing his assistance in the forming of that organization.

I would be amiss if I did not mention Ray's "egg carton collections" that he gave to young people to encourage them to take up mineral collecting as a hobby. His door was always open to young and old alike to view his collections.

When we lost Ray on May 26, 2001, at age 91, we lost a very dear friend who had a deep interest and devotion to our hobby, but I'm sure that he has found a good place to collect up there by now. And none of us should be surprised if, as we are collecting, we sense Ray looking over our shoulder and saying, "That's a keeper!"

Jerry Wood

OLIVINE

by Don Howard

The planet Earth is thought to be comprised of three regions. An inner core, made up primarily of metallic iron and nickel, has a radius of a little more than half that of the Earth. A thin crust, only 50 to 100 miles thick on the average, is made up of most of the minerals we are busy collecting. Between is probably three quarters of the volume of the Earth, a region called the **Mantle**, made up of silicates of magnesium and iron – that is, made up of the mineral olivine.

Current nomenclature designates the two end-members of the series: **Forsterite**, Mg_2SiO_4 , and **Fayalite**, Fe_2SiO_4 . The name Hortonolite was formerly applied to intermediate compositions of magnesium and iron and perhaps some manganese, but this name is now discredited. Several other end-members with identical orthorhombic crystal structure have been named:

Tephroite	Mn_2SiO_4
Liebenbergite	Ni_2SiO_4
Monticellite	$CaMgSiO_4$
Kirschsteinite	$Ca(Fe,Mg,Mn)SiO_4$
Glaucochroite	$MnCaSiO_4$

A closely related mineral with a slightly distorted monoclinic structure is

Laihunite	$Fe_{0.5}FeSiO_4$
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which contains both ferrous and ferric iron.

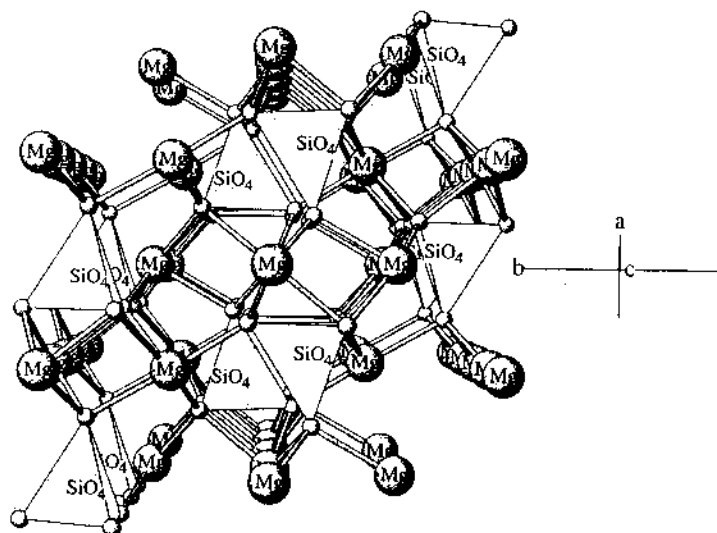
The crystal structure of olivine is best described as a hexagonal close-pack array of oxygen atoms. One eighth of the tetrahedrally coordinated sites are occupied by silicon atoms. One half of the octahedrally coordinated sites are occupied by one of the divalent atoms. This leads to an orthorhombic structure of approximately the following dimensions:

a = 4.8 Å
b = 10.3 Å
c = 6.0 Å

The structure is shown schematically below, using forsterite as an example:

The structure of Forsterite

This view shows the edge-sharing chains of M2 octahedra flanked by M1 octahedra. The octahedra are linked by Si tetrahedra that face alternately up and down in the a direction.



Generally, the chemical composition of the divalent ions in olivine is most commonly a mixture of Mg and Fe, with minor amounts of Zn, Ni, Mn and Ca. Olivine forms a continuous series between fayalite and forsterite, with all percentages of Mg and Fe allowed. The divalent ions occupy two sites that differ in symmetry:

M1 is at the center of symmetry

M2 is on a mirror plane.

In the end members, only a single species of divalent ion is present, so both of these sites are occupied by the same sort of ion. However, where mixtures are present, the various ions tend to prefer one site or the other. For instance, Ca does not care to occupy the M1 site. Thus, monticellite, kirschsteinite, glaucocroite are strictly ordered. Nickel prefers to crystallize with Mg rather than Fe, and prefers the M1 site. Mixtures of Mn and Fe are more common than Mn and Mg.

Both fayalite and forsterite can form rather equant crystals with a number of different faces. This is the most common habit for forsterite. Crystals of fayalite are often flattened, with prominent (100) faces. Particular examples for forsterite are given in the article on Obsidian Cliffs (this issue), and for fayalite in the article on Henderson's Quarry, New Zealand (Vol. VII, #7, page 21).

It is curious that a material thought to make up the major part of the Earth is not more common than it is. However, the reason that the olivine makes up the mantle region below the crust is that it is somewhat more dense than the majority of crustal rock. It therefore only occasionally gets swept up during an eruption with other igneous rocks. This may be as a major constituent of a body of rock (peridotite, olivine gabbro), but more commonly is as small inclusions (phenocrysts) in basalt or other crustal rock. Olivine in this form rarely forms distinct crystals. We have all seen the small, glassy green spots in otherwise very fine-grain black or gray matrix. Furthermore, olivine is easily broken down when exposed to weathering, taking on water and becoming serpentine, limonite, and magnesite. So only occasionally does the olivine even retain its true structure in these primary occurrences.

Fayalite also is formed as a high temperature mineral during surface eruptives, probably from the vapor phase. Small crystals can be found in scoria (Henderson's Quarry) or in the cristobalite spheres that are the first mineral to separate in some obsidians (Coso Hot Springs, Inyo Co., California). These occurrences produce small but very attractive crystals.

Forsterite also forms in contact metamorphic environments, where limestone or dolomite acts as a solvent in which crystals may form. The crystals accompanying the ludwigite are of this type.

The mineral Laihunite is an interesting modification of the basic olivine crystal lattice. In general, ferric iron does not substitute into the lattice easily. In laihunite, the ferric iron occupies all the M2 sites. To compensate for the increased positive charge, only half of the M1 sites are occupied by ferrous iron. The strain thus introduced causes the angle between the b and c axes to increase by about 1°, making the crystal monoclinic, but not distorting enough to be able to discern a difference in the external crystal habit. In fact, laihunite is an oxidized fayalite, and as such is usually microscopically twinned to retain the same external form. There may also be intergrowths of magnetite and laihunite on the same scale within the crystals.

Whether because of intergrown magnetite, or because of inherent interactions between the two valence states of iron, laihunite is weakly magnetic. This, coupled with the bladed nature of the crystals, makes a convenient test for this mineral.

Diagrams of the crystal habit of laihunite are given in the article on Obsidian Cliffs.

ROCK TRIMMERS FOR SALE

A small, reasonably light-weight rock trimmer is available from:

J. D.'s Machine and Repair
3105 H-1 Spring Grove Drive
Augusta, Georgia 30906

(706) 560 0086

This is a guillotine-style trimmer made out of steel. It operates using a screw and has no hydraulic parts. The moving bar is not spring-loaded, and so must be lifted manually.

The working space is up to about 3 ½ inches square.

Breaking tips are ½ inch tool steel and can be replaced easily.

The units are sturdy and allow very controlled trimming.

Each unit is apparently built upon receipt of an order. Price is \$100. each plus postage (about \$9 to Oregon). This is a small business. They accept orders by phone and payment by check, but do not accommodate charge cards.

The units are very nice. One will be available for your inspection at the Fall meeting in Vancouver, Washington.

Australian Minerals Available

The editor has received the following letter to the membership. Passing it on at this time seems very consistent with some of the wishes expressed in the President's poll.

Hi, my name is John Toma and I am a 46 year old amateur mineralogist and collector, micro to macro. I would consider myself an advanced collector having helped discover 5 new species (including johntomaite) and make many, first time finds of rare species in this country.

I have been collecting since I was eight and have built a collection of 5000 micro and several hundred macro specimens. A large part of my collection is self collected and I have many surplus specimens as a result of countless field trips. I am looking to contact a small number of collectors who would like to build a collection of Australian minerals, primarily micros. I would like to supply these customers with regular parcels of specimens each month, two months or quarterly.

The parcels would contain a mixture of common and rare species, cost US\$50 to US\$100 (content and price can be tailored to suit individuals) plus freight. The aim of each parcel would be to build not only a collection of minerals but knowledge of Australian localities and their mineralogy, *ie*, literature included.

Prior to sending each parcel I would e-mail/mail the customer with details for acceptance. I would also be happy to assist with want lists and have good contacts with museums and collectors. T/n, miniature and cabinet specimens can be dealt with if preferred.

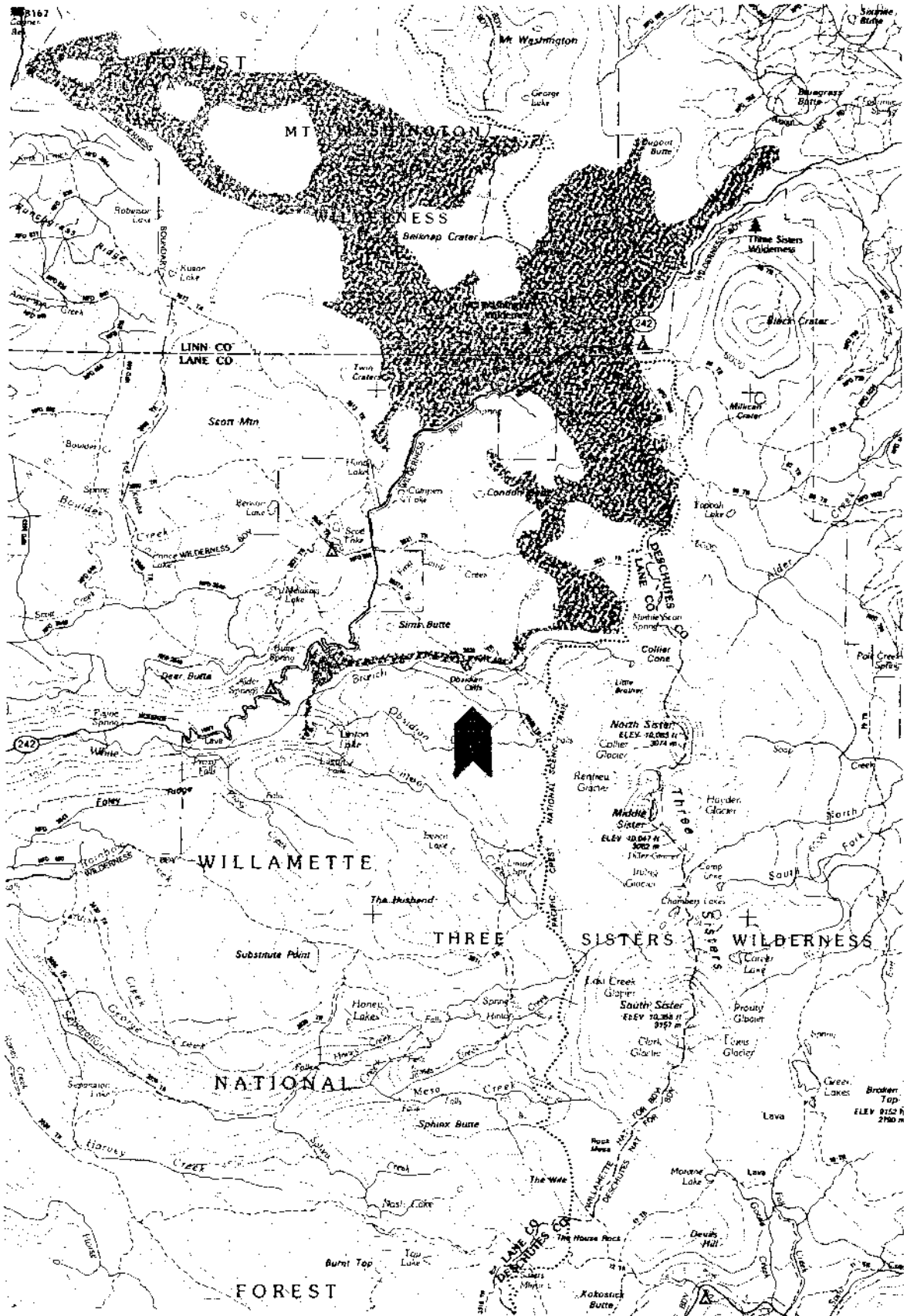
I am not looking to build a business as a mail order mineral dealer, simply help cover my collecting casts, hence the limited number of customers. Good micros and rare species are never plentiful.

Please circulate this information to any of your members who may be interested. Thank you for your assistance.

Yours truly

John Toma
13 Fullford Tce
Littlehampton 5250
South Australia

Phone: 08 83982191
e-mail: tomax5@chariot.net.au



Minerals of Obsidian Cliffs, McKensie Pass, Lane Co., Oregon

by Don Howard

Obsidian Cliffs was one of the first three locations for the mineral osumilite. Nestled as it is to the west within about 5 miles of the summit of North Sister, it is a truly beautiful setting for mineral collecting.

It is also located in the middle of a wilderness area!

The access to Obsidian Cliffs and the Sisters used to be from Frog Camp, a few miles below the summit of McKensie Pass. Frog Camp is no more, eliminated over ten years ago when the Three Sisters Wilderness area was created. Now the sign is labeled *Obsidian Trailhead*. The hike is still 4 miles, the first 3.5 gently sloping upward through open pine and fir forest, with the last half mile crossing an arm of the lava flow that came down from Belknap Crater near the pass. From the flow, you can see Obsidian Cliffs just beyond, as the photograph below illustrates.

At the foot of the last descent off the lava flow is White Branch Creek, a little trickle of water by August, running through an open green meadow. At the shallow ford, the Cliffs themselves are just a short way down the meadow to your right. Here, there is an immense scree slope completely surrounding the higher cliffs themselves. Many of the boulders are indeed obsidian, often in streaks interleaved with the rhyolite. The microminerals that you are looking for occur in the porous scoria. I found the best material at the foot of the boulder pile in the area closest to the trail.



First view of Obsidian Cliffs as you cross the lava flow on the trail.



The scree slope as seen from the trail while crossing the creek.
The best collecting area is at the foot of the pile on the extreme left.

The type locality for osumilite is in Kyushu, Japan, from which it was first reported¹ in 1953. The first mention of the Oregon location appears to be in an article by Olsen and Bunch² in 1970. At that time, three occurrences were known: Japan, Oregon, and one in Sardinia. Since that time, over a dozen other occurrences have been added, including Eifel, Germany and Lake Rotorua, New Zealand³.

During the 1980's, the property was under a claim held by Mike Grobin and Al McGuinness. This was opposed by the Forest Service, and when it lapsed, the property was included in the Three Sisters Wilderness Area. It is now in the middle of a restricted access area, where the number of people allowed in at any one time is carefully controlled. Both backpackers and day hikers need to obtain a written pass to enter the wilderness area. Day passes can be obtained from the Forest Service Headquarters a few miles east of McKensie Pass on the road to Sisters. A ranger is on duty at the Obsidian Trailhead to make sure that permission to enter has been obtained.

Four minerals appear to be present in the scoria. The matrix itself is a light gray color, and the cavities within are all lined with a layer of tridymite crystals. These are very small and can only be discerned at higher magnification, as for instance in the micrographs for this issue. The tridymite gives a very nice white background for the other three colored minerals.

The most abundant mineral present is osumilite. This occurs as small dark prisms perched on the tridymite. Generally, the height of the prisms is less than their diameter. Since osumilite is a hexagonal mineral, many of the prisms appear six-sided. However, an almost equal development of the second-order prism leaves many crystals twelve-



Collecting in the boulder field at the foot of the scree slope.
Most of the smaller rocks in this photograph are mineral-bearing scoria.

sided, and therefore appearing almost round. Other faces are small or entirely wanting on most of the crystals. The diagram below shows the primary habit. Micrograph #138 is of such a twelve-sided crystal with small bevels on alternate edges.

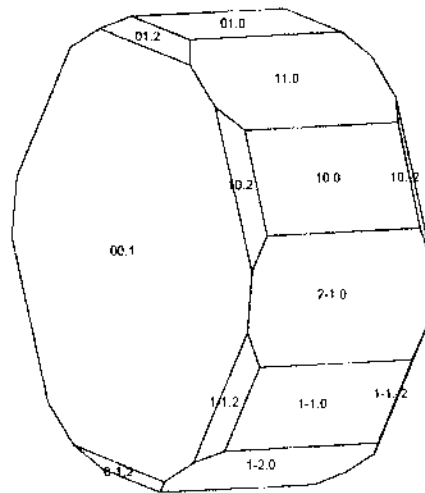
The lattice parameters of osumilite are:

$$a = 10.15 \text{ \AA}$$

$$c = 14.29 \text{ \AA}$$

The crystals appear black against the white background, but the thinner ones are a deep royal blue in light transmitted parallel to the c-axis. Internal reflections indicate that the color may be green or even an orangish brown for light that travels perpendicular to the c-axis.

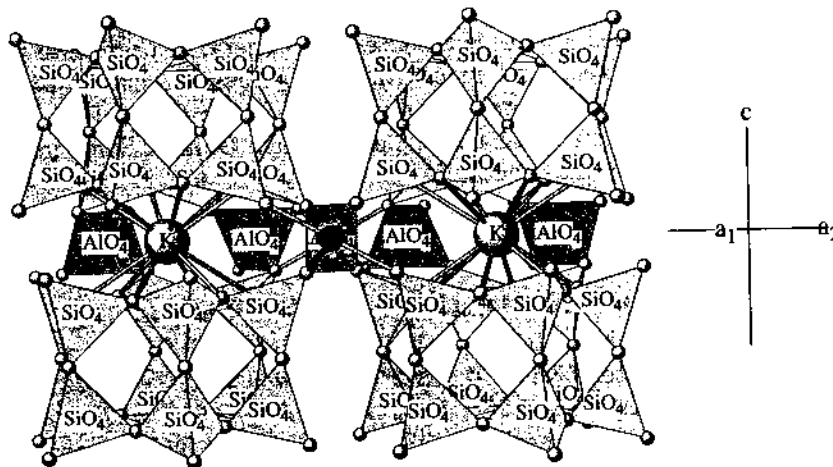
Osumilite is included in a group of about 15 members referred to as the milarite or osumilite group. The atomic structure of osumilite is similar to that of beryl, with silica tetrahedra in six-membered rings, with the potassium, iron/magnesium, and aluminum in sheets between the layers, as shown on the next page:



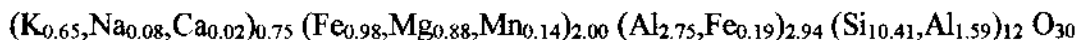
Typical habit of Osumilite-(Mg),
Obsidian Cliffs, Lane Co., Oregon.

The structure of Osumilite.

Six-membered rings of Si tetrahedra. The K are located between layers beneath the centers of the rings. The Fe are located between layers between the rings.



Chemically, osumilite is an aluminum silicate of potassium, iron and magnesium. Current nomenclature differentiates between an iron end-member, osumilite, and a magnesium end-member, osumilite-(Mg). The analysis given by Olsen and Bunch² clearly indicates that this should be the iron-rich mineral osumilite:



The second most abundant mineral occurring in the cavities of the scoria is a mica, reported² to be phlogopite. These are tiny hexagonal platelets that stand on edge. Their color varies from the usual greenish-silver of mica to a bright orange. The orange ones are undoubtedly heavily oxidized. Photograph #12 shows several of these blades in close association with an osumilite crystal. Micrograph #142 shows more detail of a bright orange blade. The surface growths give these blades an interesting texture under the microscope.

The final mineral observed in the cavities is a well-crystallized olivine. Its metallic gray color and the fact that it is weakly attracted to a magnet indicate that it is probably the oxidized olivine mineral laihunite. (For details on the structure and chemistry, see the article on *Olivine* in this issue.)

Crystals of laihunite are thin blades with prominent (100) faces. These faces are often striated, commonly parallel to [001] as in micrograph #141, but also with a complicated cross-hatched pattern of lines parallel to the (021) faces that terminate the blades, as shown on the crystal in micrograph #139. The crystals are quite simple with mainly (100) and (010) bounding the prism, and {021} terminating the blades like the picket on a fence. {101} faces may be completely absent (as in the two micrographs), or developed far enough to give the blades a rather blunted end.

Crystals usually occur singly in cavities, but groups of a dozen or more have been observed in a single cavity. This material has clearly been oxidized. Broken blades have a rusty look on the irregular ends, and rusty patches can sometimes be seen on the a-faces and edges.

Good pieces of the scoria tend to be very rich, and each piece broken off will have crystals of one or more of the minerals showing. Since this is a wilderness area, I am sure that the Forest Service frowns on collecting. However, only a piece or two is sufficient for an abundance of specimens.



Habit of Laihunite, Obsidian Cliffs, Lane Co., Oregon

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2. Olsen, E. and Bunch, T.E., *Compositions of natural osumilites*, Am. Min. **55**, 875-879 (1970).
3. Howard, D., *The minerals of Henderson's Quarry, Mt. Ngangataha, Bay of Plenty, New Zealand*, **Microprobe** Vol 7, #7, pg26 (1993).
4. Gaines, R.V., Skinner, H.C.W., Foord, E.E., Mason, B. and Rosenzweig, A., *Dana's New Mineralogy* (8th edition) (1997).

Ludwigite and Associated Minerals Spring Mountain District, Lemhi Co., Idaho

by Don Howard

The ludwigite from Lemhi Co., Idaho has become well known for the unusually large size of the crystals that are found there. Ludwigite is a borate of magnesium and iron:



It is produced in contact metamorphic environments. The crystals are orthorhombic, forming prisms without terminations – they just end irregularly. It forms a series with vonsenite, in which the ferrous iron dominates over the magnesium.

The ludwigite occurs with a few associated minerals, primarily forsterite, in a limestone vein several feet wide, and in surrounding rock. Deposits of magnetite nearby carry some ludwigite in pockets of calcite. The crystals are exposed by etching the calcite away in acid, preferably glacial acetic diluted about four to one and used warm. Dilute hydrochloric acid works, but must be used carefully because it also dissolves the ludwigite to some extent.

Fresh ludwigite is black in color. Some of the smaller crystals from this location etch out black, and stand out nicely against the white of the calcite. Most of the larger crystals have a rust-colored skin (limonite?) that gives their surface a tan coloration, and only appear black on broken edges where internal material is exposed. The skin appears to have coated the crystals during formation and is present on completely embedded crystals as well as those that have been exposed to weathering. This coating often extends out a millimeter or two at the irregular ends, giving the ends a rather skeletal appearance, particularly with some of the larger crystals.

Individual crystals of ludwigite are commonly up to a half inch in diameter and three or more inches long. Unfortunately, all the crystals tend to be cross-fractured repeatedly every few centimeters, so specimens tend to crumble into pieces if completely etched from the calcite unless the crystals are in a cluster that interlink together. The faces of the fractures are coated with the oxidized, brownish coatings similar to the prism faces, indicating that the fracturing also occurred during formation. Ludwigite probably crystallized from a flux of molten calcium carbonate that later cooled into limestone. Different coefficients of expansion caused the ludwigite to shrink more than the calcite, and the resulting strain was relieved by cross-cracking. The oxidized coating makes a very weak bond to hold the fragments together at these cracks.

Ludwigite has an orthorhombic crystal structure with dimensions:

$$a = 9.26 \text{ \AA}$$

$$b = 12.26 \text{ \AA}$$

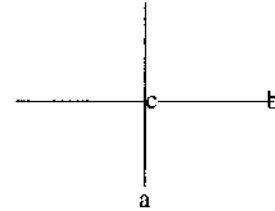
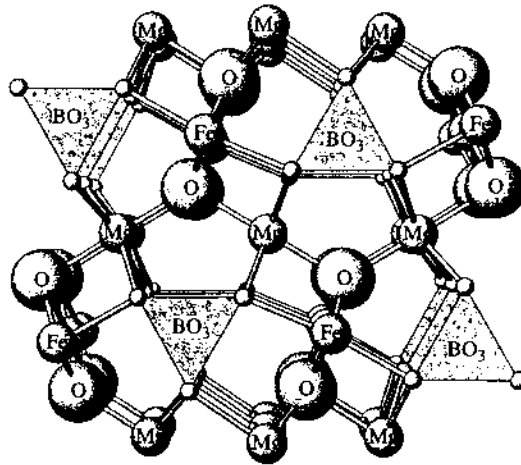
$$c = 3.05 \text{ \AA}$$

The crystals are elongated along the c axis, as prisms bounded by four {110} planes. This creates a rhombic cross-section with acute angles of about 74°. The faces tend to be somewhat rough and irregular, not sharp and well-defined.

The prisms appear to start and end at random positions in the calcite. They also point in random directions, with no particular tendency toward parallel orientations or radial structures. They are a haphazard interlacing of fractured rods. Some areas are very nearly solid ludwigite, and where present, these tend to help stabilize the specimens. A typical, partly etched specimen is shown in photograph #8.

The structure of Ludwigite

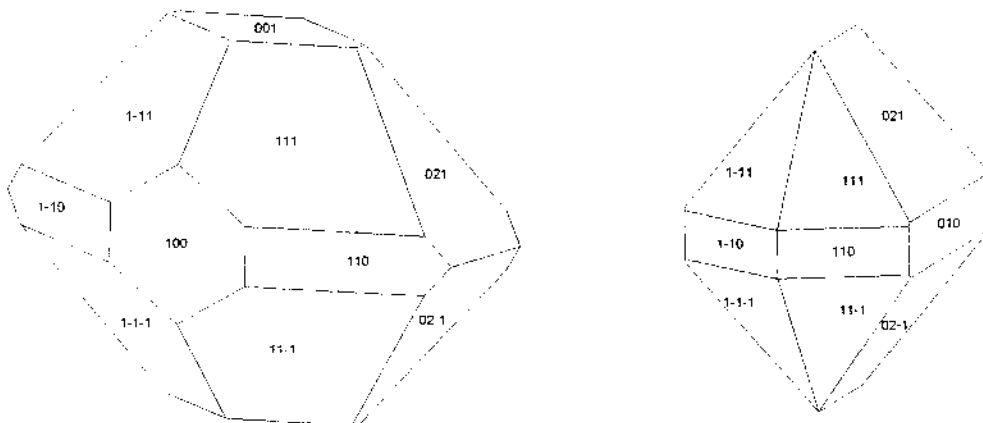
The Fe and Mg are both in octahedral coordination. In this view, the layers of Fe plus BO_3 triangles alternate with the layers containing Mg and O.



The next most common mineral in the calcite vein is forsterite. These crystals are in general much smaller and more euhedral in shape than the ludwigite. Most identifiable crystals are a millimeter or two in diameter, but individuals up to one centimeter or more are present in places. The color varies from cream to a pale yellow and from clear to opaque and milky. Considerable fracturing is visible, particularly in the clear crystals, and parts of an individual may be clear while others are not. Some crystals etched out of the calcite have sharp faces, but most have a least some of the faces rough and indistinct. This is probably a partial intergrowth at the surface with the surrounding calcite, a rather common phenomenon in metamorphic environments. Forsterite is gelatinized by hydrochloric acid, so specimens etched in acetic acid will probably have more distinct crystals.

The pale color indicates this olivine mineral is nearly end-member forsterite, with little iron substituting for the magnesium. The structure of forsterite is given in the article on olivine.

Pieces with forsterite along with the ludwigite tend to be structurally stronger than the ludwigite alone, and the color contrast makes for attractive specimens. These can be etched farther out of the surrounding calcite and still not crumble.



Crystal forms of **Forsterite** from Lemhi Co., Idaho

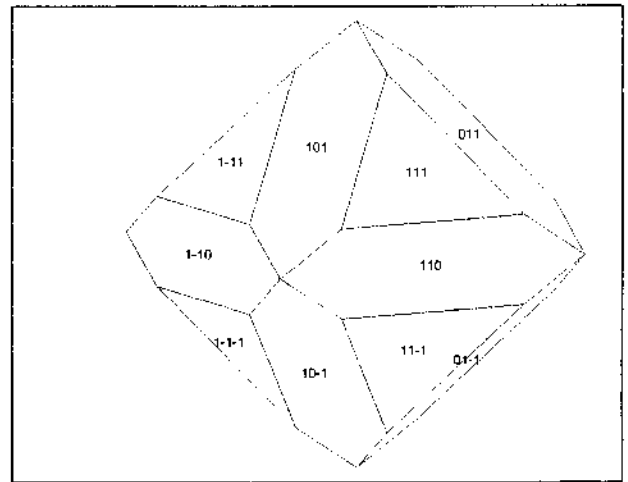
The third mineral observed is spinel, which crystallizes in the isometric system. These are black, lustrous crystals with smooth, sharp faces. Individuals are small, up to 2 or 3 mm in diameter at most. The habit is the normal one for spinel: an octahedron {111} modified on the edges by dodecahedral faces {110}.

Spinel is usually found in specimens where forsterite is also present, though the spinel crystals may be on either the forsterite or the ludwigite, or in clusters of their own. Photograph #9 shows a liberal sprinkling on ludwigite prisms as well as a few embedded in the surface of the forsterite.

Spinel is basically a double oxide of magnesium and aluminum: $Mg Al_2 O_4$.

Numerous divalent ions can substitute for the Mg and trivalent ions for the Al. In the present case, the dark black crystals indicate that there is probably considerable substitution of ferrous and/or ferric iron. The chemistry of the occurrence would indicate that Mg and Fe are the primary impurities present in the limestone during formation. Forsterite accommodated what silica was present, while the spinel accounted for the aluminum.

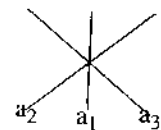
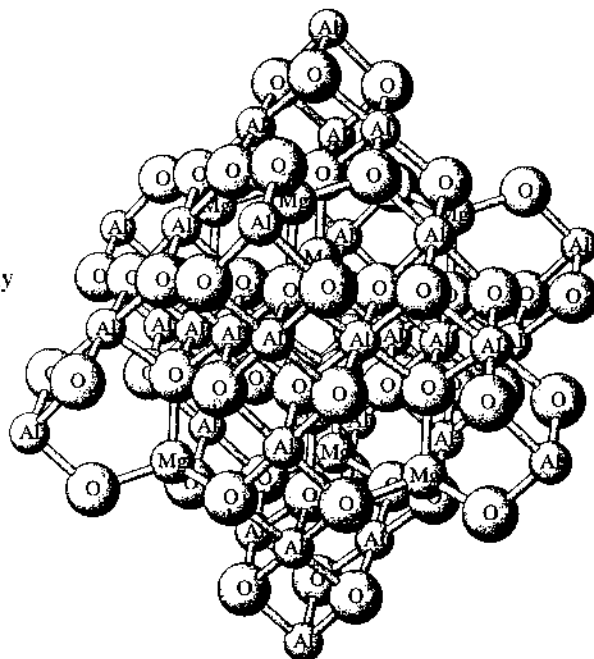
Spinel is a member of a large group of minerals of similar structure, which includes magnetite and chromite as well as more familiar spinels like gahnite, hercynite and galaxite. The structure of the spinels is given below:



Habit of **Spinel**, Lemhi Co., Idaho

Structure of **Spinel**

This model has the [111] vertical.
The oxygen atoms are approximately
in a face-centered cubic array. The
Mg occupy tetrahedral sites while
The Al are in octahedral sites.



Some of the spinel crystals appear to be epitaxially oriented to the forsterite or ludwigite they are perched upon. In photograph #9, the black crystals on the large flat forsterite crystal in the center of the specimen are all oriented so that the triangular (111) face of the spinels are parallel to the (100) face of the forsterite. This makes sense, since the (111) in spinel (diagram above) contains sheets of oxygen atoms arranged in a close-packed (hexagonal) array, and there are similar sheets of oxygen atoms in the (100) plane of the forsterite (see the diagram in the article on *olivine*).

Photograph #10 shows a section of one of the ludwigite crystals with several large spinel crystals on its (110) face. The spinel have the [100] direction perpendicular to the surface and the [110] parallel to the c-axis of the ludwigite. This would align the lines of oxygen atoms (seen most clearly on the upper left hand side of the diagram of the structure of spinel) with the lines of oxygen atoms associated with the Fe octahedra (seen most clearly on the upper right hand side of the diagram of the structure of ludwigite). Not all samples showing spinel crystals on ludwigite show this epitaxial orientation. The presence and thickness of the oxidized layer on the surface of the ludwigite may play a role in determining whether or not the alignment occurs. When present, all the spinel crystals in a given area give a flash of reflected light at the same angle, proving that they are indeed in parallel alignment.

After nearly complete etching, some of the specimens show small tufts of needle-like crystals in loose bundles. Though not enough material is available for x-ray testing, these are probably diopside, $\text{Ca Mg}(\text{SiO}_3)_2$, another mineral composed of the same suite of elements known to be present in this limestone.

Other minerals reported in the vicinity from similar environments include natrolite, mesolite, chrysotile, clinohumite, magnesioferrite (another member of the spinel group), meionite, heulandite, thomsonite, laumontite, vesuvianite, and grossular.

There is considerable magnetite nearby. Masses of calcite occur in the magnetite which, when etched away, show reasonably well-formed crystals. Interestingly enough, the crystal habit of the magnetite is exactly the same as for the spinel – octahedral faces with the edges truncated by the dodecahedron. The magnetite crystals have rougher faces than the spinel, and therefore do not have the sharp reflections of the spinel. Bundles of very small ludwigite crystals, looking tan from oxidation, can be found under the calcite mounted on the magnetite.

This is a very interesting though somewhat remote collecting spot that definitely deserves much more study.

Collecting Barite, Calcite and much more at the Elk Creek, South Dakota Locale

by Robert J. Smith

Late spring can be pretty hot in western South Dakota, but if there is a little breeze blowing it is not so bad in the Elk Creek Valley. As my family holds property along the creek, I often have collected there. This is a classic locale for some of the finest barite found in North America. Barite and other fine minerals can be found in the calcareous nodules that erode out of the shale banks. These concretions also contain some fine marine fossils.

Elk Creek is a tributary of the Cheyenne River in western South Dakota. Its headwaters are in the Black Hills, which are about 40 miles south from the major collecting areas along Elk Creek. The creek is also a little to the west of the Badlands National Park. Therefore, it is a great geological area to visit.

During most summers, the creek stops flowing and collecting is easier. But in spring the stream may still be pretty dangerous, so caution is advised.

The geology of the area is basically cretaceous shales in several horizons. The rivers have cut through the shale and overbearing to expose a number of limey nodules that seem to be septarian in nature. These nodules contain the excellent fossils as well as shrinkage cracks that contain the minerals. Every spring (depending on the amount of snowfall and rain) new nodules are eroded out of the banks of the rivers. This is the time to collect. But collecting is not easy. The nodules tend to be tough, and considering the pronounced basal cleavage of barite, collecting specimens without damage is tricky.

A number of other minerals may be found in the nodules. The most common is calcite. The calcite in the area should not be overlooked; it is often a very becoming yellow color, and tends to form distorted and twisted rhombohedral crystals that are very interesting.

Gypsum crystals of several habits are found as well. Single crystals and needle-like groups are common. Occasionally, the ram's horn form is seen. Good crystals of gypsum (selenite habit) can also be found loose in the shale of the banks. I have also found good layers of satin spar form.

I have also found small circles of pyrite, reminiscent of the pyrite discs found in coal measures. Much of the pyrite is found in association with fossils.

One of the rarest minerals found in the nodules is whewellite, a rare calcium oxalate. It is seldom found because it is easily weathered, so once exposed it does not last long.

I have found some wonderful fossils that have all of these minerals (barite, calcite, pyrite, etc.) crystallized in cavities in the fossils.

However, it is the barite that causes the most excitement in the Elk Creek area. The barite comes in fine crystals that are transparent and run from almost colorless to a dark deep golden color (thus the name: golden barite). I have seen crystals up to ten inches long and three inches across. Most are terminated, and size seems to depend on the amount of open space allowed in the shrinkage cracks in the nodules. But the average size is several centimeters. Often, at least two of the termination faces are highly striated.

Both the barite and the calcite in this area are highly fluorescent and often phosphorescent. Usually the luminescence is yellow to white in color.

Along the river, other fossils can be found, such as coral, etc. And fortification agates are also not unknown. In this area, these are called Fairburn agates in honor of the town that is not too far away.

The classic locale along Elk Creek near Wasta, South Dakota is not open to collecting. However, a number of creeks and ranches in the area may have potential collecting sites. But remember that permission is required from the land owners. And remember that this is cattle country, so be sure to close any gates that you open. And finally, be very cautious with fire during the dry months.

REFERENCES

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PICTURE CREDITS

for this issue:

Ray Schneider

Bill Tomkins

All color photos
and micrographs

Don Howard

Atomic structure diagrams

from Dana's New Mineralogy
(8th edition)

FIGURE CAPTIONS

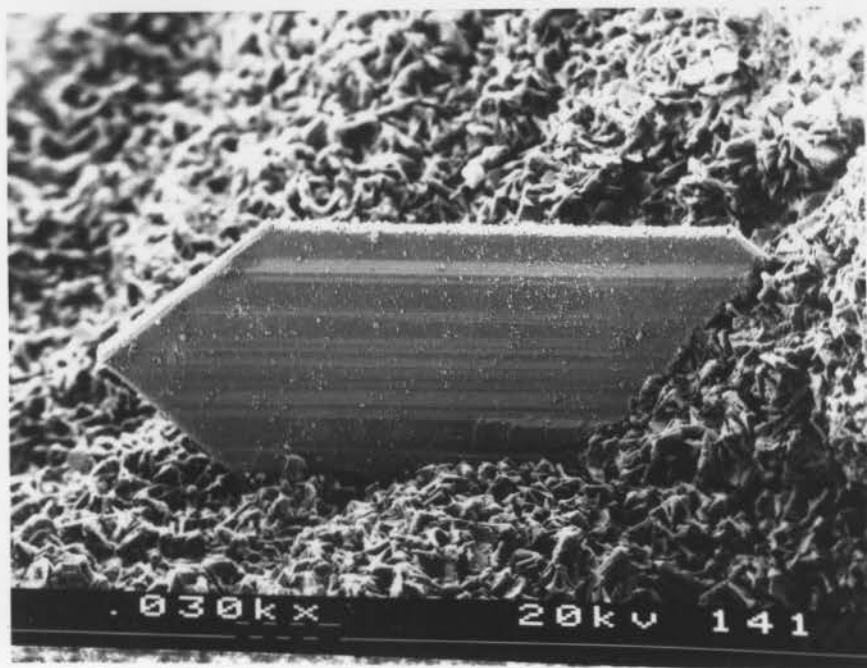
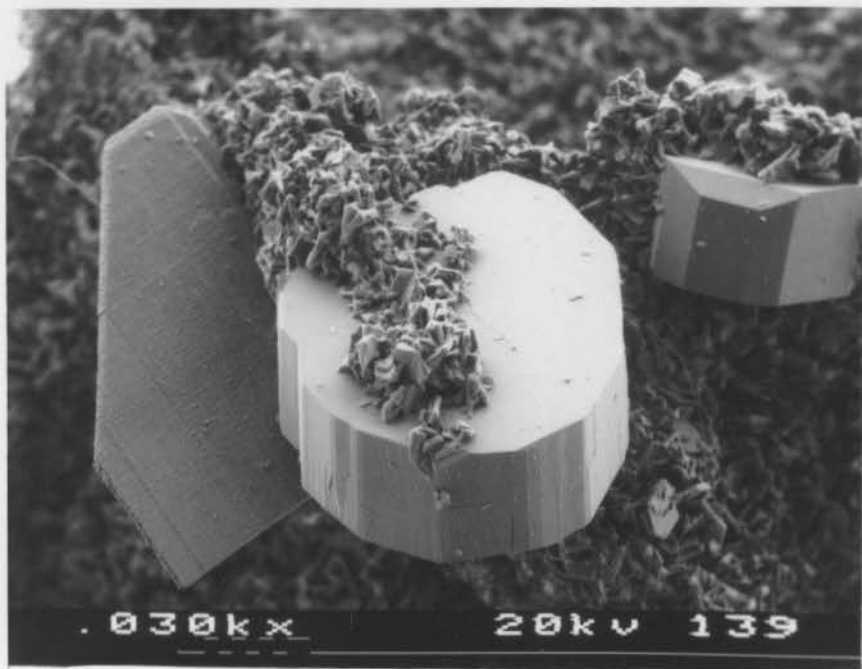
For color photographs, the number is in the upper left corner on the back.

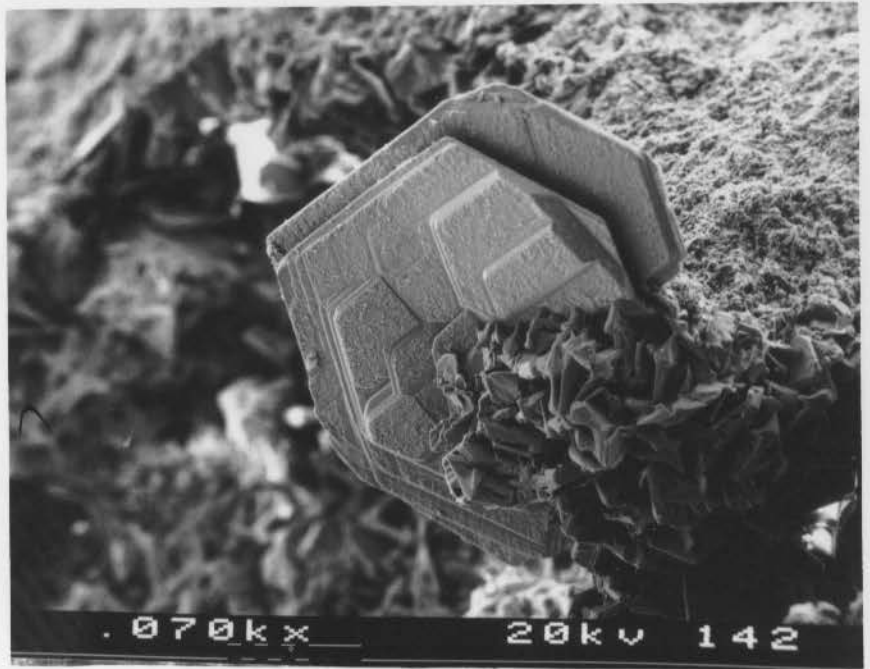
- # 8 Ludwigite in Calcite (x1)**
Spring Mountain District, Lemhi Co., Idaho
 Approximately full scale, this specimen shows the interlacing ludwigite crystals with their irregular ends. Most surfaces are covered with a tan oxide layer. Only broken crystals (lower left) show the black interior.
- # 9 Spinel on Ludwigite and Forsterite in Calcite (x2)**
Spring Mountain District, Lemhi Co., Idaho
 The roughly octagonal cream-colored crystal in the center is forsterite. The sharp black modified octahedrons are sprinkled on both the forsterite and the ludwigite.
- # 10 Spinel on Ludwigite (x8)**
Spring Mountain District, Lemhi Co., Idaho
 The individual crystals of spinel are oriented so that the (100) is perpendicular to the (110) face of the ludwigite, which is in the plane of the photograph. Notice that each grain is oriented identically, with the (110) parallel the ludwigite c-axis.
- # 11 Osumilite on Tridymite (x8)**
Obsidian Cliffs, McKensie Pass, Lane Co., Oregon
 Several dozen black prisms of osumilite clustering in a cavity in the rhyolite scoria.
- # 12 Phlogopite and Osumilite on Tridymite (x12)**
Obsidian Cliffs, McKensie Pass, Lane Co., Oregon
 The thin orange hexagonal blades are phlogopite. The osumilite just to their left shows a bright reflection off of its smooth face. Another osumilite crystal is at the right.
- For electron micrographs, the number is in the lower right corner on the front.*
- # 138 Osumilite on Tridymite (x32)**
Obsidian Cliffs, McKensie Pass, Lane Co., Oregon
 This crystal has almost equally developed first and second order prism faces. The edge bevels modify only the first order prism faces. The crystal is black on a white background.
- # 139 Laihunite and Osumilite on Tridymite (x30)**
Obsidian Cliffs, McKensie Pass, Lane Co., Oregon
 The blade of laihunite shows cross-hatched striations. Notice the one large bevel face on the smaller osumilite at the right. The osumilite crystal in the center appears to be twinned.
- # 141 Laihunite on Tridymite (x30)**
Obsidian Cliffs, McKensie Pass, Lane Co., Oregon
 Here the blade is striated longitudinally parallel to the c-axis. There are no (101) faces, so the termination comes to a sharp point.
- # 142 Phlogopite on Tridymite (x70)**
Obsidian Cliffs, McKensie Pass, Lane Co., Oregon
 An orange-colored blade made up of several pieces in parallel growth. Notice that the edges alternately slope forward and backward, the signature of a rhombohedral crystal and typical of mica minerals.











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