

Northwest  
Micro Mineral  
Study Group

# MICRO PROBE



Fall, 2017

VOLUME XII, Number 6

Fall MEETING .....CAMAS, WASHINGTON

November 4, 2017

9:30 am to 4:30 pm

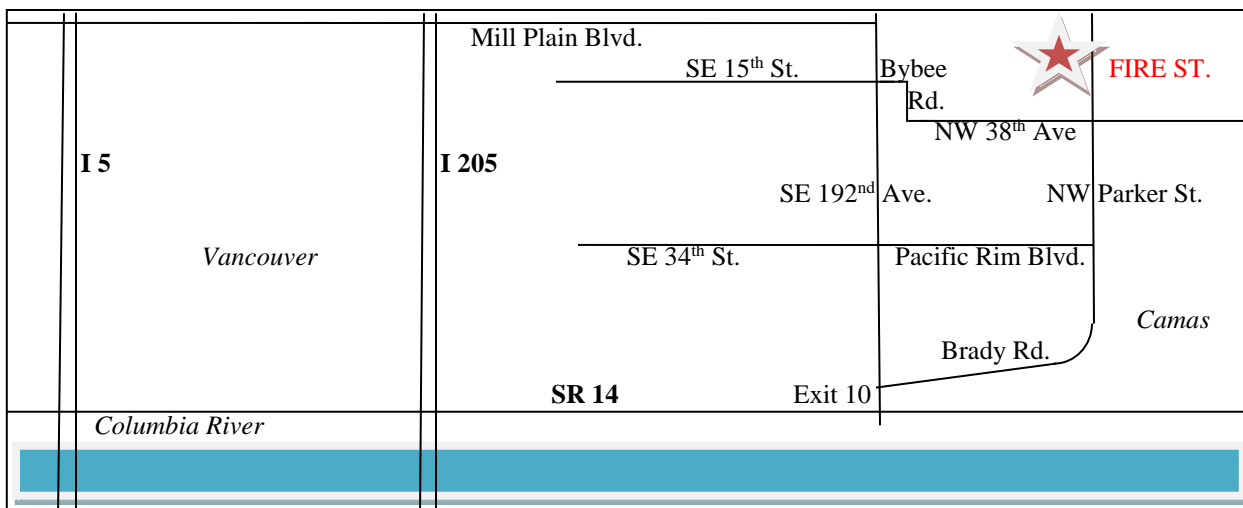
Camas-Washougal Fire Station #42  
4321 NW Parker Street  
Camas, Washington

We are looking forward to another day of fun and fellowship together examining minerals and exchanging stories. Bring microscopes and things for the give-away tables as usual.

We will be meeting again at the fire station in Camas. To get there, from north or south, take I205 and come off onto SR14 just north of the Columbia River headed for Camas. From the east, you are already on SR14. Take exit 10 onto SE192nd Ave. An immediate right turn will put you on Brady Rd., which will soon swing around to become Parker St. There are name changes on streets between Vancouver & Camas, but don't let that throw you!

We will have the Club provide sandwich makings (bread, meat, lettuce, cheese, dressings, and coffee, tea, cocoa) for our lunch potluck: Please bring salads, chips, pop, nuts, chili, cookies, pie, or cake to add to the lunch.

After lunch, **Julian Gray** will be describing the micromineral collection at the Rice Museum. The computer & projector will be available. Please bring the pictures you have to share with the group. We would love to see them.



## President's Message

Every once in a while, a group needs to look at itself, reflecting on what they want to be and what their goals are. I realize that with the change of president and the lack of expertise on my part, there has not been the focus on the "study" part of the group. There have been wonderful presentations and an abundance of shared minerals at each of the meetings. I have noticed, though, that there is less of the technical type investigations, including those focused on Washington Pass.

This leads to a questions that I have: 1) Is there a desire by members of the group for that expert level type of study? 2) Is there someone who has the expertise to lead that type of study? If not, I do not have any problem with it, but I do not want to alienate our more technical members. I also enjoy and learn a lot from these presentations even if much goes over my head.

With our planned Micro-Mineral room at the PNWFM Symposium, we can hope to bring in a few new members with maybe no experience in collecting minerals. We also need to be able to meet their needs. Until they attend a meeting and we find out their background, we cannot really assess that, but we need to think about this and be prepared

I welcome any input during our meeting in November on the continued growth, both in size and in expertise, of our group. See you on November 4th.

*Beth Heesacker, President*

### THE MICROPROBE

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## Aranga Quarry, Northland, New Zealand

Don Howard

In the Spring, 2016 issue of the *Microprobe*, I quoted Steve Sorrell saying that many new and interesting things would come from re-examining the material already in our collections (*Microprobe* Vol. XII, #3, pg 5). Doug Merson illustrated that quite nicely with interesting finds from Goble and Summit Rock in this Spring's issue (*Microprobe* Vol. XII, #5, pg 9). Now I come up with another unexpected illustration.

I was busy gathering a few pieces to send to a 12-year-old interested in minerals, and was looking through boxes of uncatalogued stuff in search of some particular pieces that I knew I had *somewhere*. In the process, I ran across an egg carton with a few specimens that Jocelyn Thornton had sent me and that had been overlooked and not catalogued. They needed to be, so I set them aside.

Several of the pieces were from the quarry at Aranga. I had a chance to visit that quarry with Jocelyn during my trip there in 1992, and I wrote up a brief article for the *Microprobe* at that time. (*Microprobe* Vol. VII, #5, pg 3). The quarry perches at the top of a basalt cliff overlooking the sea along the west coast of the North Island well north of Auckland. It was a fairly small quarry in 1992, with cows wandering about the bottom. It is a much bigger quarry today.

In 1992, the quarry sported a variety of zeolites. I was interested in the gismondine, but there was also chabazite, native copper, thomsonite, heulandite, levyne, and lots of calcite. Since that time, cavansite has been found in small, intensely blue balls, and okenite, and cowlesite, and phillipsite. It is an active quarry and often visited by collectors.

One of the pieces in the batch I just found had cavansite and okenite balls on coated chabazite. The coating on chabazite is purported to be offretite rather than erionite. I was pretty sure I had a piece with cavansite from there, but had never been able to lay my hands on it. As fig. 3 shows, it makes a pretty specimen. Another was a rather ordinary piece with phillipsite. It was the third piece that blew my socks off.

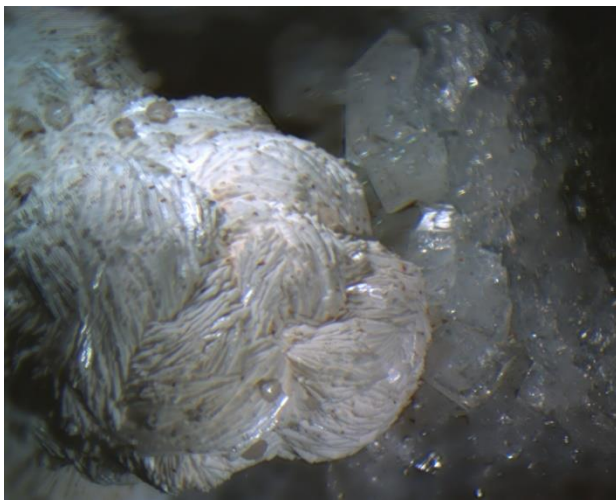


Fig. 1 Gismondine on Chabazite  
Stone's Quarry, Aranga, New Zealand

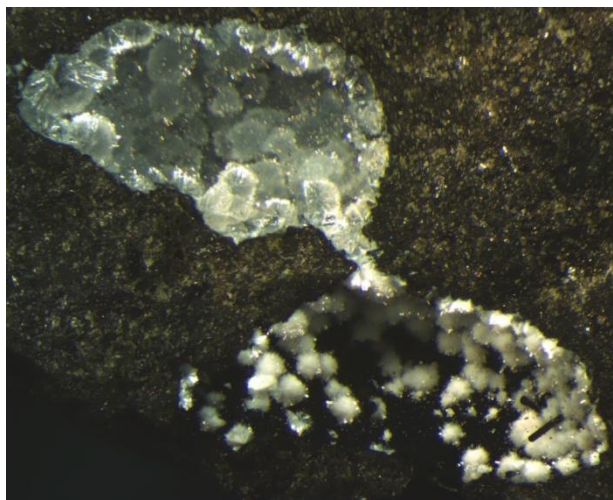


Fig. 2 Cowlesite  
Stone's Quarry, Aranga, New Zealand

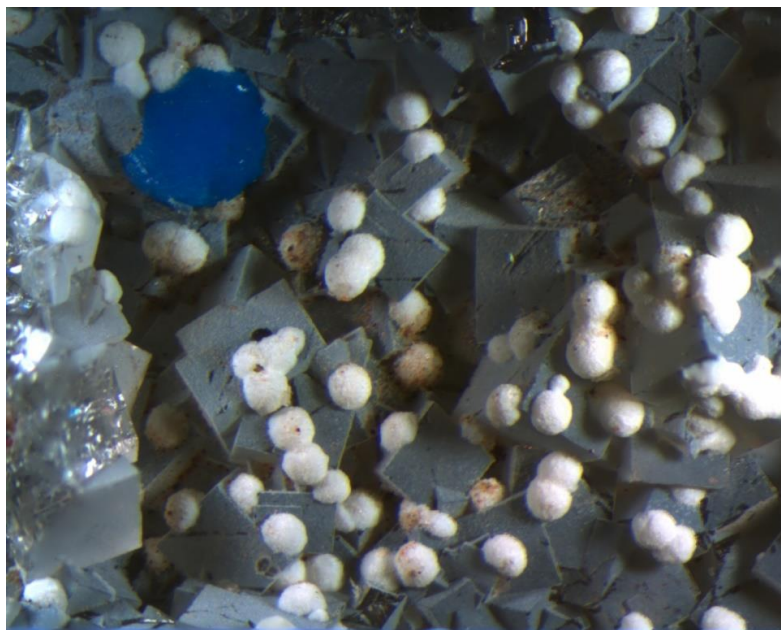


Fig. 3 *Cavansite and Okenite on coated Chabazite*  
Stone's Quarry, Aranga,  
New Zealand

The piece was not much to look at. It had a white layer mostly covering the top of a chunk of basalt about an inch square. There was a fine drusy of crystals on the top of most of the layer. The label had Aranga as the location but no identifying name. So I took a good look at it under the highest power my scope has (about x56) and thought, '*Boy, those look familiar!*' A tetragonal mineral, with steep pyramidal faces and a tiny flat c-face at the top. Most of the pyramidal faces were coated with a white stuff, but the c-faces were uncovered and they showed the clear colorless interior. And the funny, side-by-side kind of twinning. '*By golly, those look just like tschernichite!*'

I thought I had completed the survey of locations for tschernichite, but now I must add one more: **Stone's Quarry, Aranga, Northland, New Zealand**. This specimen looks unlike any from the other five sites, and especially different than the previously described New Zealand site on the Waitakere River. New Zealand becomes the first country with two tschernichite locations.

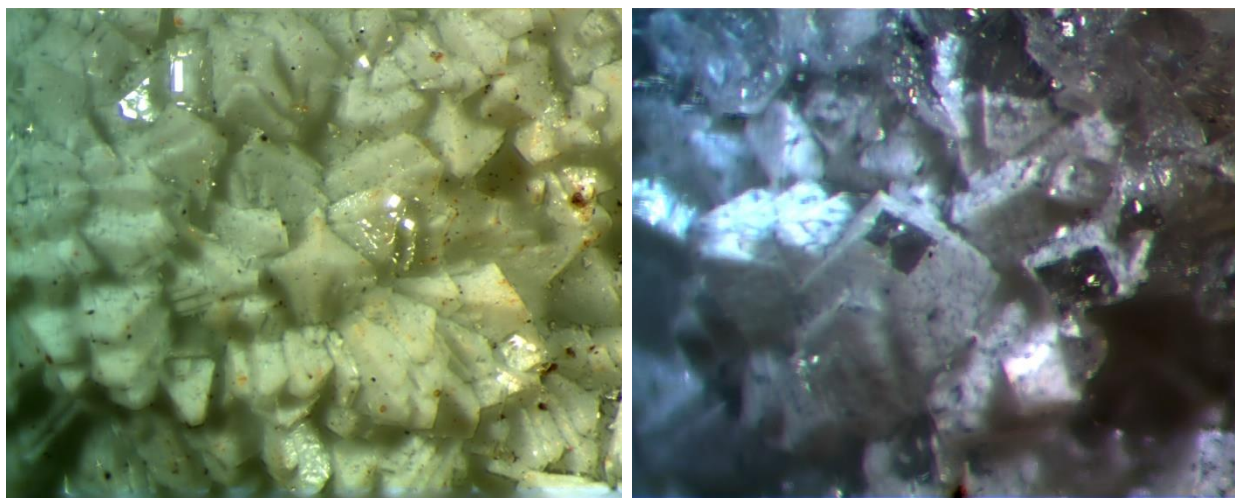


Fig. 4 Two views of coated Tschernichite crystals. Notice the uncoated c-face (right photo, 2mm FS).  
Stone's Quarry, Aranga, New Zealand

## Groups, Polymorphs, and Polytypes

Don Howard

In order to be a systematic science, mineralogy had to make some decisions early on as to how to characterize minerals. Some mineral names date very far back in history. There are biblical references to things like jasper and sapphire and alabaster. Gem stones have been known and coveted for many centuries. So what is the best way to organize the description of minerals?

Dana's approach was to gather minerals in broad categories according to their chemistry. Thus he gathered together elements, oxides, carbonates, etc. through the huge category silicates. This formed a structure based primarily on the anion radicals present that could be used to sort through and describe the known minerals. This is certainly a logical way to sort minerals. It works very well for chemistry, where the emphasis is on pure compounds obtained from solutions of just their constituents.

But minerals are formed in the real world, and the mixing pot in which they are created contains bits and pieces of many different chemicals all mashed together. So the solids that form are not in general pure anything. They have major constituents to be sure, but there is considerable substitution of one element for another, so that the final product often actually contains dozens of different kinds of atoms, at least in small concentrations. And when two or three cations are present in nearly equal amounts, the system does not lead to a very satisfying result.

The other way to characterize a solid is through its structure. Most minerals arrange their atoms in a very regular way, which we refer to as crystal structure. The substitution of small amounts of one kind of atom into the site normally occupied by another kind of atom often does not alter the overall way that atoms are arranged together. And structures are definite; they do not in general blend from one to another. So structure has been adopted as the defining property for a mineral.

There are some major advantages in using crystal structure rather than chemical content as the chief defining characteristic of a mineral. The only way to establish chemical content is by detailed analysis. That was done originally using wet chemistry, and more recently through x-ray fluorescence. Crystal structure, however, manifests itself in the external faces of the crystals. Crystal system and relative parameters can often be established by measuring the angles between faces. Crystal habit – that is, which faces are present and which are not – also gives clues to the structure and helps identify particular minerals.

### Groups

Minerals that share the same general crystal structure are gathered into **groups**. The members of a group very often all lie in one of the broad chemical categories, but not always. Groups are usually named after the most prominent mineral that possesses a particular structure, or at least the earliest mineral of that structure to be identified and named. Let us start out examining some of these groups.

The **copper group** is an example of a small group. It has three members: copper, silver, and gold, and it would fall into the broad category of elements. Each of these metals exhibit the face-centered cubic crystal structure. (See Microprobe, Vol. XII #1 page5 for a description of the atomic arrangement of the unit cell.) All three members can mix freely into each other. These three are considered to be the **end-members** of the group.



A closely related group is the platinum group: iridium, palladium, platinum, and rhodium. These elements are also face-centered cubic in structure, so as far as crystal arrangement both groups could be included as one structure. But these four metals, while mixing freely with each other, do not mix with the metals of the copper group. Each of the two groups have a common environment in which they are found that differs from that of the other group. Hence, separate groups. The lead group, aluminum, lead, and nickel, is also face-centered cubic, but tends to not mix with the others. So we see that paragenesis is also taken into account when forming groups.

The calcite group is a somewhat larger group composed of carbonates of divalent cations. The crystal structure is rhombohedral. Small amounts of the other six cations are commonly found in calcite specimens. Indeed, it is trace amounts of manganese substituting for calcium that gives some calcite specimens their lovely red fluorescence. But the substitution does not necessarily extend to mixtures at all proportions. Nearly equal mix of calcium and magnesium produces dolomite, a different crystal structure. Calcium-iron and calcium-manganese similarly lead to minerals of the dolomite group, but they require some magnesium as well to stabilize that structure.

Several groups have a very large number of members. The zeolite group currently boasts 89 members. Such large groups are commonly broken into several sub-groups. Rather than coining a name for each of the 89, a scheme has been adopted to use the sub-group name with a chemical symbol attached at the end (not in parenthesis). Thus we have Heulandite-Ca, Heulandite-Na, etc.

For some groups, there is more than one site that may be filled by numerous radicals. The apatite group is an excellent example. Members of this group are phosphates, but both the cation site (Ca,Sr) and the anion site (F,Cl,OH) need to be specified. The current specification would be Apatite-(CaOH) for the mineral formerly known as Hydroxyapatite. The jahnsite group has three separate cation sites, so the designations look like Jahnsite-(CaMnFe)

#### The Calcite Group

Calcite	Ca CO <sub>3</sub>
Gaspeite	Ni CO <sub>3</sub>
Magnesite	Mg CO <sub>3</sub>
Otavite	Cd CO <sub>3</sub>
Rhodochrosite	Mn CO <sub>3</sub>
Siderite	Fe CO <sub>3</sub>
Smithsonite	Zn CO <sub>3</sub>

#### The Dolomite Group

Ankerite	Ca (Fe,Mg,Mn) (CO <sub>3</sub> ) <sub>2</sub>
Dolomite	Ca Mg CO <sub>3</sub>
Kutnohorite	Ca (Mn,Mg,Fe) (CO <sub>3</sub> ) <sub>2</sub>
Minrecordite	Ca Zn (CO <sub>3</sub> ) <sub>2</sub>
Norsethite	Ba Mg (CO <sub>3</sub> ) <sub>2</sub>

It should be noted that the use of suffixed symbols has not been uniformly adopted. Many groups, such as the calcite group cited above, retain separate names for the members and do not employ suffixes at all. This is true for huge groups, such as the amphiboles, where there are four sites with variable composition. An interesting complication appears there: in some instances one of the sites in the crystal structure remains unoccupied in some members. To indicate this, a square box is included in the chemical formula. For ferro-actinolite: □ Ca<sub>2</sub> Fe<sub>5</sub> Si<sub>8</sub> O<sub>22</sub> (OH)<sub>2</sub>.

Current usage seems to be that where anions are different, such as phosphate versus arsenate, separate names are used, even when there may be a continuous variation possible from one to the other. Where cations are concerned, separate names are used if no continuous series exists (as for instance calcite to magnesite, where dolomite occupies the middle compositions). Where continuous variation appears to be possible, a single name with dominant chemical suffix in parentheses is to be employed, and former intermediate names have been dropped. This is nearly uniformly adopted for the rare earth minerals. A good example would be synchysite-(Y). But there are still outstanding exceptions, such as the series between olivenite Cu<sub>2</sub> (AsO<sub>4</sub>) (OH), zinc Olivenite Cu Zn (AsO<sub>4</sub>) (OH), and adamite

$\text{Zn}_2(\text{AsO}_4)(\text{OH})$ . The pyroxene group is another example where this nomenclature has not been adopted as yet.

### Polymorphs

There is another reason that structure rather than chemistry forms the basis of naming minerals. Some elements and chemical compounds can crystallize in more than one structure. The various possible forms are called **polymorphs**.

A good example of this is calcite, a rhombohedral mineral, and aragonite, which is orthorhombic. Both minerals occur in nature and are stable under ordinary conditions of temperature and pressure. At first blush, you might assume that orthorhombic and rhombohedral crystals would be relatively easy to tell apart, but aragonite commonly twins in such a way that it has a hexagonal cross-section. Both forms also may form acicular needles. They also are very much the same cream or tan color and have the same translucent appearance.

#### The Aragonite Group

Aragonite	$\text{Ca CO}_3$
Cerussite	$\text{Pb CO}_3$
Strontianite	$\text{Sr CO}_3$
Witherite	$\text{Ba CO}_3$

Calcite comes in many forms. It is purported to have the most different faces reported of any mineral. In the form of rhombohedral crystals, it is easy to recognize. Many of the other forms are much harder to recognize. The bubbling when treated with acid easily identifies a carbonate mineral, but both calcite and aragonite will do that. Probably the best way to clearly separate the two is by a broken crystal – calcite always has perfect rhombohedral cleavage and aragonite does not. But of course, if you only have one specimen, I am not advising that you break a crystal! Only aragonite will exhibit flat terminations. Needle-like calcite crystals usually have rhombohedral terminations, and may show slanted striations parallel to the cleavage plane on prism faces.

So why should there be more than one crystal form of  $\text{CaCO}_3$ ? In fact, at a given temperature and pressure, there is normally one stable form of a given compound. However, varying temperature and pressure can alter which form is stable. It is easy to see why pressure would have this effect. In



Fig. 1 Aragonite on Tschernichite and Boggsite  
Neer Road, Goble, Columbia Co., Oregon  
*A spray of flattened needles*



Fig. 2 Calcite on Heulandite  
Rock Creek, Stevenson, Skamania Co. Wash.  
*Slender three-sided crystals with rhombohedral terminations and slanted striations parallel to the major rhombohedral cleavage plane.*

general, the various structures will have more or less open space, so they will have different sized unit cell and therefore different densities. Increasing the pressure under which a mineral forms would be expected to favor the configuration with the highest density. By this criterion, aragonite, with a specific gravity of 2.947, would be favored at higher pressure over calcite, with a specific gravity of 2.710.

Temperature is a little more complicated. As temperature increases, the thermal motion of all the atoms increases (Hence thermal expansion). This in turn can affect the forces holding the system together. In the extreme case, the forces are overwhelmed and the material melts. But each crystal configuration is affected differently by increasing temperature, which may switch which form is stable at some critical temperature. For this system, aragonite is the preferred structure at lowest temperatures. Calcite is the preferred structure at somewhat higher temperatures, and there is a range in between where both are stable.

Actually, above about 400° C there is a third trimorph, vaterite, that forms. Upon cooling, it readily dissolves in water, which then allows calcite to recrystallize. Vaterite is a mineral in which the  $\text{CaCO}_3$  molecules form two-dimensional sheets that then stack together. The sheets are similar to the  $\text{CaCO}_3$  sheets that form every other layer in the mineral synchysite, alternating with layers of rare earth fluoro-carbonate. (For more about this structure, see Microprobe, Vol. XI #5 page12.)

An excellent example of temperature dependency is the case of  $\text{Ag}_2\text{S}$ . Below 177°C, the stable mineral is acanthite, which is monoclinic. Above 177°C, the cubic structure is stable. For minerals formed above this critical temperature, the external shape of the crystals would be cubic. Such specimens used to be called argentite. But the argentite structure cannot be quenched in to remain below the critical temperature, so such samples immediately recrystallize internally to adopt the acanthite structure, though they may retain the external shape of the cubic argentite. The recommended name for such specimens is 'acanthite pseudomorph after argentite'.

The case with sulfur is more complicated. The stable form at room temperature is the orthorhombic alpha structure, normally simply called sulfur. Two higher temperature monoclinic forms are known, sulfur- $\beta$  and rosickyite. Sulfur- $\beta$  can be maintained for a time by proper cooling from above 95.4°C. Rosickyite can be prepared artificially and will retain its structure for a time if cooled from the melt held above 150°C. Since the structure of each of these can be quenched in to remain at lower temperatures, samples whose external shape conform to these other two polymorphs are usually referred to by their mineral names in spite of questionable stability.

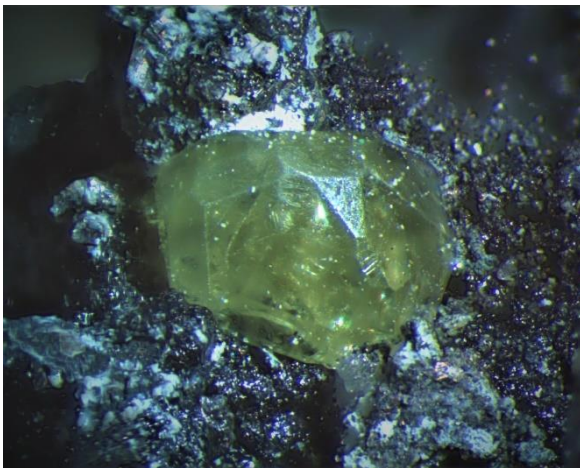


Fig. 3 Sulfur ( $\alpha$ -Sulfur, orthorhombic)  
San Rafael Mine, Nye Co., Nevada

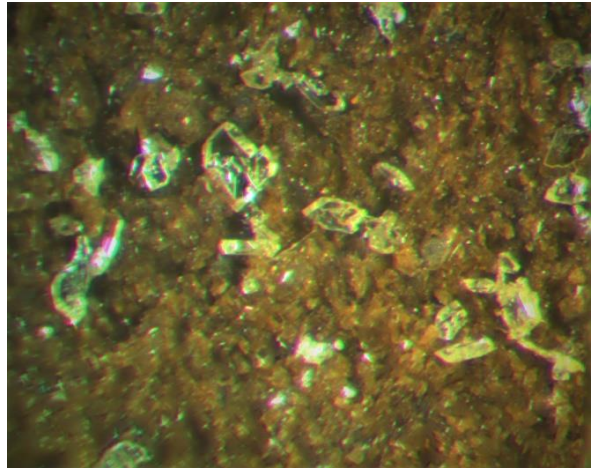


Fig. 4 Rosickyite ( $\gamma$ -Sulfur, monoclinic)  
Rincon Point, Santa Barbara Co., Calif.



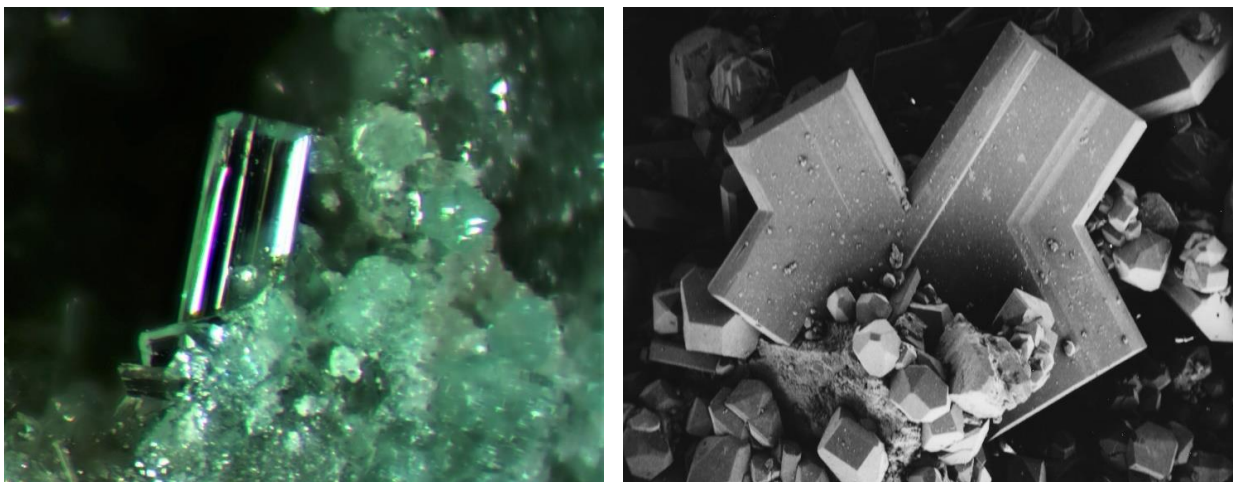


Fig. 5 Variscite and Metavariscite  
 Uthlite Claim, Lucin, Box Elder Co., Utah  
*Two dimorphs of  $\text{Al PO}_4 \cdot 2\text{H}_2\text{O}$ , bladed monoclinic metavariscite and equant orthorhombic variscite. Both minerals are nearly the same color. Light microscope for color, SEM for crystal detail.*

Still other common dimorphs exist where both structures appear to be stable. Such a case is the pair pyrite and marcasite. Both are the namesake for a group of minerals of that structure. It is not clear what conditions determine which will form in any given place. Rather than having one convert to the other, both minerals are subject to decomposition in moist air at ordinary temperatures, becoming ferrous sulfate (melanterite) with the generation of sulfuric acid. Marcasite is much more readily oxidized in this way. Samples containing either form of iron disulfide should be kept dry in containers where the sulfuric acid generated cannot harm other specimens or the drawer in which they are housed. It is very disheartening to go back to look at a nice specimen only to discover it converted to a pile of dust covered with a haze of white hairs.

One more thing can influence the stability of structures, and that is impurities. Atoms which substitute for the normal constituents in a crystal will in general be a bit bigger or smaller. This puts stress on the structure locally around the substituted atom, which in turn can lower the energy necessary to form one structure below what it would be in pure form. In extreme cases, the impurities can be a requirement to allow a mineral to form. Such is the case with ankerite (dolomite group), where a certain percentage of the magnesium is always found occupying the iron site (and similarly for ketnahorite).

Polymorphs are relatively common. In most cases, all the members of the set are similar in color, since they all involve the same chemical compound. However, there are exceptions. The system based on  $\text{HgS}$ , cinnabar, metacinnabar and hypercinnabar, is such a case. Cinnabar, a hexagonal mineral, is dark red. Metacinnabar, a cubic mineral of the sphalerite group, is black. Hypercinnabar, a hexagonal form structurally related to wurtzite, is also black. Hypercinnabar, a rare high temperature form that reverts to the other structures upon cooling, can apparently be stabilized if the mercury content is somewhat deficient.



Fig. 6 Cinnabar (hexagonal)  
Culver-Baer Mine, Sonoma Co., Calif.

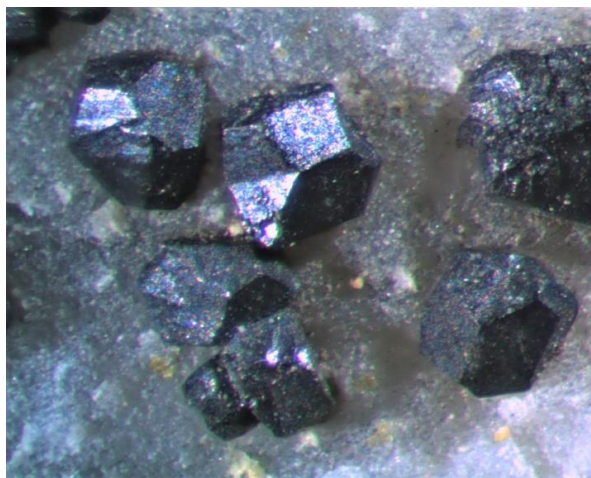


Fig. 7 Metacinnabar (cubic)  
Mt. Diablo Mine, Contra Costa Co., Calif.

Another familiar set is in the feldspar group: sanidine, microcline and orthoclase (and the relatively less stable kokchetavite and liebermannite). Here the changes in crystal structure are related to the degree that the sites of the aluminum and silicon are ordered as well as to temperature of formation. Again, these minerals have a very similar visual appearance, so they must be identified on the basis of structure, usually by x-ray diffraction. We normally depend on someone else determining which we are dealing with at a particular occurrence.

There are exceptions to naming polymorphs where the crystal structure changes are related to order/disorder. This is particularly associated with aluminum silicates, and illustrated by some of the zeolites. Analcime has a very large unit cell, with 96 oxygens atoms in the framework. It is known in cubic, tetragonal, orthorhombic, monoclinic and triclinic modifications. Thankfully, they do not all have a separate name! They differ from each other by small distortions of the unit cell caused by ordering of the aluminum and silicon in the framework. The x-ray diffraction patterns are all nearly identical, with the distorted cell leading mainly to broadening of some of the diffraction peaks. There may also be a small anisotropy in the optical properties that can be used to tell which distortion is present.

Completely disordered analcime is cubic. Crystals of this type are usually individual trisoctahedrons. Various schemes of partial ordering shift the crystal axes into the other systems. Such distorted crystals often show radial growth structure with much twinning.

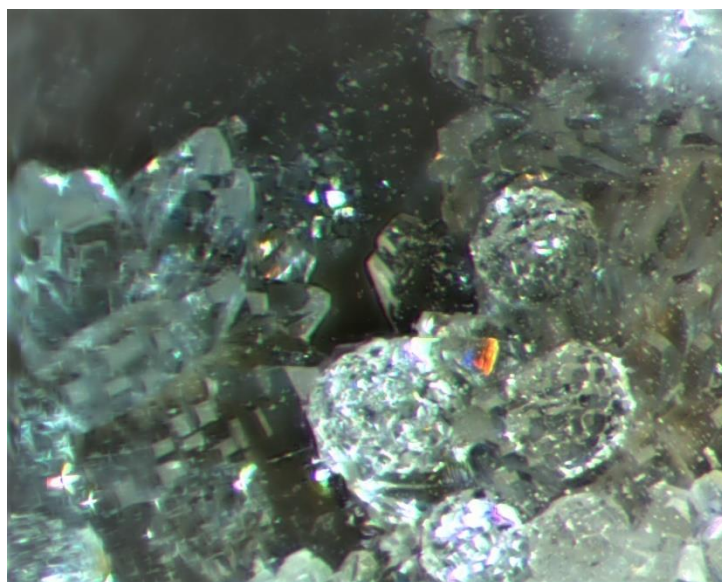


Fig. 8 Analcime on Tschernichite  
Neer Road, Goble, Columbia Co., Oregon  
*Multifaceted radial balls*

What can be expected to lead to ordering? Temperature is going to play a large role. The speed at which the crystal grows will be important; faster growth will favor disorder over order. The particular cations present at growth can be an influence.

## Polytypes

There is another general kind of structures where lattice differences do not in general lead to separate species names. These are structures that mainly involve two-dimensional sheets that then are stacked one atop the other.

To see how such layer systems work, consider a close-packed sheet of atoms. The sheet will have hexagonal symmetry in that there is a six-fold rotation axis perpendicular to the plane of the sheet. A second identical sheet can be stacked on top of the first, and the six-fold rotation symmetry is maintained. Now suppose we add a third sheet. If we place this third sheet directly on top of the first sheet, hexagonal symmetry is preserved; such a structure of alternating sheets is called Hexagonal Close Pack, or HCP. Numerous metals, such as zinc, titanium, and cobalt have this structure.

But there is another possible position for the third layer that destroys the six-fold symmetry.

The

three positions are often referred to as layers A, B, and C. HCP structure would be described as a stacking order of ABABABA. This second structure has a stacking order of ABCABCA. It does have three-fold symmetry, but not six-fold. Careful examination shows that it actually has cubic symmetry, and that the sheets are perpendicular to the [111] direction in the cubic lattice. This is the Face Centered Cubic, or FCC, lattice. Many other metals, such as those of the copper group and the platinum group, mentioned above, crystallize in this way.

The micas are typical of a layered structure. The symmetry of the crystal is dominated by the symmetry of the layer itself. The x-ray diffraction pattern is composed primarily of reflections within the layers and with the one between layers. But sometimes lines corresponding to larger lattice vectors appear, corresponding to systematic regularities in stacking that involve every third or fourth or fifth or more distant layers. These are sometimes referred to as superlattice regularities. In a given compound, several different stacking schemes may be known to occur. Again, mercifully, each one is not given a separate mineral name. Instead, these are referred to as **polytypes** and are given a symbol as designation.

The entry in Fleischer's Glossary of Mineral Species for muscovite is a good illustration:

**Muscovite**,  $\text{KA}_2\text{[AlSi}_3\text{O}_{10}(\text{OH})_2]$ , mon., the -2M<sub>1</sub>, -1M, -3T and -2M<sub>2</sub> polytypes are known.

There are a large group of such designations that have been noted for a variety of layered minerals. The number refers to the repetition distance, and the letter to the type of symmetry involved (see table at right). For more information, see:

[reference.iucr.org/dictionary/Polytypism](http://reference.iucr.org/dictionary/Polytypism)

As with the other post-mineral delineators, these are technical aspects of minerals from particular occurrences that cannot possibly be determined visually by even the most advanced collector, but require x-ray or chemical tests that only professionals can make. Use them if they are known, ignore them if not. Keeping records of where a specimen has been found at least allows updating when such tests are later performed.

### Designator Code

Cubic	= C
Hexagonal	= H
Trigonal:	
(with hexagonal Bravais lattice)	= T
(with rhombohedral Bravais lattice)	= R
tetragonal (quadratic)	= Q
orthorhombic	= O
monoclinic	= M
triclinic (anorthic)	= A

**Polymorphs of the Potassium Feldspars**

Fig. 9 Orthoclase (monoclinic)  
Lime, Baker Co., Oregon

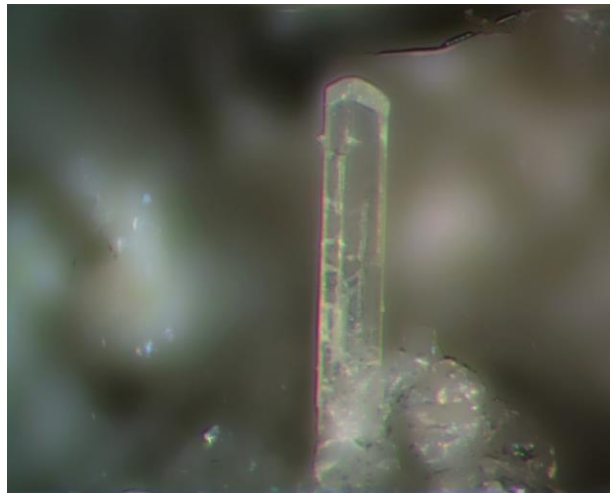


Fig. 10 Sanadine (monoclinic)  
Thomas Range, Juab Co., Utah



Fig. 11 Microcline *variety* amazonite (Triclinic)  
Pike's Peak, El Paso Co., Colorado