

Northwest
Micro Mineral
Study Group



MICRO PROBE

FALL, 2014

VOLUME XI, Number 10

FALL MEETING MILWAUKIE, OREGON

November 1, 2014

9:30 am to 4:30 pm

**Fire Station Meeting Room
2930 SE Oak Grove Boulevard
Milwaukie, Oregon**

As you can see from the above, we were unable to schedule our usual room at the Clark County PUD. Instead, we will be trying out a facility just south of Milwaukie that is a block west of McLoughlin Boulevard at the corner of SE Oak Grove Boulevard and SE East Street. There is no really easy way to get to this place.

From the south, take I-205 and use exit 9 just across the bridge over the Willamette River onto McLoughlin Blvd. Oak Grove Blvd. is about 3 miles north along McLoughlin.

From the north along I-5, it is best to take the Broadway exit, then turn south on Martin Luther King Blvd. This will eventually become McLoughlin Blvd. The total distance from the Broadway exit to Oak Grove Blvd. is about 8 miles. Do *not* get shuffled off onto the Milwaukie Expressway!

From the north along I-205, take exit 12 and go west onto SE Roots Road. When it ends, jog south on SE Webster Road to Jennings Avenue, which crosses McLoughlin Blvd. in about 1.5 miles. Turn right and go about 1 mile to Oak Grove Blvd. If you miss exit 12, you can alternatively use the Gladstone exit (#11) onto Oatfield Road, which crosses Jennings Avenue after about 1 mile. Turn left and proceed to McLoughlin Blvd.

I have tried to make a sketch of all this on the last page of this issue.

Schedule for the day;

Please note that we will be setting up for the day starting at 9:30am.

Then let us try something that the Group did successfully many years ago. Let us put together some of our best specimens so that we can pass them around and learn from them. Make sure things are properly boxed with your name on them so that they get back to you safely before the end of the day. Since the feature article in this issue is on fluorite, we suggest concentrating on specimens of **fluorite** and **pyrite**.

In the afternoon after a short business meeting, Don Howard will be talking and showing more pictures about: *Why cubic pyrite has forms that cubic fluorite does not have.*

Lunch will be the usual pot-luck, with the Group supplying basic sandwich material. Please bring chips, condiment, salads, and desserts to add to the feast.

Dinner plans will be made at the meeting. Please join us if you are able.

President's message:



We will be back together in November for another chance for some to be teachers and some to be students. I know which one I am for sure. But we all are students in one way or another. Some of us learn from other people and all of us learn from the specimens we collect. We learn in different ways: by listening, by reading, by looking/examining and by asking questions, or through a combination of these. Those of us who are less experienced need to have the help of you who have more experience. My hope is that all you who have a lot to share will reach out to those of us who need your help.

Some of this is already happening. Don Howard is providing some beginner articles for the Micro Probe. He, Genie, and Arlene Handley are holding monthly mineral identification meetings (see my other article in this newsletter).

One more thing might help. Could it be possible that during the meetings some of you who are more knowledgeable could "each one, teach one". Let it be known that you are available to work with someone. The "student" can sit across from you at the table with their microscope and whatever it is that you are looking at, share what you see and try to help the "student" to be able to see the same things. My hope is that if we can work out some of the logistics for upgrading the knowledge of beginners that will make the group more open and inviting to newcomers.

We can also reach out with our knowledge to other groups. I know that the lack of knowledge of minerals in rockhounding groups is very apparent. When Don Howard and Gerry Petitemermet came and shared with the Clackamette Gem and Mineral Club, it was an eye-opener for me and started me on a whole new pursuit. Maybe more of this type of outreach might be possible by other members of our group. Volunteering to put in a mineral display case in a rock show as another way of letting people know that we exist. Help others to fall in love with minerals.

If anyone has more ideas on how to share the wealth of knowledge in this group with others, please let me know. Thank you.

Beth



What Is That?

Beth Heesacker

That is my usual question when looking at a mineral specimen since I am so new to the mineralogical science. Sitting back and watching at the Micro Mineral Study Group meetings and the reading I was doing just was not getting me very far. I needed something more to help me identify minerals but I was not sure what it was. I discussed my frustration with Don Howard and so he wrote an article for the last Micro Probe and gave me a set of minerals to go along with it. That proved to be what I really needed, hands on examination of what I was reading about.

At the meeting in May I asked for someone to schedule some mineral identification classes to help out the beginners like myself. Both Don Howard and Arlene Handley volunteered to try it. Lorraine Allen, Gerry Petitemermet, Chuck Sweany, Paul and I have attended a few meetings at Don's and he has been helping us all in various ways. Lorraine has been studying a suite of related minerals and I have been bringing some of my unidentified minerals for some chance of getting a name on a few of them. I try to identify the specimen first and then hand it to Don for a "yes" or "no". Hopefully over time I will get more "yes" answers.

Some of what I have learned is to really look at the reflecting surfaces to try to identify the shape of the crystals. Also I need to look for all the different shapes and colors on the specimen to see what other minerals might be there and not stop with the most evident. This will probably seem very simple to most of you, but I am going from being a rockhound to being a mineral collector. This is a whole new level of detail that I need to be aware of.

I have also attended one meeting at Arlene's and she is using a different approach. Using her store's vast collection of minerals, we are looking at many of the different forms of one mineral. We devoted one meeting to calcite, looking at many specimens and discussing these forms.

Both of these types of meetings have been very helpful to me in so many different ways. They are small groups and so the individual attention is fantastic. Bringing my focus down to the micro level and being able to recognize that a mineral can come in many forms is just a beginning for me. That along with my reading will, I hope, eventually help me catch up with some of the experts in the Micro Mineral Study Group.

I want to thank Don and Genie Howard and Arlene Handley for their generous offer to host these meetings and for their help to those of us who are new to micro-minerals. We continue to meet at least once a month, and would love to have some others join us. If this sounds good to you, get in touch with one of us to see when the next get-together is scheduled.



IN MEMORY OF KIRBY HARRIS



It came as a real shock to hear of the sudden passing of one of our very active members, Kirby Harris, on July 21. Kirby has been a rock-solid member of our team to get ready and put on our meetings. He has scheduled the room and taken care of being there early and setting up the tables and the electrical outlets for us to use. He and Pam have provided the goodies for lunch and supervised the use of the kitchen area. With them in charge, everything always goes so smoothly we hardly notice, but we do want to express our appreciation for all of their hard work.

Kirby and Pam have also been very generous in including as many of us as possible in their jaunts around the area to collect. They have taken the initiative to organize the expeditions and coordinate with us to get us there and make sure we have a good time. Collecting with them has always been fun.

Kirby was also a very talented photographer. It was through his efforts that our roster included so many flattering pictures of our members. Kirby's sense of style and composition always put his subject at ease and made for a portrait that pleased everyone.

But above all, there will be two things that I will especially miss. The first is that Kirby was completely reliable. What he said he would take care of was done swiftly and carefully. I could always depend on him carrying his part of any task. And the second was his smile. Kirby was always smiling, always glad to see you and be with you. He was a delight to be around.

He will sorely be missed by us all.

Our sympathy and best wishes go out to Pam in her great loss.

Donald Howard

The Many Faces of Fluorite

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(photomicrographs © Eddy Van Der Meersche, 2014, unless otherwise noted.)

Fluorite crystals come in different shapes, and when you really focus on them, you will be surprised to see how many different forms fluorite crystals can have, and how complex they eventually can become. So let's explore some of these highly symmetrical wonders together.

Imagine that we are in Egypt, looking at one of the pyramids. Imagine that each face of that pyramid is a perfect triangle, with each side having the same length. Imagine standing in the very middle of that pyramid. Looking up, we see the top of the pyramid, and at the same distance, we see the other four points of the pyramid on the ground, all at the same distance. Drawing lines from the center to two adjacent corners of the pyramid, and a line from where we stand straight through the top, we end up with three axes that are perpendicular to each other. All the points of the pyramid are at the same distance from the center of these three axes.

Now imagine that we make a copy of this pyramid, turn it upside down, and glue it to the bottom of the first pyramid. The crystal form we get is called an octahedron. An octahedron has 8 faces ('octa' is Greek for 'eight', and 'hedron' means 'faces'); the crystallographic notation of these faces is $\{111\}$. Fluorite is regularly found in octahedral crystals.

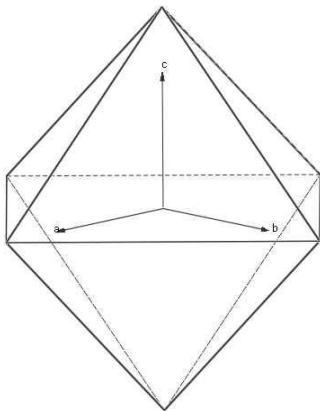


Fig. 1 *The octahedron, showing the cubic axes.*



Fig. 2 *Green fluorite octahedrons* *FOV = 32mm.*
from Riemsvasmaak, Kakamas Distr., N.Cape Prov., South Africa.
J.R. Garcia Alvarez collection, Eddy Van Der Meersche photo

Next, let's take an octahedron, and then imagine that we cut off the points. How many points does an octahedron have? Right, 6. So when we cut off those 6 points perpendicular to its 3 crystallographic axes, we'll get 6 small but perfectly square-shaped faces. The further we cut away, the more it starts resembling a cube, until finally that is all that is left: a cube or a hexahedron ('six faces'), since

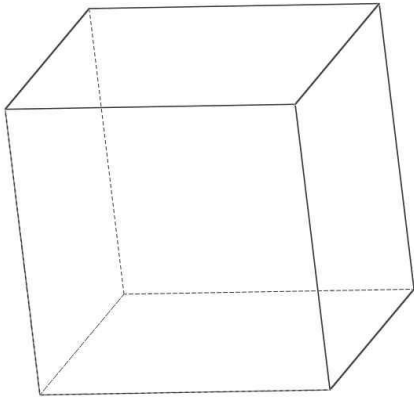


Fig. 3 *The cube, also called a hexahedron.*

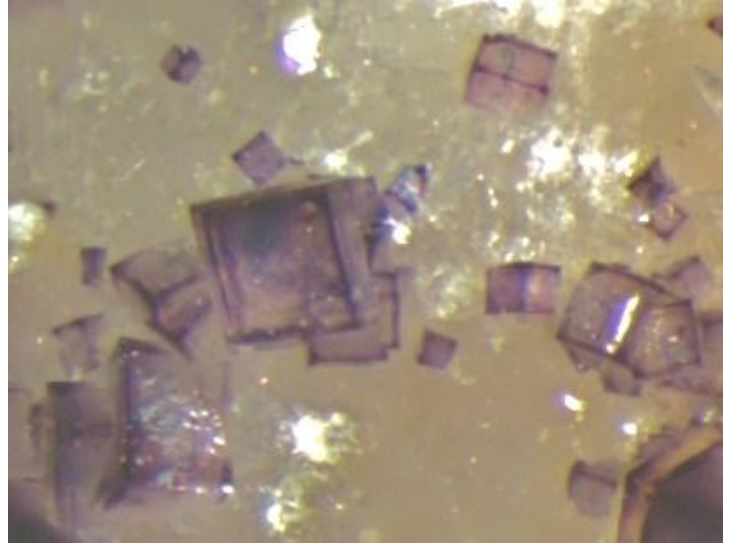


Fig. 4 *Zoned cubes of purple fluorite from the New Method Mine, San Bernardino Co., California*
Don Howard collection and photo.

a cube has indeed 6 faces. Its crystallographic notation is $\{100\}$. If you study many fluorite specimens from various locations, you will see that the cube is the most common crystal form for this mineral. Figure 5 shows a series of crystal drawings of some intermediate shapes between the cube and the octahedron. All of these are called cuboctahedrons.

As you have probably guessed by now, fluorite belongs to the cubic crystal system, sometimes also referred to as the isometric crystal system. Remember that we mentioned “same length, same size, same distance”? Well, that’s what the Greek ‘isometric’ stands for.

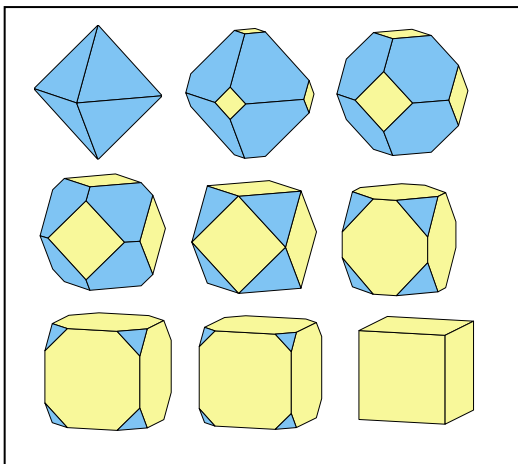


Fig. 5 *An octahedron morphing into a cube, with lots of intermediate cuboctahedrons. Octahedral faces $\{111\}$ are in blue, Cube faces $\{100\}$ are in yellow.*



Fig. 6 *Cuboctahedron with small cubic faces, from Juchem Quarry, Germany.*
Remco van Royen collection, Auke Bleeker photo.

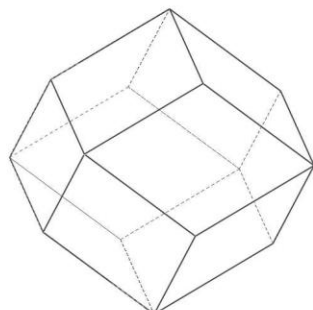


Fig. 7 *The dodecahedron*
(Greek for twelve faces).



Fig. 8 *Fluorite from Mont St-Hilaire, Quebec, Canada.* *FOV=4mm.*
G. Claeys collection, Eddy Van Der Meersche photo.

Let's go back to the cube. This time, we cut off all the edges. How many edges does a cube have? Right, 12. Now if we cut off all those edges in the same symmetrical way (at the same distance on 2 axes, and parallel to the 3rd axis), we get a crystal that looks like the one shown in fig. 9.

The further we cut away, the more our shape starts looking like a different form, until finally we end up with a dodecahedron, a crystal with twelve faces! $\{110\}$ is the crystallographic notation. The faces of the dodecahedron are quite common in fluorite crystals. However, fluorite crystals that show **ONLY** those faces are actually fairly rare!

Figure 10 is a whole series of crystal drawings showing the intermediate shapes between the cube and the dodecahedron. All of these are called cubododecahedrons.



Fig. 9 *Cubododecahedron of fluorite*
from Shangbao Mine, Hunan, China
Jordi Fabre collection and photo.

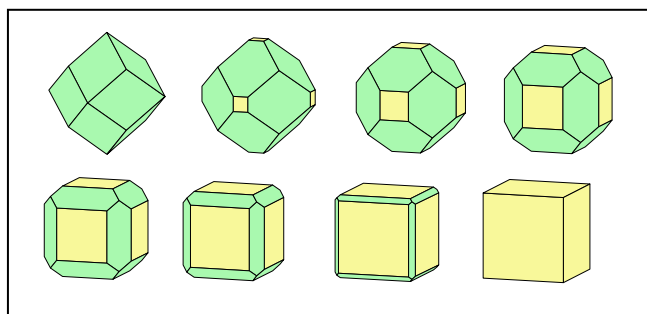


Fig. 10 *A dodecahedron morphing into a cube, with lots of intermediate cubododecahedrons. Dodecahedral faces $\{110\}$ are in green. Cube faces $\{100\}$ are in yellow.*

So far, we have seen the three most common crystal forms for fluorite: the cube, the dodecahedron and the octahedron. All three have a unique crystallographic notation. In other words: there is only one kind of octahedron (or cube or dodecahedron) that fluorite can show. There are, however, many other crystal forms that fluorite can come in, each having its own unique crystallographic code. Fortunately, all of these other forms belong to one of the four following groups: the tetrahexahedrons, the trapezohedrons, the trisoctahedrons and the hexo-octahedrons. Don't be frightened by their exotic names; they are, in fact, quite logical and straightforward.

Let's go back to the cube, and imagine putting a fairly flat pyramid on each of the 6 faces. Et voilà, here is our new crystal shape: a pyramid cube, also known as a tetrahexahedron (a "4 times 6 faces", so 24 faces in total). Fluorite can crystallize as different tetrahexahedrons, the most common ones being the {310}, the {210}, and the {730}. Note that the last digit of their crystallographic code is always a zero.

As you can see in figure 13, all these crystals have the same general shape. The only big difference between them is the inclination of the faces, resulting in a different crystallographic notation. Fluorite crystals that are 'pure tetrahexahedrons' (and thus only show the faces of a pyramid cube) are uncommon but not rare. They are known from a few localities in the world; even from a country as small as Belgium!

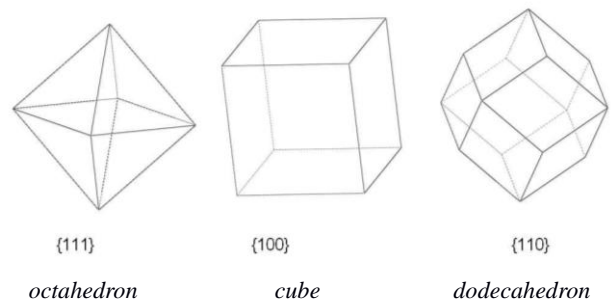


Fig. 11 The 3 most common forms of fluorite

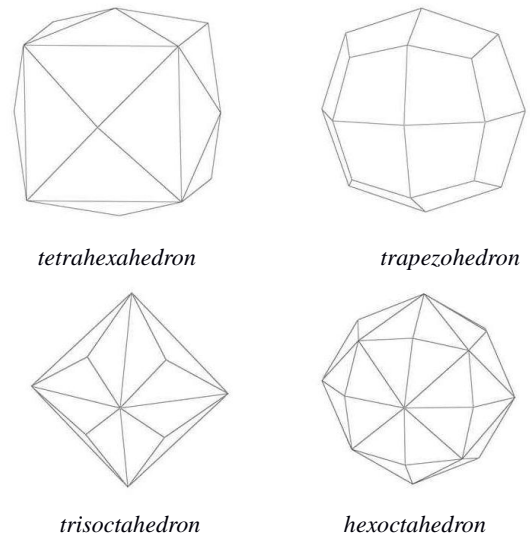


Fig. 12 The 4 groups of forms for fluorite.

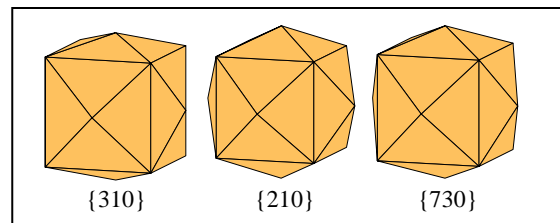


Fig. 13 The most common fluorite tetrahexahedrons.

Fig. 14 Tetrahexahedron of fluorite from Wellin, Luxemburg Prov., Belgium.
FOV=5mm.

M. Orinx collection.
Eddy Van Der Meersche photo.

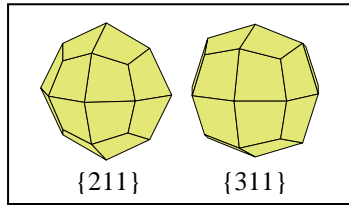
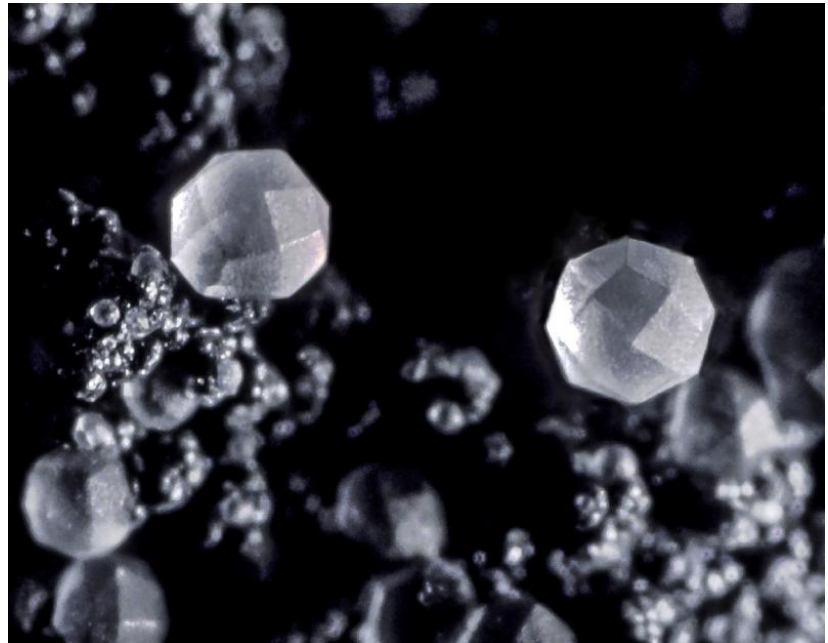


Fig. 15 *The most common trapezohedrons.*

Fig. 16 *Fluorite trapezohedrons from the Clara Mine, Oberwolfach, Germany. FOV=2.2mm W. Gunter collection Eddy Van Der Meersche photo.*



Next are the trapezohedrons, so called because each face of the crystal has the shape of a trapezium (a 4-sided plane shape where none of the sides are parallel). OK, so what do they look like? Well, imagine an octahedron, where each face has been replaced by 3 trapezium-shaped faces. Again, we get a total of $8 \times 3 = 24$ faces. Fluorite can crystallize as different trapezohedrons, the most common ones being the {311} and the {211}. Note that the last two digits of their crystallographic code are identical. Pure trapezohedrons of fluorite, such as the ones shown in figure 16, are extremely rare. In fact, good pictures of Bigfoot are more common than good pictures of a fluorite trapezohedron.

Finally, there are two more groups of crystal shapes of fluorite that look like modified octahedrons. First, imagine an octahedron where each face has been replaced by a triangular pyramid. These crystal forms are called trisoctahedrons. Again, we are dealing with a total of $3 \times 8 = 24$ faces. The most common trisoctahedrons for fluorite are the {221}, the {331} and the {332}. Note that the first two digits of their crystallographic code are identical. The pure fluorite trisoctahedron is very rare and known from very few places.

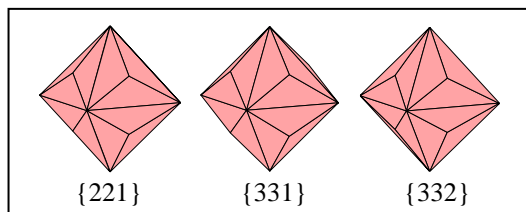


Fig. 17 *The most common fluorite trisoctahedrons.*

Fig. 18 *Fluorite trisoctahedron. FOV=3mm from Dall'negorsk, Primorskiy Kray, Far-East Region, Russia R. Brandstetter collection Eddy Van Der Meersche photo.*



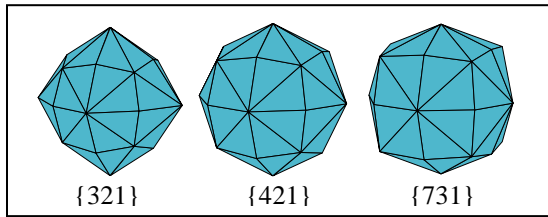


Fig. 19 *The most common fluorite hexoctahedrons.*

Fig. 20 *2 mm fluorite hexoctahedron from the Clara Mine, Oberwolfach, Baden-Wurtemberg, Germany. E. Van Der Meersche collection and photo.*



To finish up, there is a crystal shape that is known as a hexoctahedron, because each octahedral face is composed of six small triangular faces. It's also the only group of crystal forms of fluorite that have $6 \times 8 = 48$ faces! They can also be recognized by their “rounded, cubic-looking faces”, built by the acute points of the 8 triangles that join in the center of a somewhat rounded, cubic-looking face, as illustrated by figure 20. The most common hexoctahedrons for fluorite are the {321}, the {421} and the {731}. The pure fluorite hexoctahedron is equally very rare and known from very few places.

Congratulations! Together we have covered all the basic crystal forms that fluorite can display. Besides the cube, octahedron and dodecahedron, we've learned about the tetrahedron, the trapezohedron, the trisoctahedron and the hexoctahedron, and we have seen photos of examples from around the world.

In general, however, fluorite just loves to combine some or even all of these 7 basic shapes. Due to the number of faces, the resulting crystals can still be fairly simple or very difficult to recognize. So let us explore and explain some of these wonderful works of art together.

We have already described the combination of a cube and an octahedron (Fig. 5), as well as the combination of a cube and a dodecahedron (Fig. 9). But what about a combination of all three forms? Well, for fluorite, it is not unusual to find crystals that are a combination of a cube, an octahedron and a dodecahedron. With 6, 8 and 12 faces respectively, that adds up to a total of 26 faces. Depending on the size of certain crystal faces, one may still easily recognize a certain crystal form, like the octahedron in figures 21 & 22. If all faces have about the same size, the resulting crystal gets a somewhat globular appearance (Fig. 23).

Fig. 21 *Idealized drawing of the crystal in fig.22. The large octahedral faces (blue) are modified by small, circular-looking cube faces (yellow) and long, narrow rectangular dodecahedral faces (green).*

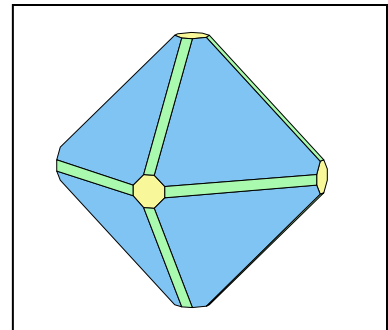
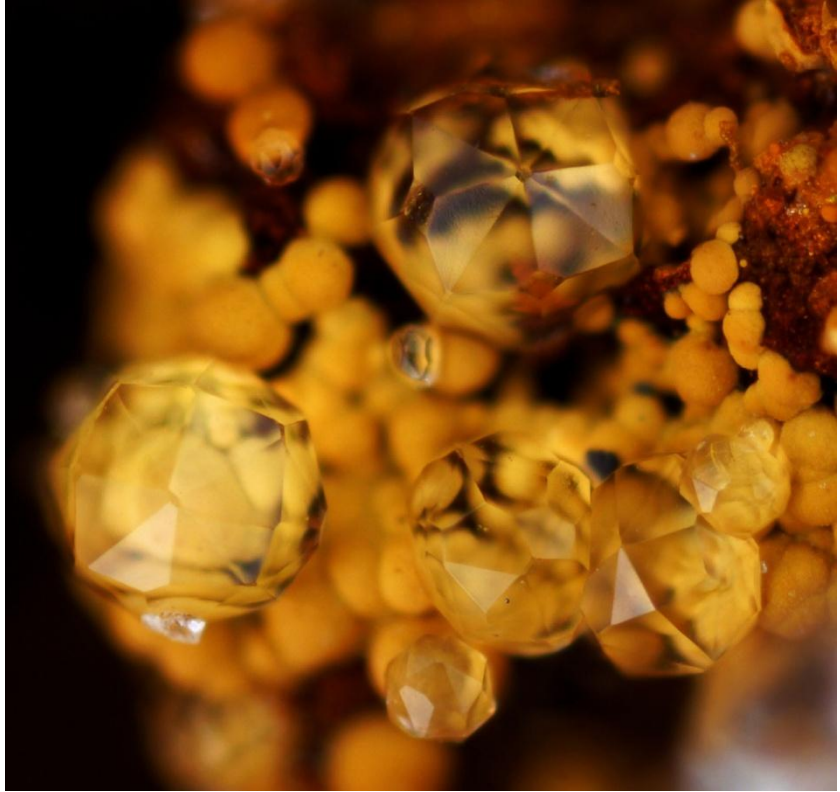


Fig 25 *Very clear modified hexoctahedrons from the Clara Mine, Germany FOV=4mm (see fig. 24 for the corresponding crystal drawing).*

Stephan Wolfsried collection and photo.



Throughout the years, many different crystal form combinations of fluorite have been found at the Clara Mine (Black Forest, Germany). Figures 27 and 28 show two slightly different views of the same crystal. Note the reflection of the small rectangular face in figure 27 (the arrow points to this tetrahexahedral face) and the reflection of an elongated triangular face in figure 28 (the arrow points to this hexoctahedral face).

Figure 26 shows the corresponding drawing: a crystal composed of large dodecahedral faces, small triangular faces of the octahedron, rounded faces of the cube, small rectangular faces of a tetrahexahedron, and sharp, elongated triangular faces of a hexoctahedron. If we do the math for this little guy, we end up with $12 + 8 + 6 + 24 + 48 = 98$ faces!

There has even been a fluorite crystal found in the Clara mine that shows all 7 “basic” different crystal forms, being a combination of a cube, an octahedron, a dodecahedron, a tetrahexahedron, a trapezohedron, a trisoctahedron and a hexoctadron. This crystal has a total of no less than $6 + 8 + 12 + 24 + 24 + 48 = 60 + 30 + 32 = 122$ crystal faces! Since it is fairly small and has so many faces, it is next to impossible to make a picture of it showing all the representative faces of these 7 different forms. Figure 29 shows an idealized drawing of such a crystal.

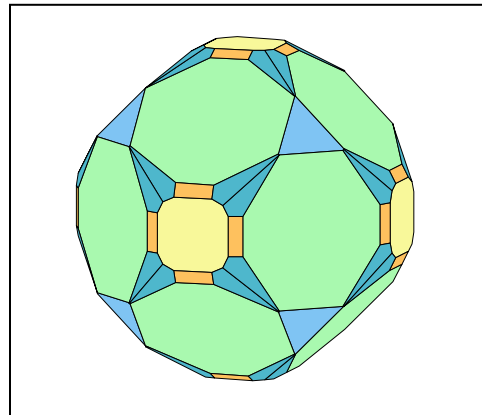


Fig. 26 *Idealized drawing of the crystal shown in figures 27 & 28. This highly modified dodecahedron has a total of 98 faces!*



Fig. 27 *Fluorite, Clara Mine, Germany. FOV=3mm. The arrow points to a tetrahexahedral face.*
Stephan Wolfsried collection and photo.

Fig. 28 *Slightly different view of the same specimen to highlight the hexoctahedral face).*

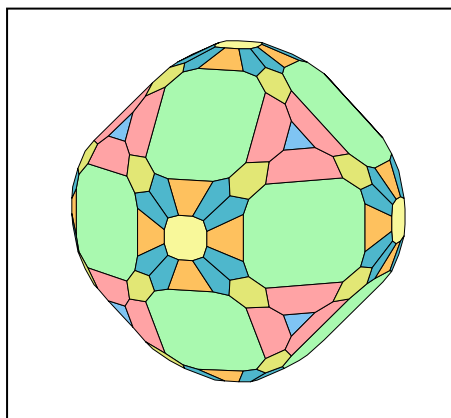


For those of you who are fascinated by the incredible diversity of crystal shapes that fluorite can show, we will end by recommending a book that recently came out in

Belgium. Its title is “Crystal Forms of Fluorite/Kristallformen von Fluorit” and it was written and published by Eddy Van Der Meersche. It is a beautiful, full color photographic Atlas of all the different crystal form combinations of fluorite that Eddy has documented during his 30 year worldwide search for “special fluorites”. Many of the pictures used in this article came from this book. People interested in acquiring a copy of this book can contact the author of this article.

The author is very grateful to Don Howard for his beautiful drawings and skillful editing that greatly improved the appearance of this article. He also wishes to thank all the photographers for their willingness to allow their wonderful photographs to be used as illustrations. Without them, the true beauty of fluorite could easily have been missed.

Fig. 29 *Idealized drawing of a fluorite crystal showing a combination of the 7 “basic” crystal forms. The colors are the same as those used in Fig.5, 10, 13, 15, 17 & 19.*



Synchysites from the Blue Dike, Liberty Bell, Washington Pass, Okanogan Co., Washington

Paul Adams
Paul.M.Adams@aero.org

& Donald Howard
pogodh@hei.net

Fluorocarbonates containing rare earth elements are widespread at Washington Pass. They have been confusing enough to identify that we have begun to simply call them ‘rare earth carbonates’ rather than try to pin specific names to them. Now, detailed SEM analysis on one sample has revealed a good deal of information on the nature of one of the occurrences.

The particular sample chosen was a loose fragment of rock originally found in the talus pile at the base of Liberty Bell. These pieces have come to be referred to as coming from the blue dike, since their very fine texture gives a bluish cast to the matrix. The location of this ‘dike’ is not known, but may very well be up on the upper reaches of Liberty Bell. The particular crystals chosen, mounted, and polished looked very similar to the one shown in fig. 1 at the right.

Small hexagonal prisms such as these have been referred to previously as “*Ferrosynchysite*” (Howard, 2009). That article reported x-ray diffraction studies that clearly identified the mineral as one of the synchysites, but the x-ray fluorescence studies were ambiguous, since they were done on on in-place samples rather than prepared cross-sections through the center of a prism itself. The current study corrects that by properly preparing the sample.

The overall cross-section of the polished sample as seen by the Scanning Electron Microscope is shown below. Several regions are clearly discernible. The core is a fairly homogeneous region, very light in color, showing numerous straight edges corresponding to a variety of prism faces. This is surrounded by a jumbled region, followed by another fairly homogeneous outer band. Finally, the very outermost skin is composed of alternating dark and light bands, ending in a dark band on the very outside. The jagged white area at the extreme right is interesting, but is not synchysite; it will be discussed toward the end of this paper.



Fig. 1 *Synchysite crystal from the Blue Dike*
 Field of view is about 2 millimeters.

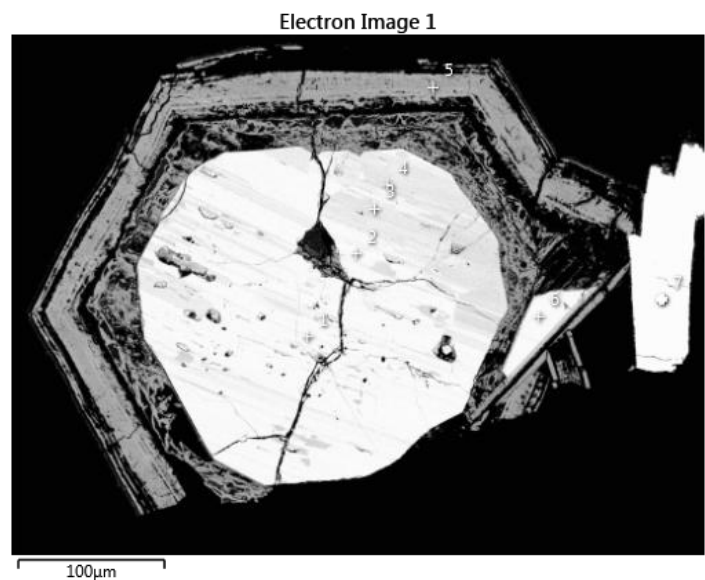


Fig. 2 *SEM image of the polished cross-section that was examined in this study.*

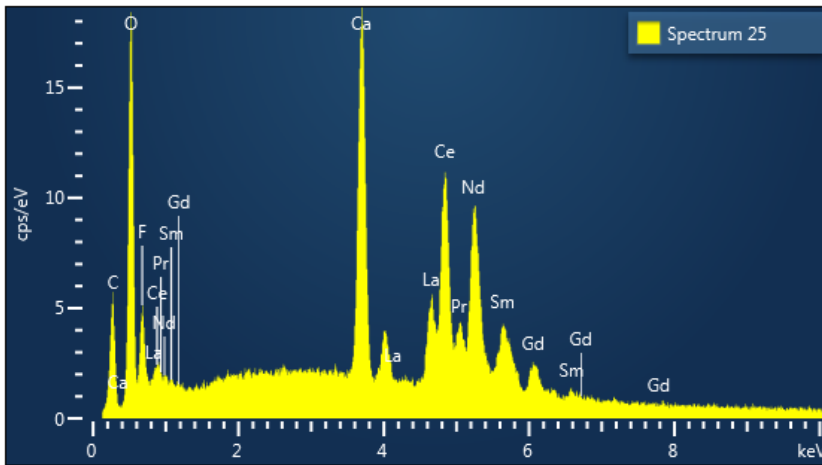


Fig. 3 EDS of the light-colored homogeneous core region of fig. 2.

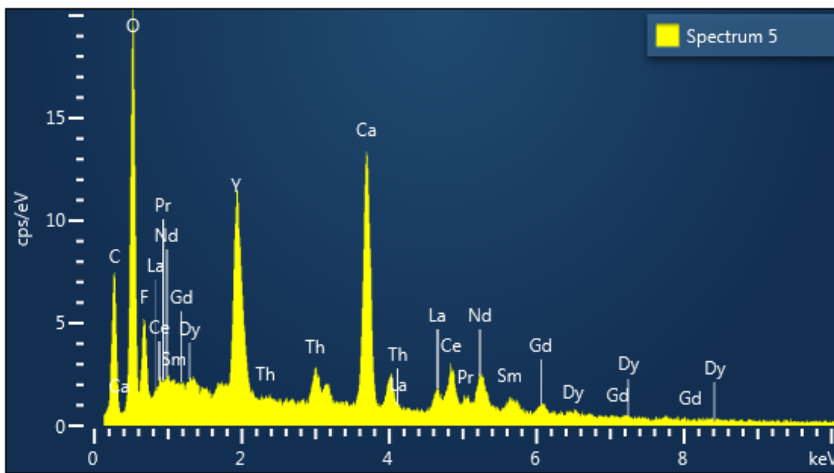


Fig. 4 EDS of the light homogeneous outer region of fig. 2.

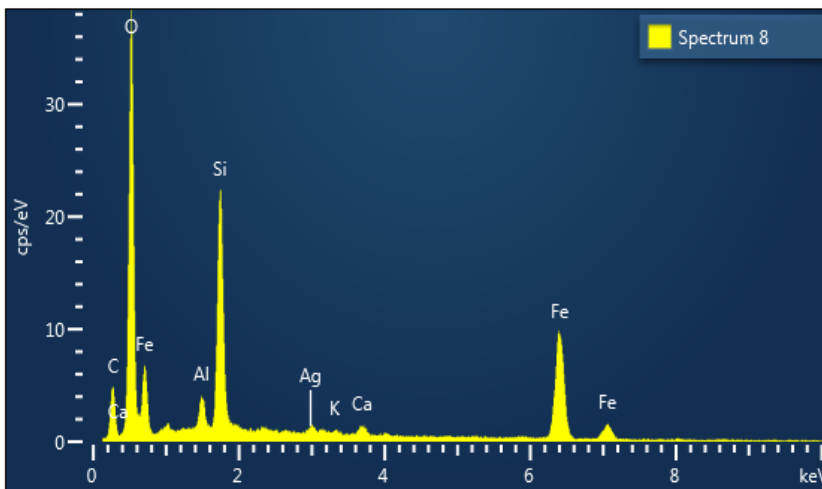


Fig. 5 EDS of the very outermost dark skin of fig. 2.

At left are energy dispersive spectra (EDS) of the three most distinctive regions of the cross-section shown in fig. 2. Fig. 3 shows that the core region is composed primarily of the cations calcium and cerium, with a considerable amount of neodymium. Note that there is no detectable amount of yttrium in this region. The anions of carbon, oxygen, and fluorine are consistent with the identification of this mineral as synchysite-(Ce).

In contrast, the major homogeneous outer band shown in fig. 4 has calcium and yttrium as cations with only minor amounts of cerium and neodymium. It has the same three anions: carbon, oxygen and fluorine. The outer portion of this crystal is therefore identified as synchysite-(Y).

The spectrum in fig. 5 is very different; it represents an iron silicate, with a minor amount of aluminum and very little calcium. (The small carbon peak comes from the coating to make the surface conductive so it will not charge up and distort images.) This material appears to be a chamosite-like mineral that is common to vesicles throughout the Golden Horn batholith.

This accounts for the well-organized regions shown in fig. 2. There remains the jumbled region in between the core synchysite-(Ce) and the outer band of synchysite-(Y). Various spectra taken in this region indicate that it is composed of small pieces of

synchysite-(Y) mixed with pieces of chamosite. Fig. 6 shows an expanded image of the left edge of fig. 2. The medium gray band at the extreme left in the image is the layer of chamosite where the spectrum shown in fig. 5 was taken. Notice that several regions of the same gray shade are scattered throughout the jumbled section shown in the middle of fig. 6. The lighter gray has the composition of synchysite-(Y). Dark bands are primarily small voids.

Another interesting feature of fig. 4 is the presence of a considerable concentration of thorium in the yttrium-rich synchysite. This is shown even more clearly in the spectrum shown in fig. 7 that was taken in the first light-colored band just in from the chamosite layer on the left edge of fig. 6. The thorium concentration appears to have reached its highest value in this near-surface layer.

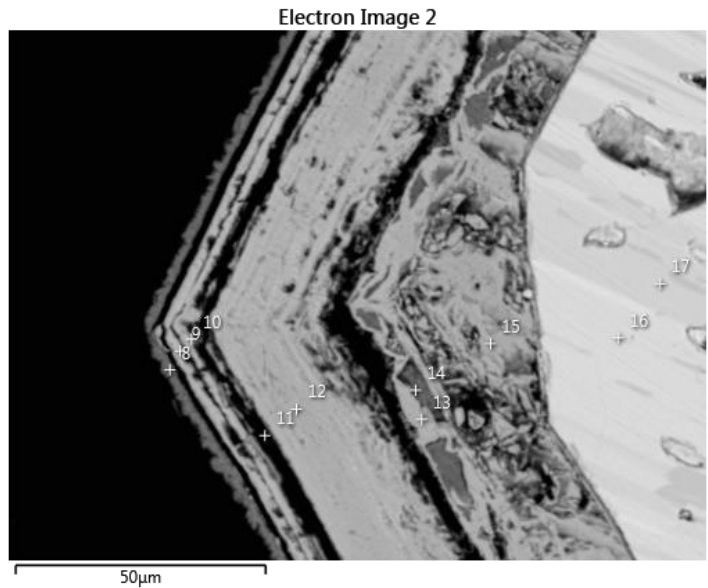


Fig. 6 Expanded view of the left edge of fig. 2.

Based on these observations, what can we say about the crystallization history of synchysite? The early formation was from solutions rich in cerium and neodymium, with little iron and silica present, so that homogeneous crystals with sharp faces were formed. There is no evidence that chamosite was forming at that time. There was virtually no yttrium in those solutions. We would describe this phase as synchysite-(Ce), $\text{Ca}(\text{Ce,Nd})(\text{CO}_3)_2\text{F}$.

There followed a rather abrupt change in conditions. There is no particular evidence of etching or solution of the previously formed crystal, but yttrium, iron and silica have entered into the process. The mixed composition of this phase suggests that both synchysite-(Y) and chamosite are forming together. The small voids might be due to excess carbonate; the form of CaCO_3 most compatible with the synchysite structure is vaterite, a phase that could easily dissolve away when conditions change. The major black band toward the end of this period could well have been vaterite.

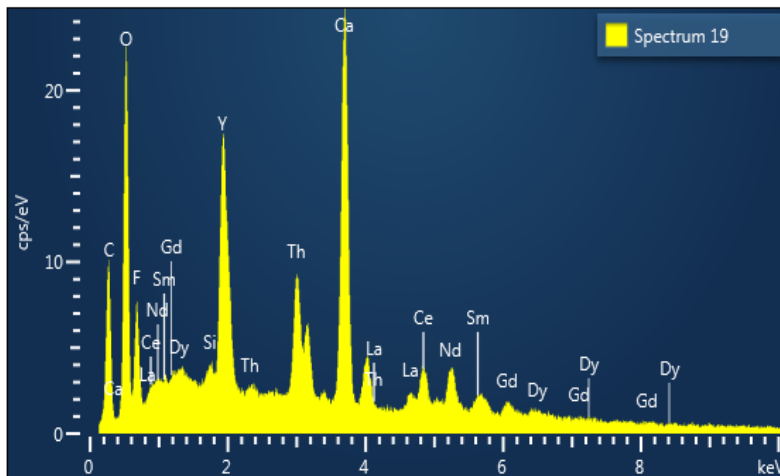


Fig. 7. The outermost, most thorium-rich band of synchysite-(Y).

Following this, the chamosite stops forming, leaving a region of mainly synchysite-(Y), $\text{Ca}(\text{Y,Th})(\text{CO}_3)_2\text{F}$. This ends with another void followed with further deposition of increasingly thorium-rich synchysite-(Y) and ending with a complete layer of chamosite.

Crystals of this type of zoned synchysite are not restricted to the Blue Dike. A strikingly similar crystal from the boulder that contained the blue-tinged calciohilairite is shown in fig. 8a. The glassy brown interior is com-

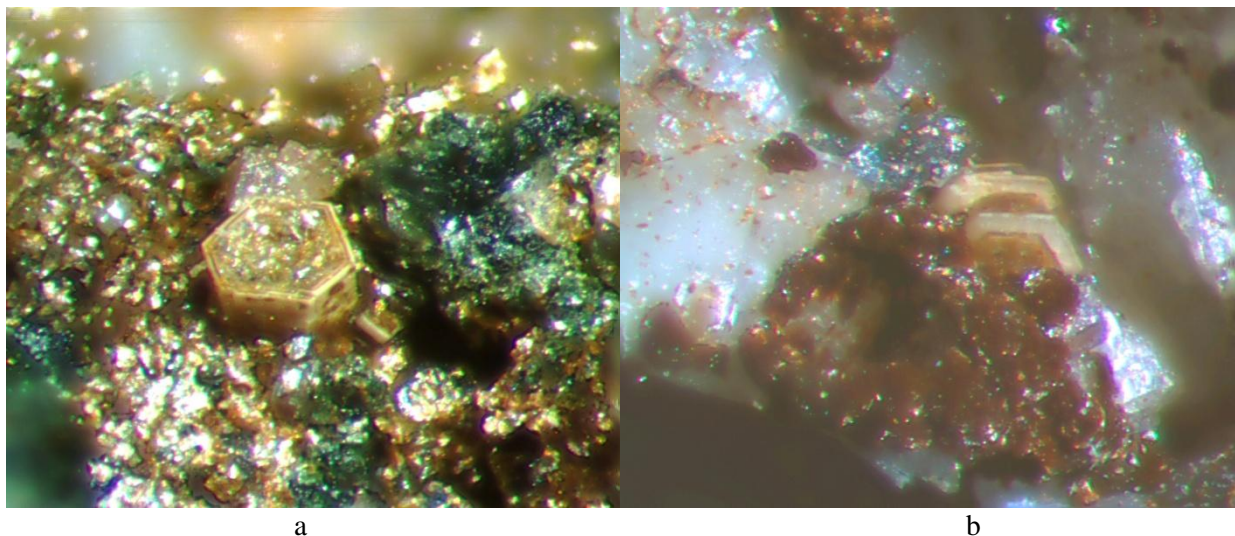


Fig. 9 Two synchysite crystals that occurred in the same boulder with the cuprian calciohilairite.

posed of cerium-rich synchysite while the white outer sheath is ytterium-rich. Since no polished section was used to study this crystal, spectra also contained contributions of iron and silica. The brown stains on the outside of the synchysite-(Y) are evidence of the chamosite-like mineral, which forms the brown rosettes around the crystal. The dark green is a copper mineral, possibly malachite, characteristic of that particular boulder.

The crystal shown in fig. 9b, taken from the same rock, is somewhat different. The bladed brown rosettes are again chamosite-like. The brown prism is synchysite-(Ce) as with the others. But instead of a sheath of white material coating the entire central core, the synchysite-(Y) has formed two thin blades that encircle the central prism. Though the geometry is different, the compositional history appears to be the same as described above.

Still a different geometry of synchysite-(Y) is found in other boulders in the Liberty Bell talus. These are small balls of randomly oriented thin hexagonal blades, generally colored white to yellow. Fig. 10a shows such a ball growing on a crystal of zircon from the Kainosite boulder on Liberty bell. Fig. 10b is a stack of parallel clear crystals with clusters of randomly oriented fine blades covering the two ends. In each case, the clusters of brown blades are chamosite. The EDS spectra of these balls

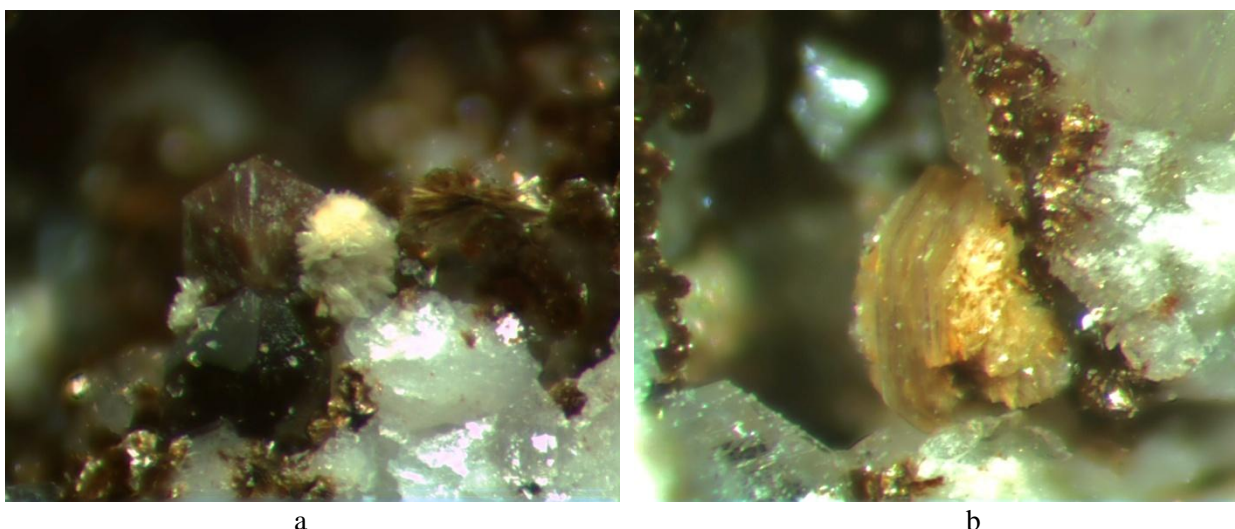


Fig. 10 Bladed balls of synchysite-(Y) from the Kainosite boulder in the Liberty Bell talus. Field of view for each picture is about 2 millimeters.

show yttrium dominating over cerium, and always include peaks for iron and silica. Similar balls have been collected from along the road near MP164, but there the blades appear to be synchysite-(Ce). Balls that appear altered and covered with silica have come from the area of MP165.

The habit of thin blades is quite different from the elongated prisms from the Blue Dike. A possible explanation is that the chamosite-like mineral may preferentially form a layer on the ‘c-face’ of the synchysite, thus slowing further growth on that face and favoring edge growth. This could also explain why the synchysite-(Y) is observed to cover the prism faces of crystals such as those shown in Fig. 1, while the ends still show the dark core of synchysite-(Ce).

Further confirmation of the change in composition of the solutions containing rare earth elements comes from a study of gadolinite reported by Krotki (2009). He reports that small crystals collected near MP165 proved to be gadolinite-(Ce) on the interior, but that in the outermost rim, yttrium is dominant.

Another observation may also point to a change in chemical conditions. Several of the minerals identified from the Kainosite boulder in the Liberty Bell talus show two very different habits, as has been reported by Howard (2012). These include two very different forms of kainosite-(Y), and two different habits of titanite. Both forms of kainosite-(Y) were composed of calcium and yttrium with very little cerium.

Finally, there is the matter of the jagged fragment on the right side of fig. 2. The EDS spectrum for that fragment is shown in fig. 11. This is another yttrium mineral with minimal cerium and neodymium, but in this case it is the niobate, which at Washington Pass has been shown to be fergusonite-beta-(Y). It was unnoticed on the original specimen. Review of the pieces from the Blue Dike reveals that several of the tiny cavities contain a light tan, rather granular deposit, often around the synchysite crystals. Only in one cavity was the deposit sufficient to produce a crystal of discernible proportions, and that is shown in fig. 12. The little crystal is mounted on the side of a quartz crystal. It is curved in shape and has somewhat rounded faces. It strongly resembles the crystal illustration presented by Bob Meyer (2010). It would appear that excess yttrium combined with niobium in the late formation of the Blue Dike or in subsequent hydrothermal activity to form this mineral.

Other forms of rare earth fluorocarbonates are present at Washington Pass, and they require the kind of careful, detailed examination that Paul Adams has given to this composite synchysite crystal. With further study, still more variations of this group of minerals may be discovered and documented.

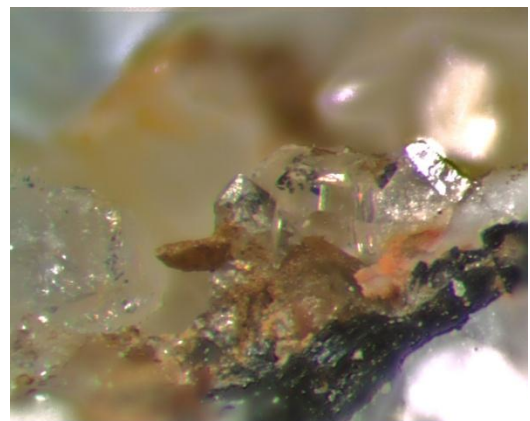
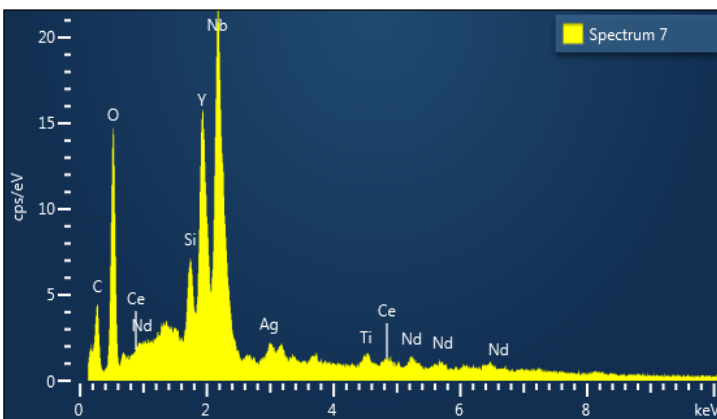


Fig. 11 EDS of the fragment of fergusonite-beta-(Y).

Fig. 12 A crystal of fergusonite-beta-(Y) on a quartz crystal from the Blue Dike. FOV is about 2 millimeters.

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