**Northwest
Micro Mineral
Study Group**

MICRO PROBE

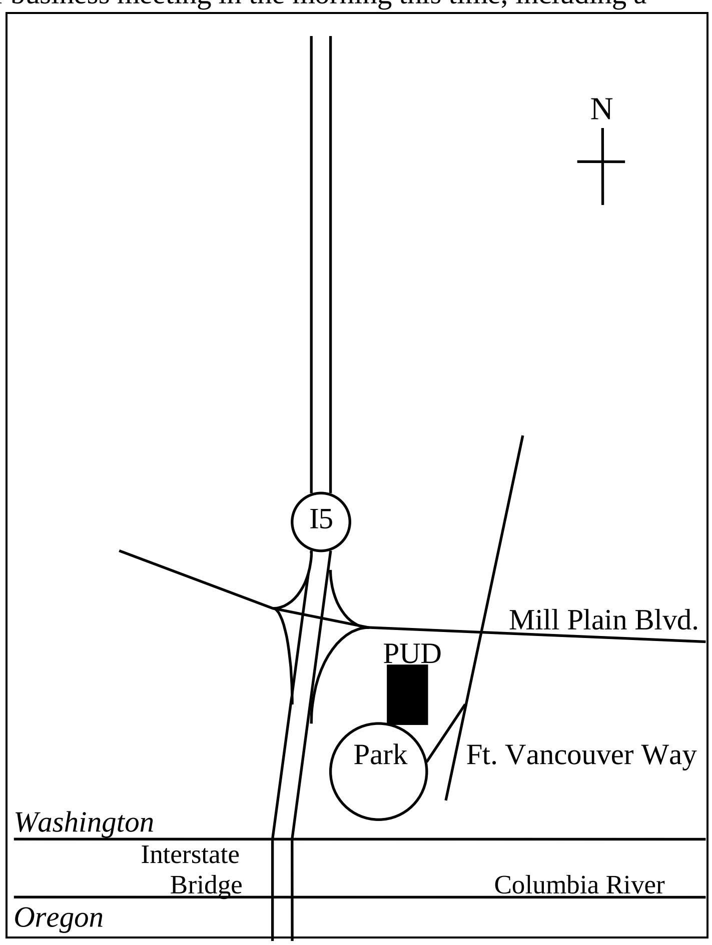
SPRING, 2009 **VOLUME X, Number 9**

SPRING MEETING . . . . .VANCOUVER, WASHINGTON

May 2, 2009 9:00 am to 5:00 pm

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

Come celebrate spring talking about your favorite minerals. Bring your microscopes and something for the free table to share with others. There should be plenty of time for sharing and swapping. We will have our usual brief business meeting in the morning this time, including a look toward future officers for our group, to be followed by our update session to find out what localities are actively producing material and are good bets for collecting trips.



In the afternoon, **Rudy Tschernich** will be showing pictures from past collecting trips that he calls "*Ghosts from the Past*" since, as he says, nearly everyone in the photos are dead. He wants to challenge us to see how many of the people we can identify. It should be a lot of fun.

The kitchen area is again available and we will plan on sharing lunch together. As always, the club will provide the basics for sandwiches, so bring goodies to make lunch special.

In the evening, many of us plan to go to a local buffet restaurant, so please join us if you can.

IN MEMORY OF ROBERT SMITH

It is with sadness that we must report once again the passing of one of our members of long standing, Robert James Smith, on June 5, 2008. Although he was not one of the original charter members, Bob has been an active part of our group for many, many years. Bob has spent the last few years in a care facility and has not been able to join in our meetings, but he is well remembered and will be greatly missed.

Bob was born in Bellingham, Washington in 1939 and was raised in the Tacoma/Puyallup area, though he spent some of his early years, and many of his summers, in South Dakota. He graduated from Bellarmine High School in Tacoma and went on to college at the Colorado School of Mines and then Seattle University, where he graduated with a degree in Chemistry in 1962. Following graduation, he continued to work at Seattle University, beginning in the chemistry Labs and later joining the faculty, where he became a Professor of Chemistry and Geology. Throughout the late 1980's, he served as the Associate Dean of the School of Science and Engineering. He is survived by his three daughters, Megan, Sholeen and Lara, and by seven grandchildren.

Bob was very active in the Northwest Chapter of Friends of Mineralogy. He hosted many FM meetings at Seattle University and for years was the organizer of the FM symposiums held in Tacoma. He was particularly remembered as the auctioneer at the symposiums. He had a way of making every specimen auctioned sound like the thing you just had to have and often he bid on the specimens he was auctioning. He was also a member of a number of other organizations, including the American Association for the Advancement of Science and the Everett Rock and Gem Club.

Bob was a very active member of the Northwest Micromineral Study Group, and was always ready to do whatever was required to keep our club functioning. He served as President for several years, and wrote articles for the Microprobe, mainly about minerals and collecting site in the Black Hills, which he remembered fondly and returned to collect whenever he could.

Bob Smith was more than just a list of vital statistics, he was a friend. Bob was a quite thoughtful man. He was never known to raise his voice in anger. Although he held the title of Doctor, he was always known just as Bob. He had a passion for mineralogy and built an extensive collection of mineral/geology books and study specimens. He specialized in phosphate minerals, particularly those from the Black Hill in South Dakota. Part of this mineral collection was donated to the Rice NW Museum of Rocks and Minerals. The bulk of Bob's collection is still in storage.

Bob always had interesting things with him when he came to meetings. He had an extensive background in the technical aspects of minerals and mineral identification, was always ready to share his knowledge with anyone who showed an interest. He had the heart of a teacher, and he dearly loved collecting. We will miss his cheery face and the enthusiasm he brought to each and every meeting he attended very much indeed.

Rudy Tschernich and Donald Howard

Some Zeolite Locations in Montana
Part 4 - Eastern Montana - South

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In southeastern Montana, zeolites occur in three different geologic settings: 1) In very small amounts in sedimentary rocks: Cretaceous bentonite deposits, lignite deposits, and Tertiary basin-filling sedimentary rocks. 2) As primary and secondary minerals in alkalic igneous rocks. 3) As secondary minerals in the Precambrian Stillwater Complex. The following is a list of occurrences gathered from a review of geologic literature and the specimens in the Montana Mineral Museum (MTMM) at Montana Tech.

Analcime
Carbon County: Sedimentary rocks, various locations - Frontier and Mowry formations - small amounts as local cement (Lizak, 1977), various locations - Livingston Group - minor amounts (Roberts, 1963).

Carter County: Sedimentary rocks, Ekalaka area - from lignite beds (Gill, 1959), Ekalaka Hills area - from lignite beds (Denson & Gill, 1965; Sheppard, 1976), Finger Butte area - from lignite beds (Denson & Gill, 1965; Sheppard, 1976).

Garfield County: Igneous rocks, Smoky Butte (Velde, 1975; Mitchell and others, 1987; Hearn, 1989b; Irving & Hearn, 2003).

Fergus County: Igneous rocks, Judith Mountains (Weed & Pirsson, 1897; Wallace, 1953a, 1953b, 1956; Barrick, 1982; Kohrt, 1991; Woodward & Giles, 1993) - Linster Peak (Kirchner, 1982, 1983) - Lewis Peak-Elk Peak area (Sorensen, 1985).

Judith Basin County: Igneous rocks, Little Belt Mountains (Larsen, 1940; Woodward, 1991) - Yogo dike (Clabaugh, 1952; Dahy, 1988, 1991; Gauthier, 1995) - Yogo Gulch area (Dahy, 1988) - Barker area (Pirsson, 1900; Witkind, 1973) - Bandbox Mountain-Yogo Gulch area - in minette (Pirsson, 1900) - Yogo district (Weed, 1900).

Petroleum County: Igneous rocks, Fords Butte dikes (Irving & Hearn, 2003).

Stillwater and Sweetgrass Counties: Sedimentary rocks, various location - Frontier and Mowry formations - small amounts as local cement (Lizak, 1977), various locations - Livingston Group - minor amounts (Roberts, 1963).

Sweetgrass County: Sedimentary rocks, various locations - Livingston Group - minor amounts (Roberts, 1963).

Chabazite
Stillwater County: Igneous rocks, Beartooth Mountains - Stillwater mine - tentative identification (Berg & Cox, 2001).

Clinoptilolite
Big Horn County: Sedimentary rocks, northeast of Crow Agency - Bearpaw Shale - trace in bentonite beds (Berg, 1969).

Carbon County: Sedimentary rocks, near Joliet - from bentonite beds in the Clagget Formation (Berg, 1969; Sheppard, 1976), near Bridger - from bentonite beds in the Thermopolis Formation (Sheppard, 1976), various locations - Livingston Group - trace (Roberts, 1963), southeast of Bridger - Thermopolis and Frontier formations - in bentonite beds (Berg, 1969), northeast of Fromberg - Frontier Shale - in bentonite beds (Berg, 1969), east of Edger - Thermopolis Shale - in bentonite beds (Berg, 1969).

Carter County: Sedimentary rocks, southwest of Alzada - Mowry Shale - in bentonite beds (Berg, 1969), west of Alzada - Belle Fourche Shale - trace in bentonite beds (Berg, 1969).

Garfield County: Sedimentary rocks, east of Mosby - Bearpaw Shale - trace in bentonite beds (Berg, 1969).

Judith Basin County: Sedimentary rocks, northeast of Geyser - in bentonitic shale (Berg & Cox, 2001), southeast portal of Daver railroad tunnel - in bentonitic shale (Berg & Cox, 2001).

Rosebud County: Sedimentary Rocks, Bearpaw Shale - minor constituent from bentonite - probable identification (Berg, 1969).

Stillwater County: Sedimentary rocks, various locations - Livingston Group - trace (Roberts, 1963).

Sweetgrass County: Sedimentary rocks, various locations - Livingston Group - trace (Roberts, 1963).

Treasure County: Sedimentary rocks, northwest of Vananda - Bearpaw Shale - in bentonite beds (Berg, 1969), near Sanders - Bearpaw Shale - trace in bentonite beds (Berg, 1969).

Yellowstone County: Sedimentary rocks, east of Acton - Bearpaw Shale - from bentonite beds (Berg, 1969; Sheppard, 1976), southwest of Billings - Bearpaw Shale - from bentonite beds (Berg, 1969).

Heulandite

Carbon County: Sedimentary rocks, various locations - Livingston Group (Roberts, 1963).

Fergus County: Near Windham (MTMM #5194).

Stillwater County: Sedimentary rocks, various locations - Livingston Group (Roberts, 1963).

Sweetgrass County: Sedimentary rocks, various locations - Livingston Group (Roberts, 1963).

Laumontite

Carbon County: Sedimentary rocks, various locations - Livingston Group - trace amounts (Roberts, 1963).

Stillwater County: Igneous rock, Beartooth Mountains - Stillwater mine (Berg & Cox, 2001) - euhedral crystals to 3 mm. from cavities recovered from drill cores in altered ultramafic rock (given to the author by company geologist); Sedimentary rocks, various locations – Livingston Group - trace amounts (Roberts, 1963).

Stillwater and Sweetgrass Counties: Igneous rocks, Beartooth Mountains - Stillwater Complex (Peoples, 1932).

Sweetgrass County: Sedimentary rocks, various locations - Livingston Group - trace amounts (Roberts, 1963).

Natrolite
Fergus County: Igneous rocks, Judith Mountains (Wallace, 1953a, 1953b, 1956; Barrick, 1982; Kohrt, 1991).

Judith Basin County: Igneous rocks, Little Belt Mountains - Yogo dike (Dahy, 1988) – Yogo Gulch area - cavity filling - questionable identification (Dahy, 1988).

Stillwater County: Igneous rocks, Beartooth Mountains - Stillwater mine - tentative identification (Berg & Cox, 2001).

Stilbite
Carter County: Sedimentary rocks, -Medicine Rocks area - nodules in the Hell Creek Formation (Hare, 1959).

Stillwater County: Igneous rock, Beartooth Mountains - Stillwater mine (Berg & Cox, 2001) - euhedral crystals to 5 mm, from cavities recovered from drill cores in altered ultramafic rock (given to the author by company geologist).

Thomsonite
Judith Basin District: Igneous rocks, Little Belt Mountains - Barker area (Witkind, 1973).

Stillwater County: Igneous rocks, Beartooth Mountains - Stillwater Complex, Minneapolis adit area (Boudreau & McCallum, 1990).

Stillwater and Sweetgrass Counties: Igneous rocks, Beartooth Mountains - Stillwater Complex (Page, 1976; Page & Zientek, 1987).

Unknown Zeolites
Carbon County: Sedimentary rocks , Bighorn Basin - Fort Union Formation (Yuretich and others, 1984).

Fergus County: Igneous rocks, Judith Mountains (Weed & Pirsson, 1897; Barrick, 1982; Kohrt, 1991) - Lewis Peak-Elk Peak area (Sorensen, 1985), Elk Creek (Rattlesnake) Butte - sodium and calcium-bearing - questionable (Irving & Hearn, 2003).

Judith Basin County: Igneous rocks, Little Belt Mountains - Yogo dike - unknown fibrous form (Clabaugh, 1952; Dahy, 1988, 1991).

Stillwater County: Igneous rocks, Beartooth Mountains - Stillwater Complex, Minneapolis adit area (Boudreau & McCallum, 1990).
Stillwater and Sweetgrass Counties: Igneous rocks, Beartooth Mountains - Stillwater Complex (Peoples, 1932; Page, 1976; Page & Zientek, 1987; McCallum and others, 1999).

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"Ferrosynchysite"

Donald Howard

Never heard of ferrosynchysite? Don't worry, neither has anyone else. You won't find it listed in Fleischer's Glossary, or any other mineral book that I know of. That is because it officially does not exist (yet). It is one of the many "unknown" minerals that have been found at Washington Pass, but for one reason or another have never been fully characterized so they could be published. Here is the story of one of them.

I was tramping around the talus pile at the foot of Liberty Bell with Bob Boggs one day when I became aware of pieces of a dike that had broken off and fallen from somewhere above. The pieces were scattered here and there, as if they had fallen some distance and spread themselves around. The dike appears bluish and is very fine grained, looking rather glassy without individual crystallites present except for very tiny black specks distributed throughout. Pieces tend to be an inch or so wide.

There are no voids in the dike itself, but it has intruded into a very light, coarsely crystalline granite that does have small openings. Some of the host rock has been included as stringers into the dike, and where this has happened, there are sometimes small flat cavities where crystal faces can be seen. And like most of the granite at Washington Pass, some of these little crystals are interesting minerals. I have seen zircon and astrophyllite in addition to the usual quartz, feldspar and a dark mineral (aegirine?). There are patches of orangey chlorite and other tiny bits of orange that could be euxenite or could be just siderite.

What caught my attention when examining this material under the microscope after I got it home was little prisms that look to be hexagonal. They are rather glassy translucent in the centers, orangey brown in color, when viewed end on. The sides of the prisms have a milky skin that is a pale yellow color. They looked different to me than most of little hexagonal prisms that dwell in cavities in the various rocks of that area. So I started to look at them.

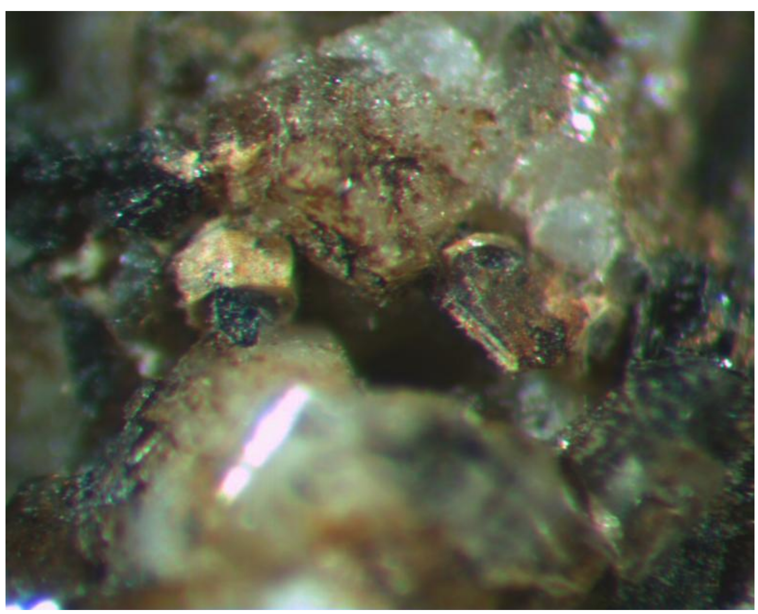

Fig. 1 Iron-rich synchysite from Washington Pass.

The crystal (left, center) shows the hexagonal shape and the pale yellow skin. Another smaller crystal (right, center) shows shape, skin, and dark center. Immediately to the left of the smaller crystal is a broken crystal showing the dark interior and the fact that the cleavage is along the prism length rather than across it.

The simplest of the minerals that form hexagonal prisms at Washington Pass is bastnasite, $CeF(CO_3)$. The structure is in the form of sheets parallel to the c-face. Bastnasite often intergrows with synchysite, $CeF(CO_3) \cdot Ca(CO_3)$, though crystals of purely synchysite are also found in places. With synchysite, the calcium carbonate also has a sheet-like structure (that of vaterite) and forms alternate layers with the cerium fluorocarbonate. Synchysite has a slight distortion of the hexagonal lattice that makes it either orthorhombic or monoclinic. Parasite, $2CeF(CO_3) \cdot Ca(CO_3)$ and rontgenite, $3CeF(CO_3) \cdot 2Ca(CO_3)$ are two closely related hexagonal minerals that have similar interleaved structures, with the numbers of each of the layer varying as shown by their formulae. Telling which one (or ones) may be present in a given sample can often be tricky.

The first step was to look at the x-ray florescence spectrum in the scatting electron microscope. Though not very quantitative, this gives an overall picture of chemical composition. The results for the interior glassy region, as shown in figure 2, were surprising. Reported analyses of synchysite do not contain iron, even as a minor impurity. This material has iron as a major constituent. Based on this analysis, the formula should look something like: $(Ce,Nd,Y,Th)F(CO_3) \cdot (Fe,Ca)(CO_3)$. The results are not sufficiently detailed enough to tell whether Ce or Nd in one layer, or Fe or Ca in the other layer, is most abundant. Similar analysis of the outer creamy skin shows it to be much richer in calcium, with significantly less iron.

The next task was to determine the crystal structure through an x-ray powder pattern. This requires removing a pure sample of the mineral. This proved tricky to do, because as mentioned above, cleavage in synchysite is along the prism length rather than across it. Therefore, when you try to lift off one of the little hexagonal prisms, they shatter into fragments. After a few attempts, two suitable fragments were separated and mounted on a Gadolfi camera (which allows the sample to rotate around two axes while in the x-ray beam, thus simulating random orientation). The resulting pattern is summarized on the next page, where it is compared to the published powder pattern for synchysite that assumes an orthorhombic cell.

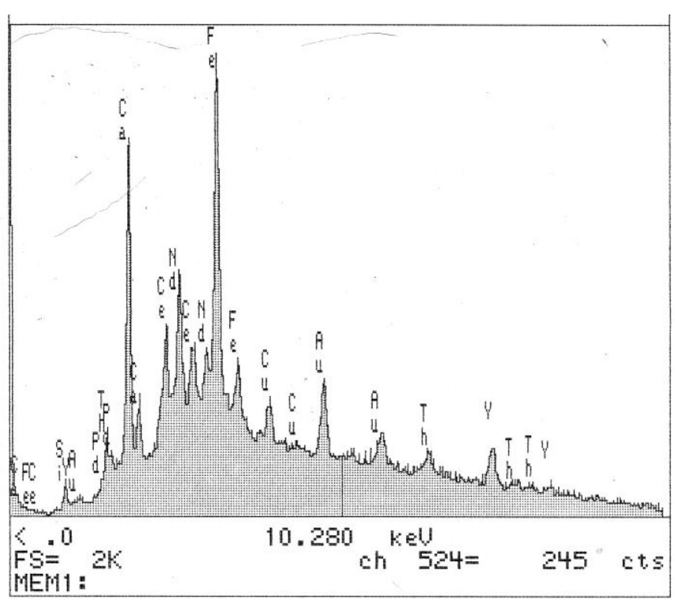

Fig. 2 Qualitative composition of the iron-rich synchysite

The Pd and Au lines are artifacts generated by the conductive coating. Fluorine and carbon do not register since the x-rays are so low energy that they do not penetrate the window of the detector.

"ferrosynchysite"				**synchysite**			
a = 4.17 A b = 6.93 A c = 9.03 A				a = 4.10 A b = 7.10 A c = 9.12 A			
d	Intensity	d(calc.)	Index	d	Intensity	d(calc.)	Index
9.02	w	9.030	(001)	9.1	60	9.12	(001)
4.49	vw	4.515	(002)	4.53	50	4.56	(002)
3.54	m	3.573	(110)	3.55	100	3.551	(110)
3.48	s	3.465	(020)			3.550	(020)
3.30	w	3.322	(111)	3.32	40	3.309	(111)
		3.235	(021)			3.308	(021)
3.11	w	3.063	(102)?				
3.04	w	3.010	(003)	3.07	30	3.040	(003)
2.77	m	2.802	(112)	2.80	100	2.801	(112)
		2.749	(022)			2.801	(022)
2.307	vw	2.302	(113)	2.30	20	2.309	(113)
		2.272	(023)			2.309	(023)
		2.258	(004)	2.28	20	2.265	(004)
2.164	s	2.146	(014)?				
2.113	vs	2.085	(200)	2.06	50	2.050	(200)
2.023	m	2.021	(130)			2.050	(130)
		2.032	(201)	2.01	20	2.000	(201)
2.002	w	1.997	(210)?				
1.971	vw	1.972	(131)			2.000	(131)
1.899	m	1.909	(114)	1.934	50	1.918	(114)
1.868	m	1.892	(024)			1.918	(024)
		1.893	(202)	1.873	40	1.870	(202)
1.840	m	1.844	(132)			1.870	(132)
		1.806	(005)	1.821	5	1.824	(005)
1.778	w	1.787	(220)	1.777	10	1.775	(220)
		1.733	(040)			1.775	(040)
1.749	w	1.753	(221)	1.749	10	1.742	(221)
1.697	vw	1.701	(041)			1.742	(041)
				1.704	10	1.700	(203)
						1.699	(133)
1.650	w	1.661	(222)	1.661	30	1.655	(222)
1.630	m	1.618	(042)			1.654	(042)
1.507	w	1.505	(006)	1.528	30	1.520	(006)

KEY TO INTENSITIES:	
vs	very strong
s	strong
m	medium
w	weak
vw	very weak

Lines whose index is followed with a (?) are questionable.

Comparison of the two patterns give a pretty good fit, except that reflections that are not resolved in synchysite, such as (110) and (020), are now resolvable as separate lines. This means that the distortion away from hexagonal is much larger in ferrosynchysite than in standard synchysite.

Three lines, marked with a (?), do not seem to fit into the pattern. The normal structure of synchysite is such that for the index (hkl), h+k should be an even number. If odd index sums are not missing in ferrosynchysite, this would indicate a rather substancial change in the structure. Alternatively, these lines could be due to impurities.

Using the Gadolfi results for plane separations, a least squares fit was run to determine an optimum set of lattice parameters, which are given at the top of the previous page. One sees that both **b** and **c** lengths have been substantially reduced. This is to be expected, since the ionic radius of divalent iron is only about 75% that of calcium ions. The slight increase in the **a** parameter is more than offset by the decreases in **b** and **c**, resulting in a cell volume of 261 A^3 as compared to 265 A^3 for synchysite.

The plan called for optical measurements next. The two fragments were unmounted and embedded in a thin film of plastic, then placed in gelatin capsules and sent to Gerald Klein. Gerald had done an outstanding job of isolating a crystal fragment in the boggsite study that was used both for the optics and the single crystal x-ray study necessary to determine the arrangement of atoms in the unit cell. After knowing something of the optics, the following step would be to embed one of the fragments in epoxy to do the detailed quantitative chemical study using a microprobe. By using the same sample for all of the measurements, it was hoped that the results would be most internally consistent.

But the plan fell apart at this point. Theft of Gerald's equipment meant the loss of the samples also. So no results were obtained. No one since has been interested in working on the optics. In all fairness, measuring the indices of refraction are not easy. The values for synchysite-(Ce) are 1.674 and 1.770. The added iron and the increasing the density would be expected to raise those values slightly. Immersion oils above 1.7 are not very stable and often involve rather nasty chemicals.

It is not clear that carrying the original plan to completion would have been sufficient to get this material approved as a new mineral. The density of the mineral, calculated from cell volume and assuming half of the calcium was replaced by iron, would be $4.18 g/cm^3$. This is much too high to find a liquid in which to suspend a fragment, so some other method would have to be used. The fragments, indeed all of the known material does not weigh enough for normal specific gravity measurements to be performed. Therefore, density could be very difficult to determine.

Even assuming that a calculated density would suffice, there would remain the question of whether the iron and calcium were randomly positioned, or whether they occupied specific sites. This would require a determination of the position of atoms in the unit cell, which could only be determined by an x-ray study of a single crystal fragment. One of the considerations of doing the optical measurements first was to see the extent of twinning present. The distortion from a hexagonal lattice could be expected to lead to twinning at a very fine level. Such twinning could make the determination of refractive indices very difficult, and would render even the smallest fragments unsuitable for a single crystal x-ray study.

So problems could abound. However, the presence of iron in a synchysite, particularly if the atomic concentration of iron exceeded that of calcium, or the iron and calcium occupied different lattice sites, would make this material very definitely a new mineral, and a very interesting one at that.

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