THE PICKING TABLE

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THE FRANKLIN-OGDENSBURG MINERALOGICAL SOCIETY, INC.

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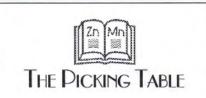Delegate   Philip P. Betancourt
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MEMBERSHIP INFORMATION:

Anyone interested in the minerals, mines, or mining history of the Franklin-Ogdensburg, New Jersey area is invited to join the Franklin-Ogdensburg Mineralogical Society, Inc. Membership includes scheduled meetings, lectures and field trips; as well as a subscription to *The Picking Table*. Dues are $15 for individual and $20 for family memberships. Please make check or money order payable to **FOMS**, and send to:

Mr. John Cianciulli, Treasurer FOMS
60 Alpine Road
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THE PICKING TABLE

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ABOUT THE COVER PHOTOGRAPH

A view of the Parker Shaft Headframe dated circa 1900. This shaft was a vertical shaft and had a depth of 1050'.
  Photo courtesy
  Sterling Hill Mining Museum

FROM THE EDITOR

Joe Kaiser
40 Castlewood Trail
Sparta, New Jersey 07871

Greetings. Here is the Autumn/Winter 1994 issue, and things are looking good. Thanks are extended to those who contributions made it possible.

The 1994 Franklin-Sterling Hill area mineral species list is printed inits entirety because there have been a few addtions to the list

FLUORESCENT MINERAL SWAP-SELL

Ralph Thomas wrote in to advise that there will be a "fluorescent minerals only" show-swap-sell event titled "Ultraviolation '94," on Saturday October 22nd from10 AM to 4 PM. The event is sponsored by the Rock and Mineral Club of Lower Bucks County, and will be held at the Emilie Methodist Church at 7300 New Falls Road,Levittown, Pa. Table space will be available for $8 half table and $12 full table with visitor admission at only $1. For more information please contact Ralph directly at (215) 295-9730.

The duties and responsibilities of being an editor were not fully understood by me until I volunterred. Some of the individual functions are simple and easy but much time and effort is required. My main goal was to maintain the quality and availability of the Picking Table.

There are several things to remind people for the new year. First, the annual mineral show has been moved to the last weekend of September this year; rather than the first weekend of October. Second, dues will be increased for the member year of 1995 by $5.

The **American Zinc Association** has begun its first newsletter, Spring/Summer 1994, their address is;

> American Zinc Association
> Suite 240
> 1112 16th Street, NW
> Washington, DC 20036

It will try to educate the public about how zinc is essential to growth and good health. It is also essential to a vast array of products. Future issues will try show new markets and their potentials. Their will also be a public policy update.

The Trotter Mine Dump was open this year and was quite active with the large group which showed up. The club is trying to arrange another collecting field trip for the coming year. 📖

AUTUMN 1994 ACTIVITY SCHEDULE

Saturday, September 17th 1994
9AM - Noon — *Field Trip* — Collecting at the Sterling Hill Mining Musum Dump, Ogdensburg, New Jersey. Fee: $10 admission, $1 per pound after first 10 pounds
1:30 - 3:30 — *Lecture* — George Rowe, His Life and Minerals by Mr. R. William Selden

Saturday and Sunday, September 24th and 25th, 1994
The 38th Annual Franklin-Sterling Mineral Exhibit.
Please note that the show will be held at the Franklin Middle School on Washington Street in Franklin.
The Annual Banquet will be held on Saturday night

Saturday, October 15th, 1994
9AM - Noon — *Field Trip* — Collecting at the Buckwheat Dump, Franklin, New Jersey.
1:30 - 3:30 — *Lecture* — Pictorial Essay on Franklin and Sterling Minerals by Gary Grenier

Sunday October 16th, 1994
9AM - 3PM — *Field Trip* — Collecting at the Lime Crest Quarry, Sparta, New Jersey.

Saturday, November 19th 1994
9AM - Noon — *Field Trip* — Collecting at the Franklin Quarry, Franklin, New Jersey.
1:30 - 3:30 — *Lecture* — "A Conversation with Pete Dunn" by Dr. Pete Dunn

Scheduled activites of the Society include meetings/lecture programs and field trips. The regular meetings are held on the third Saturday of March, April, May, June, September, October and November. Business meetings follow the lecture programs listed. Field trips are generally held on the weekend of a meeting/lecture program. Unless specified otherwise, all meetings/lectures are held in Kraissl Hall of the Franklin Mineral Museum, Evans Road, Franklin, New Jersey.

Message from the President

Chet Lemanski, Jr.
309 Massachusetts Rd.
Browns Mills, N.J. 08015

I find that time passes quickly, especially when one is collecting rocks. It hardly seems as if it were only a few months ago that I assumed the Presidency of F.O.M.S.; however, almost two years have passed. Reality dictates that this is my swansong message in the Picking Table and elections for the new officers will be upon us in a few months.

My tenure as President has been enjoyable overall, but with a few challenges. F.O.M.S. IS A mature organization and hardly needed nuturing to achieve respectability in the community of mineralogical clubs and societies. What it did need was some gentle steering and occasional persuasion.
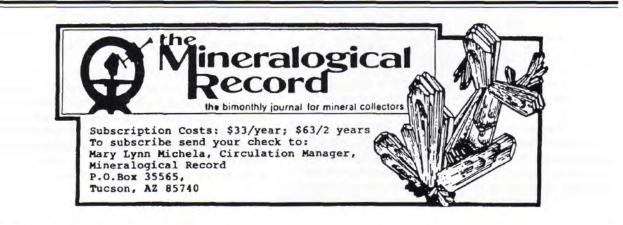
Earlier this year we voted to raise the dues based on a recommendation of the board. This move was necessary in view of the ever increasing cost of printing the Picking Table and the other recurring per capita expenses of the society, which have mounted to over $14.00 per member in the past few years. Unlike other societies and clubs, we print a journal, not a newsletter. Maintaining the quality dictates a lot of effort and expenses; however, when I am asked about THE authoritative references on Franklin minerals, I proudly state that it is a combination of the USGS Professional Paper 180 by Charles Palache AND the full set of the Picking Table. Another consideration is the fact that over the years we have been liquidating our inventory of publications without a policy of reinvesting a portion of the proceeds back into the inventory. The result of this policy has been the exhaustion of the Palache reprints and the Lehigh Symposium Proceedings, and minimal stockage levels of other publications, which now require reprinting and restocking.

During my tenure the membership has increased to a level higher than that achieved in recent years. We are near the 400 member level and still growing. Several special projects have been undertaken as well. We have instituted a policy of conserving exceptional geological and mineralogical specimens for the local museums during our collecting trips, precluding their destruction and loss to science. Several large specimens have been turned over to each of the two museums under this program. Our Field trip Chairman, Ed Wilk, has donated his collection of Lime Crest Quarry specimens to the Sterling Hill Mining Museum for perservation and public display. That commendable effort has instigated other members to enhance the collection with their own, or solicted specimens, from continuing collecting trips to that quarry. This is an effort which we hope will continue with everyone's support.

One of the F.O.M.S. programs which waned, and then extinguished, in recent years has been revived. This year we resurrected the micro group thanks to Modris Baum, a connoisseur of the tiny stuff. The revival meeting was a great success. Congradulations Modris! We also have the annual banquet continuing on track, with ever increasing proceeds from the auction, and a less-than-formal ambiance. Don't miss it this year! Of course, we can not overlook the success in negotiating with the owners of the Trotter Dump property and the conduct of the first Trotter collecting event in recent years, which drew 135 collectors.

There have been some less-than-successful efforts. Specifically, I was unable to instigate a volunteer to take up the challenge of Exhibits Chairperson (male or female) to carry on the tradition of F.O.M.S. exhibits at the NJESA show and the Franklin show. F.O.M.S. continues to be unrepresented at the EFMLS convention as well. Any takers on either issue?

I sincerely thank the other officers, board members, chairpersons, coordinators, our new editor and the volunteers who have all contributed immeasureably to the success of the F.O.M.S. program. Thank you for the opportunity to serve as your President.

NEWS FROM STERLING HILL

Steve Misiur
Editor
Sterling Hill Newsletter

This is the fourth year of operations for the Sterling Hill Mining Museum. The year's beginning was delayed several days due to the past infamous winter. Despite that, there has been a flurry of activity over the season. We have seen a successful matching of the Charles Edison Fund grant. This grant was toward the cost of the new tunnel project. At least 60 groups and individuals have contributed to the required 50% matching portion of the grant.

Other activities deserving mention are that on December 15, 1993, 10 acres consisting of the Upper Yard, were donated to the Sterling Hill Mining Museum by F & R Associates, Steven and Reginald Phillips. The eight major buildings there represent a trail of mining and milling technology. This donation opens up many possibilities that will foster new projects.

We have seen three new members added to the Foundation Board. Haig Kasabach, N.J. state geologist, will bring forth a caliber of professionalism and a background experience on a governmental level. Steve Phillips, is a successful and experienced businessman from Sussex County. William Kroth, is a professional engineer who has made many important contributions. Due to growing professional demands, it became necessary for Bernard Kozykowski to resign from the Board of Trustees. His efforts helped in making this museum a successful project. His contributions will be long remembered.

The museum now has an Education Guidance Committee. Headed by educators Dr. Alan Rein and Mikki Weiss, this committee will help initiate, guide and foster resources in the educational field that will enhance our educational program. They will reach out and explore all the available areas that will increase the awareness of this museum.

We now have two new editors for the Sterling Hill Newsletter, Bill Kroth and Steve Misiur. They were handed the reins of the editorship by Gary Grenier whose efforts to establish and maintain a viable newsletter of quality is a high achievement. His predecessor was Charles Ward who initiated and built the framework that Gary expanded upon.

We've seen the installment of an exhibit entitled "The Minerals of Limecrest Quarry, Sparta, N.J." This exhibit was made possible as a donation from Ed Wilk, F.O.M.S. Fieldtrip Chairman. Many of the display specimens were self-collected. But the exhibit also covers the history, operation and product of the quarry.

Last but not least, we have seen the new tunnel project grow and near completion Our last journal entry has just covered the initial stage of its beginnings. This tunnel has since broken out into the parking lot side on Jan. 15th while the interior breakthrough was on Feb. 17th. Then, in just over a year since this project began, the last breakthrough occurred on July 28th into an old underground stope. This project has met its initial design layout and has since incorporated a stope, an underground mining area and advanced a second tunnel, now just completed. When done, much of the geology of the Sterling Hill deposit will be exposed. Exhibits will be emplaced that will illustrate to our visitors mining techniques as used in this mine. The tunnel's public dedication is anticipated for an early fall ceremony.

NEWS FROM THE

FRANKLIN MINERAL MUSEUM

John Cianciulli
Assistant to the Curator,
Franklin Mineral Museum, Inc.

The Franklin Mineral Museum is continuing to grow and improve its programs For the first time in its history the Museum held a special mineral sale. The sale was very successful thanks to the support of the F.O.M.S. msmbers who participated in this event. The museum staff would like to plan future mineral sales events. Suggestions on ways to improve on this idea are welcome.

In general interest in serious mineral collecting seems to be on the upswing. Children are bringing parents to the museum as opposed to the other way around. This latest resurgence of youthful collectors and future scientists has museum staff working on making lecture tours more interesting and educational. Curriculum oriented lectures will focus on the academic level of the groups. Wendy Parriott is presently working with Museum Manager Carol Hunsinger in developing lower level curricula, and Jack Baum is writing higher level information which will be used during lecture tours.

The museum recently received a collection from Mrs. Minnie Franklin, widow of the late Edward A. Franklin, Carteret, New Jersey. Ed was a long time member of the F.O.M.S. and supporter of the Franklin Mineral Museum. Special thanks to Bob Boymistruk and Claude Poli for transferring the two ton collection from Carteret to Franklin. The collection has about 1,000 pounds of good Franklin grab bag material. The remaining 3,000 pounds are general specimens and fluorescent minerals. The museum still has a large variety of mineral specimens available for sale. A sales list is available at a cost of $5.00 plus $1.50 for postage.

Mineral identification ia service which the Franklin Mineral Museum has provided to collectors for many years. Some minerals from the district are easily sight identified but others, of the more common species, can be ambiguous to even the trained eye. The museum has the technology to make distinctions between suspected mineral species using optics and some simple chemistry. Feel free to discuss your mineral problems with Jack Baum or John Cianciulli.

IN MEMORIAM

Henry Van Lenten suffered a massive stroke on Memorial Day 1994 and died painlessly a few hours later. He will be remembered of his ready smile, and firm handshake, often accompanied by a good-natured jest. During his 88 years, he wore many hats, as his interests led him from camping and boating to archery, golf, minerals, wildflowers and photography, but the single thread that wound through his personality all the time he was known to us, was his strong, unshakeable Christianity. It was so intertwined with the character of the man we knew, that his faith was the cornerstone of Henry's nature.
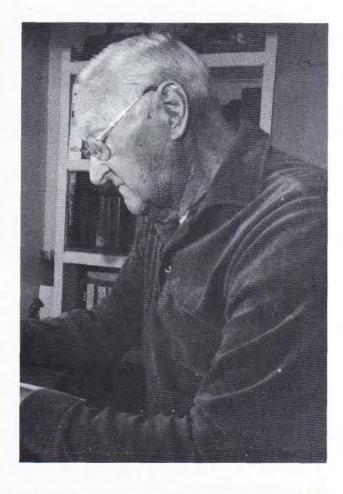
His interests, varied as they might be, were uniformly marked by his determined striving for excellance. His bow shooting stance was perfect and on the tee, his golf swing was noted as very good. However, to most readers of the Picking Table, he was known for his UV mineral photographs, numerous examples of which are recognized as, simply, the best yet executed. For a number of years, Henry gave slide presentations of his mineral photos. He authored how-to articles on fluorescent photography in enthusiast's magazines, produced fine images for Dr. Dunn's popular paper on the Sterling Museum, and two of the best selling postcards at the Franklin Mineral Museum are his work.

Much more could be written about Henry Van Lenten: for instance, he was a loving husband, father, grandfather and staunch friend. We remember him also for his commitment to Christian ideals and his fascination with beauty, both theological and in the natural world and for the stouthearted character these interests produced in him. We have lost the company of a truly decent human being

NEW MICRO GROUP - Small is Beautiful
Modris Baum - Coordinator

After several years, the FOMS "micro" group met on Saturday, March 19, 1994. A great time was had by all. The mission of the group is to bring together like minded collectors and facilitate the enjoyment of micros. The next meeting will be October 15, 1994 in Kraissl Hall at the Franklin Mineral Meusum. If you have a scope or light, please bring it. Extension cords would be helpful.

One collector found his "heaven" at the Sterling Hill Mining Museum dump, after noticing an advertisment for the Sterling Hill Mining Museum in a recent issue of the PT, which stated "on the last Sunday of every month there will be a "a fee collecting site" provided on the site of the mine property". One trip and the collector was hooked. Soon he noticed pockets and vugs of white fibrous stuff that he dismissed as "poor quality" sussexite that he took home and looked at under a scope. A few of the collector's "choicest" puzzles were analyzed. Two of the specimens turned out to have a "new to the locality" mineral. The new mineral turned out to be, at best, chlorophoenicite. The assemblage containing the new mineral also contains lots of other odd material. Systematic study is underway.

All this from a dump anyone can dig on in 1994. If you go, look for lean ore with sparse euhedral franklinite and willemite crystals. The new mineral appears to be found either with blobs of vuggy pyrochroite or in "white on white" embedded masses with a more or less vuggy appearance. There are other associations. Even if you don't find "new to the locality", a good deal of what appears to be very nice chlorophoenicite is found in this assemblage. While no longer "rare", remember that chlorophoenicite is still on the "unique" list. Specimens can be seen at the micro meetings. Come join us!

Chlorophoenicite and white "odd balls" are not the only things one can still find on the dumps. If you think small, there are many interesting and beautiful things to be found. While the cost of classic "Franklin" material is ever increasing, micros provide a better than ever means for still enjoying the "chase". Don't overlook micros on field trips to the quarry dumps. A recent trip to the Andover dumps provided nice fluorescent "beta" willemite crystals, very tiny but perfect azurite, radiating fluorescent hemimorphite and sundry unidentified curiosities. So visit our local dumps (and don't forget the museums).

Famous Graphite Crystals
from Sterling Hill, New Jersey

John A. Jaszczak
Department of Physics and the Seaman Mineral Museum
Michigan Technological University
1400 Townsend Dr.
Houghton, MI 49931-1295

In 1941, Charles Palache wrote an important paper on the morphology of graphite crystals from Sterling Hill. One of his graphite crystal drawings, which has been reproduced in many publications, is drawn down the c-axis and gives the impression of being tabular. The given Miller indices determine that the crystal was actually barrel-shaped, a rare morphology for graphite.

INTRODUCTION

In 1941, Charles Palache of Harvard University published a paper [hereafter referred to as CP41] titled, "Contributions to the Mineralogy of Sterling Hill, New Jersey: Morphology of Graphite, Arsenopyrite, Pyrite, and Arsenic" in *The American Mineralogist*. The morphology of graphite was the focus of the paper, although the other listed minerals are illustrated and discussed to a minor degree. Historically, the symmetry of graphite had been the subject of some controversy. By goniometric measurements of the crystals from Sterling Hill, Palache correctly concluded that graphite is hexagonal with full symmetry.

CP41 has since been cited in at least 29 articles and books in the fields of mineralogy, physics, metallurgy and materials science, and includes publications in German, Russian and English (see Appendix). The paper contains five crystal drawings of Sterling Hill graphite, one of Ticonderoga, New York graphite, four of Sterling Hill arsenopyrite, and one of Sterling Hill native arsenic. Two of the graphite crystal drawings have since been reproduced in other publications. Those of the Ticonderoga crystal (CP41 fig. 5) and one of the Sterling Hill crystals (CP41 fig. 3; see fig. 1 of this paper) appeared in the seventh edition of *Dana's System of Mineralogy*, which Palache co-authored (Palache, *et al.* 1944). Reproduction of the figures in *Dana's System* has probably contributed greatly to Palache's drawings being widely regarded as the "textbook" examples of graphite crystals. Along with a sketch of a synthetic, scroll-type, whisker crystal of graphite, fig. 3 of CP41 also appeared on the cover of the

Fig. 1. Crystal drawing of graphite from Sterling Hill, NJ, which appeared originally as fig. 3 in Palache's 1941 paper in American Mineralogist. The crystal shows the basal pinacoid c$\{0001\}$, the first-order dipyramid p$\{10\overline{1}1\}$ and the second-order dipyramid f$\{11\overline{2}2\}$. (Drawing recreated using the computer program SHAPE.)

book *Preparation and Properties of Solid State Materials*, vol. 4. (Wilcox, 1979). It was again reproduced, along with fig. 5 of the Ticonderoga crystal, in the book's first chapter on "Graphite Crystallization", written by I. Minkoff. In the book *The Physical Metallurgy of Cast Iron* by

Minkoff (1983), fig. 5 of the Ticonderoga, NY crystal was included once more, but fig. 3 of the Sterling Hill graphite was not.

GRAPHITE CRYSTALS

According to Palache, the source of the studied crystals was Mr. Lawson H. Bauer of Franklin, New Jersey, who found and carefully isolated the graphite crystals from a coarsely crystalline marble impregnated with graphite, arsenic, realgar, pyrite, arsenopyrite, diopside and either stibnite or a lead sulphantimonide [probably zinkenite (Kolic and Sanford, 1993)]; the specimens were collected May, 1937 from the 900-foot level of the mine at Sterling Hill. Dilute hydrochloric acid was used to separate these minerals in abundance from the marble matrix. In 1937 and in following years Bauer made contributions of isolated graphite crystals to the Harvard Mineralogical Laboratory. Mr. Bauer is said to have been a generous, careful and patient enthusiast of Franklin minerals who at one time became very fond of graphite (J. L. Baum, personal communication, 1993; Frondel, 1955).

Overall, the graphite crystals described by Palache in CP41 are considered to have been of superior quality. For example, experts in the laboratory synthesis of synthetic graphite crystals (Austerman, *et al.*, 1967) stated:

> The natural crystals described by
> Palache are the highest quality
> crystals reported in the literature
> as far as the authors are aware, and
> his description serves as a point of
> reference for the graphite crystals
> grown in the laboratory.

Palache described the Sterling Hill graphite crystals as being up to 1 or 2 mm in diameter, while the best crystals did not exceed 0.5 mm. Although hundreds of graphite crystals were examined by him, only ten were completely measured by optical goniometry. From these 10 crystals, Palache listed 15 sets of measured angles corresponding to 16 different crystal forms (see table 1). Palache noted that most of the crystals had been distorted as a result of tectonic deformation, which caused mechanical twinning of both the graphite and the surrounding calcite. Few graphite crystals remained undistorted or showed only a single twin lamella.

The most common form observed by Palache on graphite crystals from Sterling Hill was the basal pinacoid {0001}, which he described as dominant and highly lustrous. The same form is the most common in graphite form almost all other localities worldwide. After that, the first order dipyramids {10$\bar{1}$1} and {10$\bar{1}$2}, which determined the hexagonal outline of the crystals, were about equally as common. The {10$\bar{1}$3} dipyramid was slightly less common, and other dipyramids less common still. Palache noted that only rarely did any one of the dipyramids show all 6 faces on (the top half of) a crystal, and the zone of these
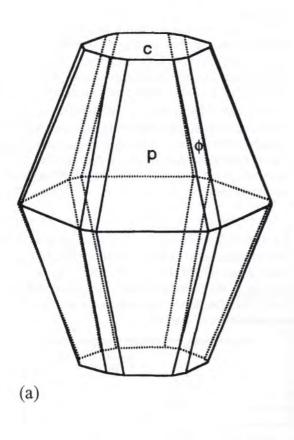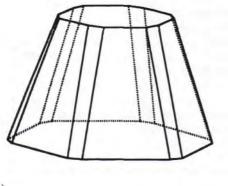
faces was often completely striated. The first order prism {10$\bar{1}$0} was rarely more than a line face, always rough when present, but often missing altogether. Second order dipyramids, such as {11$\bar{2}$2}, occurred as small faces such as truncations of first order dipyramid faces. It is noteworthy that none of the forms listed by Palache corresponds to a general form {hki$l$} (were h, k, and l are non-zero and have no special relationship to one another), as general forms of graphite not been well-documented in subsequent literature either. Palache did note, however, the existence of crystal faces which were not in the dominant zones and could not be simply indexed.

TABLE 1: Graphite crystal forms measured by Palache (1941) from a set of 10 crystals from Sterling Hill, NJ. The basal pinacoid {0001} was used for alignment of the crystals on the goniometer and was not included in table 1 of CP41. Presumably at least one {0001} faced existed on each of the 10 crystals.

	Forms	Number of	
		faces	crystals
m	10$\bar{1}$0	10	7
d	10$\bar{1}$8	2	1
e	10$\bar{1}$5	4	3
t	10$\bar{1}$4	2	2
r	10$\bar{1}$3	8	4
o	10$\bar{1}$2	12	6
w	20$\bar{2}$3	4	3
x	40$\bar{4}$5	4	3
p	10$\bar{1}$1	18	4
y	20$\bar{2}$1	2	2
π	11$\bar{2}$6	2	1
ρ	11$\bar{2}$3	7	4
φ	11$\bar{2}$2	6	1
σ	22$\bar{4}$3	4	4
τ	11$\bar{2}$1	1	1

Graphite usually forms tabular crystals, when it forms good crystals at all. Of the crystal drawings of graphite in Palache's paper, two showed the crystals from an inclined view and clearly are tabular. Palache indicates that at least figures 1, 2 and 3 represent measured crystals with the relative prominence of faces in the drawings approximately corresponding to that of the actual crystals. It is therefore easy to assume that the crystal depicted in fig. 3 of CP41 (see fig. 1 above) is also tabular. However, as determined from the Miller indices given in the paper, along with the angles of inclination of the faces from the c-axis, this cannot be the case. Using the axial dimensions given by Palache and the Miller indices corresponding to the crystal illustrated in fig. 3 of his paper, the Macintosh version of the crystal-drawing program SHAPE (Dowty and Richards, 1993) was used to redraw the crystal. The

(a)

(b)

Fig. 2. (a) Same crystal as in fig. 1 but rotated to a different viewing orientation using SHAPE. (b) Cleaved version of (a) which also appears like fig. 1 when viewed down the c axis, but is more apt to fit Palache's description of the original crystal.

sizes of the faces were adjusted to match Palache's fig. 3 when viewed directly down the c-axis (fig. 1 above). SHAPE was then simply used to rotate the crystal to be viewed away from the c-axis, whereupon its barrel-shaped morphology immediately became apparent (see fig. 2a). Such a morphology for graphite is very uncommon [compare, however, Kvasnitsa *et al.* (1988)]. As Palache mentioned that most of the crystals did not have well-

developed faces on both the top and bottom halves, the crystal corresponding to Palache's fig. 3 might be only a fraction of that depicted in fig. 2a, as shown in fig. 2b. Unfortunately, attempts to locate this or any of the other studied graphite crystals at the Harvard Mineralogical Museum have failed. A batch of insoluble residues from Bauer has been preserved in a collection recently donated by John L. Baum (J. L. Baum, personal communication, 1992) to the U.S. National Museum of Natural History, but is currently unavailable for study (P. J. Dunn, personal communication, 1993).

TWINNING

Palache sought crystals that were free from striations for goniometric measurement. Striations are commonly observed on the basal faces of graphite crystals and have long been recognized as due to mechanical twinning (Sjögren, 1884). These striations always are oriented diagonally to the hexagonal outline, i.e., along $<1\bar{1}00>$ directions, and can be induced by the application of only the slightest stress; thus, untwinned, unstriated crystals are rare. By observing an approximate 20° angle between the basal pinacoids of a twin lamella and the adjacent, untwinned parts of the same crystal, Palache determined that the twin law is by reflection and composition on $\{11\bar{2}1\}$ planes (see fig. 3). Palache was apparently the first to identify the twin law, and such is the reason that a large number of subsequent authors have cited CP41. Palache also noted a twin lamella at an angle 16° 43´, corresponding most nearly to a $\{44\bar{8}3\}$ twin plane. Growth twins on this twin law as well as other twin laws are now also known (Laves and Baskin, 1956; Freise and Kelly, 1961; Shafranovskii, 1981, 1982, 1983; Jaszczak, 1991, 1992) from several localities.

CONCLUSION

Charles Palache's 1941 paper was not only an important contribution to the mineralogy of Sterling Hill, New Jersey, but was also a unique and important contribution to the descriptive mineralogy of graphite. The natural crystals described and drawn by Palache are a recognized standard for well-formed graphite crystals and are still considered to be some of highest quality crystals reported in the literature. Information regarding the existence or availability of Palache's graphite crystals or additional material such as that etched by Bauer would be greatly appreciated.

(a)

(b)

Fig. 3. (a) Graphite crystal from Sterling Hill (fig. 6 in CP41 recreated using SHAPE) with forms c$\{0001\}$ and p$\{10\bar{1}1\}$, showing a single twin lamella on $\{11\bar{2}1\}$. The bottom of the crystal is a cleavage plane. (b) Side view of (a) showing that the twin lamella (shaded) is inclined by q = 20°36' from the adjacent, untwinned parts of the same crystal.
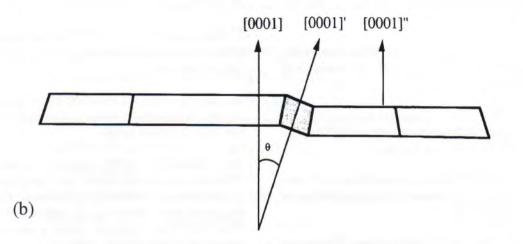
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Minkoff, I. (1983) *The Physical Metallurgy of Cast Iron.* (John Wiley and Sons, New York) p. 9.

Palache, C. (1941) Contributions to the mineralogy of Sterling Hill, New Jersey: Morphology of graphite, arsenopyrite, pyrite, and arsenic. *American Mineralogist* **26**, 709-717.

Palache, C., Berman, H., and Frondel, C. (1944) *The System of Mineralogy of James Dwight Dana and Edward Salisbury Dana, Yale University 1837-1892*. Seventh

edition, vol. 1. (John Wiley & Sons, New York) 152.

Shafranovskii, G. I. (1981) [New graphite twins.] *Zapiski Vsesoyuznogo Mineralogicheskogo Obschestva* **110**, 716-720. (In Russian.)

Shafranovskii, G. I. (1982) [Graphite twins and triads.] *Mineralogicheskii Zhurnal* **4**(1), 74-81. (In Russian with English summary.)

Shafranovskii, G. I. (1983) [Classical and non-classical graphite twins.] *Zapiski Vsesoyuznogo Mineralogicheskogo Obschestva* **112**, 577-581. (In Russian.)

Sjögren, H. (1884) Om grafitens kristallform och fysiska egenskaper. *Üfversigt af Svenska Vetenskapsakademien Forhandlingar* **44**, 29-53.

Wilcox, W. R. editor (1979) *Preparation and Properties of Solid State Materials*, vol. 4. Morphological Stability, Convection, Graphite, and Integrated Optics. (Marcel Dekker, New York).

APPENDIX

Chronologic list of publications in which Palache's 1941 paper (*American Mineralogist* **26**, 709-717) has been cited [not including this paper]. As this list is almost certainly incomplete, the author invites notification of additional publications that should be included.

1. Valter, A. A., Eremenko, G. K., Kvasnitsa, V. N., and Polkanov, Yu. A. (1992) *Udarno-Metamorphogennure Mineralur Ugleroda* [Shock-Metamorphic Minerals of Carbon.] (Naukova Dumka, Kiev) 172 pp. (In Russian.)

2. Jaszczak, J. A. (1992) Growth twinning in graphite from Crestmore and Jensen quarries, Riverside County, California. *Rocks and Minerals* **67**, 114-115. (Abstract.)

3. Pengra, D. B., and Dash, J. G. (1992) Edge melting in low-coverage adsorbed films. *Journal of Physics-Condensed Matter* **4**, 7317-7332.

4. Jaszczak, J. A. (1991) Graphite from Crestmore, California. *Mineralogical Record* **22**, 427-432.

5. Kvasnitsa, V. N., Krochuk, V. M., Melnikov, V. S., and Yatsenko, V. G. (1988) [Crystal morphology of graphite from magmatic rocks from the Ukrainian Shield.] *Mineralogicheskii Zhurnal* **10**(5), 68-76. (In Russian with English summary.)

6. Minkoff, I. (1983) *The Physical Metallurgy of Cast Iron*. (John Wiley and Sons, New York). Includes figure 5, but not figure 3, from Palache (1941) on page 9.

7. Shafranovskii, G. I. (1982) [Crystallomorphology of graphite from the Ilmen Mountains.] In, *Mineralogicheskie Issledovaniya Endogennurkh Mestorozhdenii Urala*. (Academiya Nauk SSSR- Uralskii Nauchnuri Tsentr) 44-53. (In Russian.)

8. Shafranovskii, G. I. (1982) [Graphite twins and triads.] *Mineralogicheskii Zhurnal* **4**(1), 74-81. (In Russian with English summary.)

9. Shafranovskii, G. I. (1981) [New graphite twins.] *Zapiski Vsesoyuznogo Mineralogicheskogo Obschestva* **110**, 716-720. (In Russian.)

10. Minkoff, I. (1979) Graphite crystallization. *In Preparation and Properties of Solid State Materials*, vol. 4. Morphological Stability, Convection, Graphite and Integrated Optics. Wilcox, W. R., editor. (Marcel Dekker, New York) 1-48. Includes figures 3 (also on the book cover) and 5 from Palache, 1941.

11. Munitz, A., and Minkoff, I. (1978) 45th International Foundry Congress Paper (Hungary). See Peiyue, Z., Rozeng, S., and Yanxiang, L. (1985) Effect of twin/tilt on the growth of graphite. In, *The Physical Metallurgy of Cast Iron*, Fredriksson, H. and Hillert, M., editors. MRS Symposium Proceedings, vol. 34. (North Holland, New York) 3-11.

12. Edwards, F. Z. (1976) The post Palache minerals. *The Picking Table* **17** (2), 6-10. "It is quite evident that Palache's interest was primarily with the graphite crystals imbedded in the calcite. It is also probable that the specimens submitted by Dr. Bauer were all consumed by acid. At any rate, very few pieces of this occurrence may be found in collections today." p. 7. "It should also be mentioned that equally scarce and much unappreciated are the graphite crystals which so intrigued Dr. Palache." p. 8.

13. Akhmatov, Y. S., Bunin, K. P., and Taran, Y. N. (1975) [Mechanism of formation of graphite spherocrystals in Fe-Ce melt.] *Dopovidi Akademii Nauk Ukrainskoi RSR Seriya A- Fiziko-Matematichni Ta Technichninauki* (5), 453-455. (In Russian.)

14. Nagornyi, V. G., Nabatnikov, A. P., Frolov, V. I., Deev, A. N., and Sosedov, V. P. (1975) [Occurrence of a new crystalline form of carbon.] *Zhurnal Fizicheskoi Khimii* **49**(4) 840-845. (In Russian.)

15. Akhmatov, Y. S., Taran, Y. N., Stepanchuk, A. N., Lisnyak, A. G., and Zaspenko, N. Y. (1974) Structure and mechanism of growth of graphite crystals with different genetic origins. *Russian Metallurgy- USSR* (4), 58-60.

16. Skinner, J., and Gane, N. (1973) The deformation and twinning of graphite crystals under a point load. *Philosophical Magazine* **28**, 827-837.

17. Frondel, C. (1972) *The Minerals of Franklin and Sterling Hill: A Check List.* (Wiley-Interscience, New York) p. 58. "Tiny but unusually perfect graphite crystals have been found in acid-insoluble residues of the marble—see Palache (1941)."

18. Double, D. D., and Hellawell, A. (1969) The structure of flake graphite in Ni-C eutectic alloy. *Acta Metallurgica* **17**, 1071-1083.

19. *Gmelins Handbuch der Anorganischen Chemie* (1968) System-nummer 14. C- Kohlenstoff. Teil B, Lieferung 2. Das Element: Graphit. (Verlag Chemie, GMBH, Weinheim/Gergstr.) 409, 412. (In German.)

20. Austerman, S. B., Myron, S. M., and Wagner, J. W. (1967) Growth and characterization of graphite single crystals. *Carbon* **5**, 549-557.

21. Baker, C., Gillin, L. M., and Kelly, A. (1966) Twinning in graphite. *Second Conference on Industrial Carbon and Graphite.* (Society of Chemical Industry, London) 132-138.

22. Amelinckx, S., Delavignette, P., and Heerschap, M. (1965) Dislocations and stacking faults in graphite. In, *Chemistry and Physics of Carbon*, Walker, P. L., Jr., editor. (Marcel Dekker, New York) 1-71.

23. Thomas, J. M. (1965) Microscopic studies of graphite oxidation. In, *Chemistry and Physics of Carbon*, Walker, P. L., Jr., editor. (Marcel Dekker, New York) 121-202.

24. Freise, E. J., and Kelly, A. (1961) Twinning in graphite. *Proceedings of the Royal Society* (London) A **264**, 269-276.

25. Kennedy, A. J. (1960) Dislocations and twinning in graphite. *Proceedings of the Physical Society* (Great Britain) **75**, 607-611.

26. Academiia Nauk SSSR. Institut Geologii Rudnykh Mestorozhdenii, Petrografii, Mineralogii i Geokhimii. (1960) *Mineraly; Spravochnik*, vol. 1. (Izd-vo Academii Nauk SSSR, Moscow) 69-75. (In Russian.)

27. Foster, L. M., Long, G., and Stumpf, H. C. (1958) Production of graphite single crystals by the thermal decomposition of aluminum carbide. *American Mineralogist* **43**, 285-296.

28. Platt, J. R. (1957) Atomic arrangements and bonding across a twinning plane in graphite. *Zeitschrift f•r Kristallographie* **109**, S.226-230.

29. Palache, C., Berman, H., and Frondel, C. (1944) *The System of Mineralogy of James Dwight Dana and Edward Salisbury Dana, Yale University 1837-1892.* Seventh edition, vol. 1. (John Wiley and Sons, New York) 152. Includes figures 3 and 5 from Palache, 1941.

Notes from the laboratory

&

changes to the list of species from Franklin and Sterling Hill

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Additions to the list

Bianchite:
Bianchite, a zinc sulfate hydrate mineral was first reported from Sterling Hill by John Hendricks in 1960, and was later reported by David Cook at Harvard University in 1973. Cook's material was later examined by P. J. Dunn and found to be hexahydrite. The recently verified occurrence of bianchite was described by Dr. Robert E. Jenkins, II, and Steven C. Misiur in The Mineralogical Record, 25, 95-102, 104 (1994).

Duftite:
Duftite was described from Sterling Hill by Dr. Robert E. Jenkins, II, in The Picking Table, 34, #2, 6-11 (1993), and was reported to be the beta modification of duftite, known properly as -duftite, duftite-, or duftite.

Piemontite:
Piemontite, a manganese member of the epidote group, was reported from Sterling Hill by Dr. Robert E. Jenkins, II in The Picking Table, 35, #1, 16-24 (1994).

Samfowlerite:
Samfowlerite, a new species from Franklin, is a monoclinic calcium zinc manganese beryllium silicate hydroxide, and occurs as 0.5 mm colorless crystals associated with cahnite, clinochlore, and leucophoenicite crystals on a pink, zoned garnet (andradite-grossular solid-solution), which lines vugs in willemite-franklinite ore. Further description will be available when the formal publication (Canadian Mineralogist, 32, 43-53 (1994)) is abstracted in The Picking Table.

Tetrahedrite:
Tetrahedrite, the antimony analogue of tennantite, was described from Sterling Hill by Dr. Robert E. Jenkins and Steven C. Misiur in The Mineralogical Record, 25, 95-102, 104 (1994).

Changes to the list

Molybdenite-2H:
Molybdenites from several local assemblages were examined by Pete J. Dunn using X-ray methods, and were found to be the 2H polytype, known hereafter as molybdenite-2H.

Richterite:
The statement in The Picking Table, 31, #2, page 3 (1990) deleting richterite is in error. Richterite is known from Franklin, as dark -green prismatic crystals associated with bannisterite. The error is the responsibility of Pete J. Dunn alone.

Riebeckite:
A sample previously analyzed by Pete J. Dunn was restudied using more appropriate methods and better standards and was found to be magnesioriebeckite, already known locally. Riebeckite is deleted from the list.

Rosasite:
Rosasite is no longer considered a doubtful species locally. It was verified from Sterling Hill by Dr. Robert E. Jenkins and Steven C. Misiur in The Mineralogical Record, 25, 95-102, 104 (1994), and the qualifying asterisk (*) is removed.

Changes to the unique list

Samfowlerite is added as a locally unique species.

Franklinphilite is added as a locally unique species.

Hancockite is deleted as a locally unique species. It has been found in the Jakobsberg Mine in Sweden, and the description has been published in Mineralogical Magazine, 58, 172-174 (1994).

The Franklin-Sterling Hill Area Mineral Species List

Compiled from numerous sources by Pete J. Dunn of the Smithsonian Institution and John L. Baum, Curator of the Franklin Mineral Museum, in May, 1994, following the nomenclature of the Glossary of Mineral Species (Fleischer, 1991). Procedures for adding species to this list are given in The Picking Table, 28. #1, pages 4-5 (1987).

Acanthite
Actinolite
Adamite
Adelite
Aegirine
Akrochordite
Albite
Allactite
Allanite-(Ce)
Alleghanyite
Almandine
Analcime
Anandite
Anatase
Andradite
Anglesite
Anhydrite
Annabergite
Anorthite
Anorthoclase
Antlerite
Aragonite
Arsenic
Arseniosiderite
Arsenopyrite
Atacamite
Augite
Aurichalcite
Aurorite
Austinite
Azurite

Bakerite
Bannisterite
Barite
Barium-pharmacosiderite
Barylite
Barysilite
Bassanite
Bastnaesite-group mineral
Baumhauerite
Bementite
Berthierite
Bianchite
Biotite
Birnessite
Bornite
Bostwickite
Brandtite
Breithauptite
Brochantite
Brookite
Brucite
Bultfonteinite
Bustamite

Cahnite
Calcite
Canavesite
Carrollite
Caryopilite
Celestine
Celsian
Cerussite
Chabazite
Chalcocite
Chalcophanite
Chalcopyrite
Chamosite
Charlesite
Chlorophoenicite
Chondrodite
Chrysocolla
Cianciulliite
Clinochlore
Clinochrysotile
Clinoclase
Clinohedrite
Clinohumite
Clinozoisite
Clintonite
Conichalcite
Connellite
Copper
Corundum
Covellite
Cryptomelane
Cuprite
Cuprostibite
Cuspidine

Datolite
Descloizite
Devilline
Digenite
Diopside
Djurleite
Dolomite
Domeykite
Dravite
Duftite
Dypingite

Edenite
Epidote
Epsomite
Erythrite
Esperite
Euchroite
Eveite

Fayalite
Feitknechtite
Ferrimolybdite
Ferristilpnomelane
Ferroaxinite
Flinkite
Fluckite
Fluoborite
Fluorapatite
Fluorapophyllite
Fluorite
Forsterite
Franklinfurnaceite
Franklinite
Franklinphilite
Friedelite

Gageite-1Tc
Gageite-2M
Gahnite
Galena
Ganomalite
Ganophyllite
Genthelvite
Gersdorffite
Gerstmannite
Glaucochroite
Goethite
Gold
Goldmanite
Graphite
Greenockite
Grossular
Groutite
Guerinite
Gypsum

Haidingerite
Halotrichite
Hancockite
Hardystonite
Hastingsite
Hauckite
Hausmannite
Hawleyite
Hedenbergite
Hedyphane
Hematite
Hematolite-like-mineral
Hemimorphite
Hendricksite
Hercynite
Hetaerolite
Heulandite
Hexahydrite

Hodgkinsonite
Holdenite
Huebnerite
Humite
Hyalophane
Hydrohetaerolite
Hydrotalcite
Hydroxyapophyllite
Hydrozincite

Illite
Ilmenite

Jacobsite
Jarosewichite
Jerrygibbsite
Johannsenite
Johnbaumite
Junitoite

Kaolinite
Kentrolite
Kittatinnyite
Koettigite
Kolicite
Kraisslite
Kutnohorite

Larsenite
Laumontite
Lawsonbauerite
Lead
Legrandite
Lennilenapeite
Leucophoenicite
Linarite
Liroconite
Lizardite
Loellingite
Loseyite

Magnesiohornblende
Magnesioriebeckite
Magnesium-chlorophoenicite
Magnetite
Magnussonite
Malachite
Manganaxinite
Manganberzeliite
Manganese-hoernesite
Manganhumite
Manganite
Manganosite
Manganpyrosmalite
Marcasite
Margarite
Margarosanite
Marialite
Marsturite
Mcallisterite
Mcgovernite
Meionite
Melanterite*
Meta-ankoleite
Metalodevite
Metazeunerite
Microcline
Mimetite

Minehillite
Molybdenite-2H
Monohydrocalcite
Mooreite
Muscovite

Nasonite
Natrolite
Nelenite
Neotocite
Niahite
Newberyite
Nickeline
Nontronite
Norbergite

Ogdensburgite
Ojuelaite
Orthochrysotile
Orthoclase
Orthoserpierite
Otavite
Oyelite-like mineral

Parabrandtite
Pararammelsbergite
Parasymplesite
Pargasite
Pectolite
Pennantite
Petedunnite
Pharmacolite
Pharmacosiderite
Phlogopite
Picropharmacolite
Piemontite
Pimelite
Powellite
Prehnite
Pumpellyite-(Mg)
Pyrite
Pyroaurite
Pyrobelonite
Pyrochroite
Pyrophanite
Pyroxmangite
Pyrrhotite

Quartz

Rammelsbergite
Realgar
Retzian - (La)
Retzian - (Nd)
Rhodochrosite
Rhodonite
Richterite
Roeblingite
Romeite
Rosasite
Roweite
Rutile

Safflorite
Samfowlerite
Sarkinite
Sauconite
Schallerite

Scheelite
Schorl
Sclarite
Scorodite
Seligmannite
Sepiolite
Serpierite
Siderite
Sillimanite
Silver
Sjögrenite
Skutterudite
Smithsonite
Sonolite
Spangolite
Spessartine
Sphalerite
Spinel
Starkeyite
Sterlinghillite
Stibnite
Stilbite
Stilpnomelane
Strontianite
Sulfur
Sussexite
Svabite
Synadelphite

Talc
Tennantite
Tephroite
Tetrahedrite
Thomsonite
Thorite
Thortveitite
Tilasite
Tirodite
Titanite
Todorokite
Torreyite
Tremolite
Turneaureite

Uraninite
Uranophane
Uranospinite
Uvite

Vesuvianite
Villyaellenite

Wallkilldellite
Wawayandaite
Wendwilsonite
Willemite
Wollastonite
Woodruffite
Wulfenite
Wurtzite

Xonotlite

Yeatmanite
Yukonite

Zinalsite
Zincite
Zinkenite
Zircon
Znucalite

* reported but not confirmed with
certainty.

Minerals Unique to Franklin and Sterling Hill

BOSTWICKITE $CaMn^{3+}_6Si_3O_{16} \cdot 7H_2O$

CHARLESITE $Ca_6(Al,Si)_2(SO_4)_2[B(OH)_4](OH)_{12} \cdot 26H_2O$

CHLOROPHOENICITE $Mn_3Zn_2(OH)_6[As_{0.5}H_{0.5}(O,OH)_3]_2$

CIANCIULLIITE $Mn(Mg,Mn)_2Zn_2(OH)_{10} \cdot 2\text{-}4H_2O$

FRANKLINFURNACEITE $Ca_2Fe^{3+}Mn^{2+}_3Mn^{3+}Zn_2Si_2O_{10}(OH)_8$

FRANKLINPHILITE $K_4Mn_{48}(Si,Al)_{72}(O,OH)_{216} \cdot \underline{n}H_2O$

GERSTMANNITE $(Mg,Mn)_2ZnSiO_4(OH)_2$

HARDYSTONITE $Ca_2ZnSi_2O_7$

HAUCKITE $(Mn,Mg)_{24}Zn_{18}Fe^{3+}_3(SO_4)_4(CO_3)_2(OH)_{81}$

HENDRICKSITE $K(Zn,Mg)_3Si_3AlO_{10}(OH)_2$

HODGKINSONITE $Zn_2Mn(SiO_4)(OH)_2$

HOLDENITE $(Mn,Mg)_6Zn_3(OH)_8(AsO_4)_2(SiO_4)$

JAROSEWICHITE $Mn_2Mn^{3+}(AsO_4)(OH)_6$

JOHNBAUMITE $Ca_5(AsO_4)_3(OH)$

KITTATINNYITE $Ca_4Mn^{3+}_4Mn^{2+}_2Si_4O_{16}(OH)_8 \cdot 18H_2O$

KOLICITE $Mn_7Zn_4(AsO_4)_2(SiO_4)_2(OH)_8$

KRAISSLITE $Fe^{3+}_2Mg_4Mn_{44}Zn_6(AsO_4)_6(AsO_3)_4(SiO_4)_{12}(OH)_{36}$

LAWSONBAUERITE $(Mn,Mg)_9Zn_4(SO_4)_2(OH)_{22} \cdot 8H_2O$

LENNILENAPEITE $K_6(Mg,Mn,Zn,Fe)_{48}(Si,Al)_{72}(O,OH)_{216} \cdot 16H_2O$

MAGNESIUM-CHLOROPHOENICITE $(Mg,Mn)_3Zn_2(OH)_6[As_{0.5}H_{0.5}(O,OH)_3]_2$

MCGOVERNITE $(Mn,Mg,Zn)_{273}As^{3+}_{12}As^{5+}_{30}Si_{42}O_{324}(OH)_{252}$

MINEHILLITE $K_{2\text{-}3}Ca_{28}[Zn_4Al_4Si_{40}O_{112}(OH)_4](OH)_{12}$

MOOREITE $Mg_9Mn_2Zn_4(SO_4)_2(OH)_{26} \cdot 8H_2O$

NELENITE $Mn_{16}Si_{12}O_{30}(OH)_{14}[As^{3+}_3O_6(OH)_3]$

PARABRANDTITE $Ca_2Mg(AsO_4)_2 \cdot 2H_2O$

PETEDUNNITE $CaZnSi_2O_6$

RETZIAN - (La) $Mn_2La(AsO_4)(OH)_4$

RETZIAN - (Nd) $Mn_2Nd(AsO_4)(OH)_4$

SAMFOWLERITE $Ca_{14}Mn_3Zn_2(Zn,Be)_2Be_6(SiO_4)_6(Si_2O_7)_4(OH,F)_6$

SCLARITE $(Zn,Mn,Mg)_4Zn_3(CO_3)_2(OH)_{10}$

STERLINGHILLITE $Mn_3(AsO_4)_2 \cdot 4H_2O$

TORREYITE $(Mg,Mn)_9Zn_4(SO_4)_2(OH)_{22} \cdot 8H_2O$

WALLKILLDELLITE $Ca_4Mn^{2+}_6As^{5+}_4O_{16}(OH)_8 \cdot 18H_2O$

WAWAYANDAITE $Ca_{12}Mn_4B_2Be_{18}Si_{12}O_{46}(OH,Cl)_{30}$

YEATMANITE $[Mn_5Sb_2][Mn_2Zn_8Si_4]O_{28}$

A Complex Base-Metal Assemblage
from the Sterling Mine
New Jersey

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*The Sterling Hill Cu-Zn-Pb occurrence known locally as the
"Chalcopyrite Room" is remarkably complex, with
50 species presently confirmed. The assemblage includes
one phase new to Sterling Hill, tetrahedrite, and two
additional species—bianchite and rosasite—whose
occurrence at Sterling Hill had previously been questioned,
but is here verified. A number of the species occur in
well-formed microcrystals.*

INTRODUCTION

The occurrence of base-metal sulfide minerals and their oxidation products has long been known from Sterling Hill, New Jersey (e.g. Palache, 1935), but these interesting and often colorful minerals have received relatively little attention in the literature of the deposit, perhaps because of their overall volumetric and economic insignificance or because they would appear to have little bearing on the genesis of the zinc orebody. This report therefore describes the geology, mineralogy and paragenesis of a remarkably complex Cu-Zn-Pb veinlet assemblage from the south opening of 1250 stope, a locality known to local collectors as the "Chalcopyrite Room." The name derives from the most prominent, if not most abundant mineral in the exposure at the time of discovery. The name is used for convenience here to distinguish the location from the north opening of 1250 stope, where a second and somewhat different base-metal assemblage occurs which is still under investigation.

The Chalcopyrite Room lies below the east terminus of the 1220 crosscut, 700 level (Fig. 1), along the hanging wall of the East Vein of the Sterling orebody. Secondary base-metal minerals are bracketed by approximate mine coordinates 1225N, 710W and 1290N, 708W, at depths ranging from 770 to 870 feet. Coordinates thus define a total volume of about 35 cubic meters, of which less than 10% is mineralized with the described assemblage.

The site was discovered by personnel of the Sterling Hill Mining Museum in October 1990. Samples were collected extensively until March 1991. The occurrence is now flooded.

GEOLOGY

The geology of Sterling Hill has been discussed by many authors (e.g. Metsger *et al.*, 1958; Callahan, 1966; Metsger *et al.*, 1969). Data bearing on the origin of the deposit have been added by Squiller and Sclar (1980), Carvalho and Sclar (1988), and Johnson *et al.* (1990). Hague *et al.* (1956) and Drake (1990) have given summaries of the regional geology. The reader is referred to these earlier workers for discussion of these general topics. This section will briefly describe only the geologic occurrence of the Cu-Zn-Pb assemblage of the Chalcopyrite Room. A geologic map[1] of the occurrence is shown in Figure 2. Only a portion of the east wall of the stope is shown here.

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[1] North in the New Jersey Zinc Company (NJZC) grid system is 19°5' east of True North. All locations or structural directions given in this paper are relative to "NJZC north." Also, structural directions
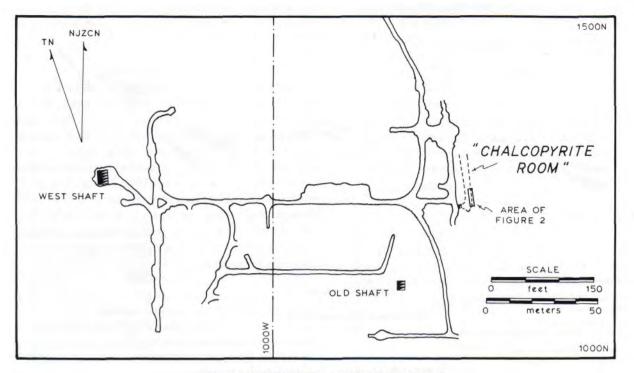
Figure 1. **Drift outlines on the 700 level and location of the Chalcopyrite Room, 70 feet below, Sterling mine (1979–1986, New Jersey Zinc Company mapping, courtesy of Sterling Hill Mining Museum).**

The base-metal assemblage of the Chalcopyrite Room is restricted to the Franklin Marble, at and near the hanging wall contact of the orebody. It is *wholly separate* from the great zinc-iron-manganese orebody which has made Sterling Hill famous. (Note that the term "ore" will hereafter be used to denote the mixture in variable proportion of franklinite, willemite and zincite in calcite which have constituted the economic minerals of the deposit.) Sulfide minerals occur (1) in a shallow trough in the ore-marble contact, generally in marble breccia lying along the contact, (2) in two steeply dipping fractures striking about N35°E, which penetrate that trough, and (3) in several fractures striking about N10°W, parallel to the strike of the orebody, but dipping in the opposite direction. The contact trough is apparently a primary fold of very low amplitude.

Sulfide minerals have formed by open-space filling and by replacement of marble and of one another. They occur as discontinuous stringers, as replacements of breccia matrix, and as more massive lenticular bodies, ranging up to 7 x 40 cm in cross-section. The main segregations of sulfides occur in and near the contact trough. Narrow sulfide-filled veinlets also extend about 20 meters northward from the trough.

Oxidation of the sulfide minerals produced a richly varied suite of secondary minerals. These occur on residual sulfides, dispersed in solution vugs, along fractures, and within calcite cleavage planes. Deposition of secondary species appears to have been controlled by

have been established by distance measurement to planar or linear features, using the south end of the stope as a baseline, drawing rough maps, and later establishing orientation by comparison to NJZC mine level and stope maps, now in the possession of Sterling Hill Mining Museum. Because of errors in the rough drawing, the angular deviation estimated for this process is ±5°.

some of the N10°W-striking fractures. Other N10°W-striking fractures are filled with (a) massive secondary carbonate minerals, (b) thin mats of serpentine and earthy red hematite with or without brucite, (c) serpentine plus secondary willemite, or (d) serpentine and intermixed calcite and zincite, the latter the variety known locally as "calco-zincite." Secondary ore minerals occur only where openings penetrate ore, and it is a notable feature of the site that where fractures containing secondary ore minerals pass into marble, those species disappear abruptly, and sulfides appear instead. Such abrupt changes from secondary ore minerals to sulfides across the ore-marble contact are not unique to the Chalcopyrite Room but have been documented before, in the 970 stope, East Vein, on the 1000 level at Sterling Hill (E. R. Verbeek and M. A. Grout, written communication, 1991).

Some massive carbonate in fractures appears to be younger than sulfide oxidation, in that oxidation minerals occur on sulfide aggregates cut by those fractures but not in the carbonate filling. Minor alteration of the ore minerals is present adjacent to the sulfide occurrence, including thin hematite rinds on a few franklinite grains and a little serpentine replacing willemite. It is not certain when this alteration occurred.

MINERALOGY

General mineralogy of the Chalcopyrite Room, together with the relative abundance of species, is shown in Table 1. Although sulfide minerals do not occur in ore, the latter species are included in the table because many specimens consist of masses of ore attached to sulfide-replaced marble. Phases of particular mineralogic-paragenetic significance or special collector appeal are described individually below.

The stope exposure and about 600 hand specimens were examined for this study. Of the hand samples, some 60 were studied in detail. To make preliminary mineral identifications, all specimens were ex-
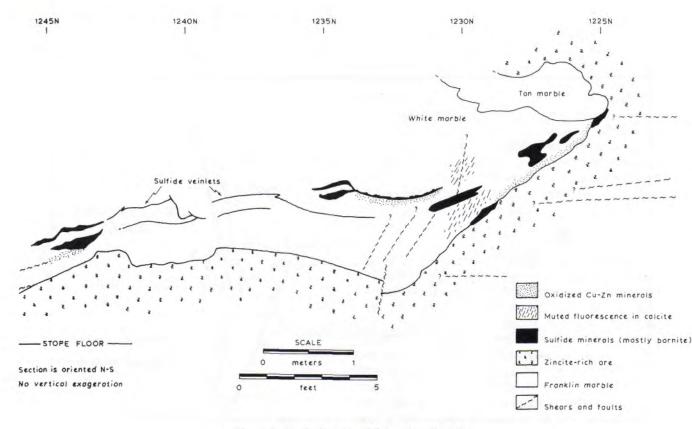
Figure 2. **Geologic map of the east wall of the Chalcopyrite Room, i.e. a vertical section, showing the sulfide occurrence and related features (mapping by Jenkins and Misiur, February 1991).**

amined with a binocular microscope, and in the case of some sulfide-rich samples, polished surfaces were studied with a metallographic microscope. Selected portions of specimens were then studied employing the following methods and instruments: scanning electron microscopy (JEOL JSM-840), electron probe micro-analysis (JEOL JXA-35, with KEVEX EDS detector, DEC PDP-1173 hardware control, and using TRACOR-NORTHERN software), X-ray powder photography and diffractometry (modified Philips Automated X-Ray Diffractometer, with DEC VAS-II hardware control and accepting 114-mm Gandolfi camera).[2] All specimens were checked for fluorescence, under both shortwave and longwave ultraviolet radiation, using Ultraviolet Products UVG-11, UVG-54 (both shortwave), UVL-21 (longwave), and Raytech LW-18L (also longwave). Also used was an experimental UVP lamp, fitted with a new generation filter, belonging to Mr. Richard Bostwick. All samples were studied by a combination of methods, but minerals are only considered verified where positive X-ray diffraction results have been obtained. Two species, although confirmed elsewhere in the Franklin-Sterling Hill area, remain unvalidated in the Chalcopyrite Room and are so noted in the table. Metal ratio data reported for bianchite and tetrahedrite-tennantite were measured using the TRACOR "SQ" semi-quantitative analysis program and the JXA-35 electron microprobe.

All instrumental work was done by the senior author at the Central Research-Experimental Station laboratories of E. I. DuPont de Nemours and Company. Mineral abundances and luminescence characteristics were documented by the second author, subsequent to laboratory investigation.

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[2] Abbreviations used: SEM = scanning electron microscope, EDS = energy-dispersive spectra, and BSE = back-scattered electron.

Aragonite $CaCO_3$

Aragonite occurs in lenticular solution vugs in calcite as coarse, radiating spherules as much as 2 cm in diameter. The solution cavities are very narrow, and the larger spherules are thus generally incomplete. Hematite, goethite, secondary rhombic calcite and quartz are associated in the openings, with aragonite the latest phase among them. All hand specimens containing aragonite also contain hemimorphite, hydrozincite and sparse malachite, but the paragenetic relationship of these minerals to aragonite is unknown. Aragonite from the Chalcopyrite Room is pale yellow to golden brown and fluoresces intense pale yellow in shortwave ultraviolet radiation. The longwave response, in contrast, is white to very pale yellow, and of moderate to bright intensity. No phosphorescence from aragonite was observed, but some specimens exhibit a brief red phosphorescence from inclusions of calcite after longwave excitation. Some also appear to contain nearly microscopic inclusions of orange-fluorescing sphalerite, although the identity of the latter was not verified instrumentally.

Aurichalcite $(Zn,Cu^{2+})_5(CO_3)_2(OH)_6$

Aurichalcite is relatively rare in the Chalcopyrite Room. It is present as typical blue-green fibers and fibrous aggregates, ranging from 1 to 5 mm in maximum dimension. It is associated with malachite and rosasite, and is deposited on calcite and corroded sphalerite. The fibrous aurichalcite on white calcite matrix makes handsome specimen material.

Bianchite $(Zn,Fe^{2+})(SO_4)\cdot 6H_2O$

Bianchite was first reported from Sterling Hill by Edwards (1971), based on an identification by John Hendricks some years earlier. No details of the method of confirmation, nor provenance of the material, were given. Later, a white efflorescent phase occurring abundantly on drift walls in red ore of the East Branch of the West Vein, 1100

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Figure 3. Aurichalcite rosettes on etched calcite; field of view is 3 x 4 mm; specimen J9133, Gary Grenier photograph.

Figure 5. Brochantite spherules on chalcocite-digenite-covellite in a vug in etched calcite; field of view is 3 x 4 mm; Gary Grenier specimen and photograph.

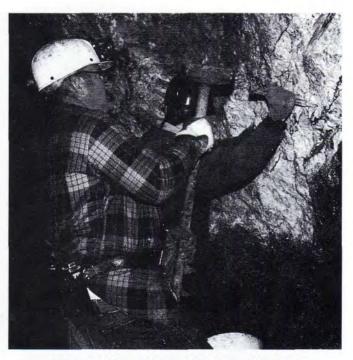*Figure 4*. Dick and Elna Hauck sampling aurichalcite and rosasite from an oxidized sphalerite-chalcocite veinlet at mine coordinates 776-1236N-710W.

Figure 6. Radiating hemimorphite aggregate on etched calcite; field of view is 3 x 4 mm; specimen J9175, Gary Grenier photograph.

level (J. L. Baum, personal communication, 1992) was examined by Cook (1973) and reported to be bianchite. Still later, Dunn (personal communication, 1992) re-examined the Baum-Cook sample and showed the efflorescent species to be hexahydrite. Bianchite is now reinstated as a Sterling Hill species and has been confirmed from the Chalcopyrite Room by both X-ray powder pattern and semi-quantitative analysis (atomic ratio, Zn:Fe:Mn approximately 55:45:5, no Mg or Cu detected for 100 seconds counting time). The mineral occurs as jackstraw aggregates of 20 to 30-micron needles or thin blades. Aggregates reach a maximum dimension of 2 mm, but most are much smaller and have the megascopic appearance of powdery coatings. Bianchite is white to yellow-white and is deposited on secondary calcite or on sulfide minerals. It has been confirmed on only one specimen, but white coatings showing similar EDS signature have been noted on a number of other samples. Bianchite is a very late, probably post-mining mineral.

Bornite Cu_5FeS_4

Bornite is the most abundant of the copper sulfide minerals and is present on about 85% of the specimens examined. Generally it forms disseminated grains either on etched calcite or imbedded in drusy quartz, but on several samples it is present as masses measuring up to 6 x 8 cm in cross-section, with the typical lavender-metallic luster and color. Much bornite has been replaced by other sulfide minerals

in boxworks described under chalcocite, and some is rimmed by chalcocite, digenite or djurleite. Marble adjacent to bornite-rich sulfide masses in many places exhibits a muted shortwave fluorescence, pink to dull red to violet-red. Bornite appears to be the earliest of the copper-bearing minerals, although its relationship to tetrahedrite-tennantite has not been established.

Brochantite $Cu_4(SO_4)(OH)_6$

Brochantite is the most abundant sulfate phase among the oxidation minerals and was found on about 10% of the samples. It is present as emerald-green to forest-green radiating globules and radial groups measuring up to 1 mm in diameter. It occurs in cavities in chalcocite-digenite-covellite boxwork masses and, less abundantly, in solution vugs in calcite. It is associated with malachite, devilline, friedelite, and locally hemimorphite. The luster of brochantite is distinctly higher
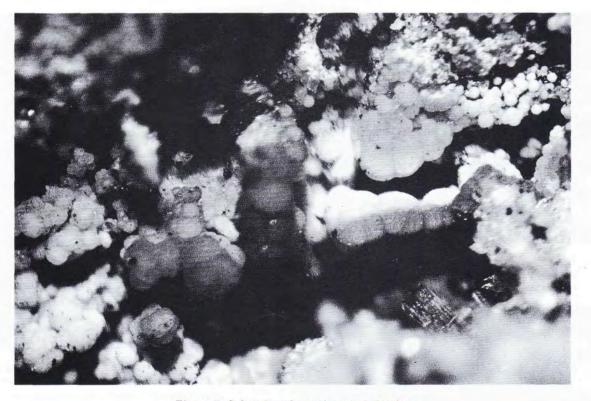
Figure 7. Spherules of rosasite on chalcocite-digenite-covellite; field of view is 3 x 4 mm; specimen ST770-1250S-11, Gary Grenier photograph.

Figure 8. Chalcopyrite-tennantite veinlet on ore-marble contact. Note replacement embayments in sulfide-calcite contacts; field of view is about 35 cm across; specimen CO241.

Figure 9. Microstalactites of wurtzite on etched calcite; field of view is 3 x 4 mm; specimen J9335, Gary Grenier photograph.

than that of the malachite with which it is associated.

Brucite $Mg(OH)_2$

Brucite, in white flakes as much as 0.5 mm across with typical pearly luster, is a minor constituent of the serpentine veinlets which fill some of the N10°W-striking fractures, lying near the orebody-marble contact.

Calcite $CaCO_3$

Calcite is common in all assemblages shown in the general mineralogic table, and the succeeding description applies only to the secondary mineral association with the oxidation products of the sulfide minerals. Secondary calcite is white to yellow-white or colorless. It occurs as rhombohedra or, more rarely, as scalenohedra, both as long
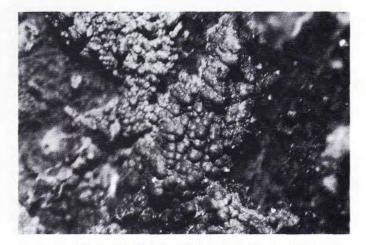
as 1.0 mm. Rhombic calcite was deposited atop various minerals, including sulfides, brochantite, friedelite and malachite, and is itself coated with hydrozincite, malachite, aurichalcite and, very rarely, bianchite. Scalenohedral calcite has been observed only as crusts deposited on etched calcite marble, on goethite, and on secondary rhombic calcite. Secondary rhombic calcites from the Chalcopyrite Room fluoresce very pale pink in shortwave ultraviolet radiation with no longwave response. One unusual specimen of the scalenohedral material, ST770-1250S-3, shows a similar shortwave response, but exhibits bright pale yellow fluorescence in longwave radiation with characteristic brief red phosphorescence. Massive carbonate, filling N10°W-striking veinlets from the site, is also calcite. This material contains variable but generally large amounts of Mg, Mn, Fe and Zn.

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Chalcocite/Digenite/Covellite $Cu_2S/Cu_9S_5/CuS$

Chalcocite, digenite and covellite are found together in complex aggregates which replace earlier chalcopyrite and bornite and commonly contain relicts of those two minerals. The aggregates range up to 10 x 15 cm in cross-section, with average size of about 3 x 5 cm. Individual copper sulfide grains measure 0.5 to 1 cm in length. The three minerals are not contemporaneous. Embayments in grain contacts (Cary texture) indicate that covellite replaces digenite, which in turn replaces chalcocite. Precursor copper-iron sulfides have been completely removed from parts of the aggregates, creating void space and leaving boxworks whose copper sulfide walls apparently follow the original chalcopyrite or bornite grain or fracture boundaries. Traces of chalcocite also occur with sphalerite in veinlets as much as 8 meters north of the principal sulfide concentration.

Chalcopyrite $CuFeS_2$

Chalcopyrite occurs as disseminated grains, veinlets and masses as large as 5 x 18 cm in cross-section. Some chalcopyrite probably developed by open-space filling, in that it is deposited against calcite cleavages, but most has replaced bornite or calcite marble. Veinlets and elongate masses of chalcopyrite strike N10°–15°W. Chalcopyrite contains inclusions of pyrite and galena and, like bornite, is partially replaced by chalcocite, digenite and covellite.

Devilline $CaCu_4(SO_4)_2(OH)_6 \cdot 3H_2O$

Devilline occurs as powdery, pale blue to pale green-blue coatings on chalcocite-digenite-covellite boxworks. Devilline coatings are seen to consist of jackstraw to parallel aggregates of 20-micron blades at SEM magnifications. The mineral is most commonly associated with brochantite and friedelite.

Djurleite $Cu_{31}S_{16}$

Djurleite is most interesting for its restricted occurrence, as thin (± 1 mm) alteration rims on a few specimens of otherwise fresh bornite. The rims are metallic in luster, medium gray in color, and are visually indistinguishable from tetrahedrite—tennantite from this site. The apparent absence of djurleite as a component of the chalcocite-digenite-covellite boxworks would appear to suggest highly localized conditions for formation of the mineral.

Friedelite $Mn_8Si_6O_{15}(OH,Cl)_{10}$

Friedelite is present as yellow to golden orange crystal crusts, which are seen to consist of simple trigonal to hexagonal plates, trigonal prisms, and lacy aggregates of indistinct habit at SEM magnifications. Maximum crystal size is about 0.1 mm. Friedelite occurs both on residual sulfides, where commonly it is coated with devilline, or on etched marble, where some is coated with secondary calcite. Although friedelite is fairly abundant in the assemblage, it only occurs in the main sulfide mass and in vuggy calcite up to 20 cm northward.

Hemimorphite $Zn_4Si_2O_7(OH)_2 \cdot H_2O$

Hemimorphite is not common in the Chalcopyrite Room, but it is one of the more attractive minerals from the location. It occurs as radiating groups of colorless blades, ranging from 0.5 to 2 mm in diameter. In cavities in altered sulfides it is associated with brochantite, devilline, malachite and, more rarely, with friedelite and siderite. In solution vugs in calcite marble it is associated with malachite and hydrozincite.

Hydrozincite $Zn_5(CO_3)_2(OH)_6$

Hydrozincite is very common, and is present on about two thirds of the samples examined. It generally occurs as white microcrystalline material lining vugs or partially filling fractures. On one exceptional specimen it is present as white spherules with radiating internal structure, ranging from 0.1 to 1.5 mm in diameter. Hydrozincite from the site fluoresces intense blue-white under shortwave ultraviolet radiation.

Malachite $Cu_2(CO_3)(OH)_2$

Malachite is the most common oxidized copper species in the assemblage, and is present on nearly half of the specimens examined. The mineral occurs on both sulfides and carbonates. On sulfide matrix malachite is generally associated with (but is later than) brochantite. On carbonates malachite is locally the only copper-containing species but elsewhere is associated with aurichalcite and, rarely, rosasite. Malachite occurs as medium green globules, as radiating masses, and as microcrystalline coatings. Globules and radiating masses average about 0.5 mm in diameter, whereas coatings cover areas up to a few cm^2. Malachite occurs over a wide area of the east wall of the stope, up to 10 meters northward from the principal sulfide mass.

Quartz SiO_2

The Chalcopyrite Room assemblage contains quartz in relative abundance. The quartz is present as drusy crusts of white to colorless crystals as long as 1.0 mm lining solutions vugs, and as massive replacements of calcite marble along fractures. It is intimately associated with the early sulfide minerals, bornite and sphalerite, but only rarely with their oxidation products. This suggests that some quartz-containing fractures were sealed prior to passage of the oxidizing fluids, perhaps by deposition of quartz itself.

Rosasite $(Cu,Zn)_2(CO_3)(OH)_2$

Rosasite was originally reported from the Sterling mine by Cook (1973), but in the mineral heretofore had been considered unconfirmed. The present study thus provides the first verification of this species from Sterling Hill. Rosasite occurs as green-blue spherules as much as 0.2 mm in diameter, associated with malachite and aurichalcite on corroded sphalerite in a N10°W-striking veinlet about 3.5 meters north of the main sulfide segregation. It also occurs within openings of sulfide boxwork masses and on tetrahedrite-tennantite in narrow veinlets. Rosasite was observed both in place and on several hand specimens, but it must be considered very rare. It is distinguishable from malachite of similar habit by the distinctive green-blue color.

Silver Ag

Native silver occurs as 0.5 to 1.0-mm sheets, tarnished black and intergrown with altered chalcocite, implanted on secondary calcite in solution vugs in bornite-rich hand specimens. Although the color of the chalcocite is slightly more bluish than that of the silver, the only certain methods of distinguishing between the two species are X-ray diffraction or chemical analysis.

Sphalerite ZnS

Sphalerite is present as typical yellow-brown to gray-black and submetallic cleavage masses and, very rarely, as crude crystals. There are two generations of the mineral. Sphalerite of the earlier generation is yellow-brown and occurs in veinlets intergrown with or deposited on quartz. Similar yellow-brown sphalerite in some hand specimens forms elongate clasts in quartz-cemented breccia. The sphalerite of this early generation is free from inclusions of galena and pyrite. Sphalerite of the later generation, in contrast, is gray to black, less abundant, and contains numerous inclusions of galena and pyrite; commonly it is intergrown with other sulfides, notably bornite, chalcocite and chalcopyrite. Most sphalerite of both generations is nonfluorescent, but some exhibits a dull orange longwave response. Early yellow-brown sphalerite is more likely to fluoresce than the second-generation material.

Tetrahedrite-Tennantite $(Cu,Fe)_{12}(Sb,As)_4S_{13}$

Both tetrahedrite and tennantite occur in the Chalcopyrite Room. Tennantite was previously reported from a Sterling Hill veinlet assemblage by Palache (1935), but the antimony-rich member of the series had gone unrecognized. Tetrahedrite is now confirmed from the Chalcopyrite Room by both X-ray powder pattern and semi-quantitative analysis. Sb:As ratios for tetrahedrite range from 80:20 to 65:35,

Figure 10. **Back-scattered electron image, tennantite (pale gray) replacing chalcopyrite (darker gray), both replaced by galena (white), in calcite; scale at base; specimen ST770-1250S-21.**

whereas the ratio for tennantite is 15:85. The two phases are megascopically indistinguishable and occur as steel-gray, granular masses as much as 1 cm across, associated with chalcopyrite, sphalerite, galena and nonfluorescent barite. Tennantite and the more As-rich varieties of tetrahedrite occur with chalcopyrite and galena, but the most Sb-rich tetrahedrite is associated with sphalerite and barite. Tetrahedrite and barite penetrate calcite of the marble along cleavages and fractures, producing embayments and indicating that both minerals have replaced calcite. A similar texture suggests that both minerals have also replaced early sphalerite. Tetrahedrite and barite appear however, to be contemporaneous. Tennantite replaces chalcopyrite and, in one specimen, is itself replaced by galena.

Wurtzite   (Zn,Fe)S

Wurtzite was identified on several specimens from the Chalcopyrite Room. It occurs as aggregates of golden brown hexagonal scales as much as 20 microns across on quartz, and as dark brown microstalactites, some masses of which reach 3.0 cm in maximum dimension. Material of both habits has been confirmed as wurtzite by X-ray diffraction analysis. It is deposited on calcite or, more rarely, on sphalerite. The specific polytype of Chalcopyrite Room wurtzite has not been determined. Wurtzite from the site is easily confused with some friedelite or with goethite coatings, and X-ray diffraction is the only certain means of identification.

DISCUSSION

The nature of the varied suite of minerals in the Chalcopyrite Room and its association with a well-defined fracture system suggest that those minerals have been derived by precipitation from hydrothermal fluids. The minerals have clearly not been formed through any single process, but rather have been formed through a succession of processes, some perhaps overlapping in time and others separated by episodes of fracturing or fracture reactivation. A possible sequence of events might be as follows:

(1) N10°W-striking fractures were developed across the ore-marble contact.

(2) Calcite was etched and quartz-sphalerite deposited along and within these early fractures.

(3) N35°E-striking fractures and associated breccias were developed in the area of the trough in the ore-marble contact before the close of quartz deposition.

Table 1. **General mineralogy and phase abundances of the Chalcopyrite Room.**

Assembl.[1]	Rarity[2]	
CS	R	Andradite
S	R	Anglesite
S	R	Antlerite (?)
S	R	Aragonite
S	C	Aurichalcite
S	C	Barite
S	A	Bornite
S	R	Bianchite
S	C	Brochantite
S	R	Brucite
All	A	Calcite
S	R	Cerussite
S	A	Chalcocite
S	C	Chalcopyrite
S	R	Chrysocolla
M	R	Clinochlore
S	A	Covellite
S	C	Devilline
S	A	Digenite
CS	R	Diopside
S	R	Djurleite
S	R	Dolomite
S	R	Fluorite
O	A	Franklinite
S	C	Friedelite
S	A	Galena
S	C	Goethite
S	R	Greenockite
S	R	Gypsum
S	A	Hematite
S	C	Hemimorphite
S	A	Hydrozincite
S	R	Kutnohorite (?)
S	A	Malachite
CS	R	Microcline
M	C	Phlogopite
S	C	Pyrite
S, CS	C	Quartz
S	R	Rosasite
M	R	Rutile
S	C	"Serpentines"
S	R	Siderite
S	R	Silver
S	R	Smithsonite
S	A	Sphalerite
S	R	Tennantite
O, CS	R	Tephroite
S	R	Tetrahedrite
M	R	Uvite
O, CS	A	Willemite
S	R	Wurtzite
O	C	Zincite

[1] Assemblages: S = secondary; O = ore; M = marble; CS = calc-silicate; All = occurs in all assemblages

[2] Rarity estimate is based on an examination of about 600 hand specimens. Species found on less than 10 specimens are considered rare (R); on 10 to 99 specimens, common (C); on 100 or more specimens, abundant (A).

Queries (?) denote species for which there is strong indication by SEM imaging and EDS signature, but for which no X-ray diffraction confirmation has been obtained.
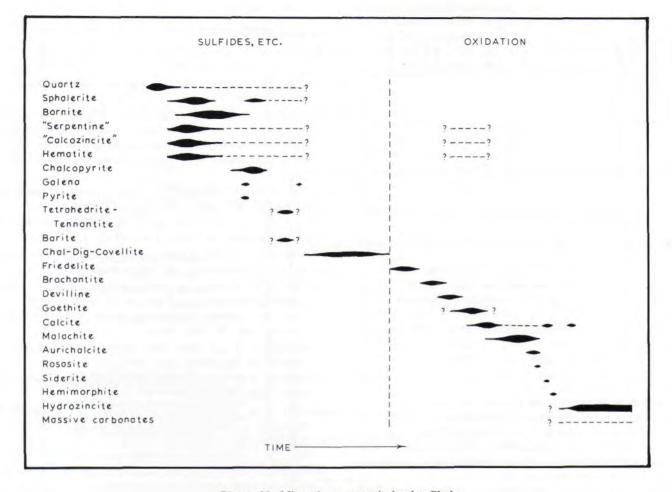
Figure 11. **Mineral paragenesis in the Chal-copyrite Room (area of symbols roughly pro-portional to phase abundance; dashed or que-ried where not certain; some minor species not included).**

(4) Bornite, sphalerite, chalcopyrite, pyrite, galena, tetrahedrite-tennantite and barite were deposited in the contact trough, breccias, and N35°E-striking fractures. Very limited deposition of the same sulfides also took place in earlier N10°W-striking openings in the same vicinity. Quartz was still a stable phase.

(5) Perhaps contemporaneous with (4) above, fluids interacting with ore minerals along fractures produced serpentine, secondary willemite and "calcozincite."

(6) The same (or perhaps other supergene) fluids enriched the copper-mineral suite to yield chalcocite-digenite-covellite boxworks, replacing bornite and chalcopyrite, and also the djurleite rims on bornite. The spatial effect of enrichment was very limited, again probably localized by the N35°E-striking fractures. There may have been little separation in time between enrichment and introduction of the earlier minerals. Note that greenockite, silver and perhaps wurtzite were probably formed during oxidation (see no. 8 below).

(7) Some N10°W-striking fractures were reactivated or new fractures of the same orientation formed.

(8) Oxidation of the sulfides and deposition of the various sulfate and carbonate species took place in and adjacent to N10°W-striking fractures. Sulfates, such as brochantite and devilline, formed only in contact with residual sulfides, whereas carbonates formed on sulfides, sulfates, and abundantly in the marble, the latter at distances up to 10 meters north from the principal sulfide concentration.

(9) Massive carbonates were deposited in other N10°W-striking

fractures.

These processes are summarized in the paragenetic diagram shown in Figure 11.

The sulfide and oxidation mineral assemblages of the Chalcopyrite Room are classic examples of rock-dominated hydrothermal fluid systems (E. R. Verbeek and M. A. Grout, personal communication, 1991), which is to say the ratio of the mass of fluid affecting mineralization and alteration to the mass of rock affected is relatively low, and the precursor mineralogy of rocks through which fluids have passed has had a profound influence on new minerals precipitated. This is reflected in the abrupt changes in sulfide-silicate mineralogy where fractures pass from marble to ore, the deposition of sulfate oxidation products directly on sulfides, and of carbonates on marble as well. It probably also explains the lack of pervasive hydrothermal alteration of the ore minerals. Excellent general discussions of the geochemistry of hydrothermal systems, including the effects of varying water:rock ratios, are found in Barnes (1979).

In a gross sense the oxidation paragenesis in the Chalcopyrite Room follows a typical trend of increasing pH with time, as indicated for example, by the deposition of carbonates atop sulfates. In a low-fluid system, however, where equilibrium may not be maintained over the entire volume being oxidized, it is conceivable that some carbonates may have formed at one location at the same time as sulfates at another.

The same argument might be advanced relative to the precipitation of Cu minerals at one site, while Zn phases were forming at a second.

The mineral suite from the Chalcopyrite Room is unusual in two respect. It is remarkably varied, about 40 hydrothermal or oxidation phases occurring within a volume of no more than a few cubic meters. Also, as already noted, quartz is a relatively important component of the paragenesis.

Beyond these two differences, however, the sulfide assemblage of the Chalcopyrite Room is similar in mineralogy to a large number of such occurrences scattered throughout the Franklin-Sterling region (Cummings, 1978, 1988). The oxidation paragenesis contains essentially no elements whose presence cannot be explained in terms of original sulfide or marble constituents. The number of species is perhaps best explained by three factors: overprint of mineralizing events; again, the low amount of fluid relative to rock affected, which aided spatial separation of different species; and by the relative abundance of various cations in solution at any given time, which would cause, for instance, Cu rather than Zn to be incorporated into a precipitating mineral and vice versa.

Quartz is not uncommon in the general area of the East Vein in which the Chalcopyrite Room workings lie. Quartz veinlets, replacement masses, and drusy coatings in cavities are widespread in all host rocks along the 700 level for distances of at least 10 meters south and 100 meters north of the presently described locality. The quartz-depositing event may also have assisted in preparation of open space for later precipitation of copper sulfide minerals, in that quartz is readily precipitated from relatively acid solutions, whereas calcite is dissolved, creating porosity.

Timing of the formation of the Chalcopyrite Room sulfide assemblage is unknown, but may relate to the development of larger scale structures not shown on Figure 2, such as the Nason Fault, a few tens of meters to the west, and a collapse-breccia body, perhaps a portion of a pipe, which intersects the orebody and separates the two openings of the 1250 stope. One or perhaps both of these structures may have served as a trunk conduit for the transmission of hydrothermal fluids into the Chalcopyrite Room vicinity, with subsequent migration of the fluids into the minor fractures in which mineral deposition took place. Metsger (1990) describes one collapse-breccia pipe at Sterling Hill and shows that its probable age is Ordovician. The age of the Nason Fault is uncertain. Oxidation is probably a relatively recent phenomenon. Metsger (1990) also describes the occurrence of oxidized copper minerals associated with the Mud Zone, a large saprolite body which partly replaces the Sterling Hill core from the surface to a depth of about 207 meters. He shows that saprolite and oxidized copper minerals have formed within the last 2 or 3 million years.

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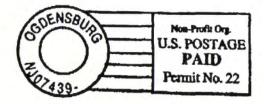$5.00 (+$0.50 postage per set)

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