Franklin Mineral Digest

Franklin Mineralogical Association

FRANKLIN MINERAL DIGEST

BOX 408 - MIDDLEBURGH, N. Y.

The following statements are taken from letters received by the secretary from Association members during the past year regarding the FMA, its activities and the Digest:

"I want to compliment you on this Digest, because I am certain it represents a great deal of work on your part and it is something you may well take pride in." G.J.S., White Plains, N.Y.

"Enjoyed the Digest and wish to compliment the Association for the nice job. I certainly feel the Association is setting out to perform a very valuable and worthwhile work." J.M.P., Bountiful, Utah

"I want to congratulate you and your club there in N.Y. I have just finished your fine work (Digest) on the Franklin complex. It will make a nice textbook, and I treasure it." G.C.D., Overland, Missouri

"This is a mighty fine issue, carrying a great deal of valuable data, and printed on extra good paper with a mighty fine mechanical job. You have done a lot of work here and I do hope it gets the support so justly deserved." H.C.D., Portland, Oregon

"It's a great service you folks have done in reprinting the Palache article as well as the other items in the first issue of the Digest." R.G.H., Des Moines, Iowa

"The Digest seems to have gone over very big in this section. Many of my friends were interested so I was able to get several to join the FMA." R.H., Bloomfield, N.J.

"I think this a wonderful organization (FMA) and the Franklin Mineral Digest is a very interesting document. I am proud indeed to be a part of this fine organization." E.J.A., Pittstown, N.J.

"We found this Digest extremely interesting and useful and would like to distribute these extra copies to some friends. I feel that every member of the club owes you a sincere vote of thanks for your efforts in producing this book." F.Z.E., Sparta, N.J.

"It looks like you have done an excellent job, and you and your organization are to be commended for your efforts and objectives in wishing to preserve the information about the Franklin minerals." K.W., Trenton, N.J.

"Congratulations on the first FMA Digest. For a mineral association so young, this is a truly great accomplishment. The publications alone are worth the price of membership." D.H., Gettysburg, Pennsylvania

"I was more than pleased to learn of the aims of the new Franklin Mineralogical Association. I should think that these aims will certainly fill a long-felt need." H.K., Union, N.J.

"I was greatly interested in the copy of the Digest you sent us." E. L., Los Angeles, California

"The copies of the Digest have been very well received here at the North Jersey Mineralogical Society." J.J.D., Clifton, N.J.

"I must compliment you and tell you what a marvelous accomplishment you have in this volume. That this represents an enormous amount of spare-time work is evident. Your material is well chosen, well edited, apparently complete and current, and beautifully presented. Again, my congratulations." C.A.B., Lansdale, Pennsylvania

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MAILING ADDRESS

Franklin Mineralogical Association, Gerald J. Navratil, Secretary-Treasurer and Editor,

Box No. 70, RFD No. 2, Middleburgh, New York

Preamble to the Constitution of the Franklin Mineralogical Association

We of the Franklin Mineralogical Association dedicate ourselves to the following principles and objectives:

(1) to unite all individuals interested in the Franklin-Sterling Hill, Sussex County, New Jersey district and to coordinate independent activities for mutual benefit.

(2) to gather and disseminate information relative to the district to all members via:

- a) a circulating library
- b) the Franklin Mineral Digest
- c) other means as prove workable

(3) to foster a spirit of individual responsibility to the group objectives.

(4) to safeguard, preserve and transmit to posterity the historical, geological and mineralogical knowledge pertinent to the Franklin district.

(5) to honor the memory of Bauer, Berman, Palache and the other giants of the Franklin era.

(6) to promote a campaign of safety-mindedness among collectors visiting the Franklin collecting areas.

(7) to aspire to a high order of scientific inquiry.

(8) to perpetuate the prominent position enjoyed by the Franklin district in the mineralogical world.

(9) to enhance the collections of individual members.

(10) to confirm the authenticity of minerals from the district.

(11) to establish a mineral museum representative of, and devoted exclusively to minerals from the Franklin district.

(12) to cooperate with existing groups and societies of kindred spirit.

THE MINERALS OF FRANKLIN AND STERLING HILL, SUSSEX COUNTY, NEW JERSEY, BY CHARLES PALACHE, GEOLOGICAL SURVEY PROFESSIONAL PAPER 180, 1935

ABSTRACT

The mineral deposits of the Franklin area are remarkable alike for their great size, their wealth of mineral species, and the unusual character of the minerals composing them. More than 140 minerals, described in this paper, have been found in the district, 32 of which were first found there, and 30 are not known elsewhere in the world. This proportion is the more noteworthy because among the 30 are included 2 of the 3 principal ore minerals of the district.

The chemical composition of the ore bodies is not less unusual than their mineral complexity. Oxides of zinc, iron, and manganese, in a ratio of 3 to $2\frac{1}{2}$ to 1, make up two thirds of their mass, and the remainder consists chiefly of calcite and silicates in a ratio of about 3 to 1. No other ore has an even remotely similar composition. It is therefore not remarkable that the interest of mineralogists has long been attracted to the deposits.

Geologists, too, find interesting problems in the area. The occurrence of similar deposits of roughly identical form at Franklin (formerly called Franklin Furnace) and at Sterling Hill, the age of the limestone containing them and its relation to other rock formations, the genesis of the ores and the processes through which they have acquired their present peculiar characters, and several minor problems—all have been and in part still are subjects of interested study and speculation.

Investigation of the Franklin ore deposits and minerals has extended over more than a century, but none of the many papers published concerning them includes an adequate description of both the deposits as a whole and of all the minerals found in them. Especially is there no comprehensive statement of the grouping of the minerals, as the lists of species issued from time to time give the reader little clue to the association of the minerals in the rocks. The preparation of this paper was first suggested by the realization of this lack, and the knowledge that the local collections are exceptionally complete and yet are inadequately described inspired the hope that it might be possible, even after a century of mining, to prepare a fairly complete and detailed description of the mineralogy of these remarkable deposits, in many respects the most interesting that this country possesses.

This paper contains a full description of the minerals of the district, preceded by a brief statement of their occurrence, geologic relations, and associations in the rocks and a resume of the several hypotheses of the origin of the ore deposits.

INTRODUCTION

Sources of Material

The study of the minerals of the Franklin area spans more than a century and is still far from complete. In this paper, data scattered through a score of journals have been compiled and combined to prepare a consistent and detailed description of the many minerals already found. The author has endeavored to summarize what has been published on the minerals known in the area and has therefore made many references to the literature. In order to avoid numerous footnotes, the papers in the practically complete bibliography, are listed chronologically and numbered serially, and references are made by inserting in the text, in parentheses, the numbers, as listed in the bibliography, of the papers cited.

It has also been possible, through the study of collections, to fill many gaps in the knowledge of some species, and the data regarding the place and mode of occurrence of all known species were obtained as completely as possible

Of the numerous collections studied, four stand out preeminently. Easily first is the Canfield collection, now in the United States National Museum. Begun about 1850 by Frederick Canfield and actively increased by his son, Frederick A. Canfield, it was long preserved in the family home near Dover, N. J. The suites of specimens from the earliest workings at both Mine Hill and Sterling Hill are very complete and are quite unrivaled. The collection is also rich in representative specimens of later discoveries. The frequent references to this collection in the mineral descriptions give some idea of the importance of the Canfield collection to the student of Franklin minerals.

The collection of Mr. E. P. Hancock, of Burlington, N. J., was particularly informing because most of its specimens were personally collected by him. During annual visits each mineral locality was watched and studied by him in company with Mr. Losey, of Franklin, and many new finds were made. Mr. Hancock was therefore able to furnish much valuable information regarding the occurrence of several minerals. After his death in 1916 his collection was acquired by Harvard University, where it is preserved intact as part of the Holden collection.

The Losey collection was long one of the mineralogic sights of Franklin. It had about the same range as the Hancock collection, as regards the earlier finds, but as the maker was no longer living when it was studied by the author it had to be viewed through Mr. Hancock's knowledge of it alone. It was acquired by Mr. A. F. Holden in 1911 and came to Harvard University as part of his bequest.

The collection of Mr. W. J. I. Kemble, at Newton, N. J., was also interesting, particularly for its personal associations. It was rich in series of the earlier mineral discoveries, and as Mr. Kemble's memories of Franklin reached back to the days when its mineral treasures were first being brought to light, and as many of his specimens had been collected on trips with visiting mineralogists of that earlier period, much valuable information was gained from study of this collection with its owner. The collection was dispersed after Mr. Kemble's death in 1915.

Other collections that furnished valuable data regarding Franklin minerals were those of J. J. McGovern, T. Lang, G. Rowe, E. D. Shuster, H. H. Hodgkinson, and G. Stanton, all in Franklin; that of W. A. Roebling, of Trenton, N. J., now in the National Museum; the collection at Rutgers College; the Bement, Caswell, and Columbia School of Mines collections in New York; the Brush collection at New Haven, with its many types of Franklin species; the Fiss collection of microminerals at Philadelphia; and the collections at Harvard University, among which the Stanton collection is now included.

ACKNOWLEDGMENTS

Through a variety of circumstances unnecessary to enumerate, this study has extended over a period of 25 years, and several of those to whom I am personally indebted are no longer living. Certain obligations, however, are too great to remain unmentioned.

Dr. John E. Wolff first suggested that I undertake the comprehensive study of the mineralogy of the Franklin district, my first visit to which was made in his company, and his aid has always been freely given. His intimate knowledge of the geology and mineralogy of the New Jersey Highlands, gained by years of close study, scant credit for which was given in the reports dealing with the area, has made his counsel particularly valuable.

To Mr. F. A. Canfield, who died in 1927, thanks were due for hospitality extended on repeated occasions, for invaluable information, for material for study, and for an excellent collection of photographs of his choicest specimens. Col. W. A. Roebling, until his death in 1927, repeatedly supplied material for investigation and comparison, and the study of his collection on more than one occasion yielded valuable data. Mr. Lazard Cahn has brought to the Harvard mineral collection, through a long term of years, many unusual specimens which his keen and discriminating eye had discovered in the local collections at Franklin, and these were placed freely at my disposal for study.

Mr. R. B. Gage, chemist of the Highway Commission of New Jersey, has supplied valuable chemical analyses and much material for study. Dr. C. H. Warren has contributed some unpublished analyses, and his friendly counsel has often been sought. During the last few years the most prolific source of information has been the staff of the chemical laboratory of the New Jersey Zinc Co. at Franklin. Mr. David Jenkins and Mr. L. H. Bauer have collaborated with me in many investigations, and several chemical analyses of Franklin minerals, made by them, are published here with the permission of the company.

To my colleague, Prof. E. S. Larsen, I am indebted for numerous optical determinations and for kindly advice, freely given. Also my assistants, Harry Berman and L. W. Lewis (died, 1933), have given me constant and unfailing help in optical and crystallographic determinations, in the separation of samples for chemical analysis, and in the preparation of many of the figures of crystals. Mr. Berman has also collaborated in the preparation of several papers on the minerals of the district. Mr. F. A. Gonyer has made several of the most recent analyses. Dr. Laurence LaForge has made a critical revision of the whole manuscript and has done much to eliminate from it the discrepancies resulting from repeated rewriting of parts of the text through a long period of years. He also made several of the drawings of crystals.

Bibliography (omitted)

THE FRANKLIN MINING DISTRICT General Features

Geology

The geologic relations of the ore deposits were described by A. C. Spencer in the Franklin Furnace folio (no. 161) of the Geologic Atlas of the United States, issued in 1908. The rocks of the district comprise limestone, sedimentary gneiss, igneous gneiss, and intrusive lenses of pegmatite, all of pre-Cambrian age, overlain on the west by the Hardyston quartzite (Cambrian) and Kittatinny limestone (Cambrian and Lower Ordovician). The pre-Cambrian rocks are cut by a few camptonite dikes of post-Ordovician age, and on the east the Kittatinny limestone is faulted down against the Franklin limestone. Glacial deposits of several sorts mask the bedrock of considerable areas.

The structure and composition of the ore bodies and the enclosing rocks are fully described in the folio, with maps and sections showing the extent and form of the ore bodies as known in 1908. The geologic map of the mining district published in the folio is reproduced as plate 1 in this paper, with the addition of the mineral localities most frequently referred to in the description of the minerals.

Little has been published since 1908 regarding the geology, and there has been no detailed description of the extensive mining developments of recent years, but the papers by Ries and Bowen and by Spurr and Lewis contain some valuable new information.

The two main ore bodies are essentially alike in form and composition. Both are tabular masses, folded in warped synclines with hookshaped outcrops and both are wholly enclosed in Franklin limestone, their folds pitching northeastward in accord with the general structure of the pre-Cambian rocks. Both consist chiefly of franklinite, willemite, zincite and calcite, the first three commercially valuable ores of zinc, manganese, and iron, and the fourth the only important gangue mineral. Normally these minerals are intimately intermixed in granular form, the grains of the ore minerals being in general noticeably rounded and the interlocking calcite grains forming the matrix of the mass. Generally also one or more of the ore minerals is somewhat concentrated in layers roughly parallel to the walls of the deposit, giving a markedly banded appearance to the mass of the ore.

History

Scientific knowledge of the Franklin minerals began with the discovery of zincite by Bruce in 1810, but scanty records of earlier date show that the deposits had long before attracted the attention of miners. Old deeds exist in which Sterling Hill, then known as the "Stirling tract," when returned to the heirs of Anthony Rutgers in 1730, was called the "copper tract." According to Farrington, mining engineer of the first New Jersey Zinc Co., the locality was probably first exploited by Dutch miners from the Hudson Valley, who worked copper deposits in the Delaware River drainage basin in 1640, sending their product through the Wallkill Valley to the Hudson at what is now Kingston. What ore they sought at Sterling Hill is not certain, but to them are assigned considerable mine workings there that were already ancient when Lord Stirling owned the property about 1770. They had probably mistaken the red zinc oxide for copper oxide, as did Lord Stirling, who about 1772 shipped some tons of it to England for smelting as an ore of copper. The ore shipped seems neither to have been smelted nor to have been recognized as really a zinc ore. Pieces of it, however, found their way into English mineral collections and later, their origin having been forgotten, were credited to various localities where zincite has never been found. Lord Stirling's attempt to utilize the abundant franklinite on his property as a source of iron was similarly unsuccessful. He sent a large amount of it to his furnace at Charlottesburg at great expense, but the unsuspected zinc and manganese in the ore prevented its successful smelting, and for years it lay on the ground unused. In spite of this failure an iron furnace was erected at Franklin about 1770, which was unsuccessful for the same reason and by 1820 had fallen into ruin.

The paper of Dr. Bruce, an enthusiastic mineralogist of New York City, describing the zincite and calling attention to its abundance and value as a zinc ore, was the first step toward a right understanding of its chemical composition. He did not, however, discover the true character of the more abundant franklinite, which he mistook for magnetite, as all before him had done. Still, Bruce's description of zincite caused the geologist Maclure to send abroad specimens of it, which contained franklinite. Some of these reached the French chemist Berthier, by whom that mineral was properly described as an oxide of zinc, manganese and iron. He named it from its place of origin and pointed out its value as an ore of all three of the contained metals.

In 1816 the mineral-bearing property came into the hands of Dr. Samuel Fowler, a man of scientific attainments and business talent of a high order. He was the first to appreciate the unusual character and great potential value of his mineral deposits, and he took every means of informing himself about them. His son, Col. Samuel Fowler, who later inherited the tract, resumed mining operations. The two Fowlers interested many leading chemists and geologists of the period, who visited the locality and recorded their observations in a number of papers. Between 1820 and 1844 the district was visited by Alger, Gibbs, C. T. Jackson, Keating, Maclure, Nuttall, Seybert, Torrey, Troost, and Vanuxem, and doubtless others of similar tastes made the pilgrimage to the hospitable home of the Fowlers. Nuttall and Torrey, especially, were deeply interested, visited the area frequently, and sent many specimens abroad, which were studied by European mineralogists and added much to our knowledge of the minerals. Vanuxem and Keating discovered willemite, the third important ore mineral, and they and Troost described jeffersonite and other new minerals. Alger, who about 1844 became part owner of the property, was also interested in the minerals, experimented at his Boston foundry on the reduction of the ores-unsuccessfully, it must be said-and was active in distributing broadcast to the scientific world specimens of the unique minerals of the district.

Dr. Fowler also attempted to develop his property commercially. Failing to enlist capital to work the deposits on a large scale, he used his own means to experiment on the uses of the newly discovered ores. He was not very successful but Ballou, one of his associates, was able to prepare white zinc oxide directly from. zincite and, grinding it in oil, to make paint that was used on the Fowler house at Franklin some years before that pigment was developed in Europe. In 1838 metallic zinc was reduced from zincite on a small scale, at Colonel Fowler's suggestion, to make brass for a new set of standard weights and measures for the United States government. Ultimately, Colonel Fowler sold the mineral properties, reaping but a scanty reward for his unceasing labor in making them known.

In 1850 the ore bodies were first successfully exploited by the first New Jersey Zinc Co., and since then there has never been a question of their value and usefulness. The complicated history of the mining and litigation during the development of the district to its present flourishing status will not be given here, but that history and that of the progress in the dressing and metallurgical treatment of the ores has been related by Wetherill, one of the participants in the events described. Further details of the early history of the mines may be found in the pamphlet by Shuster. Those interested in the present methods of mining the ores will find an excellent account in the paper by Haight and Tillson.

The outlines of the geologic structure and the principal minerals in the ore deposits having been described in the early papers, considerable time ensued during which little of scientific interest appeared. Local collectors, however, were actively watching developments at the mines, and several new and interesting minerals were found and preserved during those years. Colonel Fowler, Frederick Canfield, Woodruff, Losey, Hancock, and Kemble were the best known among the collectors of that period.

The exploitation of the calamine deposits at Sterling Hill, in 1870 led to the discovery of several new minerals, with whose description are associated the names of Moore, Roepper, and Brush. Active interest in the geology of the deposits was renewed with the sinking of the Trotter shaft in 1880 and the opening and stripping of the hook-shaped mass of ore in the Buckwheat open cut on Mine Hill. The discussion of the age of the ores and the white limestone containing them was settled only with the paper by Wolff and Brooks in 1898. The many minerals developed in pneumatolytic zones about the pegmatite at the Trotter shaft were described by Koenig and Penfield and reawoke mineralogic interest in those unique deposits, which was further heightened by the remarkable suite of new species found by Hancock and Ferrier in the workings at the Parker shaft in 1896 and described by Penfield and Wolff.

Since 1900 there have been many interesting additions to the list of Franklin minerals. As the bibliography shows, new species are frequently discovered and described. Every large collection of Franklin minerals contains much material not yet identified, and there seems to be almost no end to the variety of chemical compounds that might be formed under the peculiar conditions attending the development of this mineral deposit.

Mines and Mineral Localities

More than a century has passed since minerals from this area were first described. Few of the earlier papers gave details of the localities and the mode of occurrence of the minerals, and changing conditions of mining operations have made obsolete some of the locality names formerly used. In order to make clear many of the references to such localities a brief statement of the mining operations in the district seems necessary.

The original outcrop at Franklin (named Franklin Furnace until 1913) in the township of Hardyston, was a small eminence named at an early date Mine Hill. The outcrop, half a mile long, of the western leg of the ore body was first opened by cuts and inclined shafts worked independently. Such were the Hamburg mine, the Trotter mine, and the Dingdong shaft. In 1852 the eastern leg of the ore body was discovered in what was then called the Buckwheat field. The pitching synclinal connection of the two legs was laid bare much later and came to be known as the Buckwheat mine or Southwest opening, and still later, when worked by stripping, as the Buckwheat open cut. The Taylor mine was on the eastern leg of the ore body near the north end of the outcrop. About 1890 diamond drilling on the east side of Mine Hill proved the northward extension underground of the eastern leg of the ore body, which was reached by sinking the vertical Parker shaft, nearly 1,000 feet deep.

In 1897 all the properties at Mine Hill were consolidated under the management of the present New Jersey Zinc Co. and a new method of mining was established.

The Palmer shaft, an incline 1,500 feet long sunk in the footwall gneiss near the north end of the western outcrop of the ore body, was driven to the bottom of the syncline, and through it all ore is hoisted to a single concentrating plant. The ore is removed by a system of stope slicing and topslicing introduced by R. M. Catlin and described in a paper by Haight and Tillson, engineers of the mine. The ore as it reaches the shaft head is thrown on a grizzly. and the oversize passes on, after being washed, to a circular picking table, where waste is removed by several men. Specimens found on the picking table may therefore have come from any part of the mine, and only specimens actually found in the mine and located by the finder can be assigned to any definite locality other than merely Franklin. Many exact locations in the mine are given, however, in recent papers. Localities are designated by the depth and by pillar numbers, north or south of an east-west line through the Palmer shaft.

As pillars and slices are emptied of ore they are filled with waste, part of which is tailings and waste from the picking table but much more of which is rock broken from the mass of limestone between the two legs of the ore body and conveyed into the mine by chutes. All the older localities on and about Mine Hill that were within the original outcrops of the ore body, including all the older mines, have been obliterated by the later operations.

At Sterling Hill, in the township of Sparta, where the ore originally cropped out, as at Franklin, in an eastern and western leg or "vein," were the earliest authentically known workings, the Lord Stirling pits. The space between the two legs of the ore body was worked for calamine by two open-cut mines called the Passaic and the Noble. Work on the main ore body ceased about 1900, and the property was idle for a time. About 1913 a shaft was sunk and extensive underground development was begun. At Sterling Hill also there is a picking table, on which specimens are sometimes found. Caving operations to obtain filling material have obliterated the evidence of earlier mining in considerable parts of the Sterling Hill area, as at Franklin.

THE ORE DEPOSITS

Average Composition of The Ore

The average mineral and chemical composition of the ore of the Franklin district, as established by many hundred mill and assay tests, is approximately as follows:

Mineral		Chemical	
composition	Percent	composition	Percent
Franklinite	43	ZnO	31
Zincite	1	FeO	25
Willemite	26	MnO	10
Other silicates,	,		
such as garnet			
and rhodonite	5	SiO2	9
Calcite	25	CaCO3	25
	100		100

The data in the first column was kindly supplied by the New Jersey Zinc Co., with permission to publish them. The chemical composition was computed from them and is not exact, as some of the iron and manganese should be stated as sesquioxide.

In contrast to the rather simple mineral composition of the ore bodies as a whole are the number and variety of the minerals they contain in very minor amount. Of the more than 140 minerals found in the district, at least 120 are found in the zinc-ore deposits, and nearly 100 are found only in those deposits. (See list below). In the following sections the association of the minerals in groups according to their geologic occurrence, is described, with special reference to the further grouping of the minerals in the zinc ores according to their genetic relations. In order to concentrate attention on the problem of the origin of the zinc ores, the minor mineral associations will be described first.

Alphabetic list of the minerals of the Franklin district, showing their geologic occurrence:

(Occurrence in the zinc ores is indicated by A, in the pegmatite bodies by B, in the magnetite ores by C, in the Franklin limestone by D, and in the Kittatinny limestone by E. Minerals seen only as essential constituents of the rocks of the district are not included.)

Andradite-A,B,C,
D.
Anglesite-A.
Anhydrite-A.
Anorthite-D.

Apatite-A,B,C,D. Apophyllite-A. Aragonite-A. Arseniosiderite-A. Arsenopyrite-A,C, D,E. Aurichalcite-A. Azurite-A. Barite-A. Barvlite-A. Barysilite-A. Bementite-A. Beryllium vesuvianite-A. Bornite-A. Bustamite-A. Cahnite-A. Calamine-A. Calciothomsonite-A. Calcite-A,D,E. Calcium larsenite-Α. Celestite-A. Cerusite-B. Chalcocite-A. Chalcophanite-A. Chalcopyrite-A, B.D. Chloanthite-A. Chlorite-A. Chlorophoenicite-A. Chondrodite-D. Clinohedrite-A. Copper-A. Corundum-D. Crocidolite-A. Cuprite-A. Cuspidine-A. Cyprine-A. Datolite-A. Desaulesite-A. Descloizite-A. Diopside-A. Dolomite-A,D. Edenite-D. Epidote-A,B,C. Ferroaxinite-C. Ferroschallerite-A. Fluoborite-A. Fluorite-A.B.D.E. Fowlerite-A.B. Franklinite-A.

Friedelite-A. Gageite-A. Gahnite-A.D. Galena-A,B,D,E. Ganophyllite-A. Glaucochroite-A. Goethite-A. Graphite-D. Greenockite-A. Gvpsum-A. Hallovsite-A. Hancockite-A. Hardystonite-A. Hastingsite-A. Hedyphane-A. Hematite-A.D. Hetaerolite-A. Heulandite-A. Hodgkinsonte-A, D. Holdenite-A. Hyalophane-A. Hydrohetaerolite-A. Hydrozincite-A. Ilmenite-D. Jeffersonite-A,B. Kentrolite-A. Larsenite-A. Lead-A. Leucaugite-A,C,D. Leucophoenicite-A. Limonite-A. Lollingite-A. Losevite-A. Magnesium chlorophoenicite-A. Magnetite-A,B,C, D. Malachite-A. Manganbrucite-A. Manganite-A. Manganoaxinite-A. Manganophyllite-A.C. Manganosite-A. Marcasite-D. Margarosanite-A. Mcgovernite-A. Microcline-B,C. Millerite-A. Molybdenite-C,D.

Mooreite-A. Siderite-A. Muscovite-B.D. Silver-A. Nasonite-A. Smithsonite-A. Neotocite-A. Sphalerite-A,B,E. Spinel-B,C,D. Niccolite-A. Norbergite-D. Stilbite-A.B. Pargasite-A. Sussexite-A. Pectolite-A. Svabite-A. Phlogopite-C,D. Talc-A,D. Prehnite-A. Tennantite-A. Psilomelane-A. Tephroite-A. Pvrite-A.C.D. Thorite-B. Pyrochroite-A. Titanite-B.C.D. Pyrrhotite-D,E. Tourmaline-D. Quartz-A,B,D,E. Tremolite-A.D. Rhodochrosite-A. Willemite-A. Roeblingite-A. Xonotlite-A. Roepperite-A,D. Zincite-A. Rutile-C,D. Zinc cummington-Scapolite-C.D. ite-A. Schallerite-A. Zinc schefferite-A. Zircon-B,C. Schefferite-A. Zoisite-B. Serpentine-A.

Utilization of The Ores

The minerals that are saved as ore concentrates or that are recognized in milling operations as considerable constituents of the waste are not numerous. The ore minerals are franklinite, willemite, and zincite, and the chief waste minerals are calcite, garnet, fowlerite, tephroite, zinc schefferite, and sphalerite.

Franklinite, the most abundant mineral in the ore, is removed from the crushed ore by magnetic separators, and the concentrate, shipped to the smelting works as franklinite, constitutes about 36 percent of the crude mineral ore. The concentrate from the Franklin mine contains 14 to 18 percent of zinc, 34 to 40 percent of iron, and 12 to 16 percent of manganese. The franklinite from Sterling Hill has about the same composition, but some of it runs higher in both zinc and iron, and it is generally lower in manganese. The silica rarely exceeds 3 percent. The variation in the composition of the concentrate is due partly to the wide range in the composition of franklinite itself and partly to tiny particles of various silicates that may still be attached to the grains of franklinite, after the crushing. Franklinite is used in the manufacture of zinc oxide and of spiegeleisen.

Willemite is the most abundant constituent of the nonmagetic part of the ore. It is separated from the waste minerals by treatment in jigs for the coarser material and on tables for the finer material. The willemite concentrate from the Franklin mine, which constitutes about 18 percent of the crude milled ore, contains 44 to 49 percent of zinc, 1.2 to 3 percent of iron, 4 to 6 percent of manganese, and 3 to 7 percent of lime. From willemite is made a high-grade spelter.

Zincite constitutes less than 1 percent of the crude ore and in the milling is separated with the willemite.

Besides these definite mineral concentrates, about 25 percent of the crude ore is comprised in products known as half-and-half, dust fines, and slimes. The first is an intermediate magnetic product consisting of mixed grains of franklinite and silicates; the other two are mill products and are, of course, not of simple mineral composition.

The minerals separated as waste in milling constitute at the Franklin mine about 20 percent of the crude milled ore. Calcite, more or less manganiferous, forms 92 to 96 percent of the tailings, and next in abundance is andradite garnet, which sometimes is scarcely appreciable and at other times forms as much at 2 percent of the crude ore. Part of it is separated with the magnetic fraction and part with the willemite concentrate, in both of which it is an undesirable impurity. Fowlerite and tephroite are rarely present in large amounts. Both are separated mainly with the willemite and are undesirable because they increase the manganese content of the concentrate. Zinc schefferite is rare at Franklin, but at Sterling Hill it is in places sufficiently abundant to lower the grade of the willemite concentrate. Sphalerite is rare at Franklin but is common at Sterling Hill, both disseminated in the ore and as a vein filling. It may at times amount to nearly 1 percent of the willemite concentrate, in which it is separated. As it is not reduced in the smelting process it can be regarded only as a waste product.

Another element of economic importance in the mineralogy of the ore deposits is the presence of minute amounts of compounds of lead and arsenic, as even a trace of lead in the concentrate is objectionable. Besides its sparse occurrence as native lead and in galena, lead is found in the very rare silicates margarosanite, barysilite, nasonite, calcium larsenite, larsenite, and roeblingite and in the arsenate hedyphane. Of more importance is its persistent presence in hardystonite, as that mineral is much less rare than the true lead compounds. The arsenic compounds, though rather numerous, are rare and local. They include the arsenides chloanthite lollingite, and niccolite; the arsenates allactite, arseniosiderite, cahnite, chlorophoenicite, hedyphane, holdenite, and svabite; and the arseniosilicates schallerite and ferroschallerite and some of the friedelite.

All the minerals listed in the preceding paragraph are removed from the crude ore wherever possible, both in the mine and on the picking table. Their total amount in the ore as mined is inconsiderable, and such are the pains taken to check the lead content of the concentrate before smelting that the zinc manufactured from the ore is practically lead free.

PARAGENESIS OF THE MINERALS

Minerals In The Pegmatite Bodies Masses of pegmatite, ranging from rather large lenses to small dikes, form a considerable part of the pre-Cambrian complex. They cut both the gneiss and the limestone, and some of them at least are younger than the zinc-ore deposits, hence their intrusion probably continued through a long period. Spurr and Lewis pointed out that in some places the pegmatite dikes have been squeezed into lenses or even sheared into blocks that have reacted on their whole surface with the enclosing limestone. A shearing movement sufficient to dissect the pegmatite dikes so effectively could hardly have failed similarly to affect the nearby ore bodies had they been then in existence. As they are not so dislocated, it seems more reasonable to suppose that they were formed after the intrusion and deformation of the older pegmatites. The later pegmatites, on the contrary, cut the ore deposits and are not extensively deformed.

The pegmatites are of granitic composition and consist essentially of dominant microline and oligoclase, subordinate quartz, and accessory apatite, muscovite, titanite, epidote, and allanite and rarely thorite and zircon. Magnetite is rarely absent and may be dominant, as described in the next section. Galena and sphalerite in minute grains are common and are believed to be original constituents. Zoisite occurs as an alteration product of microcline. At the contacts of the pegmatite with the limestone and with the zinc-ore bodies, groups of reaction minerals and of pneumatolytic minerals have generally been developed. They are described on the next few pages.

Minerals In The Magnetite Deposits

Minable deposits of magnetite are found at several places in the Franklin district, both in the Franklin limestone and in the gneiss, and so intimately associated with the pegmatite bodies that the genetic relation of the two can scarcely be doubted. The minerals composing the iron ores, most of them except magnetite being in small amounts or very locally developed, are magnetite, microcline, leucaugite, epidote, allanite, biotite, phlogopite, scapolite, iron axinite, iron garnet, iron spinel, apatite, pyrite, arsenopyrite, molybdenite, rutile, titanite, and zircon. This grouping of minerals makes highly probable the genetic relations of the magnetite bodies to the pegmatites that is indicated by their geologic relation. The absence of zinc and manganese compounds is also a noteworthy feature of the iron ores, although minute traces of both those metals have been detected in the magnetite.

Minerals In The Franklin Limestone

The Franklin limestone, commonly called the "white limestone" from its color, is a coarsely crystalline rock, ranging in composition from nearly pure calcium carbonate to a magnesian carbonate with almost the ratio of dolomite. The differences in compostition do not affect its appearance or degree of crystallinity. Near the ore deposits the rock is manganesian and weathers black.

The white limestone, long guarried as a flux at Franklin, Sterling Hill and Rudeville, is well exposed and has yielded much material to mineral collectors. It contains a group of minerals that carry neither zinc nor manganese and are either very rare or unknown in the zinc-ore deposits. In some places these minerals are found near dikes of pegmatite or of basic rocks, and their formation was probably due to interaction with the igneous material. More commonly, however, they are quite isolated in the limestone and either are products of its recrystallization during metamorphism or were formed by the introduction from intrusive rocks of new elements that had migrated far from their source.

The minerals in the pegmatite contact zone in the limestone include amphiboles, mainly tremolite and edenite; pyroxenes, especially diopside and leucaugite; scapolite; green and brown magnesian tourmaline; and chondrodite and norbergite, intergrown or separate. The author

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has never seen garnet in the limestone away from the zinc ores, though Spurr and Lewis describe it from the wall of the ore body. All the minerals named above except pyroxene contain some "mineralizer" such as hydroxyl, chlorine, fluorine, or boron—a fact that hardly supports the statement of Spurr and Lewis that the minerals are due to simple heat reactions without the presence of gas.

The minerals found in isolated crystals or grains in the Franklin limestone include all those named in the preceding paragraph and also graphite, molybdenite, chalcopyrite, pyrite, pyrrhotite, arsenopyrite, fluorite, quartz, corundum, hematite, ilmenite, magnetite, spinel, rutile, anorthite, phlogopite, titanite and apatite. This group is typical of such highly metamorphosed limestones, and it is duplicated, with minor changes, at the well-known mineral localities in Orange County, N. Y., a score of miles to the north in the same belt of Franklin limestone, and in many other limestones. In its formation it clearly owed nothing to the agencies that produced the ore bodies.

Minerals In The Kittatinny Limestone

The Paleozoic strata have not been notably metamorphosed or mineralized, but they were invaded, presumably late in Triassic time, by dikes of camptonite and nephelite syenite, and they have been profoundly faulted, probably late in the Paleozoic era and again at the end of the Triassic period. Spurr and Lewis record "irregular subsequent impregnations of fluorite, arsenopyrite, pyrrhotite, sphalerite, galena and many other minerals" of the sort associated with such dikes cutting limestone. At several places in the limestone there are irregular cavities on whose walls are crystals of fluorite, quartz, calcite, albite, and sphalerite.

These occurrences are of minor significance in the mineralogy of the district but show the presence of sulphide-bearing solutions, probably during the latest marked deformation. To such solutions, quite possibly, are due the small and rare veins of quartz, pyrite, sphalerite, and carbonates that cut the ore deposits.

Minerals In The Zinc Ores Genetic Classification

There remain for consideration the minerals found in the zinc-ore deposits, by far the most valuable as well as the most numerous association found in the district. They have been grouped for discussion as follows: Primary minerals.

- Minerals of the pegmatite contact zones.
 - Reaction and recrystallization products, or "skarn."
- Pneumatolytic products.
- Minerals of the hydrothermal veins.
- Minerals resulting from surface oxidation, hydration and carbonization.

It is clearly recognized that the several groups merge more or less, as all stages of alteration are represented, and several of the minerals are found in more than one group.

This suggested classification in genetic groups is of course hypothetical, but it serves to simplify the description of the paragenesis. Most of the conclusions here presented are based primarily on the study of the hand specimens, as no detailed or systematic study of the ores in place has been made by the author nor, so far as he is aware, by any other geologist or mineralogist of the many who have visited or who have written about these deposits.

Primary Minerals

The minerals certainly to be regarded as primary are the four-franklinite, willemite, zincite, and calcite-that make up nearly the whole mass of the two ore bodies, at Franklin and at Sterling Hill. To these may be added tephroite as a rare, probably primary associate of willemite. The average percentage of each of the four principal minerals in the ore has previously been given. There are, however, several wide departures from the average. Franklinite, alone or with calcite, forms some large masses of ore, and zincite is segregated in some masses almost to the exclusion of the other minerals. Willemite is in a few places the only ore mineral in the calcite gangue. The typical ore, however, is a layered mass of all four minerals in rather coarse grains.

The relative age of the four ore minerals was determined by Ries and Bowen through the study of thin sections of the ore. These show that tephroite and willemite are the earlier minerals and that their formation was followed by that of the franklinite and zincite but with some overlap in time.

Of the four ore minerals, only tephroite and willemite have been found elsewhere, and only as subordinate constituents of ores of manganese and zinc. The exceptional mineral character of the Franklin ores is convincing evidence of unusual conditions controlling their deposition.

Minerals In The Pegmatite Contact Zones

General features.—The minerals in the pegmatite contact zones form a complex group that includes more than half of the species peculiar to the district, as listed below:

Minerals found only at Franklin or Sterling Hill, N. J.

(Species found at Franklin, F; at Sterling Hill, S; Margarosanite and nasonite first found at Franklin, are known elsewhere only at Langban, Sweden.)

Cahnite, F. Chalcophanite, S. Magnesium chloro- phoenicite, F. Desaulesite, F.	Mooreite, S. Roepperite, S. Sussexite, F. Zinc cummington-
Calcium larsenite, F. Chlorophoenicite,	ite, F. Gageite, F. Hancockite, F.
F. Clinohedrite, F. Ferroschallerite, F. Franklinite, F, S.	Hetaerolite, F. Holdenite, F. Larsenite, F. Loseyite, F.
Glaucochroite, F. Hardystonite, F. Hodgkinsonite, F. Jeffersonite, F, S.	Mooreite, S. Roeblingite, F. Schallerite, F. Zincite, F, S. Zinc, schefferite, F.
Mcgovernite, S.	S.

There is a lack of detailed observations in most of the mines to support conclusions based on the chemical nature of the minerals, but in the Trotter mine the relations displayed were definite and conclusive. Plainly the great heat of the intrusive pegmatite not only caused recrystallization of the primary minerals of the ore but also set up a vigorous interaction between those minerals and the constituents of the pegmatite magma near the contact, and the magma was rich in volatile constituents, differing from place to place, which combined with the ore minerals in a variety of new compounds. These reactions seem to have continued through a long period of falling temperature to merge at length with purely hydrothermal processes, whose products are classed in another group.

The group of contact—zone minerals comprises two overlapping sub-groups. One, to which the convenient Swedish mining term "skarn" is applied, includes silicates and oxides, which are conspicuous, especially at Franklin, for their abundance and brilliant colors. Most of them are direct reaction products between ore minerals and the silica and alumina of the pegmatite. The other subgroup is termed pneumatolytic because it includes mostly minerals that contain volatile elements or metals clearly derived from the pegmatite magma.

Skarn and recrystallization products. — The skarn minerals, are chiefly characterized by containing zinc, iron, or manganese, or all three. Rhodonite is particularly abundant at Franklin, in great masses crystallized against calcite. At Sterling Hill the skarn was composed chiefly of jeffersonite and gahnite, but roepperite was abundant in places, as were large crystals of manganese hornblende. The cyprine varietv of vesuvianite occurs at Franklin intergrown with pegmatite and with rhodonite. Hardystonite, found only at Franklin, seems to be transitional to the next subgroup, as it invariably contains traces of lead.

The primary ore minerals, in coarse aggregates and large well-formed crystals, are found with skarn in many places and also in independent masses. Franklinite in octahedrons and dodecahedrons as much as 6 inches in diameter; willemite, particularly the manganiferous variety troostite, in stout hexagonal prisms a foot or more long; and zincite in broad plates as much as 6 inches across, are examples of recrystallization. Their association with skarn in some places indicates that they are related to the pegmatite intrusions, but in some places they have no such visible relation. The most notable occurrence of the latter sort was found in the early workings at Sterling Hill, where pegmatite is less abundant than at Mine Hill. At such places local accumulations of water may have become an active solvent through heating by intrusions at some distance.

In a few places recrystallization seems to have been accompanied by some breaking down of the original minerals. This is indicated by the occurrence of manganosite, although the MnO molecule is usually present only as a constituent of franklinite or in solid solution in zincite. Another example of it is the development of masses of hematite with a remarkable cubelike parting, intergrown with franklinite. These masses may have been formed by the separation of some of the iron of franklinite during the recrystallization.

Pneumatolytic products. — The subgroup composed of pneumatolytic products, which is practically confined to Franklin, includes a great variety of minerals, chiefly silicates, containing some element not normally present in either the ore or the pegmatite, such as lead, chlorine, fluorine, boron, arsenic, and sulphur, with or without hydroxyl. A number of metallic sulphides are placed in this subgroup with considerable doubt.

The mode of occurrence of these minerals is various. Some of them form irregular masses mingled with skarn minerals, which they seem to replace; others fill definite veins in ore or skarn, along whose walls more or less replacement of the older minerals has occurred. The detailed paragenesis is almost infinitely variable, and only a few examples are mentioned.

The early development of the Trotter mine brought to light a pegmatite which was notable for the presence of green microcline and allanite. At the surface about the mine there was an abundance of garnet skarn, and throughout the mine rhodonite and manganese axinite were plentiful. Niccolite and chloanthite were found in considerable masses mingled with sphalerite and purple fluorite.

The ore body in the vicinity of the Parker shaft contained great masses of garnet-rhodonite-axinite skarn, associated with which were many lead silicates. Here were first found nasonite, margarosanite, roeblingite, and hancockite, and with them the hydroxyl silicates leucophoenicite, clinohedrite, pectolite, and prehnite. At this locality fluorine is a constituent of fluorite, cuspidine, and apatite, and copper occurs native and in cyprine. Much the same suite of minerals was found in the replacement veins containing the recently found lead silicates, larsenite and calcium larsenite. Cahnite, a calcium boroarsenate, was found in cavities in axinite, in veins with willemite, hedyphane, and datolite, and in open vugs in rhodonite veins.

Veins with the succession garnet, tephroite, willemite, barite, calcite seem to belong in this subgroup. Hodgkinsonite and leucophoenicite, the latter especially likely to be associated with sussexite, are widespread both as replacement and as vein minerals. Willemite in particularly fine, complex crystals is characteristic of the subgroup, and franklinite, where developed in open veins, has a rare cubical habit.

The metallic sulphides of this subgroup occur mostly in ill-defined masses that apparently have replaced normal ore. They rarely show any relation to the pegmatites and may be of much later introduction. As typical examples of their grouping may be mentioned chalcocite surrounding octahedrons of magnetite and separated from them by films of native silver; films of native copper and of native lead in axinitewillemite-barite veins; and granular aggregates of galena, chalcopyrite, bornite, pyrite, lollingite, and sphalerite, alone or variously mingled. All these occurrences of sulphides are small and rare.

There is no sharp delimitation between the pneumatolytic veins and those of the next or hydrothermal group. Some species of minerals are found in both, but in the hydrothermal group there is less evidence of replacement in the walls, the veins being in general clearly fissure veins.

Minerals of The Hydrothermal Veins

The mineralogy of the hydrothermal veins is scarcely less complex than that of the pneumatolytic yeins. Many of the minerals, however, were obviously formed at lower temperatures than the pneumatolytic minerals and either farther from the pegmatitic intrusions or during later fissuring. The fissures are either wholly filled or are open and crystal-lined, and the veins are of characteristic form with cleancut walls. They are generally short and small, as a rule but a few inches thick, and many are mere seams less than an inch thick. Thus, although they are fairly numerous, their total bulk is insignificant compared to the great mass of the ore bodies. Their most notable characteristic is their great variety of mineral contents, as may be gathered from the following selected examples of associations found in the collections.

A typical example is the paragenesis, garnet, willemite, zincite, leucophoenicite, gageite, chlorophoenicite, pyrochroite, calcite. Another is the combination hodgkinsonite, willemite, hetaerolite, calcite. Rhodonite, friedelite, schallerite, and mcgovernite are each found as the sole filling of numerous fissures. Friedelite is ordinarily followed by barite and calcite. Willemite, especially the light-green or white fibrous variety, low in manganese and highly phosphorescent, is a common vein filling. Zincite is known in crystals only from vugs in calcite veins, and the form called "calcozincite" is really a mixture of granular zincite with fibrous calcite, generally coating slickensides in ore.

The arsenates hedyphane, holdenite, and allactite are found in veins with calcite, whereas chlorophoenicite is found with gageite and acicular willemite. Ganophyllite and heulandite are found in veins with rhodonite or sulphides. The other zeolites of the list are minor vein minerals. Sussexite is typically a vein mineral, its asbestiform fibers filling narrow cracks or coating slickensides in ore. It is closely simulated by veins of fibrous tremolite mixed with calcite.

Another type of vein common at Franklin consists dominantly of some carbonate, as a rule strikingly layered parallel to the walls. In some places the filling is calcite with or without fibrous willemite, in other places it is siderite or an intermediate calcium - magnesium - iron carbonate, and in still others it is rhodochrosite or smithsonite. Dolomite constitutes the filling of a few veins with open vugs lined with crystals of dolomite, calcite, albite, quartz, or sphalerite, and more rarely with millerite, marcasite, or the oxides goethite, manganite, and hematite. Pyrochroite and chalcophanite are also found in calcite veins, and aragonite, in radiating needles, coats cracks.

Compact quartz, alone or with massive sphalerite or pyrite, forms thin clean-cut veins and in places shows crystals on free surfaces. On the whole, quartz is rare at Franklin. The parageneses calcite, sphalerite, and calcite, sphalerite, quartz, willemite, crocidolite are common and conspicuous vein formations. In fact, it is only in these veins that sphalerite occurs in any noteworthy amount at Franklin, except in the mass at the Trotter mine.

Bementite and the closely related manganesebearing serpentine are not uncommon as vein fillings, alone or more commonly with a carbonate such as rhodochrosite or smithsonite.

It seems highly probable that the carbonate and quartz veins containing sulphides were formed during the much later post-Paleozoic deformation, as suggested in an earlier paragraph.

Minerals Resulting From Surface Oxidation And Other Alteration

With one notable exception the minerals formed by surface alteration are of minor interest in the Franklin district. Manganese-bearing serpentine forms pseudomorphs after rhodonite, and desaulesite has replaced niccolite and chloanthite at the Trotter mine. Quartz, hematite, and limonite form gossans on a few pyritic veins at Franklin, and small amounts of calamine and hydrozincite are found in the gossans of veins of sphalerite. The ordinary copper oxidation minerals form about the rare copper sulphides, and descloizite, cerusite, and anglesite are the alteration products of galena in a pyroxene skarn at Sterling Hill.

The exception noted above was so remarkable that it requires special description. During the seventies the Nobel and Passaic mines, open pits in two great bodies of calamine lying in the angle between the two legs of the ore body were the chief sources of zinc ore mined at Sterling Hill. When mining was begun there that area was a shallow watercourse, and the pits were carried to a depth of more than 40 feet below the original surface. In 1906 the sites of the ore bodies were occupied by two great excavations, having roughly the shape of inverted cones, separated by a wall of barren pegmatite. The bare limestone walls of the ore bodies then remained as they were left by the stripping and were clearly seen to be solution surfaces, probably the result of long-continued action by ground water. These exposures have long since been caved in by the later mining at Sterling Hill.

Mr. O. J. Conley, superintendent of the Nobel mine in 1878, kindly went over the ground with the author and described the deposit, of which no contemporary account was published. According to Mr. Conley the calamine formed a layer 6 to 12 inches thick, lying directly on the limestone. The principal filling of the excavated mass was more or less fragmental, consisting of sand, clay, limestone fragments, and loose and broken crystals of franklinite, willemite, garnet, and the like, all stained by oxides of iron and manganese. Separating this loose material from the calamine layer on the north side of the pit was a layer, as much as 4 inches thick, of greasy black mud, rich in manganese, which was the cause of dangerous slides in the pit. On the south side, in a similar relation to the calamine, were found the deposits of chalcophanite and hydrohetaerolite characteristic of this locality. Excellent specimens of the calamine are preserved in collections, and nearly all those examined showed considerable harsh brown or yellow clay adhering to their lower surfaces. This clay is rich in zinc and has been called vanuxemite.

The relations of the calamine deposits to the main ore bed, as described by Mr. Conley, fully established their secondary nature. There is however, other direct evidence in the presence, in the fragmental material from the pit, of crystals of willemite still retaining their form but wholly covered with needles of calamine stained with manganese and of deeply corroded franklinite crystals enclosed by and embedded in calamine. These zinc and manganese ore deposits resulted from the weathering of a part of the outcropping ore body, the products of solution being carried to a lower position, where they replaced the limestone with zinc silicate and hydrous oxides of zinc, iron, and manganese. The reason for describing this deposit at such length is that it seems to throw some light on the origin of the major deposits, as shown in the next section.

ORIGIN OF THE ZINC ORE DEPOSITS

The vexed question of the origin of these unique ore deposits has often been discussed, and a full treatment of the matter will not be attempted here. The paper by Ries and Bowen contains an excellent summary of the several hypotheses that have been proposed, and this may well be repeated with some comments. Among these hypotheses those outlined below are outstanding.

Igneous - injection hypothesis. - This hypothesis was first offered by Rogers in 1836 and was suggested by Spencer in the Franklin Furnace folio in 1908 as the best of several alternatives. It was rejected by Ries and Bowen in 1922 on the ground that it does not account for the admixture of grains of Franklin limestone with the ore minerals. Nevertheless it was advocated by Spurr and Lewis in 1925, the ores being regarded by them as igneous vein dikes of sulphide magma that lost their sulphur by a later distillation at a temperature above that of fusion. How the required oxygen was supplied is not revealed. To the present author it seems that the strongest evidence against this hypothesis lies in the mineral and chemical character of the ores.

Sedimentary — deposition hypothesis. — The hypothesis that the zinc ores were originally sediments deposited with the enclosing limestone and since metamorphosed with it was first proposed by Kitchell in 1855 and was maintained by the geologists of the New Jersey Survey as late as 1896. It is difficult to establish, as there is no way of determining whether the layering of the ore is parallel to the original bedding of the limestone, and it does not explain the structure of the Sterling Hill deposit as now developed by more recent mining operations.

Contact—metamorphism hypothesis. — The hypothesis of the development of the ores through contact metamorphism due to the intrusion of the pegmatites was first proposed by Nason in 1890 and was advocated in 1893 by Kemp, who misinterpreted the relations of the pegmatite dikes, then poorly exposed, to the ore bodies. It was rejected by Ries and Bowen on evidence similar to that given above, proving that the pegmatites that are in contact with the zinc-ore bodies are intrusive into them.

Hypothesis of replacement from magmatic solutions.—This hypothesis was adopted by Ries and Bowen. They were in some doubt whether the replacement preceded or followed the folding of the limestone but decided that it preceded the folding. According to them the "primary" minerals — willemite, franklinite, and zincite — were deposited directly, in the order given, from magmatic solutions.

The chemical nature of these minerals is such that it seems unlikely to the author that they originated through deposition from magmatic solutions. As far as he is aware, wherever zinc ores have indubitably been so deposited, it was the sulphide that was formed, and the absence of metallic sulphides is one of the characteristics of the primary ores of the Franklin district.

Metasomatic—emplacement hypothesis.—The author has reached the conclusion that the ore bodies were formed by metasomatic emplacement in the limestone in pre-Cambrian time, before its regional metamorphism. He believes also that they were deposited near the surface under oxidizing conditions, and that they probably consisted largely of the hydrous zinc silicate, calamine, together with hydrous oxides of iron and manganese and perhaps carbonates of zinc and manganese. The depositing solution is believed to have derived its metallic contents from the products of oxidation of a previously existent mass of mixed sulphides.

These oxidized minerals were probably deposited in more or less well layered masses whose form may have been determined by a previous folding of the limestone, which directed the flow of the depositing solution. The minerals at present constituting the deposits were, on this hypothesis, formed by dehydration and recrystallization during later profound and longcontinued regional metamorphism of all the pre-Cambrian rocks of the region. Thus the minerals of the ore deposits acquired their characteristic texture and structure, so very like those of the enclosing limestone. The established sequence in the ages of the minerals, the oxides being developed after the silicate, seems entirely consonant with the suggested mode of origin.

That these ore bodies originated through metasomatic emplacement was first suggested to the writer by the characters of two other deposits of zinc ores having a related origin. The first is a small-scale illustration that has the advantage of being situated in the Franklin area — the calamine deposit at Sterling Hill. There had been accumulated a rich ore deposit made up of parallel layers of calamine, smithsonite, zinciferous clay and hydrous oxides of iron and manganese, and the layering followed the walls of the cavity in the limestone by whose solution a place for the new ore was formed. The source of this ore was the nearby franklinite-willemite mass, and the new ore was constituted in such a fashion that, had it and the surrounding limestone been subjected to a vigorous deep-seated, high-temperature metamorphism, there might well have resulted from its dehydration and recrystallization a new deposit closely analogous to the parent mass.

The second illustration is drawn from the published descriptions of the well-known deposits of zinc ore at Moresnet, Belgium, where there are vast sphalerite replacement deposits in Paleozoic dolomite. The sphalerite has undergone profound oxidation, and the soluble products have been transferred to the nearby dolomite and have there been accumulated in synclinal folds that halted the circulation. Extensive deposits consisting principally of calamine, with some smithsonite and limonite, have thus been formed in bodies whose shape, although in general determined by the structure of the dolomite, is independent in detail of anything except the solvent action of the depositing solution. It seems not unlikely that the Belgian deposits of desulphurized zinc and iron ores are in all respects except in the absence of manganese a good presentment of the New Jersey zinc ores before the great metamorphism.

This hypothesis of metasomatic emplacement of the ore seems to account for the observed facts without essential conflict. The localization in the limestone is necessary, and the duplication is not remarkable. The form of the ore

bodies may be quite independent of the sedimentary structure. The pitching synclines conform in attitude to the general structure of the gneiss, but how much of the folding may have been effected during metamorphism cannot be determined. However, that does not matter, as the original form of the deposits may have been anything from a simple layer to a mass whose form was not unlike that now seen. The identical texture of ore and country rock, the layering of the ore, the abrupt passage from ore to barren limestone, the dying out of the ore northward along the strike at Mine Hill, the sporadic occurrence of disseminated ore within the fold in the limestone at Sterling Hill-all are satisfactorily accounted for by the suggested process.

The chemical composition of the ore is unusual, chiefly in the association of zinc with both iron and manganese, but metamorphosed metasomatic deposits of iron and manganese ore are not unknown, and the addition of the third metal merely indicates deposition under unusual original conditions. The mineral composition of the ore is conformable to the hypothesis-there is no comparable example for willemite, but franklinite is a spinel and is therefore to be expected as a product of the postulated mode of formation. Light is thrown on the presence of zincite in the recent study by Magnusson of the Langban deposits, where manganosite (MnO) and periclase (MgO with a trace of ZnO) are shown to have been formed from the carbonates of manganese and magnesium, respectively, by high-temperature metamorphism. In such fashion zincite may have been formed by the breaking down of smithsonite in these deposits.

The modifications that have affected the ore bodies since their primary crystallization in their present form are relatively insignificant and have been sufficiently illustrated in the foregoing paragenetic study. The only clear evidence of the direct introduction of magmatic materials is found in the contact zones about the pegmatites, which were certainly far later than the ore deposits themselves.

This theory, originally outlined about 1915, was first published by the author in 1929. It was followed a month later by the paper by Tarr in which the same mode of origin is postulated, but the effort is made to determine quite exactly the mineralogic nature of the metasomatic deposit before metamorphism. In Tarr's paper attention is drawn to Rastall's brief formulation of a similar theory, which had escaped the notice of the author.

THE MINERALS

Form of Description

The minerals are, with a few exceptions, described under the same classification and in the same serial order as in Dana's "System of Mineralogy," sixth edition, 1892. For each the order of treatment is, in general, first, crystallography, including both facts previously noted by other authors and new observations, if any, made in the course of this investigation; second, physical and optical properties, including the latest data obtainable; third, composition, with tabulated chemical analyses and for some species a discussion of the chemical formula; fourth, occurrence at Franklin and at Sterling Hill; and lastly, for the more important species, notes on the history of the minerals as known at Franklin.

This paper contains descriptions of 148 minerals, many of which, of course, are of slight importance and require but brief notes. Minerals seen only as essential constituents of the local rocks are not included. Many species already known elsewhere were added to the list of those found in the district, and 18 new species were discovered and described in the course of this investigation. Much new information on the crystallography, optical constants, and composition of the already known minerals was acquired during the course of the work, and the more important data of the sort have already been published in scientific periodicals.

In the table that follows all the species and varieties of minerals that have been definitely identified in the district and described in this paper are listed in alphabetic order.

Alphabetic List of Minerals Described

(Names in italic are those of varieties; names followed by (v) are those of species represented by more than one variety or only by an uncommon variety.)

Actinolite Allactite Amphibole (v) Anglesite Anorthite Apophyllite Arseniosiderite Aurichalcite Azurite Barylite Bementite Biotite (v) Brucite (v) Cahnite Calciothomson'te Calcium larsenite Cerusite Chalcophanite Chloanthite Chlorophoenicite Clinohedrite Corundum Cummingtonite (v) Cuspidine Datolite Descloizite Dolomite Epidote Ferroschallerite Fluorite Franklinite Gageite Galena Garnet (v) Goethite Greenockite Hallovsite Hardystonite Hedyphane Hetaerolite Hodgkinsonite Hyalophane Hydrozincite Ieffersonite Larsenite Leucaugite Limonite Losevite Magnetite Manganbrucite Manganoaxinite Manganosite Margarosanite Microcline Molvbdenite o-Mooreite Nasonite Niccolite Pargasite Phlogopite Psilomelane Pyrochroite Pyrrhotite Rhodochrosite Roeblingite

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Rutile Schallerite Serpentine Silver Sphalerite Stilbite Svabite Tennantite Thomsonite (v) Titanite Tremolite Willemite Zincite Zinc schefferite Zoisite Albite Allanite Andradite Anhydrite Apatite Aragonite Arsenopyrite Axinite (v) Barite Barysilite Beryllium vesuvianite Bornite Bustamite Calamine Calcite Celestite Chalcocite Chalcopyrite Chlorite Chondrodite Copper Crocidolite Cuprite Cyprine Desaulesite Diopside Edenite Ferroaxinite Fluoborite Fowlerite Friedelite Gahnite Ganophyllite Glaucochroite Graphite Gypsum Hancockite Hastingsite

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Heulandite Pyrite Holdenite Pyroxene (v) Hydrohetaerolite Quartz Ilmenite Rhodonite (v)	
Holdenite Hydrohetaerolite Ilmenite Kontrolite Rhodonite (y)	
Hydrohetaerolite Ilmenite Kontrolite Rhodonite (y)	
Rhodonite (v)	
Lead Roepperite	
Leucophoenicite Scapolite	
Lollingite Schefferite	
Magnesium chloro- Siderite	
phoenicite Smithsonite	
Malachite Spinel	
Manganite Sussexite	
Manganophyllite Talc	
Marcasite Tephroite	
Mcgovernite Thorite	
Millerite Tourmaline	
Mooreite (v) Vesuvianite (v)	
Muscovite Xonotlite	
Neotocite Zinc cummington	n-
Norbergite ite	
Pectolite Zircon	

NATIVE ELEMENTS GRAPHITE

C. Hexagonal-rhombohedral

Graphite is abundant in the Franklin limestone in cleavage scales and plates, at both Franklin and Sterling Hill, and in the iron ores in the limestone. At all the limestone quarries near Franklin it is more or less abundant wherever metamorphism through invasion by pegmatite has been effective. It has been found occasionally in the immediate wall rocks of the zinc-ore bodies but not in either ore body.

In a unique specimen in the Canfield collection graphite forms spheroids about half an inch in diameter, with fibrous structure and mammillary surface. The specimen is labeled from Franklin, but its exact source is not known.

SILVER

Ag Isometric

Silver is exceptionally rare at Franklin, having been found there, so far as known, only once. This occurrence, according to Mr. E. D. Shuster, was on the 1,050-foot level of the mine, about 400 feet south of the Parker shaft and a few feet from the footwall but entirely within the ore body. The total amount of material was probably not more than a few pounds, of which silver formed an insignificant part. The specimens, of which but a few are preserved and which were received in 1909, consist chiefly of massive steel-gray chalcocite. Fracture surfaces reveal scattered, sharply formed octahedrons of magnetite, whose faces are faintly marked with triangular striations. The silver forms thin sheets or films between the chalcocite and the magnetite, exactly outlining the form of the octahedrons. It does not coat all the crystals nor does it completely envelop all on which it is present. The silver is discolored when freshly exposed, but it is perfectly malleable and possesses the typical color and other characteristics.

The specimens contain a little massive white quartz, which is later than the magnetite and is of the same age as the chalcocite. There is, however, no evidence of a distinct vein, and all the minerals merge insensibly into typical, massive, franklinite-willemite ore.

It is stated by Mr. Nitchie, spectroscopist in the Palmerton laboratory of the New Jersey Zinc Co., that silver is present in spectroscopic traces in many of the Franklin minerals.

COPPER

Cu Isometric

Forms.—a(100), o(111), d(110), and an undetermined tetrahexahedron (h01).

Habit.—Copper crystals are very rare. Foote describes minute distorted dodecahedrons, and in the collection of Mr. Shuster are two crystals a quarter of an inch in diameter—one a cube modified by the dodecahedron and a flat tetrahexahedron, the other a dodecahedron modified by the octahedron. These crystals are but thin shells of copper enclosing cores of granular datolite, and they are embedded in a matrix of massive axinite, datolite, and willemite.

Occurrence.—Commonly the copper is found in irregular hackly masses, films, wires or spangles, generally associated with one or more of the minerals willemite, hancockite, roeblingite, datolite, axinite, cyprine, garnet, caswellite, or barite. It was first known from the Parker shaft and was apparently fairly common there, some pieces weighing a pound having been found in the crushed ore after it had passed through the rolls.

Copper was first noted by Wolff in specimens taken from a depth of about 800 feet in the Parker shaft. He regarded it as surely later than the zinc ore and as having been introduced along shear zones by solutions. In some specimens, however, it is embedded in clear crystalline willemite, and must have been contemporaneous with that mineral. The associated minerals indicate a pneumatolytic origin and a derivation from the intrusive pegmatite. It has also been found in thin veins containing hodgkinsonite, with barylite, and with the recently discovered arsenate hedyphane.

LEAD

Pb. Isometric

Lead is found, in minute amount, as scales, globules, and irregular branching masses, among the rare minerals of the Parker shaft, associated especially with the lead silicate roeblingite and with hancockite, native copper, and garnet. It was first noted by Foote. The author has seen it in several specimens, together with barite and the altered mica caswellite, and in one specimen as faint films in cracks in green willemite. It is also found in thread-like disseminations in rhodonite, which it stains gray, and as scales in veins in manganese serpentine.

(to be continued)

CONTRIBUTIONS TO FRANKLIN MINERALOGY - THE FLUORESCENT MINERALS

by

COOK, FISHER, MUTSCHLER, NAVRATIL

The purposes which prompted the following work are multiple. First, it was our purpose to present the findings of not just one individual but rather to present a composite drawn from the knowledge and experience of a number of collectors. In this respect it was our hope that we had managed to present a comprehensive cross section of a number of amateur mineral collectors who we further hope, typify the heart and mind of the dedicated Franklin collector.

Secondly, attention is given to the colloidal nature of a number of fluorescent minerals.

Third it is our intention to show that a dependence solely on fluorescent properties as a means of positive identification of some of the minerals is currently inadequate.

Fourth we hope to show that some of the fluorescent minerals are variable in their responses.

We concede the margin of error which may exist where the human element is a deciding factor.

Lastly it is our purpose to draw attention to the fact that additional research work in many areas of the Franklin fluorescents is imperative.

Least among the purposes of this paper is that it should serve as a guide to the amateur in determining the identity of a Franklin mineral solely on the basis of ultra violet inspection.

THE MINERALS

SPHALERITE

As far as has been determined the common zinc sulphide so abundant at Franklin and Sterling Hill, is not fluorescent. In the variety named cleiophane, an iron-free zinc sulphide, the mineral does fluoresce and phosphoresce. In daylight the mineral generally will be colorless with a pearly luster. No crystals have been reported and usually the mineral is found in isolated, small grains or as massive, compact bunches.

Two distinct characteristic occurrences have been noted at the Parker and Buckwheat dumps. The more common occurrence is small, scattered grains of cleiophane in a matrix of massive bustamite with granular franklinite and willemite. In this same matrix may also occasionally be encountered grains of chlorophane (see Fluorite).

The other occurrence is what appears to be transverse veins cutting the ore at Franklin. Here the cleiophane forms seams and tiny veinlets which cut willemite-franklinite ore. Associated with the cleiophane is what appear to be tiny cubic pyrite crystals.

As a minor constituent in other mineral associations, cleiophane has been noted frequently. As Mutschler noted (1) in some of its forms, the mineral may be mistaken for friedelite, willemite and other minerals. He also showed that the mineral is usually triboluminescent and thermoluminesces orange. Fisher (2) is in agreement with Mutschler on the triboluminescent qualities of the mineral.

Some specimens of the mineral can be detected with the short wave ultra violet light but unlike most fluorescents from the district, normally the mineral is more readily detected, and, appreciated under long wave ultra violet. Here it will commonly fluoresce with a salmonorange and occasionally a sky-blue response. It will also usually phosphoresce the same color.

Cook (3) contends that it has not yet been determined whether the blue-fluorescent mineral is actually sphalerite or an alteration product of that mineral.

FLUORITE

Most of the fluorite of the district which fluoresces is commonly of the variety, chlorophane. In daylight the mineral is normally flesh, rose or pale red in color. At Franklin the mineral commonly occurs as isolated granular masses in bustamite, willemite, franklinite mixtures. Normally the bustamite will be altered possibly due to surface oxidation of the manganese content. The mineral will be encountered at the dump localities only with difficulty except on specimens exhibiting a fresh fracture for this reason.

Some specimens of chlorophane are theroluminescent, meaning that when heated sufficiently they will exhibit a luminescence in the dark. For this reason specimens of the mineral should not be exposed to direct sunlight for appreciable periods as they have been noted to lose or lessen their fluorescent properties.

The mineral generally will fluoresce long wave with a blue-green color. It will also usually phosphoresce briefly the same color. Some specimens have been shown to react with similar results to short wave only while still others are known to fluoresce and phosphoresce a characteristic blue-green color in both wave lengths. The cause for this variability has not as yet been determined.

CORUNDUM

Mutschler stated that red and purplish gray crystals and grains of the mineral in crystalline limestone may fluoresce bright red under long waves. This statement is in general agreement with the findings of most investigators of the Franklin fluorescents. Cook contends however, that a very weak, deep red fluorescence can be detected with the short wave lamp but is not readily apparent.

CALCITE

At the Buckwheat dump calcite is unquestionably the most conspicuous fluorescent mineral. In daylight the mineral is normally colorless, white or grey. In the variety manganocalcite, it will take on strongly pink or orange shades. In some of the weathered, manganeserich varieties, the calcite may have a brownish or black color due to surface alteration. This latter variety quite normally will fail to react to ultra violet radiations.

The mineral occurs in granular or cleavage blocks and crystals are considered rare. Being a common gangue mineral of the ore body, it has a wide range of mineral associations. Commonly it will form the matrix for willemite or franklinite or both.

In short wave ultra violet the mineral commonly fluoresces various shades of red, pink and rarely lavendar. Occasionally it will have an orange-red fluorescence. It has a very brief phosphorescence. Under long wave ultra violet light the mineral may also fluoresce a faint red or pink. Also in long wave it may fluoresce a dull yellowish. Several specimens were recently encountered which react under long wave with a bluish-white color. Whether this is true fluorescence or merely reflection of visible light could not be determined.

Cook shows that the short wave phosphorescence of the Franklin-area, red-fluorescing calcite is invariable and characteristic, and serves as a positive identification of the mineral, especially in distinguishing it from axinite which likewise fluoresces red under short wave but does not show the same type of phosphorescence. She further shows that the calcite afterglow which is so fleeting as to be merely a flash, shows a distinct change of color from the red or pink of the fluorescent response to a vivid, true orange.

Mutschler reported that calcite from the Franklin limestone occasionally fluoresces and phosphoresces bright blue in short waves and that crystallized calcite from the magnetite ores may fluoresce and phosphoresce a delicate bluish-green. He also cited from Brown (4) who found the presence of manganese carbonate, varying from 0.24% to about 17 per cent, to activate the fluorescence of calcite with about 3.5%giving maximum brilliance. More recently, he continues, Schulman, Evans, Ginther and Murata (5) have presented evidence that the presence of lead as a coactivator is essential for the red luminescence of manganiferous calcite from Franklin.

SMITHSONITE

Mutschler stated that smithsonite usually fluoresces a yellowish-cream tone under the long wave lamps. Material from the Parker dump collected by the editor showed isolated coatings on thin fractures in a matrix of massive franklinite with some cleiophane. Long waves only produced a dull yellow or yellowcreamish response. It has since been noted on a number of other specimens, notably on one as crusts and coatings on manganophyllite, with andradite, willemite and calcite.

Fisher noted on his smithsonite, which was not crystallized material but coatings on zincite, no fluorescent response whatsoever.

Cook observed that on both of her smithsonites she received negative results with both short and long wave ultra violet.

Mutschler (6) further noted later that he had collected several additional Franklin smithsonite specimens, not all of which fluoresced, so the reaction is not a diagnostic test. He also stated that some calcites and aragonites which have a response like that of smithsonite were also detected by him.

ARAGONITE

Mutcshler noted that some crystalline aragonite from secondary hydrothermal veins at Franklin fluoresces a yellowish-cream and phosphoresces briefly with the long wave lamp. Short wave responses, he added, were less intense.

Cook described a number of aragonite specimens consisting mostly of small crystalled material which reacted similarly.

HYDROZINCITE

This mineral is encountered not infrequently at the Buckwheat dump as films and crusts upon calcite or as disseminations on dolomite. When associated with calcite it forms attractive fluorescent specimens. Pyrite and other sulphides may also be present in the dolomite. In short wave the mineral normally fluoresces blue to blue-white.

Cook calls the fluorescence of hydrozincite chalky blue; Mutschler showed that the mineral was found infrequently as an alteration product on zincite and responded to ultra violet radiations with a pale blue fluorescence.

ANORTHITE

Anorthite from the pegmatites which cut the ore body at Franklin sometimes exhibits a pale blue fluorescence under short waves, Mutschler maintained.

Specimens from the Franklin limestone consisting of isolated, colorless grains exhibit a white or creamish fluorescence in short wave.

DIOPSIDE

Commonly this mineral is found in the Franklin limestone as small grains either isolated or in bands. It is usually associated with the metamorphic minerals abundant in the limestone. Usually the grains are colorless or faint green. Short waves commonly produce a whitish fluorescence and may exhibit a bluish-white fluorescence.

Mutschler stated that light grey crystals from the Franklin limestone may give a pale bluishcream fluorescence under short waves.

PECTOLITE

Pectolite is commonly found in association with variable amounts of franklinite and willemite. In daylight the mineral may have a grey, white, flesh or colorless appearance. With short waves it commonly fluoresces orange or yelloworange.

Mutschler noted that pectolite fluoresces and phosphoresces yellow under the iron-arc and gives a feeble yellow reaction with other lamps.

Cook calls the fluorescence of pectolite chalky orange-yellow. She further remarks that all the Franklin pectolite she has examined under short wave shows a fleeting flash of phosphorescence or afterglow comparable in duration to that of Franklin calcite, and similar to calcite in the distinct change in color response from the chalky orange-yellow of the fluorescence to the bright orange of the phosphorescent flash. She believes that this characteristic is peculiar to pectolite alone of all the yellow and orange fluorescing Franklin minerals and that it can be considered to serve as a positive identification of pectolite from that area.

WOLLASTONITE

Mutschler showed the mineral as Franklin in origin, as occurring in crystalline masses which fluoresce a brilliant orange to orange-pink in short waves and sometimes gave a weaker pinkish response to long wave. He noted the presence of manganese in his material and concluded, from tests, that the manganese was probably the activator for the fluorescence in the mineral.

Wollastonite has not been discovered by the editor in all dump specimens studied, the mineral having apparently been discovered only after dumping operations ceased at Franklin.

Colorless grains and masses of the mineral found in specimens of fluorescent calcite may also be associated with minor amounts of barite. Some of the wollastonite noted by the editor also phosphoresces briefly an orange color in short wave ultra violet.

Cook reports that quite rarely the mineral will be found with fluorescent calcite, barite and a little willemite.

MARGAROSANITE

Mutschler showed that the mineral fluoresces a distinctive vivid pale blue-violet under the iron-spark and short wave apparatus. The mineral is white with a distinctive pearly luster. Like wollastonite, the mineral has not been noted among the various dump fluorescents, apparently having been uncovered in that part or parts of the ore body which were worked after the termination of dumping operations.

CALCIUM LARSENITE

This mineral may yet be found sparingly at the Parker dump but has not been noted as yet by the editor at the Buckwheat dump. In daylight the mineral usually is dull white or grey. It commonly may be associated with willemite, calcite and franklinite. In short wave it responds with an intense lemon-yellow color. In long waves it is dull yellow or negative.

Mutschler's material was a whitish mass associated with other pneumatolytic products which resulted in short waves with an intense lemon-yellow fluorescence. He states that this serves as a positive test for the mineral's identification.

WILLEMITE

Found at both dumps, willemite is second only to calcite in abundance. In daylight it will have a wide range of colors. commonly red, yellow, or green; also orange. Less commonly it will be grey, brown or colorless. It is but rarely found in the "horse flesh" variety.

It is abundant as isolated grains scattered throughout much calcite with granular franklinite. Less commonly at the Buckwheat dump it may have a banded nature, occurring in streaks and bands throughout the matrix, a form which was considered common in the mine workings at Franklin.

In short wave the mineral commonly will fluoresce yellow-green or greenish-yellow, this latter the editor would describe as about three parts yellow to one part green. Some material will also fluoresce various shades of green. Some willemite may exhibit a bluish-green reaction, possibly due to mixtures of other minerals with the willemite. The yellow-green fluorescent willemite tends to be the most phosphorescent type, the very deep green-fluorescing willemite seldom showing any visible phosphorescence. Most yellow-green fluorescent willemite will phosphoresce for appreciable periods.

Most dump willemite is in the massive or granular form and distinct crystals are quite rare. The few crystals collected in recent years by the editor are usually isolated, single crystals, generally about a half inch in diameter and an inch in length, being prismatic in form. Calcite is the dominant associate mineral with minor amounts of franklinite. Three or four such specimens have been collected of this type. In one specimen of Parker origin about five or six prismatic crystals are readily detected. Calcite and granular yellow-brown andradite are also present.

Cook mentioned the sidewall, radiating willemite, in fans, that phosphoresces for a considerable time.

Mutschler declared that some willemite crystals may show a zoned fluorescence. He also contended that many specimens of the mineral also triboluminesce and thermoluminesce. He added that the fluorescence is activated by manganese and that it further seems possible that the presence of beryllium may in part, control phosphorescence. He found that two strongly phosphorescent specimens, one of white radiating crystalline material, the other of massive white willemite, were analysed spectrographically, beryllium was found to be present in both. A non-phosphorescent white specimen did not contain beryllium. Mutschler further showed that at Sterling Hill small crystals of willemite, containing traces of lead and copper, were found recently in secondary veins. These crystals, he reported, fluoresce and phosphoresce with a strong lemonyellow color. Bauer reported similar material from the same mine.

Similar specimens were reported by Cook but she calls the fluorescence not lemon-yellow but a true chrome yellow.

BARYLITE

Mutschler stated that in short waves the mineral was pale blue or negative. Palache described a bright blue fluorescence under the iron-arc. Cook's material fluoresced blue in short wave but not what she would call bright.

AXINITE

Mutschler said that the mineral, variety manganoaxinite, sometimes gives a red fluorescence and rarely a red phosphorescence under short waves. He added that crystallized axinite is more likely to respond than massive material.

Cook states that much, if not all, fluorescent axinite is most-equally responsive to powerful long wave apparatus.

CLINOHEDRITE

The editor noted this mineral in fair abundance at the Parker dump. In daylight it appears grey or colorless. It is normally associated with willemite, franklinite and calcite. When associated with hardystonite, it may present quite striking specimens. Many specimens of the mineral obtained from local collectors show traces to large masses of the mineral in association with hardystonite.

Clinohedrite will usually fluoresce orange or chalky orange in short waves. Much of the material is also phosphorescent the same color but some specimens phosphoresce only with difficulty or not at all. Long wave responses are less pronounced or negative.

Mutschler's and Cook's material reacted similarly.

THOMSONITE

Mutschler's material, variety calciothomsonite, fluoresced pale blue under long waves and negative with short waves.

Cook's material which was a thick coating on clinohedrite crystals fluoresced blue under long wave on one edge of the specimen. Several areas in the center fluoresced cream-white. She thinks it possible that the associated clinohedrite may have been in some way responsible for the cream-white reaction of the thomsonite.

APATITE

Mutschler stated that bluish crystals of apatite in limestone may show a very pale greenish fluorescence with short waves.

Material collected by the editor which was not tested, reacted similarly. Associated with this material were a number of the metamorphic minerals.

Cook's blue apatite crystals reacted similarly. Her manganapatite, a variety of apatite, fluoresced an old-rose in short waves.

Fisher has a number of apatites, from light blue to dark green (daylight colors) and he reports that not one of them fluoresced. However, one of his manganapatites from the time of the last mining at Franklin, fluoresced orange, not as vividly as clinohedrite.

SVABITE

As noted by Palache the limestone apatites appear to be free of arsenic while the apatites found in the ore bodies associated with the zinc minerals, do contain arsenic. Palache conceded that apatite and svabite are so alike as possibly not to be identified from each other except through a quantitative chemical test for arsenic.

Whether svabite and manganapatite can be identified from each other solely by ultra violet apparatus has not presently been conclusively proven. Material identified by John L. Baum (7), resident geologist of the N. J. Zinc Company which fluoresced short wave orchid to pink, was indeed svabite. This material was pale greenish, granular in a matrix of andradite and massive franklinite.

Mutschler showed that svabite sometimes fluoresces yellowish-orange with short wave apparatus, while Cook reports the fluorescent color of svabite as a pinkish-orange.

BARITE

This mineral has not been positively identified by the editor in material he has collected at either of the dumps. Some specimens obtained from local collectors are white or colorless in daylight and occur as grains or granular masses in calcite, usually with willemite and franklinite. Most specimens react uniformily in short waves with a creamish fluorescence. Mutschler's material, as pale blue masses disseminated in calcite, fluoresced a delicate blue to greyish-cream upon exposure to short waves. He added, some specimens of crystallized barite also exhibit a bluish luminescence.

Cook reports that some of her barite specimens fluoresce pale blue; some blue-white; some a rich cream. Drusy barite crystals, she continues, often associated with pectolite, fluoresce a navy blue.

TREMOLITE

Mutschler reported that elongated, grey white crystals of tremolite from the Franklin limestone exhibit a very faint greenish fluorescence (?). Similar cystals in the Cook collection fluoresce pale blue-green or blue-white.

RECENT DISCOVERIES

TOURMALINE

Cook drew the editor's attention to fluorescent tourmaline from the Franklin district. Several other collectors, one in New Jersey, another in Pennsylvania, have confirmed this finding. Cook describes her material as fluorescing short wave a soft, clear yellow. Similar tourmaline in the Fisher collection fails to fluoresce. It is therefore conceded that the fluorescence of the Franklin district tourmaline is variable. Cook's material is from Sterling Hill.

МІСА

Cook may also be credited with being responsible for the announcement of the first specimen of fluorescent mica from the district. Her specimen consists of ruby-red, long wave fluorescent corundum with some calcite from Sterling Hill. Upon exposure to short waves she discovered several spots at the end of the specimen fluorescing a decided dull yellow. It was mica.

Mr. Frederick H. Pough examined her specimen visually. It was mica, he agreed, and probably phlogopite and beyond all question it did fluoresce.

Cook has recently further noted that other mica specimens from the Franklin limestone which she has collected also fluoresce yellow. Material collected by the editor at the Buckwheat dump several years ago fluoresced (?) a dull yellow. This material is associated with chondrodite and other metamorphic minerals in limestone. The material thus described was overlooked as a fluorescent mineral as the editor had considered it merely as reflection since the mica, reacting under the short wave apparatus, did so only at certain given angles.

Similar material from the Tuckahoe marble quarry, Tuckahoe, New York, also responds with a similar response.

MICROCLINE

Just as the Digest went to press, information was received from Sunny Cook that microline has been identified as one of the fluorescent minerals from the Franklin district. Not all microcline fluoresces. Specimens uncovered at the Buckwheat dump early in 1958 show light green microcline associated with epidote, quartz and calcite. In short wave ultra violet light the microcline fluoresces blue-white and occasionally white or cream.

In several such specimens shiny, drusy dark green crystals in micromount size, proved to be gahnite.

Thanks to the persistence and determination of Sunny Cook, this to our knowledge is the first factual reporting of fluorescent microcline from Franklin. We are pleased indeed to add this mineral to her list of firsts. The identification of the fluorescent microcline was substantiated by Mr. John L. Baum, resident geologist of the New Jersey Zinc Co., at Franklin.

DISPUTED MINERALS

Included under this heading are a number of minerals, or the properties of some, which were not mentioned at length with the usually accredited fluorescent minerals from the district. In this category are mentioned the "half-breed" or colloidal minerals such as bustamite, fowlerite, leucaugite and roeblingite. Attention is also given to the dispute between chondroditenorbergite as well as to hardystonite-larsenite. Brief mention is also given to pectolite plus a description of what may be sphalerite.

SPHALERITE

What has been termed "Golden Sphalerite" by some collectors, fluoresces pale chalky orange in long wave ultra violet light. The mineral occurs either in massive bustamite with granular willemite and franklinite or, associated with the secondary transverse veins. Few specimens have been observed and preserved. Some of the material is white or colorless in daylight. Some of the material may phosphoresce a faint chalky orange or not at all. None of the material in the editor's knowledge has been accurately analyzed as yet.

PECTOLITE

The reliability in determining some pectolites by the removal of the short wave filter which results in a rich, reddish-orange phosphorescence, is questioned by some investigators.

LEUCAUGITE

At present it is not considered a fluorescent mineral from the district. Material occurring in a colloidal state with pectolite, does give a short wave fluorescent response. The mixture is generally grey to steel-blue in daylight color. Commonly it is associated with massive garnet, manganophyllite and occasionally willemite and franklinite. In short waves it may usually fluoresce various shades of brown. The identification of the leucaugite-pectolite combination was kindly confirmed by John L. Baum, N. J. Zinc Company.

BUSTAMITE

Much of the material collected at both dumps by the editor and obtained by him from the local collectors which undoubtedly from visual means is taken to be bustamite, does not fluoresce. A number of collectors at Franklin consider bustamite to be a non-fluorescent mineral. Fisher also concurs in this belief.

Mutschler's material fluoresced pink to deep red under long wave. However, he does not appear to be completely convinced of the diagnosis of bustamite. He reports (6) that in 1954 he felt certain he had one specimen of bustamite that actually fluoresced. He had several however, that did not. After the specimen was soaked in HC1 to remove any calcite, it continued to fluoresce. Later, he continues, optical and X-ray defraction studies indicated that the specimen was indeed bustamite but suggested the presence of some carbonate material. He does not therefore consider the test conclusive and the question whether the bustamite itself is fluorescent or if admixed calcite causes the fluorescence, is still unanswered in his mind.

Cook contends that specimens which are either bustamite or fowlerite, do fluoresce a deep crimson under a powerful long wave light such as a B-50. However, she considers a colloidal mixture of calcite causes the fluorescence.

LARSENITE

Palache showed that under the iron-arc spark gap larsenite shows either a pale-violet fluorescence or none at all.

Mutschler contended that the inconsistent pale violet reactions of Palache was probably due to visible light.

Cook states that one of her specimens of larsenite crystals on clinohedrite crystals appears to fluoresce pale violet but that the reaction may be reflection. She also reports that massive material sold to her for larsenite "fluoresced," much like the best hardystonite, but perhaps with a more translucent appearance. Whether this reaction is in fact fluorescence or merely a reflection of the ultra violet light, has not yet been determined to her satisfaction.

A noted chemist conceded that he himself could never tell larsenite from hardystonite without a chemical test.

While Palache did not specifically mention massive larsenite, apparently both Mutschler and Cook have maintained the possible existence of the massive form of the mineral.

Fisher stated that he had an excellent crystallized larsenite from the Billy Ball collection, the authenticity of the crystals confirmed by Mr. Lawson Bauer, and these did not fluoresce.

Since larsenite and hardystonite are apparently so much alike in many of their properties, the question of identification of either mineral either by normal visual or ultra violet inspection does not appear to be at present resolved.

HARDYSTONITE

Palache noted that the mineral reacted under the iron-arc spark gap with a dull, faint violet or not at all.

Mutschler's material sometimes fluoresced a dull, deep violet with the short wave lamp and the iron-arc. To him it was negative with long waves.

Material collected by the editor at the Parker which appears to conform to hardystonite, is grey or colorless masses commonly associated with franklinite and willemite and not infrequently with clinohedrite. In short wave ultra violet the mineral reacts with a violet response. Much of the same material reacts similarly under long waves.

Cook contended that her hardystonite continued to respond with the same visible reaction when viewed under glass.

NORBERGITE-CHONDRODITE

There exists some question in the minds of many as to the proper use of short wave ultra violet inspection in the determination of these two minerals which normally occur in the Franklin limestone and are associated with the metamorphic minerals of that formation.

What is generally conceded to be norbergite occurs usually as dull yellow grains or granular masses in limestone and fluoresce in short waves a dull, golden yellow.

The material which has been designated as chondrodite is similar in form and occurrence. Here however, the material in daylight is of a brown or orange color and fluoresces short wave a rusty-brown to tawny color. Much material of this type was collected by the editor at the Buckwheat some years previously. Included in this material were a small number of specimens which clearly show crystal faces. These crystals, though small, are readily detected by the unaided eye.

Mutschler maintains that without petrographic examination the chondrodite-norbergite question may not be satisfactorily resolved. It is possible that these crystals may provide us with some of the answers.

ROEBLINGITE

Fisher's material gave a dull, red reaction which he feels certain is fluorescence.

Cook's material reacts similarly, pink in short wave but she believes it is due to colloidal calcite. Her pure roeblingite failed to fluoresce.

Mutschler found that some of his material had admixed calcite and upon removal of the calcite, the remaining roeblingite failed to fluoresce.

ABOUT THE AUTHORS

SUNNY COOK was in charge of fluorescent minerals for Ultra-Violet Products of California from August 1953 to September 1956. As an amateur mineral collector for some years prior to this post, her private collection contains approximately 150 different varieties of Franklin and Sterling Hill minerals.

KENNETH FISHER has been an amateur mineral collector of the Franklin and Sterling Hill minerals for more than twenty-five years.

FELIX MUTSCHLER has been a collector of the district's minerals for many years and has contributed invaluable information particularly about the district's fluorescent minerals to mineral publications. He is currently serving with a mining concern in Utah,

GERALD NAVRATIL has been an amateur mineral collector of Franklin minerals since 1954. He was the founder of the Franklin Mineralogical Association.

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(1) Felix Mutschler, "The Luminescent Minerals of Franklin, New Jersey," Rocks and Minerals Magazine, Sept.-Oct. 1954, p. 482-485.

(2) Kenneth Fisher. From notes and other correspondence Mr. Fisher made available to the editor for use by the FMA.

(3) Sunny Cook. Mrs. Cook's voluminous correspondence concerning the Franklin minerals contained considerable invaluable information much of which is incorporated into this paper.

(4) W. L. Brown. This information was contained in the Mutschler paper.

(5) Schuman, Evans, Ginther and Murata. Same as (4).

(6) Felix Mutschler. From a letter to the editor in 1958.

(7) John L. Baum. In a letter some time ago, Mr. Baum identified svabite and the leucaugitepectolite combination. This paper, the first of a series, is designed to act as a guide to the amateur mineral collector in becoming better acquainted with the minerals which may be collected at the popular Buckwheat and Parker dumps at Franklin, New Jersey.

Particular attention has been given to describe the minerals with as much information as possible, to show the various forms and colors in which the minerals are known to occur and to give special attention to the associate minerals accompanying each mineral under discussion.

Since many of the minerals of the district are not unlike identical minerals from other localities, it has been proven that where a reference with descriptions is available, many questionable or "mystery" minerals may readily be identified.

As many of the known associations of many of the minerals appear to be nearly limitless, in the course of future studies this first and any subsequent parts of the series will of necessity be amended and brought up to date.

Not the least among the purposes of this series is to focus attention upon the various dump minerals and in their value in the study of and appreciation for, the mineralogy of the district.

THE MINERALS

GALENA

Galena has been observed in but one specimen from the Buckwheat dump which was collected early in 1958. The specimen is composed largely of massive greyish-green willemite, white calcite and quartz, brown granular sphalerite and traces of cleiophane. Franklinite is conspicuous by its absence. The galena consists of two small isolated bluish-grey masses neither more than a quarter of an inch in diameter.

SPHALERITE

The mineral is quite common in the Buckwheat dolomite. Frequently it is noted as brownish and yellowish masses embedded in grey dolomite. The mineral has not been observed to date in material from the Parker dump since the host dolomite appears to be confined solely to the Buckwheat open cut.

In one specimen of Buckwheat dump origin brownish and yellowish resinous masses of sphalerite coat fracture surfaces in grey massive dolomite. The sphalerite appears to be secondary to the dolomite. Apparently contemporaneous with the sphalerite are masses of yellow pyrite. Bluish-grey crusts of hydrozincite coat part of one end of the specimen.

Massive brown sphalerite is also noted covering an entire surface of one specimen of grey dolomite.

In another specimen small brownish crystals of sphalerite protrude from a specimen of grey massive dolomite. Parts of two other crystals also are present. In several spots the dolomite is crystallized in cavities. Massive brown sphalerite is also disseminated throughout the dolomite. Small, scattered bronze and yellow pyritohedrons of pyrite are also present on several surfaces embedded in the dolomite.

BORNITE

Although bornite has not been noted as a major constituent of any single specimen, its occurrence in dump specimens is quite common. It has been collected at both the Parker and the Buckwheat dumps.

In its most abundant form at the Buckwheat dump bornite has been noted as blue, green and purple iridescent disseminations in granular calcite. The associate minerals are granular franklinite and greyish willemite, the latter usually as small granular masses embedded in the calcite. Zincite as blood-red and orange grains may also occasionally be present.

The same type of specimen is encountered at the Parker dump. At the Parker however, bornite is found in a specimen consisting mostly of granular white calcite and colorless hardystonite with some scattered grains of willemite. Franklinite as grains and bunches are present. Some yellow-green andradite garnet is present. The bornite, implanted upon and next to the franklinite grains, is of typical peacock colors. In another of the Buckwheat type specimens, bornite is encountered in a less common association. Here the matrix is composed of a crumbly, decomposed granular quartz which is in part coated with limonite. The quartz is also stained with malachite. The malachite is also present as minute crusts on some of the franklinite which is present as granular masses. The bornite is implanted upon and throughout the franklinite. The bornite displays typical blue and purple iridescence. Small scales of hematite also are present.

Bornite is seen in a specimen with zincite, as reddish grains in a gangue of colorless grains of willemite and white calcite. The bornite is in small granular masses associated with grains of franklinite.

From both the Parker and Buckwheat dumps, bornite has been seen as minor amounts with zincite, franklinite and willemite in white bustamite.

From the Parker in massive grey hardystonite devoid of either calcite or andradite, iridescent masses of purple, green, and blue bornite occur with granular franklinite and colorless willemite.

PYRITE

Though pyrite is not known from the zinc ores, it is quite common in the Buckwheat dolomite and in the Franklin limestone. It may also be found occasionally in secondary transverse veins which cut the ore in a number of places. The mineral commonly is not unlike pyrite from other localities. Generally it is brassyellow in color. It may show tarnished or bronze-colored surfaces. Generally it is massive and granular but small crystals, either singly or in groups, may be found without difficulty.

Two, small pyritohedrons of pyrite of bronze color are seen in a specimen of white crystalline limestone. Several elongated gray masses of diopside are also present. Several flakes of colorless phlogopite and lead-grey graphite are also noted.

In the Buckwheat dolomite, granular and crystallized pyrite appears to be conspicuous. In one large specimen bronze-colored pyritohedrons of pyrite are liberally sprinkled over the surface of the grey dolomite. Granular, yellow pyrite also is present. Besides the dolomite and pyrite are hydrozincite as whitish films and crusts, calcite in white cleavable masses and to one end of the specimen massive brown sphalerite. Though the pyrite crystals are small, they are readily detectible.

In one specimen of small bronze-colored pyritohedrons of pyrite, in grey dolomite, scattered grains of franklinite are also present. Some of the pyrite in granular form has an iridescent tarnish.

Both the pyritohedron and the cube are in evidence on adjoining faces of one specimen of massive grey dolomite. The yellow crystals occur as minute clusters. Yellow and brown grains of sphalerite are present in the dolomite. (See Dolomite.)

QUARTZ

Quartz is not to be considered uncommon at the Buckwheat dump. It is frequently encountered in the Buckwheat dolomite and has also been noted in pegmatite specimens as well. It is more common in the white, massive form but it may also be found as single crystals or in small groups.

A specimen of massive grey dolomite reveals numerous shallow cavities covered with groups of colorless and grey rhombohedral crystals of dolomite. In some cavities the dolomite crystals have a yellowish tinge. In three small cavities on one face of the specimen, quartz crystals, none longer than half an inch, are found. In two of the pockets the crystals are in small groups, four to six crystals clustered together. The crystals are of simple prismatic habit. In the third pocket, a terminated, slender crystal of quartz juts from the bottom where its attachment to the matrix is obscured.

Several small terminated white crystals of quartz are also noted in one specimen with willemite and slender "pencil" epidote crystals of typical yellow-green color.

In one specimen of Buckwheat origin, massive colorless quartz is present on the end of the specimen with granular franklinite, colorless to flesh-colored willemite and a small amount of brown andradite.

What is probably a secondary vein specimen shows quartz as milky white masses associated with granular masses of cleiophane. Colorless willemite is disseminated throughout the quartz. A black, manganese mineral masks some of the surfaces of the specimen, which is of Buckwheat origin.

Quartz is also present in a stained, decomposed form with malachite and bornite and is discussed under those two minerals. From the Buckwheat milky-white granular quartz is found associated with pale greenish, massive microcline.

It is also found in minor amounts in the colorless, massive form in a specimen with traces of willemite, white calcite, pale green microcline and brownish andradite, the latter of which is partially crystallized.

ZINCITE

Almost everywhere zincite is abundant in specimens from both the Buckwheat and Parker dumps but it is rarely present in large amounts in any given specimen. Crystals of the mineral have not been observed in the various dump specimens collected. Normally the mineral is found as isolated grains.

In typical Buckwheat dump material zincite occurs as small, scattered reddish grains disseminated throughout a matrix of granular black franklinite, white calcite and pale-green or yellow-green willemite. Also in this type material, zincite may occur in layers or banded streaks. Not infrequently too, the willemite as granular masses, will occur in layers or bands, usually parallel to the zincite.

The common form of zincite at the Parker is as small grains attached to franklinite in a matrix of white calcite. Willemite as colorless or green or yellow masses usually is present. In one such specimen the zincite is attached to the grains of franklinite or is perched upon the franklinite. In many such specimens zincite appears to have an affinity for such attachment to franklinite. Some grains of franklinite in this specimen display a blue iridescent tarnish.

From the Parker was collected a single specimen consisting of massive franklinite, ash-grey tephroite with minor amounts of colorless and orange-colored willemite. Zincite as small, isolated reddish grains is present but constitutes but a small fraction of the specimen.

Bright reddish and orange granular masses of zincite are present with franklinite and bornite in a matrix of colorless willemite.

Small, reddish grains of zincite are also noted in a matrix of colorless bustamite. Granular willemite and franklinite are scattered throughout the mass.

With the same above minerals of the preceding paragraph, zincite in typical reddish grains is also noted with chlorophane which is present as small granular masses. In some such specimens collected at both dumps, cleiophane has been observed as colorless or white disseminations.

HEMATITE

The mineral has been noted in many specimens from the Buckwheat dolomite and should be considered as common. It has been noted but sparingly in zinc specimens. Its occurrence at the Parker has not been confirmed in the writer's experience.

The color is usually lead-grey and normally it occurs as flakes or small plates embedded in the matrix material.

Typical of the Buckwheat material is a small specimen of grey massive dolomite, partly crystallized in one small cavity. Two small crystals of 'brown sphalerite are attached to the walls of the cavity. The hematite as lead-grey flakes, is conspicuously scattered throughout the dolomite.

In a specimen of porous grey dolomite, part of which is crystallized in a number of small cavities, hematite is abundant as lead-grey masses scattered throughout the matrix. Some of these inclusions of hematite are an eighth of an inch to a quarter of an inch in diameter. Several colorless, transparent crystals of quartz, one with a perfect termination, are attached to the crystals of dolomite.

Plates of shiny hematite, several a quarter of an inch to half an inch in diameter, are embedded in massive, colorless quartz. Massive dark-green epidote is present as well as granular reddish-brown andradite.

The association of hematite with bornite and malachite is discussed briefly under those two headings. In one specimen showing all three minerals in fair abundance, malachite as green streaks and films is closely united with blue and purple masses of iridescent bornite which is attached to or next to franklinite grains which are partly enclosed in a white, massive quartz. The hematite, of a lead-grey color, is embedded as flakes and plates in both the quartz and franklinite.

FRANKLINITE

As the dominant ore mineral of the district, franklinite is conspicuous in specimens from the Parker and Buckwheat dumps. Normally the mineral is confined to typical zinc-ore specimens. It has not been observed in the limestone specimens and has been observed but once in a specimen of Buckwheat dolomite.

The minerals which are associated with franklinite are almost too numerous to list. The preceding mineral descriptions are only a sample of the many mineral associations. For the purpose of this paper, therefore, attention has been concentrated primarily on the crystallized specimens and other noteworthy forms of the mineral.

The mineral is black and has a metallic luster. It is sparingly found as small octahedral crystals, the edges of which may be truncated. Generally it is most commonly found as small, rounded grains or misshapened crystal aggregates. It may also be found in granular form or in large massive chunks.

A number of crystallized specimens have been found at both dumps. Typical of the Buckwheat dump material is a specimen consisting largely of white calcite. Four or five small octahedrons of franklinite are embedded here and there in the calcite. In such specimens phlogopite and willemite may also be noted in association.

A group of five or six octahedrons of franklinite approximately $\frac{1}{8}$ to $\frac{1}{4}$ inch in size, are noted in a matrix of calcite, granular franklinite and orange zincite with traces of willemite. The specimen is from the Parker dump.

In another Parker specimen three crystals protrude from a matrix of granular franklinite, willemite and calcite. Also, a specimen of massive, grey willemite with calcite encloses a number of bruised franklinite crystals.

A single, half-inch crystal of franklinite was found recently at the Parker. Three faces of the rough crystal are visible and one edge is truncated. In the matrix is bright red zincite, grey to black willemite with franklinite inclusions and a lavender fluorescent calcite.

From the Buckwheat too was found a single crystal of franklinite with granular franklinite and traces of willemite in a matrix of calcite. Grains of leucophoenicite were also noted in abundance.

Some franklinite displays an iridescent tarnish. This has been noted only recently in material from both dumps. In a specimen of cleavable calcite, granular franklinite and willemite, almost every grain of the franklinite reveals a bright, blue iridescence.

DOLOMITE

Greyish masses of granular and cleavable dolomite is abundant at the Buckwheat dump and forms the matrix for the common minerals, such as pyrite, quartz, sphalerite and hydrozincite. Dolomite is readily recognized by two prominent features — its grey color and the numerous cavities present in the massive material. Not uncommonly such cavities will reveal groups of grey or colorless rhombohedrons of dolomite.

In a large specimen of massive dolomite, a cavity approximately six inches across exhibits a large group of dolomite crystals. Pyrite as very small cubic crystals are seen here and there attached to the dolomite crystals. A number of smaller scattered cavities are devoid of any crystallized material.

On a similar specimen, three-fourths of whose surface is exposed by open cavities, small, pearly rhombohedrons of dolomite are present. Isolated cubic pyrite crystals are attached to the crystallized dolomite. An unidentified, black mineral coats part of one side of the specimen, possibly a product of alteration.

Additional information and descriptions of dolomite are included under the headings of Quartz and Pyrite.

MALACHITE

In material from the Buckwheat dump, malachite has been observed but sparingly. It has been noted only as small crusts and coatings on other minerals.

In one specimen of massive, grey willemite with massive franklinite and colorless calcite, malachite is present as pale greenish disseminations in the willemite.

The association of malachite with bornite and quartz is partially mentioned under those two headings. In this type of material, malachite is present as small, greenish coatings and crusts on grains of franklinite. Bornite and hematite are also present. Quartz and franklinite are conspicuous, the quartz being of a decomposed nature, crumbly and partly stained by limonite. What may be a trace of chalcopyrite, is also noted.

Far less common an occurrence of malachite was found in a single specimen, probably of contact origin. Green granular epidote forms the matrix and white massive quartz with some traces of purple fluorite are present. The malachite is conspicuous for its abundance as it covers almost all of one side of the specimen, as bluish-green crusts and films.

THE POST-PALACHE FRANKLIN AND STERLING HILL MINERALS-SUNNY COOK COLLECTION

ANKERITE

My only specimen and the only one I have seen, is 1"x2", with very small pale-yellowish hexagonal crystals of ankerite implanted on a thin layer of calcite which fluoresces red in short wave. The calcite encrusts a calcium-carbonate that looks like a brecciated quartz, seamed and coated with a reddish mineral, probably earthy hematite, and also coated with small patches of an unknown moss-green mineral. The ankerite crystals are non-fluorescent.

KUTNAHORITE

In all of my specimens the kutnahorite is associated with fluorescent calcite and small amounts of fluorescent willemite, but does not itself appear to fluoresce. It has a more "sugary" sparkle. The color is a very pale pink.

ANDRADITE, Variety TOPAZOLITE

This specimen is from the Hoadley and the D'Agostino collections and the identification was verified by Bauer in May of 1952. It is a $1\frac{1}{4}$ "x1 $\frac{1}{4}$ "x1" specimen of fluorescent calcite, fluorescent willemite, franklinite and very pink fowlerite. The microscopic topazolite crystals are a sparkling clear, topaz color; they completely coat the botryoidal surfaces of a vug that reaches from the center to one edge of the specimen. Implanted on the topazolite crystals

are translucent, gemmy fowlerite crystals of a very deep pink color, and highly-phosphorescent willemite.

Should read: Variety MELANITE

ANDRADITE, Variety CEYLONITE

This is a $1\frac{1}{2}$ "x $1\frac{1}{2}$ " specimen with groups of almost-black twinned garnet crystals, the largest one-half inch long, in a quartz matrix. The identification was made by the Stevens Institute of Technology.

PYROXENE, Variety JOHANNSENITE

The johannsenite looks like minute darkbrown specks in a $2\frac{3}{4}$ "x $2\frac{3}{4}$ " specimen of bustamite, glaucochroite and green-fluorescing willemite. Johannsenite is the manganese analogue of diopside and hedenbergite. The identification was verified by Dr. Wolfe of Boston University in January of 1958.

DATOLITE, Variety BOTRYOLITE

This is a $2^{2}x2\frac{1}{2}^{2}$ specimen of hancockite, non-fluorescent axinite, andradite, manganophyllite, fluorescent clinohedrite and fluorescent willemite — obviously from the Parker Shaft. The botryolite, in the form of china-white minute "balls," coats transparent honey-colored axinite crystals and transparent red hancockite crystals in several small areas.

(to be continued)

To Mr. Gerald S. Wharton, publisher of The Middleburgh News who accepted the task of printing the Franklin Mineral Digest for the Association and to his entire staff, I wish to express my personal heartfelt thanks as well as the gratitude of the membership of the Association. Mr. Wharton in the course of this printing extended to me many personal courtesies for which he has my deepest appreciation. The Digest represented a formidable challenge to him and his staff and the finished product is a tribute to their journalistic acumen.—Editor, FMA. In memory of Bauer, Berman, Palache and the other giants of the Franklin era.