NOTES ON SOME FRANKLIN MINERALS

L. H. Bauer, *New Jersey Zinc Company, and*
Harry Berman, *Harvard University.*

In the course of a year many interesting new facts come to light about the minerals of this famous locality. This paper is a record of some of the more interesting data collected by the authors during the past year.

I. Zinc-bearing Amphibole

A recent analysis, by Bauer, of an amphibole occurring at Franklin, long called actinolite because of its external resemblance to that member of the group, has shown that it is really a zinc-manganese-cummingtonite having the general formula, $H_2(Mg, Fe, Zn, Mn)_7(SiO_3)_8$. The zinc has replaced about 15 per cent molecularly of the iron and magnesium. The ratio is $Mg:Fe:Mn:Zn = 20:18:19:13$.

	Per cent	Mol. Ratios
SiO_2	49.74	.828
Al_2O_3	1.72	.017
FeO	12.80	.178
MgO	8.31	.206
ZnO	10.46	.128
MnO	13.79	.194
CaO	0.49	.009
Na_2O	0.22	.004
H_2O+	2.16	.120
	99.69	

Specific Gravity = 3.44 for the heaviest pieces.

The amphibole occurs as large green prismatic crystals with cleavage angle $m \wedge m' = 54°28'$. It is imbedded in rhodonite or garnet, in one case in feldspar, and with it occurs ferroschallerite also described in this paper.

The optical properties are as follows:

$$Bx(-). \quad 2V = 75° \pm 2°$$
$$Z \wedge c = 15°. \quad Y = b.$$
$$\alpha = 1.657, \quad \beta = 1.674, \quad \gamma = 1.685.$$

II. Apophyllite

Groups of pale pink radiating crystals of apophyllite in crumbly limestone were found in the mine a number of years ago. An analysis, by L. H. Bauer, is as follows:

	PER CENT.	MOLECULAR RATIOS		
SiO_2	50.90	.844	.844	$=3\times281$
CaO	24.74	.442	.442	
K_2O	3.70	.039	.078	
Na_2O	0.42	.007	.014	$.562=2\times281$
MnO	0.47	.006	.006	
ZnO	1.79	.022	.022	
H_2O	17.71	.983	.983	$=3\frac{1}{2}\times281$

The formula derived from this analysis is:

$$(Ca, K, Na, Mn, Zn)_2Si_3O_8 \cdot 3\tfrac{1}{2}H_2O.$$
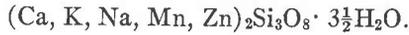
As seen from the analysis this formula agrees well with the determined values. It is of less complexity than any formula heretofore given for this species.

The crystals, not very good for crystallographic measurement, have the forms (001), (111), (110), with the pyramid dominant.

III. BARYSILITE

The original barysilite from Franklin[1] was so scarce that difficulty was encountered in obtaining enough for analysis. An adequate sample recently acquired had prompted a new analysis by Mr. Bauer which is shown below.

	PER CENT	MOLECULAR RATIOS	
SiO_2	16.84	.280	$=2\times.140$
PbO	77.35	.347	
MnO	3.33	.047	
FeO	0.23	.003	
Al_2O_3	0.59	.006	$.424=3\times.141$
CaO	0.21	.004	
MgO	0.78	.019	
ZnO	0.30	.004	
H_2O	0.07	.004	
	99.70		

This yields the formula, $3PbO \cdot 2SiO_2$.

Barysilite occurs as thin films or narrow veinlets in the ore, associated with garnet, axinite and hardystonite.

The following optical properties were determined by the dispersion method.

Uniaxial $(-)$, $\omega = 2.033 \pm .004$, $\epsilon = 2.015 \pm .004$, for sodium light.

Figure 1 is a dispersion curve for barysilite. The method used in obtaining the values given above and the other values on the curve, may be briefly mentioned since it is useful in obtaining fairly accurate values for material from which prisms cannot be cut and
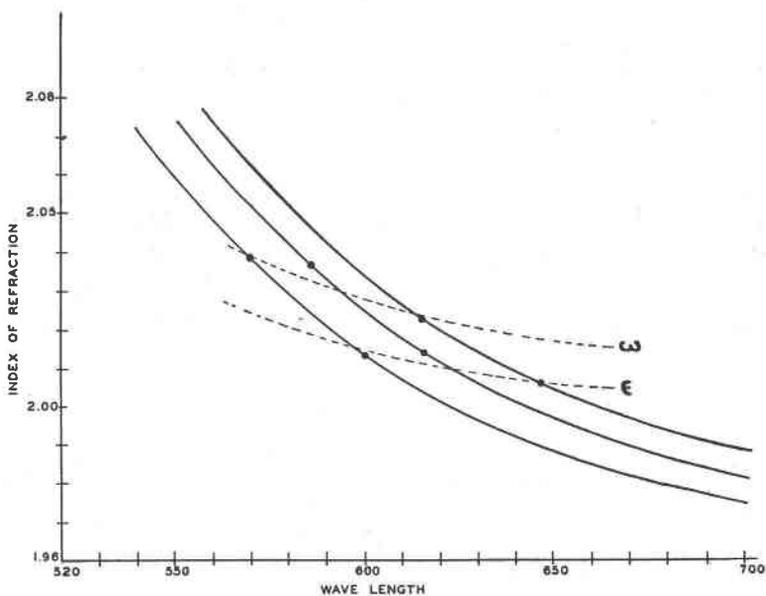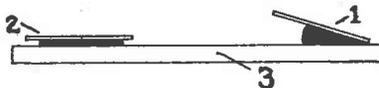

FIG. 1. Index of Refraction of Barysilite.
Solid lines = dispersion curve for melts.
Dotted lines = dispersion curve for barysilite.

immersions in high refractive index melts must be used. The following sketch, illustrates the method.

The melt in which the mineral is to be imbedded is placed in two positions (1 and 2) on the object glass (3) as shown in the sketch. In the first position a prism of small angle is made by the use of a cover glass raised from the object glass on one side. In the second position the mineral is immersed in the same melt in the ordinary manner. The cover glass is then heated so that the melts in the two positions receive identical heat treatment. The prism is then

used to establish the dispersion curve for the melt and the immersion is used to match the mineral and the melt for a particular wave length of light. In this way, by using several melts the dispersion curve for the minerals may be obtained (Fig. 1.). This method is not rapid but it gives fairly accurate results when other methods are not applicable. The principle advantage of the method lies in its freedom from error due to variation in the heat treatment of powders under the usual method.
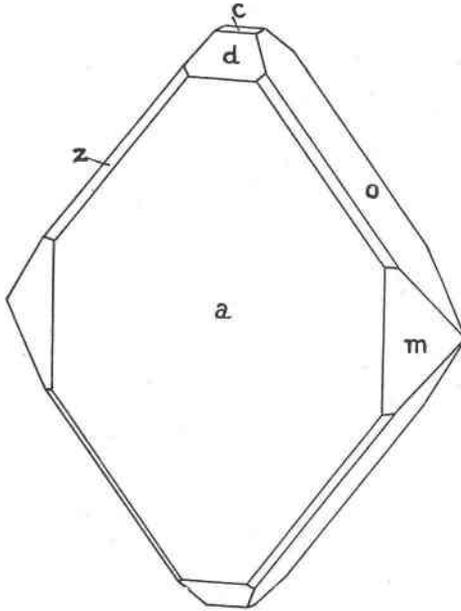

Fig. 2. Celestite, Franklin, N. J.

IV. Celestite

This mineral, although known at Franklin, has not been heretofore reported from Sterling Hill. It occurs in a cavity in franklinite ore as good crystals tabular parallel to $a(100)$, Fig. 2. A partial analysis and optical examination indicate that the crystals are pure in composition.

V. Correction

"Clinozoisite" from Franklin is Chlorophoenicite

A number of years ago a mineral was found at Franklin which seemed to possess a crystallographic and optical relation to the

minerals of the epidote group. This material was recently described in this journal as clinozoisite,[2] without an analysis, due to the scarcity of material. Subsequent examination of the material has shown conclusively that it is chlorophoenicite in a somewhat different association, and in slightly better crystals than any found heretofor.   The approximate agreement of interfacial angles of epidote and chlorophoenicite by bringing into coincidence the (100) form of the latter with the (001) of epidote, and the generally poor quality of the crystals combined to bring about the misinterpretation. The optical orientation of the two minerals is also quite similar.   The following table gives the relations of the angles and optical properties of the erroneously described clinozoisite, and chlorophoenicite.

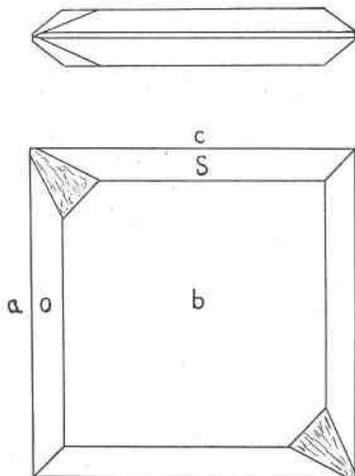| "CLINOZOISITE"	CHLOROPHOENICITE
$(001) \wedge (\bar{1}01) = 63°43'$	$(100) \wedge (106) = 66°34'$
$(\bar{1}01) \wedge (\bar{1}11) = 55°26'$	$(106) \wedge (146) = 54°35'$
$\alpha = 1.684$	$\alpha = 1.682$
$\beta = 1.691$	$\beta = 1.690$
$\gamma = 1.698$	$\gamma = 1.697$
Optical orientation $Y = b$	$Y = b$

FIG. 3. Datolite, Franklin, N. J. Projection on the side pinaoricd (010).

VI. DATOLITE

An interesting new habit of datolite was recently found at Franklin. The crystals are tabular parallel to $b(010)$ with equal development of the forms $o(120)$ and $s(021)$ which have an approximately equal inclination to b. Thus a pseudotetragonal symmetry is developed as shown in Figure 3. The forms present are $c(001)$, $a(100)$, $b(010)$, $s(021)$, $o(120)$ and a vicinal face in the position of a steep positive pyramid.

The determination of the crystals as datolite was confirmed by optical means and a partial analysis.

VII. FERROSCHALLERITE

A number of years ago schallerite was described from Franklin.[3] The composition is essentially an arseno-silicate of manganese. Recently a variety of this mineral was found at the same mine (1597 pillar, 50 feet south of Trotter Shaft), in which the manganese has been partly replaced by iron, so that this new variety may well be called ferroschallerite. It is interesting to note this replacement relation between the iron and manganese in schallerite because essentially the same relation exists between friedelite and pyrosmalite, two other members of the same group.

An analysis on the ferroschallerite by L. H. Bauer follows:

ANALYSIS OF FERROSCHALLERITE

	PER CENT	MOLECULAR RATIOS	
SiO_2	31.12	.518	$=6\times.086$
MnO	29.22	.422 ⎫	
FeO	17.12	.238 ⎬ $.708=8\times.089$	
MgO	0.12	.003	
ZnO	3.63	.045 ⎭	
As_2O_3	12.46	.063	$=\frac{3}{4}\times.084$
H_2O	6.42	.356	$=4\times.089$
	100.09	Sp. Gr.$=3.44$	

This yields the formula:

$$8RO\cdot\tfrac{3}{4}As_2O_3\cdot 6SiO_2\cdot 4H_2O$$
$$R=Mn:Fe=2:1$$
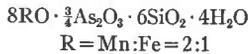
VIII. MANGANBRUCITE

A single specimen of manganbrucite has been found as a narrow veinlet cutting the franklinite-willemite ore. The crystals are acic-

ular parallel to the c-axis. The individuals are closely compacted to form sub-parallel aggregates with a curved termination made up of many basal planes not quite parallel to each other. The color of the material varies from pure white to deep brown, depending presumably on the amount of oxidation the manganese has suffered. The refractive index varies somewhat but is higher than that of pure brucite. The average values determined were: $\omega = 1.59$, $\epsilon = 1.60$. The following analysis by Bauer was made on light colored material and yields a Mg to Mn ratio of 5:1.. The Jakobsberg material has a ratio Mg:Mn of 7:1.

ANALYSIS OF MANGANBRUCITE FROM FRANKLIN

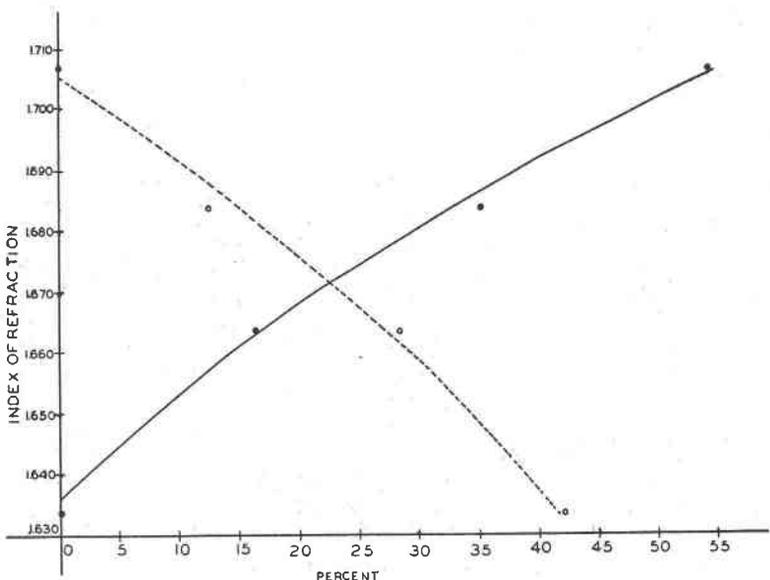|	PER CENT
H_2O	25.97
MnO	17.58
ZnO	3.56
MgO	49.94
CaO*	undet.
	97.05

*Present as $CaCO_3$

FIG. 4. Relations of refractive index and composition in the Apatite-Svabite series. Solid line, variation of refractive index (ω) with As_2O_5 content. Dotted line, variation of refractive index (ω) with P_2O_5 content.

IX. SVABITE

Many of the so-called apatites occurring in the ore at Franklin have been found to contain more or less arsenic replacing the phosphorus. All of the apatites embedded in the limestone, however, have been found to be free from arsenic. One of the highly arsenical varieties has been analyzed by Bauer and this analysis is given below.

ANALYSIS OF SVABITE

	PER CENT	MOLECULAR RATIOS	
Insol.	0.29		
H_2O	1.32	.0733	
F	1.41	.0742	$.1104 = 1 \times .1104$
CO_2	trace		
CaO	45.89	.8195	
ZnO	1.54	.0189	
MnO	1.23	.0173	$.8788 = 10 \times .0879$
MgO	0.84	.0208	
PbO	0.51	.0023	
As_2O_5	35.24	.1532	
P_2O_5	12.54	.0883	$.2415 = 3 \times .0805$
	100.81		
Less $O = F_2$	0.59	$H_2O : F_2 = 2:1$	
	100.22		

Molecularly $36\frac{1}{2}$ per cent. apatite.
$63\frac{1}{2}$ per cent. svabite.

$G = 3.542$ $\omega = 1.684$

TABLE I. VARIATION IN INDEX OF REFRACTION AND COMPOSITION IN THE APATITE-SVABITE SERIES.

	Percentage of		Index of Refraction (ω)	Specific Gravity
	Phosphate	Arsenate		
Apatite	42.3	0	1.634	$3.20\pm$
Apatite	28.4	16.2	1.664	3.446
Svabite	12.5	35.2	1.684	3.542
Svabite[5]	0	54.4	1.707	$3.54\pm$

Another sample was partially analyzed for its arsenic and phosphorus content. The data for these intermediate members as well as the two end members, apatite and svabite, are given in table 1, from which a graph has been constructed (fig. 4) to show the vari-

ation in index of refraction with As_2O_5 and P_2O_5 in solid solution. The graph is not intended to be of great accuracy, since other factors such as flourine, chlorine, CO_2, and water have considerable effect on the optical properties. These have not been considered since the correlation data is not adequate. The graph is useful, however, in giving the approximate composition of any of the apatites found in the Franklin ores.

BIBLIOGRAPHY

1. E. V. Shannon and H. Berman. *Am. Mineral.*, Vol. **11**, 5, 1926, pp. 130–132.
2. *Am. Mineral.*, **13**, 7, 1928, p. 304.
3. R. B. Gage, E. S. Larsen, H. E. Vassar. *Am. Mineral.*, **10**, 1, 1925, pp. 9–11.
4. E. S. Dana. *System Min.* (6th ed.) p. 252.
5. Hj. Sjögren. *Contr. Swedish Min., Bull. Geol. Inst. Upsala*, Vol. **1** (1892), p. 50