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ART. XLI.—*Some new Minerals from the Zinc Mines at Franklin, N. J., and Note concerning the Chemical Composition of Ganomalite;* by S. L. PENFIELD and C. H. WARREN.

THE minerals to be described in the present paper came for the most part from the one-thousand-foot level of the Parker Shaft on North Mine Hill. Unfortunately at the time that they were brought to the surface, about two years ago, the fact that several new species were being mined was not known, and a quantity of material, which it is believed would prove to be very profitable hunting ground for the new species, was thrown upon the dump and subsequently covered up. Our attention has been called to these minerals at different times by Messrs. E. P. Hancock, of Burlington, N. J., J. J. McGovern, of Franklin, F. L. Nason, of West Haven, Conn., F. A. Canfield, of Dover, N. J., and W. M. Foote, of Philadelphia, Pa., while both of the authors at separate visits to the locality have been able to collect a few specimens. The new species were found in a somewhat limited area, and it is especially interesting to note the minerals which are associated with them, for they are very unusual even for Franklin, N. J., and would seem to indicate that peculiar conditions prevailed during the period when these minerals were being formed. The associated minerals are as follows: Native lead[*] and copper,[†] clinohedrite,[‡] roeblingite,[§] axinite in transparent yellow crystals, willemite in exceptionally fine, transparent green crystals, vesuvianite, datolite, barite, garnet, brownish-black phlogopite and a little franklinite. The presence of axinite and datolite containing boron and of phlogopite would seem to indicate that the minerals, part of them at least, have resulted from metamorphism brought about by the action of intruded igneous masses either during the pneumatolitic period when such masses were giving off heated aqueous vapors carrying boron and fluorine compounds, or during a period when heated waters, laden with mineralizing agents, were circulating through the deposit.

1. HANCOCKITE.

This mineral was found in considerable quantity both massive and in cellular masses of a brownish-red or maroon color, and attention has already been called to it as a new species by Penfield and Foote in their description of clinohedrite.[‖] Thus

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[*] This Journal, vi, p. 187, 1898.

[†] Proc. Am. Acad. of Arts and Sci., xxxiii, p. 429, 1898.

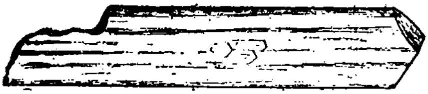
[‡] This Journal, v, p. 289, 1898.

[§] Ibid., iii, p. 413, 1897.

[‖] Loc. cit.

far it has been observed only in very small, lath-shaped crystals, the largest being not over $0{\cdot}5^{mm}$ in length and $0{\cdot}15^{mm}$ in diameter, and these generally are so intimately associated with garnet, axinite and phlogopite that it was for a long time difficult to secure a specimen from which a sufficient quantity of the pure material could be obtained for the chemical analysis. The accompanying figure is a sketch of one of the crystals as seen under the microscope. The faces are striated parallel to the longer axis of the crystals, and they round into one another owing to oscillatory combinations. The terminal faces, necessarily very small, are vicinal, and it has thus far been impossible to find any crystal from which satisfactory measurements of the interfacial angles could be obtained. As may be seen from the figure the habit of the crystals is like that of epidote; that is, the prominent faces are parallel to the axis of symmetry, and the crystals are terminated by two faces corresponding to the form *n* ($\bar{1}11$) of epidote. On one of the crystals it was possible to obtain approximate measurements with the Fuess reflecting goniometer by using a strong illumination of the signal and the δ ocular. The measurements, given in the accompanying table, although not sufficiently accurate for establishing an axial ratio, indicate that the forms and angles of hancockite are similar to those of epidote.

1



	Hancockite, Approximate measurements.	Epidote.
$c \wedge e$, $001 \wedge 101$ =	36° 15′	34° 43′
$e \wedge a$, $101 \wedge 100$ =	30 45	29 54
$c \wedge r$, $001 \wedge \bar{1}01$ =	63	63 42
$r \wedge a$, $\bar{1}01 \wedge \bar{1}00$ =	55 30	51 41
$n \wedge n$, $\bar{1}11 \wedge 11\bar{1}$ =	67	70 29
$c \wedge n$, $001 \wedge \bar{1}11$ =	77	75 11

Although the appearance of the mineral in the hand specimen varies from a dark to a light brownish-red, single crystals, as seen with a pocket lens, have a yellowish-brown color. Crystals like fig. 1, when examined with the polarizing microscope, exhibit distinct pleochroism, yellowish-brown for vibrations parallel to $\mathfrak{b}$, which corresponds to the crystallographic axis *b*, and somewhat variable for vibrations at right angles to this direction, being delicate rose color at the attached end and grading to pale, somewhat greenish-yellow at the terminated end. On some very small individuals the delicate rose color was observed throughout the whole length of the crystals. With crossed nicols the crystals show an extinction when their longer or symmetry axis is parallel to the plane of the polarizer. In convergent light something of the outer rings of the biaxial interference figure could be seen, accompanied by a dark bar, indicating plainly that the optical axes are in the symmetry plane. By rotating a crystal, when immersed in the potassium mercuric-iodide solution, the optical axes could be brought separately to the center of the field and their divergence 2 V was found to be approximately 50°.

The luster of the hancockite crystals is vitreous, and the hardness is about 6·5–7. Owing to the small size of the crystals and their intimate association with garnet, axinite and willemite, considerable difficulty was experienced in finding a specimen from which a sufficient quantity of pure material could be obtained for analysis. A specimen, however, finally came to us through Mr. Hancock, consisting of a cellular mass in which the walls and the drusy lining consisted chiefly of hancockite. By crushing this specimen, picking out the small fragments and examining them with a lens, it was possible to obtain the mineral almost absolutely free from the associated garnet and axinite, which could be distinguished by their lighter color. An attempt to separate the minerals by differences in their specific gravity was not successful. The specific gravity of the carefully selected material was found to be 4·030.

Concerning the method of analysis the only points which need to be specially commented upon are the following: After separation of the silica, the lead was precipitated with hydrogen sulphide and subsequently converted into sulphate and weighed. The iron and alumina were separated from the bivalent metals by a basic acetate precipitation, reprecipitated by ammonia and weighed as oxides, the iron being estimated subsequently by means of potassium permanganate. The calcium and strontium were converted into nitrates and separated by means of amyl alcohol as directed by Browning.* Water was estimated by loss on ignition. Careful tests failed to reveal the presence of any ferrous iron. The deep color of the crystals at first suggested the idea that the mineral would be rich in manganese, which is by no means the case. The color, however, is probably due to the presence of some higher oxide of manganese which is known to impart an intense color to silicates and was estimated by the method described by Penfield.†

* This Journal, xliii, p. 50, 1892.

† Ibid., xlvi, p. 291, 1893.

The results of the analysis by Warren are as follows :—

			Average.	Ratio.				Partial Analysis.	
SiO_2	30·99		30·99	·516		SiO_2	6	SiO_2	30·88
Al_2O_3	17·89		17·89	·173				Al_2O_3	17·99
Fe_2O_3	12·30	12·37	12·33	·077	·259	R_2O_3	3·00	Fe_2O_3	12·96
Mn_2O_3	1·38		1·38	·009					- - - -
PbO	18.47	18·59	18·53	·083				PbO	17·47
MnO	2·12		2·12	·029				MnO	2·96
MgO	0·52		·52	·013	·367	RO	4·26	MgO	1·02
CaO	11·50		11·50	·205				CaO SrO	15·33
SrO	3·89		3·89	·037					
H_2O	1·62		1·62	·090		H_2O	1·06		1·62
			100·77						100·23

The ratio of $SiO_2 : R_2O_3 : RO : H_2O$ approximates closely to 6 : 3 : 4 : 1, which gives as the empirical formula $H_2R''_4R'''_6Si_6O_{26}$, or $R''_2(R'''\cdot OH)R'''_2(SiO_4)_3$. The general formula is that of epidote, but the material differs from any variety of that mineral previously described in having the bivalent metals lead and strontium isomorphous with calcium. Owing to its color and the presence of manganese sesquioxide the mineral is allied to piedmontite. It will be observed that the quantity of protoxide, RO, indicated by the analysis, is a trifle high, SiO_2 : RO being 6 : 4·26 instead of 6 : 4, as it should be to satisfy the epidote formula. The analyses, however, were made with very great care, and in the determination of the calcium and strontium the separated oxides were converted into sulphates and thus found to have the correct molecular weight. The partial analysis given was made on material taken from the same specimen as used for the other analysis, but the higher oxide of manganese was not determined and strontium was not separated from the calcium.

In its chemical as well as in its crystallographic relations, hancockite is a member of the epidote group of minerals, and should occupy a position next to piedmontite in a system of mineralogy. It is especially interesting on account of the considerable quantities of lead and strontium which it contains, elements thus far observed in combination with silicic acid in only a few rare mineral species.

Before the blowpipe, hancockite fuses with intumescence at 3 to a black, slightly magnetic globule. The globule becomes more strongly magnetic if heated on charcoal. With sodium carbonate on charcoal a coating of lead oxide is obtained. Reacts for manganese with the sodium carbonate bead in O. F. The mineral is insoluble in hydrochloric acid, but, like epidote, after fusion it dissolves and yields gelatinous silica upon evaporation. In the closed tube, at a high temperature, a little water is given off.

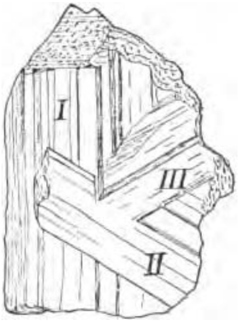
A considerable quantity of hancockite was taken from the mine at one time, and it is the most abundant of the new species described in this paper. It is named after Mr. E. P. Hancock of Burlington, N. J.

2. GLAUCOCHROITE.

This mineral was collected by S. L. Penfield in September, 1898, and was subsequently sent to New Haven for identification by Mr. W. M. Foote, who had collected several specimens of it earlier in the season. It occurs in prismatic crystals belonging to the orthorhombic system, and in columnar aggregates imbedded in a white matrix. The largest crystals thus far observed do not average over 2^{mm} in greatest diameter, while the length of some of the columnar aggregates somewhat exceeds 10^{mm}.

Isolated crystals generally show the form of a prism *m* (110), sometimes in combination with a second prism *s* (120), and thus far all attempts to find a crystal with terminal faces have proved unsuccessful. A few penetration and contact twins have been observed, the twinning plane being the brachydome (011), and the vertical axes of the individuals crossing at angles of about 60° and 120°. Fig. 2 is an illustration of one of these penetration twins, drawn with the camera lucida as it appeared under the microscope. On the twin crystals the pinacoid *a* (100) is generally developed, although it was not observed on any of the simple crystals.

2



The prismatic faces, although bright, were vicinal, and consequently it was difficult to obtain reliable measurements of the prismatic angle. The average of a number of measurements of $m \wedge m$, $110 \wedge 1\bar{1}0$, was found to be 47° 32′, and this angle, taken as fundamental, agreed very closely with the measurements derived from the best reflections. As terminal planes were not observed, the angle between the vertical axes of two prisms in twin position was measured under the microscope and found to be 121°. Assuming the twinning plane to be the brachydome (011), the angle of $011 \wedge 0\bar{1}1$ was thus found to be 59°, and taken as a fundamental angle. From the foregoing fundamental angles the axial ratio has been calculated, and is given below, together with the axial ratios of monticellite and chrysolite, to which species glaucochroite is closely related, it being a manganese monticellite.

Glaucochroite, $a : b : c$ = 0·440 : 1 : 0·566
Monticellite, " " " = 0·431 : 1 : 0·576
Chrysolite, " " " = 0·466 : 1 : 0.586

No reliable reflections could be obtained from the second prism s (120). Approximate measurements are $120 \wedge \bar{1}20 = 99°$, calculated 97° 16′ and $m \wedge s$, $110 \wedge 120$, = 17° 21′, calculated 17° 36′. A rather poor basal cleavage was detected, and measurements from this cleavage onto the prism faces gave angles of 90°.

The hardness is about 6. The specific gravity, taken with the pycnometer is 3·407. The fracture is conchoidal. The luster is vitreous and the color is a delicate bluish green, very similar to that of the aquamarine variety of beryl. Minute crystals are almost colorless, and on a few of the specimens there were small areas where the mineral exhibited a delicate pink color.

The optical orientation is $\mathfrak{a}=b$, $\mathfrak{b}=c$ and $\mathfrak{c}=a$. The plane of the optical axes is the base (001) and the acute bisectrix is normal to the brachypinacoid b (010). The double refraction is therefore negative. Prismatic crystals served as prisms for determining the indices of refraction $\alpha=1·686$ and $\beta=1·722$. These values were each derived from the mean of four independent measurements which showed considerable variation, owing to the vicinal character of the prismatic faces, but it is believed that they represent a close approximation to the true values. On a section parallel to the pinacoid (010), which measured $0·5 \times 1·5^{mm}$, the divergence of the optical axes for yellow light, Na flame, was measured on the Fuess axial angle apparatus as follows: $2\,E=121° \; 30'$ and $2H$ in α-monobromnaphtalene$=63° \; 27'$. From these values $2V_y$ was found to be 60° 53′ and 60° 49′, respectively. The dispersion was marked $\rho > v$. From the values α, β and V, γ was calculated and found to be 1·735. The optical orientation, dispersion and the character of the double refraction of glaucochroite are like those of monticellite as determined by Penfield and Forbes.* The indices of refraction for yellow light and the divergence of the optical axes, 2V, of glaucochroite, monticellite and chrysolite are given below for comparison:

	α	β	γ	$\gamma-\alpha$	2 V over α
Glaucochroite,	1·686	1·722	1·735	0·049	60° 51′
Monticellite,	1·6505	1·6616	1·6679	0·0174	75° 2′
Chrysolite,†	1·661	1·678	1·697	0·036	92° 14′

Very pure material for the chemical analysis was obtained by picking out the small prismatic crystals which separated readily from the matrix. The results of the analysis by Warren are as follows:

		Ratio.		Corrected analysis.	Theory for $CaMnSiO_4$
SiO_2	31·48	·524	1·00	31·98	32·08
MnO	38·00	·535	1·02	38·60	37·97
CaO	28·95	·517	·99	29·42	29·95
PbO	1·74				
FeO	trace			100·00	100·00
	100·17				

Leaving out of consideration the small amount of PbO, which, owing to its high molecular weight, had only a slight effect upon the ratio, the ratio of SiO_2: MnO: CaO=1·00: 1·02: 0·99, or a very close approximation to 1:1:1. The formula of glaucochroite is therefore $CaMnSiO_4$, that of monticellite being $CaMgSiO_4$. With the above analysis we have given the corrected analysis, after disregarding 1·74 per cent of PbO and calculating to 100 per cent, and also the theoretical composition corresponding to the formula $CaMnSiO_4$. Glaucochroite takes therefore a place in the system of mineralogy next to monticellite as a member of the chrysolite group.

Glaucochroite fuses quietly before the blowpipe at about 3·5 to a brownish black globule, and imparts no color to the flame. The powdered mineral dissolves easily in hydrochloric acid, and the solution yields gelatinous silica upon evaporation. A little of the concentrated solution, when brought in contact with a drop of sulphuric acid on a watch glass, gives a precipitate of calcium sulphate. With either the borax or sodium carbonate beads a strong reaction for manganese is obtained.

So far as known, only a small amount of glaucochroite has been found. Its crystals occur imbedded in a white matrix, nasonite (see beyond), and intimately associated with brown

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* This Journal, 1, p. 135, 1896.

† Des Cloizeaux, Memoirs de l'Institute de France, T. xviii, p. 591.

garnet and yellow axinite. The name glaucochroite has been given to this species because of its color, from *γλαυκός=blue-green* and *χροια=color.*

3. NASONITE.

This material constitutes the matrix in which the crystals of glaucochroite are generally imbedded. It occurs massive, of white color, greasy to adamantine luster, hardness about 4, and hand specimens usually present a mottled or spotted appearance owing to numerous inclusions of yellow axinite and brown garnet, which are scattered rather uniformly through the massive nasonite. The material that has been examined consists of a few specimens collected by S. L. Penfield and some sent to us by Mr. W. M. Foote.

Thin sections when examined with the polarizing microscope show that the material is crystalline, and that the masses consist of an intergrowth of crystal particles, some of which are several millimeters in diameter. No pronounced cleavages were observed under the microscope, and no crystal boundaries were detected which gave any clue to the system of crystallization. In convergent polarized light, however, certain sections gave a uniaxial interference figure, and, since the massive mineral broke up at times into rude rectangular blocks, it may be inferred that the crystallization is tetragonal and that the cleavage, which is poor, is prismatic and basal. The birefringence is rather strong, and the character of the double refraction is positive.

Material for the chemical analysis was obtained by crushing a large fragment and picking out the purest material by hand. The specific gravity was found to be 5·425, and the results of the analysis by Warren are as follows:

	I	II	Average	Ratio		
SiO_2	18·47	18·47	18·47	·308		3·00
PbO	65·84	65·52	65·68	·294	·516	5·03
ZnO	0·84	0·80	0·82	·010		
MnO	0·90	0·76	0·83	·011		
FeO	0·10	——	0·10	·001		
CaO	11·20	11·20	11·20	·200		
Cl	2·80	2·82	2·81	·079	·108	1·05
H_2O	0·27	0·26	0·26÷9	·029		
			100·17			
Oxygen equivalent of Cl			·63			
			99·54			

The ratio of SiO_2 : (Pb+Zn+Mn+Fe+Ca) O : (Cl+OH) = 3·00 : 5·03 : 1·05 which approximates closely to 3 : 5 : 1, and, since two chlorine atoms are equivalent to one oxygen, this leads to the general formula $R_{10}Cl_2Si_6O_{21}$, R = Pb and Ca, and only traces of Zn, Mn and Fe. Before discussing the general formula further, it may be stated that there were observed, intimately associated with the nasonite, a few particles of clinohedrite, $H_2CaZnSiO_5$, and it is probable therefore that the small percentage of zinc (0·82 per cent ZnO) was derived from a slight admixture of this latter mineral. It seems therefore best to deduct from the foregoing analysis the ZnO, and sufficient amounts of SiO_2, CaO and H_2O to form the clinohedrite molecule. The ratio then becomes SiO_2 : (Pb+Mn+Fe+Ca) O : (Cl+OH) = ·298 : ·496 : ·098 = 3·00 : 5·01 : 0·99 or almost exactly 3 : 5 : 1. Furthermore the ratio of SiO_2 : PbO : (Ca+Mn+Fe) O : (Cl+OH) = ·298 : ·294 : ·202 : ·098 = 3·00 : 2·97 : 2·04 : 0·99 or, very closely, 3 : 3 : 2 : 1. Since Fe, Mn, and water (hydroxyl) are present only in very small amounts, they may practically be disregarded, and the empirical formula expressed as $Pb_6Ca_4Cl_2(Si_2O_7)_3$, or $Pb_4(PbCl)'_2Ca_4(Si_2O_7)_3$.

Below we have given the analysis, after deducting 2·16 per cent of clinohedrite, substituting for MnO and FeO equivalent amounts of CaO, for the remaining 0·09 per cent of water (hydroxyl) an equivalent of chlorine, and calculating to 100 per cent, while, for comparison, the theoretical composition corresponding to the formula $Pb_6Ca_4Cl_2(Si_2O_7)_3$ is also given.

	Analysis corrected.	Theory.
SiO_2	18·32	18·21
PbO	67·32	67·68
CaO	11·59	11·33
Cl	3·57	3·59
	100·80	100·81
O = 2Cl	·80	·81
	100·00	100·00

Before the blowpipe, nasonite is very apt to decrepitate, but if a fragment can be held in the forceps it fuses at about 2 to a semi-transparent globule, and the characteristic flame coloration of lead is obtained. In the closed tube the mineral gives a trace of water and an abundant sublimate of lead chloride, the residual mineral fusing to an amethystine glass in the bottom of the tube. The powdered mineral, when heated alone on charcoal in the reducing flame, gives a white sublimate of lead chloride distant from the assay, a yellow coating of oxide nearer, and globules of metallic lead. The mineral is readily soluble in dilute nitric acid, and the solution yields gelatinous silica upon evaporation.

The mineral is named after Mr. Frank L. Nason of West Haven, Connecticut, formerly of the Geological Survey of the State of New Jersey.

Note concerning the Chemical Composition of GANOMALITE.

Nasonite is closely related to ganomalite, to which the empirical formula $Pb_3Ca_2Si_3O_{11}$ has been assigned, a little calcium being replaced by manganese. The foregoing formula, when doubled, may be written as a slightly basic salt, as follows: $Pb_4(Pb_2O)''Ca_4(Si_2O_7)_3$, which is like the formula of nasonite, except that the bivalent basic lead oxide radical (Pb_2O) of ganomalite takes the place of the two univalent lead chloride radicals (PbCl) of nasonite. The analogy between the two minerals, however, becomes still closer if two univalent lead hydroxide radicals (PbOH) are substituted for the bivalent basic lead oxide radical as follows: $Pb_4(PbOH)_2Ca_4(Si_2O_7)_3$, and we hope to be able to show that this is undoubtedly the correct formula for ganomalite. The amount of water necessary to yield two hydroxyls in the complex ganomalite molecule is a trifle less than one per cent, a quantity which might have been easily overlooked. In two analyses of ganomalite from Jakobsberg, Sweden, by Wiborgh, quoted by Sjögren,[*] neither water nor loss on ignition are recorded, while in an analysis by Lindström[†] a loss on ignition of 0·57 per cent is given, and, what is also very significant, the presence of a little chlorine is recorded. Lindström's analysis is as follows:

	Analysis.	Ratio.			Analysis recalculated.		Theory for $Pb_4(PbOH)_2Ca_4(Si_2O_7)_3$
SiO_2	18·33		·306	3·00	SiO_2	18·51	18.56
PbO	68·80		·308	3·02	PbO	69·46	68·97
MnO	2·29	·032	·202	1·98	CaO	11·40	11·55
MgO	·11	·003			H_2O	·63	·92
CaO	9·34	·167				———	———
Cl	·24	·007	·070	0·70		100·00	100·00
Ign.	·57	÷9=·063					
‡X	·35						
	———						
	100·03						

The ratio of SiO_2 : PbO : CaO : (OH+Cl)=3·00 : 3·02 : 1·98 : 0·70 or, excepting the hydroxyl and chlorine, a very close approximation to 3 : 3 : 2 : 1, thus agreeing with the ratio of nasonite.

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[*] Geol. För. Förhandl., vi, p. 537, 1883.

[†] Ibid., p. 663.

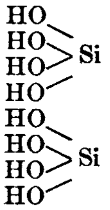
[‡] X=CuO 0·02, Al_2O_3 0·07, Fe_2O_3 0·12, alkali 0·10, P_2O_5 0·04.

The water (loss on ignition) is low, owing undoubtedly either wholly or in part to the partial oxidation of the manganese during ignition. It is also possible that a trace of fluorine was present, since the amount necessary to bring the ratio of (OH+Cl+F) up to 1 would be trifling and might easily be overlooked. In connection with Lindström's analysis we have given his values recalculated to 100 per cent, after substituting an equivalent of CaO for the small amounts of MnO and MgO, an equivalent of water (hydroxyl) for chlorine, and disregarding the 0·35 per cent designated as X. The theoretical composition corresponding to the formula $Pb_4(Pb.OH)_2Ca_4(Si_2O_7)_3$ is also given, and, except for the water, which is 0·31 per cent low, the agreement between the recalculated analysis and the theory is most satisfactory.

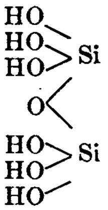
Ganomalite is tetragonal, and, in all probability, nasonite crystallizes in the same system, for, as already stated, the latter is optically uniaxial and breaks out into rude rectangular blocks, corresponding to the form produced by a combination of the prismatic and basal cleavages. The cleavage of nasonite, however, should be designated as poor, scarcely distinct, while ganomalite is described as having distinct cleavages parallel to the prism *m* (110) and the base. Both minerals exhibit strong positive birefringence. The specific gravity of nasonite, 5·425, is less than that of ganomalite, 5·738, which would be expected, for, although nasonite contains chlorine which is heavier than hydroxyl, ganomalite contains more lead and hence should be heavier. The percentages of lead according to theory are, respectively, nasonite 67·28 and ganomalite 68·98. Thus in their physical properties nasonite and ganomalite are closely analogous, and it may be confidently expected, on the one hand, that if crystals of nasonite are discovered they will be tetragonal, thus conforming to ganomalite, while, on the other hand, ganomalite will be found to contain water in sufficient quantity to yield with the chlorine a ratio of SiO_2: $(OH+Cl)=3:1$. The two minerals furnish an excellent example of the isomorphous relation existing between chlorine and hydroxyl in complex molecules, nasonite being essentially the pure chlorine compound but containing a trace of hydroxyl (water), and ganomalite being essentially the pure hydroxyl compound but containing a trace of chlorine. Both minerals contain a little manganese isomorphous with the calcium.

The acid, $H_6Si_2O_7$, of which nasonite and ganomalite are salts, is intermediate between orthosilicic acid, H_4SiO_4, and metasilicic acid, H_2SiO_3, and it may be regarded either as equivalent to their algebraic sum, or as derived from two molecules of orthosilicic acid by taking away one molecule of water. The latter relation may be expressed as follows:

Two molecules of
orthosilicic acid.



Intermediate or
mesosilicic acid.



The intermediate acid $H_6Si_2O_7$ is one which has been recognized by mineralogists, but its salts have not generally received a prominent place in the systematic classifications of silicates, because they are not very numerous. Groth* calls attention to the acid and its salts, and has given the name "*Diorthokieselsäure*" to the acid. Clarke † also has discussed the chemical relations of the minerals of this group, adopting Groth's name *diorthosilicic acid*, and calling the minerals *diorthosilicates*. The name *diorthosilicic* seems, however, inappropriate, since $H_6Si_2O_7$ is not an orthosilicic acid as the name signifies, but a derivative of orthosilicic acid. We feel, therefore, warranted in suggesting new names, *mesosilicic* for the acid and *mesosilicates* for its salts, the prefix *meso* being derived from *μέσος*, signifying middle or between. The intermediate relation of mesosilicic acid is evident from the following:

Orthosilicic acid, two molecules,	$H_8Si_2O_8$.
Mesosilicic acid,	$H_6Si_2O_7$.
Metasilicic acid, two molecules,	$H_4Si_2O_6$.

The mesosilicates are classed by Dana in the small group of "Intermediate Silicates" on page 416 of his Mineralogy, and by Groth as "*Intermediäre Silikate*" on page 138 of his *Uebersicht der Mineralien.*

The commonest mesosilicate is iolite, the composition of which may be expressed as a slightly basic salt, as follows: $(Mg, Fe)_4Al_6(Al.OH)_2(Si_2O_7)_5$, although the two hydroxyls may be in combination with the bivalent metals instead of with the aluminium. One of the few lead silicates, barysilite, $Pb_3Si_2O_7$, is a normal salt of mesosilicic acid, as is also the Franklin mineral hardystonite, $Ca_2ZnSi_2O_7$, recently described by Wolff.‡ Hardystonite is said to occur at the Parker shaft, North Mine Hill, but we have not yet observed it associated with any of the new minerals described in the present paper.

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* Tabellarische Uebersicht der Mineralien, IV Auflage, pp. 105 and 140.

† Constitution of the silicates; Bull. of U. S. Geolog. Survey, No. 125, p. 81.

‡ Proceedings of the Am. Acad. of Arts and Sci., xxxiv, p. 479, 1899.

4. LEUCOPHŒNICITE.

This mineral made up the larger part of a specimen about two inches in length and breadth by one inch in thickness, which was found by Mr. J. J. McGovern of Franklin, and given to C. H. Warren in 1897. It has also been observed in small amount on a few specimens sent to us by Mr. W. M. Foote. The mineral has a crystalline structure, vitreous luster, hardness about 5·5–6, and is conspicuous on account of its light purplish-red or raspberry color. It was supposed at first to be clinohedrite, rather deeply colored by manganese. It is intimately associated with willemite of almost gem-like quality and beautiful light green color, and with small idiomorphic crystals of brown vesuvianite, showing prisms of the first and second order, pyramid of the first order and base. Occasional crystal faces were observed on the leucophœnicite, but none which gave any clue to the system of crystallization.

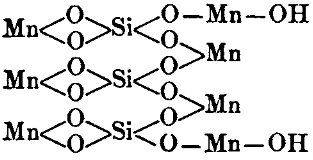
When small fragments of the mineral are imbedded in balsam and examined with the microscope it may be seen that the fragments are mostly irregular, although some are flat and appear to lie upon imperfect cleavage faces. There also may be seen irregular cracks indicating a second but not distinct cleavage. In polarized light the extinction seemed to be slightly inclined to the direction of the second cleavage, and in convergent light an optical axis was observed near the limit of the field. The fragments showed a slight pleochroism, pale rose for vibrations parallel to the direction of cleavage, and colorless at right angles to this direction. These properties indicate that the material probably crystallizes in one of the inclined systems, although wholly satisfactory conclusions could not be drawn.

Very pure material for the chemical analysis was obtained by crushing a portion of the best specimen, and selecting the purest particles by hand. The specific gravity was found to be 3·848. The results of the analysis by Warren are as follows:

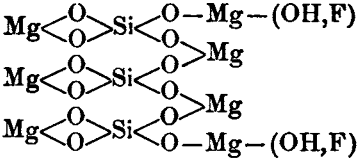
	I.	II.	Average.		Ratio.	
SiO_2	26·31	26·41	26·36	·439		3·03
MnO	60·59	60·67	60·63	·854	1·015	7·00
ZnO	4·03	3·72	3·87	·047		
FeO	----	----	trace	----		
MgO	0·21	----	0·21	·005		
CaO	5·64	5·70	5·67	·101		
Na_2O	0·39	----	0·39	·006		
K_2O	0·24	----	0·24	·002		
H_2O	2·70	2·58	2·64	·146		1·01
			100·01			

Letting R stand for the metals (chiefly manganese) the ratio of $SiO_2 : RO : H_2O$ is 3·03 : 7·00 : 1·01, or a close approximation to 3 : 7 : 1, and this leads to the general empirical formula $H_2R_7Si_3O_{14}$. Since water is not expelled from the mineral much below a red heat, the hydrogen must exist in the form of hydroxyl, and, consequently, the foregoing formula may be written $R_5(R.OH)'_2(SiO_4)_3$ or as a basic orthosilicate, exactly equivalent to humite except that no fluorine is present. Considering the base wholly as manganese, the following is suggested as a structural formula of the mineral, which certainly appears simple and reasonable, and for comparison the structural formula of humite is also given.

Leucophœnicite.



Humite.



Leucophœnicite is therefore a manganese humite, but it contains no fluorine isomorphous with the hydroxyl. As humite is a magnesium mineral resulting from metamorphism due to fumerole or pneumatolitic action, so leucophœnicite is a similarly constituted mineral, produced probably by like causes at a locality where manganese was abundant. It is probable that the crystallization of leucophœnicite is analogous to that of the minerals of the humite group, and, since the examination of fragments of leucophœnicite in polarized light indicated one of the inclined systems (page 351), it may be inferred that its crystallization is monoclinic, with $\beta=90$, analogous to chondrodite and clinohumite, rather than orthorhombic like humite. Furthermore, the discovery of this mineral suggests the possibility of finding a series of manganese compounds, corresponding to prolectite, chondrodite, humite and clinohumite. Attention may also be called to the fact that Jannasch and Locke* have described a variety of humite from Valais, Switzerland, exactly analogous to leucophœnicite in that it contains no fluorine.

Before the blowpipe, leucophœnicite fuses quietly at about 3 to a brownish black globule. In the closed tube it yields a little water. Reacts for manganese with the fluxes. The powdered mineral dissolves very easily in hydrochloric acid, and the solution yields gelatinous silica upon evaporation.

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* Zeitschr. für anorganische Chemie, vii, p. 92, 189.

The name leucophœnicite has reference to the color of the mineral, and was derived from λευκόσ = pale or light and φοίνιξ = purple-red.

There are other minerals from the locality, some of them evidently new, which have been partially examined, and it is hoped that a full description of them may be given in a future article.

In closing we desire to express our thanks to those gentlemen, named at the beginning of this article, who have generously supplied us with material for carrying on this investigation, and especially to Mr. W. M. Foote, who spent some weeks collecting at the locality in the summer of 1898 and who has called our attention to a number of interesting specimens and associations.

Laboratory of Mineralogy and Petrography,
Sheffield Scientific School of Yale University, September, 1899.