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ART. IV.—*On a new and remarkable mineral locality in Fairfield County, Connecticut; with a description of several new species occurring there;* by GEORGE J. BRUSH and EDWARD S. DANA. First Paper.

Historical Note.

THE new locality of manganesian phosphates, which we shall describe in this and following papers, is situated near the village of Branchville, in the town of Redding, Fairfield County, Connecticut. Its remarkable character will be evident from the statement that we have thus far discovered, among the material which we have obtained from there, no less than six new and well defined species, besides many other known species of more or less rarity.

The locality was first opened some two years since by Mr. A. N. Fillow, upon whose land it is situated, and who made considerable excavations in the search for mica of commercial value. Only a limited quantity of this was obtained, so that the work was finally discontinued and the opening filled up; by which means the ledge was buried under six to eight feet of soil. With most commendable thoughtfulness, however, he laid aside and preserved a large number of specimens which seemed to him to be of some interest. In the latter part of the summer of 1877, Prof. Dana visited the region and his attention was called by Mr. Fillow to the collection of minerals mentioned, and by him several specimens were brought to New Haven. Later, Rev. John Dickinson of Redding, the adjoining village, happened to visit the locality and obtained a considerable amount of the minerals, some of which he sent to New Haven for determination. It was not, however, until the early spring of the present year that we were able personally to visit the locality. Appreciating then the unusual interest connected with it, we immediately made arrangements with Mr. Fillow to uncover the ledge and to go forward with the exploration as thoroughly as possible. We have now pushed the matter as far as is practicable for the present, but later in the season we hope to accomplish more. The result of our work has been to place in our hands a large amount of material, in the examination of which we are at present engaged, and we are now ready to make public* a portion of the results. In addition to the material we have personally obtained, we have, through the liberality of Mr. Dickinson, come into the possession of a large number of additional specimens collected by

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* Short notices of the new species eosphorite, triploidite, dickinsonite, and lithiophilite (by mistake printed *lithiolite*) were published on pp. 398, 481, of the preceding volume.

himself before our first visits to Branchville. These have been of the greatest service to us in the study of the species occurring at the locality, and we would here express our great appreciation of his generosity. We would also mention our obligations to Mr. Fillow and his brother, who have been most careful in obtaining the best results possible in the explorations of which they have taken charge.

Brief general description.

All the minerals which we have obtained are from a single vein of albitic granite, and the line along which the explorations have been carried does not exceed twenty feet. The general description of the vein and of the minerals which compose it—with the exception of the manganesian phosphates and the immediately associated species—we reserve for a later paper; we will mention, however, that outside of these we have identified the following species:—

Albite, quartz, microcline in large masses, a hydro-mica near damourite having a peculiar concentric spherical structure, spodumene in crystals weighing one to two hundred pounds, cymatolite as a result of the decomposition of spodumene crystals, sometimes nine inches in width, apatite, microlite (sp. gr. = 6), columbite (sp. gr. = 5·6), apatite, garnet, tourmaline and staurolite.

The manganesian phosphates and related minerals occur in nests imbedded in the albite. A single deposit yielded almost all the material obtained, it being probable that what came out as the result of our work was a part of the same body of minerals which Mr. Fillow had blasted into two years before. A second deposit will be mentioned later as having furnished the lithiophilite.

The minerals which form the mass of the first mentioned bed are:—Eosphorite, dickinsonite, triploidite and rhodochrosite. Of these, the first three are new and are described at length in this paper. These four minerals, together with quartz, occur associated in the most intimate manner possible, it being not at all unusual to find all of them in a single hand specimen. This is especially true of the three new minerals: the eosphorite is often found in crystals entirely imbedded in the dickinsonite, and again the finely disseminated plates of dickinsonite give a green color to much of the massive eosphorite. Quartz is also contained in much of the massive eosphorite, thus giving it a very anomalous appearance; it also forms the mass in which the triploidite crystals are imbedded—both these points are spoken of more particularly later. Quartz is also often associated with the rhodochrosite, that mineral being disseminated in crystalline grains through the quartz, in which occasional brilliant cubes of pyrite are also imbedded.

In addition to the above minerals, as original constituents of the same deposit, are amblygonite (hebronite), and a phosphate of manganese isomorphous with scorodite which we shall describe under the name reddingite. As secondary products we have apatite and quartz coating together crystals of eosphorite, vivianite in thin layers and crystals, besides other species, which as yet, owing to lack of sufficient material for examination, we have been unable to determine.

Furthermore, there are a variety of alteration products: each one of the manganesian phosphates yields on alteration a black or purple phosphate of manganese and iron sesquioxides, and the rhodochrosite gives a pseudomorph of hydrated oxides.

The second smaller nest discovered consisted almost exclusively of lithiophilite. Of the previously mentioned minerals rhodochrosite is the only one we have observed with it, and that occurs very sparingly. In addition, however, a peculiar green manganiferous apatite, spodumene and cymatolite are intimately associated with the lithiophilite, besides the black phosphate produced from its oxidation, and occasional crystals of uraninite and both green and yellow hydrated phosphates of uranium.

From the large amount of black oxidized material, rich in lithia, found with the first deposit it is probable that lithiophilite, or some other similar mineral of the triphylite group, formed one of the original constituents of that mass. In fact it was the discovery of lithia in the black product of decomposition, and its absence in eosphorite, triploidite and dickinsonite, which led us to make further search for the source of this alkali. Fortunately, in the deepest part of our explorations in the vein we struck a small nest which afforded us the fresh unaltered mineral.

We wish here to express our great obligations to Messrs. Samuel L. Penfield and Horace L. Wells of the Sheffield Laboratory, for the excellent analyses which their enthusiastic devotion to the work has enabled us to present in this paper. The carrying through of these analyses has involved in many cases more than usual difficulty, and we appreciate fully to what an extent the value of this article is dependent upon the skill and patient care with which these difficulties have been overcome.

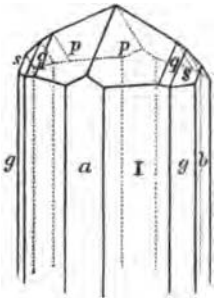
1. EOSPHORITE.

General physical characters.—Eosphorite occurs in prismatic crystals, sometimes of considerable size, which belong to the *orthorhombic system.* They show a nearly perfect macrodiagonal cleavage. It also and more commonly occurs massive, some specimens showing the cleavage finely, but graduating into others which are closely compact. The hardness is 5. For the specific gravity, three perfectly pure rose-colored specimens gave 3·124, 3·134 and 3·145; mean 3·134. The luster of crystallized specimens is vitreous to sub-resinous, upon cleavage surfaces exceedingly brilliant; of the massive mineral often greasy. The color of the crystals is pink, some having the bright shade common in rose-quartz, while others are paler and have a yellow to gray hue; the smallest crystals are nearly colorless. The massive compact mineral is pale pink, also grayish-, bluish-, and yellowish-white, and white. Some varieties closely resemble in color and luster green elæolite; the green color, however, is shown by the examination of thin sections under the microscope to be due to finely-disseminated scales of dickinsonite. Some varieties again are rendered impure by the presence of quartz through the mass, and they then have a whitish color and granular texture; this subject is expanded in a later paragraph.

The mineral is transparent to translucent. The streak is nearly white, and the fracture uneven to subconchoidal.

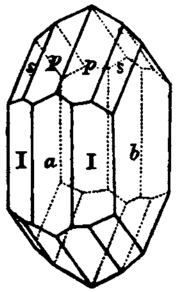
Description of crystals.—Specimens of crystallized eosphorite are rare. The most of those obtained seem to have come from a single cavity, the crystals standing free, and projecting to some length. Again they are found completely imbedded, as, for instance, in dickinsonite. These crystals are in general small; but occasionally imperfect crystals of a considerable size are met with, one of these exposes a width of about an inch, and is two inches long; in another, a single plane has a width of nearly two inches. The planes are seldom well polished, and only in rare cases are exact measurements obtainable. This is due in part to the fact that the surfaces of the crystals are often coated with drusy quartz, and again with minute crystals of apatite, and also because the prismatic planes almost always, and the pyramidal planes very commonly, are finely striated. This striation of the prismatic planes is a marked characteristic and gives rise to rounded barrel-shaped crystals analogous to those observed of tourmaline and many other species.

1.



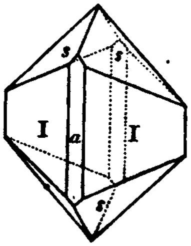
Eosphorite.

2.



Childrenite, Hebron, Me.

3.



Childrenite, Tavistock.

The crystals are invariably prismatic in habit, and show but one terminated extremity; in this respect they differ from the ordinary childrenite of Tavistock, to which it will be shown they are closely related. The general form is shown in fig. 1.

The crystallographic measurements and also the optical examination prove that the crystals belong to the ORTHORHOMBIC SYSTEM.

The fundamental angles were obtained from measurements on a small crystal whose pyramidal planes gave excellent reflections. The mean of a considerable number of readings, whose extremes differed by only 1½′, was taken in each case. A goniometer provided with two telescopes was always employed.

These angles* are as follows:—

$$p \wedge p' \text{ or } 111 \wedge 1\bar{1}1 = 46^\circ\ 27'\ 45''$$
$$p \wedge p'' \text{ or } 111 \wedge \bar{1}11 = 61^\circ\ 1'\ 54''$$

From these the following axial ratio is obtained:—

c (vert.)	$\bar{b}$	$\breve{a}$
0·66299	1·28732	1·00000

The observed planes are as follows:

a	$i\text{-}\bar{i}$	100†	*p*	1	111
b	$i\text{-}\breve{i}$	010	*q*	$\frac{3}{2}\text{-}\breve{\frac{3}{2}}$	232
I	*I*	110	*s*	$2\text{-}\breve{2}$	121
g	$i\text{-}\breve{2}$	120			

The following is a list of the most important angles both calculated and measured, so far as the last have any value. The angles obtained from the prismatic planes in general, and conspicuously the macropinacoid *a* (100) were in most cases entirely unreliable.

			Calculated.	Measured.
$I \wedge I$	$110 \wedge 1\bar{1}0$	=	75° 41′	75° 36′
$g \wedge g$	$120 \wedge 1\bar{2}0$	=	114° 28′	
$a \wedge I$	$100 \wedge 110$	=	37° 50′	
$a \wedge g$	$100 \wedge 120$	=	57° 14′	
$b \wedge I$	$010 \wedge 110$	=	52° 10′	52° 12′
$b \wedge g$	$010 \wedge 120$	=	32° 46′	
$a \wedge p$	$100 \wedge 111$	=	59° 29′	
$a \wedge q$	$100 \wedge 232$	=	62° 19′	
$a \wedge s$	$100 \wedge 121$	=	65° 13′	
$b \wedge p$	$010 \wedge 111$	=	66° 46′	
$b \wedge q$	$.010 \wedge 232$	=	57° 13′	

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* The supplement angles, that is, the angles between the normals of the planes, are in all cases given.

† In making the shorter lateral axis *a*, and giving the symbol 100 to the macropinacoid, and 010 to the brachypinacoid, we follow Groth's Zeitschrift für Krystallographie. With Miller (whose method is adopted in Dana's Text-Book of Mineralogy) the reverse is true.

			Calculated.	Measured.
$b \wedge s$	$010 \wedge 121$	=	49° 21′	
$I \wedge p$	$110 \wedge 111$	=	49° 59′	49° 55′
$g \wedge s$	$120 \wedge 121$	=	39° 13′	
$p \wedge p'$	$111 \wedge 1\bar{1}1$	=	*46° 28′	46° 28′
$q \wedge q'$	$232 \wedge 2\bar{3}2$	=	65° 33′	
$s \wedge s'$	$121 \wedge 1\bar{2}1$	=	81° 18′	
$p \wedge p''$	$111 \wedge \bar{1}11$	=	*61° 2′	61° 2′
$q \wedge q''$	$232 \wedge \bar{2}32$	=	55° 22′	
$s \wedge s''$	$121 \wedge \bar{1}21$	=	49° 34′	49° 39′
$p \wedge p'''$	$111 \wedge \bar{1}\bar{1}1$	=	80° 2′	80° 0′
$q \wedge q'''$	$232 \wedge \bar{2}\bar{3}2$	=	91° 1′	
$s \wedge s'''$	$121 \wedge \bar{1}\bar{2}1$	=	101° 33′	
$p \wedge s$	$111 \wedge 121$	=	17° 25′	17° 18′

Eosphorite is in crystalline form closely homœomorphous with childrenite. Fig. 2 represents the common form of the childrenite from Hebron, Maine,* as we have found from an examination of the specimens in New Haven. The crystals are sometimes terminated at both extremities as here represented. It is placed in such a position as to correspond with the eosphorite, the pyramid *s* being identical in the two, as are also the prisms. Fig. 3 shows a common form of the Tavistock crystals; other crystals have the plane *b* present and resemble fig. 2 more closely in habit. The angles given below show the close relation in form between childrenite and eosphorite.

	Eosphorite.	Childrenite. Tavistock (Cooke.)	Childrenite. Hebron (Cooke.)	Childrenite. Tavistock (Miller.)
$I \wedge I$	75° 41′	75° 24′	74° 20′	75° 46′
$s \wedge s'$	81° 18′	81° 20′	80° 38′	82° 8′
$s \wedge s''$	49° 34′	49° 50′	50° 36′	49° 56′
$s \wedge s'''$	101° 33′	101° 43′	101° 36′	102° 41′

In order to bring the crystals of childrenite into this position the clinodome (2-ĭ, or *n* of Miller) is made the unit prism.

Optical properties.—A careful examination in the stauroscope proved that the three axes of elasticity coincide with the crystalline axes, showing that the crystals are really orthorhombic. The optic axes lie in the macrodiagonal section, or plane of cleavage, the acute bisectrix (first mean-line) being normal to the brachypinacoid, and the obtuse bisectrix consequently to the basal plane. The axial angle could not be obtained with very great accuracy, owing to the fact that the best sections left much to be desired in the way of clearness. The measurements gave:—

$$2E = 54°\ 30' \quad \text{red rays.}$$
$$= 60°\ 30 \quad \text{blue rays.}$$

The dispersion of the axes is strong, $v > \rho$; the character of the double-refraction is negative.

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* This Journ., II, xxxvi, 257, 258.

An examination of a parallelopided cut with its edges parallel to the three axes of elasticity (crystalline axes) showed a very distinct trichroism. The axial colors are as follows:

For vibrations parallel to $\mathfrak{a}$ (that is $\bar{b}$) yellowish.
$\mathfrak{b}$ (that is $\breve{a}$) deep pink.
$\mathfrak{c}$ (that is c (vert.)) faint pink to nearly colorless.

Chemical composition.—The finest of the pink crystals were used for the chemical examination of eosphorite, which was made by Mr. Samuel L. Penfield, assistant in the Sheffield Laboratory. A qualitative analysis having shown the presence of alumina, protoxides of iron and manganese, lime, soda, phosphoric acid and water, the following method was employed in the quantitative separation of the constituents. The total phosphoric acid was determined by means of ammonium molybdate. To determine the bases, one gram of the mineral was fused with sodium carbonate, the fused mass soaked out in water and the solution filtered from the residue of oxides of iron and manganese. Most of the alumina went into solution with the sodium phosphate. The residue of oxides of iron and manganese was dissolved in hydrochloric acid and the iron separated from the manganese by means of a basic acetate precipitation. To insure the complete separation of the alumina from the iron, the precipitate of basic acetate of iron was boiled with sodium hydroxide, the solution filtered off and added to the solution from the fusion, the oxide of iron was then dissolved in hydrochloric acid, the iron precipitated with ammonia and weighed as iron sesquioxide. The iron was then dissolved in hydrochloric acid, evaporated with nitric acid and ammonium molybdate added to precipitate any phosphoric acid which might not have been separated by the sodium carbonate fusion. In this case there was a complete separation. From the filtrate from the basic acetate precipitation, manganese was precipitated by means of bromine, the precipitate dissolved in hydrochloric acid, the manganese again precipitated as ammonio-manganese phosphate and weighed as pyrophosphate. From the filtrates from the precipitation by bromine, lime was thrown down as oxalate. The solutions containing the alumina were acidified with hydrochloric acid, boiled to expel carbonic acid, and aluminum phosphate precipitated by means of ammonia; the precipitate was filtered, washed, dissolved and again precipitated and weighed as aluminum phosphate. As this precipitate is not constant in composition, after weighing, it was dissolved in nitric acid and the phosphoric acid separated by means of ammonium molybdate. The phosphoric acid was determined and deducted from the weight of the aluminum phosphate.

The sodium was determined by precipitating the bases from an acid solution by means of ammonium carbonate, evaporating the filtrate to dryness, igniting to drive off ammonium salts. The residue was taken up in water, barium hydroxide added to precipitate any phosphoric acid or manganese which might have remained in solution, the excess of barium separated and the sodium weighed as sodium chloride. Care was taken to carry on the evaporations in platinum and avoid contact with glass as much as possible. Water was determined by igniting in a Bohemian glass tube in a gas furnace, the water being collected in a chloride of calcium tube.

Two analyses gave:

	I.	II.	Mean.	Relative number of atoms calculated from the mean.			
P_2O_5	31·10	30·99	31·05		·219	1·	1·
$\text{Ⱥl}O_3$	21·99	22·40	22·19		·216	·99	1·
FeO	7·42	7·39	7·40	·103	·449	2·05	2·
MnO	23·47	23·56	23·51	·331			
CaO	·54	·54	·54	·010			
Na_2O	·33	·33	·33	·005			
H_2O	15·66	15·54	15·60		·866	3·95	4·
	100·51	100·75	100·62				

The ratio $P_2O_5 : \text{Ⱥl}O_3 : RO : H_2O = 1 : 1 : 2 : 4$ corresponds to the empirical formula $R_2\text{Ⱥl}P_2O_{10}, 4H_2O$, which may be written $\text{Ⱥl}P_2O_8 + 2H_2RO_2 + 2aq$. The analogy in the composition of eosphorite to that of childrenite suggests, however, that the better way of writing the formula is:

$$\left\{\begin{matrix} R_3P_2O_8 \\ \text{Ⱥl}P_2O_8 \end{matrix}\right. + \left\{\begin{matrix} H_2RO_2 \\ H_6\text{Ⱥl}O_6 \end{matrix}\right. + 4aq.$$

In the formula R corresponds to Mn and Fe with small quantities of Ca and Na_2; the ratio for $Mn : Fe+Ca+Na_2 = 3 : 1$, and for $Mn : Fe = 10 : 3$; for the last ratio the above formula requires:—

	Eosphorite. Calculated from the formula.	Childrenite, analyzed by Rammelsberg.	Childrenite, analyzed by Church.
P_2O_5	30·93	28·92	30·65
$\text{Ⱥl}O_3$	22·35	14·44	15·85
FeO	7·24	30·68	FeO_3 3·51 FeO2 3·45
MnO	23·80	9·07	7·74
MgO		0·14	1·03
H_2O	15·68	16·98	17·10
	100·00 G.=3·134	100·23 G.=3·247	99·33 G.=3·22

The identity between the crystalline form of eosphorite and that of childrenite has been pointed out in a preceding paragraph, and the analogy between them in chemical composition, and at the same time the wide difference, will be seen from the above. The ratios obtained from the analyses of Rammelsberg and Church for the childrenite from Tavistock and that of eosphorite are as follows:—

		P_2O_5	:	$\bar{\mathrm{R}}\mathrm{O}_3$	:	RO	:	H_2O	
Childrenite	Rg.	3	:	2	:	8	:	15	
	Ch.	4	:	3	:	9	:	18	
Eosphorite		1	:	1	:	2	:	4	and

		P_2O_5	:	$\bar{\mathrm{R}}\mathrm{O}_3 + \mathrm{RO}$	:	H_2O
Childrenite	Rg.	1	:	3½	:	5
	Ch.	1	:	3	:	4½
Eosphorite		1	:	3	:	4

It can hardly be doubted from the above relations and the other facts given that the two species are in fact isomorphous, although the uncertainty that hangs over the composition of childrenite makes it useless to compare the formulas. It is quite possible that, when the composition of childrenite shall be definitely settled, it will be found to be analogous to that given for eosphorite. It cannot be questioned, however, that the two species though closely isomorphous, are at the same time perfectly distinct: the physical characters, the habit of crystals, and method of occurrence speak emphatically for this. Chemically, too, they are not to be confounded, although they may be similar compounds; eosphorite is essentially a phosphate of aluminum and *manganese*, and childrenite of aluminum and *iron*.

Pyrognostics.—In the closed tube eosphorite decrepitates, whitens, gives off abundance of neutral water, and the residue turns first black, then gray, and finally liver-brown with a metallic luster, and becomes magnetic. B.B. in the forceps it cracks open, sprouts and whitens, colors the flame pale-green, and fuses at about four to a black magnetic mass. It dissolves completely in the fluxes, giving iron and manganese reactions. It is soluble in nitric and hydrochloric acids.

In order to make certain that our conclusions that the compact mineral with greasy luster and resembling elæolite was but a variety of eosphorite, we selected a grayish white and apparently homogeneous specimen, which was analyzed by Mr. Horace L. Wells, with the following results:

P_2O_5	26·93
$\bar{\mathrm{A}}\mathrm{lO}_3$	18·70
FeO	5·86
MnO	19·21
CaO	2·58
H_2O	12·92
Residue	14·41
Alkalies and fluorine	*traces*
	100·61

An examination of the residue insoluble in acids proved it to consist chiefly of quartz. The 0·144 gram of insoluble residue gave 0·131 silica (92·8 per cent), and contained besides traces of iron, alumina and perhaps other bases. The examination of a thin section of this variety of eosphorite showed the quartz scattered as grains through the mass.

Deducting the residue from the analysis and calculating again to 100·61, we have

		Atoms.		
P_2O_5	31·43	·221	·221	1
$\overline{Al}O_3$	21·83	·212	·212	1
MnO	22·43	·316	·466	2
FeO	6·84	·096		
CaO	3·01	·054		
H_2O	15·07	·837	·837	4

This is very nearly the composition of eosphorite as analyzed by Penfield. The excess of lime is in part due to the presence of apatite which is found associated with much of the eosphorite. The compact mineral is simply eosphorite intimately mixed with quartz and other species found at the locality. The greener colored varieties contain dickinsonite and are somewhat more fusible than pure eosphorite, while the lighter colored varieties such as analyzed are more difficultly fusible. The density of these varieties varied from 2·92—3·08.

The name eosphorite is from the Greek ἠωσφόρος (a synonym of φωσφόρος, whence the name phosphorus), which means *dawn-bearing*, in allusion to the characteristic pink color of the crystallized mineral.

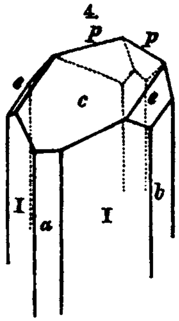
2. TRIPLOIDITE.

Physical characters.—Triploidite occurs in crystalline aggregates which are distinctly parallel-fibrous to columnar in some cases, and in others divergent; and again confusedly fibrous to nearly compact massive. Occasionally individual prismatic crystals are distinct, being separated from one another by the transparent quartz in which they are imbedded and from which they become detached when the mass is broken into small fragments. The isolated crystals have sometimes a length of an inch or more, but it is not possible to detach them except in very small pieces. The conditions are obviously extremely unfavorable to the formation of terminated crystals, but a careful and long-continued search upon a large amount of material was at last rewarded by the discovery of a few more or less perfect specimens. In rare instances the crystals have been observed standing free in small cavities in the massive mineral. The crystals have perfect orthodiagonal cleavage.

The hardness of triploidite is 4·5–5, and the specific gravity 3·697. The luster is vitreous to greasy-adamantine. The color is yellowish to reddish-brown, in the distinct crystals also topaz- to wine-yellow, and occasionally hyacinth-red. The streak is nearly white. Transparent to translucent. The fracture is subconchoidal.

Crystalline form.—Of the few terminated crystals obtained, three only were suitable for measurement and only one of these had the terminations complete. These were extremely small, but the planes were of so high a luster that they gave good reflections, but little inferior to those obtained from the best eosphorite crystals. The planes in the prismatic zone are in the larger crystals so much striated as to admit of no satisfactory measurements. In the crystals selected for careful measurement the only planes in this zone which could not be used at all were the clinopinacoids, for the others the reflections were reasonably good. The crystals show occasionally false planes, bearing no relation to the axes of the crystal, and which are evidently impressions of portions of adjoining crystals.

4.



The crystals belong to the MONOCLINIC SYSTEM and their habit is shown in figure 4. The axial ratio was obtained from the following fundamental angles:—

$c \wedge e = 001 \wedge 011 = 54° 48'$
$a \wedge I = 100 \wedge 110 = 60° 27'$
$a \wedge c = 100 \wedge 001 = 71° 46'$

These angles are good, though a little less so than those given for eosphorite—the probable error, however, does not exceed ±1'. The axial ratio is:

c (vert.)	b	ă
0·80367	0·53846	1·00000.

The observed planes are:

c,	O,	001.	I,	I,	110.
b,	i-ī,	010.	e,	1-ī.	011.
a,	i-i,	100.	p,	2-2,	$\bar{2}11$.

The following are the principal angles, both calculated from the above data, and as measured on the same crystal (1) and on the two others (2 and 3):

		Calculated.	Measured. (1)	(2) (3)
$I \wedge I'$,	$110 \wedge 1\bar{1}0$,	=120° 54'		120° 52' (3) 120° 54'
$I \wedge I''$,	$110 \wedge \bar{1}10$,	= 59° 6'		
$a \wedge c$,	$100 \wedge 001$,	= 71° 56'	*71° 56'	71° 55' (3)
$a \wedge e$,	$100 \wedge 011$,	= 79° 37'	79° 36'	
$a \wedge I$,	$100 \wedge 110$,	= 60° 27'	*60° 27' 60° 26'	
$a \wedge p$,	$\bar{1}00 \wedge \bar{2}11$,	= 52° 49'	52° 45'	
$b \wedge e$,	$010 \wedge 011$,	= 35° 12'		
$b \wedge m$,	$010 \wedge 110$,	= 29° 33'		
$b \wedge p$,	$010 \wedge \bar{2}11$,	= 48° 33'		
$c \wedge e$,	$001 \wedge 011$,	= 54° 48'	*54° 48'	54° 49' (2)

		Calculated.	Measured. (1)	(2)	(3)
$c \wedge I$,	$001 \wedge 110$,	= 81° 7′	81° 6′		
$c \wedge I'$,	$001 \wedge \bar{1}10$,	= 98° 53′	98° 52′		
$c \wedge p$,	$001 \wedge \bar{2}11$,	= 76° 35′	76° 20′ approx.		
$I \wedge p$,	$\bar{1}10 \wedge \bar{2}11$,	= 29° 6′			
$e \wedge I$,	$011 \wedge 110$,	= 36° 53′	36° 50′	36° 57′ (2)	
$e \wedge I'$,	$011 \wedge \bar{1}10$,	= 51° 33′	51° 24′		
$e \wedge p$,	$011 \wedge \bar{2}11$,	= 47° 34′	48° approx.		
$e \wedge e'$,	$011 \wedge 0\bar{1}1$,	=109° 36′			
$p \wedge p'$,	$\bar{2}11 \wedge \bar{2}\bar{1}1$,	= 82° 53′			

A comparison of the above angles with those given by Brooke and Miller for wagnerite shows that the two species are homœomorphous.

Thus in the three diametral zones, we have :—

	Triploidite.	Wagnerite (Miller).
$I \wedge I'$,	$110 \wedge 1\bar{1}0$,=120° 54′	$g \wedge g$ =122° 25′
$c \wedge a$,	$001 \wedge 100$,= 71° 46′	$c \wedge a$ = 71° 53′
$e \wedge e'$,	$011 \wedge 0\bar{1}1$,=109° 36′	$e \wedge e'$=110° 6′

As the crystal of wagnerite is placed by Miller, the planes *g*, *a*, *c* and *e* have the symbols (120), (100), (001), (021) respectively. In the figure given by Miller the prism *g* 120 (= *I*, (110) triploidite) has the greatest development; it was made the unit prism by Naumann.

Optical properties.—The only point that could be established in regard to the optical character of triploidite was the position of the axes of elasticity. The crystal used for measurement had the clinopinacoid so far developed that it could be examined directly in a Rosenbusch microscope. It was found that of the two axes which lie in the plane of symmetry, one very nearly coincides with the vertical axis, being inclined behind (see fig. 4) 3°–4°, and the other consequently is almost normal to the orthopinacoid. The position of the optic axes could not be fixed. The crystals show no perceptible absorption phenomena.

Chemical composition.—Triploidite was analyzed by Mr. Penfield. This hydrous phosphate was found to contain iron and manganese, both being in the lowest state of oxidation, with a small amount of lime; it is entirely free from fluorine. The method of analysis was substantially the same as that of eosphorite, (described on page 39). There being no alumina in the mineral, the phosphoric acid was determined directly from the solution of the fusion. The fusion did not effect a complete separation of the phosphoric acid from the iron and manganese, as it was retained by the small amount of lime present. It was weighed with the iron, and afterwards was separated from the iron by means of ammonium molybdate, determined, deducted from the weight of the latter and added to the phosphoric acid determination. The results of two analyses are:

	I.	II.	Mean.	Relative number of atoms calculated from the mean.			
P_2O_5	32·14	32·08	32·11		·226	1·	1·
FeO	15·07	14·69	14·88	·207	895	3·96	4·
MnO	48·35	48·55	48·45	·682			
CaO	·36	·29	·33	·006			
H_2O	4·01	4·15	4·08		·226	1·00	1·
	99·93	99·76	99·85				

The ratio $P_2O_5 : RO : H_2O = 1 : 4 : 1$ corresponds to the formula $R_4P_2O_9 + H_2O$, or $R_3P_2O_8 + H_2RO_2$, where $R = Mn : Fe = 3 : 1$. This formula requires:

P_2O_5	31·91
FeO	16·18
MnO	47·86
H_2O	4·05
	100·00

Among the other phosphates and arsenates the following seem to be closely related to triploidite in composition:

Libethenite	$Cu_3P_2O_8 + H_2CuO_2$	Orthorhombic.
Olivenite	$Cu_3(P_2,As_2)O_8 + H_2CuO_2$	Orthorhombic.
Lazulite	$\bar{A}lP_2O_8 + H_6\bar{A}lO_6$	Monoclinic.

None of these species has any relation to triploidite in crystalline form. On the other hand the similarity between the angles of wagnerite and triploidite has already been shown; moreover, the composition of triplite is analogous to that of wagnerite and for these reasons a relation between triplite and triploidite immediately suggests itself. The composition of these minerals is:

Wagnerite	$Mg_3P_2O_8 + MgF_2$
Triplite	$(Fe, Mn)_3P_2O_8 + (Fe, Mn) F_2$
Triploidite	$(Mn, Fe)_3P_2O_8 + (Mn, Fe) (OH)_2$

It should be stated that the perfect transparency and brilliant luster of the crystals analyzed prove beyond all question that the absence of fluorine and the presence of water (determined directly) are not due to any alteration. The fact that all the bases are in the lower state of oxidation would be confirmatory evidence were it needed. The conclusion to which we are led is this—that in the compound triploidite the radical hydroxyl (OH) plays the same part as the element fluorine, the molecule $R(OH)_2$ taking the place of the RF_2.

Pyrognostics.—In the closed tube triploidite gives neutral water, turns black and becomes magnetic. Fuses quietly in the naked lamp flame and B. B. in the forceps, colors the flame green. Dissolves in the fluxes, giving reactions for manganese and iron. Soluble in acids.

An analysis of another specimen of triploidite gave P_2O_5 32·24, FeO 18·65, MnO 42·96, CaO not determined, H_2O 4·09, quartz 1·09. The lime was accidentally lost but calculating from the amount of phosphoric acid retained by the iron it amounted to 0·90 per cent. The analysis is interesting as showing that the iron and manganese vary in different specimens, the darker colored varieties containing the most iron.

The name *triploidite* given to this species, from *triplite*, and *εἶδος form*, indicates its resemblance to triplite in physical characters, and its relation in chemical composition.

(To be continued.)

Art. V.—*On Dinitroparadibrombenzols and their Derivatives;* by Dr. P. Townsend Austen, F.C.S., Assistant Prof. of Chemistry in Rutgers College. Third paper.*

In my former papers, I have described the formation of three dinitroparadibrombenzols, and proved the α and β variations to be isomeric compounds. With regard to the third, I am still somewhat in doubt.

The peculiar formation of nitroparadibromaniline by treatment of alpha dinitroparadibrombenzol with ammonia, has led me to make experiments with other reagents, and I have been gratified at encountering some quite unexpected phenomena. These I shall mention in another paper.

Beta-dinitroparabromphenol.

By pouring a very concentrated alcoholic solution of potassa over the beta-dinitrodibrombenzol, the mass became scarlet-red, indicating the formation of a salt. Examination showed, however, that much of the substance was left unaffected. On heating, an action set in, and fine bubbles were formed. On diluting with alcohol and acidifying with hydrochloric acid, a dark brown flocculent mass was obtained, insoluble to any extent in alcohol. It was soluble in glacial acetic acid and acetic ether, separating in the form of an amorphous powder. As it was also soluble in a solution of sodium hydrate, and was precipitated therefrom by hydrochloric acid, I take it to be an azoxyphenol.

Various attempts to obtain a good yield of the phenol by direct treatment with potassa, or soda, in different amounts and solvents, did not meet with success, except on a small scale. Although in most cases, the phenol salt was formed, as could be discerned from the red color of the liquid, yet on application

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* Compare this Journal, III, ix, 118, and xiii, 95.

1842, records the occurrence of "bitumen" in connection with the trap rock of Connecticut. Those who are fortunate enough to possess a copy of this report will find that Percival with his usual accuracy of observation, mentions several times the occurrence of this substance while describing the Triassic formation of the Connecticut Valley. Mr. Percival speaks particularly of "indurated bitumen" as occurring in the cavities of amygdaloid trap, and in small veins in the indurated shale adjoining. Associated with these rocks occur, also, bituminous limestones and shales containing fossil fishes. Similar bituminous rocks he describes as occurring in the small isolated Triassic area of Southbury and Woodbury in Western Connecticut. In reference to the reported discovery of coal in Connecticut the statement is made* that "This substance, however, is a more or less indurated bitumen, similar to that occasionally occupying the pores of amygdaloid, or accompanying metallic veins in the trap and the adjoining indurated sandstones, and is perhaps derived from the same volcanic source as the trap it accompanies."

It will be noticed from the above that the bitumen described by Percival has the same geological associations as the mineral occurring at Plainfield, N. J. A specimen of this mineral from Connecticut which we have just received from Dr. H. C. Bolton of Trinity College, and obtained by him from seams in trap rock near the new college buildings at Hartford, seems identical in its physical and chemical properties with the solid hydrocarbon we have described from New Jersey. The rocks with which this mineral is associated in Connecticut correspond in lithological characters and geological position with the eruptive rock of New Jersey, and are a portion of the great system of trap ridges which traverse the Triassic formation in Connecticut and Massachusetts.

ART. XII.—*On a new and remarkable mineral locality in Fairfield County, Connecticut; with a description of several new species occurring there;* by GEO. J. BRUSH and EDWARD S. DANA. First Paper.

[Continued from page 46.]

3. DICKINSONITE.

Physical characters.—Dickinsonite occurs most commonly in crystalline masses, which have a distinctly foliated, almost micaceous, structure. It is also lamellar-radiated and sometimes stellated, the laminæ being usually more or less curved. This massive variety forms the gangue in which crystals of eosphorite are often imbedded, and also sometimes triploidite. It more-

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* Percival's Geol. Rep. of Conn., p. 452.

over occurs in minute scales distributed through the massive eosphorite and giving it a green color, and is sometimes imbedded in the rhodochrosite. Minute tabular crystals are rare; they are observed implanted upon the gangue, and also scattered through the reddingite. In general aspect the mineral resembles some varieties of chlorite though very unlike in its brittleness.

It has perfect basal cleavage. The hardness is 3·5–4, and the specific gravity 3·338–3·343. Luster vitreous, on the cleavage face somewhat pearly. The color of the purest crystal is oil- to olive-green, in the massive varieties generally grass-green though sometimes quite dark; the streak is nearly white. Transparent to translucent, the crystals being perfectly clear. The laminæ are very brittle; fracture uneven.

Crystalline form.—Distinct crystals of dickinsonite are not often found, and owing to the extremely brittle character of the mineral, it is only in very rare cases that they can be obtained showing more than the basal plane. The crystallographic data which are given here were all obtained from two crystals, which, though extremely small and yielding only approximate angles, yet served to decide all the essential points. Other less perfect crystals gave confirmatory results.

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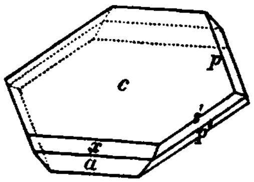

Dickinsonite crystallizes in the MONOCLINIC SYSTEM. The axial ratio and obliquity were obtained from the following angles:—

Plane angle of the base=120° 0′
c ∧ *a*, 001 ∧ 100, = 61° 30′
c ∧ *x*, 001 ∧ 301, = 42° 30′

The axial ratio is:—

c (vert.)	*b*	*ȧ*	
0·6917	0·5773	1·0000	β=61° 30′

For the unit prism (not observed),

I ∧ *I* = 66° 36′, and 113° 24′

The observed planes are as follows:—

c,	*O*,	001.	*p*,	1,	$\bar{1}$11.
a,	*i*-*ī*,	100.	*s*,	2,	$\bar{2}$21.
b,	*i*-*ì*,	010.	*x*,	-3-*ī*,	301.

The adjoining figure shows all of these planes except the clinopinacoid, which was only once observed.

The following are the most important angles, measured and calculated:

			Calculated.	Measured.
$c \wedge a$,	$001 \wedge 100$,	=	*61° 30′	
$c \wedge x$,	$001 \wedge 301$,	=	*42° 30′	
$c \wedge p$,	$001 \wedge \bar{1}11$,	=	61° 8′	61°–62°
$c \wedge s$,	$001 \wedge \bar{2}21$,	=	82° 2′	82°–82° 30′
$a \wedge x$,	$100 \wedge 301$,	=	19° 0′	
$a' \wedge p$,	$\bar{1}00 \wedge \bar{1}11$,	=	81° 7′	
$a' \wedge s$,	$\bar{1}00 \wedge \bar{2}21$,	=	68° 22′	68°
$b \wedge p$,	$010 \wedge \bar{1}11$,	—	40° 40′	
$b \wedge s$,	$010 \wedge \bar{2}21$,	=	30° 56′	
$p \wedge p'$,	$\bar{1}11 \wedge \bar{1}\bar{1}1$,	=	98° 40′	
$s \wedge s'$,	$\bar{2}21 \wedge \bar{2}\bar{2}1$,	=	118° 9′	

It will be seen from the above table that the angle between the base and one of the two pyramids ($c \wedge p = 61° 8'$) differs but little from the angle between the base and the orthopinacoid ($c \wedge a = 61° 30'$); there are thus three planes which have nearly equal inclinations to the base. This fact, which is analogous to that true of the Vesuvian biotite (meroxen) as pointed out by Tschermak,* gives to the crystals a marked *rhombohedral* aspect especially as the planes x (301) and s ($\bar{2}21$) have usually a minor development. As exact measurements were not possible the true relations could hardly be established beyond doubt until recourse was had to an optical examination. This showed that the cleavage planes are not isotrope as they must be if rhombohedral; on the contrary one plane of vibration is exactly parallel to the edge c/a, and the other normal to it.

The rhombohedral pseudo-symmetry is also shown in the fact that the plane angle of the base differs very little if at all from 120°. The most careful measurements practicable failed to establish any variation. That the angle really is 120° seems, moreover, to be indicated by the fact that on many cleavage laminæ triangular markings are visible, which are apparently equilateral the angles measuring 60°; other analogous markings have four or five sides but always with angles of 60° or 120° as near as the measurements can be made.

The above facts show that crystallographically dickinsonite is related to the micas and chlorites, although most unlike chemically.

The plates of dickinsonite are sometimes striated parallel to the edges c/p, c/p', and also c/a, corresponding to the triangular markings mentioned and still more increasing the rhombohedral aspect of the crystals. No twins have been observed, although some very imperfect crystals early suggested their possible occurrence.

The cleavage plates show a marked dichroism, parallel to the edge c/a, the rays being grass-green and much absorbed

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* Groth, Zeitschrift für Krystallographie, ii, p. 19, 1877.

and normal to this yellow-green. No examination of a section perpendicular to the cleavage was possible, so that the position of the axes of elasticity in the plane of symmetry could not be determined.

Chemical composition.—The following analysis was made by Mr. S. L. Penfield. The method of analysis was essentially the same as that already described. The purest material available was selected, but it was found impossible to separate it entirely from a little admixed quartz and eosphorite. The small amount of alumina present is assumed to belong to the eosphorite, and the calculations made accordingly. In the table below, column (1) gives the original analysis; (2) gives the amount of each constituent of the impurities to be deducted; (3) gives the remainder after this deduction has been made, and (4) the final composition after being averaged up to the original amount.

	(1)	(2) Eosphorite and quartz.	(3)	(4)
P_2O_5	37·49	2·13	35·36	39·36
AlO_3	1·55	1·55		
FeO	11·64	·50	11·14	12·40
MnO	24·18	1·63	22·55	25·10
CaO	12·00		12·00	13·36
Li_2O	·03		·03	·03
K_2O	0·80		0·80	·89
Na_2O	4·71		4·71	5·25
H_2O	4·55	1·08	3·47	3·86
Quartz	3·30	3·30		
	100·25	10·19	90·06	100·25

The ratio calculated from analysis (4) is as follows:—

P_2O_5	= ·277	·277	1·	4·
FeO	= ·172	·858	3·09	12·
MnO	= ·353			
CaO	= ·238			
Li_2O	= ·001			
K_2O	= ·009			
Na_2O	= ·085			
H_2O	= ·215	·215	0·77	3·

The ratio $P_2O_5 : RO : H_2O = 4 : 12 : 3$ corresponds to the formula $R_3P_2O_8 + \frac{3}{4}H_2O$. If $R = Mn : Fe : Ca : Na = 5 : 2\frac{1}{2} : 3 : 1\frac{1}{2}$; this formula requires:—

P_2O_5 = 40·05
FeO = 12·69
MnO = 25·04
CaO = 11·85
Na_2O = 6·56
H_2O = 3·81
100·00

This corresponds as closely as could be expected with the analysis (4) given above.

Another analysis by Mr. Penfield on a separate sample of dickinsonite is given below, the lime having been lost is determined by difference. The results are arranged as before: (1) is the original analysis; (2) the amount of quartz and eosphorite present; (3) the result after deducting these, and (4) the final result calculated again to 100.

	(1)	(2) Eosphorite and quartz.	(3)	(4)
P_2O_5	38·18	2·13	36·05	39·53
AlO_3	1·55	1·55		
FeO	11·36	·50	10·86	11·90
MnO	23·48	1·63	21·85	23·96
CaO	[13·67]		[13·67]	[14·98]
Li_2O	·22		·22	0·24
K_2O	·67		·67	·73
Na_2O	4·36		4·36	4·78
H_2O	4·62	1·08	3·54	3·88
Quartz	1·89	1·89		
	100·00	8·78	91·22	100·00

Pyrognostics.—In the closed tube gives water, the first portions of which react neutral to test paper, but the last portions are faintly acid. The residue is magnetic. Fuses in the naked lamp flame and B.B. in the forceps colors the flame at first pale green then greenish yellow. Dissolves in the fluxes and affords reactions for iron and manganese. Soluble in acids.

There is no known phosphate, so far as we are aware, which bears any relation to dickinsonite in crystallographic character, and in chemical composition it seems also to be without any very near relatives.

We have named this most interesting mineral *dickinsonite* in honor of the Rev. John Dickinson of Redding, Conn., our obligations to whom we have already acknowledged.

4. LITHIOPHILITE.

The occurrence of this mineral in the deepest explorations made has already been mentioned. It is found imbedded in albite in irregular rounded masses one to three inches in diameter and coated with a black mineral, the result of its own oxidation; some of these masses have only a small core of unaltered mineral.

Physical characters.—No crystals of lithiophilite were found, although some of the imbedded masses have in external form a somewhat crystalline aspect. There are three distinct cleavages: one quite perfect, always observable whenever the mineral is broken; a second nearly perfect at right angles to the first; and a third interrupted, which is prismatic, having an angle of 128°–130°, and inclined at right angles to the first named cleavage, and 115°–116° to the second. The similarity in composition between this species and triphylite makes it possible to identify these three cleavages with those shown by Tschermak to belong to the latter mineral: the most perfect cleavage is basal, the second nearly perfect is brachydiagonal, and the third interrupted cleavage is prismatic ($I \wedge I = 133°$ triphylite, Tschermak).

The hardness is about 4·5; and the specific gravity, in two trials, 3·424, and 3·482. The color of the unaltered mineral is generally bright salmon-color, occasionally honey-yellow,—varying to yellowish-brown and on rare instances to umber-brown; this darker color is probably due to incipient alteration. It has a vitreous to resinous luster, and is generally translucent, though small cleavage fragments are occasionally perfectly transparent. Fracture uneven to subconchoidal.

Optical properties.—The optic axes in lithiophilite lie in the basal section or plane of most perfect cleavage, the acute bisectrix being normal to the brachypinacoid. The axial angle is very large the axes being partially visible in the extreme border of the field in the polariscope. The angle could not be measured satisfactorily except in oil ($n = 1·47$); the result of the measured was as follows:

$2\mathrm{H}a = 74° \ 45'$ for red rays.
$2\mathrm{H}a = 79° \ 30'$ for blue rays.

The dispersion of the axes is strong, $v > \rho$. The character of the double refraction is positive. The three axial colors are quite distinct, as follows:

For vibrations parallel to	$\mathfrak{a}$	(that is) $\breve{a}$	deep pink.
" " "	$\mathfrak{b}$	(that is) c	pale greenish-yellow.
" " "	$\mathfrak{c}$	(that is) $\bar{b}$	faint pink.

Chemical composition.—The following analyses are by Mr. Horace L. Wells. The method was the same as that employed by Mr. Penfield in the analysis of triphylite (see beyond).

	I.	II.	Mean.	Quantivalents.		Ratio.	
P_2O_5	44·83	44·51	44·67	·314	·314	1·	1·
MnO	40·80	40·91	40·86	·576	·632	2·01	2·
FeO	3·99	4·04	4·02	·056			
Li_2O	8·72	8·55	8·63	·288	·290	0·93	1·
Na_2O	·13	·16	·14	·002			
H_2O	·77	·87	·82				
SiO_2	·63	·66	·64				
	99·87	99·70	99·78				

The ratio $P_2O_5 : \overset{\mathrm{II}}{R}O : \overset{\mathrm{I}}{R}_2O = 1 : 2 : 1$ proves lithiophilite to be a normal phosphate analogous in composition to triphylite. Its formula is $LiMnPO_4$ or $LiPO_4 + Mn_3P_2O_8$. This formula requires:—

P_2O_5	45·22
MnO	45·22
Li_2O	9·56
	100·00

The mineral lithiophilite is consequently a manganese member of the triphylite group. Mr. Penfield has previously shown that the true formula of triphylite, hitherto doubtful, is $\overset{\text{I}}{R}_3PO_4+\overset{\text{II}}{R}_3P_2O_8$,* where $\overset{\text{I}}{R}=Li$, and $\overset{\text{II}}{R}=Fe$ mostly, also Mn. His conclusions are confirmed by the results of Mr. Wells' analysis of lithiophilite.

Rammelsberg found (as a mean of four analyses) in the Bodenmais mineral 39·97 p. c. FeO, and 9·80 p. c. MnO. Mr. Penfield, in his analysis of the Grafton, New Hampshire, obtained 26·09 p. c. of FeO and 18·17 p. c. MnO. The altered triphylite from Norwich, Mass., also contains a considerable amount of manganese, but as manganese sesquioxide (22·59–24·70 p. c.); the unaltered mineral has never been analyzed. These facts go to show that between the true triphylite,—the *iron*-lithium phosphate—,and the lithiophilite,—the *manganese*-lithium phosphate—a number of different compounds exist, containing varying amounts of iron and manganese, as is true in many other analogous cases of isomorphous groups of compounds. It is probable, however, that to all varieties of the two minerals belongs the general formula:—

$$\overset{\text{I}}{R}_3PO_4+\overset{\text{II}}{R}_3P_2O_8.$$

Pyrognostics.—In the closed tube gives traces of moisture, turns dark-brown and fuses but does not become magnetic. Fuses in the naked lamp-flame and B.B., gives an intense lithia-red flame streaked with pale green on the lower edge. Dissolves in the fluxes giving in O.F. a deep amethystine bead, and in R.F. a faint reaction for iron. Soluble in acids.

The name lithiophilite, from *lithium* and *φιλός*, *friend*, may properly be given to this species as it contains a very high percentage of lithia.

5. REDDINGITE.

Physical characters.—Reddingite occurs sparingly in minute octahedral crystals, belonging to the *orthorhombic system.* It is also found more generally massive with granular structure; it is associated with dickinsonite, and sometimes with triploidite. As compared with the other species which have been described it is a decidedly rare mineral. The massive mineral shows a distinct cleavage in one plane, the crystallographic direction of which could not be ascertained in the crystals owing to their small size.

The hardness is 3–3·5; and the specific gravity for the mineral analyzed, containing 12 p. c. quartz is 3·04; this gives on calculation for the pure mineral 3·102. The luster is vitreous to sub-resinous: the color of the perfectly unaltered mineral

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* This Journal, III, xiii, June, 1877.

pale rose-pink to yellowish-white, sometimes with a tinge of brown; crystals are occasionally coated dark reddish-brown from surface alteration; the streak is white. Transparent to translucent; fracture uneven; brittle.

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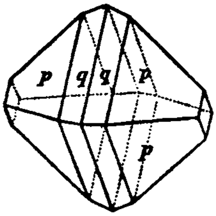

Crystalline form.—The crystals of reddingite are rare and occur only in cavities in the massive mineral. They have uniformly an octahedral habit; sometimes only the unit pyramid is present and in other cases a second macrodiagonal pyramid, with the brachypinacoid as shown in the accompanying figure. The crystals belong to the ORTHORHOMBIC SYSTEM. The fundamental angles are as follows:—

$p \wedge p''$, $111 \wedge \bar{1}11 = 76° 50'$
$p \wedge p'''$, $111 \wedge \bar{1}\bar{1}1 = 110° 43'$

These angles are only tolerably exact, the probable error being as high as ± 5′. The axial ratio calculated from the above angles is:—

c (vert.)	$\bar{b}$	$\breve{a}$
1·0930	1·1524	1·0000

The angles of the fundamental prism (not observed), are $I \wedge I = 98° 6'$ and $81° 54'$. The observed planes are:—

b,	i-$\breve{i}$,	010;
p,	1,	111;
q,	1-$\bar{2}$,	212.

The important angles are as follows, calculated from the axial ratio:—

$p \wedge p'$, $111 \wedge \bar{1}11. = 65° 16'$
$p \wedge p''$, $111 \wedge \bar{1}11, = 76° 50'$
$p \wedge p'''$, $111 \wedge \bar{1}\bar{1}1, = 110° 43'$
$q \wedge q'$, $212 \wedge 2\bar{1}2, = 35° 30'$
$q \wedge q''$, $212 \wedge \bar{2}12, = 89° 17'$
$q \wedge q'''$, $212 \wedge \bar{2}\bar{1}2, = 99° 59'$
$b \wedge p$, $010 \wedge 111, = 57° 22'$
$b \wedge q$, $010 \wedge 212, = 72° 15'$

Of the above angles the only ones that admitted of exact measurement were the three pyramidal angles, of which two have been taken as the basis of calculation and the third gave $111 \wedge 1\bar{1}1 = 65° 22$, required 65° 16′.

Reddingite is closely isomorphous with scorodite and strengite; the corresponding pyramidal angles for the three species are as follows:—

		Reddingite.	Scorodite. (vom Rath.)	Strengite. (Nies.)
$111 \wedge \bar{1}11$	=	76° 50′	77° 8′	78° 22′
$111 \wedge 1\bar{1}1$	=	65° 16′	65° 20′	64° 24′
$111 \wedge \overline{11}1$	=	110° 43′	111° 6′	111° 30′

The axial ratios of the three species are as follow :—

	c (vert.)	$\bar{b}$	$\breve{a}$
Reddingite	1·0930	1·1524	1·
Scorodite (vom Rath)	1·1020	1·1530	1·
Strengite (Nies)	1·1224	1·1855	1·

The relations of the three species in chemical composition are spoken of in a later paragraph.

Chemical composition.—The best available material was used in the analyses by Mr. Horace L. Wells; it was free from every impurity with the exception of the quartz, which was so intimately intermixed that separation was impossible. The presence of the quartz, however, did not interfere in the least with the accuracy of the composition finally deduced. The water was determined directly.

Two analyses gave:

	I.	II.	Mean.
Quartz	12·09	12·07	12·08
P_2O_5	30·17	30·56	30·37
MnO	40·85	40·58	40·71
FeO	4·88	4·70	4·79
Na_2O (trace Li_2O)	·32	0·23	0·27
CaO	0·70	0·64	0·68
H_2O	11·70	11·33	11·51
	100·71	100·11	100·41

Excluding quartz, the mean of the two above analyses gives:

P_2O_5	34·52	·243	·243	1·
MnO	46·29	·652	·746	3·07
FeO	5·43	·075		
Na_2O (tr. Li_2O)	0·31	·005		
CaO	0·78	·014		
H_2O	13·08	·727	·727	3·00
	100·41			

The ratio $P_2O_5 : RO : H_2O = 1 : 3 : 3$, corresponds to the formula $Mn_3P_2O_8 + 3aq$, which requires the following percentage composition:—

P_2O_5	=	34·72
MnO	=	52·08
H_2O	=	13 20
		100·00

It is interesting to note here that the same formula was deduced by M. Debray* for an artificial salt which he obtained in brilliant crystalline grains by boiling a solution of phos-

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* Annales de Chimie et de Physique, III, lxi, 433, 1861.

phoric acid in excess with pure magnanese carbonate. He gives, however, no description of the form of the crystals obtained.

The close correspondence of reddingite with scorodite and strengite has already been pointed out; chemically the relation is not so close, for the manganese is all in the lowest state of oxidation and only three molecules of water are present. The formulas for the three minerals are as follows:—

Reddingite	$Mn_3P_2O_8+3aq.$
Scorodite	$FeAs_2O_8+4aq.$
Strengite	$FeP_2O_8+4aq.$

Pyrognostics.—On heating in the closed tube, whitens at first, then turns yellow and finally brown, but does not become magnetic. In the forceps fuses in the naked lamp flame (F=2). B.B. colors the flame pale green and fuses easily to a blackish-brown non-magnetic globule. Dissolves in the fluxes and reacts for manganese and iron. Soluble in hydrochloric and nitric acids.

Reddingite is named from the town in which the locality is situated. It was the last of the above species to be discovered, and we were led to make an especial search for it by finding black octahedrons implanted upon one specimen which were obviously pseudomorphs and which could not be referred to any known species. Another specimen exhibited pseudomorphs of the same species, but where the alteration was not so far advanced.

Concluding note.

In a second paper upon this locality which we expect to publish within a few months we shall describe under the name of *fairfieldite* a sixth new species, whose character has been determined too late to find a place in these pages. It is a hydrous phosphate of manganese and lime, having the formula $R_3P_2O_8+2H_2O$, where the protoxide elements are manganese and lime chiefly; also iron and soda in small quantities. Fairfieldite is a yellowish-white to colorless transparent mineral, with an adamantine luster on the surface of eminent cleavage; the hardness is 3·5, and the specific gravity is 3·15

We intend also to give descriptions and, so far as possible, analyses of the other associated minerals, as, rhodochrosite, hebronite, the black massive products of decomposition and other species of special interest.