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umes, and enough water to increase the total volume to 100 cm^3, or a little more. A platinum spiral is introduced, a trap made of a straight two-bulb drying-tube cut off short is hung with the larger end downward in the neck of the flask, and the liquid is boiled until the level reaches the mark put upon the flask to indicate a volume of 35 cm^3. Great care should be taken not to press the concentration beyond this point on account of the double danger of losing arsenious chloride and setting up reduction of the arseniate by the bromide. On the other hand, though 35 cm^3 is the ideal volume to be attained, failure to concentrate below 40 cm^3 introduces no appreciable error. The liquid remaining is cooled and nearly neutralized by sodium hydrate (ammonia is not equally good), neutralization is completed by hydrogen potassium carbonate, an excess of 20 cm^3 of the saturated solution of the latter is added, and the arsenious oxide in solution is titrated by standard iodine in the presence of starch.

With ordinary care the method is rapid, reliable and easily executed, and the error is small. In analyses requiring extreme accuracy all but accidental errors may be eliminated from the results by applying the corrections indicated.

ART. XXVI.—*On the Mineral Locality at Branchville, Connecticut:* Fifth Paper; by GEORGE J. BRUSH and EDWARD S. DANA. *With analyses of several manganesian phosphates;* by HORACE L. WELLS.

IT is now nearly twelve years since we published our first paper* upon the Branchville minerals. It will be remembered that the material which formed the basis of our early work was that which Mr. Fillow had brought to light in his excavations, some two years previous, in search for mica. It was this lot of minerals, sagaciously selected and preserved by Mr. Fillow, that we found so remarkably rich in phosphates of manganese, including a number of new and interesting species.† During

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* See this Journal, xvi, 33, 114, July and August, 1878; Second Paper, xvii, 359, 1879; Third Paper, xviii, 45, 1879; Fourth Paper, xx, 257, 1880.

† It may be useful here to recall that our investigations have shown that, besides apatite, amblygonite and some others, the following phosphates are present:

Lithiophilite: a manganese triphylite, essentially $LiMnPO_4$; massive, cleavable, of a salmon-pink to clove-brown color.

Eosphorite: a manganese childrenite, essentially $MnAl(OH)PO_4+2H_2O$; in orthorhombic crystals and massive, of a rose-pink color.

Triploidite: near triplite, essentially $Mn(MnOH)PO_4$ in fibrous aggregates and monoclinic crystals isomorphous with wagnerite.

Dickinsonite: a phosphate of manganese, iron and sodium; in bright green chlorite-like foliated aggregates, rarely in pseudo-rhombohedral crystals.

the years of 1878 and 1879, we carried on a somewhat extended search for these minerals in the ledge from which they had been obtained, but the spot from which the most interesting specimens had been derived was very unfavorably situated for work, being ten feet or more below the level of the ground, and our efforts were only in part successful. Some of the results we have already announced in subsequent papers.

Perhaps the most important result of our early explorations was to prove the presence of large amounts of potash feldspar (microcline) and quartz in the vein—in fact, before we ceased our private work, we had brought to the surface several hundred tons of these minerals. This material was of so excellent quality for technical use and the supply seemed to be so large that negotiations were presently entered into between Mr. Fillow, the owner of the property, and the Messrs. Smith, of the Union Porcelain Works, of Greenpoint, New York, with the final result of the sale of the property to the latter gentlemen. This was accomplished in 1880. Since that time the work of quarrying for feldspar and quartz has been carried forward uninterruptedly and with gratifying success; up to the present time Mr. Fillow informs us that from three to four thousand tons of feldspar and four thousand tons of quartz have been shipped from the locality. The arrangement has proved also a very successful one from a scientific point of view. The Messrs. Smith have very liberally placed at our disposal all the material obtained from the locality which was of no technical value, while the daily presence of Mr. Fillow, with his active interest and keen eye, has resulted in saving for science practically everything which the locality has yielded. The covering of earth was early removed, and the ledge opened to as great a depth as the drainage would allow; since then the drain has been repeatedly cut deeper until in the summer of 1888, ten years after our first work, the time to which we had been constantly looking forward arrived and the deep spot from which the first supply of phosphates came was reached.*

In the meantime, however, the work had not been unproductive, and the contents of our third paper upon certain deposits of lithiophilite, eosphorite and other associated minerals, and of our fourth paper upon the spodumene and its

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Reddingite: $(Mn,Fe)_3PO_4+3H_2O$; in pinkish orthorhombic crystals near scorodite in form, also in granular masses.

Fairfieldite: a phosphate of manganese and calcium $(Ca,Mn)_3P_2O_8+2H_2O$; triclinic, usually in foliated masses, of a white or yellowish color and pearly to adamantine luster.

Fillowite: a phosphate of manganese, iron, calcium and sodium; in granular aggregates of monoclinic crystals of a honey-yellow color and resinous to adamantine luster.

* It may be added that at present the depth of the opening is some 40 feet and is length and breadth about 160 by 45 feet.

alteration-products, show in part what was accomplished. In addition to what is mentioned in these papers, the locality has at several different times yielded a not inconsiderable amount of uraninite, in part in octahedral crystals with a specific gravity of 9·3; this has been investigated chemically by Comstock.[*] With the uraninite have been found two or more uranium phosphates which have not as yet been thoroughly studied. Columbite has also been found in considerable quantity, aggregating more than 500 pounds. This occurs in crystalline masses, and in part well developed crystals and groups of crystals in parallel position of remarkable size. It has a specific gravity of 5·73, and as shown by an analysis by T. B. Osborne[†] contains 19·2 per cent of Ta_2O_5. Another kind of columbite has also been found in minute reddish brown translucent crystals usually implanted upon the spodumene.[‡] This variety Comstock has shown to be exceptionally interesting in the fact that it contains manganese with practically no iron, and further has the niobium and tantalum in the ratio of 1:1; it has a specific gravity of 6·59. Other points of interest that have been brought out are the occurrence on a rather abundant scale of a mineral, both massive and indistinctly fully crystallized, which resembles cyrtolite but has not yet been investigated; also of smoky quartz, in part well crystallized, and remarkable for its richness in fluid inclusions (CO_2, etc.) as described microscopically and chemically by Hawes and Wright;[§] also of beryl in large columnar masses sometimes two feet or more in length; still further of albite in finely crystallized specimens. Apatite has been found in a variety of forms; one variety, of a dark bluish green, has been found by Penfield[‖] to contain 10·6 per cent of MnO. Other kinds are interesting crystallographically and resemble the Swiss crystals in habit and complexity. Mica has been obtained in limited amount of a merchantable form (300 pounds of plates cut to pattern); the most common variety, however, is that occurring in curved plates, presenting a smooth convex surface like a watch-glass; these aggregates have a radiated as well as concentric structure. Specimens of the Branchville mica have been analyzed by Rammelsberg.[¶]

The most important developments, however, have been those of the summers of 1888 and 1889, when considerable quantities of the manganesian phosphates were brought to light. This result has been especially gratifying to us, since it has given us specimens of all but one of the new species described in 1878 (cf. p. 202), several of which we had almost despaired of

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[*] This Journal, xix, 220, 1880.

[†] This Journal, xxx, 336, 1885.

[‡] Ibid., xix, 131, 1880.

[§] Ibid., xxi, 203, 209, 1881.

[‖] Ibid., xix, 367, 1880.

[¶] Jahrb. Min., ii, 224, 1885.

finding again. It has also afforded another new member of the triphylite group, a sodium-manganese phosphate, which we shall call *natrophilite.* Besides this we have identified another phosphate of manganese, and one which from the first we had hoped to find, viz: the rare mineral *hureaulite*, thus far only certainly known from Limoges, Commune of Hureaux, in France.

The general method of occurrence of the phosphates of manganese is such as to confirm the opinion that we have expressed in a former paper, that the manganesian triphylite or lithiophilite is the parent species. This is beyond all doubt an original mineral in the vein, occurring intimately associated with the albite, quartz and spodumene. With it, sometimes entirely enclosed by it, we find another of the Branchville species, triploidite, which seems to be also an original mineral.

The masses of lithiophilite are as a rule unaltered, showing only a little oxidation on the outer surfaces, and on the fracture surfaces an occasional thin film of a bright blue crystallized mineral in minute amount, resembling vivianite. In some few cases they have a distinct though rough crystalline form, and the planes 110, 120 and 021 have been identified; one of these rough crystals is no less than eighteen inches in length and weighs fifteen pounds. The angles measured are mere approximations, but they are interesting as showing, as has been assumed, that the form of lithiophilite is the same as that of triphylite. We may add here that a small crystal found some years ago resembles fig. 450 in Dana's System.

	Lithiophilite.	Triphylite (Tschermak).
$110 \wedge 1\bar{1}0 =$	48°	47°
$110 \wedge 120 =$	17 –18°	17 31′
$010 \wedge 021 =$	42	43 31

The cleavage angle $110 \wedge 1\bar{1}0$ was found to be 48° 30′ to 49°. Occasionally the masses of lithiophilite are extensively changed; this is true especially of some of the large nodular inclusions in the vein. It is most interesting in these masses to note the change from the perfectly fresh lithiophilite through a zone in which the green chlorite-like dickinsonite is more or less distinctly represented to the hureaulite beyond. This change of the lithiophilite into hureaulite can often be observed, and the interpenetration of the two minerals is well shown under the microscope in sections cut parallel to the basal cleavage. A thin line of eosphorite often crosses the hureaulite. Sometimes with the dickinsonite we have also fairfieldite in clear foliated masses, and reddingite in light pinkish crystals and crystalline masses. It is impossible to lay down any general rules in regard to the order of occurrence of these minerals or their method of arrangement. On the contrary they occur closely together, now one and now another prominent, and it is not uncommon to find five or six of the phosphates in characteristic form on a single hand specimen a few square inches in surface. In one such specimen, for example, we have at one extremity lithiophilite and triploidite, then hureaulite and natrophilite interpenetrated by a narrow zone of eosphorite and again lithiophilite. In another specimen which gives a section into the interior of a nodular mass, we pass from the exterior albite through a nondescript zone blackened by oxidation and showing some dickinsonite, through distinct foliated masses of the same mineral enclosing patches of natrophilite, then hureaulite abundant with fairfieldite and some reddingite, and finally the unchanged lithiophilite.

Much of the material is of the most ill-defined and problematical character, being an intimate mixture sometimes of eosphorite and quartz, such as we have before described, or of others of the phosphates in indistinct form. Typical specimens of the different species are as characteristic as could be desired and recognized at once; in others less characteristic they resemble one another so closely that identification is often a matter of much difficulty. It may be added that much of the triploidite can hardly be told by the eye from a massive red garnet commonly associated with it, while the fairfieldite similarly resembles the albite; in these cases, however, a simple test of hardness is all that is required. We go on now to a detailed account of some of the more interesting species identified.

NATROPHILITE.

The sodium-manganese member of the triphylite group, to which we give the name *natrophilite*, has been identified only in the material obtained during the last summer. It occurs sparingly, usually closely associated with lithiophilite, and upon a superficial examination could be confounded with it, although distinguishing characters are not wanting. It appears in cleavable masses for the most part, the cleavage surfaces often broad, and showing something of a pearly luster. Occasionally smaller grains appear imbedded in the cleavage mass, and these show at times a more or less distinct crystalline form. On one of these the usual planes of triphylite were identified, 110, 120, 021, 001 (cleavage). The angles could not be obtained accurately but were sufficient to determine the forms, viz:

	Natrophilite.	Triphylite.
$110 \wedge 1\bar{1}0 =$	50° 30	47°
$120 \wedge 1\bar{2}0 =$	87	82 1′
$001 \wedge 032 =$	47 –49°	46 29

In crystalline form, then, it agrees as was to be expected with triphylite and lithiophilite. Optically it also corresponds so far as it has been investigated; the optic axes lie in basal section and the acute bisectrix (positive) is normal to the brachypinacoid. The characteristic basal cleavage is always a prominent character, but the brachydiagonal cleavage 010 is less distinct than is shown by lithiophilite, and the prismatic cleavage (110) is interrupted; the measured angle was 50°; these cleavages are seen more clearly in thin sections. The fracture is conchoidal, more perfectly so than with lithiophilite. The color is a rather deep wine-yellow, much like that of the Brazilian topaz. The luster is brilliant resinous to nearly adamantine; it was, in fact, the brilliancy of the luster which first attracted our attention, and which is, so far as the eye is concerned, its most distinguishing character. The mineral itself is perfectly clear and transparent, but the masses are much fractured and rifted. The surfaces are often covered by a very thin scale of an undetermined mineral, having a fine fibrous form, a delicate yellowish color and silky luster. This same mineral penetrates the masses wherever there is a fracture surface of cleavage or otherwise. What the exact nature of this mineral is we are unable to say, since the amount is too small to admit of a satisfactory determination—it appears to be a manganesian phosphate. It is evidently an alteration-product and would seem to imply that natrophilite is rather subject to easy chemical change. In any case this silky film is one of the characteristic features of the mineral, and directs attention to it at once even over the surface of a hand specimen where it is associated with lithiophilite and perhaps three or four other of these phosphates.

Before the blowpipe natrophilite fuses very easily and colors the flame intensely yellow, thus being at once distinguished from lithiophilite. It also gives the usual reactions for manganese. The following is an analysis of natrophilite made by Wells. The specific gravity on two fragments was found to be 3·40 and 3·42.

	I.	II.	III.	Mean.		
P_2O_5 ..	41·03	----	---	41·03	÷142=	·289=1 =1
MnO ..	38·19	----	----	38·19	÷ 71=·538	·580=2·01=2
FeO ...	3·06	----	----	3·06	+ 72=·042	
Na_2O ..	----	16·77	16·81	16·79	÷ 62=·271	·279=0 97=1
Li_2O ..	----	0·20	0·19	0·19	+ 23=·008	
H_2O ...	----	0·40	0·45	0·43		
Insol. .	0·81	0·81	0·81	0·81		
				100·50		

The formula is therefore $\overset{I}{R}_2O\,.\,2\overset{II}{R}O\,.\,P_2O_5$ or $\overset{I}{R}\overset{II}{R}PO_4$, or essentially $NaMnPO_4$. It will be noticed that iron is present in very small amount only (3 p. c.) and of lithia there is hardly more than a trace (0·2 p. c.). With the discovery of natrophilite, the triphylite group receives an important addition, and we now have:

$$\left.\begin{array}{ll}\text{Triphylite,} & LiFePO_4\\ \text{Lithiophilite,} & LiMnPO_4\end{array}\right\}\begin{array}{l}\text{Connected by many intermediate}\\ \text{compounds, } Li(Fe, Mn)PO_4.\end{array}$$
Natrophilite, $NaMnPO_4$.

These three species are, as is to be expected, closely isomorphous. To them is also related in composition and in some degree in form the new sodium-beryllium phosphate, beryllonite, $NaBePO_4$, which was described by one of us a year and a half ago.*

The relation of natrophilite in origin to the common lithiophilite is an interesting question. In view of the extensive changes that, as we have shown, have taken place in the spodumene, by which the lithium has been removed and its place taken more or less fully by sodium, or sodium and potassium, it is natural to suggest that a similar change has resulted in forming the $NaMnPO_4$ out of $LiMnPO_4$, and this we regard as very probable. Its limited method of occurrence suggests the same thing, although it must be remarked at the same time that it seems to pass into hureaulite as readily as the lithiophilite. If in fact formed from lithiophilite, the change probably took place before the formation of most of the other phosphates.

HUREAULITE.

Perhaps the most interesting of recent developments at Branchville is the discovery of the rare mineral hureaulite. Thus far our knowledge of hureaulite has been limited to the account of crystals from Limoges by Dufrénoy† and the later and more thorough description by Damour and DesCloizeaux.‡ In addition we have only the single remark by Websky that it probably occurs at Michelsdorf, Silesia, with sarcopside.

The crystals described by DesCloizeaux belong to three varieties showing two distinct types of form, though having the same composition, as shown by Damour. These varieties are respectively violet-rose, brownish orange and pale rose pink in color. Their crystallographic relation to each other is anomalous, in fact, it would be difficult to find another case equally so. The crystals of the two types have the fundamental prism in common, but otherwise no plane of the one occurs on the other, and what is more remarkable, the symbols assigned to a number of the planes of the second type are complex in the extreme. The axial ratio calculated from DesCloizeaux's fundamental measurements is

$$\grave{a}:b:\acute{c} = 1{\cdot}6977:1:0{\cdot}8887;\ \beta = 89°\ 27'.$$

The planes observed on crystals of the two types are as follows:

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* This Journal, xxxvi, 290, Oct., 1888; xxxvii, 23, Jan, 1889.

† Ann. Chim. Phys., xli, 338, 1829. ‡ Ibid, III, liii, 293, 1858.

First type			DesCl.	Second type.			DesCl.
b	010	*i-ì*	*g*	*a*	100	*i-i*	h^1
c	001	*O*	*p*	*m*	110	*I*	*m*
m	110	*I*	*m*	*o*	105	$-\frac{1}{5}$-*i*	o^5
g	301	−3-*i*	$o^{\frac{1}{3}}$	*a*	$\bar{1}\bar{5}\cdot0\cdot8$	$\frac{15}{8}$-*i*	$a_{\frac{8}{15}}$
e	011	1-*ì*	e^1	*δ*	435	$-\frac{4}{5}$-$\frac{4}{3}$	*δ*
u	$\bar{3}11$	3-3	*u*	*k*	$\bar{1}\bar{9}\cdot5\cdot8$	$\frac{19}{8}$-$\frac{19}{5}$	*k*
t	$\bar{3}41$	4-$\frac{3}{4}$	*t*	*x*	$\bar{1}\bar{1}\cdot9\cdot10$	$\frac{11}{10}$-$\frac{11}{9}$	*x*
				ε	$\bar{9}\cdot11\cdot10$	$\frac{11}{10}$-$\frac{11}{9}$	*ε*

The Branchville crystals, like those from Limoges, vary in color from pale violet to reddish brown and deep orange-red. The habit of the crystals, however, is nearly constant and the angles also so far as our measurements have gone; they correspond to the second type of the Limoges crystals. The crystals are not easy to decipher, since they are very small, united by parallel grouping and as a rule present only a few planes in such a way as not to exhibit the symmetry. The angles are not as accurate as could be desired, although the crystals are much better than those of Limoges, since DesCloizeaux gives his observed angles to whole degrees in many cases and the majority are stated to be approximations only.

For the sake of greater simplicity of symbols, the position of DesCloizeaux is modified somewhat in that his plane 105 (o^5) is taken as the base and the pyramid *δ* is made the unit pyramid.

For fundamental angles the following have been assumed:

$$100 \wedge 001 = 84° \ 1'$$
$$110 \wedge 1\bar{1}0 = 62° \ 21'$$
$$\bar{1}10 \wedge \bar{4}01 = 70° \ 54'$$

whence we obtain:

$$\grave{a}:b:\acute{c} = 1{\cdot}9192 : 1 : 0{\cdot}5245;\ \beta = 84° \ 1'.$$

The observed planes with the symbols of the corresponding planes so far as observed by DesCloizeaux are as follows:

			DesCloizeaux.	
a	100	*i-i*	100	h^1
c	001	O	105	o^5
m	110	I	110	*m*
a	$\bar{4}01$	4-*i*	$\bar{1}5\cdot0\cdot8$	$a_{\frac{8}{15}}$
β	$\bar{5}01$	5-*i*		
p	223	$-\frac{2}{3}$		
δ	111	−1	435	*δ*
e	$\bar{2}21$	2	$\bar{9}\cdot11\cdot10$	*ε*
k	$\bar{5}11$	5-5	$\bar{1}9\cdot5\cdot8$	*k*
z	$\bar{6}21$	6-3		
l	$\bar{8}41$	8-2		

The attempt to transform the symbols of DesCloizeaux, according to the usual methods, into those required by this change of position meets with only partial success. Thus the plane $\bar{1}9\cdot5\cdot8$ becomes by the transformation $\bar{4}11$ while the observed angles of DesCloizeaux make it for the axial ratio here taken $\bar{5}11$. As will be seen below the angles of a number of forms on the Branchville hureaulite agree pretty well with the angles measured by DesCloizeaux, with the single exception of the prism. For this he found 119°, while we make it for the Branchville crystals 124° 42′. It is this discrepancy which causes the want of agreement which we have just alluded to. Furthermore, it is seen that the complex symbols of several of the planes, in DesCloizeaux's position and referred to his axes, become simplified when referred to the axes here adopted. Of the planes noted by DesCloizeaux on type 2, all but one ($\bar{1}\bar{1}\cdot 9\cdot 10$) it will be seen, occurs on the Branchville crystals and to this the symbol $\bar{5}32$ probably belongs in our position. Of the forms of the first type, only the prism occurs with us, but to the other planes the probable symbols in our position may be assigned.

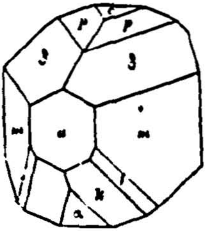
DesCloizeaux.			DesCloizeaux.		
001	*p*	$\bar{1}03$	$\bar{3}11$	*u*	$\bar{1}2\cdot 3\cdot 2$?
011	*c*¹	$\bar{1}53$	$\bar{3}41$	*t*	$\bar{6}61$?

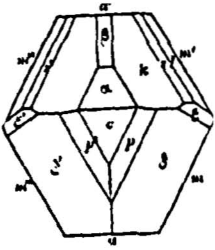
The following table gives the more important angles calcu-

	Branchville.		DesCloizeaux.	
	Calculated.	Measured.	Calculated.	Measured.
100 ∧ 110	*62° 21′	62° 18′, 62° 25′, 62 27 62 35 62 45	59°	59°
001 ∧ 100	*84 1	83 26	83 29′	83° 39′
" $\bar{1}00$	95 59	96 9	96 31	96 30
" ∧ $\bar{1}03$	5 13½			(5 58)
" $\bar{4}01$	50 49		50 42	50 50
$\bar{1}00$ ∧ $\bar{4}01$	45 10	45 54	45 49	45 40
$\bar{1}00$ ∧ 223	74 47½			
" 111	71 25	71 9		
$\bar{1}00$ ∧ $\bar{8}41$	47 59			
" ∧ $\bar{5}11$	41 40	42 12, 42 14, 42 35		42 10
001 ∧ 223	21 3	21 3, 21 58		
" ∧ 111	29 46	29 40, 29 28	30 40	29 25
" ∧ 110	87 14	87°, 87° 4′, 87 12′	86 42	86
" $\bar{2}21$	51 17		50 17	50 29
" ∧ $\bar{5}11$	59 30			59 30
" ∧ $\bar{1}10$	92 46	92° 56′		
223 ∧ $2\bar{2}3$	37 9	37 37		
111 ∧ 1 1	52 14½	51 54	52 13	51
511 ∧ $5\bar{1}1$	35 58	36 7, 36 31	38 33	37
110 ∧ 111	57 28	57 32, 57 22, 57 42	56 2	55 45
" 223	66° 11′	66 12, 67 8		
$\bar{1}10$ $\bar{2}21$	41 29	42 1	43 2	43
" ∧ $\bar{5}11$	51° 9′	51 40, 51 50, 51 52	48 57	49
" ∧ $\bar{8}41$	25° 13′	25 13, 25° 22′		
" ∧ $\bar{4}01$	*70° 54′	70 53, 71° 19′		

lated from our axial ratio compared with our measurements and also with the *measured* angles of DesCloizeaux. It is seen that the correspondence between our measured and calculated angles is not in all cases as great as could be desired, although as much as could perhaps be expected from the nature of the material. It has been stated that the crystals are often grouped in parallel position, but as is common in such cases, the parallelism is not perfect and furthermore the parts show slight variations in position, even when the planes are smooth, which are doubtless to be referred to the same cause.

The habit of the Branchville crystals is short prismatic as shown on figure 1: a basal projection of a more complex form is given in fig. 2. The grouping in parallel position gives rise to a repetition of the prismatic planes which may result in a deep striation or furrowing of this face. Besides this, the zone of planes *m*, *l*, *k*, *a*, is often striated or channeled parallel to their common direction of intersection. The crystals show rather perfect cleavage parallel to the orthopinacoid. For analysis, carefully selected portions of the purest crystals were taken by Prof. Wells. The specific gravity was found to be 3·149. The results are satisfactory as agreeing fully with those of Damour and leading to the same formula. For comparison we quote Damour's analysis of the pale rose crystals which differs but little from that of the yellow crystals; it is to be noted that the violet crystals (type I) have not been analyzed and it is possible that some difference in composition may explain the difference noted in the form. The Branchville mineral contains a little less iron than the Limoges.





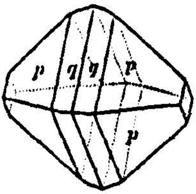
	Branchville. G.=3·149					Limoges. rose, G.=3·186
	I.	II.	Mean.			
P_2O_5	38·28	38·44	38·36		·270=1·00=2	37·83
FeO	4·76	4·37	4·56	·063	·676=2·50=5	8·73
MnO	42·29	....	42·29	·596		41·80
CaO	0·94	....	0·94	0·17		
H_2O	12·25	12·15	12·20		·678=2·51=5	11·60
Quartz	1·76	....	1·76		Gangue	0·30
			100·11			100·26

The formula is $5RO . 2P_2O_5 . 5H_2O$ or $H_2R_5(PO_4)_4+4H_2O$. The percentage composition calculated for manganese only is: P_2O_5 38·96, MnO 48·69, H_2O 12·35=100.

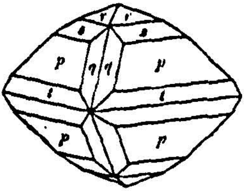
REDDINGITE.

The species reddingite has been known thus far only in a few specimens, showing it in a granular form of a reddish color, or rarely in octahedral crystals often superficially black from oxidation. The material first found though scanty was sufficient to admit of the determination of the form, which was shown to be similar to that of scorodite and strengite. Among the specimens recently discovered, reddingite is not uncommon, and we have been gratified to obtain it not only well crystallized but also in massive form, perfectly fresh and unaltered. The color is a pale rose-pink, often hardly more than a pinkish-white. The most intimately associated minerals are fairfieldite and dickinsonite, the latter of which is often imbedded in it in isolated scales or more often in stellate groups of green folia. The octahedral habit of the crystals, which appear in occasional cavities, is usually apparent at a glance, but not infrequently the crystals are distorted by the elongation of a pair of pyramidal planes which gives them a misleading oblique prismatic appearance. The common form of the crystals is shown in fig. 3 from our former paper. Some of the crystals are more complex (fig. 4) and show also the unit pyramids *r*, *s* and *t*, whose symbols are respectively 338, 223, 774. These planes do not give sharp measurements but the angles are sufficient for identification. The axes taken are those previously obtained by us, viz:

3.



4.



$$\breve{a}:\bar{b}:\dot{c} = 0·8678:1:0·9485$$

and the measured and calculated angles are,

	Measured,	Calculated.
111 ∧ 338	= 20° 11′	20° 0′
111 ∧ 223	= 10° 10′	9° 54′
111 ∧ 774	= 16° 41′	15° 46′

It seemed especially desirable to have a new analysis of this species, both because the material was more abundant and better than what we had had before, and also since the composition—though in fact fully established—may have appeared to some anomalous, in view of its failure to correspond with that of scorodite and strengite in the degree of oxidation of the manganese and in the amount of water. The new analysis by Wells fully confirms the former one made by him, only differing in the larger percentage of ferrous iron present.[*] This analysis of a carefully selected portion with a specific gravity of 8·204, gave:

	I.	II.			
P_2O_5	34·90	....	+ 142 = ·246		= 1·00 = 1
FeO	17·13	....	+ 72 = ·238		
MnO	34·51	....	+ 71 = ·486	·735	= 2·99 = 3
CaO	0·63	....	+ 56 = ·011		
H_2O	13·18	13·18	+ 18 = ·732		= 2·98 = 3
Quartz	0·13	....			
	100·48				

The formula is hence $R_3(PO_4)_2+3H_2O$, and if R=Fe : Mn=1 : 2, this requires P_2O_5 34·64, FeO 17·56, MnO 34·63, H_2O 13·17=100.

FAIRFIELDITE.

Fairfieldite appears among the specimens recently obtained not infrequently, and in a form much fresher and purer than that in which we had it before. It is usually in foliated masses intimately associated with reddingite and fairfieldite, and hardly less so with hureaulite. The color varies from white to yellowish or greenish white; it is usually perfectly transparent and the luster is very brilliant, varying from adamantine to pearly according to the surface on which it is viewed, the latter on the surface of perfect cleavage. A tendency to crystallization is at times apparent but no crystals suitable for measurement have been found, which is to be regretted since the early results left much to be desired. An analysis of the perfectly fresh mineral has been made by Wells. This agrees with those of Penfield previously published; the amount of iron is less and that of the manganese greater, but it is worthy of note that the ratio of 2 : 1 for Ca : Mn+Fe is still maintained.[†] The analysis of pure material having a specific gravity of 3·07 is as follows:

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[*] The earlier analysis gave FeO 5·43, MnO 46·29.

[†] *It is interesting to call* attention here to the identification of fairfieldite by Sandberger at Rabenstein, Jahrb. Min., i, 185, 1885. It is also worthy of note that a new hydrous phosphate of ferrous iron and calcium, near fairfieldite but with $2\frac{1}{2}H_2O$, has been recently named messelite by Muthmann (Zs. Kryst., xvii, 93, 1889); like fairfieldite it is triclinic. Furthermore the brandtite of Nordenskiöld is $Ca_2Mn(AsO_4)_2+2H_2O$, corresponding exactly to fairfieldite, Œfv. Ak. Stockh., 489, 1888, Groth, Tab. Ueb. Min., p. 80, 1889.

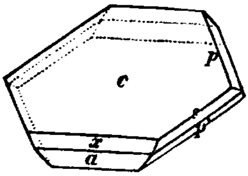
P_2O_5	[37·69*]	÷ 142 = ·265		= 1·00 = 1
FeO	3·42	÷ 72 = ·047	·292	= 1·10 = 1
MnO	17·40	÷ 71 = ·245		
CaO	30·02	÷ 56 = ·536		= 2·02 = 2
H_2O	9·81	÷ 18 = ·545		= 2·06 = 2
Quartz	1·66			
	100.00			

The formula is hence essentially $Ca_2Mn(PO_4)_2+2H_2O$, which requires P_2O_5 39·34, MnO 19·67, CaO 31·02, H_2O 9·97=100. This analysis confirms the earlier one by Penfield and further makes it probable that there is a definite ratio of 1 : 2 for Mn (with Fe) : Ca.

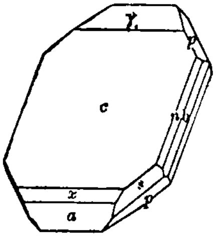
DICKINSONITE.

One of the most remarkable and novel of the species first described from Branchville was the chlorite-like dickinsonite—a mineral of a bright green color, micaceous structure and pseudo-rhombohedral form. Recent developments have enabled us to add materially to our knowledge of the species. The number of specimens obtained is relatively large and in some of them it shows itself in tolerably well-defined crystallized forms. It will be remembered that for our earlier work we had only one or two minute crystals. The habit of most of the crystals now found differs from that before described, fig. 5, the hexagonal form is rather rare and the crystals appear as rectangular tables united in slightly diverging groups, fig. 6.

5.



6.



A closer examination shows that they agree with the same fundamental form before accepted. These crystals are elongated parallel to the orthodiagonal axis, and the basal surfaces are bent and striated in this direction. In addition they show on the edges, sometimes in traces only, the pyramidal planes, which when developed give the hexagonal habit before noted. In addition to the planes *a*, *b*, *c*, *x* (301), *p* ($\bar{1}11$) and *s* ($\bar{2}21$), we have identified also a steep clinodome, *n*, which has the symbol (051) and a hemi-orthodome, *y* ($\bar{1}03$). We retain our former axial ratio

$$\grave{a} : b : \dot{c} = 1·73205 : 1 : 1·19806 ;\ \beta = 61° \ 30'.$$

---

* By difference.

And the measured and calculated angles are:

	Calculated.	Measured.
$001 \wedge 051 =$	79° 15′	79°
$001 \wedge \bar{1}03 =$	12 50	13–14

Optically we find the crystals as before stated to be biaxial, the optic axes being situated in the clinodiagonal section and the bisectrix nearly normal to the cleavage-face; the double refraction is negative and the axial angle large.

Besides the crystals occasionally appearing in the cavities, and often united in slightly diverging groups with edges parallel to *b* projecting, the mineral occurs foliated to almost massive and granular, the folia, however, usually distinct and often grouped in rosettes or stellate forms.

Dickinsonite is the species about whose composition we felt most doubt when we first published. The material then in hand was very scanty and not entirely pure, and although excellent analyses were made by Penfield, their interpretation was a matter of some doubt because of admixture of more or less eosphorite as well as quartz. Two independent sets of new analyses have been made by Professor Wells. The material for the first was picked with great care, but in order to

DICKINSONITE, BRANCHVILLE.

Analysis of first sample.

Sp. Gr. 3·148,

	I.	II.	Mean.				
P_2O_5	39·57	----	39·57	+ 142	= ·279		=1·00=1
FeO	----	13·25	13·25	+ 72	= ·184	·814	=2·92=3
MnO	31·74	31·42	31·58	+ 71	= ·445		
CaO	2·15	----	2·15	+ 56	= ·039		
MgO	trace						
Na_2O	7·47	7·44	7·46	+ 62	= ·124		
K_2O	1·49	1·55	1·52	+ 94·2	= ·017		
Li_2O	0·20	0·14	0·17	+ 34	= ·005		
H_2O	1·66	1·65	1·65	+ 18	= ·094		=0·34=⅓
Quartz	2·58	2·58	2·58				
			99·93				

Analysis of second sample.

	I.	II.	Mean.				
P_2O_5	40·89	----	40·89	+ 142	= ·288		=1·00=1
FeO	12·96	----	12·96	+ 72	= ·180	·811	=2·82=3
MnO	31·83	----	31·83	+ 71	= ·448		
CaO	2·09	----	2·09	+ 56	= ·038		
MgO	none	----					
Na_2O	----	7·37	7·37	+ 62	= ·120		
K_2O	----	1·80	1·80	+ 94·2	= ·019		
Li_2O	----	0·22	0·22	+ 34	= ·006		
H_2O	1·64	1·62	1·63	+ 18	= ·092		=0·32=⅓
Quartz	0·85	0·79	0·82				
			99·61				

remove all question as to whether the results gave the true composition of the mineral, a second and independent analysis was made. For this the very best material was selected and after being separated was minutely examined microscopically to make sure of its purity. The results as will be seen are identical with those of the first.

The two samples were picked from separate specimens and the material was apparently very pure. Unusual care was taken in picking the second sample and its purity is indicated by the small amount of quartz present.

The formula indicated by both the analyses is $3RO \cdot P_2O_5$, $\frac{1}{8}H_2O$ or $R_3(PO_4)_2+\frac{1}{8}H_2O$ where R=Mn, Fe, Ca, Na_2, K_2 and Li_2. There is no simple ratio between the alkalies and the remaining bases. The results vary considerably from those of Penfield in his original analysis. This is undoubtedly due to the fact that the present material was much purer than that analyzed by him. Penfield found about 14 per cent CaO, (probably due to admixed fairfieldite) only about 6 per cent of alkalies and 3·87 per cent of H_2O. The formula which he arrived at, however, is confirmed except in the amount of H_2O. It will be seen that the composition now established is essentially the same with that deduced for fillowite on the basis of Penfield's original analysis.

FILLOWITE.

The fact just stated, that our former formula for fillowite is the same as that now obtained for dickinsonite, has made us very anxious to prove that our early results were trustworthy, especially since the material in hand at the time of our first investigation was very scanty. Unfortunately, among the large number of specimens recently obtained from Branchville, we have not succeeded in finding a trace of this mineral. We have been forced consequently to revert to the few original specimens still in hand. The best of these we gave to Mr. Wells, and from it he picked out about 0·75 gram, in the homogeneity of which he had entire confidence. A new analysis of this has been made by him with the following results; for comparison we quote the original analysis by Penfield.

		Ratio.			Analysis (1878) Penfield.
P_2O_5	39·68	÷ 142 = ·279		1·	39·10
FeO	9·69	÷ 72 = ·135	·847	3·04	9·33
MnO	39·58	÷ 71 = ·557			39·42
CaO	3·63	÷ 56 = ·065			4·08
Na_2O	5·44	÷ 62 = ·088			5·74
Li_2O	0·07	÷ 30 = ·002			0·06
H_2O	1·58	÷ 18 = ·088		0·31	1·66
Quartz	1·02				0·88
	100·69				100·27

It will be seen that the two analyses agree throughout and the formula, is the same, viz: $\dot{R}_3P_2O_8+\frac{1}{3}H_2O$. As noted above it is identical with that of dickinsonite, although the latter species contains more alkalies and less manganese. The two species are then essentially dimorphous forms of the same compound, and the relation between them is made all the more interesting in that with the striking differences in physical characters, there is yet an obvious relation in form. Dickinsonite is monoclinic with marked pseudo-rhombohedral symmetry and of fillowite the same is true as we have proved by a reëxamination of fragments parallel to the distinct but interrupted basal cleavage. Moreover the dimensions of the forms show a close relation, thus we have:

	Dickinsonite.	Fillowite.
$100 \wedge 001 =$	61° 30′	58° 31′
$001 \wedge \bar{2}21 =$	61 8	58 40
$001 \wedge 221 =$	61 8	58 40

We have then in these two species an example of a very close and interesting case of dimorphism. The suggestion that the two could be regarded as independent forms of the same mineral differing in habit and state of aggregation could not possibly be made by one who had seen and examined the specimens. We have still hope that in future explorations at Branchville we may find a new supply of this rare and interesting species, named in honor of our good friend, Mr. A. N. Fillow.

ART. XXVII.—*A simple Interference Experiment;* by ALBERT A. MICHELSON.

THERE is probably no experiment connected with the wave-theory of light of greater fundamental importance than the justly celebrated one known as "Fresnel's mirror experiment," and accordingly many find it necessary to repeat the experiment for their own edification or for class demonstration.

Without the use of rather elaborate and costly apparatus even skilled experimenters find some difficulty in producing the desired effect—the interference of two pencils of light as manifested by the appearance of colored fringes on a screen, or in the focus of an observing lens; and unskilled observers find it almost impossible, even with these aids. Even when produced under the most favorable conditions the phenomenon is complicated and often much obscured by diffraction effects.