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*On Childrenite from Crinnis mine, Cornwall, and  
Eosphorite from Poland, Maine.*

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UP to the present time only one of the several childrenite occurrences known has been examined both chemically and crystallographically. This is the well-known occurrence at the George and Charlotte mine near Tavistock, from which nearly all the specimens seen in collections were obtained. The crystals often attain a dimension of 1 cm., so that material for analysis can be easily obtained free from gangue. Crystals from this locality were analysed by Rammelsberg,<sup>1</sup> Church,<sup>2</sup> and Penfield,<sup>3</sup> and it is on the results obtained by the last-named that the comparatively simple formula for this mineral is based. A crystallographic examination by Brush and Dana<sup>4</sup> of eosphorite, a new manganese alumino-phosphate from Branchville, Connecticut, brought out a striking similarity to childrenite, and led them to suggest the chemical comparison of the two minerals. This was undertaken by Penfield, who showed, first of all, that the formula of eosphorite was a comparatively simple one, viz.  $2(\text{Mn,Fe})(\text{OH})_2 \cdot \text{Al}_2\text{O}_3 \cdot \text{P}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$ ; secondly, that by using carefully picked childrenite, its formula is proved to be identical with that of eosphorite, childrenite having mainly iron as its divalent metal, while in eosphorite manganese predominates. The older analyses of childrenite

<sup>1</sup> C. F. Rammelsberg, Ann. Phys. Chem. (Poggendorff), 1852, vol. lxxxv, p. 485.

<sup>2</sup> A. H. Church, Journ. Chem. Soc., 1873, vol. xxvi, p. 103.

<sup>3</sup> S. L. Penfield, Amer. Journ. Sci., 1880, ser. 3, vol. xix, p. 315.

<sup>4</sup> G. J. Brush and E. S. Dana, Amer. Journ. Sci., 1878, ser. 3, vol. xvi, p. 35.

by Rammelsberg and Church, on the other hand, did not agree with each other, and led to much more complex formulae.

Besides the George and Charlotte occurrence of childrenite, some others are known, viz. Wheal Crebor, also near Tavistock; the Crinnis mine near St. Austell, Cornwall; Hebron, Maine, U.S.A.; and finally in the granite of Greifenstein near Ehrenfriedersdorf in Saxony. None of these occurrences have been investigated chemically, although the probability of the existence of gradations between the ferriferous childrenite and the manganiferous eosphorite would render such investigation of interest.

The Oxford Mineralogical Department having a large number of specimens of the Crinnis occurrence, Prof. Bowman suggested to me their more detailed study, and while I was still engaged in this work, a lucky chance brought into my hands a hitherto undescribed find of eosphorite from a new American locality, namely, Poland, Maine. I have to thank Prof. Palache of Harvard University for entrusting me with this material, which he had already recognized as eosphorite. It was part of the very large store of valuable, and often unique, mineralogical material awaiting detailed study in the Holden Collection,<sup>1</sup> lately bequeathed in its entirety to Harvard University. Besides eosphorite, several more of the rare Branchville phosphate minerals are present on these specimens, but these will not be dealt with in this paper, the object of which is to compare childrenite and eosphorite.

#### CHILDRENITE FROM THE CRINNIS MINE, CORNWALL.

The mineral occurs as minute (rarely reaching 1 mm.) but distinct crystals on the surface of the walls of narrow cracks in killas, sometimes on quartz, and is almost always coated with a layer of hydrated ferric oxide, which colours it dark brown. The real colour is a very pale buff to almost colourless. The crystals on quartz are generally free from this coating, and these show bright, though much striated faces. The crystals adhere closely to the matrix, and their small size makes it difficult to obtain pure material for analysis by picking off the separate crystals, which was the method first attempted. The procedure found most useful was as follows: The crystals were gouged away from the killas with a strong, pointed dentist's chisel, the point of which was pushed well under the crystals, to prevent breaking them up too much. The loosened material was next sifted through a wide-meshed sieve, the

<sup>1</sup> See this volume, p. 117.

coarser killas flakes being left behind. The finer killas dust was next removed by rolling the powder down an inclined plane of moderately coarse paper. The childrenite grains roll down easily, whilst the flatter killas particles remain behind. Warm concentrated hydrochloric acid was next poured on to the material and washed away after a few minutes. This was repeated till all oxidized ferruginous matter had been dissolved away and the fresh acid remained colourless. As far as could be seen, childrenite is not acted on by the acid under these conditions, though eosphorite does not withstand the same treatment: it seems to become partially dehydrated and then to dissolve readily in hydrochloric acid. Quartz was next removed by suspension in a mixture of methylene iodide and toluene, and the remaining specks of impurities removed by hand-picking with a wet camel's-hair brush.

The usual methods were employed in the analyses; but in some of the analyses one modification was used which may be mentioned here. The phosphoric acid was precipitated by ammonium molybdate immediately after dissolving the ignited material in acid, and the analysis continued in presence of the molybdate. There seems, however, to be greater difficulty in completely precipitating the manganese by bromine, but otherwise the method seems quite serviceable if each precipitation is repeated before weighing. The analyses (I-V) show slight variations, due to the fact that different samples of material were used. The mean results (VI) agree well with Penfield's analyses of childrenite from the George and Charlotte mine, which are quoted under VII and VIII for comparison. The mineral from Crinnis mine, however, contains rather more iron and correspondingly less manganese.

	Crinnis mine.					George and Charlotte mine (Penfield).		
	I.	II.	III.	IV.	V.	VI. (Mean)	VII.	VIII.
P <sub>2</sub> O <sub>5</sub> ...	29.83	—	—	—	29.80	29.80	30.19	29.98
Al <sub>2</sub> O <sub>3</sub> ...	21.09	—	—	—	21.34	21.20	21.17	21.44
FeO ...	28.41	27.96	28.03	28.55	28.60	28.30	26.54	26.20
MnO ...	2.94 <sup>1</sup>	3.58	—	3.35	3.26	3.35	4.87	—
CaO ...	0.97	0.98	—	1.08	0.61	0.90	1.21	—
Na <sub>2</sub> O ...	0.25	—	—	—	—	0.25	—	—
H <sub>2</sub> O ...	15.31	15.28	15.41	15.24	—	15.30	15.87	—
Insoluble ...	1.08	0.92	1.06	—	0.88	0.95	0.10	—
	<u>99.83</u>					<u>100.05</u>	<u>99.95</u>	

<sup>1</sup> There was some loss of manganese in this analysis.

The crystals are not suitable for accurate measurement, the faces being invariably striated or rounded and complicated by vicinal forms. A few measurements of the interfacial angles are given below for comparison

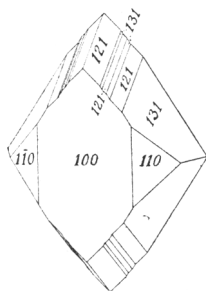


FIG. 1.—Crystal of Childrenite from Crinnis mine, Cornwall.

with those of Miller for the George and Charlotte crystals. Two crystals of the latter occurrence were also measured, and the results are given below:—

Angle.	Crinnis mine.			George and Charlotte mine.		
	Crystal No. 1.	No. 2.	No. 3.	Miller.	No. 1 (J. D.).	No. 2 (J. D.).
(121):(121)	49° $\left\{ \begin{array}{l} 39' \\ 32 \\ 30 \end{array} \right.$	49° $\left\{ \begin{array}{l} 29' \\ 29 \end{array} \right.$	49° $\left\{ \begin{array}{l} 49' \\ 29 \\ 28 \\ 41 \end{array} \right.$	49° 56½'	49° 35'	49° 37'
(121):(121)	81° $\left\{ \begin{array}{l} 38' \\ 46 \\ 47 \\ 58 \end{array} \right.$	...	...	82° 7½'	82° 4'	81° $\left\{ \begin{array}{l} 51' \\ 50 \\ 50 \\ 54 \end{array} \right.$
(110):(110)	...	75° 31'	...	75° 46'	76° $\left\{ \begin{array}{l} 1' \\ 2 \\ 3 \\ 2 \end{array} \right.$	75° $\left\{ \begin{array}{l} 33' \\ 43 \\ 44 \end{array} \right.$

The results, as may be seen, are not sufficiently reliable to enable one to calculate the elements with any accuracy. It was therefore considered unnecessary to carry out detailed optical measurements of this material, especially as the preparation of accurately orientated prisms from such small crystals would have presented great difficulties. Such measurements would have been of value if one could have been certain that the material was quite homogeneous. Analyses and measurements

tend to show, however, that the material is not homogeneous, and Des Cloizeaux's observation that the axial angle is variable confirms this. The comparatively large tabular or prismatic crystals from Hebron, Maine, might prove valuable material for completing our knowledge of the isomorphous childrenite-eosphorite series.

The author has been able to procure several well-crystallized specimens of the Greifenstein occurrence, which will probably also be useful for chemical and crystallographic investigation, though not for optical examination. The form (120) was observed on several crystals of one specimen, otherwise the habit is similar to that of the specimens from Cornwall and Devon; (121) is the best-developed form, and is generally accompanied by (110) and (100). The forms (111) and (131) were not observed, except as narrow strips on some of the more striated crystals. The large crystals, up to  $1\frac{1}{2}$  cm. in width, show unstriated though superficially rough (121) faces. This occurrence differs from the British ones chiefly in that the mineral forms more or less indefinite nodules or large rough crystals in the cavities of the pegmatitic granite, instead of being found as small distinct crystals coating the walls of a fissure.

It may be useful, in this place, to draw attention to certain inaccuracies which have crept into the literature concerning childrenite. The mineral was first described by H. J. Brooke<sup>1</sup> in 1823, and named by him after J. G. Children, of the British Museum. Several subsequent publications gave the correct reference to his original description, but Allan,<sup>2</sup> in 1834, states that Lévy was the discoverer and namer of the species. I have, however, been unable to find any record of a description of this mineral by Lévy before 1837,<sup>3</sup> when he published further details about childrenite with new drawings, but this makes no claim to be a first description of the mineral. From this time onwards the error has been perpetuated in several works, including the standard treatise on mineralogy, Dana's 'System', the sixth edition (1892) giving the correct reference to Brooke's original article, but erroneously under Lévy's name. The mistake is, I think, traceable to a short note in Berzelius's 'Jahres-Bericht' (1825, vol. iv, pp. 149 and 150). Here a number of new minerals are described, and the paragraph which mentions Brooke's discovery of childrenite begins rather ambiguously and follows imme-

<sup>1</sup> H. J. Brooke, *Quart. Journ. Sci. Lit. and Arts (Roy. Inst. Great Britain)*, 1823, vol. xvi, pp. 274-275; sometimes called *Brandé's Journal*.

<sup>2</sup> R. Allan, '*Manual of Mineralogy*.' Edinburgh, 1834, p. 39.

<sup>3</sup> A. Lévy, '*Description d'une collection de minéraux formée par M. H. Heuland . . .*' London, 1837, vol. iii, pp. 409-410, and Plate 81, fig. 2.

diately on a paragraph describing some new minerals of Lévy's. The first part of the paragraph may be quoted:—'Brooke fährt fort, die Mineralogie bisweilen mit neuen Mineralien, aber oft und in Menge mit neuen Namen zu bereichern; solche sind: Cleavelandit, Arfvedsonit, Latrobit, Childrenit, Sommervillit. Man darf jedoch nicht glauben, dass diese alle neue Verbindungen bezeichnen.' This ambiguous note immediately following a paragraph with Lévy's name is the probable origin of the error; this impression becoming strengthened by Lévy's publication of new drawings and descriptions.

The statement is made in a number of publications that childrenite also occurs in Cumberland, though no description of such an occurrence has ever been published. This statement rests on an error which appears in Rammelsberg's chemical investigation of childrenite.<sup>1</sup> He begins thus: 'Zu den seltensten und in chemischer Beziehung fast ganz ungekannnten krystallisirten Mineralien gehört der Childrenit, welcher auf einem Gang der George- und Charlotte-Grube bei Tavistock in Devonshire, begleitet von Spatheisenstein, Quarz und Kupferkies vorkommt, und nur noch bei *Callington in Cumberland* sich gefunden haben soll.' Cumberland as a childrenite locality should therefore be struck out, for Callington is in Cornwall. The locality referred to is probably the George and Charlotte mine itself, or one of the other occurrences near Tavistock, which are also near to Callington over the Cornwall-Devonshire boundary.

It may be well also to draw attention here to the second volume of V. Goldschmidt's 'Atlas der Krystallformen' (Heidelberg, 1913), in which the collected drawings and list of references to childrenite have much facilitated my search after childrenite literature. The following minor slips in the text-volume may be corrected:—

On p. 136, in the 'Bemerkung', line 3, for '(unsere Fig. 9)', read '(unsere Fig. 8)'.

On p. 137, following Fig. 1, for 'Brandes' read 'Brooke'.

On p. 137, following Fig. 4, for 'Taf. 76, Fig. 480', read 'Taf. 76, Fig. 460'.

In Goldschmidt's 'Atlas' the original drawings are exactly reproduced, so that most of the crystals of childrenite appear in the old setting, in which the pseudo-hexagonal character of the vertical axis (now *b*-axis) is made plain. The distinctly prismatic character of some childrenite crystals, and more especially of those of eosphorite, led Brush and Dana to a change in setting, in which this direction of elongation becomes the

<sup>1</sup> C. F. Rammelsberg, loc. cit.

vertical axis, and the *c*-axis of most of the older drawings becomes the *b*-axis. The last three drawings in the 'Atlas', one of which is of an eosphorite crystal, are given in this new setting, which seems to me well entitled to supersede the older ones.

#### EOSPHORITE FROM POLAND, MAINE, U.S.A.

The material examined is from the Holden Collection, now in the Harvard Mineralogical Museum, and it came from A. R. Berry's quarry at Poland, Maine. The matrix on which the eosphorite occurs consists largely of rhodochrosite, often well crystallized in dog-tooth forms, mixed with a black oxidized manganese compound. This latter generally coats the eosphorite prisms, but can readily be flaked away with the help of a small, pointed chisel, exposing the bright surfaces of the eosphorite undamaged. The eosphorite forms small, roughly radiated aggregates of prismatic crystals, some of which have very sharp end-faces giving excellent readings on the goniometer. The colour is a pale pink, and both crystal measurements and analyses show this eosphorite to be very similar to the Branchville occurrence described by Brush and Dana and analysed by Penfield. It approaches, however, more closely to the ideal iron-free eosphorite, having appreciably less iron than the original mineral from Branchville.

The analyses are given in the table below (Nos. I-III) with those of Penfield (IV and V) and Wells (VI). In No. I a certain amount of rhodochrosite was noticed after ignition, but was readily removed, allowance being made for its loss of weight on ignition. This was determined on a separate sample of pure rhodochrosite. In No. III some of the eosphorite was somewhat opaque, having probably already suffered slight dehydration; hence the rather high result for its alumina and lower water percentage. Otherwise this sample was very pure. No. II contained a small proportion of rhodochrosite, in grains too small to be removed after ignition; hence, probably, the higher manganese and lower phosphoric acid percentages.

	Poland, Maine.			Branchville, Connecticut.		
	I.	II.	III.	IV.	V.	VI.
P <sub>2</sub> O <sub>5</sub> ...	31.31	30.71	...	31.05	31.43	31.39
Al <sub>2</sub> O <sub>3</sub> ...	...	...	22.23	22.19	21.03	21.34
FeO ...	5.55	4.74	...	7.10	6.84	6.62
MnO ...	25.79	26.26	...	23.51	22.43	22.92
CaO ...	0.81	...	...	0.54	3.01	1.48
Na <sub>2</sub> O ...	...	...	...	0.32	...	...
H <sub>2</sub> O ...	15.46	15.59	14.75	15.60	15.07	15.28
Insoluble ...	...	...	...	...	...	1.46
				100.31	99.81	100.49

Six of the terminated crystals were measured and gave concordant results. These are probably sufficiently accurate to serve for a re-calculation of the elements; the hitherto accepted values having been obtained from the measurement of a single crystal. The faces observed were (111), (121), (110), (010), (100), with some less definite vicinal faces in the prism-zone. Prof. Palache mentions one good (320) face observed by him. The cleavage parallel to  $a$  (100) mentioned by Brush and Dana was not confirmed on these crystals. There is marked elongation parallel to the  $c$ -axis, and so far no doubly-terminated crystals have been observed. Fig. 2 shows the habit, which is very similar to that of the Branchville crystals.

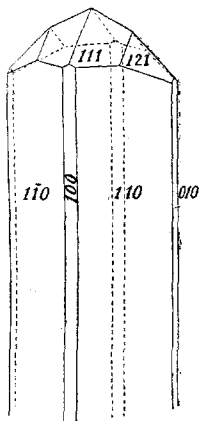


FIG. 2.—Crystal of Eosphorite from Poland, Maine.

Angle.	No. of observations.	Poland, Maine.		Branchville (Brush and Dana).	
		Observed.	Calculated.	Observed.	Calculated.
(010):(110)	11	52° 19' $\begin{smallmatrix} +4 \\ -2 \end{smallmatrix}$	*	52° 12'	52° 10'
(111):( $\bar{1}11$ )	6	61 8 $\pm$ 1	*	61 2	*
(010):(121)	15	49 28 $\begin{smallmatrix} +3 \\ -1 \end{smallmatrix}$	49° 30'	...	...
(121):(111)	6	17 20 $\begin{smallmatrix} +3 \\ -1 \end{smallmatrix}$	17 22.5	17 18	17 25
(100):(111)	10	59 26.5 $\pm$ 0.5	59 26	...	...
(100):(121)	6	65 8 $\begin{smallmatrix} +11 \\ -5 \end{smallmatrix}$	65 8	...	...
(121):( $\bar{1}21$ )	7	49 41 $\begin{smallmatrix} +5 \\ -2 \end{smallmatrix}$	49 44	49 39	49 34
(110):(111)	6	50 0 $\begin{smallmatrix} +3 \\ -6 \end{smallmatrix}$	50 1	49 55	49 59
(111):( $\bar{1}11$ )	2	80 0 + 1	79 58	80 0	80 2
(121):( $\bar{1}21$ )	5	101 24 $\begin{smallmatrix} +4 \\ -9 \end{smallmatrix}$	101 22	...	...
(010):(320) <sup>1</sup>	1	62 55	62 45	...	...
(110):(110)	...	...	75 22	75 36	75 41
(111):( $\bar{1}11$ )	...	...	46 15	46 28	*

<sup>1</sup> Communicated by C. Palache.



The calculated axial ratios are :—

$$a : b : c = 0.7724 : 1 : 0.5126 \text{ (Poland, Maine).}$$

$$\text{(Brush and Dana) } 0.7768 : 1 : 0.5150 \text{ (Branchville).}$$

Brush and Dana's results would approach the new measurements much more closely if they had not chosen the angle  $(111) : (\bar{1}\bar{1}1)$  of  $46^\circ 28'$  as one of their fundamental angles. This is the one showing the maximum divergence when compared with the new measurements, the actual differences being only about  $5'$  in the extreme cases for all the other angles. Measurements of a greater number of crystals of childrenite would probably also bring the parameters of that mineral nearer to those of eosphorite. Unfortunately, childrenite appears to be formed under less favourable conditions than eosphorite, and striated and vicinal faces are the rule.

The plane of the optic axes is  $a$  (100) and the acute bisectrix is normal to  $b$  (010). A prism cut from a crystal of eosphorite from Poland, Maine, with its refracting edge parallel to  $c$  (001) and its refracting angle bisected by the axis  $a$  accurately to  $4-5'$ , gave the following values for the greatest and least indices of refraction; and a plate cut parallel to  $b$  (010) gave the following value for the optic axial angle :—

$\lambda$ in $\mu\mu$	$a$	$\gamma$	2E
567 (Tl)	1.6438	1.6706	$66^\circ 37'$
589 (Na)	1.6420	1.6691	65 27
671 (Li)	1.6386	1.6643	62 48

A more detailed comparison of the childrenite-eosphorite isomorphous series will only be of real interest when the pure end-members of the series are available in sufficiently perfect crystals for all their properties, chemical, geometrical, and optical, to be determined. A full examination of the other material already known, i. e. that from Hebron and that from Greifenstein, should, however, be carried out.

I wish to thank Professor H. L. Bowman for his friendly advice during the course of the work described here.

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