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ART. XXXIX.—*On Clinohedrite, a new mineral from Franklin, N. J.*; by S. L. PENFIELD and H. W. FOOTE.

THE mineral that is to be described in the present paper was first brought to our notice in the autumn of 1896 by Mr. Frank L. Nason of West Haven, Conn., who sent a few specimens of it to the Mineralogical Laboratory of the Sheffield Scientific School for identification. When informed that the mineral was a new species Mr. Nason visited the locality for the special purpose of obtaining more material, but so little was found that it seemed best to postpone the investigation until more could be secured. About a year later Mr. E. P. Hancock of Burlington, N. J., sent some Franklin minerals to our laboratory for identification, among them specimens of the new mineral, and on learning the nature of the material he took a keen interest in having it investigated, generously placing at our disposal for that purpose the few specimens he had collected. A short time later Mr. W. F. Ferrier of Ottawa, Canada, also called our attention to an exceptionally fine specimen of the mineral, which he had had the good fortune to find at the locality.

The specimens were all obtained from the dump of one of the new shafts of the Trotter mine, and are supposed to have come from a depth of about one thousand feet. The mineral is associated with transparent prisms of green willemitite, a massive variety of brown garnet, phlogopite mica, small yellow crystals of axinite, dull crystals of datolite, and a reddish-brown mineral, occurring in slender prismatic crystals, which is now being investigated, and proves to be a new silicate containing lead, iron and calcium as essential constituents.

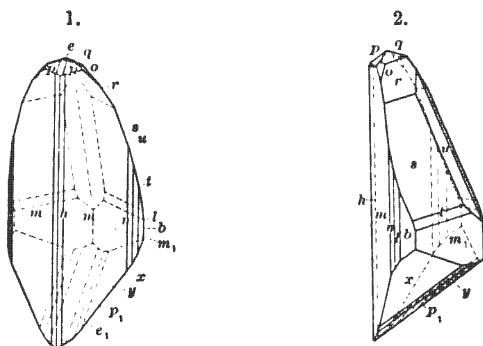
The crystallization is *monoclinic*, and the crystals are especially interesting as they belong to that division of the monoclinic system characterized by a plane of symmetry, but not an axis of symmetry, or to the class of crystals called by Groth\* the "*domatische Klasse*." No form in this class consists of more than two faces, and the pinacoid  $b, 010$ , is the only one where the faces are parallel. The prevalence of forms without parallel faces gives to the crystals a peculiar *inclined faced* character or appearance, which has suggested the name of the mineral, *clinohedrite* (*κλίνειν*, incline, and *ἔδρα*, face). Very few examples of this kind of symmetry have been observed among mineral substances, the best being some crystals of pyroxene described by Williams,† but pyroxene generally

\* *Physikalische Krystallographie*, 3 Auflage, p. 356, 1895.

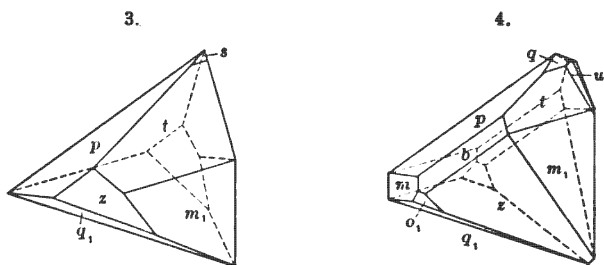
† *This Journal*, xxxviii, p. 115, 1889.

exhibits the normal or most highly developed type of monoclinic symmetry, and specimens which show the lower degree of symmetry are so rarely met with that it seems probable that they are only the result of an accidental development of a part of the crystal faces.

The crystals of clinohedrite on a specimen sent to us by Mr. Hancock were exceptionally fine and well adapted for crystallographic study. They were about 4<sup>mm</sup> long, and from 2 to 3<sup>mm</sup> in diameter, and had the habit represented in figs. 1 and 2, the



latter being drawn with the pinacoid  $b, 010$ , in front. They were generally attached at the end represented as the lower one in the figures, and the forms at that end, when they could be observed, were rounded and graded into one another so that



it was difficult to decide what ones were present and how they should be represented in the figure. At the upper, or free ends of the crystals, however, the faces were exceptionally perfect, and gave beautiful reflections. The crystals on the specimens sent by Mr. Nason were not so well suited for crystallographic study, several of the forms being striated and rounded, and it was so difficult to obtain satisfactory measurements that

the relations of the forms did not become wholly clear until the crystals from Mr. Hancock's specimen had been studied. Some of the crystals were 3<sup>mm</sup> in diameter, and figs. 3 and 4, drawn in the same position as fig. 2, will serve to exhibit the curious habit which they present.

The position which has been adopted seems well suited for representing the forms of the crystals which are given in the following table:

$b, 010$	$n, 120$	$p, 111$	$r, \bar{3}31$	$o, \bar{1}31$
$h, 320$	$l, 130$	$p_1, \bar{1}\bar{1}\bar{1}$	$s, \bar{5}51$	$o_1, 13\bar{1}$
$m, 110$	$e, 101$	$q, \bar{1}11$	$t, \bar{7}71$	$x, \bar{1}3\bar{1}$
$m_1, \bar{1}\bar{1}0$	$e_1, \bar{1}0\bar{1}$	$q_1, 11\bar{1}$	$u, \bar{5}31$	$y, \bar{1}2\bar{1}$

The form  $z$ , figs. 3 and 4, is probably  $\bar{1}6\bar{1}$ , but no measurements could be obtained from it.

The axial ratio was derived from the measurements marked by an asterisk in the accompanying table, and is as follows:

$$a : b : c = 0.6826 : 1 : 0.3226, \beta = 100 \wedge 001 = 76^\circ 4'$$

Following is a list of measurements with the calculated angles:

	Calculated.	Measured.	Calculated angle on $b, 010.$	Measured angle on $b, 010.$
$m \wedge m, 110 \wedge \bar{1}\bar{1}0 =$	$67^\circ 2'$	$66^\circ 57'$	$56^\circ 29'$	$56^\circ 29'^*$
$h \wedge h, 320 \wedge 320 =$	$47 \ 38$	----	$66 \ 11$	$65 \ 5$
$n \wedge n, 120 \wedge \bar{1}20 =$	$105 \ 54$	----	$37 \ 3$	$37 \ 12$
$l \wedge l, 130 \wedge \bar{1}30 =$	$126 \ 34$	----	$26 \ 43$	$26 \ 55$
$p \wedge p, 111 \wedge \bar{1}\bar{1}\bar{1} =$	$29 \ 8$	$29 \ 8^*$	$75 \ 26$	----
$q \wedge q, \bar{1}\bar{1}\bar{1} \wedge \bar{1}\bar{1}\bar{1} =$	$34 \ 52$	$34 \ 49$	$72 \ 34$	$72 \ 36$
$r \wedge r, \bar{3}31 \wedge \bar{3}31 =$	$63 \ 15$	$62 \ 56$	$58 \ 22\frac{1}{2}$	----
$s \wedge s, \bar{5}51 \wedge \bar{5}51 =$	$67 \ 43$	$67 \ 43$	$56 \ 8\frac{1}{2}$	$56 \ 20$
$t \wedge t, \bar{7}71 \wedge \bar{7}71 =$	$68 \ 32$	----	$55 \ 44$	----
$u \wedge u, \bar{5}31 \wedge \bar{5}31 =$	$43 \ 52$	$44 \ 6$	$68 \ 4$	$68 \ 0$
$x \wedge x, \bar{1}3\bar{1} \wedge \bar{1}3\bar{1} =$	$75 \ 52$	----	$52 \ 4$	$51 \ 56$
$y \wedge y, \bar{1}2\bar{1} \wedge \bar{1}2\bar{1} =$	$54 \ 56$	----	$62 \ 32$	----
$p \wedge e, 111 \wedge 101 =$	$14 \ 34$	$14 \ 36$		
$m \wedge p, 110 \wedge 111 =$	$51 \ 54$	$51 \ 54^*$		
$p \wedge q, 111 \wedge \bar{1}\bar{1}\bar{1} =$	$58 \ 37$	$58 \ 29$		
$q \wedge r, \bar{1}\bar{1}\bar{1} \wedge \bar{3}31 =$	$36 \ 21$	$36 \ 20$		
$r \wedge s, \bar{3}31 \wedge \bar{5}51 =$	$12 \ 45$	$12 \ 44$		
$s \wedge t, \bar{5}51 \wedge \bar{7}71 =$	$5 \ 50$	$5 \ 47$		
$y \wedge e_1, \bar{1}2\bar{1} \wedge \bar{1}0\bar{1} =$	$27 \ 28$	$27 \ 42$		
$b \wedge o, 010 \wedge \bar{1}31 =$	$46 \ 43$	$46 \ 43$		

The cleavage is perfect parallel to the pinacoid  $b, 010$ , but is not often observed. The hardness is 5.5 and the specific gravity 3.33. Many of the crystals are transparent, and the color varies from amethystine to nearly colorless or white.

The crystals exhibit very distinctly the phenomenon of pyroelectricity when tested with the red oxide of lead and sulphur method described by Kundt.\* On cooling a crystal of the type represented by figs. 1 and 2 the  $p$ ,  $e$ , and the upper extremities of the  $m$  faces in front became positively electrified and attracted the particles of sulphur, while the diagonally opposite faces  $x$ ,  $y$ ,  $p$ ,  $e$ , and the lower extremities of  $m$ , became negatively electrified and attracted the red oxide of lead.

A section parallel to the pinacoid 010 when examined in polarized light showed an extinction of about  $28^\circ$  from the vertical axis in the obtuse angle  $\beta$ , and this direction corresponds to  $b$ . The plane of the optical axes is at right angles to 010. The crystallographic axis  $b$  is the obtuse bisectrix, and corresponds to  $c$ . The double refraction is not very strong, and is negative.

Material for the chemical analysis was first carefully selected by hand picking, and was then further purified by pulverizing and separating by means of the barium mercuric iodide solution. That portion which was used for the analysis varied in specific gravity between 3.344 and 3.327.

The method of analysis was as follows: Water was determined as loss on ignition, and the residue, after fusion with sodium carbonate, was dissolved in hydrochloric acid. The solution was evaporated twice to separate the silica, and in the filtrate from the silica the acid was neutralized with a slight excess of ammonia, formic acid of specific gravity 1.12 was added so as to make about one-fourth of the final volume, and hydrogen sulphide was passed into the hot solution until the zinc was precipitated. After filtering, the zinc sulphide was dissolved in hydrochloric acid, and the zinc reprecipitated as carbonate and weighed as oxide. In the filtrate from the zinc the small quantities of iron and alumina were precipitated twice with ammonia. To the filtrates acidified with hydrochloric acid bromine was added, and on making alkaline and heating to boiling all of the manganese was precipitated, but as it carried a little calcium it was redissolved, precipitated from an acetic acid solution with bromine, and finally determined as pyrophosphate. Calcium and the trace of magnesium were separated and determined in the usual manner.

The results of the analysis by Foote are as follows:

\* Ann. d. Phys. u. Chem., xx, p. 592, 1883.

	I.	II.	Average.	Ratio.			Theory for H <sub>2</sub> CaZnSiO <sub>4</sub> .
SiO <sub>2</sub> .....	27·14	27·29	27·22		·454	0·97	27·92
ZnO .....	37·43	37·46	37·44	·462	} ·469	1·00	37·67
MnO .....	·49	·50	·50	·007			
CaO .....	26·31	26·19	26·25	·469	} ·471	1·00	26·04
MgO .....	·07	·08	·07	·002			
H <sub>2</sub> O .....	8·53	8·59	8·56	·476		1·01	8·37
(Fe. Al) <sub>2</sub> O <sub>3</sub> .....	·26	·31	·28				
			100·32				100·00

The ratio of SiO<sub>2</sub> : (Zn + Mn)O : (Ca + Mg)O : H<sub>2</sub>O is very nearly 1 : 1 : 1 : 1, from which the formula H<sub>2</sub>ZnCaSiO<sub>4</sub> is derived, in which the zinc and calcium are replaced to a slight extent by manganese and magnesium respectively. The formula may also be written (ZnOH)(CaOH)SiO<sub>4</sub>, and that hydroxyl is present is proved by the fact that water is not expelled much below a faint redness. The formula is analogous to that of calamine H<sub>2</sub>Zn<sub>2</sub>SiO<sub>4</sub> or (ZnOH)<sub>2</sub>SiO<sub>4</sub>.

The pyrognostic properties are as follows: In the closed tube at a gentle heat the mineral is unchanged, but at a temperature approaching faint redness it exfoliates, whitens and gives off water. Heated before the blowpipe the mineral exfoliates at first, and then fuses at about 4 to a yellowish enamel. A coating of zinc oxide is obtained when the mineral is heated alone or with a little sodium carbonate on charcoal. The powdered material dissolves readily in hydrochloric acid, and gelatinous silica is obtained when the solution is evaporated.

In conclusion we take great pleasure in expressing our sincere thanks to Messrs. F. L. Nason and E. P. Hancock, who have generously placed at our disposal all of the specimens of this rare mineral which they have been able to collect.

Mineralogical-Petrographical Laboratory,  
Sheffield Scientific School, March, 1898.