1. Contributions to Swedish Mineralogy.

by

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Part I.

1. On Axinite from Nordmarken[1]. Pl. I. Fig. 1—5.

The occurrence of axinite in the Nordmark mines has long been known, though the mineral was always scarce there, and crystals were exceedingly rare. Having recently received, through Mr. G. Flink, two very fine and interesting crystals from Nordmarken, I took occasion to examine also some older specimens from the same locality.

1. An old find of Axinite in Nordmarken 1812.

The axinite from Nordmarken was first mentioned by HISINGER in a paper: »Analys af ett grönaktigt prismatiskt kristalliseradt Fossil från Nordmarks grufvor»[2].

From the description of HISINGER I quote the following lines: »Detta fossil, som synes ega mycken gemenskap med Axinit, uppfants år 1812 af Hr STRÖM d. yngre. Kristallerna ligga inbäddade lösa i grå lera. Det fås i Grundsjö Grufvan vid Nordmarken i Wermland. Färgen är ljus grönaktig, som i tjockare skifvor sedda mot dagen faller i brunaktig. Förekommer endast kristalliserad. Kristallerna som äro små och af medelstorlek äro mycket platta, efter längden refflade prismer, merändels för ändan afbrutne, sällan med spets, som då består af två glatta ändytor med 135 och 153 gr. vinkel mot prisman. Den platta och oftast kullriga prismans sidor, göra vinklar af v. p. 37 och 148 gr., som likväl äro omöjliga att noga bestämma. Tunna kristaller äro genomskinliga, de tjockare genomlysande.»

The description further contains a mention of the physical and chemical properties of the mineral, its blowpipe characters, and HISINGER's analysis.

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[1] A preliminary note on this subject was already published by me in the Geolog. Föreningens i Stockholm Förhandl. Vol. 14. p. 249. 1892.

[2] Afhandlingar i Fysik, Kemi och Mineralogi Bd 4 s. 352. Sthlm 1815.

This first find of axinite in Nordmarken is represented in the Mineralogical Collection of the University of Upsala by a dozen fragments of crystals, most of which have a length of about 1 centimetre, and are a little more than a couple of millimetres in thickness. They correspond so closely to the description of Hisinger that nothing need be added. The original label contains, in an unknown handwriting, »Anthophyllith Nordmark 1812 STROEM. Finnes inuti en lös lera.»

Most of these fragments are broken at both ends; only a few show terminating planes in one direction. One of these, which was complete enough to be measured, is represented in fig. 5. It is 1,5 centimetre long by about 1 centimetre in breadth and deeply striated longitudinally. This striation is caused by a repetition of the planes *l* and *c*, which together form the convex surfaces of the flat, tabular crystals. The plane *u* of the same zone also occurs, but is not so well developed as the two others. The thin end of the crystal is partly formed by the planes *r*, *a*, and *s*, but is partly so rounded that no crystal plane could be determined. The list of planes of this crystal contains, therefore, the following seven, viz:

$c(001)\ \mathrm{oP}$[1]
$a(100)\ \infty\bar{\mathrm{P}}\infty$
$s(101)\ {}'\bar{\mathrm{P}}'\infty$
$Y(\bar{2}01)\ 2{}_{,}\bar{\mathrm{P}}_{,}\infty$
$u(111)\ \mathrm{P}'$
$r(1\bar{1}1)\ {}'\mathrm{P}$
$l(112)\ \frac{1}{2}\mathrm{P}'$

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[1] Here, as in the whole of this paper, the primary form proposed by SCHRAUF is adopted, as it seems to be the most convenient of the numerous proposals made by different authors. It is also accepted by HINTZE, among others, in his "Handbuch" Vol. 2. p. 487. According to this primary form the system of axes is

$$a : b : c = 1.14752 : 1 : 0.86256$$
$$\alpha = 97^0\ 2' \qquad \beta = 98^0\ 53\tfrac{1}{2}' \qquad \gamma = 102^0\ 45'$$
$$\mathrm{A} = 99^0\ 21\tfrac{1}{2}' \qquad \mathrm{B} = 100^0\ 49' \qquad \mathrm{C} = 104^0\ 9'$$

As here the *a*-axis is greater than the *b*-axis, we have, by using the symbols of Naumann, the anomaly that the planes which have the position of "brachydiagonal" forms are named "macrodiagonal", and vice versa. To avoid this, I adopt a proposal, recently made by Mr. A. HAMBERG (Geol. Fören. i Stockholm Förhandl. Vol. XIII p. 537), according to which, when using the symbols of Naumann in the rhombic, monoclinic and triclinic systems, no consideration should be paid to the relative lengths of the non-vertical axes, but only to their directions. I had special occasion long ago to become familiar with the difficulties of the method as now generally followed, when I examined the closely related minerals humite and chondrodite, to which an analogous crystallographical position must be given.

How easily confusion is caused by changing the order of the axes, might be shown by many examples. Here I may only note that even Hintze, in his list of planes of axinite, could not avoid it (l. c. p. 487). He writes for instance (100) $\infty\bar{\mathrm{P}}\infty$ and (010) $\infty\breve{\mathrm{P}}\infty$, but some lines later (011) ${}'\bar{\mathrm{P}},\infty$ and (101) ${}'\breve{\mathrm{P}}'\infty$, which is evidently not consistent.

Table of measurements.

	Measured.	Calculated.
$l(112) : c(001)$	28° 45′	28° 55′
$c(001) : u(111)$	44 56	44 29
$c(001) : r(1\bar{1}1)$	43 48 45 27	45 15
$l(112) : r(1\bar{1}1)$	55 15	55 $22\frac{1}{2}$
$l(112) : s(101)$	21 18	21 37

It is striking how much these crystals resemble those from Nordmarken which G. v. RATH described several years ago[1]. All the above mentioned planes, excepting *Y,* occur also in the crystals described by v. RATH. Also the »wurmförmige Vertiefungen» mentioned by v. RATH are to be noticed on the crystals of the first find in 1812. Yet v. RATH'S crystals, according to his figures, had not such a thin, tabular form as is characteristic of the older crystals, but were more prismatic.

v. RATH does not mention how he got these crystals, but it seems probable that they belonged to the collection of A. KRANTZ, which furnished him with such excellent crystals from Dauphiné and Cornwall. Crystals of the same kind that v. RATH described, do not occur in the Swedish collections, either in those of the Riksmuseum or of the University of Upsala, or in any private collection, so far as I know.

If we give these crystals the same position and primary form as used above, they show, according to v. RATH, the following planes, viz:

$a(100)$	$\infty \bar{P} \infty$
$c(001)$	oP
$m(1\bar{1}0)$	$\infty{}'P$
$g(2\bar{1}0)$	$\infty{}'\bar{P}2$
$f(3\bar{1}0)$	$\infty{}'\bar{P}3$
$s(101)$	$'\bar{P}'\infty$
$u(111)$	P'
$r(1\bar{1}1)$	$'P$
$l(112)$	$\frac{1}{2}P'$

The crystals are prismatic through the dominating of the planes $c(001)$ and $u(111)$, or tabular along $l(112)$. These three planes occur also in repetition. Among the terminating planes, $s(101)$ is best developed. The crystals, which reach a size of 3 centimetres, resemble, in colour and appearance, certain epidotes.

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[1] Ein Beitrag zur Kenntniss des Axinits, Poggend. Ann. Vol. CXXVIII. 1866, p. 251.

2. **Description of two recently found crystals of Axinite.**

These crystals, which came to me through Mr. FLINK, are quite unlike those above mentioned. As to their mode of occurrence he gave me the following information: »The crystals were enclosed in coarse crystalline calcite together with crystallized magnetite and clear, colourless diopside, also crystallized; they were isolated by dissolving the calcite in diluted hydrochloric acid, by which they were not at all affected.»

The crystals have a size of only about 3 millimetres, but show great brilliancy of surface as well as richness in forms, some of which are new to the mineral. The crystals are clear and transparent, and of a fine yellowish brown colour.

Especially remarkable in these crystals is their strange deviation from the common axinite type, as they have not the sharp edges which are generally characteristic of this mineral, but edges and corners truncated by several planes.

Crystal 1. Fig. 1 and 3. This crystal is fully developed on all sides, and does not show any point of attachment; though a front and back side may be distinguished, the former marked by more even and brilliant planes; on the backside a smaller crystal is attached to the main one in a parallel position; the crystal is thus properly a complex of two parallel individuals.

The list of planes in the complex is:

$a\,(100)\ \infty\,\bar{\mathrm{P}}\,\infty$
$b\,(010)\ \infty\,\check{\mathrm{P}}\,\infty$
$c\,(001)\ \ 0\mathrm{P}$
$M(110)\ \infty\,\mathrm{P}'$
$m\,(1\bar{1}0)\ \infty\,{}'\mathrm{P}$
$\mu\,(130)\ \infty\,\check{\mathrm{P}}'3$
$*R(350)\ \infty\,\check{\mathrm{P}}'\tfrac{5}{3}$
$*U(210)\ \infty\,\bar{\mathrm{P}}'2$
$n\,(0\bar{2}1)\ {}'\check{\mathrm{P}}'\infty$
$s\,(101)\ {}'\bar{\mathrm{P}}'\infty$
$x\,(201)\ 2'\bar{\mathrm{P}}'\infty$
$Y(\bar{2}01)\ 2'\bar{\mathrm{P}}'\infty$
$u\,(111)\ \mathrm{P}'$
$r\,(1\bar{1}1)\ {}'\mathrm{P}$
$w\,(11\bar{1})\ \mathrm{P}_{,}$
$e\,(1\bar{1}\bar{1})\ {}_{,}\mathrm{P}$
$l\,(112)\ \tfrac{1}{2}\,\mathrm{P}'$
$\pi\,(1\bar{1}2)\ \tfrac{1}{2}\,{}'\mathrm{P}$

*$\gamma\,(11\bar{2})\,\frac{1}{2}\,\mathrm{P}_{,}$
*$X(221)\,2\,'\mathrm{P}'$
$z\,(2\bar{2}1)\,2\,'\mathrm{P}$
*$Z\,(\bar{1}14)\,\frac{1}{4}\,'\mathrm{P}$
$\varrho\,(31\bar{3})\ \ \bar{\mathrm{P}}_{,}3$
*$\lambda\,(\bar{4}11)\,4\,'\bar{\mathrm{P}}4$
*$Q(6\bar{1}4)\,\frac{3}{2}\,'\bar{\mathrm{P}}6$

Thus no less than 25 forms are represented in this interesting crystal, and of them the seven marked in the list with an asterisk, are new to the mineral.

As shown in figure 1, which is a very true representation, the crystal is thickly tabular along the plane $r\,(1\bar{1}1)$. Among the other dominating forms the following may be mentioned:

$c\,(001)$, which forms a big plane at each end of the crystal;

$s\,(101)$, which occurs as a large quadrilateral plane on the front side, on the back as a smaller triangular one;

$x\,(201)$ which also forms a large face on the front, but on the back is much smaller and interrupted by an irregular excavation, partly determined by the plane $r\,(1\bar{1}1)$.

$M(110)$ forms on the front side a large regular plane, but occurs on the back as two smaller planes both in the main individual and in the small attached crystal.

$m\,(\bar{1}10)$ constitutes on the back in the right upper quadrant a large broad plane, but its parallel face $m\,(1\bar{1}0)$ in the opposite quadrant (front left lower) forms only a very insignificant narrow truncation of the edge between $z\,(2\bar{2}1)$ and $e\,(1\bar{1}\bar{1})$.

$l\,(112)$ is at the back a large plane, but in the front a very diminutive one.

The unequal development of most of the planes on the front- and back-sides makes the crystal very irregular, and an ideal figure would give no good representation of its real appearance.

Of the seven new forms the following may be mentioned:

1. $R\,(350)\,\infty\check{\mathrm{P}}'\,\frac{5}{3}$ is found only on the back side of the smaller crystal, attached to the main individual. It belongs to the zone of the vertical prisms, and is determined by the following measurement

		Measured.	Calculated.
$R\,(\bar{3}\bar{5}0)\ :\ M\,(\bar{1}\bar{1}0)$	=	10° 20′	10° 42′

2. $U\,(210)\,\infty\bar{\mathrm{P}}'2$ is located in the zone of the vertical prisms between $a\,(\bar{1}00)$ and $M\,(\bar{1}\bar{1}0)$. It only occurs on the back, but there as a large plane:

		Measured.	Calculated.
$a\,(\bar{1}00)\ :\ U\,(\bar{2}\bar{1}0)$	=	23° 45′	25° 55½′.

The difference from the calculated value is, thus, very great, but no other simple symbol is forthcoming. Also it must be noted that the differences between measured and calculated angles on the back of the crystal, are often considerable, and that there are several irregularities in the construction of the crystal.

3. $\gamma(11\bar{2})\,\frac{1}{2}\mathrm{P}_{,}$ occurs both above and below, but in both cases as a very small face. These faces are determined by their location in the two zones $\{c(001)\ u(111)\}$ and $\{Y(\bar{2}01)\ r(1\bar{1}1)\}$, and the following measurements will act as a control:

		Measured.	Calculated.
$\gamma(11\bar{2})$	: $Y(\bar{2}01)$ =	41° 45′	41° 47½′
	: $c(001)$ =	51 20	51 18½
	: $w(11\bar{1})$ =	24 7	24 6
	: $n(0\bar{2}1)$ =	41 0	41 1.

4. $X(221)\,2\,\mathrm{P}'$ is found only on the back, and is determined by its location in the zone $\{M(\bar{1}\bar{1}0)\ u(\bar{1}\bar{1}\bar{1})\}$ between the two faces $M(\bar{1}\bar{1}0)$ and $u(\bar{1}\bar{1}\bar{1})$, and by the measurements

		Measured.	Calculated.
$X(\bar{2}\bar{2}\bar{1})$	: $M(\bar{1}\bar{1}0)$ =	18° 54′	19° 8½′.

5. $Z(\bar{1}14)\,\frac{1}{4}{}_{,}\mathrm{P}'$ occurs as a narrow plane situated in the zone $\{c(001)\ m(1\bar{1}0)\}$, and is fully determined by the angles

		Measured.	Calculated.
$Z(\bar{1}14)$	: $c(001)$ =	14° 21′	14° 52′.

6. $\lambda(\bar{4}11)\,4\,{}_{,}\bar{\mathrm{P}}4$ is determined by the two zones $\{Y(\bar{2}01)\ z(2\bar{2}1)\}$ and $\{a(100)\ e(1\bar{1}\bar{1})\}$. As this plane is quite rough and lustreless, no measurements could be made, but the edges of conjunction are very distinct, so that there cannot be any doubt about the zones.

7. $Q(\bar{6}1\bar{4})\,\frac{3}{2}\,\bar{\mathrm{P}}6$ occurs only on the back of the crystal as a small triangular plane, truncating the corner between $r(1\bar{1}1)$ $s(101)$ and $x(201)$. The form is fully determined by the following measurements:

		Measured.	Calculated.
$Q(\bar{6}1\bar{4})$	: $r(\bar{1}1\bar{1})$ =	31° 5′	31° 8′
	: $s(\bar{1}0\bar{1})$ =	11 5	11 48.

It is remarkable that of these seven new planes four are represented only on the back of the crystal, which is thus richer in forms than the front side. Among the new planes $\gamma(11\bar{2})$ completes the pyramid with the general symbol $\frac{1}{2}{}'_{,}\mathrm{P}'_{,}$ of which hitherto only two viz: $l(112)\ \frac{1}{2}\mathrm{P}'$ and $\pi(1\bar{1}2)\ \frac{1}{2}{}'\mathrm{P}$ were known, and $X(221)$ in the same way completes the pyramid with the general symbol $2\,{}'_{,}\mathrm{P}'_{,}$ of which only $z(2\bar{2}1)\,2\,{}'\mathrm{P}$ was hitherto known.

Several planes show remarkable irregularities in respect of their evenness, and give two or more reflections, when measured with the goniometer. This is especially the case with $r\,(1\bar{1}1)$ on the front, which is divided into three fields, all of which give good reflections. The plane $c\,(001)$, though very even and brilliant, is distorted about a whole degree from the zone $\{r\,(1\bar{1}1)\;z\,(2\bar{2}1)\}$, and the whole zone $\{u\,(111)\;M\,(110)\}$ is much disturbed, as will be seen later by comparison of the measured with the calculated angles.

The angles measured on this crystal, arranged according to the dominating zones, are given in the following table; the calculated angles are mostly taken from the tables given by v. RATH and HINTZE.

	Measured.	Calculated.
Zone $\{r\,(1\bar{1}1)\;z\,(2\bar{2}1)\}$		
$\pi\,(1\bar{1}2) : r\,(1\bar{1}1) =$	18° 16′	
$r\,(1\bar{1}1) : c\,(001) =$	45 25	45° 15′
$c\,(001) : e\,(\bar{1}11) =$	44 51	45 19
$e\,(\bar{1}11) : m\,(\bar{1}10) =$	44 50	44 36½′
$m\,(\bar{1}10) : z\,(\bar{2}2\bar{1}) =$	26 27	26 20
$z\,(\bar{2}2\bar{1}) : r\,(\bar{1}1\bar{1}) =$	18 20	18 21
$r\,(\bar{1}1\bar{1}) : \pi\,(\bar{1}1\bar{2}) =$	18 33	
$r\,(\bar{1}1\bar{1}) : c\,(00\bar{1}) =$	45 24	45 15
$c\,(00\bar{1}) : e\,(1\bar{1}\bar{1}) =$	45 23	45 19
$c\,(00\bar{1}) : Z\,(1\bar{1}\bar{4}) =$	14 21	14 52
$e\,(1\bar{1}\bar{1}) : m\,(1\bar{1}0) =$	44 37	44 36½′
$m\,(1\bar{1}0) : z\,(2\bar{2}1) =$	26 16	26 20
$z\,(2\bar{2}1) : r\,(1\bar{1}1) =$	18 27	18 21
Zone $\{M\,(110)\;u\,(111)\}$		
$M\,(110) : u\,(111) =$	33° 33′	32° 47′
$u\,(111) : l\,(112) =$	15 31	15 34
$l\,(112) : c\,(001) =$	28 17	28 55
$c\,(001) : w\,(\bar{1}\bar{1}1) =$	60 10	60 29
$w\,(\bar{1}\bar{1}1) : M\,(\bar{1}\bar{1}0) =$	42 45	42 15½′
$M\,(\bar{1}\bar{1}0) : X\,(\bar{2}\bar{2}\bar{1}) =$	19 4	19 8½′
$X\,(\bar{2}\bar{2}\bar{1}) : u\,(\bar{1}\bar{1}\bar{1}) =$	13 40	13 38½′
$u\,(\bar{1}\bar{1}\bar{1}) : l\,(\bar{1}\bar{1}\bar{2}) =$	15 38	15 34
$l\,(\bar{1}\bar{1}\bar{2}) : c\,(00\bar{1}) =$	27 34	28 55
$c\,(00\bar{1}) : \gamma\,(11\bar{2}) =$	37 40	
$\gamma\,(11\bar{2}) : w\,(11\bar{1}) =$	24 14	
$w\,(11\bar{1}) : M\,(110) =$	41 54	42 15½′

		Measured.	Calculated.
Zone {*M* (110) *x* (201)}			
M(110) : *x* (201)	=	45° 59′	45° 53′
x (201) : *r* $(1\bar{1}1)$	=	40 49	40 46½′
r $(1\bar{1}1)$: *n* $(0\bar{2}1)$	=	43 53	43 47
n $(0\bar{2}1)$: *M* $(\bar{1}\bar{1}0)$	=	49 17	49 32
M $(\bar{1}\bar{1}0)$: *x* $(\bar{2}0\bar{1})$	=	45 54	45 53
x $(\bar{2}0\bar{1})$: *r* $(\bar{1}1\bar{1})$	=	40 46	40 46½′
r $(\bar{1}1\bar{1})$: *n* $(02\bar{1})$	=	43 52	43 47
n $(02\bar{1})$: *M* (110)	=	49 30	49 32
Zone {*u* (111) *s* (101)}			
r $(1\bar{1}1)$: *s* (101)	=	36° 33′	36° 25′
s (101) : *u* (111)	=	27 58	27 57
u (111) : *b* (010)	=	47 15	47 14
b (010) : *r* $(1\bar{1}1)$	=	68 30	68 24
Zone {*s* (101) *c* (001)}			
c (001) : *s* (101)	=	33° 10′	33° 18′
s (101) : *x* (201)	=	16 7	16 7
x (201) : *a* (100)	=	29 48	29 47
a (100) : *Y* $(\bar{2}01)$	=	36 16	36 12
Y $(\bar{2}01)$: *c* (001)	=	65 28	64 36
Zone {*a* (100) *M* (110)}			
a $(\bar{1}00)$: *U* $(\bar{2}\bar{1}0)$	=	23° 45′	25° 55½′
M $(\bar{1}\bar{1}0)$: *R* $(\bar{3}\bar{5}0)$	=	10 20	10 42
M $(\bar{1}\bar{1}0)$: *μ* $(\bar{1}\bar{3}0)$	=	20 17	20 11½′

Crystal 2. Fig. 2, 4. This crystal is also composed of two individuals in a parallel position. The front side is easily distinguished from the back by the greater lustre and evenness of the faces. Here also the secondary crystal is attached to the back [1]).

On this crystal the following faces are represented:

a (100) ∞ P̄ ∞
b (010) ∞ P̆ ∞
c (001) 0 P
M(110) ∞ P′
m $(1\bar{1}0)$ ∞ ′P

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[1]) In order to give both the figures 1 and 2 the same position, according to SCHRAUF's, system of axes it was necessary to give crystal 2, represented by fig. 2, such a position, that the back — i. e. the side with less brilliant faces — was placed foremost.

$n\ (0\bar{2}1)\ {}'\check{\mathrm{P}}_{,}\infty$
$s\ (101)\ {}'\bar{\mathrm{P}}'\infty$
$x\ (201)\ 2'\bar{\mathrm{P}}'\infty$
$Y(\bar{2}01)\ 2_{,}\bar{\mathrm{P}}_{,}\infty$
$u\ (111)\ \mathrm{P}'$
$r\ (1\bar{1}1)\ {}'\mathrm{P}$
$w\ (11\bar{1})\ \mathrm{P}_{,}$
$l\ (112)\ \frac{1}{2}\mathrm{P}'$
$\pi\ (1\bar{1}2)\ \frac{1}{2}'\mathrm{P}$
$*\gamma\ (11\bar{2})\ \frac{1}{2}\mathrm{P}_{,}$
$*X(221)\ 2\mathrm{P}'$
$z\ (2\bar{2}1)\ 2'\mathrm{P}$
$\varrho\ (31\bar{3})\ \bar{\mathrm{P}}_{,}3$
$*\lambda\ (\bar{4}11)\ 4_{,}\bar{\mathrm{P}}4$

All these 19 forms are the same as those occurring in crystal 1. Among the new faces found on crystal 1, the three marked by asterisks were also found on crystal 2, viz:

$\gamma\ (11\bar{2})\ \frac{1}{2}\mathrm{P}_{,}$ which constitutes a narrow, but brilliant face at each end of the crystal;

$X(221)\ 2\mathrm{P}'$ forms the largest plane at the back of the crystal, where it occurs three times, alternating with $M(110)$, $u(111)$, and $l(112)$;

$\lambda\ (\bar{4}11)\ 4_{,}\bar{\mathrm{P}}4$ appears only as a small face on the back side of the crystal.

As is shown in the figures, this crystal has quite a different habit from that of the first. Crystal 1 is thickly tabular along $r(1\bar{1}1)$, and the faces in the zone $\{r(1\bar{1}1)\ c(001)\}$ are generally the best developed: the zone $\{M(110)\ c(001)\}$, on the contrary, is characteristic of the development and habit of crystal 2. This crystal is further remarkable for the great development of the face $\pi\ (1\bar{1}2)$ at the back and $Y(\bar{2}01)$ at the front.

The secondary, attached crystal has also, on the whole, the same habit, being tabular along $M(110)$ and showing the faces of the zone $\{M(110)\ c(001)\}$ best developed.

In this crystal, too, the measurements show certain irregularities, such as double reflections in several faces, or considerable divergences from the parallel position, or from the zones. For instance, the planes $c(001)$, $l(112)$ and $u(111)$ are each divided into two fields parallel to the zone-axis. The fields of $c(001)$ make an angle of 0° 39′, those of $l(112)$ are separated 1° 10′, and those of $u(111)$ 1° 14′ from one another. Most of the faces are, however, very even and brilliant, and allow of very exact measurements.

		Measured.	Calculated.
Zone $\{r\,(1\bar{1}1)\ x\,(201)\}$			
$r\ (\bar{1}1\bar{1}) : x\ (\bar{2}0\bar{1})$	=	40° 42′ — 52′	40° 46½′
$x\ (\bar{2}0\bar{1}) : M(\bar{1}\bar{1}0)$	=	45 58	45 53
$M(\bar{1}\bar{1}0) : n\ (0\bar{2}1)$	=	49 25	49 32
$n\ (0\bar{2}1) : r\ (1\bar{1}1)$	=	43 46	43 47
$r\ (1\bar{1}1) : x\ (201)$	=	41 56	40 46½′
Zone $\{r\,(\bar{1}1\bar{1})\ u\,(\bar{1}\bar{1}\bar{1})\}$			
$r\ (\bar{1}1\bar{1}) : u\ (\bar{1}\bar{1}\bar{1})$	=	63° 51′ — 64° 37′	62° 22′
$u\ (\bar{1}\bar{1}\bar{1}) : b\ (0\bar{1}0)$	=	47 4 — 50	47 14
$b\ (0\bar{1}0) : r\ (1\bar{1}1)$	=	68 13	68 24
$r\ (1\bar{1}1) : s\ (101)$	=	36 47	36 25
Zone $\{r\,(1\bar{1}1)\ \pi\,(1\bar{1}2)\}$			
$r\ (\bar{1}1\bar{1}) : \pi\ (\bar{1}1\bar{2})$	=	18° 9′ — 49′	
$r\ (\bar{1}1\bar{1}) : c\ (00\bar{1})$	=	44 59 — 45 39	45° 15′
$r\ (1\bar{1}1) : \pi\ (1\bar{1}2)$	=	18 53	
$\pi\ (1\bar{1}2) : c\ (001)$	=	26 56	
$c\ (001) : m\ (\bar{1}10)$	=	89 52	89 55½′
$m\ (\bar{1}10) : r\ (\bar{1}1\bar{1})$	=	44 24	44 41
Zone $\{M\,(110)\ l\,(112)\}$			
$l\ (\bar{1}\bar{1}\bar{2}) : u\ (\bar{1}\bar{1}\bar{1})$	=	15° 6′ — 16° 6′	15° 34′
$u\ (\bar{1}\bar{1}\bar{1}) : M(\bar{1}\bar{1}0)$	=	32 55 — 33 55	32 43
$M(\bar{1}\bar{1}0) : w\ (\bar{1}\bar{1}1)$	=	42 1	42 15½′
$w\ (\bar{1}\bar{1}1) : \gamma\ (\bar{1}\bar{1}2)$	=	24 9	
$\gamma\ (\bar{1}\bar{1}2) : c\ (001)$	=	36 14 — 37 11	
$c\ (001) : l\ (112)$	=	27 47 — 28 44	28 55
$l\ (112) : w\ (11\bar{1})$	=	90 59	90 36½′
$w\ (11\bar{1}) : c\ (00\bar{1})$	=	60 32	60 29
$c\ (00\bar{1}) : l\ (\bar{1}\bar{1}\bar{2})$	=	29 8	28 55

A comparison with axinite from other localities shows that these crystals do not in their habit resemble any of the former. They mostly differ from the old, well-known finds of Bourg d'Oisans (Dauphiné) and from the nearly related crystals of the Alps (Piz Valatscha, Baveno etc.). The Nordmark axinite rather resembles the crystals of Botallak in Cornwall and Poloma in Hungary. The paragenetic conditions here also show some similarity, especially as the mineral, in all these localities, occurs in, or together with crystalline amphibole rocks.

The finds of crystallized axinite in the Nordmark mines thus belong to three different types, viz:

I. The tabular crystals first described by HISINGER, with the zone $\{l\,(112)\ c\,(001)\}$ predominating.

II. The nearly related type described by v. RATH, prismatic along the zone $\{c\,(001)\ u\,(111)\}$.

III. Smaller crystals not decidedly tabular or prismatic, and very rich in faces.

2. Crystallized Hedyphane from the Harstig Mine.[1] Pl. I, Fig. 6—9.

The species hedyphane, introduced by Breithaupt in 1851, is known to stand nearest to mimetite, and may be considered as a Ca- and sometimes a Ba-bearing variety of this mineral. Chemically it corresponds perfectly to the minerals of the apatite-group, which are all hexagonal. Whether the crystallographical form of hedyphane also agrees with this group, has not hitherto been ascertained, as it very seldom occurs in crystals.

The only investigations regarding the crystallographical form, to be found in literature, were made by DES CLOIZEAUX, who twice examined it. In his first note[2] he places hedyphane among uniaxial crystals, and states that its optical properties correspond with those of mimetite. »Le véritable hédyphane, en masses clivables, blanchâtres, à éclat adamantin dans la cassure, qui accompagne la rhodonite et la Schefférite de Långbanshytta en Suède, contient une notable proportion d'arséniate et de phosphate de chaux. Ses caractères optiques sont d'ailleurs les mêmes que ceux des cristaux de mimetèse, et à travers des lames minces parallèles au clivage basique on observe, malgré leur faible transparence, une croix noire peu ou point disloquée et une double réfraction *négative* peu énergique.»

In a later paper[3] DES CLOIZEAUX changed this statement in the following manner, and I quote it here at length, as, later on, I shall have occasion to come back to it.

»J'ai annoncé autrefois que l'hédyphane de Longban offrait, à travers une lame parallèle au clivage basique, une croix noire se disloquant très peu et une double réfraction *négative* peu énergique. J'avais opéré alors sur une petite lame très mince, faiblement transparente, avec le grand microscope d'AMICI, et les phénomènes observés ne présentaient pas une grande netteté. Ayant soumis dernièrement mon ancienne lame au microscope de M. BERTRAND, j'y ai vu une croix noire beaucoup plus prononcée qu'avec l'appareil d'AMICI et une compensation *positive* incontestable.

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[1] A preliminary note on this subject was already published by me in Geolog. Fören. i Stockholm Förhandl. Vol. 14, p. 250, 1892.

[2] Nouvelles recherches sur les propriétés optiques des cristaux. Mémoires présentés par divers savants à l'Institut, tome XVIII, année 1867, page 13.

[3] Bulletin de la société minéralogique de France. Tome IV, p. 93. 1881.

En présence de ces nouveaux résultats, j'ai repris l'examen d'un échantillon d'hédyphane paraissant offrir deux clivages, l'un à surface large, assez unie, un peu terne (correspondant selon toute probabilité à ce que j'avais regardé autrefois comme la base d'un prisme hexagonal), l'autre à surface interrompue, d'un éclat adamantin, faisant avec le premier un angle d'environ 84°. L'essai de plus de 26 lamelles minces, parallèles ou perpendiculaires à chacun de ces clivages, a toujours conduit à des anneaux plus ou moins complètement excentrés; je ne suis parvenu à les redresser convenablement qu'à l'aide de plaques, taillées sur l'arête obtuse d'environ 96° qui sépare les deaux clivages, et s'inclinant de 150° à 155° sur le clivage à large surface. En tournant la plaque dans son plan, la croix se disloque plus ou moins, mais toujours d'une très faible quantité, et on ne peut apercevoir de dispersion d'aucun genre. Il est vrai que, vu la faible transparence du minéral, les plaques doivent être excessivement minces.

Les caractères optiques conduisent donc à regarder l'hédyphane comme appartenant au système clinorhombique et paraissent établir son isomorphisme avec la Karyinite (RO^3, $As^2 O^5$), dont j'ai parlé dans le dernier numéro de notre Bulletin.»

DES CLOIZEAUX' later statement has been adopted in the ordinary mineralogical manuals, as the following extracts show.

J. D. DANA'S »System» (6th edition 1892) takes hedyphane as a member of the apatite group and says: »Massive, perhaps monoclinic. Two cleavages at 84°. Hedyphane has ordinarily been included as a calcium variety of mimetite, to which it seems to correspond in composition, but if monoclinic, as suggested by DES CLOIZEAUX, it must stand independently. It needs further investigation.»

TSCHERMAK, Lehrbuch d. Mineralogie, I^{st} edition 1884, places hedyphane under mimetite and says: »Mit dem Mimetesit verwandt ist der Achrematit und der monokline Hedyphan.»

NAUMANN-ZIRKEL, Elemente d. Mineralogie, 12 edition 1883, s. 552, says: »Der ebenfalls von BREITHAUPT eingeführte Hedyphan, welchen DES CLOIZEAUX 1881 aus optishen Gründen für monoklin (vermutlich isomorph mit Karyinit) erklärte, schliesst sich chemisch an den Mimetesit an — — — —; er bildet kleine derbe Massen, deren Individuen nach Des Cloizeaux zwei einander under 96° kreuzende Spaltungsrichtungen aufweisen, sonst muschlig brechen.»

GROTH, Tabellarische Üebersicht d. Mineralien, 3 edition 1889, p. 75, refers hedyphane to the group of apatite and vandinite with the following remark: »Hedyphan hat die Zusammensetzung eines Mimetesit, in welchem ein Theil des Bleis durch Ca oder durch Ca und Ba ersezt ist; nach seinen optischen Eigenschaften scheint das Mineral jedoch dem monosymmetrischen Krystallsystem anzugehören. Optische Zweiaxigkeit wird allerdings auch bei reinem Mimetesit angegeben. Entweder liegt also hier eine Dimorphie der Substanzen dieser Gruppe vor, oder die Zusammensetzung des Hedyphan ist eine andere, vielleicht der des Karyinit analoge.»

Not long ago I received, from Mr G. FLINK, some crystals of hedyphane from the mine of Harstigen in Wermland, which proved suitable for measurement and for ascertaining whether the hedyphane also agreed crystallographically with the apatite group.

The crystallized hedyphane occurs in fissures, filled with calcite, which traverse massive magnetite, massive grey tephroite and manganophyllite. Besides hedyphane one finds in the fissures crystals of grey tephroite, a centimetre in length also imbedded in calcite. With regard to their relative ages the minerals of these fissures evidently stand in the following order:

1. Tephroite,
2. Hedyphane,
3. Calcite.

The hedyphane crystals are a centimetre at most in length, of a yellowish white colour with resinous lustre; it has only been possible to detach fragments of these crystals from the enclosing calcite. These fragments exhibit numerous faces, which nevertheless, owing to their unevenness and feeble lustre, are little suitable for exact measurements. But partly from measurements and partly by the help of the zones I have succeeded in determining a number of forms. The crystals prove to belong to the hexagonal system, with apparently holohedral development. They seem to be partly altered or decomposed, as shown in thin sections, and thus appear cloudy and impure, owing to interpositions.

All these crystals have a flat lenticular shape, being shortened or contracted in the direction of the chief axis. It is worthy of note that they are always implanted on the massive magnetite and tephroite, so that the chief axis lies parallel to the plane of implantation. For this reason, the crystals are only half developed and have a semilenticular form. I here give some details as to the three fragments specially examined.

Crystal 1. (Pl. I. Fig. 8) Is the largest of the three fragments and about a centimetre in length. The forms are as follows:

$$c = \mathrm{oP},\ r = \tfrac{1}{2}\mathrm{P},\ x = \mathrm{P},\ y = 2\mathrm{P},\ m = \infty\mathrm{P},\ s = 2\mathrm{P}2.$$ [1]

The basal plane $c = (0001)$ is in this crystal, as in the others, one of the largest faces; it shows a more vivid lustre than the other faces, but gives so many reflections as to be quite unfit for measurements. The fundamental pyramid $x = (10\bar{1}1)$ is the best developed form; the other pyramids, as well as the prism $m = (10\bar{1}0)$, only occur as narrow truncations.

Crystal 2. (Pl. I. Fig. 7) Is also a fragment, smaller than the preceding and about 6 mm. in its greatest extension. The forms occurring in it are as follows:

$$c = \mathrm{oP},\ m = \infty\mathrm{P},\ x = \mathrm{P},\ y = 2\mathrm{P},\ r = \tfrac{1}{2}\mathrm{P},\ v = \mathrm{P}2,\ s = 2\mathrm{P}2.$$

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[1] The letters are the same as for the corresponding planes in apatite, mimetite etc.

The character of the faces is the same as in the first crystal; here also the faces $x = P$ are best developed, next to them $s = (11\bar{2}1)$ and $c = (0001)$.

Crystal 3. (Pl. I. Fig. 6) Is of about the same size as the second, and exhibits the following forms:

$$c = 0P,\ r = \tfrac{1}{2}P,\ x = P,\ y = 2P,\ v = P2,\ s = 2P2.$$

In shape this crystal differs a little from the former, as will be seen in the figures.

The exactly determined forms in these crystals are therefore as follows:

$$c = (0001)\ 0P,\ m = (10\bar{1}0) \infty P,\ x = (10\bar{1}1)\ P,\ y = (20\bar{2}1)\ 2P,$$

$$r = (10\bar{1}2)\ \tfrac{1}{2}P,\ v = (11\bar{2}2)\ P2,\ s = (11\bar{2}1)\ 2P2.$$

The fig. 9, Pl. I, is an ideal representation of a hedyphane crystal, with all these faces developed.

Not exactly determined are $\alpha = (30\bar{3}2)\ \tfrac{3}{2}P$ (in Crystal 1) and $g = (70\bar{7}4)\ \tfrac{7}{4}P$ (in Crystal 3).

On comparing these forms with those determined in mimetite[1], we find that the following have not been observed in mimetite, viz:

$$r = \tfrac{1}{2}P,\ v = P2$$

while the following forms are found in mimetite, but do not occur in hedyphane, viz:

$$b = \infty P2,\ h = \infty P\tfrac{3}{2},\ \pi = 4P,\ m = 3P\tfrac{3}{2},$$

The forms of hedyphane are thus rather different from those of mimetite.

Though, as has already been mentioned above, the crystals are little suitable for exact measurements, some of those obtained are, nevertheless, given below. They show great irregularities, and even if the angular measurements are not very exact, the considerable differences shown between the different crystals, as well as when compared with the theoretic values, cannot be attributed to the unavoidable inaccuracy in measurement, but to the great irregularities in the crystals themselves.

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[1] Goldschmidt: Index d. Krystallformen Bd. II, p. 397.

Table of angles.

	1.	2.	3.	Calculated			
				Hedyphane	Differ.	Mimetite	Differ.
x : *x*	101° 14′	102° 13′	102°	101° 36′	0′	99° 56′	+ 1° 40′
	100 12	102 19	—	101 36		99 56	
r : *r*	134 5	—	—	135 38	—1° 33	134 26	— 21
α : *α*	78 28	—	—	78 32	— 4	76 52	+1 36
r : *x*	17 38	17 5	—	17 1	+ 19	17 15	+ 5
	—	17 18	—	17 1		17 15	
y : *y*	62 46	—	—	63 1	— 15	61 46	+1
s : *x*	26 17	26 33	26 26′	26 33	— 8	26 46	— 21
v : *s*	—	19 2	18 52	19 18	— 21	19 28	— 31
v : *x*	—	17 57	18 54	18 25	+ ½	18 48	— 22½
x : *y*	19 29	19 26	20 27	19 17½	+ 11½	19 12	+ 17
	18 34	—	—	19 17½		19 12	
x : *g*	—	—	15 17	15 47	— 30	15 44	— 27
a : *g*	—	—	34 38	35 1	— 23	34 14	+ 24
a : *x*	—	—	49 55	50 48	— 53	49 58	— 3
					Meandifference. —12.7		Meandifference. +21.6

The differences in the observed angles are thus very great and sometimes reach one degree or more. The measurements, nevertheless, allow of some conclusions with regard to the dimensions of the fundamental form, and it is obvious that this cannot be brought into full conformity with that adopted in the case of mimetite. The measurement of the angle at the middle edge of the fundamental form varies from 100° 12′ to 102° 19′, and is, on an average of five measurements, 101° 36′. The corresponding angle in mimetite is 99° 56′, being thus nearly 2° smaller, and lying entirely outside the limits of the angles observed in hedyphane. On calculating the fundamental form and the other angles of the mineral from the above mentioned average value, one finds that they agree much better with the observed angles, than is the case with the angles calculated from the fundamental form of mimetite. To prove this, it will be sufficient to refer to the above table, where the angles calculated from the fundamental form of mimetite, as well as those derived from the fundamental form of hedyphane, are indicated.

The mean difference between the measured angles and the values calculated from the system of axes of hedyphane is — 12.7′, while, in the angles of mimetite the corresponding difference is $+21.6'$, which shows the better correspondence of the new system of axes.

The chief axis, derived from the above average value 101° 36' of the middle edge of the fundamental pyramid, is

$$c = 0.7063,$$

to which corresponds in mimetite (acc. to DANA)

$$c = 0.7276.$$

The optical examination of hedyphane sustains the result of the crystallographical examination, as regards the system. From crystal 1 two sections were sawn, one parallel, and the other perpendicular, to the basal plane. In parallel polarized light the former showed extinction in all positions when revolved; the section perpendicular to the basal plane showed extinction parallel and perpendicular to the trace of the basal plane. In convergent light it was impossible to obtain any axial image, the plate being so full of interpositions and products of decomposition, that the image was entirely obscured.

How the results here mentioned are to be reconciled with those obtained by DES CLOIZEAUX, is difficult to say. However, I may be allowed to attempt an explanation. DES CLOIZEAUX speaks of two cleavages as making an angle of about 84 and 96° with one another. As the most distinct cleavages in hedyphane are those parallel to the fundamental pyramid, one may almost take it for certain that it must be those which DES CLOIZEAUX refers to, though, on account of their indistinctness, he regarded them as not being of the same value, and determined their inclination to about 96° instead of 101° 36'. A section cut after a plane symmetrically truncating the obtuse angle between the two cleavages, will thus show an axial image, such as that described by DES CLOIZEAUX. That the mineral is really uniaxial, is indicated by the fact that DES CLOIZEAUX — who had purer and more transparent material at his disposal — found that the cross, in revolving, opens very little[1]. This suggests that the mineral exhibits the same optical anomalies as those found in its relations, apatite, pyromorphite etc.

3. Humite, 4. Chondrodite and 5. Clinohumite from Nordmarken.[2]

In the summer of 1891 minerals of the humite group, hitherto not met with in this locality, were abundantly found in the Ko-mine in Nord-

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[1] En tournant la plaque dans son plan, la croix se disloque plus ou moins, mais toujours d'une très faible quantité.

[2] A first preliminary communication on the occurrence of these minerals in the Nordmark mines was given by me at the meeting of the Geol. Society of Stockholm on Nov. 5 1891, and in a later note I added some remarks on the crystallography of the same minerals. Geolog. Fören. i Stockholm Förhandl. Vol. 14, p. 423. 1892.

marken. In older times Hausmann[1] mentioned the occurrence of crystallized chondrodite in the neighbouring mines of Taberg, but of this occurrence nothing more was known[2].

The preliminary examination showed that all the three minerals of the humite-group, humite, chondrodite and clinohumite were present, a case of great interest, which is only paralleled in the volcanic blocks of Vesuvius and in the Tilly Foster Iron Mine N. Y.

The minerals occur in the iron-ore, at a depth of about 250 m., in the part of the mine which is named the »Bjelkes stopes». The associated minerals are: magnetite often crystallized; light green or grass-green transparent crystallized tremolite in prisms with terminations, ripidolite also crystallized, massive calcite and dolomite. Serpentine, generated through the alteration of the humite-minerals and of tremolite, is also abundant. Yellow sphalerite and massive or crystallized löllingite occur too, but rarely.

All the humite-minerals at Nordmarken show a great tendency to alter to an ashgrey serpentine of resinous lustre, which in the microscope appears to consist of a felted mass of fine anisotropic fibres. In spite of this alteration, the crystals keep their lustre, so that even those which are fully changed into serpentine are suitable for measurement, only a slight rounding of the edges accompanying the alteration. The process can go still further, so that the crystals are completely changed into dolomitic calcite[3].

The associated minerals also change; I have already mentioned above that the tremolite is subject to a similar alteration, the result ot which is also serpentine. Often too the dolomite passes into an amorphous mass of serpentine. In one and the same specimen one may thus observe serpentine, partly generated through the alteration of the humite minerals, partly from tremolite, and also from dolomite. These three kinds of serpentine are easily recognized from each other, even if the crystal forms are not preserved, through their different structure, as visible in thin sections.

On the whole, the association and occurrence of these minerals remind one of the Tilly Foster Iron Mine N. Y. When the author, in the summer of 1891, had the opportunity of visiting this interesting place, he was surprised by the striking resemblance to Nordmarken and its minerals, whose paragenesis had for a long time been a subject of study with him. The ore is, in both places, magnetite, with amphibole and pyroxene as gangue; generally the silicates of magnesia are abundantly represented. As examples of characteristic resemblance may be mentioned the occurrence

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[1] Skandinavische Reise 1818, Vol. 5, p. 355.

[2] Quite lately, in the autumn of 1892, chondrodite has been found in the Taberg mine this time massive and uncrystallized in dolomite.

[3] The same pseudomorph has also been observed by J. D. Dana in the Tilly Foster Iron Mine. American Journal Vol. 8, p. 371, 1874.

of crystallized magnetite in similar forms and of the same appearance; calcite in the same forms; yellow sphene and clear, colourless apatite. Not only these primary minerals, but even their products of alteration are the same, for instance the characteristic change of the tops of the tremolite crystals into asbestos, the generation of mountain cork, serpentine etc. This remarkable resemblance in the mineral association is made still greater by the occurrence of the minerals of the humite group and their products of alteration at Nordmarken.

The resemblance, in respect of association, to the humite from the Ladu-mine in Wermland, described by me ten years ago, is evident. There also the mineral occurs in a bed of iron ore, together with magnetite, calcite and serpentine; in the Ladu-mine, too, the latter mineral is a result of the decomposition of the humite.

The minerals of the humite group at Nordmarken occur in the magnetite either massive or crystallized in fissures, which are afterwards filled up with dolomitic calcite. The three minerals generally occur crystallized in individuals, which vary from one mm to three cm.

Among the three minerals at Nordmarken the chondrodite is the commonest, while humite and clinohumite are comparatively rare. They all occur together, and are sometimes so like each other that they are only to be distinguished by measurement. In most cases, however, after some practice, one can easily distinguish them by their different habit.

When two of them occur together in the same specimen, it may be seen that one of the minerals belongs to a more recent generation than the other. Such is the case with the humite and chondrodite, as the humite occurs im small crystals implanted on the larger of chondrodite. This is of particular interest, because it may perhaps support the hypothesis, that the variation in the crystalline forms of these minerals is due to the varying exterior circumstances in which identical or nearly identical substances have crystallized.

I shall have occasion to come back to this point in a future account of the chemical investigation of these minerals.

It was not difficult, from the very rich material which I had at my disposal, to pick out crystals well suited for good and sharp measurements. A great part of this I secured in person during several visits to Nordmarken in the years 1891 and 92. A valuable material of all the three minerals I also bought from Mr Flink, consisting of more than 50 specimens and about 30 loose crystals for measurements. Further, some specimens from the collections of the Riksmuseum in Stockholm (Royal State Museum) and Stockholms Högskola were placed at my disposal, among others an excellent crystal of chondrodite (N:o 13 in the table of measurement, figured as N:o 10 Pl. III) belonging to the collection of the Riksmuseum.

With regard to their geometrical development, the minerals show such an abundance of forms and types, that the Nordmark specimens are, in this respect, not inferior to those hitherto known from Vesuvius and Tilly Foster, with all their richness of form.

In order to give the corresponding forms of these closely related minerals, analogous designations, though the minerals crystallize in different systems, I have also here adopted the method proposed by Mr A. HAMBERG, which I have already used in the description of axinite. Of the horizontal axes the longer is taken as the *a*-axis, and thus the first figures in the symbols of MILLER refer to this axis, as also do the signs which stand after $\breve{P}$ in the symbols of NAUMANN. The second figure in the symbol of MILLER, as also the figure after $\bar{P}$ of NAUMANN, refers to the *b*-axis.

The figures on Plates II, III and IV are all drawn, independently of the crystallographical designation in the text, with *C* in the front, a method which I have already used in my description of the chondrodite from Kafveltorp[1], and which is in full accordance with the proposal of E. S. DANA[2].

3. **Humite.** Plate II, fig. 1—10.

On Plate II a number of humite crystals are represented, figs. 1, 2, 3, 5, 7, 8, 9 and 10 being drawn from nature, while figs. 4 and 6 are idealized. The crystals vary from one mm to a few cm in length; among those reproduced and measured N:o 3 is only 2 mm, N:o 2 is 4 mm, N:o 4 also about 4 mm, while N:o 6 is 1 cm and N:o 1, though only fragmentary, is nearly 2 cm.

The smaller crystals are generally fresher and less altered than the larger; they are in fresh condition honey-yellow to resin-brown and translucent; such, for instance, are crystals 2, 3, 7 and 8. The larger crystals, as well as some of the smaller, are generally more or less altered. The colour is then yellowish grey on the surface and darker in the interior; often irregular coloured zones, partly parallel with A (001), i. e. with the cleavages, are to be observed. This change of colour is evidently due to decomposition following irregular cracks. Such for instance is the large fragment N:o 1 as well as crystal 5. Sometimes the altered zones have a spotted appearance, as is the case with N:o 6. Also crystals of a dark brown or nearly black colour occur, as for instance N:os 9 and 10. The two latter seem, in spite of their dark colour, to be quite fresh and undecomposed; most of the faces are brilliant, and thin sections of such crystals are clear and transparent.

The fresh crystals are generally brilliant and the faces give good

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[1] Groths Zeitschrift, Vol. VII, pag. 113, 1883.

[2] E. S. DANA Chondrodite from the Tilly Foster Iron Mine. Transact. of the Conn. Acad. Vol. III, p. 76. 1876.

reflections; also in the altered crystals the faces have kept their lustre, and are quite suitable for measurement.

Fundamental Form. As the fundamental form I have chosen the pyramid *n*, with the length of axes determined by SCACCHI for the humite from Vesuvius. It will be seen from the measurements that the values of the angles agree very closely with the corresponding angles of the humite from Vesuvius. This is especially the case with some of the best developed crystals, e. g. N:o 2. On this crystal the different angles between the faces of the *r*-series and the basal plane do not differ more than 2′ at most from the calculated angles, and the mean difference from the calculated values is only 1′. Though this crystal has not very brilliant faces, it is, however, very regularly developed.

Some of the other crystals do not show quite so much agreement between measured and calculated angles, but these also seem to be very regularly developed. When there are considerable differences, they seem to be due to a want of brilliancy in the faces, which made exact measurement impossible.

The following system of axes, deduced by SCACCHI from his measurements of the Vesuvian humite, is also adopted for the humite from Nordmarken

$$a : b : c = 1.0809 : 1 : 4.4033.$$

The following table of angles (p. 23, 24) gives the measurements made on ten crystals, as well as the angles calculated from the fundamental form above mentioned. In a separate column the differences between the mean value of the measured angles and the corresponding calculated angles are given.

Forms: On the humite from Nordmarken the forms shown in the following Table have been observed.

The Table of forms also indicates the combinations showed by the 10 crystals measured and figured on Pl. II. A glance at the table further shows which of the faces are common and which occur only exceptionally.

Table of forms.

	1	2	3	4	5	6	7	8	9	10
A (001) oP	—	1	1	—	—	—	1	1	1	1
B (100) $\infty \bar{P} \infty$ . .	—	—	—	—	1	—	—	1	1	1
C (010) $\infty \check{P} \infty$ . .	1	1	1	1	1	1	1	1	1	—
o (120) $\infty \check{P} 2$ . . .	—	1	1	1	1	—	—	—	—	—
$\frac{1}{2} o$ (110) ∞P	—	—	—	—	1	—	—	—	—	—
$\frac{1}{3} o$ (320) $\infty \bar{P} \frac{3}{2}$ . . .	—	1	1	1	1	1	1	1	1	—
i (011) $\check{P} \infty$	1	—	1	—	—	—	—	—	1	—
$\frac{1}{3} i$ (013) $\frac{1}{3} \check{P} \infty$ . . .	1	1	1	—	1	—	1	1	1	—

	1	2	3	4	5	6	7	8	9	10
$\frac{1}{5}i$ (015) $\frac{1}{5}\check{\mathrm{P}}\infty$ . . .	—	—	1	—	—	—	—	—	—	—
e (101) $\bar{\mathrm{P}}\infty$	—	—	—	—	1	1	—	1	1	1
$\frac{1}{2}e$ (102) $\frac{1}{2}\bar{\mathrm{P}}\infty$ . . .	—	—	—	—	—	—	1	1	1	—
$\frac{1}{4}e$ (104) $\frac{1}{4}\bar{\mathrm{P}}\infty$ . . .	—	—	—	—	—	—	1	1	1	—
n (111) P	—	—	—	—	1	—	—	—	—	—
$\frac{1}{2}n$ (112) $\frac{1}{2}$P	—	—	—	—	—	—	—	—	1	—
$\frac{1}{3}n$ (113) $\frac{1}{3}$P	—	—	—	—	—	—	—	—	1	—
r (122) $\check{\mathrm{P}}2$	—	1	1	1	1	1	—	—	1	1
$\frac{1}{2}r$ (124) $\frac{1}{2}\check{\mathrm{P}}2$	—	1	1	1	1	1	—	—	1	1
$\frac{1}{3}r$ (126) $\frac{1}{3}\check{\mathrm{P}}2$	1	1	1	1	1	1	1	1	1	1
$\frac{1}{4}r$ (128) $\frac{1}{4}\check{\mathrm{P}}2$	—	1	1	1	1	1	1	1	1	1
$\frac{1}{5}r$ (1.2.10) $\frac{1}{5}\check{\mathrm{P}}2$ . .	—	—	—	—	—	—	1	—	1	—

These 20 forms are all known before from the Vesuvian humite, which also shows some other faces. On the other hand, the humite from Nordmarken surpasses the same mineral from Tilly Foster and Ladugrufvan in number of faces.

As to the frequency of these faces the following statements may be given: the most usual are $\frac{1}{4}$ *r*, $\frac{1}{3}$ *r*, and *C*, which are scarcely missing on any crystal. Also $\frac{1}{2}$ *r*, *r*, $\frac{1}{3}$ *i*, $\frac{1}{3}$ *o* and *A* are among the common ones. Next comes *B* and the faces of the e-series, which are often missing or badly developed; this is also the case with the *i* and *o* faces. The faces $\frac{1}{2}$ *o*, $\frac{1}{5}$ *i* are rare, as also are the three of the *n*-series, each of which has only been observed on a single crystal.

As to the physical character of the faces, it may be remarked that the pyramidal planes of the *r*-series and also *A* and *C* are more brilliant than the others; $\frac{1}{3}$ *o* and $\frac{1}{3}$ *i* are without any lustre, as are also all the planes of the *n*-series.

On several crystals angles turned inwards occur, especially in the *r*-and *e*-zones, formed by the repetition of the faces. Fig. 10, Pl. II. Also a coarse striation occurs, parallel with the edges of the planes of the *r*-and *e*-series. These features, which are also observed in the humite from Ladugrufvan, may be regarded as due to an accumulation of several individuals in parallel position.

The Nordmarken humite differs in general appearance from the same mineral from other localities. It is especially some few faces that give the Nordmarken crystals their characteristic form, and which occur on all the specimens examined. These faces are the two pyramids $\frac{1}{3}$ *r* and $\frac{1}{4}$ *r* and the pinacoid *C*. Owing to this, the crystals have a more or less compressed lenticular habit, which is only slightly modified by the subordinate forms. Thus there appear, as truncations of the mean edges of the principal form $\frac{1}{3}$ *r*, the subordinate pyramids $\frac{1}{2}$ *r* and *r*, belonging to the same series, and also the corresponding vertical prism *o*. All these three forms are usually present, though sometimes as very narrow planes and forming only a rounding of the mean edges. The most subordinate of these forms is the vertical prism *o*, the faces of which are generally too narrow to give good reflections.

The obtuse pole edges of the principal forms $\frac{1}{3}$ *r* and $\frac{1}{4}$ *r* are truncated and modified by the domes of the *i*-series. The most developed of these is $\frac{1}{3}$ *i*; the other dome *i* is always subordinate, but is sometimes the only one among these domes present, and then appears as a little triangular face between the pinacoid *C* and the two adjoining faces of $\frac{1}{3}$ *r*.

These forms contribute to give the crystals a lenticular habit. As seen from the front — in the position which they have in the drawings — they have a rounded profile, and the faces, meeting in the circumference, form rather acute angles.

This sharp outer edge, by which the crystals in complete development should be surrounded, is, however, generally defectively developed being sometimes as if crushed; and in most cases the planes which form this edge are less smooth and even than the others. As a rule it may be stated, that the pinacoid *C* is the most brilliant and perfectly developed face, and in proportion as the faces are more distant from *C*, they are also less brilliant and smooth. Also the faces in the zone parallel to the b-axis, i. e. the domes of the series *e*, the basal plane *A*, and the pinacoid *B*, which are all located in this defective circumference, are seldom well developed. They too are generally in these crystals somewhat subordinate. To this the dome *e* is an exception, because this form in some crystals is one of the principal (i. g. crystal 5.) It is, however, even if smooth, almost lustreless, and does not allow of very exact measurement.

Also the pinacoid *B* is subordinate. The basal plane is the best developed face in this zone.

The majority of the forms last mentioned sometimes occur in one and the same crystal, which, if ideally developed, would have the appearance shown by fig. 6. In this, only the rare forms $\frac{1}{2}$ *o*, *n*, $\frac{1}{2}$ *n*, and $\frac{1}{3}$ *n* are not drawn. Fig. 4 shows the ideal appearance of a simpler crystal.

Twins are not hitherto with certainty proved to occur on the Nordmarken, humite in which respect these crystals differ widely from those of Vesuvius, among which twins are common[1].

Comparison with humite from other localities. Though, as has already been said, the humite from Nordmarken, in respect of the angles,

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[1] In my preliminary note in G. F. F. I mentioned the occurrence of twins with $\frac{1}{7}$ *e* as twinning plane, which statement later investigation shows not to be correct.

comes very near to the same mineral from Vesuvius, the crystals from these localities differ, however, in their general shape. As already shown, the crystals from Nordmarken generally have a lenticular form, while the single crystals from Vesuvius, owing to the dominating *e*-faces, have a more parallelopipedal appearance. Another difference is that twins are common from Vesuvius, while they are not known from Nordmarken. At Ladugrufvan, too, they are rare; in the material I examined from the last named locality, I could only pick out one fragment of a twin.

On the other hand, the humite from Nordmarken exhibits a very great likeness to that from Ladugrufvan, previously described by me, though the latter does not show so many faces as the former. It is principally the pyramid $\frac{1}{3}r$, the dome $\frac{1}{3}i$, some faces of the *e* series and the basal plane, that cause the resemblance in form between the two. One difference is, however, that the characteristic face *C* of the Nordmarken humite does not seem to occur in the crystals from Ladugrufvan.

With the humite from Tilly Foster, too, the Nordmarken crystals show great agreement. It is of interest that the crystals from these three localities, Nordmarken, Ladugrufvan, and Tilly Foster, show, geometrically also, such great agreement, since the paragenesis at these three magnetite mines is nearly the same. A further resemblance is that at all these localities the humite is more or less altered into serpentine. However, fresh crystals are far more common at Nordmarken than at Ladugrufvan.

Since the crystals from Ladugrufvan and Tilly Foster were not suitable for good measurements, no comparison could be made as to the lengths of axes of the crystals from these localities. Such a comparison could only be made with the Vesuvian humite, with which, as I have already said, full agreement in the dimensions of the axes can be proved.

Table of angles.

	Measured										Calculated.	Differences.
	1	2	3	4	5	6	7	8	9	10		
A (001) : $\frac{1}{5}r$ (1 . 2 . 10)	—	—	—	—	—	—	44° 10′	—	44° 11′	—	44° 8 $\frac{1}{2}$′	+ 2′
: $\frac{1}{4}r$ (128)	—	50° 28′	50° 19′	—	—	—	50 15	50° 45′	50 25	50° 10′	50 30	— 6$\frac{1}{3}$
: $\frac{1}{3}r$ (126)	—	58 14	58 17	—	—	—	57 54	58 29	58 10	57 58	58 16	— 5$\frac{2}{3}$
: $\frac{1}{2}r$ (124)	—	67 36	—	—	—	—	—	—	67 41	67 26	67 36	— 1$\frac{2}{3}$
: *r* (122)	—	78 20	78 14	—	—	—	—	—	78 18	—	78 21	— 3$\frac{2}{3}$
: *o* (120)	—	—	—	—	—	—	—	—	89 55	—	90 0	— 5
r (122) :	—	—	—	11° 37′	11° 38′	11° 9′	—	—	—	—	11 39	—11
$\frac{1}{4}r$ (128) : $\frac{1}{4}r$ (128)	—	—	—	78 47	—	—	—	—	—	—	79 0	—13

	Measured										Calculated.	Differences.
	1	2	3	4	5	6	7	8	9	10		
$\frac{1}{3}r$ (126) : $\frac{1}{3}r$ (12$\bar{6}$)	—	—	—	63° 24'	63° 10'	63° 26'	—	—	—	—	63° 28'	— 8'
$\frac{1}{2}r$ (124) : $\frac{1}{2}r$ (12$\bar{4}$)	—	—	—	45 26	—	43 30	—	—	—	—	44 48	— 20
r (122) : r (12$\bar{2}$)	—	—	—	23 15	—	22 18	—	—	—	—	23 18	— 1½
A (001) : $\frac{1}{5}i$ (015)	—	—	41° 23'	—	—	—	—	—	—	—	41 22	+ 1
: $\frac{1}{3}i$ (013)	—	—	55 59	—	—	—	—	—	—	—	55 44	+ 15
: i (011)	—	—	77 19	—	—	—	—	—	—	77° 51'	77 12	+ 23
: C (010)	—	—	90 6	—	—	—	—	—	—	—	90 0	+ 6
i (011) :	12° 47'	—	—	—	—	—	—	—	12° 41'	—	12 48	— 4
$\frac{1}{3}i$ (013) :	34 8	—	—	—	—	—	34° 13'	—	34 7	—	34 16	— 6½
$\frac{1}{3}r$ (126) : $\frac{1}{3}n$ (113)	—	—	—	—	16 29	—	—	—	16 24	—	—	—
: B (100)	—	—	—	—	68 49	—	—	—	—	—	—	—
: $\frac{1}{3}r$ (1$\bar{2}$6)	—	—	41 26	—	41 52	—	40 70	—	—	—	—	—
: $\frac{1}{3}i$ (013)	21 54	—	20 54	—	—	—	20 53	—	20 52	—	—	—
$\frac{1}{4}r$ (128) : $\frac{1}{4}r$ ($\bar{1}$28)	—	—	—	—	37 52	40 13	—	37° 43'	—	—	—	—
: B (100)	—	—	—	—	70 53	—	—	71 24	—	—	—	—
$\frac{1}{3}r$ (126) : C (010)	39 19	—	—	—	39 34	39 16	39 46	—	—	—	—	—
$\frac{1}{2}r$ (124) :	—	—	—	39 22	—	—	—	—	—	—	—	—
B (100) : e (101)	—	—	—	—	13 49	—	—	13 26	13 49	13 57	13 47	— 2
: $\frac{1}{2}e$ (102)	—	—	—	—	—	—	26 16	26 37	26 14	—	26 8	+ 14
: $\frac{1}{4}e$ (104)	—	—	—	—	—	—	44 37	44 33	44 42	—	44 27½	+ 10
: o (120)	—	—	—	—	—	65 15	—	—	65 53	—	65 10	+ 24
: $\frac{1}{2}o$ (110)	—	—	—	—	47 25½	—	—	—	—	—	47 12½	+ 13
: $\frac{1}{3}o$ (320)	—	—	—	—	35 50	35 44	—	35 54	—	—	35 45½	+ 4

Optical properties.

For examination in parallel and convergent polarized light some sections were prepared. The examination with the stauroscope of a plate, parallel with *C*, showed extinction parallel with the edges of the two other pinacoids *A* and *B*. This furnishes a confirmation of the orthorhombic system. In convergent polarized light the same plate proved to be vertical to the acute bisectrix, which in the ordinary way was determined to be +.

Angles of optic axes. The measurement of the angles of optic axes was performed in a solution of mercuric iodide in potassium iodide in order, if possible, to determine also the obtuse angle, which is not measurable in fluids of smaller refractive power. The index of refraction of the solution has been determined to 1.6703 for Na-light at + 18° C, which fully corresponds to the value derived from GOLDSCHMIDT'S table. The measurements were made with monochromatic light from Li-, Na- and Tl-flames.

Two sections, vertical to the acute (I) and obtuse (II) bisectrices and cut from the same crystal, showed the following results.

$$\text{(I)}\ \begin{cases} 2\ K_{ar} = 67^\circ\ 0' \\ 2\ K_{ay} = 66\ 40 \\ 2\ K_{agr} = 66\ 15 \end{cases}$$

$$\text{(II)}\ \begin{cases} 2\ K_{or} = 109^\circ\ 45' \\ 2\ K_{oy} = 109\ 25 \\ 2\ K_{ogr} = 109\ \ 0 \end{cases}$$

From these angles the real angles of the optic axes are calculated, viz:

$$\begin{aligned} 2\ V_{ar} &= 68^\circ\ 1' \\ 2\ V_{ay} &= 67\ 54 \\ 2\ V_{agr} &= 67\ 44 \end{aligned}$$

Using the above mentioned value of the index of refraction for the solution, we arrive at the middle index of refraction for Na-light

$$\beta = 1\,.\,643$$

A third plate (III), cut from another crystal vertically to the acute bisectrix, gave the following values, only slightly differing from those of section (I).

$$\text{(III)}\ \begin{cases} 2\ K_{ar} = 66^\circ\ 48' \\ 2\ K_{ay} = 66\ 35 \\ 2\ K_{agr} = 66\ 18 \end{cases}$$

As will be seen, the dispersion of the optic axes is weak and its character $\varrho > v$.

What I have said above concerning the humite from Nordmarken, may be thus summarized:

1:o The humite from Nordmarken agrees in angular dimensions so closely with the crystals from Vesuvius, that it may be regarded as most suitable to refer them to the same fundamental form.

2:o The general appearance is determined by the forms $C, \frac{1}{4}r, \frac{1}{3}r, \frac{1}{3}i$, to which as subordinate forms usually come $A, \frac{1}{2}r, r, \frac{1}{3}o, i, e$. Many rare forms also occur. Twins have not been observed.

3:o In their general form the crystals agree most with those from Ladugrufvan in Wermland and Tilly Foster N. Y.; these localities also show the greatest resemblance to Nordmarken in respect of paragenetical relations.

4. **Chondrodite.** Pl. III, Fig. 1—12.

The figures in Plate III give an idea of the appearance of the chondrodite crystals. Some of these drawings are from nature, viz. fig. 1, 2, 5, 6, 8, 10, 12; the others are rather idealized. These figures indicate that the crystals occur in many different types, and vary widely with regard to form.

This is also the case as regards the size and other properties which cannot be represented in the figures. For example, fig. 4 represents a crystal of only 1 mm., translucent and of a pale honey-yellow colour. Fig. 12, on the other hand, is part of a crystal originally about 4 cm and completely altered to an ash-grey serpentine with a resinous lustre.

The crystals, when fresh, are of a resin-brown or yellowish brown colour. They are, however, comparatively rare. It will often be observed that the crystals are traversed by numerous irregular cracks, round which, owing to an incident alteration, the substance has received a lighter, yellowish grey colour. The crystals are, however, well preserved on the surface, and exhibit smooth and bright faces. In other crystals the alteration has gone so far, that the serpentine process is fully completed. In these crystals no cracks are to be seen, but the substance is perfectly homogeneous, ash-grey to greyish green, with resinous or greasy lustre, and translucent at the edges. In spite of this great alteration, the crystals exhibit such smooth and bright faces, that they can very well be measured. The only external change to be observed in such altered crystals, is that the edges are a little rounded off.

Fundamental form. In conformity with v. RATH'S proposal the pyramid n is chosen. When calculating the system of axes from the measured angles, it was found that these approach so closely to the axes derivated by E. S. DANA from his measurements on the Tilly Foster chondrodite, that no difference could be established with certainty. I thus abandoned to set up a system of axes for the Nordmarken chondrodite separately, and adopted the axes given by E. S. DANA. The table of angles given beneath shows how closely the measured angles correspond with those calculated from the axes proposed by DANA.

The system of axes was calculated on the supposition that the angle $\beta = 90°$, for which there is good reason, because from the measurements no difference between corresponding angles in positive and negative quadrants can be deduced. For the sake of comparison, in addition to the system of axis derived by E. S. DANA from measurements of the chondrodite from Tilly Foster (I), I give that which v. RATH gives for the chondrodite from Vesuvius (II)

$$\begin{aligned} a : b : c &= 1.08630 : 1 : 3.14472 \qquad \text{I} \\ &= 1.0828 : 1 : 3.1457 \qquad \text{II}^1 \\ \beta &= 90° \, 0' \end{aligned}$$

In the tables of angles which follow, the measured angles are compared not only with the angles calculated from the system of axes I, but also with those from system II. In order to facilitate the comparison, I

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[1] This system of axes is derived from measurements of clinohumite, and has thus only an indirect connection with chondrodite. v. RATH Pogg. Ann. Erg. Bd. V. 337.

have indicated, at the side of each of the calculated angles, how much it differs from the average of the corresponding measured angles. A glance at the table shows that the differences between the average of the measured angles and those calculated from the system of axes I, are nearly always smaller than the differences from the corresponding angles of system II.

From this the conclusion may be drawn that the Nordmarken chondrodite, in angular dimensions, stands nearer to that from Tilly Foster than Vesuvius, and agrees so closely in respect of lengths of axes with the former, that scarcely a system of axes could be established that corresponds better with its angles.

For the sake of comparison, the angles mentioned, are arranged in three tables: I angles with A, II angles with C, and III other measured angles. They contain only a part of the measurements made on eighteen crystals. A great many more might be given, but I think it unnecessary, as those furnished are more than sufficient to determine the faces as well as to give an idea of the connection that exists between the measured angles and those calculated from different systems of axes.

Forms: The chondrodite from Nordmarken appears to be richer in forms than the same mineral from any other known locality[1]. It shows no less than 29 forms, viz:

Table of Forms.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A (001) o P	1	1	1	1	1	1	1	1	1	1	1	1	1	1	—
B (100) $\infty \bar{P} \infty$	1	—	1	—	—	1	1	1	—	1	—	1	—	—	1
C (010) $\infty \check{P} \infty$	—	1	1	1	1	1	—	1	1	1	1	1	1	1	1
$\frac{1}{2} o$ (110) ∞P	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
i (012) $\frac{1}{2} \check{P} \infty$	—	1	—	1	—	1	—	1	1	—	1	1	1	—	1
$\frac{1}{2} i$ (014) $\frac{1}{4} \check{P} \infty$	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—
$+ e$ (101) $- \bar{P} \infty$	1	1	1	1	1	1	1	1	1	1	1	—	1	—	1
$- e$ $(\bar{1}01)$ $+ \bar{P} \infty$	1	—	1	—	1	1	1	1	1	1	—	—	1	—	1
$+ \frac{1}{3} e$ (103) $- \frac{1}{3} \bar{P} \infty$	—	1	1	—	1	1	1	1	1	1	1	1	1	—	—
$- \frac{1}{3} e$ $(\bar{1}03)$ $+ \frac{1}{3} \bar{P} \infty$	1	—	1	1	1	1	—	1	1	1	—	—	1	—	—
$+ \frac{1}{5} e$ (105) $- \frac{1}{5} \bar{P} \infty$	—	—	—	—	1	1	—	—	—	1	1	—	1	—	—
$- \frac{1}{5} e$ $(\bar{1}05)$ $+ \frac{1}{5} \bar{P} \infty$	—	—	—	—	1	1	—	1	—	—	—	—	1	—	—
$+ n$ (111) $- \bar{P}$	—	1	1	—	—	—	—	1	1	—	1	—	1	—	—
$- n$ $(\bar{1}11)$ $+ P$	1	1	—	—	—	1	1	1	1	—	1	—	1	—	1
$- \frac{1}{2} n$ $(\bar{1}12)$ $+ \frac{1}{2} P$	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—

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[1] The numerous vicinal planes observed on chondrodite from Kafveltorp as well as from Tilly Foster are not considered here.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$+\frac{1}{3}n$ (113) $-\frac{1}{3}P$	—	1	—	—	—	1	1	1	—	—	1	—	1	—	—
$-\frac{1}{3}n$ $(\bar{1}13)$ $+\frac{1}{3}P$	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
$+\frac{1}{5}n$ (115) $-\frac{1}{5}P$	—	—	—	—	1	—	—	—	—	—	1	1	—	—	—
$-\frac{1}{5}n$ $(\bar{1}15)$ $+\frac{1}{5}P$	1	1	1	1	1	—	—	1	—	—	—	—	1	—	1
$+r$ (121) $-2\,\bar{P}2$	—	1	1	1	1	1	1	1	1	1	1	1	1	1	1
$-\frac{1}{3}r$ $(\bar{1}23)$ $+\frac{2}{3}\check{P}2$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
$+\frac{1}{5}r$ (125) $-\frac{2}{5}\check{P}2$	—	1	1	1	1	1	1	1	1	1	1	1	1	1	1
$-\frac{1}{7}r$ $(\bar{1}27)$ $+\frac{2}{7}\check{P}2$	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
$+m$ (321) $-3\,\bar{P}\,\frac{3}{2}$	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—
$-m$ $(\bar{3}21)$ $+3\,\bar{P}\,\frac{3}{2}$	1	1	—	1	—	1	1	1	—	1	1	—	1	—	1
$-\frac{1}{5}m$ $(\bar{3}25)$ $+\frac{3}{5}\bar{P}\,\frac{3}{2}$	1	—	—	1	—	1	—	1	—	1	—	—	1	—	—
$+\frac{1}{7}m$ (327) $-\frac{3}{7}\bar{P}\,\frac{3}{2}$	—	1	—	—	—	1	1	1	—	1	1	—	1	—	—
$+\frac{1}{11}m$ (3. 2. 11) $-\frac{3}{11}\bar{P}\,\frac{3}{2}$ . . .	—	1	—	—	—	—	1	1	—	1	1	—	1	—	—
$-\frac{1}{2}l$ $(\bar{2}12)$ $+\bar{P}2$	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Of these 29 forms the following six are new, viz:

$-\frac{1}{2}n$, $+\frac{1}{5}n$, $-\frac{1}{5}n$, $+\frac{1}{7}m$, $+\frac{1}{11}m$, $-\frac{1}{2}l$.

These new forms divide into the two series *n* and *m* in a most regular and remarkable manner. The series *n*, of which $\pm n$ and $\pm\frac{1}{3}n$ are already known, is now completed by $\pm\frac{1}{5}n$. The new face $-\frac{1}{2}n$, only met with in one crystal (N:o 3), stands outside the ordinary rule that dominates the pyramidal faces, and according to which the parameters are proportional to the inverse values of the odd numbers. As concerns the series *m*, $\pm m$, $+\frac{1}{3}m$ and $-\frac{1}{5}m$ were known before, and $+\frac{1}{7}m$ and $+\frac{1}{11}m$ are now added. To make this series complete, $-\frac{1}{9}m$ is still wanting, but this form has not been observed in any of the crystals examined. It is, nevertheless, to be supposed that it exists. Thus the *m* series can show one more member in the chondrodite from Nordmarken than the *r* series, which is so characteristic of chondrodite. The vertical parameters in both these series are in the same ratio as the inverse values of the odd numbers 1, 3, 5 etc. But in the *r* series the numbers 1 and 5 belong to the positive, and 3, 7 to the negative quadrants, while in the *m* series 1, 5 lie in negative, and 3, 7 in positive quadrants. The new face $\frac{1}{2}l$ is also of interest from its regularity. It forms the first member in a new series of orthodiagonal hemipyramids, the *l* series, the faces of which intersect *a* and *b* in the ratio of 1 : 2. As is known, the intersections of the axes in the other series show the following relations:

the r series $a : b = 2 : 1$
» n » $= 1 : 1$
» m » $= 2 : 3$, to which is now added
» l » $= 1 : 2$

With regard to the faces this may be noted: $\pm \frac{1}{5} e$ are very common in the chondrodite from Nordmarken (e. g. N:o 5, fig. 4), though $- \frac{1}{5} e$ was hitherto known only from the chondrodite from Tilly Foster, while $+ \frac{1}{5} e$ is common as a twin plane in the Vesuvian chondrodite and the crystals from Kafveltorp. The faces $\pm \frac{1}{5} n$ are very common in the crystals from Nordmarken, and appear e. g. in N:o 1 (fig. 1), N:o 2 (fig. 2), N:o 4 (fig. 3), N:o 5 (fig. 4), N:o 8 (fig. 5), and sometimes as the most dominating faces of these crystals, as shown by the figures. $- \frac{1}{5} n$ is more common than the corresponding positive form, though the latter also occurs. Upon the whole, one may say that, among the forms of the n series, n and $\frac{1}{5} n$ occur more frequently in the negative quadrants, or are better developed in these than in the corresponding positive, while $\frac{1}{3} n$ is chiefly positive [1].

The new faces of the m series, $+ \frac{1}{7} m$ and $+ \frac{1}{11} m$, are observed in several crystals, for instance in N:o 2 (fig. 2), N:o 7, N:o 8 (fig. 5) N:o 10, N:o 11 (fig. 8), N:o 13 (fig. 10). On the other hand, as already mentioned, the missing link $- \frac{1}{9} m$ has not been met with, as also not the $+ \frac{1}{3} m$, known from the Vesuvian crystals.

The new face $- \frac{1}{2} l$ is only found in a single crystal (N:o 1, fig. 1) and then only as a very insignificant face.

With regard to the physical properties of the faces, it is to be noted that those of the r series are generally the most brilliant. C and i also give good and sharp reflections. The pyramids of the n and m series, on the contrary, are not so well developed, and A, as well as the faces of the e series, is nearly always dull. The difference between $+ e$ and $-e$, noted by me in the chondrodite from Kafveltorp and also by DANA in the crystals from Tilly Foster, that $+ e$ is dull, $- e$ more lustrous, is also to be observed in the mineral from Nordmarken, though it is less apparent than in the Kafveltorp crystals.

Habit. The chondrodite crystals from other localities, Vesuvius, Tilly Foster, and Kafveltorp, show great variation in form, which is also the case with the crystals from Nordmarken, as the figures show. Scarcely two crystals are perfectly similar with regard to combination of faces and general form. They could be divided into several different types with regard to their general habit, but these types are not sharply distinguished from one another. As to the habit of the crystals, it must first be noted that they are, in most cases, perfectly monoclinic. This monoclinic development, as

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[1] This does not fully agree with E. S. DANA's statement regarding the chondrodite from Tilly Foster: "n^2 ($= n$) is both + and −, but where occurring alone is generally negative; n^1 ($= \frac{1}{3} n$) is generally — — — — negative."

is apparent from the table of forms, is owing to the circumstance that the faces do not correspond to each other in positive and negative quadrants. This is especially the case with faces belonging to the *r*-series, among which *r* and $\frac{1}{5}$ *r* are only positive, while $\frac{1}{3}$ *r* and $\frac{1}{5}$ *r* are only negative. But the forms of the *m*-series also contribute to this monoclinic habit. It is true that both *m* and — *m* occur, but the other faces of this series are only positive or negative, viz. $\frac{1}{3}$ *m*, $\frac{1}{7}$ *m*, and $\frac{1}{11}$ *m* positive, while $\frac{1}{5}$ *m* is negative.

That the forms of the *n*-series, though occurring both in positive and negative quadrants, generally appear as negative, has already been mentioned. The case is the reverse as regards the forms of the *e*-series; *e* and $\frac{1}{5}$ *e* especially are more common in positive than in negative quadrants, and, if present in both, are more developed in the positive.

Nevertheless, crystals are found of nearly perfect orthorhombic symmetry, owing to the formation of twins, as to which more will be said below.

The annexed figures on Pl. III give, better than any description, an idea of the different types of the crystals. Among the larger crystals the type with tabular development parallel to *C*, represented by figs. 11 and 12, often occurs. These crystals reach a size of 1—6 cm, and are, in most cases, strongly altered or serpentinized. In spite of this alteration the faces have kept their lustre and are quite measurable, the edges being only a little rounded off. The combination in these larger crystals is very simple, and frequently consists only of the following forms:

$$C, A, i, -\tfrac{1}{7} r, +\tfrac{1}{5} r, -\tfrac{1}{3} r, r, -m, +e;$$

to which are often added *B*, — $\frac{1}{5}$ *m* and $\frac{1}{3}$ *e*.

Another type consists of crystals tabularly developed parallel to *A*. This type is very common in smaller crystals of 1—10 mm. N:os 4, 5, 8, represented by figs. 3, 4 and 5, belong to this type. They are generally much richer in faces than the crystals of the foregoing larger type.

A third type is intermediate between the two former, and is distinguished by a more parallelopipedal development; *A* and *C* being strongly developed, without the crystals being tabular parallel to either. The *e* zone is more developed in crystals of this type than in the former. As an example of these crystals N:o 13, fig. 10 may be mentioned.

Twins. As is known, the chondrodite from some localities, especially Vesuvius and Kafveltorp, shows a great tendency to form twins and trillings when either $\frac{1}{5}$ *e*, $\frac{3}{5}$ *e* or *A* are twin-plans. In the chondrodite from Nordmarken twinning only occurs with *A*. In this it agrees with the chondrodite from Tilly Foster. This twinning can be best observed in the sections which, for the measurement of the optic axial angle, have been cut parallel to the plane of symmetry. In some cases one finds this twinning repeated, so that the crystal becomes polysynthetic like the chondrodite from Kafveltorp. To judge from the numerous sections made, it seems, however, as if the polysynthetic twinning were not as characteristic a trait in the Nordmarken chondrodite as in that from Kafveltorp.

The polysynthetic twinning shows itself partly by re-entering angles or striation of the faces, in series *e, m, r* and *n,* and partly by the fact that faces belonging to either the positive or negative quadrants appear in both. A typical crystal of this kind is N:o 9, represented in fig. 6 and 7. It is one cm long and nearly black in colour. What, at first sight, distinguishes this crystal from the other types, is its orthorhombic symmetry. The forms of the *r*-series, as well as of the others, which generally appear only in positive or negative quadrants, are here present in both. Nevertheless, the separate forms are not developed symmetrically, as is indicated in figure 7, which is idealized, but the crystal is very irregular, as fig. 6 shows. In fact it consists of a complex of lamellae, parallel to *A,* laid upon each other, and it is this which gives rise to the orthorhombic symmetry. This twinning, parallel to the basal plane, is not, indeed, rare even in crystals of the other types above described. Twin-lamellae are often found inserted in the otherwise homogeneous crystal. But in N:o 9 the two systems of lamellae appear to balance one another, and the separate lamellae are very thin. All faces, excepting the basal plane, are, therefore, more or less striated horizontally.

In some crystals one finds striations of the *e, m* and *n*-zones, and even re-entering angles in these zones, but from this one cannot with certainty argue a formation of twins, if faces, originally belonging to one quadrant, do not appear in another. On the contrary, this striation has probably, in many cases, arisen from a repetition of the normal faces. If twinning be present or not, can only in such cases be proved by the examination of a section in polarized light.

A comparison with chondrodite from other localities. The chondrodite from Nordmarken exhibits, crystallographically, more conformity with the same mineral from Tilly Foster, than with that from other localities. The habit of the crystals is often the same, and this is especially the case in the type tabularly developed parallel to C. Some crystals, as for instance those represented in figs. 11 and 12, might very well pass for crystals from Tilly Foster. On the other hand, the type which is distinguished by a tabular development parallel to *A,* does not seem to have any corresponding type at the latter locality.

As regards the forms, there are also points of resemblance with the crystals from Tilly Foster. The domes $\pm \frac{1}{5} e$ only occur in the Nordmarken and Tilly Foster crystals.

Another resemblance, already pointed out, is in the twinning, which takes place polysynthetically parallel to *A,* twinning otherwise being quite wanting.

The Nordmarken crystals differ from the Kafveltorp chondrodite, partly in their different habit, *C* being as a rule much better developed than in the latter, and partly by the crystals from Kafveltorp being in the majority of cases twins or trillings with $\frac{1}{5}$ *e* as twinning plane. The Nordmarken chondrodite certainly has most faces in common with that from Vesuvius, but as to habit there is no strong resemblance between them.

Table of Measurements I.

Upon *A* (001).

	Measured												Calculated			
	1	2	3	4	5	7	8	9	10	11	12	13	I	Diff.	II	Diff.
$+ e$	—	71° 6′	70° 53′	—	70° 42′	71° 7′	—	71° 12′	71° 15′	—	—	70° 31′	70° 56½′	+ 1½′	71° 2′	— 4′
$- e$	71° 15′	—	—	—	—	—	70° 53′	—	70 17	—	—	71 7	70 56½	— 3½	71 2	— 9
$+ \frac{1}{3} e$	—	—	44 20	—	43 46	44 3	—	43 38	43 54	—	—	43 40	43 59	— 5½	44 8	— 14½
$- \frac{1}{3} e$	—	—	—	44° 27′	—	—	—	—	43 53	—	—	44 18	43 59	+ 13½	44 8	+ 4½
$+ \frac{1}{5} e$	—	—	—	—	29 51	—	—	29 56	29 40	—	—	29 43	30 4	— 16½	30 11	— 23½
$- \frac{1}{5} e$	—	—	—	—	—	—	30 29	—	—	—	—	—	30 4	+ 25	30 11	+ 18
B	89 57	90 25	—	—	—	89 30	—	90 8	90 21	—	—	—	90	+ 4	90	+ 5
i	—	57 43	—	57 29	—	—	57 28	—	—	57° 32′	57° 31′	57 33	57 33	± 0	57 32	+ ½
C	—	90 5	—	90 8	—	—	89 59	—	—	90 7	90 9	90 0	90	+ 4½	90	+ 4½
$- \frac{1}{7} r$	—	44 46	44 46	44 31	44 38	44 38	44 38	—	—	44 42	44 44	44 44	44 41	± 0	44 42	— 1
$+ \frac{1}{5} r$	—	54 11	54 10	—	54 17	54 5	54 7	54 23	—	54 6	54 8	54 4	54 10	± 0	54 11	— 1
$- \frac{1}{3} r$	66 30	66 39	66 47	65 57	66 28	—	66 38	67 9	67 15	66 40	66 47	66 35	66 34	+ 6½	66 35	+ 5½
$+ r$	—	81 45	81 24	—	81 55	81 36	81 38	—	81 14	81 43	—	81 42	81 47	— 10	81 47	— 10
$+ \frac{1}{5} n$	—	—	—	—	40 13	—	—	39 56	—	41 33	40 33	—	—	—	40 35	— 1
$- \frac{1}{5} n$	40 36	41 27	40 47	40 47	—	—	40 18	—	40 38	—	39 47	—	—	—	40 35	+ 2
$+ \frac{1}{3} n$	—	55 9	—	—	—	55 15	54 53	55 14	54 44	55 3	—	—	54 56	+ 7	54 57	+ 6
$+ n$	—	76 45	—	—	—	—	76 53	77 4	76 11	76 58	—	—	76 50	— 4	76 50	— 4
$- n$	76 53	—	—	—	—	76 55	—	—	77 5	76 28	76 42	—	76 50	— 1½	76 50	— 1½
$+ \frac{1}{11} m$	—	43 12	—	—	—	—	—	43 24	43 54	44 9	—	—	—	—	44 21	— 41
$+ \frac{1}{7} m$	—	56 20	—	—	—	—	—	57 20	56 13	56 52	—	—	—	—	56 56	— 15
$- \frac{1}{5} m$	65 6	—	—	64 50	—	—	—	65 44	64 46	—	—	—	65 6	+ ½	65 7	— ½
$+ m$	—	—	—	—	—	—	—	84 41	84 13	84 39	—	—	84 40	— 9	84 42	— 11
$- m$	84 40	84 35	—	84 31	—	84 10	84 40	—	—	84 13	—	—	84 40	— 12	84 42	— 14

Table of Measurements II.

Upon C (010).

	Measured				Calculated			
	6	11	12	13	I	Diff.	II	Diff.
$\frac{1}{5}$ *r* (125)	42° 29′	42° 28′	42° 34′	42° 37′	42° 34′	— 2′	42° 37′	— 5′
— $\frac{1}{3}$ *r* $(\bar{1}23)$	—	33 31	—	—	33 32	— 1	33 37	— 6
r (121)	—	—	—	25 59	25 58	+ 1	—	—
n (111)	—	—	—	44 48	44 15	+ 33	44 23	+ 25
$\frac{1}{5}$ *n* (115)	—	—	61 31	—	—	—	—	—
i (012)	—	—	32 35	32 29	32 27	+ 5	32 28	+ 4
e (101)	—	—	—	89 48	90 0	— 12	90 0	— 12

Table of Measurements III.

	Measured									Calculated			
	1	2	4	5	6	7	8	9	13	I	Diff.	II	Diff.
e : + *r*	—	63° 48′	—	—	63° 56′	—	—	—	—	64° 2′	— 10′	63° 55′	— 3′
: *m*	75° 51′	76 17	—	—	—	76° 36′	76° 27′	75° 40′	—	—	—	76 23	— 13
$\frac{1}{5}$ *n* : $\frac{1}{5}$ *n*	57 3	—	—	56° 52′	—	—	—	—	—	—	—	57 2	— $4\frac{1}{2}$
: $\frac{1}{7}$ *r*	12 48	—	12° 52′	—	—	—	12 51	—	12° 42′	—	—	12 46	+ 2
n : $\frac{1}{3}$ *r*	19 46	19 46	—	—	—	19 46	19 48	19 22	20 3	—	—	19 43	+ 2
m : $\frac{1}{3}$ *r*	33 33	33 26	33 37	—	—	—	33 29	33 22	33 38	—	—	33 37	— 6
$\frac{1}{5}$ *r* : $\frac{1}{5}$ *e*	—	—	—	47 28	47 27	—	—	—	—	—	—	47 23	+ $4\frac{1}{2}$
: *e*	—	58 43	—	—	59 10	59 29	—	58 33	—	59 14	— 15	59 10	— 11
: $\frac{1}{7}$ *m*	—	23 32	—	—	24 20	—	—	24 7	24 25	—	—	24 27	— 21
: $\frac{1}{3}$ *n*	—	14 15	—	—	—	—	—	—	14 34	—	—	14 38	— $13\frac{1}{2}$

Optical properties.

For the optical examination some sections vertical to the acute and obtuse bisectrices were prepared. As known the acute bisectrix as also the plane of optic axes is vertical to that of symmetry. This was confirmed through the sections cut parallel to C, (010) which showed an axial image with a great axial angle. The character of the bisectrix was found +. An examination with the stauroscope showed that the optic axial plane makes an angle of about 27° 30′ with A (001) and lies parallel to a hemidome with symbol $+ \frac{1}{n} e(10n) — \frac{1}{n} \overline{P} \infty$. Thus the axis of the greatest elasticity lies between the crystallographical axes —*a* and *c*, making, with the former, an angle of about 27° 30′. This fully confirms my investigations on the Kafveltorp chondrodite regarding the position of the optic axial plane and axes of elasticity[1]; I there say »die Elasticitätsaxen $\mathfrak{a}$ und $\mathfrak{b}$ liegen in der Symmetriebene, jene in den negativen, diese in den positiven Qvadraten» which is also illustrated by fig. 26 and 30 of the same paper[2].

Optic axial angle. The results of the determination of the optic axial angle made on seven sections are here given. The measurements were all made in a solution of mercuric iodide in potassium iodide with a refracting power = 1.6703 for Na-light at + 18° C.

	1	2	3	4	5	6	7	Average.
$2K_{ar}$	78° 20′	77° 32′	78° 29′	—	—	—	—	78° 71′
$2K_{ay}$	77 59	77 8	78 22	—	—	—	—	77 50
$2K_{agr}$ . . .	77 30	77 9	77 50	—	—	—	—	77 32
$2K_{or}$	—	—	—	98° 10′	98° 5′	98° 19′	97° 50′	98 6
$2K_{oy}$	—	—	—	97 57	97 52	97 52	97 22	97 45
$2K_{ogr}$ . . .	—	—	—	97 36	97 37	96 16	96 59	97 29

From these apparent angles the following real angles are calculated:

$$2\,V_r = 79°\,40'$$
$$2\,V_y = 79\;\;40$$
$$2\,V_{gr} = 79\;\;38$$

As visible, the dispersion of axes is very insignificant; it seems to be $\varrho > \nu$ but cannot be certainly stated, as the above given values of V for different colours cannot be regarded as certain within the limits of one or two minutes.

The middle index of refraction is according to the given statements calculated for Na-light $\beta = 1.659$.

We here summarize the statements above made as to the crystallographical form and properties of the Nordmarken chondrodite:

1:o The chondrodite from this locality agrees so closely in angular dimensions with the crystals from Tilly Foster, that the same system of axes may be accepted.

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[1] Groth Zeitschr. f. Krystallographie Vol. 7, p. 150.

[2] The other statements on this subject found in literature are contradictory. Des-Cloizeaux (Neues Jahrb. 1876, p. 643) gives to the optic axial plane an inclination from "backwards to forwards" which agrees with my examination. On the contrary, Michel-Levy and Lacroix (Min. des Roches 1888, p. 225) state the inclination to be "d'avant en arrière" i. e. parallel to a hemidoma $-\frac{1}{n}e\,(\bar{1}0\,n) + n\,\overline{\mathrm{P}}\,\infty$. In the "System" of Dana one finds the following statements: "$\mathrm{Bx}_0 \wedge \acute{c} = \mathfrak{a} \wedge \acute{c} = 28^0\,56'$ Kafveltorp, Sj.", which may be corrected to: $\mathrm{Bx}_0 \wedge \acute{c} = \mathfrak{a} \wedge \acute{c} = -\,61^0\,4'$ or $\mathfrak{b} \wedge \acute{c} = +\,28^0\,56'$ Kafveltorp, Sj."

2:o The chondrodite from Nordmarken is richer in forms than the same mineral from any other locality. The faces A, C, together with the *e* and *r* series generally dominate; twins parallel to A occur, sometimes polysynthetically.

3:o In habit the crystals mostly resemble those from Tilly Foster aud less those from Kafveltorp and Vesuvius; also with respect to twinning the agreement with the Tilly Foster crystals is greater.

4:o The plane of optic axes makes an angle of about 27° 30′ against A with the position of a hemidome $+\frac{1}{n}e\,(10n)$, the position of the optic axial plane thus agrees with the statement earlier made by Des CLOIZEAUX and the author but is contradictory to the data given by Michel LEVY and LACROIX.

The interior axial angle for Na-light is 79° 40′ and the middle index of refraction $\beta = 1.659$.

5. **Clinohumite.** Pl. IV, Fig. 1—8.

The crystals of clinohumite resemble, in colour, alteration and general appearance, the related minerals, humite and chondrodite, so much, that I need only here refer to what has already been said in describing these minerals. The crystals of clinohumite, which I examined, do not show such great variation in size as the related minerals, varying only between two and five mm. As already mentioned, the clinohumite is, in the Nordmark mines, the rarest of the three minerals of the humite group, but in spite of this I had about 15 larger and smaller specimens, besides a number of loose crystals, at my disposal, the greatest part of the material having been collected by Mr G. FLINK.

Fundamental Form. As the fundamental form I have taken the pyramid *n* in conformity with my description of humite and chondrodite. This pyramid *n* is determined by the axes calculated by v. RATH from his measurements on the clinohumite of Vesuvius. As appears from the Table of measurements (p. 38), the differences between the measured angles and those which v. RATH calculated are sometimes rather great, and generally greater than those of the humite and chondrodite. This circumstance, however, seems to be due to casual irregularities in the crystals, rather than indicating any difference in their fundamental form.

As a rule, the angles of the clinohumite from Nordmarken, show less constancy than those of the other humite minerals from the same locality.

Thus the following system of axes, identical with that given by v. RATH, for the clinohumite from Vesuvius, may be accepted for the clinohumite from Nordmarken, viz:

$$a : b : c : = 1.0803 : 1 : 5.6588$$
$$\beta = 90^\circ\ 0'$$

The angles measured on eight crystals are given on page 38 and compared with the corresponding calculated angles.

Forms. 26 different faces are found on the clinohumite from Nordmarken, which occur on the eight examined crystals in the manner shown by the following table.

Table of Forms.

	1 Fig. 3	2 Fig. 2	3 Fig. 1	4	5 Fig. 4	6 Fig. 5	7 Fig. 6	8
A (001) o P	1	1	1	1	1	1	1	1
C (010) $\infty \check{P} \infty$	—	1	1	—	1	—	—	—
$\frac{1}{2} o$ (110) ∞ P	—	—	—	—	1	—	—	—
i (012) $\frac{1}{2} \check{P} \infty$	1	—	1	—	1	1	1	—
$\frac{1}{2} i$ (014) $\frac{1}{4} \check{P} \infty$	1	1	1	1	1	1	1	1
$\frac{1}{3} i$ (016) $\frac{1}{6} \check{P} \infty$	1	—	1	1	—	—	1	—
$+ e$ (101) $- \bar{P} \infty$	1	1	1	1	1	1	—	1
$- e$ $(\bar{1}01)$ $+ \bar{P} \infty$	1	1	1	—	1	1	1	—
$+ \frac{1}{3} e$ (103) $- \frac{1}{3} \bar{P} \infty$	—	—	1	—	1	1	1	1
$- \frac{1}{3} e$ $(\bar{1}03)$ $+ \frac{1}{3} \bar{P} \infty$	1	—	—	1	1	1	1	1
$+ \frac{1}{5} e$ (105) $- \frac{1}{5} \bar{P} \infty$	1	1	—	1	1	1	—	1
$- \frac{1}{5} e$ $(\bar{1}05)$ $+ \frac{1}{5} \bar{P} \infty$	1	1	1	—	1	1	1	1
$+ \frac{1}{9} e$ (109) $- \frac{1}{9} \bar{P} \infty$	—	—	—	—	—	—	1	—
$+ n$ (111) $-$ P	1	—	1	1	—	—	—	1
$- n$ $(\bar{1}11)$ $+$ P	—	—	—	—	—	—	1	1
$+ \frac{1}{3} n$ (113) $- \frac{1}{3}$ P	1	1	—	—	—	—	—	—
$- \frac{1}{3} n$ $(\bar{1}13)$ $+ \frac{1}{3}$ P	—	1	1	—	1	1	—	1
$+ \frac{1}{5} n$ (115) $- \frac{1}{5}$ P	1	—	1	1	—	—	—	—
$+ r$ (121) $- 2 \check{P} 2$	1	—	1	—	—	1	1	—
$- \frac{1}{3} r$ $(\bar{1}23)$ $+ \frac{2}{3} \check{P} 2$	1	—	—	1	—	—	—	—
$+ \frac{1}{5} r$ (125) $- \frac{2}{5} \check{P} 2$	1	1	—	—	—	1	—	—
$- \frac{1}{7} r$ $(\bar{1}27)$ $+ \frac{2}{7} \check{P} 2$	1	1	1	1	1	1	1	1
$+ \frac{1}{9} r$ (129) $- \frac{2}{9} \check{P} 2$	1	1	1	1	1	1	1	1
$- \frac{1}{11} r$ $(\bar{1}.\ 2.\ 11)$ $+ \frac{2}{11} \check{P} 2$	1	—	1	1	1	1	1	1
$- m$ $(\bar{3}21)$ $+ 3 \bar{P} \frac{3}{2}$	—	—	—	—	—	—	1	—
$- \frac{1}{9} m$ $(\bar{3}29)$ $+ \frac{1}{3} \bar{P} \frac{2}{3}$	1	—	—	—	—	—	—	—

All these faces are known also on the Vesuvian clinohumite.

From the table of forms appears which of these faces are common, and which occur only sparingly. Also the monocline symmetry is evident, being caused chiefly by the alternating faces of the *r*-series. Thus *r*,

$\frac{1}{5}\,r$, $\frac{1}{9}\,r$ occur as positive, $\frac{1}{3}\,r$, $\frac{1}{7}\,r$ and $\frac{1}{11}\,r$ as negative pyramids. The faces of the *e*- and *n*-series occur equally in positive and negative quadrants, as is also the case on the clinohumite from Vesuvius. As is seen from the table, the forms of the *m*- and *o*-series are very scarce on the Nordmarken clinohumite.

With regard to the frequency of the different faces, it may be noted, that the basal plane *A* occurs on all crystals; among the faces of the *e*-zone $\pm\, e$ are the most common, though neither $\pm \frac{1}{3}\, e$ nor $\pm \frac{1}{5}\, e$ is scarce; on the other hand, $\frac{1}{9}\, e$ is only found on a single crystal (N:o 7).

Among the faces of the *r*-series the more obtuse pyramids, as $-\frac{1}{7}\, r + \frac{1}{9}\, r$, and $-\frac{1}{11}\, r$ are most common, and occur on nearly every crystal; also $+\frac{1}{5}\, r$ is prevalent, but *r* and $-\frac{1}{3}\, r$ are rare.

Among the faces of the *n*-series none can be said to be more common than the others. The dome $\frac{1}{2}\, i$ is the most common of the *i*-series; *i* and $\frac{1}{3}\, i$ are less common.

As a remarkable feature in the development of these crystals, it may be mentioned, that the plane of symmetry *C* rarely occurs, and then always as a small and subordinate face. This circumstance forms a distinguishing mark of this mineral when compared with the chondrodite as in the latter the face *C* is always present, often as a great and dominating face.

The only face of the *o*-series, $\frac{1}{2}\, o$, is found but on a few crystals, and face *m* and $\frac{1}{9}\, m$ only on a single crystal.

With regard to the physical properties of the faces it may be noted that those of the *e*-, *i*- and *r*-series, as well as *A*, are generally brilliant, but the *n*-faces, on the contrary, are dull and rough. These could not therefore be measured, but were determined by means of their zones.

Habit. Most of the crystals are lenticular in shape. The dominating zone is then generally the *e*-zone. Such crystals are represented in fig. 1, 2, 3 and 6, Pl. IV which are exact copies, and in the somewhat idealized fig. 8. The lenticular form is chiefly due to the faces of the *r*-series, $-\frac{1}{7}\, r$, and $+\frac{1}{9}\, r$, their obtuse pole edge being truncated by the domes of the *i*-series, while the mean-edge is not truncated by any faces, as the corresponding face of the *o*-series does not occur. Another type of development is represented in fig. 5 and 7, the former an exact copy from nature, the latter drawn symmetrically. These crystals, which are prolonged in the direction of the *c*-axis, remind one of a common type of clinohumite from Vesuvius.

Twins have not hitherto been observed among the clinohumite crystals from Nordmarken. Some with reentering angles, at first supposed to be twins, proved on examination, to be single crystals, the reentering angles simply being due to a repetition of certain faces in the *e*-zone. The thin sections, examined in polarized light, have not shown the presence of twinning lamellae parallel to *A*, as is generally the case in crystals of the Vesuvian clinohumite.

Table of Angles.

Upon A (001).

	Measured								Calculated	Mean-differences
	1	2	3	4	5	6	7	8		
$\frac{1}{2}$ *o*	—	—	—	—	89° 44′	—	—	—	90° 0′	— 16′
i	—	—	70° 57′	—	—	70° 19′	70° 40′	—	70 32	+ 6½
$\frac{1}{2}$ *i*	54° 44′	—	54 26	54° 44′	54 42	54 46	54 43	—	54 45	— 4
$\frac{1}{3}$ *i*	43 55	—	44 38	—	—	—	43 39	43° 27′	44 59½	— 1° 5
+ *e*	—	79° 34′	—	79 7	79 13	79 15	79 9	—	78 11½	+ 14
— *e*	79 3	78 30	79 5	—	79 20	79 3	79 31	—	78 11½	+ 54
+ $\frac{1}{3}$ *e*	—	—	—	—	60 18	60 20	59 57	60 10	60 12	— 1
— $\frac{1}{3}$ *e*	60 12	60 8	61 15	60 14	59 27	60 21	59 27	60 12	60 12	+ 20
+ $\frac{1}{5}$ *e*	—	46 25	—	46 8	46 22	46 28	46 10	46 30	46 20	+ ½
— $\frac{1}{5}$ *e*	45 38	—	46 44	—	46 20	46 13	46 16	46 12	46 20	— 6
+ $\frac{1}{9}$ *e*	—	—	—	—	—	—	31 9	—	30 12	+ 57
+ *n*	—	—	82 16	82 39	—	—	—	—	82 36	— 8½
— *n*	83 58	—	—	—	—	—	—	—	82 36	+ 1° 22
— $\frac{1}{3}$ *n*	—	—	68 43	—	—	—	—	—	68 42½	+ ½
+ $\frac{1}{5}$ *n*	56 50	—	—	57 18	—	—	—	—	57 0	+ 4
+ *r*	85 14	—	85 10	—	—	—	84 59	—	85 25	— 17½
— $\frac{1}{3}$ *r*	77 31	—	76 37	76 31	—	—	76 29	—	76 28½	+ 18½
+ $\frac{1}{5}$ *r*	68 5	67 36	—	—	68 10	—	—	—	68 9	— 12
— $\frac{1}{7}$ *r*	60 42	60 34	61 41	60 41	60 37	60 28	60 46	—	60 41½	+ 5½
+ $\frac{1}{9}$ *r*	54 5	54 22	54 4	54 8	54 18	54 6	54 4	54 20	54 11	— ⅛
— $\frac{1}{11}$ *r*	48 31	—	48 44	48 27	48 27	48 48	48 31	48 58	48 35	+ 3
— *m*	—	—	—	—	—	—	86 22	—	87 3	— 41
— $\frac{1}{9}$ *m*	65 10	—	—	—	—	—	—	—	65 7	+ 3

A comparison with clinohumite from other localities. The clinohumite was hitherto known only from Vesuvius and Tilly Foster. When comparing the Nordmarken crystals with those from the said localities, we shall find that all faces found on the former are already known on the same mineral from Vesuvius, which, besides represents a number of faces making in all 39. The Vesuvian mineral thus seems to be much richer in forms, but this difference may be removed, because, on further examination, when a richer material has been obtained, the Nordmarken clinohumite will possibly show as great a number of faces as the Vesuvian crystals. As to habit the crystals from Nordmarken show great agreement with those from Vesuvius. This chiefly depends upon the predominating development of the faces of the *e*-series as well as upon the wanting or subordinate face *C*. Some of the drawings given by v. RATH[1] of the Vesuvian clino-

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[1] Pogg. Ann. Erg. Bd. 5, 1872.

humite, i. e. fig. 1 and 2 Pl. VI and fig. 10 Pl. VII, might as well represent Nordmarken crystals, if only the faces of the *m*-series were missing. The circumstance that the faces of the *n*-series in the Nordmarken crystals are rough and only subordinate, and that the *m*-faces are so scarce, constitutes, indeed, the whole difference in habit between the crystals from Nordmarken and those from Vesuvius.

With the clinohumite from Tilly Foster the agreement is not so great, if at all a comparison can be founded only upon the two crystals described and reproduced by E. S. Dana [1]. The subordinate development of the *e*-series as well as the dominating of the faces *C*, exhibited in those crystals, gives them quite another habit than those from Nordmarken and Vesuvius.

While in the humite and the chondrodite from Nordmarken one finds the greatest resemblance in forms and habit to the Tilly Foster crystals, with which also in respect of occurrence and paragenesis of the localities they show the greatest analogies, no such agreement can be proved for the clinohumite.

Optical properties.

Two sections parallel with the plane of symmetry showed in polarized light extinction 12° and 15° against *A*, different in the two sections; an examination in convergent polarized light proves that the plane of optic axes lies 12° to 15° against *A*, and has the position of a hemidome $+\frac{1}{n}e(10n)-\frac{1}{n}\bar{\mathrm{P}}\infty$ [2].

The acute bisectrix is positive.

The measurements on the acute (I) and obtuse (II) axial angles made in a solution of mercuric iodide in potassium iodide ($n = 1.6703$) give the following results:

$$\text{(I)}\ \begin{cases} 2\,K_{ar} = 76^\circ\ 40' \\ 2\,K_{ay} = 76\ \ 27 \\ 2\,K_{agr} = 76\ \ 16 \end{cases}$$

$$\text{(II)}\ \begin{cases} 2\,K_{or} = 103\ \ 48 \\ 2\,K_{oy} = 103\ \ 35 \\ 2\,K_{ogr} = 103\ \ 22 \end{cases}$$

From these apparent angles the following interior angles of the optic axes are derived, viz:

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[1] Transact. of the Conn. Acad. Vol. 3, part I, p. 88.

[2] This agrees with the statements of Des Cloizeaux and C. Klein with regard to the position of the optic axial plane but is contradictory to the data given by Michel Levy and Lacroix, according to which the plane of optic axes should correspond to a hemidome $-\frac{1}{n}e(\bar{1}0n)+\frac{1}{n}\bar{\mathrm{P}}\infty$.

$$2\,V_{ar} = 76^\circ\ 29'$$
$$2\,V_{ay} = 76\ \ 27$$
$$2\,V_{agr} = 76\ \ 24$$

As in this case the apparent acute angle and the real angle for Na-light become identical, it is evident that the middle index of refraction must be equal to that of the solution; thus

$$\beta = 1.670.$$

Here the following comparison of some of the optical data of the humite-minerals from Nordmarken may find place

	$2\,V_{ay}$	β
Humite . . .	67° 54′	1.643
Chondrodite	79 40	1.659
Clinohumite	76 27	1.670

What has been above said concerning the clinohumite from Nordmarken may be thus summarized:

1:o The lengths of the crystallographical axes agree closely with those derived from measurements made by v. RATH on the Vesuvian crystals but the values of the angles are less constant than in humite and chondrodite, and show greater variations.

2:o The clinohumite from Nordmarken shows at least 26 forms, all known before in the same mineral from Vesuvius; twins have not been observed.

3:o In habit the crystals most resemble those from Vesuvius and less those from Tilly Foster. The forms A, $\pm e$, $\frac{1}{2} i$, $\frac{1}{5} r$, $-\frac{1}{7} r + \frac{1}{9} r$ and $-\frac{1}{11} r$ are most common and generally dominate.

4:o The plane of optic axes makes an angle of 12—15° against A, with the position of a hemidome $+\frac{1}{n} e\ (10n)$; the interior axial angle for Na-light is 76° 27′, and the middle refraction index $\beta = 1.670$ for the same colour.

A further communication will give the results of the chemical examination of the three humite-minerals from Nordmarken as well as of their products of alteration. I shall also then have an opportunity to give an account of some interesting crystals which I have not hitherto been able to identify with any of the above described minerals. It seems that they differ from them both in angles and optical properties and should thus constitute a new species of the humite group.

6. Longbanite from the Långban Mine[1]. Pl. V, Fig. 1—7.

1. The First Find of Longbanite.

In the spring of 1878 I examined, at that time, quite an unknown mineral, from the Långban mine; but as my analysis only resulted in a considerable loss, and materials for a second wanting, I put it aside in an unfinished state; but, nevertheless, exhibited the mineral and gave a short account of the observations I had made at one of the meetings of the »Geolog. Föreningen i Stockholm»[2]. The following was the result of my analysis:

SiO_2 — 10.92 %
Fe_2O_3 — 12.78
Mn_2O_3 — 60.90
Loss — 15.40
100.00
Gravity = 4.67

Then, on reading about Mr G. FLINK'S interesting discovery of Longbanite, some years later[3], I found good reason to suppose, that the new mineral was identical with the one I had previously examined; the proportions of silica, iron and manganese being nearly the same in our analyses although FLINK considered the two latter ingredients to be present as protoxides, whereas I regarded them as sesquioxides, and the 15.42 % Sb_2O_5 which the mineral, according to FLINK, should contain, evidently corresponded with the loss of 15.40 % in my analysis.

In order to ascertain whether the mineral I partly examined, in 1878, were longbanite or some other, as yet unknown, I recommenced an analysis of it in 1891, because, although my specimen resembled FLINK'S to a certain extent, there still appeared to be some important external differences.

Mr TIBERG, Manager of the Långban mines, kindly sent me material, for this second examination, similar to that I had had in 1878.

The agreement, of the chemical properties of my mineral, with that of FLINK'S, having been put beyond doubt, I further examined his material, with the object of determining its position in the mineralogical system, whereof the formula, set up by FLINK, could not be considered as affording any definite information. In September, 1892, I procured, from Mr FLINK, some fine crystals of a new type with decided rhombohedral habits and, in them I purposed examining the crystallographical form of the mineral.

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[1] Part of the contents of this paper was already published in Geol. Fören. i Stockholm Förhandl. Vol. 13, p. 256—265, 1891.

[2] Geolog. Fören. i Stockholm Förhandl. Vol. 4, p. 116, transactions of the meeting of May 3rd, 1878.

[3] Zeitschrift für Krystallsgraphie. Vol. 13, pag. 1, 1888.

Material, of the same kind as FLINK described, is in the following represented by type *A*, the material I originally examined, by type *B*, and the crystals with rhombohedral development by type *C*.

In the specimens I examined in 1878 (type B) the mineral was imbedded in brown, compact, finegrained schefferite, besides which, they contained in smaller quantities, richterite and rhodonite. In appearance it was either massive or formed tables of a hexagonal shape 0.5 — 1 cm. in diameter and some mm. in thickness. The specimen now analyzed can be similarly described, and is, as far as I know, the only one of its kind [1].

The crystals, some mm. in size, described by FLINK mostly occur on schefferite inclosed in calcite, and it is clear from his drawings, that these, having a great number of faces, show a more prismatic form, vastly different to the tabular, this being peculiar to the large crystals of type B, on which only a hexagonal prism and the basal plane, are observable.

2. Three New Analyses of Longbanite.

Below three analyses, by Mr R. MAUZELIUS, are given, of which I and II refer to type B, and III to type A.

I partly got material for analyses I and II by carefully picking under loop and partly by separation, using »Rohrbach's Solution»; but for analysis III, crystals, disengaged from the calcite by diluted hydrochloric acid, were resorted to. As to the method employed for the analyses the following remarks may suffice.

In analyses I and II the finely powdered mineral was fused together with carbonates of alkalies, after which dissolved in HCl and what then remained of the silicic acid was again fused with alkalies; but in analysis III, the mineral was directly dissolved in HCl; the undissolved part — consisting of SiO_2 and some undecomposed mineral substance — was fused with carbonates of alkalies, dissolved, and the solution added to the former. By dissolving the mineral in HCl chlorine was perceptibly disengaged, thus indicating the presence of oxide of manganese, an observation I had already noted on my first analysis in 1878 and this then decided me in considering the iron and manganese as oxides. From the solutions, sulphurete of antimony was precipitated with H_2S, oxidized with fuming nitric acid and weighed as Sb_2O_4; whilst SiO_2, Fe, Mn, Ca and Mg were determined in the usual manner. The amount of disengaged oxygen was ascertained by BUNSEN'S method i. e. dissolved in HCl, absorption of the chlorine in KJ and titration on free iodine; whilst the water was directly weighed.

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[1] Specimens of massive and indistinctly crystallized longbanite, resembling the original find, were also met with, in the Långban mines, in the year 1892, but have not yet been examined.

Analysis I.

Longbanite. Type B. (R. Mauzelius).

G = 4.65 at 15° C.

	%	Molecular-Ratio		
Sb_2O_3 . . .	11.76	0.041	—	—
Fe_2O_3 . . .	14.15	0.088	—	—
SiO_2	12.23	0.204	0.505	1
MnO_2 . . .	26.15	0.301		
MnO . . .	31.54	0.447	0.527	1.04
CaO . . .	2.24	0.040		
MgO . . .	1.61	0.040		
	99.68	—	—	—
O	3.50	—	—	—

Analysis II.

Longbanite. Type B. (R. Mauzelius).

G = 4.73 at 13.5° C.

	%	Molecular-Ratio		
Sb_2O_3 . . .	11.61	0.040	—	—
Fe_2O_3 . . .	14.31	0.089	—	—
SiO_2	11.32	0.189	0.501	1
MnO_2 . . .	27.13	0.319		
MnO . . .	32.30	0.455	0.512	1.02
CaO . . .	2.04	0.036		
MgO . . .	0.86	0.021		
H_2O	0.32	0.018	—	—
	99.89	—	—	—
O	3.70	—	—	—

Analysis III.

Longbanite. Type A. (R. Mauzelius).

G = 4.83 at 14.5° C.

	%	Molecular-Ratio		
Sb_2O_3 . . .	12.92	0.045	—	—
Fe_2O_3 . . .	4.33	0.027	—	—
SiO_2	8.95	0.149	0.553	1
MnO_2 . . .	35.15	0.404		
MnO . . .	36.39	0.513	0.560	1.01
CaO	1.95	0.035		
MgO . . .	0.47	0.012		
	100.16	—	—	—
O	5.03	—	—	—

Comparing the molecular ratio of Sb_2O_3, Fe_2O_3, $\overset{IV}{R}O_2$ and $\overset{II}{R}O$ we find the following proportions:

	Sb_2O_3	Fe_2O_3	$\overset{IV}{R}O_2$	$\overset{II}{R}O$
Analysis I . . .	0.082	0.176	1	1.04
» II . . .	0.080	0.178	1	1.02
» III . . .	0.090	0.054	1	1.01

As is apparent from these figures the ratio between the Sb_2O_3 and Fe_2O_3 as well as between these two constituents and $\overset{IV}{R}O_2$ and $\overset{II}{R}O$ is not constant but varies greatly in the three analyses, thus proving that the Sb_2O_3 and Fe_2O_3 must be regarded as isomorphous components which partly replace each other. On the other hand, the ratio between $\overset{IV}{R}O_2$ and $\overset{II}{R}O$ is constant, viz: as 1 to 1 and they constitute together a group $\overset{IV}{R}\overset{II}{R}O_3$ corresponding to the two other components Fe_2O_3 and Sb_2O_3.

Regarded from this point of view the analyses evidently lead to the general formula

$$\left\{\begin{array}{l} m\ Sb_2O_3 \\ n\ Fe_2O_3 \\ p\ \overset{IV}{R}\overset{II}{R}O_3 \end{array}\right\}$$

in which the values of the coefficients *m*, *n* and *p*, are diverse, $\overset{IV}{R}$ = Mn, Si and $\overset{II}{R}$ = Mn, Ca, Mg. By interpreting the analysis in this way, one may presume, that the antimony is contained as Sb_2O_3 instead of

Sb_2O_5 as suggested by Flink. Infact, it is impossible, in presence of oxide of manganese, to determine the state of the oxidation of the antimony, as by dissolving the mineral in HCl the disengaged chlorine transforms the antimony to pentachloride of antimony in whatever state it may originally have occurred.

This has been shown by experiments, made especially for the purpose, when determined quantities of antimonic acid (Sb_2O_3) and peroxide of manganese (MnO_2) were treated with HCl, by which process no chlorine was disengaged until all the antimonic acid was transformed into pentachloride of antimony. Thus, though it cannot be directly proved, that the antimony occurs as antimonic acid, the supposition, all the same, agrees with the results of the analysis.

That the iron enters as sesquioxide, and not as protoxide, is evident by the presence of peroxide of manganese. The amount of the latter as peroxide, is declared by the directly determined oxygen + the quantity required to change Sb_2O_3 into Sb_2O_5.

The small amount of water found in analysis II has been considered inessential to the mineral but rather depending on its being slightly decomposed.

The proportion of the different isomorphous components seems to be rather variable as the values of the coefficients m, n and p, in the formula are not constant.

Thus the ratios of the above coefficients are in

Analysis I $m : n : p$ = 10 : 21 : 126
» II = 10 : 22 : 127
» III = 10 : 6 : 124

These differences in composition correspond to the variation of the external characters as, for instance, the gravity of the mineral, which exhibits most considerable inequalities.

In the three now analyzed samples the gravities of 4.66, 4.73 and 4.84, have been obtained, and also to these may be added the gravity of the specimen examined by me in 1878, with 4.67 and the gravity indicated by Flink of 4.918. If we compare the specific gravities of the different samples as regards the proportions in which the isomorphous components are contained, we find the highest gravity 4.84 in III (type A) corresponding to the greatest quantity of Sb_2O_3; in both samples of type B (analyses I and II) with more equal gravity (4.66 and 4.73) Sb_2O_3 is present in almost the same quantity.

3. The Crystallographical Development of Type C.

In the autumn of 1892 I got through Mr Flink some crystals of longbanite of a new type, distinguished by their rhombohedral habit. On mentioning these crystals here, it is not my intention to give a complete description of them, but only to put their hemihedral character beyond doubt.

This kind of crystals occurs implanted on crystallized schefferite and richterite and is enclosed in massive hedyphane in such a manner that the relative ages of the minerals is evidently 1 richterite, 2 longbanite, 3 hedyphane.

The associating minerals thus differ from those accompanying the other types, which circumstance probably has some connection with the different forms of the types. The Table of Forms below gives the former known faces, as well as three new, which have been found in this type.

FLINK'S system of axes is maintained unaltered, but the symbols are given with regard to the hemihedral development here for the first time proved. Thus the six faces of pyramid $o = P$ are divided into two rhombohedrons $+ R$ and $- R$ and it is therefore considered proper to give to each a separate letter. So the letter o is maintained for $+ R$ and ω for $- R$. As $d = (20\bar{2}1)$ and $h = (21\bar{3}1)$ have not been met with on hitherto examined crystals of type C it could not be determined as to whether these faces occur as positive or negative. The new forms are prism $s = (41\bar{5}0)$ $\infty P \frac{5}{4}$ the rhombohedron $k = (10\bar{1}3)$ $+ \frac{1}{3} R$ and the scalenohedron $l = (41\bar{5}3)$ $- R \frac{5}{3}$.

Table of Forms.

$c = 0001$ $0R$

$o = 10\bar{1}1$ $+ R$

$\omega = 01\bar{1}1$ $- R$

$p = 10\bar{1}2$ $- \frac{1}{2} R$

$d = 20\bar{2}1$ $\pm$ (?) $2R$

$m = 10\bar{1}0$ ∞R

$n = 11\bar{2}0$ ∞P_2

$s = 41\bar{5}0$ $\infty P\frac{5}{4}$

$e = 11\bar{2}6$ $\frac{1}{3} P2$

$f = 11\bar{2}3$ $\frac{2}{3} P2$

$g = 22\bar{4}3$ $\frac{4}{3} P2$

$h = 21\bar{3}1$ $\pm$(?)$R3$

$i = 41\bar{5}6$ $- \frac{1}{2} R\frac{5}{3}$

$k = 10\bar{1}3$ $+ \frac{1}{3} R$

$l = 41\bar{5}3$ $- R\frac{5}{3}$

A few words will suffice to explain the peculiarities of this type.

Crystal 1. Fig. 3 Pl. V[1] is a true representation of a crystal of prismatic habit.

On account of the great development of the basal plane *c*, this crystal in appearance closely resembles type A. On the same the two new forms $k = + \frac{1}{3} R$ and $l = - R\frac{5}{3}$ occur.

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[1] This figure is turned 60^0 in order better to show the real appearance of the crystal.

The hemihedral development is apparent through the positive rhombohedron *o*, which always occurs with large, somewhat dull faces, whilst the corresponding negative is developed with smaller but more brilliant faces. Further the new rhombohedron $k = \frac{1}{3}R$ only occurs in zones between $o = +R$ and $c = oR$ and is thus positive, whilst $p = -\frac{1}{2}R$ is only found in zone $\{\omega\ c\}$ thus being negative.

Crystal 2, represented in figs 4, 5 and 6, shows hemihedral development still more clearly. The faces belonging to $o = +R$ quite dominate and give to the crystal a decidedly pyramidal habit; $\omega = -R$ are, on the other hand, subordinate here; also $p = -\frac{1}{2}R$ contributes to the hemihedral development. No scalenohedron occurs on this crystal but pyramids of the second order $f = \frac{2}{3}P2$ and $g = \frac{4}{3}P2$ are present with their full number of faces.

Crystal 3, fig. 7, shows at the top the same combination as the preceding but has a thin prismatic development. For the sake of comparison a crystal of type A. is also represented (fig. 1 and 2). According to Flink this type should be holohedral but from the figure it is apparent that crystals of this type may likewise have a hemihedral development, produced by the alternating occurrence of faces $o = +R$ and $p = -\frac{1}{2}R$. I think it unnecessary to give all the numerous angles measured on the crystals of type C, as they so closely agree with those given by Flink that there can be no doubt that the system of axes must also correspond.

Therefore I shall only show how the new forms were determined.

1. Prism $s = (41\bar{5}0) \infty P\frac{5}{4}$ (Crystal 2)

	Measured.	Calculated.
$m(10\bar{1}0) : s(41\bar{5}0) =$	10° 9′	10° 53½′
$m(0110) : s(\bar{1}5\bar{4}0) =$	11 1	» »
$m(\bar{1}100) : s(\bar{5}410) =$	10 57	» »
$m(11\bar{2}0) : s(41\bar{5}0) =$	19 14	19 6½
$m(\bar{1}2\bar{1}0) : s(\bar{1}5\bar{4}0) =$	19 6	» »
$m(\bar{2}110) : s(\bar{5}410) =$	19 3	» »

2. The rhombohedron $k = (10\bar{1}3) + \frac{1}{3}R$ (Crystal 1). This face as situated in zone $\{o(10\bar{1}\bar{1})\ c(0001)\}$ is fully determined through the following measurements.

$c(0001) : k(10\bar{1}3) =$	32° 40′	32° 19′
» $: k(0\bar{1}13) =$	32 18	» »

3. The scalenohedron $l = (4\bar{5}13) - R\frac{5}{3}$ is determined by its situation in the two following zones:

$\{n(2\bar{1}\bar{1}0)\ \omega(0\bar{1}11)\}$ and $\{m(1\bar{1}00)\ f(1\bar{2}13)\}$

It may be remarked, that the new prism $s(41\bar{5}0)$ corresponds with the scalenohedrons $l(41\bar{5}3)$ and $i(41\bar{5}6)$ of which the former is new, the latter having already been referred to by Flink.

4. The Systematical Relation of Longbanite.

As we have above settled the question of the chemical formula of Longbanite and also shown, that the mineral belongs to the rhombohedral division of the hexagonal system, we can now proceed to discuss its systematical relations. It lies, then, close enough to refer it to the group of hematite and ilmenite. The general appearance of the mineral as well as its gravity, metallic lustre etc., remind one of this group, as FLINK has already pointed out.

Longbanite also resembles the minerals of this group in chemical composition; as shown above it contains both oxygen-salts of the general formula $\overset{IV}{R}\overset{II}{R}O_3$ and sesquioxides $\overset{III}{R}_2O_3$ and these two different compounds constitute also the minerals of the hematite-ilmenite-group.

According to HAMBERG[1] this group can be divided into two sections of which the one contains the rhombohedral sesquioxides corundum Al_2O_3 and hematite Fe_2O_3, the other the tetartohedral ilmenite $\overset{II}{Fe}\overset{IV}{Ti}O_3$ and pyrophanite $\overset{II}{Mn}\overset{IV}{Ti}O_3$. Thus longbanite contains compounds of both these general types. It is true that among the components of longbanite we only know of Fe_2O_3 in the hematite-group[2] but the general formulae of the other components also agree with the minerals of the hematite-ilmenite-group. It seems to be the substance Fe_2O_3, which in longbanite determines the crystallographical form, as the other component with a composition $\overset{IV}{R}\overset{II}{R}O_3$ is nearly identical with the tetragonal braunite.

There is, then, from a chemical point of view, no argument against considering the longbanite as a member of the hematite group, but there is less agreement with respect to the crystallographical form.

When comparing the length of the vertical axis of longbanite $c = 1.6437$ with that of hematite $c' = 1.3656$, we find that they stand in the proportion of 6 : 5 *i : e.*

$\frac{5}{6}c = 1.3697$ corresponds to the value of $c' = 1.3656$.

If, on this account, we calculate the symbols of the faces of longbanite, when referred to the axes $c = 1.3697$, we arrive at very complicated symbols and which, in most cases, do not correspond with those of hematite, although so rich in forms.

This is shown by the following comparison

$a : c = 1 : 1.6437$	$a : c = 1 : 1.3697$
$c = oR$	oR
$o = +R$	$+\frac{6}{5}R$
$\omega = -R$	$-\frac{6}{5}R$
$p = -\frac{1}{2}R$	$-\frac{3}{5}R$

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[1] Geol. Fören. i Stockholm Förhandl. Vol. 12, p. 604, 1890.

[2] The small amount of Sb_2O_3 found in pyrophanite seems to be too insignificant to prove the existence of a hexagonal modification of this substance.

$d = \pm\,(?)\,2R \qquad \pm\,(?)\,\frac{12}{5}R$

$m = \infty R \qquad \infty R$

$n = \infty P2 \qquad \infty P2$

$s = \infty P\frac{5}{4} \qquad \infty P\frac{5}{4}$

$e = \frac{1}{3}P2 \qquad \frac{2}{5}P2$

$f = \frac{2}{3}P2 \qquad \frac{4}{5}P2$

$g = \frac{4}{3}P2 \qquad \frac{8}{5}P2$

$h = \pm\,(?)\,R3 \qquad \pm\,(?)\,\frac{6}{5}R3$

$i = -\frac{1}{2}R\frac{5}{3} \qquad -\frac{3}{5}R\frac{5}{3}$

$k = +\frac{1}{3}R \qquad +\frac{2}{5}R$

$l = -R\frac{5}{3} \qquad -\frac{6}{5}R\frac{5}{3}$

Thus it is evident that the length of $c = 1.6437$ gives simpler symbols and is more natural to the geometrical development of longbanite than the *c*-axis so changed that it should correspond with the *c*-axis of the hematite-group.

It seems, however, that the isomorphy with the hematite-group could be suggested without changing the length of the vertical axis of longbanite. The difference between the axial lengths of longbanite and hematite being 0.285 i. e. not more than the difference in axial lengths, of several other isomorphous groups [1] this is no sufficient argument against the isomorphy.

Among the 14 faces, found on longbanite, all except three occur on hematite.

If their agreement, as to fundamental form, is not very great this can depend on the great differences of chemical composition, which certainly influence the length of the vertical axis. With respect to general properties there is no mineral-group that longbanite resembles more than the hematite-group [2].

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[1] In the group of the orthorhombic sulphates we find for instance the following axial lengths:

	a	*b*	*c*
Anhydrite	0.8932 :	1 :	1.0008
Celestite	0.7789 :	1 :	1.2800
Diff.	— 0.1143	0	+ 0.2792

Thus in this case the difference between the *a*-axes is about 13 $^0/_0$ of the length of the greater, and the difference between the *c*-axes 22 $^0/_0$, whilst the corresponding difference between the *c*-axes of longbanite and hematite is only about 18 $^0/_0$.

[2] H. Bäckström simultaneously with me published two analyses of longbanite (Type A.) which, although not complete as to the degree of oxidation of the manganese, both led to the same chemical formula as the above stated. He suggests, that longbanite may crystallographically be referred to the calcite-group on account of $\frac{1}{2}\,c = 0.8219$ coming close to the lengths of the vertical axes of the rhombohedral carbonates (calcite = 0.8543, smithsonite = 0.8063). Geol. Fören. Förhandl. Vol. 13 p. 271, 1891; Zeitschr. für Krystallographie. Vol. 19, p. 276—283, 1891.

I do not find this sufficient ground for referring a substance, with a gravity of 4.66—4.92, hardness more than 6, metallic lustre and cleavages parallel oR, to the calcite-group.

7. **Svabite a New Member of the Apatite Group.** Pl. V, fig. 8—11.

1. Svabite from the Harstigen Mine.

Of late years an unknown mineral has several times been observed in massive granular pieces of schefferite from the Harstigen mine, Pajsberg, but always in such small quantities, that an examination was scarcely possible[1]. In the spring of 1891, Mr G. FLINK, of Stockholm, kindly sent me some of the above material.

The mineral occurs as small hexagonal prisms, one or two millimetres in length, in druses of massive, dark-brown schefferite, together with yellow garnet, manganophyllite, brandtite and sarkinite. Of these schefferite is evidently the oldest, next to which comes garnet, occasionally occurring as globular aggregates showing small faces of ∞O (011), whilst manganophyllite, the hydrous arseniates, sarkinite, brandtite and the new mineral named svabite constitute a third generation[2].

The crystals are white, colourless, transparent; lustre vitreous to resinous; streak colourless; H. 5; G. 3. 52; brittle. Before the blowpipe the mineral fuses slowly to a black slag; with soda on charcoal gives an arsenical odour. Soluble in diluted acids.

On the quantitative analysis, only 0.1390 grammes were expended.

Analysis IV.
Svabite from Harstigen (R. Mauzelius).
Gravity = 3.52 at + 18° C.

	%	Molecular-Ratio.		
Insoluble . . .	2.1	—	—	—
As O_5	52.2	0.227	0.227	3.
$Fe_2O_3 + P_2O_5$	0.9	—	—	—
Ca O	42.5	0.759	0.776	10.26
Mg O	0.7	0.07		
Pb O	trace	—	—	—
H_2O	1.0	0.056	0.058	0.78
Cl_2	0.1	0.002		
	99.5			

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[1] A. HAMBERG mentions a white, hexagonal arseniate occurring with lead, karyopylite, sarkinite and brandtite. Probably the mineral I am here describing is one and the same, although HAMBERG denominates it an arseniate of lead and also adds that it occurs chiefly on and together with metallic lead. See Hamberg's "Ueber Krystallisirtes Blei von der Grube Harstigen bei Pajsberg in Wermland". Zeitschr. f. Krystallographie Bd. 17, s. 258, and "Om kristalliseradt bly från Harstigsgrufvan vid Pajsberg i Wermland", Öfversigt af K. Vetenskaps-Akad. Förhandl. 1888, s. 484.

[2] The relative ages of these minerals are also recorded by HAMBERG in his papers above mentioned.

The insoluble remainder was a brown powder, probably schefferite or garnet, occurring as impurities in the crystals. P_2O_5 and Fe were proved to be present but in such small quantities, that they could not be separated and determined, neither could Mn O and Sb_2O_5 be testified.

In a special experiment, carried out on a very small scale, the presence of Fl could be traced but not quantitatively determined and it is probable that the loss in the analysis of 0.5 per cent, was due to the presence of this component.

The above given molecular ratio, as deduced from the analysis, points to the formula

$$HO . Ca_5 As_3 O_{12}$$
$$\text{or} \quad 3 As_2O_5 . 10 CaO . H_2O$$

which evidently corresponds with that of apatite and can be derived from the latter if P_2O_5 is exchanged for As_2O_5 and Fl and Cl for HO. To show the close agreement with the formula, the analysis is calculated at 100, the insoluble impurities and the undetermined Fe_2O_3 and P_2O_5 being excluded. The small amounts of MgO and Cl_2 are reduced to quantivalents of CaO and H_2O, in order to facilitate comparison.

	As found.	Calculated.
As_2O_5	54.1	54.42
CaO	44.9	44.16
H_2O	1.0	1.42

The agreement is therefore satisfactory, being greater than the above figures show, because no attention, in this calculation, is paid to the amount of Fl, which is qualitatively, but not quantitatively determined.

If the loss in the analysis of 0.5 per cent is assumed to be Fl, the ratio of 0.78 is raised to 0.94 thereby agreeing closely with the formula which demands the value 1 for this ratio.

The chemical relation of the mineral to apatite is evident. Especially interesting is the occurrence of the hydroxyl-group H O, which is only partly replaced by Cl and Fl. This is, I believe, without analogy, in the apatite group. If, with GROTH, we deduce the formula of apatite from five molecules $Ca(OH)_2$ in which only nine (OH) have been replaced by three AsO_4, the tenth (OH) can either be substituted by Cl and Fl, as in apatite, or remain unreplaced in the formula, as is the case in question.

I think the occurrence of a mineral of this constitution must confirm the above mentioned view on the apatite formula.

Crystallographically also full agreement is found with apatite.

The crystals are of a prismatic type and belong to the hexagonal system.

The following forms are observed:

a[1] $= \infty$ P $(10\bar{1}0)$
$x =$ P $(10\bar{1}1)$
$v =$ P2 $(11\bar{2}1)$
$c =$ oP (0001)

The prism $a = \infty$ P predominates and gives the crystals their long prismatic form. The unit pyramid $x =$ P occurs on all crystals and the corresponding one of the second series $v =$ P2 is also common. The basal plane when present is always small. Fig. 8, 9, Pl. V.

The measurements of two crystals are shown in the following table.

	Crystal I.	Crystal II.	Calculated.
$a : x$	50° 11'—42' Average of 6 angles 50° 28'	50° 17'—51' Average of 6 angles 50° 30'	50° 29'
$x : x$ (top)	Average of 3 angles 78° 46'	Average of 3 angles 78° 36'	79° 2'
$x : x$ (top-edge)		36° 10'	36° 20'
$x : v$		Average of 3 angles 17° 36'	18° 10'

The angles mark rather great differences; especially in the vertical zone as will be seen below.

The system of axes calculated from these angles is

$$a : c = 1 : 0.7143$$

To facilitate comparison I will also give the systems of axes of some of the minerals belonging to the apatite-group, viz:

Apatite . . . . $a : c = 1 : 0.7346$
Pyromorphite . . . $= 1 : 0.7362$
Mimetite . . . . . . $= 1 : 0.7276$
Vanadinite . . . . . $= 1 : 0.7122$

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[1] The letters are chosen to agree with the corresponding ones of apatite.

Thus the system of axes of svabite closely agrees with that of the other members of the apatite group. It would also be interesting to determine whether the svabite belongs to the pyramidal-hemihedral section or not, as is the case with apatite. But this cannot be decided, as dihexagonal pyramids and prisms are absent. But there really is a fact, which points to the conclusion that svabite is hemihedral, for by measurements in the vertical zone, one obtains for each prismatic plane, double images, i. e. beyond the ordinary plain image, there appears, at some distance from it, a second, duller one. It is worthy of notice, that these latter always lie on the same side of the main image. On crystal N:o 1, the measurement gave the following angles, which I have arranged by putting in the first line the main images, in the second the less clear secondary images and in the third the differences between each main image and the corresponding secondary one.

	I.	II.	III.	IV.	V.	VI.
Main images	0° 0′	60° 32′	122° 31′	182° 5′	242° 16′	302° 6′
Second . images		57 36	117 28	176 20		300 43
Differences		2 56	5 3	5 45		1 23

Thus, four among the six main images of the prismatic faces, are accompanied by secondary ones, all lying on the same side of the main.

In this fact we must probably see a case of hemihedral development and ascribe the secondary images to different prismatic planes of the third series.

The crystallographical examination is fully confirmed by the properties of the crystals as shown in parallel and convergent polarized light. A section cut parallel with a prismatic plane, marks extinction in the stauroscope rectangularly and parallel to the axis.

Cleavages parallel to ∞P are thereby noticeable. Another section cut vertical to the *c.*-axis, shows extinction in parallel polarized light during a complete revolution of 360°.

In convergent light the same section shows an uniaxial interference figure, viz: a broad, dark cross without any rings, owing to the weak double refraction. On turning, the cross slightly opens, showing a feeble aud anomalous biaxial character as is also sometimes the case with apatite. The double refraction is negative.

2. **Svabite from the Jakobsberg Mine.**

The same mineral was also met with, some time later, in the Jakobsberg Manganese Mine, near Nordmarken, where I found it in October 1891. The appearance of the mineral here is so unlike that at Harstigen that only by quantitative analysis can its identity with svabite be proved. The svabite from Jakobsberg is massive, yellowish white or quite colourless, translucent and of a vitreous to resinous lustre. No trace of crystalline form and no cleavage can be seen and the blowpipe characters are the same as those mentioned for the Harstigen mineral.

The mineral at Jakobsberg is enclosed in granular and crystalline hausmannite.

Mr R. MAUZELIUS has made two analyses of different varieties.

Analysis V.

Svabite from Jakobsberg (R. Mauzelius).

G = 3.77 at 16° C.

	%	Molecular-Ratio.		
As_2O_5	51.05	0.222	0.225	3.
P_2O_5	0.38	0.003		
SO_3	0,69	0.009	0.077	1.03
Cl_2	0.12	0.002		
Fl_2	1.99	0.052		
H_2O	0.25	0.014		
PbO	3.02	0.014	0.795	10.6
FeO	0.08	0,001		
MnO	0.26	0.004		
CaO	42.07	0.751		
MgO	0.52	0.013		
K_2O	0.30	0.003		
Na_2O	0.56	0.009		
	101.29			
$O = Fl_2, Cl_2$	0.87			
	100.42			

By dissolving the mineral in HCl an insoluble remainder of 2.22 % was found which proved to be barite. The quantities of H_2O, Fl and Cl were each determined in different assays.

The molecular ratio shown above of 3 : 10.6 : 1.03 evidently corresponds with the formula

$$FlCa_5As_3O_{12}$$

$$\text{or}\quad 3As_2O_5 . 9CaO . CaFl_2$$

in which some Fl is replaced by Cl and HO, and Ca partly by Pb, Mg and alkalies.

In this formula we recognise that of apatite with P replaced by As.

Analysis VI,

Svabite from Jakobsberg (R. Mauzelius).

$G = 3.82$ at 15° C.

	%	Molecular-Ratio.		
As_2O_5	50.92		0.221	3.
P_2O_5	trace			
SO_3	0.57	0.007	0.100	1.36
Cl_2	0.08	0.001		
Fl_2	2.80	0.074		
H_2O	0.33	0.018		
PbO	4.52	0.020	0.796	10.8
FeO	0.14	0.002		
MnO	0.19	0.003		
CaO	37.22	0.665		
MgO	3.90	0.097		
K_2O	0.28	0.003		
Na_2O	0.39	0.006		
	101.34			
$O = Fl_2, Cl_2$	1.20			
	100.14			

This analysis does not show as good agreement with the formula as the above, because the molecular ratio is 3 : 10.8 : 1.36 instead of 3 : 10 : 1, but I think it is most probable that the composition of this variety is alike [1].

Although in the latter, by dissolving the mineral, a small quantity of barite was discovered. A comparison with Analysis IV shows that in the Jakobsberg mineral Fl replaces, for the most part, HO, which circumstance still more increases the agreement in composition with apatite. Also in the mineral from Jakobsberg Pb, Mg, K and Na enter in larger amounts replacing Ca.

The differences in gravity are thus explained in the varying quantities of Pb, as the gravity is greatest (= 3.82) in the variety from Jakobsberg which contains most Pb (4.52 %) and smallest in the mineral from Harstigen with only traces of Pb.

Crystallized Svabite from Jakobsberg. Through MR G. FLINK, I received a specimen from the above locality, which he suggested was identical with the svabite from Harstigen about which I had just published

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[1] The molecular ratio, also written as 2 : 7.17 : 0.9 corresponds better with the formula $Ca_7As_4O_{16}Fl_2 = 2Ca_3As_2O_8 + CaFl_2$.

a preliminary note. The specimen showed exceedingly small needle-shaped white crystals, at most 0.5 m.m. in length, implanted in small cavities in black, massive hausmannite. Under the microscope the crystals were found to be formed in the shape of hexagonal prisms $\infty P(10\bar{1}0)$ terminating only in the basal plane $oP(0001)$ (Fig. 10, Pl. V.), the prismatic faces were definitely striated in the direction of the axis. A section vertical to the axis shows an uniaxial image with negative character. Also a decided zone structure is observable (Fig. 11, Pl. V). A qualitative analysis of a very minute quantity of material proved As_2O_5 and CaO to be present and so the identity with svabite was regarded as fixed.

The Harstigen crystals allow of an accurate determination of their crystallographical form, while their constitution could not exactly be fixed, on account of the small quantity of material employed for the analysis. On the other hand, the mineral from Jakobsberg, which was not crystallized, allowed of a complete and exact determination of its chemical formula. So there can now be no doubt as to the constitution and systematical relations of the mineral.

The mineral is named after the eminent Swedish mineralogist and metallurgist of last century »Bergsråd» Anton SVAB.

Characters. Hexagonal, probably pyramidal hemihedral; $a:c = 1:0.7143$. Isomorphous with apatite etc. Cleavage ∞P, imperfect. In crystals of prismatic habit (Harstigen and Jakobsberg) and massive (Jakobsberg) H = 5. G = 3.52 (Harstigen) or 3.77 — 3.82 (Pb-bearing, Jakobsberg). Lustre vitreous to subresinous. Crystals colourless or white, massive yellowish white; streak white. Transparent or translucent. Fracture uneven and chonchoidal. Brittle. Composition $HO.Ca_5As_3O_{12} = 9CaO.3As_2O_5 + Ca(OH)_2$ with some P_2O_5 replacing As_2O_5 and PbO, MgO, MnO, FeO and alkalies replacing CaO; H and Cl also enter instead of (HO). Before the blowpipe fuses with difficulty to a black slag; gives with sodium on charcoal arsenical odour. Occurs in the Harstigen iron and manganese mine, in druses as small crystals on massive schefferite and garnet, together with brandtite, sarkinite and manganophyllite and massive or as very minute crystals in hausmannite in the manganese mine of Jakobsberg in Vermland.

8. Adelite a New Basic Arseniate from Nordmarken, Jakobsberg and Långban, Vermland[1]. Pl. V. Fig. 12, 13.

1. Adelite from the Kittel-mine. Nordmarken.

In the year 1887 or 1888 there was found in the Kittel-mine, Nordmarken, a grey, massive mineral occurring in considerable quantities, which, before the blowpipe, gave the reactions of berzeliite. Further in-

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[1] Part of this paper was already published as a preliminary note in Geol. Fören. Förhandl. Vol. 13, p. 781, 1891.

vestigations have shown that it constitutes a new mineral, with a different composition to that of berzeliite. It occurs together with hausmannite and other manganese ores in a layer, separate from that of the iron ore.

The mineral is grey in colour, translucent and has a resinous lustre.

It occurs as great massive pieces, thickly permeated by magnetite in small grains and scales of metallic copper. Fracture uneven or chonchoidal. Streak uncoloured; hardness = 5. In the microscope the mineral is colourless and in polarized light shows grey, bluish-grey, yellew or yellow-grey. Before the blowpipe, the mineral fuses easily to a grey enamel; with soda on charcoal it gives an arsenical odour. Soluble in diluted acids.

Analysis VII.

Adelite from Kittel-Mine (R. Mauzelius).

Gravity 3.71 at + 14° C.

	%	Molecular Ratio		
As_2O_5	50.04	0.218	0.218	0.97
CaO	25.43	0.454	0.902	4.
MgO	17.05	0.423		
BaO	trace	—		
MnO	1.64	0.023		
PbO	0.39	0.002		
Cl_2	0.24	0.007	0.243	1.08
H_2O	4.25	0.236		
Fe_2O_3 + Al_2O_3 . . .	0.30	—	—	—
Copper	0.26	—	—	—
	99.60	—	—	—
O corresponding to Cl_2	—0.05	—	—	—
	99.55	—	—	—

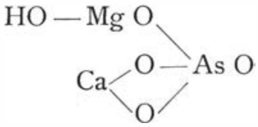
The amount of water given in the analysis has been determined as loss by heating. An attempt has been made to determine the amount of water directly but without decided results. By heating in a gas-oven, to the greatest heat the oven could give, the loss was only 1.5 per cent, which was directly determined.

That the mineral contains still more water is evident from the fact that when the powder, already heated in the oven, is further heated in a closed glass-tube over the full flame of a Bunsen burner it gives off water freely. This amount, given off only at a high temperature, is determined at about 2.75 percent.

The molecular ratio corresponds closely to the formula

$$2\,CaO\,.\,2\,MgO\,.\,H_2O\,.\,As_2O_5$$

or, as it may also be written



The mineral is therefore a basic orthoarseniate of lime and magnesia.

Its relations to berzeliite must now be considered. The composition of the minerals known under the common name of berzeliite is not yet decided, as the latest analyses show different results[1]. But whether the formula $3\,RO\,.\,As_2O_5$ or $10\,RO\,.\,3\,As_2O_5$ is adopted, the difference of its composition from that of adelite is evident. The berzeliites are either true normal orthoarseniates $3\,RO\,.\,As_2O_5$ or come very close to this formula, while adelite, on the contrary, is a highly basic arseniate with the formula

$$5\,RO\,.\,As_2O_5.$$

Another essential difference is that adelite contains basic hydrogen while berzeliite is a saturated arseniate.

With regard to its composition, adelite is closely related to the natural group of minerals, the general formula of which is

$$(\overset{II}{R}\,.\,OH)\,\overset{II}{R}\,\overset{V}{Q}\,O_4$$

in which R is some biatomic metal and Q five-atomic P, As or V. To this group, which contains an orthorhombic and a monoclinic section belong among others the species

$$\left.\begin{array}{ll} \text{Libethenite} & = (Cu\,.\,OH)\,Cu\,PO_4 \\ \text{Adamine} & = (Zn\,.\,OH)\,Zn\,As\,O_4 \\ \text{Descloizite} & = (Pb\,.\,OH)\,(Pb,\,Zn)\,VO_4 \end{array}\right\}\ \text{orthorhombic}$$

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[1] The analyses of LINDGREN and FLINK, the former of an anisotrope, the latter of an isotrope berzeliite from Långban, both give the formula of a normal orthoarseniate $3\,RO\,.\,As_2O_5$; on the other hand, HÖGBOM's analysis of an isotrope variety from the same locality seems to confirm the formula proposed by KÜHN $10\,RO\,.\,3\,As_2O_5$ while IGELSTRÖM's analyses of berzeliite from Nordmarken come between these formulas. LINDGREN Geologiska Föreningens i Stockholm Förhandlingar Vol. 5, p. 552; FLINK Bihang till Kongl. Vet. Akademiens Handl. Vol. 12, p. 27. HÖGBOM Geologiska Föreningens Förhandlingar Vol. 9, p. 398. IGELSTRÖM Geologiska Föreningens Förhandlingar Vol. 7, p. 101.

and

$$\left.\begin{array}{l}\text{Wagnerite} = (\mathrm{Mg} \,.\, \mathrm{Fl})\ \mathrm{Mg\ PO_4} \\ \text{Sarkinite} = (\mathrm{Mn} \,.\, \mathrm{OH})\ \mathrm{Mn\ As\ O_4}\end{array}\right\}\ \text{monoclinic}$$

Of these sarkinite also occurs in the Swedish manganese mines under the same conditions as adelite.

It was not possible, from the Kittel-mine find, to determine whether adelite belonged to the orthorhombic or monoclinic system, as it did not occur in crystals. In one of the thin sections of massive adelite I happened to find some grains which were cut normal to the acute bisectrix and in convergent polarized light showed a wide optical angle, which, by measurement under the microscope, was approximately determined at

$$2\,E = 106^\circ\ 40'$$

The dispersion of the axes is $\varrho > \nu$[1]; the acute bisectrix is positive.

2. A Mineral related to Adelite from Moss-mine, Nordmarken.

It is of interest to compare, with the above described mineral, another found some years earlier in the Nordmark mine. It was described by me in a paper on »the Paragenical Relations of the Arseniates of Nordmarken» in the year 1884[2]. It was found as irregular grains in the »manganese vein» of Moss-mine, together with calcite, hausmannite, pyrochroite, manganosite, manganostibite and the hydrous arseniates, allaktite, diadelphite[3], synadelphite, hemafibrite, manganostibiite, etc. and I suggested that it was the primary arseniate, from which all the secondary, hydrous arseniates above mentioned were derived.

On this occasion I gave an analysis of the mineral, made by Dr C. H. LUNDSTRÖM, which showed a loss of 2.32 per cent, but the water was not determined. The mineral further contained 1.44 per cent of insoluble, foreign material. On the supposition that the loss is only water, the analyses, calculated at 100 per cent, show

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[1] In my preliminary note in Geol. Fören. Förhandl. Bd. 13, p. 787 it stands $2\,H = 106^0\ 40$ which may be corrected to $2\,E = 106^0\ 40$; also $\varrho < \nu$ is erroneous and must be $\varrho > \nu$.

[2] Geol. Fören. i Stockholm Förhandl. Vol. 7, p. 407.

[3] I use the name diadelphite (A. Sjögren) instead of aimatolith (hematolith Igelström) for the following reason. The papers of the two authors were published *simultaneously* i. e. in the same number of the Geol. Fören. i Stockholm Förhandl. (Number 88 for Aprii 1884). Therefore it cannot justly be said that the one "name has the priority" (Dana's System Ed. VI, p. 803). As IGELSTRÖM'S analysis later on was considered to be partly incorrect and his name declared objectionable, the two authors agreed that the name "aimatolith" should be disused and replaced by "diadelphite". This agreement was published in Geol. Fören. Förhandl. Vol. 7, p. 726. In spite of it, GROTH (Tabell. Uebersicht d. miner. Ed. 3, p. 78 as well as DANA, seem to prefer the name given by IGELSTRÖM after having changed it to the more proper form of hematolith.

Analysis VIII.

Adelite-like Mineral from Moss-mine (C. H. Lundström 1884).

	%	Molecular Ratio		
As_2O_5	49.73	0.216	0.216	1
CaO	25.52	0.455	0.958	5.041
MgO	18.98	0.474		
BaO	0.81	0.005		
MnO	1.69	0.023		
ZnO (?)	0.08	0.001		
Al_2O_3 + Fe_2O_3 . .	0.83	—	—	
H_2O (loss) . . .	2.36	0.131		
	100.00	—	—	—

This mineral is therefore like adelite represented by the general formula

$$5RO . As_2O_5$$

but it seems that the mineral from the Moss-mine only contains half as much water as that from Kittel-mine. This circumstance may be looked at in two different ways. Either the former mineral really only contains half the amount of water and is composed as

$$9RO . HO_2 . As_2O_5. \qquad (R = Ca, Mg)$$

or it was originally an anhydrous compound

$$10RO . 2As_2O_5,$$

the small amount of water being due to incipient decomposition. This interpretation is supported by the fact, that the mineral in thin sections proves to be somewhat decomposed.

The mode of occurrence in the two mines is also rather different although the minerals in both cases occur together with manganese ore.

In order to prevent ambiguity I confine the name adelite to the mineral of the composition $4RO . H_2O . As_2O_5$ and leave future examinations to decide the relation of the mineral from Moss-mine to the true adelite.

3. **Crystallized Adelite from the Jakobsberg-mine.**

During a visit at this mine in October 1891 I found a yellowish-grey, berzeliite-like mineral, occurring massive in hausmannite-bearing limestone together with manganophyllite, piedmontite etc. The mineral shows externally no resemblance to the Nordmarken adelite and only the chemical analysis proved the identity. By cautiously dissolving the calcite in acetic acid I happened to get some crystals and fragments of crystals, which allowed the determination of the crystallographical form and optical properties. The chemical composition of the adelite from Jakobsberg is shown in the following analysis.

Analysis IX.

Adelite from Jakobsberg (R. Mauzelius).

Gravity 3.72 at 15° C.

	%	Molecular Ratio		
As_2O_5 . .	48.52	—	0.211	0.95
SO_3 and Cl	trace	—	—	—
Pb O . . .	2.41	0.012	—	—
Fe O . . .	0.09	0.001	—	—
Mn O . . .	1.27	0.018	0.922	4.15
Ca O . . .	23.13	0.413	—	—
Mg O . . .	19.25	0.478	—	—
H_2O . . .	3.99	0.222	0.222	1
SiO_2	1.88	0.031	—	—
	100.54			

If we leave the silicic acid out of consideration, as this certainly does not belong to the mineral, the molecular ratio is $As_2O_5 : RO : H_2O = 0.95 : 4.15 : 1$ which evidently answers to the formula of adelite.

The agreement with the formula will be still greater if we subtract from the basic components as much as corresponds to the silicic acid for constituting ortho-silicate. This way of interpreting the existence of the silicic acid in the analysis is probably the most natural as a mineral of the olivine group often occurs in crystalline limestones of this kind and such a mineral, by its yellowish-grey colour, could easily escape detection when picking out the material for analysis. The above molecular ratio then will be

$$1 : 4.08 : 1.05$$

evidently corresponding to the formula

$$\left.\begin{array}{r} HO\,.\,Mg \\ Ca \end{array}\right\} AsO_4$$

in which small amounts of Ca are replaced by equivalent quantities of Pb, Mn and Fe.

The crystallographical form of adelite. The disengaged crystals are a few millimetres in size, and mostly fragmental. They show rounded edges and corners and only few faces are smooth enough to allow of measurement. The measurements of four crystals have shown that the mineral belongs to the monoclinic system with the following system of axes:

$$a : b : c = 1.0989 : 1 : 1.5642$$

$$\beta = 73^\circ\,15'$$

This axial system is derived from the following fundamental angles

$$\begin{aligned} c\ (001) : a\ (100) &= 73^\circ 15' \\ M(110) : M(1\bar{1}0) &= 87\ \ 5 \\ M(\bar{1}10) : d\ (\bar{2}21) &= 24\ \ 45 \end{aligned}$$

The following faces are observed:

$$\begin{aligned} a &= \infty \bar{P} \infty\ (100) \\ c &= 0P\ \ (001) \\ M &= \infty P\ \ (110) \\ f &= \acute{P} \infty\ (011) \\ d &= P\ \ (\bar{2}21) \end{aligned}$$

The crystals are either tabular parallel with $c(001)$ (as fig. 12, Pl. V) or prismatic with $M(110)$ dominating (fig. 13 Pl. V). The faces M are smooth and give good reflections; distinct cleavages are found parallel to these faces. The face a is smooth but less brilliant than the M-faces; c is often curved and gives double or indistinct images; this face is deeply striated parallel with the edge of intersection with $a(100)$. The pyramid d is uneven and allows only of approximate measurements The dome f is observed only on one crystal.

Table of Angles.

	1.	2.	3.	4.	Calculated.
$M(110) : M(1\bar{1}0)$	87° 0′	86° 56′	87° 12′	87° 20′	87° 5′
$c\ (001) : M(110)$		79 3		79 5	78 33
$M(\bar{1}10) : d\ (\bar{2}21)$		24 58	25 15		24 45
$c\ (001) : a\ (100)$				73 15	73 15
$c\ (001) : f\ (011)$				56 27	56 17
$c\ (001) : d\ (\bar{2}21)$		76 26			75 27

Optical Properties. The examination in polarized light shows that the mineral is strong double refracting. The optical axes lie in the plane of symmetry and the acute bisectrix makes an angle of 38° 45′ with the c axis; this bisectrix lies in the obtuse angle between the crystal axes. The double refraction is positive. The optical orientation is thus

$$B_a \wedge c = + 38^\circ 45'.$$

The optical angle for Na-light was measured in a solution of mercuric iodide in potassium iodide ($n = 1.6703$) with the following result

$$2 K_{ay} = 58^\circ 47'.$$

The dispersion is $\varrho > \nu$.

The chemical relation to the wagnerite group has already been alluded to. On account of showing the crystallographical agreement with this group one may multiply the *a*-axis by 2. The correspondence is then evident as shown in the following comparison:

Triploidite	$a : b : c$ =	1.8572 : 1 : 1.4925	β = 71° 46'
Wagnerite	=	1.9145 : 1 : 1.5059	= 71 53
Sarkinite	=	2.0017 : 1 : 1.5154	= 62 13½
Adelite	$2a : b : c$ =	2.1978 : 1 : 1.5642	= 73 15

One may thus refer adelite to a system of axes fully corresponding to that of the wagnerite but I found it preferable to use the system of axes which gives the simplest symbols to the faces.

Also in optical properties adelite agrees with the other members of the wagnerite-group as they all have the plane of optic axes parallel to that of symmetry.

4. **Adelite from Långban.**

Adelite occurs also at Långban but with a somewhat different appearance and in different association from that at Nordmarken. Specimens show a pale yellow-grey colour, much resembling certain varieties of berzeliite. It occurs together with impure calcite, braunite and asbestos-hedyphane[1].

Analysis X.

Adelite from Långban (R. Mauzelius).

G. = 3.76 at 15° C.

	%.	Molecular Ratio.		
As_2O_5	50.28	0.219	0.219	0.97
Ca O	24.04	0.429	0.900	4
Mg O	17.90	0.444		
Ba O	0.23	0.002		
Pb O	2.79	0.013		
Cu O	0.32	0.004		
Fe O	0.08	0.001		
Mn O	0.48	0.007		
Cl	trace	—		
H_2O	3.90	0.217	0.217	0.97
	100.02			

---

[1] The designation of a peculiar compound of two minerals, found at Långban for some years in different parts of the mine. It formed fibrous aggregates up to an inch in length of a grey to brownish colour and silky lustre. A microscopical examination has shown that it is composed of two different minerals of which one, in the form of thin needles with a starlike intersection permeates the other, and gives the whole compound a fibrous, asbestos like appearance. The needle-like mineral is a hydrous silicate of magnesia with a composition similar to that of serpentine; the other mineral is chiefly an arseniate of lead with some lead chloride, but it does not seem to be identical with the common hedyphane. Both minerals are double refracting.

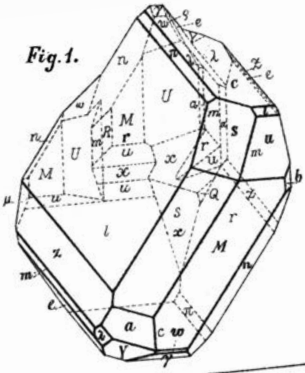
It is evident that this mineral is of exactly the same composition as that from Kittel-mine, Nordmarken. The water is also here determined partly direct (1.52 per cent, which goes off at a moderate heat) partly as loss by heating (2.38 per cent).

The name is derived from αδηλος i. e. unclear.

Characters. Monoclinic but seldom crystallized. $a : b : c = 1.0989 : 1 : 1.5642$ $\beta = 73^\circ 15'$ Forms $a(100)$, $c(001)$, $M(110)$, $f(011)$, $d(2\bar{2}1)$. Geometrically isomorphous with the wagnerite-group. Generally massive or compact. Cleavage parallel $M(110)$, distinct. $H = 5$. G. 3.71 — 3.76. Lustre resinous. Colour grey (Kittel-mine, Nordmarken) or yellowish-grey (Jakobsberg and Långban). Streak uncoloured. Translucent. Fracture uneven or chonchoidal. Double refraction strong, positive. Angle of optic axes $2H = 58^\circ 47'$ (in a medium of the refracting power $n = 1.6703$). Dispersion $\varrho > \nu$. Composition: $2\,CaO \, . \, 2\,MgO \, . \, H_2O \, . \, As_2O_5$ with small amounts of Mn, Pb, Fe, and Ba replacing some Ca or Mg, thus in composition analogous to wagnerite, sarkinite etc. Before the blowpipe fuses easily to a grey enamel; with soda on charcoal arsenical odour. Soluble in diluted acids. Found in the Kittel-mine, Nordmarken, in Jakobsberg and Långban-mines, Vermland, together with other arseniates and manganese minerals. A closely related mineral is known from the Moss-mine, Nordmarken, with the composition $9\,RO \, . \, H_2O \, . \, 2\,As_2O_5$. $(R = Ca, Mg)$.

Axinite Fig. 1—5.

Fig. 1.



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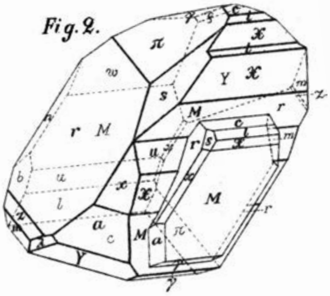
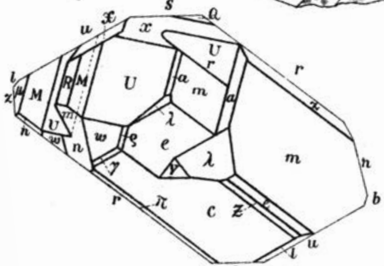


Fig. 5.

Fig. 3.



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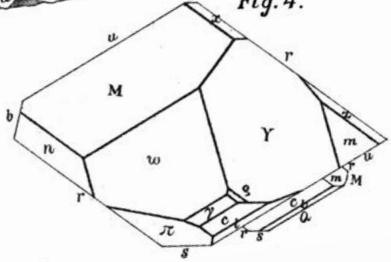


Hedyphane Fig. 6—9.

Fig. 7.

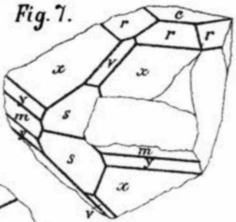
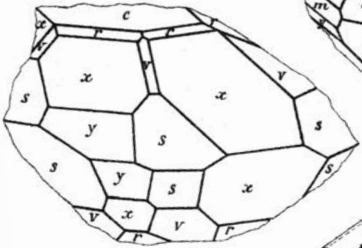


Fig. 6.



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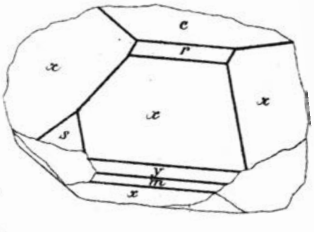

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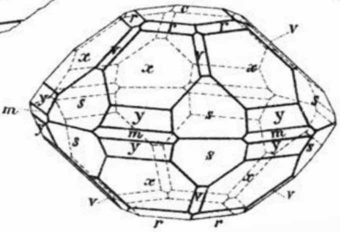
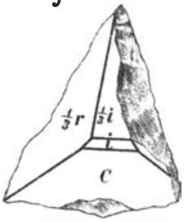


C. Morton del. *Lith. L. L. Ljunggren.*

HJ. SJÖGREN. Humite from Nordmarken. Pl. II.

Humite Fig. 1—11.

Fig. 1.



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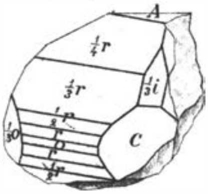

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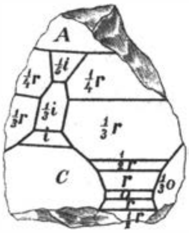
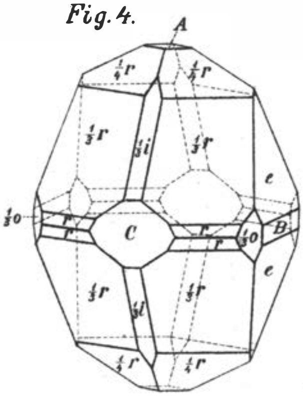


Fig. 4.



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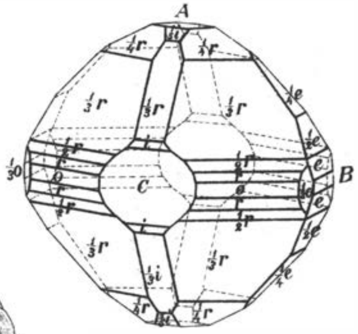

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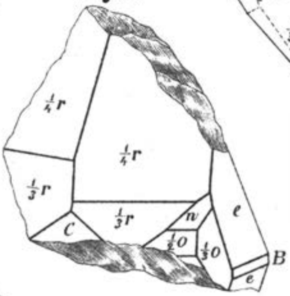

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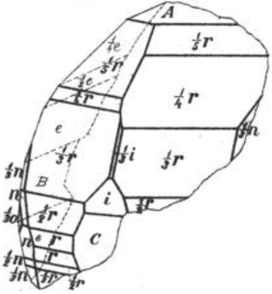

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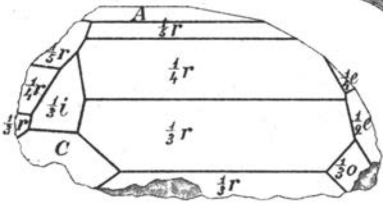

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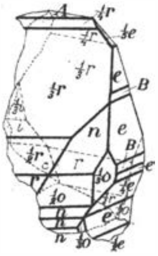

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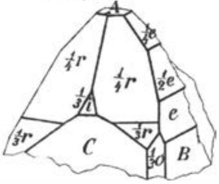

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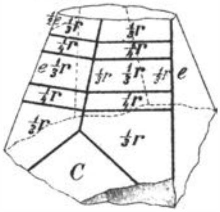

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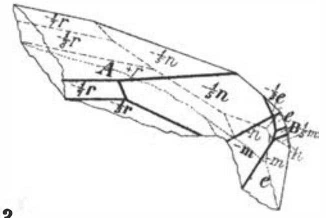
Chondrodite Fig. 1—12.

Fig. 1.



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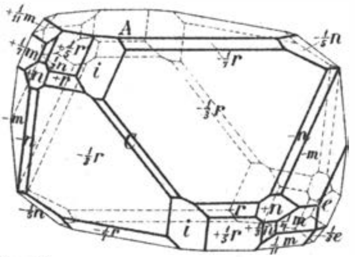

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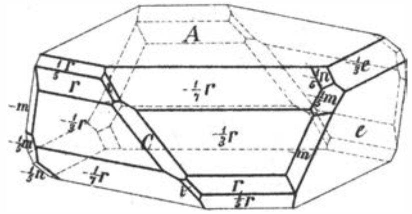

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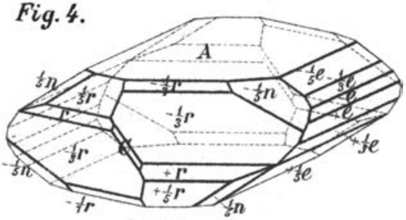

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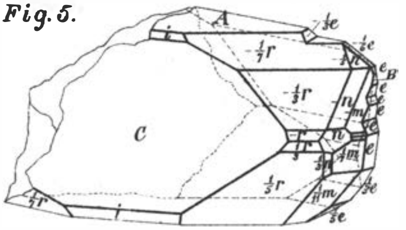

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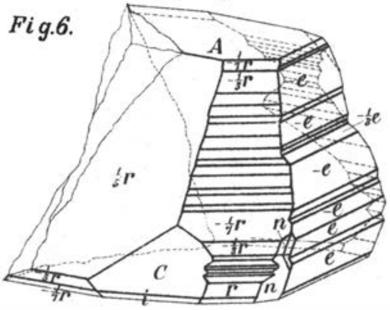

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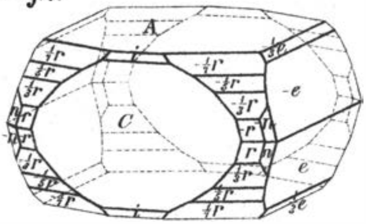


Fig. 8.

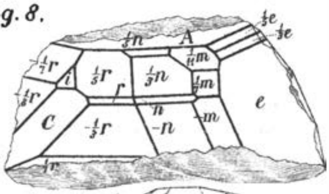
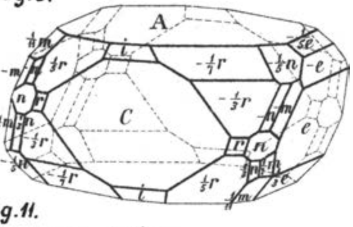


Fig. 9.



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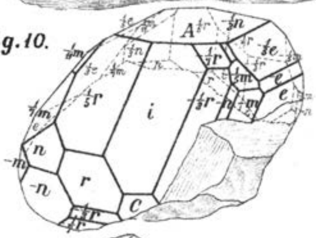

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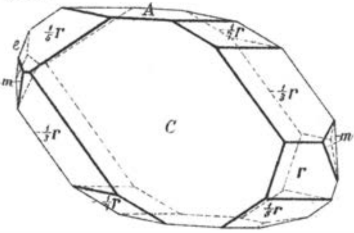

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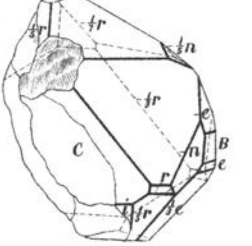

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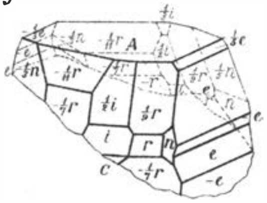
Clinohumite Fig. 1–8.

Fig. 1.



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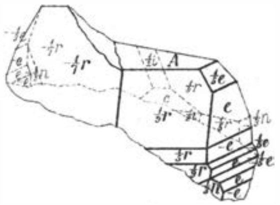
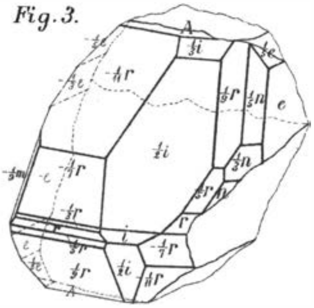


Fig. 3.



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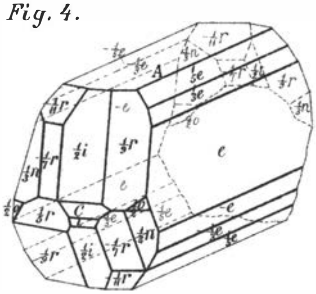

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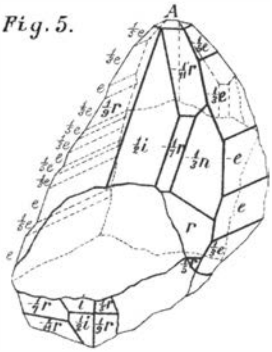
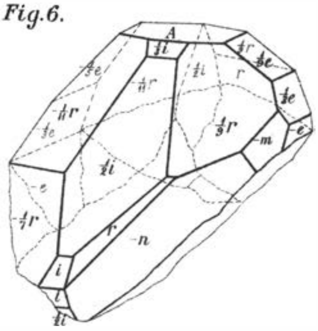


Fig. 6.



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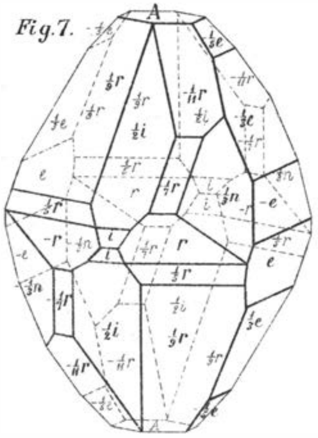

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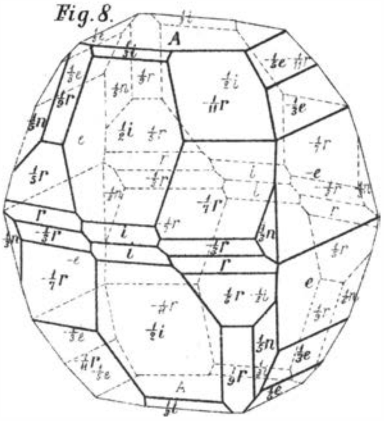


C. Morton. del.

Lith. L. L. Ljunggren.

Longbanite Fig. 1—7.

Fig. 1.

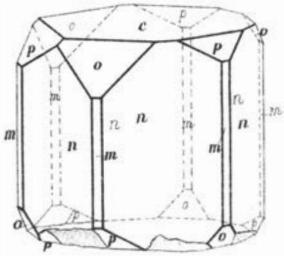
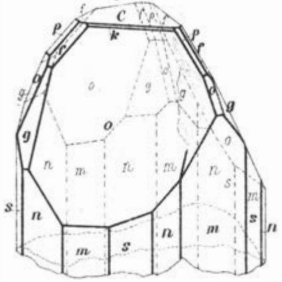


Fig. 4.



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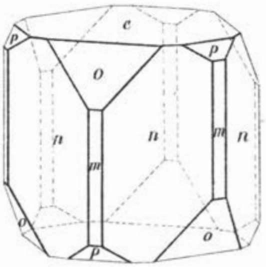
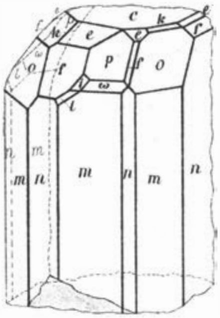


Fig. 3.



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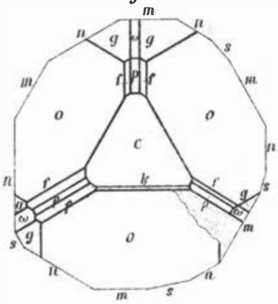

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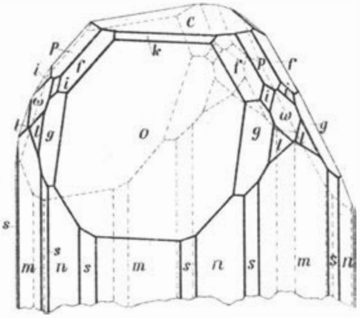
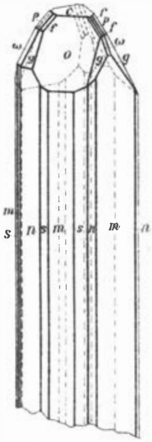


Svabite Fig. 8—11.

Fig. 7.



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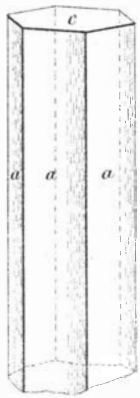


Fig. 8.

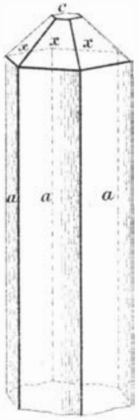
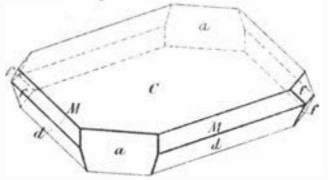


Fig. 9.

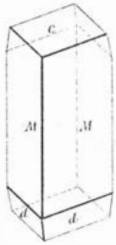
Fig. 12.



Adelite Fig. 12—13.

Fig. 11.

Fig. 13.



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