THE AMERICAN MINERALOGIST

JOURNAL OF THE MINERALOGICAL SOCIETY OF AMERICA

VOL. 15 JUNE, 1930 No. 6

CENOSITE FROM NORTH BURGESS TOWNSHIP, LANARK COUNTY, ONTARIO

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INTRODUCTORY

Some years ago Dr. W. F. Ferrier and Mr. W. L. McLaren noted the occurrence of minute pink or pale rose colored crystals on some specimens of calcite and quartz that they collected on lot 8, con. V, North Burgess township, Lanark county, Ontario. Ferrier recognized that these crystals did not resemble any known species, and he therefore concluded that they must either be a new mineral, or else an unusual variety of a very rare one. At that time, a specimen carrying a few of the pink crystals was sent to one of the writers for examination, and the results of this appeared to confirm the view that the species was new, since search of the literature revealed no other mineral having the same specific gravity, crystal angles, and refractive indices. At a later date, Ferrier and McLaren furnished the writers with a suite of specimens, and it has been possible to make a more complete examination of the material, including a detailed chemical analysis.

As will appear, the mineral has essentially the same composition as cenosite, and like the latter it is orthorhombic. Here, however, any very close resemblance between the two ceases. The crystal constants of the Ontario material are quite markedly different from those recorded by Sjögren for cenosite from Nordmark, and the same is true of the refractive indices, which were determined for the Nordmark cenosite by E. S. Larsen. The Ontario mineral has a specific gravity of 3.612, as compared with 3.413 for cenosite from Hitterö and 3.38 for that from Nordmark, and its color ranges from very pale to deep pink, whereas cenosite from the two previously recorded localities is described as yellow-brown to dark chestnut-brown.

Until the chemical analysis had been completed, there was, therefore, little to indicate that the mineral might be identical with, or even closely related to, cenosite. On learning that it was probably a new species, Mr. W. L. McLaren, of Forest Lodge, Perth, Ontario, who has contributed so largely to the knowledge and preservation of the minerals of the district in which he lives, devoted a great deal of his time during three seasons to collecting all the specimens he could find of the mineral.

There are three published analyses of cenosite—two by A. E. Nordenskiöld of the original material from Hitterö, and one by R. Mauzelius on 0.0666 grams of material from the Nordmark locality. The results of these analyses, and also of that of the North Burgess mineral, are reproduced below. As will be noted, these analyses differ from one another in several important respects, which are discussed in the section dealing with the chemical composition; but in their main essentials there is a fairly close correspondence, and the North Burgess analysis agrees as closely with the analyses of the two accepted occurrences of cenosite as do these with one another. Under the circumstances, therefore, it seems best to regard the North Burgess mineral also as cenosite, and not as a new species closely related to cenosite. The differences observed in its crystallographic, optical, and other characters, as compared with those previously recorded for cenosite, must be ascribed either to variations in the compositon, which is both complex and unusual, or to the fact that the material available from the Hitterö and Nordmark localities was both poor and scanty, as witness the very small amount used by Mauzelius in his analysis.

HISTORICAL

Cenosite, or more properly kainosite, was first described by A. E. Nordenskiöld in 1886[1] from Igeltjern, on the island of Hitterö, Norway, and was so named owing to its peculiar composition (*καιγός*, unusual). The mineral was obtained only in a single specimen as a fragment of a six-sided prismatic crystal, which appeared to be either orthorhombic or monoclinic, and was described as having a distinct cleavage in one direction, and indistinct cleavage along two other planes inclined at 90° or thereabouts. The material was yellowish-brown and semi-transparent, with a somewhat greasy lustre, resembling in this respect apatite and nephelite. H = 5.5. Sp. Gr. = 3.413. Nordenskiöld gave the results

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[1] Kainosit, ein neues Mineral von Hitterö in Norwegen: *Geol. Fören. Förhandl.*, **1886**, 8, pp. 143–146.

of two analyses of the cenosite (see below), and from these he deduced the formula: $4SiO_2+CO_2+(Yt_2O_3,Er_2O_3)+2CaO+2H_2O$.

He called attention to a possible relationship in chemical constitution between cenosite and cancrinite. The mineral is soluble in acids, slowly in the cold and readily when heated, with evolution of carbon dioxide. It gives off water at a low red heat, and carbon dioxide at a higher temperature, and fuses with difficulty to a white enamel.

The only other recorded occurrence of cenosite is at the Ko mines, Nordmark, Sweden, and was described by H. J. Sjögren in 1897.[2] Here the mineral occurs in short prismatic crystals (orthorhombic) which have a yellow-brown to dark chestnut-brown color and a greasy lustre. Cleavage was not observed. H=5-6. Sp. Gr.=3.38. Common forms: $m\{110\}$, $c\{001\}$, $d\{011\}$, with subordinate $b\{010\}$, $e\{021\}$, $f\{023\}$, $g\{201\}$, and $h\{230\}$. Sjögren states that the basal plane is often rounded and the brachydomes corroded, so that the crystals do not lend themselves to accurate measurement. He gives the angles $(110):(\bar{1}10)=92°\ 50'$ and $(011):(010)=41°\ 33'$, and the axial ratio $a:b:c=0.9517:1:0.8832$; and he calls attention to the fact that this axial ratio is near that of cerite, for which $a:b:c=0.9988:1:0.8127$.

It has been pointed out (see *Dana*, Appendix I, p. 15) that the value 41° 33′, given in Sjögren's original paper as the angle (011):(010), is not in agreement with his calculated axial ratio, and assuming the latter to be correct the angle (011):(010) is 48° 33′.

Sjögren's paper did not contain any account of the optical characters of the mineral, but in a footnote he stated that these were to be dealt with in a subsequent paper, which was to contain also further crystallographic data and figures of the crystals. This supplementary paper, apparently, was never published. The paper cited, however, gives the results of an analysis by R. Mauzelius. This is reproduced below.

The Nordmark cenosite occurs in druses, which have apparently originated through the solution of calcite, in the fine grained magnetite ore of the Ko mine. The associated minerals are diopside, magnetite, clinochlore, and apatite, which have been formed in the

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[2] Kainosit von der Kogrube im Nordmarkgebiet: *Geol. Fören. Förhandl.*, **1897**, 19, pp. 54–60,

order named. The cenosite crystallized last of all, as isolated crystals a few millimeters in size.

The only other original reference to cenosite that can be found is in a paper by E. S. Larsen[3], who gives the following optical characters for the Nordmark mineral: Optically–, $2V$ = medium large. Brownish and clouded in section and non-pleochroic.

$$\alpha = 1.667 \pm 0.003,\ \beta = 1.681 \pm 0.003,\ \gamma = 1.683 \pm 0.003.$$

MODE OF OCCURRENCE OF THE NORTH BURGESS CENOSITE

The following particulars are from notes kindly communicated to the writers by Dr. Ferrier, Mr. McLaren, and Dr. Chas. Palache.

The specimens came from an old pit about 50 feet deep, now filled with water, which was originally opened for apatite on a vein running north and south. It was also worked for mica some years prior to 1907 and again in that year.

The indications are that the material in which the cenosite occurs was taken out during the last days of the work done in 1907, which consisted of drifting along the vein at a depth of 25 feet from the surface.

In the dump there are large masses of brecciated material made up of phlogopite, apatite, and calcite which are often coated with a later layer of calcite, and it appears as if the cenosite and its closely associated minerals have been formed in solution cavities in this calcite.

The specimens showing cenosite have a matrix of coarsely granular limestone containing apatite grains, plates of phlogopite, and a few grains of sphalerite. Solution cavities in the limestone are lined with crystals of quartz or of calcite. In some cavities, planted on both these minerals, are crystals of cenosite. Chalcopyrite, in well formed but deeply striated crystals, is sparsely present. The latest mineral to form is celestite, in platy aggregates which sometimes cover all the other minerals on the cavity walls.

On one specimen, tiny rosettes of silvery needles are implanted on quartz and calcite. Optical tests indicated that these are a soda pyroxene near aegirite. The needles are thin blades.

The order of deposition may be shown approximately by the following diagram:

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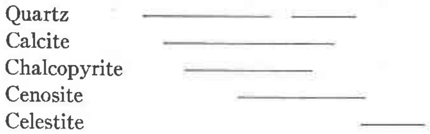
[3] The Microscopic Determination of the Non-opaque Minerals: *U. S. G. S., Bull.* **679**, 1921, p. 54.



Calcite.—The crystals are combinations of the scalenohedron $v(21\bar{3}1)$ with r $(10\bar{1}1)$ and f $(02\bar{2}1)$. The faces of v are bright but uneven; r is smooth and dull; f is bright. The scalenohedron is dominant in most crystals, and on those in some of the cavities the unit rhombohedron has been overgrown at a late stage by rounded scalenohedral faces. On crystals in other cavities, the scalenohedral faces are reduced to mere lines on the edges of the rhombohedron. The color of the calcite is pale buff to faintly pink.

Quartz.—The crystals are of the common habit, with prism m $(10\bar{1}0)$ dominant, r $(10\bar{1}1)$ and z $(0\bar{1}11)$ generally equally developed. A marked etching of the prism faces is noteworthy, in its early stages developing narrow straight furrows but finally producing a network of grooves which destroys the lustre of the faces. A rounding of three alternate edges of the prism was also noted. The rhombohedra r and z remain quite unetched.

Clear transparent crystals, some up to 2 inches in length and doubly terminated, have been found at the locality.

Apatite.—Besides the massive variety, small doubly terminated translucent crystals of a bright green color occur imbedded in a white calcite.

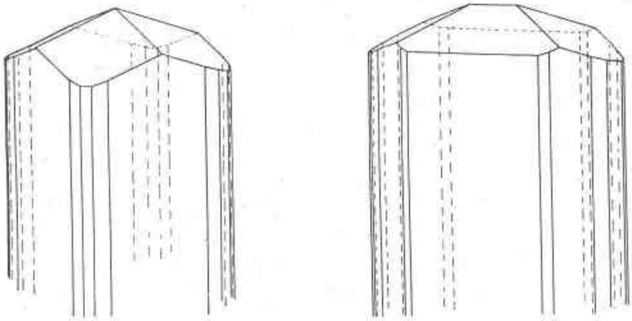
Pyrite.—One or two sharp-angled, brilliant, elongated octahedra up to three-quarters of an inch in length, resembling closely the well-known crystals from French Creek, Penna., were found.

Sphalerite.—This mineral occurs rarely at the locality in very small well formed isolated tetrahedral crystals, which are sometimes twinned.

CRYSTALLOGRAPHY

The best crystallographic material consists of minute prismatic crystals, 0.5 to 1.0 mm. in diameter, which occur either as isolated crystals, which may be doubly terminated, or in more or less solid crusts from which the free ends of the prisms, singly or in interfering groups, project. Less commonly the crystals are larger than this, and on some of the specimens there are composite crystals in nearly parallel intergrowth which measure half an inch across.

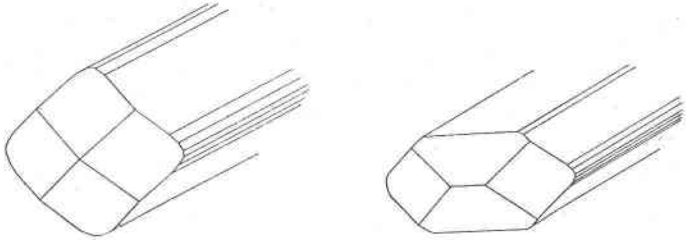
The smaller crystals are perfectly transparent and nearly colorless, but invariably with a faint pink tint. With increase in size this color becomes more pronounced until in the larger crystals and more coarsely crystallized material the color is rose-red to a fairly deep pink. The greater depth of color is accompanied by a loss in transparence, the larger crystals being clouded and some of them barely translucent.



Prismatic Orientation

$a:b:c=0.8759:1:0.4638$

Forms: (101), (011), (100), (320), (110), (340), (120), (010).



Sjögren's Orientation

$a:b:c=0.9517:1:0.8832$

Forms: (001), (023), (011), (043), (021), (010), (201), (210).

In the orientation adopted here, the direction of elongation of the crystals is taken as the prism zone, although, as noted below it is believed that this is not the same as Sjögren's orientation. Regarded in this way, the typical crystals are orthorhombic prisms terminated at either end by four faces of the macro and brachy domes or prisms. The prism zone usually includes, in addition to the dominant unit prism, narrow faces of several other prisms and also of the macro and brachy pinacoids; and the large, deeply colored crystals, while still prismatic in habit, are commonly tabular owing to the relatively large development of the macro pinacoid *a* (100). The accompanying figures illustrate these two habits. The basal pinacoid, recorded by Sjögren as a dominant form on the Nordmark cenosite, was not observed on any of the crystals measured or examined.

Although the small, transparent crystals appear at first sight to be almost ideal for measurement, it was found that as often as not the faces yield diffuse or multiple images. In the prism zone the multiple images are due to the presence of extremely narrow faces of a series of nearly coincident prisms, as a result of which there is a tendency to curvature. In some of the crystals measured also, the dome faces, and especially the brachy dome faces, were found to be composite, each consisting of two faces meeting in an edge in the direction of the vertical axis and inclined to one another at a salient angle ranging up to about 5 degrees. No evidence of twinning was observed, however, either on the goniometer or in the course of the optical examination of the crystals.

In all, fifteen crystals were measured. The results tabulated below are based on the most reliable and consistent of the readings obtained. Owing to the uncertainty whether the orientation adopted here is the same as that of Sjögren, it has been thought advisable to derive the crystal constants independently and for this purpose the dominant prism is taken as the unit prism (110), and the only two domes observed on the crystals are taken as the unit domes (101) and (011).

System: Orthorhombic (Normal Class)

$a:b:c=0.8759:1:0.4638$; $p_0=0.5295$, $q_0=4638$. Forms observed: (100), (010), (120), (340), (450), (110), (320), (101), (011).

In addition to the above, one or more faces of the following prisms are present on some of the crystals measured: (490), (590), (230), (670), (780), (890), (11.12.0), (650), (430).

Table of Calculated and Observed Angles

Symbol		Calculated		Measured		No.	Limits, ϕ or ρ
Mlr	Gdt.	ϕ	ρ	ϕ	ρ		
100	$\infty 0$	—	—	—	—		—
010	0∞	—	—	—	—		—
120	$\infty 2$	29°43′	90°00′	29°49′	90°00′	16	28°15′–31°28′
340	$\infty\,{}^{4}/_{3}$	40 34	90 00	40 37	90 00	6	39 44 –41 43
450	$\infty\,{}^{5}/_{4}$	42 24	90 00	42 42	90 00	6	42 05 –43 09
110	∞	48 47	90 00	48 47	90 00	50	47 47 –49 37
320	${}^{3}/_{2}\,\infty$	59 43	90 00	59 42	90 00	5	58 40 –60 36
101	10	90 00	27 54	90 00	27 54	6	27 47 –27 58
011	01	00 00	24 53	00 00	24 55	7	24 09 –25 30
490	$\infty\,{}^{9}/_{4}$	26 54	90 00	27 11	90 00	9	26 21 –27 46
590	$\infty\,{}^{9}/_{5}$	32 23	90 00	32 30	90 00	3	32 16 –32 43
230	$\infty\,{}^{3}/_{2}$	37 16$\frac{1}{2}$	90 00	37 14	90 00	1	37 14
670	$\infty\,{}^{7}/_{6}$	44 23	90 00	44 13	90 00	4	43 54 –44 37
780	$\infty\,{}^{8}/_{7}$	44 58	90 00	44 52	90 00	2	44 51 –44 53
890	$\infty\,{}^{9}/_{8}$	45 25	90 00	45 35	90 00	3	45 22 –45 59
11.12.0	$\infty\,{}^{12}/_{11}$	46 18	90 00	46 36	90 00	4	46 19 –46 58
650	${}^{6}/_{5}\,\infty$	53 52	90 00	54 00	90 00	2	53 38 –54 21
430	${}^{4}/_{3}\,\infty$	56 42	90 00	56 48	90 00	2	56 46 –56 50

Comparison with Sjögren's Data:

As stated above, Sjögren recorded the following forms on cenosite from Nordmark: *b*(010), *c*(001), *m*(110), *h*(230), *g*(201), *f*(023), *d*(011), and *e*(021). He gave the angle $(110):(\bar{1}10)=92°\ 50'$, and $(011):(010)=41°\ 33'$ (the latter presumably a misprint for 48° 33′), and also the axial ratio $a:b:c=0.9517:1:0.8832$.

On the assumption that the orientation adopted for the North Burgess cenosite is the same as that of Sjögren, there is a rather remarkable difference in the forms exhibited by the crystals from the two localities. Thus, the basal pinacoid, a dominant form on the Nordmark crystals, is apparently never present on those from North Burgess. On the other hand, the case is just the reverse with the macro pinacoid, *a*(100), which usually appears, and is sometimes very largely developed, on the North Burgess crystals, but is not recorded on those from Nordmark. Lastly, there are three brachy domes on the Nordmark crystals, whereas on those here described there is only one; and the latter exhibit a series of forms in the prism zone, as compared with only two prisms on Sjögren's crystals.

These divergences would largely disappear by a transposition of the *a* and *c* crystal axes; and if at the same time the unit length of the former *c* axis for the North Burgess crystals is doubled, the crystal constants become more nearly comparable, as follows:

	$a:b:c$	p_0	q_0
Nordmark	0.9517:1:0.8832	0.9280	0.8832
North Burgess, with *c* doubled and *a* and *c* transposed	0.9276:1:0.8759	0.9443	0.8759

Unfortunately, the writers have not a crystal of the Nordmark cenosite at their disposal to test this point, which might be done by measurement of one or two of the crystal angles combined with an observation of the optical characters. Should this be the correct explanation of the apparent differences in crystallographic characters of the material from the two localities, the forms present on the North Burgess cenosite, using Sjögren's orientation, would be as shown in column 4 in the accompanying table. The nine prismatic forms which were observed only as occasional very narrow faces on the North Burgess crystals are not included in the table. None of these are recorded on the Nordmark cenosite. They would become brachy prisms or domes, and their symbols would remain the same with transposition of the *a* and *c* intercepts [4]

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[4] Since the above was written, Professor C. Palache has very kindly furnished the writers with a crystal of the Nordmark cenosite, and it has been possible to compare the orientation adopted here for the North Burgess crystals with that of Sjögren. On the basis of the latter, the crystal is a simple orthorhombic prism terminated by the basal plane, with minute faces of the brachy prism or dome (011). The prism angle, from two fair faces, was measured as 93° 20′ ($\phi=46° 40'$), and the angle between the basal plane and the dome as about 43° 04′, both faces yielding very faint images. On this particular crystal, therefore, the prism and dome angles are practically identical ($110:1\bar{1}0=86° 40'$ and $011:0\bar{1}1=86° 08'$), and transposition of the *a* and *c* crystal axes would not materially affect the values of the crystal constants. It was not found possible to make an accurate determination of the refractive indices, but results obtained by the immersion method showed that, using Sjögren's orientation, crystal axis $a=\alpha$, $b=\beta$, and $c=\gamma$. In the North Burgess crystals, on the other hand, the acute bisectrix, α, is in the direction of elongation of the crystals, here taken as the crystal axis c, and $a=\gamma$, $b=\beta$, and $c=\alpha$. It is definitely established, therefore, that to correspond with Sjögren's orientation, the North Burgess crystals must be regarded as elongated along the *a* crystal axis and not as prismatic in the ordinary sense of the term. The crystals are far superior, however, to those hitherto known from Hitterö or Nordmark, and for this reason it may be deemed preferable to adopt for the mineral the new prismatic orientation and the crystal constants as given in the body of this paper.

Comparative Table of Forms

Letter (Sjögren)	For axial ratio $a:b:c$ .8759:1:.4638	For axial ratio $a:b:c$ .8759:1:.9276	For axial ratio $a:b:c$ .9276:1:.8759	Calculated Angles	
				North Burgess	Nordmark‡
c	(100)	(100)	(001)*	—	—
b	(010)	(010)	(010)*	—	—
e	(120)	(120)	(021)*	$\rho=60°17'$	$\rho=60°29'$
	(340)	(340)	(043)		
	(450)	(450)	(054)		
d	(110)	(110)	(011)*	$\rho=41$ 13	$\rho=41$ 27
f	(320)	(320)	(023)*	$\rho=30$ 17	$\rho=30$ 29
g	(101)	(102)	(201)*	$\rho=62$ 06	$\rho=61$ 42
	(011)	(012)	(210)	$\phi=65$ 07	$\phi=64$ 33
m			(110)*†	$\phi=47$ 09	$\phi=46$ 25
h			(230)*†		$\phi=35$ 01

* Forms recorded by Sjögren on crystals from Nordmark.

† These forms were not observed on the North Burgess crystals.

‡ Calculated from Sjögren's axial ratio, $a:b:c=0.9517:1:0.8832$.

Optical Characters

The refractive indices were determined by the total reflection method, the crystal being suspended and immersed in a liquid of index 1.7335. For this purpose the larger deep-pink crystals were used, total reflection being obtained from a polished face of the prominent macro pinacoid, a (100), and also from a polished surface cut at right angles to the prism zone and representing the basal plane. (The 'prismatic' orientation of the crystals is here referred to.) The results of a series of fairly consistent determinations gave refractive indices as follows, for sodium light: $\alpha=1.664$, $\beta=1.689$, $\gamma=1.691$. (All ± 0.001).

Crystal axis $a=\gamma$, $b=\beta$, $c=\alpha$. If the axes a and c are transposed, this becomes $a=\alpha$, $b=\beta$, $c=\gamma$.

The mineral is optically negative, with strong dispersion, $\rho<v$.

The optic axial angle for sodium light was measured in air and also in the liquid of refractive index 1.7335, with results as follows:

$2E=70°\ 32'$, giving $2V=39°\ 59'$
$2H=38°\ 38'$, ″ $\overline{2}V=39°\ 42'$

As calculated from the refractive indices, $2V=31°\ 20'$. This is in as close agreement with the other calculated values as might be expected. An error of 0.001 in the determination of either of the indices β and γ, making them respectively 1.688 and 1.692, or a much smaller error in both β and γ, but in oppostie directions, would be sufficient to account for the difference. Thus, the indices $\alpha=1.664$, $\beta=1.6884$, $\gamma=1.6916$ would give $2V=39°\ 20'$. It is probable, therefore, that the true internal optic axial angle for sodium light is near 39° 45′.

The only published data on the optical characters of cenosite are those of E. S. Larsen,[5] who gives the refractive indices for the Nordmark material as: $\alpha=1.667$, $\beta=1.681$, $\gamma=1.683$, all ± 0.003. These indices were determined by the immersion method. It is certain that, for the North Burgess cenosite, the values of both β and γ are considerably higher than those given by Larsen.

OTHER CHARACTERS

Hardness between 5 and 6. Specific Gravity, 3.612. Lustre vitreous, with tendency to pearly on some faces. Cleavage not observed. Fracture uneven.

Soluble in hydrochloric acid with evolution of carbon dioxide, and with separation of gelatinous silica on evaporation. A fragment of standard size heated before the blowpipe expands or exfoliates somewhat and fuses on corners or small projections to a whitish enamel. Flame coloration, yellowish-red (calcium).

CHEMICAL COMPOSITION[6]

The material available for analysis consisted of a little less than two grams of clean transparent to translucent crystals and crystal fragments which had been very carefully selected by Graham under the microscope. This was further checked by Ellsworth under the binocular microscope equipped with a Silverman illuminator and not the slightest trace of foreign matter could be seen. Thus it may be stated with confidence that only crystal material of apparently unimpeachable purity was comprised in the lot analyzed.

Two specific gravity determinations were made on the whole 2 gram lot, using a silica pycnometer. One determination at 20.60°

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[5] The Microscopic Determination of Non-opaque Minerals: *U. S. Geol. Surv., Bull.* **679,** 1921, p. 54.

[6] Published by permission of the Director, Geological Survey of Canada.

C. gave the result 3.612, the other at 23. 32° yielded the value 3.610.

After taking the specific gravity, the mineral was allowed to dry in the air at ordinary temperature and was then crushed and ground for analysis. One gram of the air-dry mineral was taken for the main analysis. This was heated first at 110° C. and later as high as 130°. The total loss after 4 hours heating from 110° to 130° was 0.04 per cent.

The mineral, in a platinum crucible, was then ignited to drive off CO_2 and water. After ignition at a full red heat for about two minutes the loss was 0.31 per cent. Evidently the water is firmly held and must be considered as hydroxyl of constitution. Ignition was continued, at first with a large Meker burner and finally by blasting. The following table shows the course of the loss and the long time required to drive off the last traces of CO_2.

TIME	HEAT	TOTAL LOSS IN PERCENT FROM AIR DRY CONDITION, INCLUDING CRUCIBLE LOSS
4 hrs.	110°–130°	0.04
2 mins.	Meker	0.31
30 "	"	8.43
30 "	"	8.58
15 "	"	8.64
15 "	Blast	9.06
15 "	"	9.11
15 "	"	9.15
15 "	"	9.18
15 "	"	9.24
15 "	"	9.24

After the crucible loss is deducted from the above values the net total loss is 9.16 per cent.

There was no evidence of the loss of any volatile oxides, as the under side of the crucible lid remained absolutely clean throughout the ignition. This ignited material was used for the main analysis. The ignited mineral did not show any indication of fusion and it appeared to be attacked by hydrochloric acid perhaps even more readily than the original mineral.

Water was determined directly on a separate portion of about a half gram.

The difference between loss by ignition and total water plus SO_3 is considered to represent the carbon dioxide present. A qualitative test on a small quantity of the mineral in which the gas was passed through barium hydroxide solution proved that CO_2 is present in important quantity, and as there are no oxides present which might gain weight on ignition, except a very little iron and cerium, the determination of CO_2 by difference should be reasonably exact.

The possible relationship of the mineral to cancrinite and microsommite suggested the necessity of tests for SO_3 and Cl. A little SO_3 was found but no chlorine. Fluorine, also, was not detected, and electroscopic and chemical tests for thorium gave negative results. The cerium group was separated from the neutral

ANALYSES OF CENOSITE

	NORTH BURGESS ONT. (Ellsworth)	HITTERÖ (Nordenskiöld)		NORDMARK (Mauzelius)
		A	B	
SiO_2	34.66	34.05	35.21	31.7
$(Ce, La, Di)_2O_3$	3.22[1]	trace	trace	—
$(Yt, Er)_2O_3$	35.46[2]	38.00	37.34	35.9
CaO	16.72	16.10	15.80	16.5
SrO	0.31[3]			
Al_2O_3, Fe_2O_3, BeO, etc.	0.22[4]	0.29†	0.22†	2.9‡
MnO	0.02	—	—	—
Na_2O	0.27	0.38	0.43	3.6
K_2O	trace	—	—	
MgO	0.19	0.04	0.03	1.4
CO_2	6.58	5.54	6.25	[5.1]
SO_3	0.04[5]	—	—	—
H_2O	2.54	[5.60]	4.92	2.9
H_2O 110°–130°	(0.04)			
Total	100.23	100.00	100.20	100.0
Sp. Gr.	3.612	3.413	3.413	3.38

† FeO. ‡ Fe_2O_3.

[1] The oxides after heating in air were a strong brown colour indicating the presence of considerable praseodymium. After heating in hydrogen they became white.

[2] Mean equivalent atomic weight by oxide-sulfate ratio about 108.4.

[3] Barium not detected by flame test. The strontium was separated by repeated amyl alcohol treatments and appeared perfectly pure.

[4] Little iron, apparently mostly alumina. No test for beryllium.

[5] Determined on 0.2 grams.

rare-earth sulphates by two precipitations with potassium sulphate.

Special care was taken to be certain that all the calcium was separated from the rare earths, as small quantities are likely to be rather tenaciously retained by rare-earth precipitates.

The analysis yielded results as shown in the preceding table, analyses of the Hitterö and Nordmark minerals being included for comparison.

As may be seen from the following tables of molecular ratios, the North Burgess mineral comes about as close to the composition expressed by the formula $2CaO \cdot Yt_2O_3 \cdot 4SiO_2 \cdot CO_2 \cdot 2H_2O$, which was proposed by Nordenskiöld for the Hitterö mineral, as does the Hitterö cenosite itself, with the exception that the Canadian mineral has only one molecule of water.

Burgess Cenosite

	Mol. Ratio		
SiO_2—	34.66÷60.1	=0.5767	÷4=0.1442
$(Ce, La, Di)_2O_3$—	3.22÷330	=0.0097	÷1=0.1452
$(Yt, Er)_2O_3$—	35.46÷265	=0.1338	
Al_2O_3, etc.—	0.22÷130	=0.0017	
CaO—	16.72÷56.07	=0.2982	÷2=0.1531
MgO—	0.19÷40.3	=0.0047	
Na_2O—	0.27÷62	=0.0043	
CO_2—	6.58÷44	=0.1495	÷1=0.1495
H_2O—	2.54÷18	=0.1411	÷1=0.1441

Thus the simplest formula for the North Burgess mineral is $2CaO \cdot (Ce,Yt)_2O_3 \cdot CO_2 \cdot 4SiO_2 \cdot H_2O$. It may be noted that the Nordmark mineral also has only one molecule of water.

The corresponding molecular ratios calculated for the Hitterö and Nordmark minerals are as follows, using 260 as the molecular weight of the yttrium-erbium group:

	Hitterö		Nordmark			
	A	B	N	A	B	N
SiO_2	0.5665	0.5858	0.5274	÷4=0.1416	0.1464	0.1318
Yt_2O_3	0.1462	0.1432	0.1381	÷1=0.1462	0.1432	0.1562
Fe_2O_3			0.0181			
FeO	0.0040	0.0030		÷2=0.1491	0.1463	0.1435
CaO	0.2871	0.2818	0.2943			
MgO	0.0010	0.0008	0.0347			
Na_2O	0.0061	0.0070	0.0580			
CO_2	0.1260	0.1420	0.1160	÷1=0.1260	0.1420	0.1160
H_2O	0.3111	0.2733	0.1611	÷2=0.1555	0.1366	0.0806

It is unfortunate that the North Burgess material was not available in sufficient quantity to permit further chemical study of larger quantities.

Reactions indicating the possible presence of scandium to the extent of perhaps between 0.5 to 1 per cent were obtained, but up to the time of writing this point was still under investigation.

The analyses agree well enough to indicate the extremely close relationship of the three minerals. The Burgess mineral has a higher specific gravity than the others, somewhat different indices, and only one molecule of water, but perhaps these differences can be accounted for by the possibility that the earlier minerals were more or less altered and hydrated. For the present, therefore, it appears advisable to consider the North Burgess mineral as cenosite.