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On some Minerals from the Sodalite-Syenite in Juliane-haab district, south Greenland.[*]

BY JOH. LORENZEN.

Communicated by PROF. JOHNSTRUP.

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IT is well known to mineralogists, that *Giesecke*, who in the years 1806—13 travelled in Greenland, brought home from Julianehaab district some new minerals, which he handed over to the Copenhagen Museums. In 1853-4 *Dr. Rink* supplied the museum of the Copenhagen University with a large collection of the same minerals, mostly in large and fine specimens, and the same collections have lately received a most valuable and considerable addition, through the travels of *Mr. K. J. V. Steenstrup* of the Danish Geological Survey of Greenland. Some of these interesting minerals, occurring in the Syenite on both sides of the fjords Tunugdliarfik and Kangerdluarsuk, have already long been known, whereas others had either been not found there before or at least not analysed or described.

As better materials for the examination of the minerals than those which were at the disposal of former investigators are now available, I have at the suggestion of Professor Johnstrup, undertaken the following examination.

The chief constituents of the Sodalite-syenite, the name of which is due to *Mr. Steenstrup*, are a greenish-white *felspar*, *arfvedsonite* (and

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[*] Translated from Meddelelser fra Grönland, 2det Hefte, Kjoebenhavn, 1881, where a French resumé is given.

ægirine) together with *sodalite*[†]. In some places the minerals assume very considerable dimensions, especially the arfvedsonite. The chief accessory is *eudialyte,* the garnet-like colour of which, when occurring in larger quantity, gives to the rock a reddish-brown tinge; more scarcely are found crystallized *nepheline* and two new minerals mentioned below. There likewise occurs, at single spot, crystallized *lievrite,* together with calcareous spar, and finally some zeolites, in particular analcime and natrolite. A circumstance which gives this rock a peculiar interest is, that most of the minerals above mentioned are found connected in a very similar way in the south of Norway, viz: in the syenite of the Langesunds fjord, where also occur arfvedsonite, ægirine, sodalite, nepheline (elæolite), eudialyte (eukolite), analcime and natrolite (brevicite).

I have examined most of the constituents of the sodalite-syenite, and perhaps it will not be out of place briefly to mention some former investigations. Firstly we find published a series of analyses of the *arfvedsonite* from Kangerdluarsuk, and no analysis of the *ægirine* from the same locality, but in the following it will be shown that the materials analysed in all cases have been either ægirine, or a mixture of arfvedsonite and ægirine The *eudialyte* is the best known of these minerals, but I have found that it contains a small quantity of cerium not indicated in the former analyses, which perhaps may be of some interest, an equal quantity having been found in the corresponding Norwegian mineral *eukolite.* As to the *sodalite,* the former analyses show clearly that the substance cannot have been fresh.

I shall now detail the several investigations.

I. Felspar.

The felspar occurs in greenish-white masses, often of perfect cleavage. In thin plates it is almost transparent. Under the microscope it has proved to be a microcline. The composition is :—

SiO_2	62·74
Al_2O_3	19·60
Na_2O	3·56
K_2O	13·09
	98·99

II.—Arfvedsonite.

Literature: Annnals of Phil., 1823 (Brooke). — Berz. Jahresber. 1825, 149 (Arfvedson).—Annales des mines 1832, T., I., 192 (Thomson)— Journ. f. pr. Ch. 13, 3, and 91, 449 (Kobell).—Pogg. Ann. 105, 292 and

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[†] For further communications, maps, etc., see the paper of *Mr. Steenstrup,* in Meddelelser fra Grönland, etc.

306 (Rammelsberg).--Zeitsch. f. Kryst. u. Min., IV. 94 (Doelter).—Berg— u. Hüttenmann. Zeitung 1865-66, (separately printed as: *mineralogische Studien* v. Aug. Breithaupt).

The arfvedsonite, the first name of which was "ferriferous hornblende," was distinguished by *Brooke* in 1823 as a peculiar mineral species. He did not examine the chemical composition, which indeed has not since been fully understood. The angle of cleavage he found to be 123° 55 · *Mitscherlich* likewise showed it to be the same as that of hornblende, and finally an analysis by *Arfvedson* seemed to show a conformity in its chemical composition.

Later on, the cleavage was examined by *Breithaupt*, and the chemical composition by *Thomson*, but although his analysis differs considerably from Arfvedson's, he has not observed the most characteristic peculiarity, finding no soda, but instead of this 8 per cent. manganous oxide.

That these analyses cannot have been made on veritable arfvedsonite, and so must be set aside, is now most evident, newer ones having been made by *Kobell* (I.), *Rammelsberg* (II.), and *Doelter* (III), as follows.

	I.	II.	III.
Cl.	0·24	—	—
SiO_2	49·27	51·22	52·22
Al_2O_3	2·00	trace	0·64
Fe_2O_3	14·58	23·75	28·15
FeO	23·00	7·80	5·35
MnO	0·62	1·12	0·54
CaO	1·50	2·08	2·19
MgO	0·42	0·90	1·45
Na_2O	8·00	10·58	10·11
K_2O	—	0·68	0·34
Loss by heat	—	0·16	—
	99·63	98·29	100·99

It will be seen that the analysis of Kobell differs considerably from the others, between which the difference is not greater than will be often found in analyses of minerals, of which material of absolute purity cannot be secured.

Already in 1866 *Breithaupt*, by mere crystallographic investigation, made the observation that several minerals in collections are called arfvedsonite incorrectly, and with respect to this he says: "von allen scheint in die Sammungen am häufigsten ein Pyroxen, nämlich der Aigirin, als Arfvedsonit zu existiren ‡." This remark however has not had any influence on the position of *arfvedsonite* in the system.

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‡ l. c., page 50.

The arfvedsonite occurs at Siorarsuit and Kangerdluarsuk, partly massive, partly crystallized. The crystals, which have not before been described, are seldom found, but sometimes they attain a considerable development. The biggest crystal in the museum of the University is c. 9 inches long and c. 3½ inches in diameter; the terminating planes however are missing in this crystal; this often is the case on account of the growing together of the arfvedsonite with other minerals in the sodalite-syenite. The colour of fresh crystals is dark, but often they are grey, owing to an alteration on the surface; still a fracture shows the dark colour. The surfaces most frequently are dull, so that reliable measurements cannot be made. The prismatic and pinacoid planes are the best reflecting, whereas I could not measure the angle between a terminal plane and a pinacoid by the reflecting goniometer on more than one crystal. The rest of the angles are measured by the hand goniometer, but the planes being often very small, the measurements cannot be very precise. The result of the examination is that many of the characteristic forms of the amphibole are found to occur in the arfvedsonite.

Most commonly combinations of ∞ P and ∞ Ꝑ ∞. P and 2 Ꝑ ∞, are found. I have further found oP on a single crystal. Twins occur with the orthodome as composition-face.

The following angles were obtained by the reflecting goniometer:—

∞ P = 123°37′ — 124°48′
2 Ꝑ ∞ : ∞ Ꝑ ∞ = 119°48′
∞P : ∞ Ꝑ ∞ = 117°38′

From the two last is calculated.

2 Ꝑ ∞ : 2 Ꝑ ∞ = 120°24′
∞ P = 124°44′

The most exact measurement, however, may be made on the cleavage-faces, which frequently are excellently reflecting. On such the angle was found to be 124°22′.

By the hand-goniometer we obtain:—

P : P = c. 148° P : 2 Ꝑ ∞ = c. 150°

One thing is especially worth remarking:—the crystals are *never striated.*

The massive arfvedsonite is either dark and breaks easily,—the cleavage-faces then are both distinct and reflecting—or it is somewhat greyish. In the last case the cleavage-faces become more dull, the coherence more solid, and the mineral penetrated with small fissures, which are filled with a whitish mineral. The substance used for the analysis was taken from the first variety, large massive specimens of which are preserved in the museum; besides it is also found adherent to ægirine, eudialyte and sodalite.

Cleavage-faces: the prismatic and pinacoid planes; the last being more distinct than the corresponding ones of amphibole.

The fracture sometimes is conchoidal, often vitreous in lustre.

Streak and powder *dark-blue grey*, a very important distinction between it and ægirine.

Hardness between that of felspar and that of apatite. Specific gravity 3·44 (*Brooke* also found 3·44).

Fuses easily and forms vesicles in a Bunsen's gas lamp without the use of the blowpipe. Yields a dark magnetic bead.

For the chemical analysis the above mentioned dark massive arfvedsonite was used, which, when carefully selected, might be obtained very pure, and the analysis was effected in the usual manner. The iron oxide and sesquioxide were separated according to the method indicated by *Doelter*, (Fres. Zeits. f. analyt. Chemie 18 Jahrg. P. 50), viz: the mineral is decomposed by a mixture of hydrofluoric and sulphuric acids, in an atmosphere of carbonic acid, and the solution titrated with permanganate of potash. Three titrations gave accordant results.

SiO_2	43·85	0·731	0·731
Al_2O_3	4·45	0·044	0·068
Fe_2O_3	3·80	0·024	
FeO	33·43	0·464	0·716
MnO	0·45	0·006	
CaO	4·65	0·083	
MgO	0·81	0·020	
Na_2O	8·15	0·132	
K_2O	1·06	0·011	
Loss by heat	0·15		
	100·80		

From the analysis is then obtained:—

$$\begin{aligned} R : R : Si &= 0·716 : 0·068 : 0·731 \\ &= 10·53 : 1 : 10·75 \\ &= 11 : 1 : 11 \end{aligned}$$

which affords the formula:—

$$11\ R\ SiO_3 + R_2O_3.$$

Further:—

$$\begin{aligned} Fe\ (Mn) : Ca\ (Mg) : Na_2(K_2) &= 0·470 : 0·103 : 0·143 \\ &= 14 : 3 : 4 \end{aligned}$$

which approximatively affords:—

$$\left.\begin{matrix} 4\ Na_2\ SiO_3 \\ 3\ R\ SiO_3 \\ 14\ R_1\ SiO_3 \end{matrix}\right\} + 2R_2O$$

where $Fe_2 : Al_2 = 1 : 1·8$. The above formula gives the following composition:—

$21SiO_2$	1260	SiO_2	43·04
$\frac{4}{3}Al_2O_3$	137·33	Al_2O_3	4·68
$\frac{2}{3}Fe_2O_3$	106·66	Fe_2O_3	3·64
$14FeO$	1008	FeO	34·43
$3CaO$	168	CaO	5·74
$4Na_2O$	248	Na_2O	8·47
	2927·99		100·00

It will be seen that neither my analysis nor the formula agrees with the former ones. I was surprised to find almost the whole quantity of iron present as protoxide, but the smaller quantity of silica and the rather considerable amount of alumina are also remarkable. To explain this difference it may not be out of place to state and consider what former investigators say about the substances used for their analyses.

Kobell had obtained a specimen from one of Giesecke's collections, on which the arfvedsonite was adherent to eudialyte. The description of its appearance accords with that of the arfvedsonite; unfortunately he does not mention, whether he has used a crystal or a massive specimen, nor does he give the specific gravity. Still he is surprised (Journ. f. pr. Ch. 91, 450,) by the difference between his analysis and that of

Rammelsberg, who does not state the angle of cleavage obtained by his own measurements. The specific gravity he states to be 3·589, which is somewhat more than that of the arfvedsonite; further he says: "der Arfvedsonit, welchen ich zur Analyse benutzte, bildete *stark gestreifte, am Ende zerbrochene Prismen*," (it will be remembered the arfvedsonite never occurs as such; but the description strikingly agrees with ægirine) and he continues; "und war mit Eudialyt und Sodalith stark verwachsen."

Doelter says, that the angle of cleavage places the mineral in the amphibole-group, but then he adds: "an den mir vorliegenden Stücken von Arfvedsonit, der mit Eudialyt vergesellschaftet war, fand ich nur Krystallen ohne Endflächen, die die Combination des Prismas mit einer Längsfläche zeigten. *Die starke vertikale Riefung gestattete keine Messung mit dem Reflexions-goniometer.*"

The museum of the university now possesses a great many specimens, with which the descriptions of *Doelter* and *Rammelsberg* agree very well, if one single alteration be made; viz: *to put the name of ægirine in the place of arfvedsonite.* That the angle of cleavage nevertheless is found by Doelter to be the same as that of amphibole, is easily explained by the circumstance, that arvedsonite and ægirine often are very closely grown together and as the cleavages are more distinct in arfvedsonite than in ægirine, these have been determined by the first, although it may perhaps have been in small quantity.

The arfvedsonite has hitherto held an isolated place in the system, but can now be referred to the general formula of aluminiferous amphibole, which *Rammelsberg* has adopted in the last edition of his Mineralchemie, viz:

$$\left\{\begin{array}{l} m\ R\ SiO_3 \\ n\ \not{R}\ O_3 \end{array}\right\}$$

III. Ainigmatite.

Several crystals of this mineral, which firstly was determined by *Breithaupt** are preserved in our museum, and have been found at Naujakasik. Their form is monoclinic, and at the first look they seem to resemble the arfvedsonite. The general combination is ∞P, $\infty \not{P} \infty$, $\infty \bar{P} \infty$, together with a pyramid and two sets of planes, which, as the base is absent, cannot be rigorously determined. Perhaps they are clinodomes. The orthopinacoid plane is very characteristic, this plane not being developed on arfvedsonite. Further, the two minerals differ considerably in other respects, which will be evident from the following properties of the ainigmatite.

Prismatic angle (measured with hand-goniometer) = 114°.

Streak reddish-brown.

Specific gravity of a perfect, small, tolerably pure crystal was found = 3.80.

Still the two minerals resemble each other, as both are dark coloured and have the hardness = 5.5. If the streak is not tried or the prismatic angle not measured, one is easily mistaken. An analysis of the ainigmatite was not undertaken, as the few crystals in the museum do not seem to be pure enough to give a satisfactory result.

Together with the ainigmatite *Breithaupt* has mentioned an isomorph mineral, *Koelbingite*, which differs from the first by a green streak and a smaller specific gravity; he supposes the ainigmatite to be pseudomorphous from the koelbingite. To which I shall merely remark, that our museum does not possess any koelbingite, but several crystals of ainigmatite, which being all very fresh and unaltered, can scarcely be admitted to be pseudomorphous.

IV. Ægirine.

Literature, Pogg. Ann. 61, 543 (Scheerer). 80, 314 (Plattner & Breithaupt) 103, 286 and 302 (Rammelsberg), 122, 118 (Rube & Gutzkow). Comptes Rendus 56, 846 (Pisani).—Zeits. f. Kryst. Min. IV, 91 (Doelter).

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l.c. P. 51.

Ægirine till now has been known chiefly as an augitic mineral from Brevig, showing a remarkable resemblance in chemical composition to arfvedsonite. That this, with respect to the last, was not correct, has already been stated above.

The specific gravity of the Norwegian ægirine is stated by *Breithaupt* to be 3.432—3.504; by *Rammelsberg* 3.578 and the prismatic angle 86°52′. I give here the analyses of *Rammelsberg* (I), *Pisani* (II), Rube (III).

	I.	II.	III.
TiO_2	—	—	1.06
SiO_2	50.25	52.11	50.03
Al_2O_3	1.22	2.47	0.55
Fe_2O_3	22.07	22.80	28.68
FeO	8.80	8.40	1.98
MnO	1.40	—	1.52
CaO	5.47	2.60	1.42
MgO	1.28	0.41	1.33
Na_2O	9.29	12.10	12.20
K_2O	0.94	—	—
Loss by heat	—	0.30	1.05
	100.72	101.19	99.82

Ægirine is found at Kangerdluarsuk, Siorarsuit and Kumernit, grown together with eudialyte, sodalite and arfvedsonite. Often the arfvedsonite is coated with crystallized ægirine, which may very easily mislead in the determination of the minerals, the streak however immediately shows the difference. The mineral generally occurs in distinct, broken crystals, much striated along the axis, nearly always unaltered and with a certain metallic lustre. Some few non-striated crystals are also found, such as may be measured by the reflecting goniometer. On some crystals I found besides the fundamental pyramid, a very acute pyramid, and two clinodomes, the angles of which I was not able to measure by the hand-goniometer on account of the smallness of their planes. The general combination is ∞P. ∞Ᵽ∞. ∞₽∞. P. By the reflecting goniometer ∞P=86°58′—87°6′ and P : ∞P=120°51′ were found. By the hand-goniometer the angle between the polar edge of the pyramid and ∞₽∞ was found to be c.105°. These angles agree with those of augite.

The cleavage is prismatic, not so well developed as in the arfvedsonite, still it is easily observed when a polished face of the mineral is turned in the sunlight.

Streak and powder, light green.

Hardness, 5.5—6. Specific gravity, 3.63.

Fuses easily before the blowpipe to a dark magnetic bead. Is not decomposed by acids.

For the chemical analysis a fresh crystal was used, which under the microscope had proved to be very pure. The oxides of iron were determined as with arfvedsonite. The analysis yielded the following results:

		Quotients.	
SiO_2	49.04	0.818	0.818
Al_2O_3	1.80	0.017	0.201
Fe_2O_3	29.54	0.184	
FeO	4.82	0.067	0.115
MnO	trace	—	
CaO	2.70	0.048	
MgO	trace	—	
Na_2O	13.31	0.215	0.215
K_2O	trace	—	
	101.21		

$Na_2 : R = 0.215 : 0.115$
$= 2 : 1$

$\bar{R} : R = 0.201 : 0.115$
$= 1.75 : 1$
$= 2 : 1$

$R : Si = 0{\cdot}108 : 0{\cdot}815$
$= 1 : 7{\cdot}6$
$= 1 : 8$

Hence the formula:

$$Na_4\,R\,\bar{R}_2\,Si_8\,O_{25}$$

or

$$\left\{\begin{matrix} 2\,Na_2\,SiO_3 \\ R\,SiO_3 \\ \bar{R}_2\,Si_5\,O_{16} \end{matrix}\right\}$$

wherein $Ca : Fe = 2 : 3$ $\quad Al_2 : Fe_2 = 1 : 11$

then:

$8\,SiO_2$	= 480	SiO_2	49·03
$2\,\bar{R}_2O_3$	= 310	$\bar{R}_2O_3$	31·66
RO	= 65	RO	6·64
$2\,Na_2O$	= 124	Na_2O	12·67
	979		100·00

The ægirine examined is therefore a mixture of bisilicates, in which, however, the sesquioxides form a basic salt.

The analysis of *Rammelsberg*, which does not at all agree with *Pisani's* or with *Rube's* leads to the formula.

$$\left\{\begin{matrix} 6\,Na_2\,SiO_3 \\ 10\,R\,SiO_3 \\ 5\,Fe_2\,Si_2O_9 \end{matrix}\right\}$$

The small quantity of soda and the large quantity of lime are striking; perhaps therefore it may be supposed that the substance used for his analysis was not very fresh.

V. Sodalite.

Literature of the Greenland sodalite: Ann. of. phil. I, 104 (Ekeberg) Gilbert's Ann. 39, 127 and 40, 98 and Journal des Mines 1811 (Thomson). Pogg. Ann. 109, 576 (Rammelsberg.)

Sodalite was first found in Greenland, and was by the *Count de Bournon* considered to be a green felspar; in 1811 the mineral was named by *Thomson* with especial regard to the great quantity of soda contained in it. He finds in the mineral two p. ct. of water, but only a small quantity of chlorine, which shows that the substance analysed by him cannot have been either very pure or fresh. I give the analyses of *Thomson* (I) and *Ekeberg* (II) together with an analysis of an unaltered sodalite from Ilmengebirge by *G. Rose* and *E. Hofmann* (III) for comparison with mine.

	I.	II.	III.
SiO_2	38·52	36·00	38·40
Al_2O_3	27·48	32.00	32·04
Fe_2O_3	1·00	0·25	—
CaO	2·70	—	0·32
Na_2O	23·50	25·00	24·47
Cl	3·00	6·75	7·10
Loss by heat	2·10	—	—
	98·30	100·00	102·33

Obviously the analysis of *Ekeberg* was made on a fresher substance than *Thomson's*, but it cannot be quite correct, as it does not show any surplus.

The sodalite is always coloured green, which under the microscope is seen to arise from an intermixture of microscopical crystals of arfvedsonite. The crystals are dodecahedra, imbedded in arfvedsonite or felspar, less frequently in eudialyte, and form, especially in the last case, a very beautiful rock.

The size of these dodecahedra is generally equal to that of a pea. The Museum however possesses some broken specimens, which are an inch in diameter; these are imbedded in felspar.

The fracture is conchoidal, with a vitreous lustre; the cleavage faces are parallel to the planes of the dodecahedra.

Hardness=5·5—6. Specific gravity=2·31.

Before the blowpipe it does not fuse so easily as the Vesuvian sodalite, and becomes grey and opaque.

At first it seemed somewhat difficult to isolate the substance, but I always preferred to take the sodalite which was imbedded in arfvedsonite, these two minerals being distinctly separated through the difference in colour. Still a complete separation is impossible, the sodalite, as above mentioned, being penetrated with microscopic crystals of arfvedsonite, but fortunately also unnecessary, as on solution in hydrochloric acid the whole quantity of felspar and of arfvedsonite remain unaltered and can be filtered from the solution.

If the mineral be dissolved in nitric acid, the chlorine can very easily be determined; there are but one or two milligrams of silica precipitated with the chloride of silver. The analysis yielded the following result:

		Quotients.	
SiO_2	36·50	0·608	0·608
Al_2O_3	31·53	0·306	0·309
Fe_2O_3	0·19	0·003	
CaO	0·25	0·004	0·430
Na_2O	26·30	0·424	
K_2O	0·18	0·002	
Cl	7·30	0·206	0·206
	102·25		

then

$Na : Cl = 0{\cdot}848 : 0{\cdot}206$ $\quad Al_2O_3 : SiO_2 = 0{\cdot}309 : 0{\cdot}608$
$= 4{\cdot}1 : 1$ $\quad = 1 : 2$

$Na_2 : Al_2 = 0{\cdot}424 : 0{\cdot}309$

if the quantity of sodium contained in Na Cl be subtracted, we have:

$Na_2 : Al_2 = 0{\cdot}319 : 0{\cdot}309$
$= 1 : 1$

and obtain the formula

$$\left\{ \begin{array}{c} 2\,NaCl \\ 3\,Na_2\,Al_2\,Si_2\,O_8 \end{array} \right\}$$

the same as stated in *Rammelsberg's* Mineralchemie. The formula yields the following result:

6 Si	= 168	SiO_2	37·08
3 Al_2	= 163·8	Al_2O_3	31·71
8 Na	= 184	Na_2O	25·55
24 O	= 384	Cl	7·31
2 Cl	= 71		
	970·8		101·65

VI.—Nepheline.

The Greenland Nepheline is found at Naujakasik and Siorarsuit in Tunugdliarfik, on the northern side of Nunasarnausak, and at Kangerdluarsuk: it has not till now been examined. It occurs crystallized in hexagonal prisms, terminated by the basal pinacoid; and very seldom in combination with small planes belonging to the first pyramid. The crystals are greyish white or greenish, in the last case translucent on the edges; they are seldom larger than a hazel-nut, and frequently smaller; the surface is coated with small shining laminæ of mica. It also occurs massive, closely connected with arfvedsonite and felspar, and very much resembling sodalite. In this form it was found on a specimen from which in the course of time part of the nepheline had disappeared, leaving in the ground mass of arfvedsonite and felspar, larger and smaller cavities, the form of which reminded of crystals of sodalite, so that I considered it to be sodalite until I had analysed the mineral. This mineral however sometimes has pretty distinct cleavage-faces, and, if these are missing, a sort of conchoidal fracture,—the conchoidal face being very small,—which has vitreous lustre; on the other hand, on the nepheline I have never seen distinct cleavage-faces, but an uneven or splintery fracture and a greasy lustre. To decide whether a specimen be the first or the second, it is always sufficient to to dissolve a bit in nitric acid and search for chlorine.

The specific gravity of the crystal used for analysis I, was 2·60, that of the massive mineral 2·63. Moreover it must be remarked, that, although the crystal also contained a small quantity of arfvedsonite and felspar, the massive mineral contained thrice as much. In the first analysis, the crystal did not yield substance enough for the determination of the water. The second analysis was made on the massive mineral. Of course the alumina was in both cases purified from silica. The following results were obtained.

	I.	Quotients.	II.	Quotients.
SiO_2	43·39	0·723	41·87	0·698
Al_2O_3	32·28	0·313	33·94	0·335
Fe_2O_3	0·92	0·005	0·70	0·004
CaO	0·70	0·012	0·47	0·008
K_2O	5·62	0·060	6·68	0·071
Na_2O	16·52	0·266	15·03	0·243
Cl	Trace		Trace	
Loss by heat	——		0.94	
	99·43		99·63	

There is some difference between the analyses. Perhaps it might be supposed that, when the nepheline in II was dissolved in hydrochloric acid, a small quantity of silica had remained with the felspar and arfvedsonite, and had been filtered from the solution along with these. In fact, the whole residue was more unhesitatingly set down as undecomposed mineral, because at the beginning of the analysis I supposed the mineral to be altered sodalite, whith might be fully and easily dissolved in hydrochloric acid. I will therefore take both minerals into consideration when calculating the formula.

	$R_2 + R_1$	:	Si	R_2	:	Ɍ	K	:	Na
I	0·656	:	0·723	0·338	:	0·318	0·060	:	0·266
	= 1	:	1·1	1·06	:	1	1	:	4·4
II	0·661	:	0·698	0·322	:	0·339	0·071	:	0·243
	= 1	:	1·05	1	:	1·05	1	:	3·4

If we venture to change the ratio to :—

$\dot{R} + R : Si = 1 : 1 \quad R_2 : R = 1 : 1 \quad K : Na = 1 : 4$

It will afford the plain formula.

$$R_2SiO_3 + Al_2SiO_5 = R_2Al_2\,Si_2O_8$$

And the composition will be

2 SiO_2 =	120·	SiO_2 =	41·18
Al_2O_3 =	103·	Al_2O_3 =	35·35
$\frac{1}{5}$ K_2O =	18·8	K_2O =	6·45
$\frac{4}{5}$ Na_2O =	49·6	Na_2O =	17·02
	291·4		100·00

The above formula is the same which *Rammelsberg* formerly admitted, but has now given up. It is exactly the same as that of the silicate in sodalite, while the formula which *Rammelsberg* prefers is that of the silicate in sodalite-leucite. It is true that in the formula here used there is the drawback that it gives too small a quantity of silica and too much of the bases, but on the other hand it seems preferable on the ground of simplicity.

VII.—Eudialyte.

Literature: Crells chem. Ann. I, 493. 1801 (Trommsdorf). Gilbert's Ann. 13,491. 1803 (Gruner) and 63,379. 1819 (Stromeyer). Schweigger's Beiträge z. Chem. u. Phys. 29,1. 1820 (Pfaff). Pogg. Ann, 63, 142. Oefvers. Sv. Vet. Ak. Forh., 1845, 37 (Svanberg).—Comptes Rendus 43, 1197 (Damour).—Acta. Univ. Lund. II., 1—25, 1870 (Nylander).

Eudialyte, which on account of its colour and whole appearance, resembles somewhat both garnet, and zircon, was first examined by *Trommsdorf*, who, in 1801 found Zirconia in it, and gave it the name "dichter Hyacinth." A few years later *Gruner* mentions, that the Prince *Galitzin* has referred it to coccolite, which recently had been discovered by *Abildgaard*, but to that *Gruner* objects, since coccolite contains manganese dioxide, eudialyte zirconia. He proposes the name "blättrige-Hyazinth," although the mineral in the title of his paper is called "der rothe blättrige Granat aus Groenland." In 1819 finally *Stromeyer* made an analysis more trustworthy than the previous ones, and called it by the name of eudialyte, because it is easily dissolved in acids; and this name has remained unaltered. A contemporaneous analysis was instituted by *Pfaff*, but all these analyses are now superseded by newer ones, instituted by *Rammelsberg* (I), *Damour* (II), and *Nylander* (III).

	I	II	III
TaO_2	—	0.35	—
SiO_2	49·92	50·38	51·86
ZrO_2	16·88	15·60	14·67
FeO	6·97	6·37	6·54
MnO	1.15	1·61	1·46
CaO	11·11	9·23	9·82
Na_2O	12·28	13·10	12·32
K_2O	0·65	—	—
Loss by heat	0·37	1·25	1·43
Cl	1·19	1·48	1·37
	100·52	99·37	99·47

In his report on an investigation of larger quantities of eudialyte, *Svanberg* mentions, but without adding a quantitative analysis, that the Greenand eudialyte contains besides the oxides of the cerium group, two other oxides, one of them resembling yttrium.

The eudialyte, as is well known, is found partly massive, partly crystalized. The crystals almost always show a great many planes. Still I have not been able to discover others than those already mentioned in the Mineralogy of *Des Cloizeaux*. The cleavage faces corresponding to ¼ R, and the base are distinct, the cleavage formerly indicated as being indistinct is not easily discovered. The fracture is granular to conchoidal, and exhibits a strong vitreous lustre.

Hardness 5·5. Specific gravity 2·85.

The streak is white, still, the powder has a faint rose colour, which is scarcely observable in the streak.

Before the blowpipe it fuses pretty easily to a green glass. When treated with acids it gelatinizes, evolving a distinct odour of sulphuretted hydrogen.

Three analyses were made besides two determinations of chlorine and two of water. To determine the chlorine I distilled the mineral with diluted sulphuric acid, and precipitated the chlorine in the distillate. The water was at first determined as loss by heat; the second time by direct weighing in a tube with calcium chloride.

The silica always contains a considerable portion of the zirconia. This was dissolved in sulphuric acid, and, after evaporation, was added to the filtrate from the silica. The filtrate was precipitated by ammonia, and the precipitate having been dissolved in hydrochloric acid, the zirconia was precipitated by sodium hyposulphite. In the filtrate the cerium oxides were thrown down by oxalic acid, and in the filtrate from the last precipitate the iron oxide by ammonia. The precipitate of the cerium oxide agreed perfectly with the usual reactions of this substance.

The result of the analysis was as follows :—

		Quotients.	
SiO_2 ..	48·63 ..	0·811	0·930
ZrO_2 ..	14·49 ..	0·119	
FeO ..	5·54 ..	0·077	0·297
MnO ..	0·42 ..	0·006	
CeO (LaO, DiO)	2·27 ..	0·021	
CaO ..	10·57 ..	0·189	
MgO ..	0·15 ..	0·004	
Na_2O ..	15·90 ..	0·256	0·256
K_2O ..	trace ..	—	
Cl ..	1·04 ..	0·030	0·030
Water ..	1·91 ..		
	100·92		

Then Cl : Na = 0·030 : 0·512 = 1 : 17·1
Na_2 : R = 0·256 : 0·297 = 0·86 : 1
If the NaCl be substracted = 0·8 : 1
Or approximately = 1 : 1
R : (Zr,Si) = 0·297 : 0·930, Zr : Si = 0·119 : 0·811
= 1 : 3·1 = 1 : 6·8

This ratio affords tolerably correctly the formula:

$$NaCl + 8\ Na_2\ R\ (Si,Zr)_3\ O_8$$

or

$$\left\{ \begin{array}{c} NaCl \\ 8 \left\{ \begin{array}{l} Na_2\ \ (Si,\ Zr)_2\ O_5 \\ R\ \ \ (Si,\ Zr)\ O_3 \end{array} \right. \end{array} \right\}$$

Further we have :

Ce : Ca = 0·021 : 0·189. Fe : Ca = 0·077 : 0·189
= 1 : 9 = 1 : 2·5

The formula differs somewhat from that which may be deduced from the analyses of *Rammelsberg* and *Nylander*, (with which that of *Damour* does not agree), according to whom eudialyte has the following composition :—

$$\left\{ \begin{array}{c} NaCl \\ 6 \left\{ \begin{array}{l} Na_2\ (Si,\ Zr)_2\ O_6 \\ R_2\ \ (Si,\ Zr)\ O_5 \end{array} \right. \end{array} \right\}$$

containing a much smaller quantity of soda, but more zirconia and silica, which perhaps is owing to a less fresh substance.

VIII.—Lievrite.

The Greenland Lievrite* here described for the first time, occurs both massive and crystallized. The colour is in both cases dark; the crystals are quite fresh and show an intense metallic lustre. They occur in highly striated prisms, the terminal planes are often missing, because the crystals have grown to other minerals; but are also

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* On the occurrence of lievrite and lepidolite in Greenland, see the remarks of Prof Johnstrup, p. 69

frequently well developed. The common combination is $\infty \breve{P} \infty$, $\bar{P} \infty$, $\frac{3}{2} \breve{P} \infty$ connected with some more indistinct prisms. Besides the brachydome $\frac{3}{2} \breve{P} \infty$ is commonly seen a curved plane, continuing the pinacoid—consisting of some more brachydomes. On several crystals is the fundamental pyramid associated with these in very small planes, commonly striated parallel to the long polar edge, and in this case not to be accurately measured; I therefore give but one measure, taken from the most distinct crystal. All the angles were measured by the reflecting goniometer, and have yielded the following results, with regard to which it should be remarked that the prismatic angle could not be measured exactly on account of the striation, and therefore I do not state its measurements.

					Des Cloizeaux
$\bar{P} \infty$	:	$\bar{P} \infty$	=	112°46′—112°49′	112°49′
$\frac{3}{2} \breve{P} \infty$	:	$\frac{3}{2} \breve{P} \infty$	=	96°6′	96°57′
P	:	P	=	139°29′	139°31′

Often the crystals are twins, with the brachy-pinacoid the composition-face. The streak and powder are coal black.

The hardness is 6, parallel to the longer-axis of the crystals, vertically to this direction, 5·5. Specific gravity 4·05.

Before the blowpipe the mineral fuses pretty easily. Is easily dissolved in acids.

When heated in a small combustion-furnace, it lost only a small quantity of water. As late analyses by *Sipoecz*† and *Staedeler*‡ have shown contrary to the previous supposition, that lievrite contained water chemically combined, it was necessary to see if this could be admitted for the Greenland lievrite. The crystals which were at my disposal were excellently fit for this investigation, being intensely shining and showing a fresh dark fracture; that these should have taken up water in consequence of some alteration, seemed altogether impossible. Two examinations were made; the first time the lievrite was heated in a platinum tube, the second time in an iron tube well heated beforehand in a combustion furnace; both tubes were about $\frac{3}{8}$ inch in diameter and eighteen inches long. The powdered lievrite was placed in a small platinum boat and introduced in the tube, which was now heated before the blowpipe, while a current of dry air passed through the tube. The water expelled was collected in a tube filled with calcium chloride and weighed. This method is the same as that which was used by *Sipoecz*. I found respectively 1·71 and 1·90 p.ct. of water. When heating the last time, I obtained a higher temperature, and I therefore think the figure 1·90 is to be preferred.

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† Tschermak, Mineralog., Mittheilungen 1875, 71.

‡ Journal f. prakt. Chem. 99, 70.

The result was as follows :—

		Quotients.	
SiO_2	29·30	0·488	0·488
Fe_2O_3	20·30	0·127	0·127
FeO	33·50	0·465	0·493
MnO	1·97	0·028	
CaO	13·71	0·245	0·245
Loss by heat	1·90	0·106	0·106
	100·68		

Then Ca : (Fe Mn) : Fe_2 : Si = 0·245 : 0.493 : 0·127 : 0·488
= 1·94 : 3·9 : 1 : 3·84
= 2· : 4 : 1 : 4·
and H_2 : Fe_2 = 0·106 : 0·127
= 1 : 1·2

This ratio affords the formula :—

$$\left.\begin{cases} 2\ Fe_2\ Si\ O_4 \\ Ca_2\ Si\ O_4 \\ Fe_2\ Si\ O_5 \end{cases}\right\} + H_2\ O$$

or $H_2\ Fe_4\ Fe_2\ Ca_2\ Si_4\ O_{18}$

Whence the following composition is deduced :—

4 $Si\ O_2$ =	240	$Si\ O_2$	29·34
$Fe_2\ O_3$ =	160	$Fe_2\ O_3$	19·56
4 Fe O =	288	Fe O	35·21
2 Ca O =	112	Ca O	13·69
H_2O =	18	$H_2\ O$	2·20
	818		100·00

The above formula is the same which the analyses of *Sipoecz and Staedeler* yielded.

IX.—Lepidolite.

Lepidolite occurs together with ægirine, arfvedsonite, eudialyte, sodalite, and the following mineral at Kangerdluarsuk. It herė exhibits two axes of double refraction. The colour is white, it forms very shining laminæ, in several places intermixed with very small crystals of ægirine, in other places quite pure. The hardness is 2·5, the specific gravity 2·81.

When heated, it fuses very easily (in a candle-flame) to a white bead and communicates to the flame a red colour. It is not decomposed by acids, not even by boiling concentrated sulphuric acid. It contains water in great quantity, but no fluorine. For this I have carefully searched by fusing the mineral with sodium carbonate, and proceeding in the usual way. When calcium chloride had been added, a small precipitate was obtained, but it proved to be only carbonate of calcium.

The lepidolite used for the analysis was extremely pure. The beginning of the analysis was conducted in the usual manner. The alumina being precipitated, the filtrate contained the sulphates of the alkalies. When by evaporating and heating they had been separated from the salts of ammonia, they were dissolved, and the sulphuric acid was precipitated by calcium-chloride and alcohol. In the filtrate the lime was precipitated by oxalic acid, and the alkalies were weighed as chlorides. The chlorides were treated by a mixture of ether and absolute alcohol. The lithium chloride being thereby dissolved, the chlorides of sodium and potassium, remaining as residue, were separated by platinum tetrachloride.

To determine the quantity of water I heated the lepidolite before the blowpipe flame; as no fluorine was present, all the loss by heat might be set down as water. The lepidolite only very slowly lost all its water; until the 13th weighing I did not obtain a constant weight; the mineral had then been exposed to the heat for altogether 5 or 6 hours. In the crucible it fused instantly to clear beads of a vitreous lustre.

The result of the analysis was :—

SiO_2	58·93	——	58·93	0·982	0·982
Al_2O_3	12·87	12·79	12·83	0·125	0·132
Fe_2O_3	1·04	1·18	1·11	0·007	
K_2O	——	5·37	5.37	0·057	0·482
Na_2O	——	7·63	7·63	0·123	
Li_2O	——	9·07	9·07	0·302	
Loss by heat	——	4·99	4·99	0·277	0·277
			99·93		

Then :—

$$Si : Al_2 : R_2 : H_2 = 0{\cdot}982 : 0{\cdot}132 : 0{\cdot}482 : 0{\cdot}277$$
$$= 7{\cdot}4 : 1 : 3{\cdot}7 : 2{\cdot}1$$

If we may assume the ratio to be :—

$$7 : 1 : 4 : 2$$

It will afford the plain formula :—

$$\left\{\begin{matrix} 4 & R_2 & Si & O_3 \\ & Al_2 & Si_3 & O_9 \end{matrix}\right\} + 2\,H_2O$$

Wherein $K : Na : Li = 1 : 2 : 5.$—

The formula shows this lepidolite to be a hydrate of bisilicates, but it does not, it is true, agree fully with the composition obtained by the analysis :—

$7\,SiO_2$	= 420	SiO_2	56·53
Al_2O_3	= 103	Al_2O_3	13·86
$\frac{1}{2}\,K_2O$	= 47	K_2O	6·34
Na_2O	= 62	Na_2O	8.34
$\frac{5}{2}\,Li_2O$	= 75	Li_2O	10·09
$2\,H_2O$	= 36	H_2O	4·84
	743		100·00

This lepidolite has thus been proved to contain a much larger quantity of silica than the species of mica formerly known, and less than half of the quantity of alumina usually contained in lepidolite. Further, it contains unusual quantities of alkalies and of water, while the fluorine, which has been found in all other lepidolites, is wholly wanting.*

X.—Steenstrupine.

The analysis of this mineral has shown it to be a new species, and, as suggested by Prof. Johnstrup, I have therefore given it the name of *Steenstrupine*, after Mr. *Steenstrup*, who not only first found the mineral, but to whom the Museum is also indebted for the acquisition of excellent specimens of the numerous and rare minerals from the Julianehaabs district.

The mineral has a brown colour, a faintly brown, almost white, streak, The hardness is 4, and the specific gravity 3·38. It is pretty easily fused before the blowpipe to a grey, dull bead. Occurs massive and crystallized, together with lepidolite and ægirine in the sodalite-syenite at Kangerdluarsuk.

The crystals are almost always curved, or appear as if they were gnawed off both on the edges and on the planes; only on two small crystals have I been able to observe tolerably distinct planes and edges of combination. They have a certain resemblance to the crystals of eudialyte, and seem to be combinations of a rhombohedron and the basal pinacoid; to these,on the above mentioned two small crystals, there are associated a second positive rhombohedron, and perhaps more than one negative. The angle between the base and the fundamental rhombohedron could not be accurately measured, but was found to be about 128°. As in eudialyte, it is 112° 18′, the two minerals cannot by any means be connected.

The chemical composition being somewhat intricate, I shall give a detailed account of the analysis. The mineral seems to be totally decomposed by acids; however, as it always contains a small quantity of ægirine, which cannot be separated from the silica, I preferred to treat the mineral as if it was not decomposable by acids. I made a single separate determination of the silica, and three analyses; in one of these the mineral was decomposed by carbonate of sodium, and in two by hydrofluoric acid.

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* Compare *Reuter's* analysis of the lepidolite from Rozena: Fl 4·86, SiO_2 50·43, $Al_2 O_3$ 28·07, $Mn_2 O_3$ 0·88, Mg.O, 1·42, K O 10·59, Na_2 O 1·46, Li_2 O 1·23,—98-94, *Rammelsberg*, Mineralchemie 1875, 521.)

The *silica* had a red-brown colour, somewhat resembling that of silica containing iron oxides. After having been heated it was brownish and proved to be extremely impure; 0·2795 gr. was once mixed with 0·234 gr. of the bases (total weight = the impure silica = 0·5135 gr.). The bases on being heated by themselves, were of a dirty grey colour, after cooling, brown. They were dissolved in sulphuric acid, except a small in soluble residuum, and the solution was added to the filtrate from the silica.

Decomposition by hydrofluoric and sulphuric acid.—The mineral was totally decomposed and dissolved, except a small residue, which before the blowpipe in a bead of ammonium-sodium phosphate remained uncoloured; it was further insoluble in sulphuric acid, and was supposed to be tantalic acid. The solution was precipitated with ammonium sulphide, the precipitate dissolved and again precipitated.

The precipitate was now dissolved in hydrochloric acid, which was expelled by sulphuric acid and concentration. The oxides of the cerium-group were then precipitated by sodium sulphate. The filtrate from this precipitate, being a concentrated solution of sodium-sulphate, was precipitated by ammonium-sulphide and the precipitate dissolved. The solution was boiled with sodium acetate, after which only the *manganese* remained in solution; this was determined in the usual manner. In the precipitate thorium and iron were separated from the *alumina* by soda. The *thorium* and *iron* were separated from one another by hyposulphite of sodium.

I have tried to separate the oxides of the cerium-group, in all the analyses, by the method of *Gibbs* (American Journ. 37, 252. 1864), according to which the oxides are oxidized by nitric acid and lead dioxide. Thereupon the basic salts are produced by warming and treated with water containing a small quantity of nitric acid, when the salts of lanthanum and didymium are dissolved, the cerium salt remaining.* I did not find the method practical, especially because it is at times almost impossible to filter the solution from the basic cerium salt. If the solution contains a certain quantity of lead nitrate, the filtration proceeds somewhat easier. For the rest I may remark, that after having been heated, the oxides of lanthanum and didymium were easily dissolved in water containing a drop of nitric acid, but the cerium oxide only when warmed with sulphuric acid, whereas when mixed together, as they were before the separation, they were easily dissolved in hydrochloric acid.

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* Before this operation the sulphates of sodium and cerium, etc., were dissolved; the solution was precipitated by oxalic acid and the oxalates, when heated, dissolved in hydrochloric acid, which finally was expelled by nitric acid.

The quantity of alumina is doubtful, some of it being always dissolved in hydrochloric acid with a yellow colour, which I have not been able to explain.

The *thoria* yielded the following re-actions:—

[1] With *tannic acid*, no precipitate and no colour,

[2] With *zinc and sulphuric acid*, no precipitate and no colour,

[3] With *oxalic acid*, a white, heavy, granular precipitate; *all* was precipitated even in a very acid solution.

[4] With *ammonia*, a white, bulky precipitate.

[5] When boiled the solution yielded a granular precipitate, which after cooling was again dissolved.

The two first reactions show that no titanic acid is present, the third that there is no zirconia, and, together with the fifth, that the substance must be thoria.

I have further searched for chlorine and fluorine, which were found not to be present. When determining the water I first dried the mineral over sulphuric acid, after which it lost 0.95 $^{\circ}/_{\circ}$ water at 100°. The remaining water was expelled in a combustion furnace and weighed directly in a tube with calcium chloride, as the loss by heat above had proved to yield too small a figure, on account of the peroxidation of the mineral.

The analysis yielded the following result:—

$Si\,O_2$	27·95
$Ta\,O_2$	0·97
$Fe_2\,O_3$	9·71
$Al_2\,O_3$	2·41
$Th\,O$	7·09
MnO	4·20
$Ce\,O$	10·66
$La\,O$ $Di\,O$	17·04
$Ca\,O$	3·09
$Na_2\,O$	7·98
$H_2\,O$	7·28
	98·38

As the separation of thoria from the oxides of the cerium-group which is effected by sodium sulphates is not exact, and as moreover the composition of the mineral is very intricate, I shall not attempt to deduce any formula, until more analyses have been instituted.—

Prof. *Johnstrup* has kindly communicated to me the following remarks on the occurrence of lievrite and lepidolite in Greenland:—

> On examination of the minerals, which in 1874 had been brought home from Tunugdliarfik and Kangerdluarsuk by *Mr. Steenstrup*, I perceived, that besides the arfvedsonite and ægiriae a third mineral was present, which differed somewhat from

the others as to crystallization, lustre and specific gravity. An analysis convinced me, that it was *lievrite*. As I have informed you, that this mineral had not previously been found in Greenland, though the contrary has been stated in several works on Mineralogy, I think it necessary to account for this apparent contradiction, even if this rather unessential question should thereby be treated somewhat more at length than I wished to do.

When *Dr. Rink* names lievrite amongst the "doubtful Greenland fossilia,"* it is not without reason; for in the collections of Greenland minerals, which *Giesecke* in the years 1814, 1817, and 1818 sent to the Copenhagen Museums, is only found a single specimen which might contain this mineral. The label says: "Jenait (ought to be Jenit or Yenit) mit Granat, in Granit von Kangerdluluk." Giesecke does not however mention it in his Journal, and therefore cannot have attributed much weight to this occurrence. As probably there have been similar specimens from this locality in the collections which he supplied to the foreign museums, it is easily explained that *Leonhard* in his "Handbuch der Oryktognosie, 1821," amongst the lievrite localities also mentions *North Greenland (Kangerdluluk, mit Granaten in Granit?)* whence it was adopted in his son's "Handwörterbuch der topographischen Mineralogie."

To Leonhard the correctness of this statement may have seemed doubtful, which the sign of interrogation sufficiently shows, and an examination which I undertook of the specimen named, also proved it only to contain amphibole, not lievrite. As upon the whole he deposited the finest specimens in the Copenhagen Museums, there can hardly be finer ones abroad. Therefore the lievrite ought not to be considered as a Greenland mineral till 1874, as till then there had never been pointed out any other occurrence than that above mentioned.

When *Des Cloizeaux* in his Manuel de Minéralogie (1862) in the section "Ilvaite" does not mention *Kangerluluk* (North Greenland) but *Kangerdluarsuk* (South Greenland), he has probably been mistaken about these two localities, the latter being better known on account of its rare minerals. Hence also *Dana* may have adopted this occurrence in the fifth edition of his Mineralogy (1868), while it is not mentioned in the fourth edition (1854). It is then a remarkable case, that the first locality where the lievrite really has been found in Greenland, is the same, which has been given by mistake, while the locality originally stated, viz: Kangerdluluk in North Greenland, should now disappear from the catalogues.

With regard to the *lepidolite*, which in your paper is stated to be new for Greenland, it ought to be remarked that *Giesecke* in his journal† says, that he found it in the immediate neighbourhood of Julianehaab, but, as I have remarked in a note, from this locality it is not found either in the Copenhagen or the Dublin collections. A lepidolite from Kangerdluarsuk he does not at all mention, although it is found in small quantities on the sodalite-syenite brought home by himself. Probably he has thought it to be a common potassium-mica.

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* *Rink*: Groenland geographisk og statistisk beskrevet. Tillæg, p. 152.

† *Giesecke*: Mineralogisk Rejse i Groenland. Kjoebenhavn, 1878, p. 16.