Meddelelser om Grønland,

udgivne af

Commissionen for Ledelsen af de geologiske og geographiske Undersøgelser i Grønland.

Fire og tyvende Hefte.

Med 20 Tavler,
et særskilt heftet, farvetrykt Bilag

og en

Résumé des Communications sur le Grönland.

Kjøbenhavn.

I Commission hos C. A. Reitzel.

1901.

Part I.

On the Minerals

from Narsarsuk on the Firth of Tunugdliarfik in Southern Greenland

by

Gust. Flink.

manganese, which soils everything that comes into contact with it, occurs frequently in the drusy cavities on Narsarsuk; as no other mode of origin of this substance can be indicated than its being due to the alteration of the rhodochrosite, this carbonate must have formerly occurred in considerable quantities.

9. Parisite.

The mineral parisite was discovered about 65 years ago in the emerald mines of the Muso valley, Colombia, South America, by J. J. Paris, the proprietor of the mines at that time. It was sent to Medici-Spada of Rome, who in 1835 gave it the name Musite from the locality. Afterwards, however, this name was changed for parisite after the discoverer. The mineral was first submitted to a closer investigation by R. W. Bunsen[1]). The material he had to examine consisted of one of the two pieces that had been sent to Medici-Spada. It was a crystal broken at both ends, 11^{mm} in breadth and 15^{mm} in thickness. On this material Bunsen made out, so far as the means of the time allowed, the chemical constitution as well as the crystallographical relations of the mineral and found it to be holohedral hexagonal.

The chemical composition was afterwards determined in accordance with more modern methods by Damour and Deville[2]). Des Cloizeaux[3]) came to the same conclusion as Bunsen with regard to the crystallographical character of the mineral; and he also found 13 new forms, more or less certain. He also gives tha indices of optical refraction that had been determined by Senarmont. Lastly Vrba[4]) has examined the mineral. His material consisted of a rather large number of crystal

---

[1]) Annalen d. Chemie u. Pharmacie 1845, Vol. 53, p. 147.
[2]) Comptes-Rendus 1864, Tom. 69, p. 270.
[3]) Manuel de Min. 1874, T. II, p. 162.
[4]) Zeitschr. f. Krystallographie 1889, Vol. 15, p. 210.

fragments and two entire, small, translucent crystals. From the angular values found by him and stated to be fairly accurate an axial ratio is calculated which deviates not a little from the one proposed by Bunsen (and Des Cloizeaux).

A related mineral from Övre Arö in the Langesundfjord, Norway, was investigated by Brögger[1]. The material for investigation was, however, so scanty and so intimately mixed with another mineral (Weibyeïte), that no analysis of it could be made. Neither could the crystallographic examination of it give a decisive result, as no forms occurred other than a hexagonal prism together with the base. But its optical and other physical characters agree with those of the parisite. As, therefore, this mineral cannot be with certainty regarded as parisite and as, further, the two varieties, hamartite[2] from the Bastnås mine, Riddarhyttan, Sweden, and Kyschtym-parisite[3] from a locality in the Ural mountains, are also too imperfectly known to be recognized as true parisite, the Muso valley was the only certain locality of this mineral, until G. Nordenskiöld[4] found it in the «Lützen Collection»[5].

The material from Greenland that G. Nordenskiöld had at his disposal, was very scanty. For the analysis only 0,0966 gr. could be used, and the crystals on which he made the measurements of the angles, were very small and by no means of the best development. The result of his investigation, however, was to show that the Greenland mineral was really parisite. But while the South-American mineral is known only in the form of holohedral hexagonal crystals, Nordenskiöld found the Greenland mineral to be trigonal. The angular values obtained by him agree tolerably well with

[1]) Zeitschr. f. Kryst. 1890, Vol. 16, p. 650.

[2]) Öfvers. K. Vet. Ak. Handl. Vol. 25, p. 399.

[3]) Bull. Ac. St. Pet. Tome 4, p. 401.

[4]) Geol. Fören. Förh. 1894. Vol. 16, p. 338.

[5]) A collection of minerals from Narsarsuk partly described by the author in Zeitschrift f. Krypt. Vol. 23, 1864, pag. 344.

those found by Vrba, but owing to his confusing, somehow
or other, the pyramids of the first and second order, he cal-
culates one more axial ratio.

The material described by G. Nordenskiöld was found
in only very small quantity, as has already been stated, in the
Lützen collection. At the locality, however, it is by no means
of rare occurrence. It is found there only crystallized, and the
crystals are mostly rather small in size. Individuals measuring
$1-2^{mm}$ in length and 0.5^{mm} in thickness are most common.
These crystals are often grouped into loosely coherent aggre-
gates which sometimes cover comparatively large portions of
the surfaces of other minerals as aegirine and feldspar, and
sometimes fill the spaces between the crystals of other minerals.
Not infrequently, however, crystals 1^{cm} in length and thickness
are met with. These larger crystals generally consist of a con-
siderable number of smaller individuals grown together in pa-
rallel position. The largest crystal aggregation of this kind that
has been found is 6^{cm} in length and 3^{cm} in thickness.

Like G. Nordenskiöld, I have found all crystals of this
mineral that I have examined, of trigonal (rhombohedral)
development. Holohedral hexagonal crystals, such as the pari-
site crystals from Muso are said to be, I have never found. All
the crystal faces on the Greenland mineral, except the base, are
more or less dull; on the goniometer they generally give only
shimmering reflexions. They are, besides, almost always deeply
striated horizontally, which also makes the results of the angular
measurements uncertain. Therefore the values obtained by me
can at the most only serve to identify some forms, but are
hardly suitable for an accurate determination of the axial ratio.
However, the better among the values found by me agree more
with those found by Vrba than with the older ones of Bun-
sen and Des Cloizeaux, and therefore the axial ratio calcul-
ated by Vrba is given here also for the Greenlandi mineral:

$$a : c = 1 : 3,36456.$$

Referred to this system of axes, the 16 forms observed by me that could be determined with any degree of certainty, receive the following symbols:

$c = \{0001\}$, $m = \{10\bar{1}0\}$, $n = \{11\bar{2}0\}$, $i = \{1\bar{1}05\}$, $t = \{20\bar{2}9\}$, $u = \{2\bar{2}09\}$, $q = \{1\bar{1}02\}$, $r = \{20\bar{2}3\}$, $v = \{30\bar{3}4\}$, $y = \{3\bar{3}04\}$, $p = \{10\bar{1}1\}$, $s = \{40\bar{4}3\}$, $\alpha = \{30\bar{3}2\}$, $\beta = \{3\bar{3}02\}$, $\gamma = \{3\bar{3}01\}$, $z = \{11\bar{2}1\}$.

The crystals most frequently met with are, as already mentioned, small in size and of acute rhombohedral habit. The predominant form is α, which, together with the base, is in most cases alone present, fig. 2, Plate II. Besides these forms the crystals often show the more acute negative rhombohedron γ, forming with the former parallel combination-edges (fig. 3, Plate II). The more obtuse negative rhombohedron y is less common on these crystals; it occurs in combinations represented by fig. 4, Plate II. This form, as well as the other more obtuse rhombohedra is present chiefly on the larger crystals.

These larger crystals present, with regard to their development, a highly prominent peculiarity. While on most crystals the more obtuse forms (those with the c-axis shorter) are found at the ends and the more acute forms at the middle edges, the reverse is the case with the larger crystals. They are terminated at the upper and lower ends by the acute forms (those with a long c-axis), and the more obtuse forms present a larger or smaller protuberance at the middle, fig. 5, Plate II. These balllike central parts of the crystals often differ as to their character or condition from the rest of the mineral. While the mineral in general is quite fresh, there portions seem to have undergone some sort of alteration. The faces that occur have only a waxy shimmer or are quite dull, so that perceptible reflexions are seldom obtained from them. The determination of the forms in these portions has, therefore, presented great difficulties. The forms i, t, u and s have been determined

with full certainty. Besides them there, however, occur several others which it has not been possible to identify. Thus, both positive and negative rhombohedrons, hexagonal bipyramids, and perhaps also scalenohedral forms occur that are undetermined. Owing to the strong horizontal striation or step-like structure of the crystals the zonal relation between the different forms also remains uncertain. The hexagonal prism of the second order, n, whose faces likewise always are dull, could, however, be determined by its zonal position (Fig. 5, Pl. II).

As has already been mentioned, also the small unaltered crystals and the unaltered end-portions of the larger crystals are not well adapted for accurate angular measurements. Sometimes the faces certainly are tolerably brilliant, but owing to the striation the reflections are in most cases multiplied and consequently uncertain. Of the great number of angular values obtained by numerous measurements on about twenty crystals the majority had to be rejected as not leading to simple symbols for the various forms. Only such forms as have been more regularly met with on several crystals have been regarded as certain and put down in the above list.

The crystals generally present a very distinct rhombohedral development; this is especially true of the small individuals. On the larger individuals the positive and negative forms are not infrequently of nearly equal development. It is then doubtful which are of one and which of the other kind. In most cases, however, the form a predominates and can serve to decide the question. No other means of distinguishing between positive and negative forms can be given.

With regard to the different forms the following remarks may be added. The base occurs constantly on every crystal, not infrequently with both faces, especially on the small crystals, on which it forms small triangular planes. It is the only form whose faces are always brilliant; they are also mostly quite even. On the larger crystals, which are often thickly

tabular parallel to the base, the faces of this form are not infrequently somewhat uneven so as to give multiple and indistinct reflections. The prism of the second order, n, occurs only on the protuberant middle part of the larger crystals. On the smaller crystals this form has not been observed. Its faces are always dull. The hexagonal bipyramid is present under the same circumstances as the preceding form. Its faces are likewise dull.

The rhombohedral forms may be grouped into positive and negative forms as follows.

Positive	Negative
. . . . . .	$i = \{1\bar{1}05\}$
$t = \{20\bar{2}9\}$	$u = \{2\bar{2}09\}$
. . . . . .	$q = \{1\bar{1}02\}$
. . . . . .	$r = \{2\bar{2}03\}$
$v = \{30\bar{3}4\}$	$y = \{3\bar{3}04\}$
$p = \{10\bar{1}1\}$	. . . . . .
$z = \{40\bar{4}3\}$	. . . . . .
$a = \{30\bar{3}2\}$	$\beta = \{3\bar{3}02\}$
. . . . . .	$\gamma = \{3\bar{3}01\}$

To the positive forms t, v and a correspond, as will be observed, respectively the negative forms u, y and β. The negative forms i, q, r and γ have no corresponding positive, and the positive forms p and z no corresponding negative forms.

Common to the South American parisite and the Greenland mineral are only the forms c, m, r, p and s. Consequently the other forms observed by me would be new for parisite. Most of the other forms occurring on the parisite of Muso are hexagonal bipyramids (of the second order). Such forms are also present on the Narsarsuk mineral, though it was not, from reasons stated above, possible to determine them. It is, therefore, probable that several more forms are common to the minerals from the two localities.

As G. Nordenskiöld has shown, twin formation is very

common with the Narsarsuk mineral. The twins have the base
as composition-face, and one of the individuals is revolved 60°
about the vertical axis with reference to the other individual.
A twinning of this kind would not, of course, be possible, if
the mineral were holohedral hexagonal. The twins are easily
recognizable by alternating re-entrant and salient angles at the
line of twinning. Sometimes the twinning is repeated, several
lamellæ in twin position having grown together, which gives
the crystals a step-like or strongly striated appearance. If both
negative and positive rhombohedrons occur, the twins will re-
semble hexagonal bipyramids. It might be supposed that the
South American parisite were formed in such a manner and
that, consequently, it is only seemingly holohedral.

In the table on the following page I have brought together
the results of measurements from which the different forms have
been determined, and also the corresponding calculated values.

The specific gravity of the mineral from Narsarsuk I found
by weighing in benzole, to be $= 3,902$. The specific gravity
of the parisite from Muso is according to Damour $= 4,358$,
according to Vrba $= 4,364$. By way of control I have also
determined the sp. gr. of a crystal of the Muso mineral by the
same method as I used for the mineral from Narsarsuk; I
found it to be $= 4,3915$. The material used for both deter-
minations was pure and homogeneous. The hardness of the
Greenland mineral is the same as that of the Muso parisite,
viz. 4,5. The mineral is brittle and easily pulverized. The
fracture is subconchoidal to splintery. In quite fresh material
i. e. in the small crystals and in the end portions of the
larger ones no cleavage is observable. The middle portions
of the larger crystals, on the other hand, may often be divi-
ded parallel to the base. Cut parallel to the c-axis they also
show in their middle part interrupted partings parallel to
the base. These partings, however, are probably not to be
regarded as true cleavages, but as partings of secondary origin,

3*

	1	2	3	4	5	6	7	8	9	Calculated
(0001) : (1̄105)	. . . . .	. . . . .	37° 51'	. . . . .	37°55'	. . . . .	. . . . .	. . . . .	. . . . .	37° 51'
: (202̄9)	40° 39'	40° 40'	40° 45'	. . . . .	41° 1'	. . . . .	. . . . .	40° 47'	. . . . .	40° 48'
: (22̄09)	. . . . .	40° —	. . . . .	40° 23'	40° 17'	. . . . .	. . . . .	. . . . .	40° 30'	"
: (1̄102)	. . . . .	63° 3'	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	62° 59'	62° 46'
: (22̄03)	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	68° 42'	. . . . .	. . . . .	. . . . .	68° 53'
: (303̄4)	70° 48'	70° 55'	70° 36'	70° 26'	70° 54'	. . . . .	. . . . .	70° 49'	70° 27'	71° 4'
: (33̄04)	70° 51'	. . . . .	71° 59'	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	"
: (101̄1)	75° 36'	. . . . .	74° 11'	. . . . .	. . . . .	75° 22'	. . . . .	. . . . .	. . . . .	75° 34'
: (404̄3)	78° 16'	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	79° 5'
: (303̄2)	80° 36'	. . . . .	80° 8'	. . . . .	80° 52'	. . . . .	80° 15'	80° 10'	. . . . .	80° 13'
: (33̄02)	80° 47'	. . . . .	. . . . .	. . . . .	80° 23'	. . . . .	. . . . .	. . . . .	. . . . .	"
: (33̄01)	. . . . .	. . . . .	. . . . .	85° 41'	84° 57'	85° 27'	. . . . .	85° 57'	. . . . .	85° 6'
: (112̄1)	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	81° 18'	. . . . .	81° 33'
: (101̄0)	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	89° 45'	. . . . .	. . . . .	. . . . .	90° —
(03̄32) : (303̄2)	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	117° 8'	. . . . .	. . . . .	117° 4'
(033̄1) : (33̄01)	. . . . .	. . . . .	. . . . .	119° 30'	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	119° 16'

since they do not occur in such portions of the crystals as are undoubtedly fresh.

The colour of the mineral is wax-yellow passing into light greyish yellow or hair-brown. The projecting central portion of the larger crystals is almost always of a light ash-grey colour with a faint tinge of yellow or brown. Only in thin plates is the mineral translucent, otherwise only subtranslucent. The crystal planes that are not dull have a vitreous or, owing to the striation, almost a silky lustre, approaching on the base to adamantine. The fracture shows a greasy lustre, or sometimes only a waxy glimmer.

A section of a small homogeneous crystal, oriented parallel to the c-axis, shows under the microscope a straw-yellow colour without any perceptible pleochroism. Even if the section is very thin, the interference colours are vivid, indicating strong double refraction. In sections from a crystal with the central portion projecting, oriented as before, the end portions perfectly agree with sections of the small crystals. The middle part is also straw-yellow faintly inclining to green. Weak pleochroism is observable here; the ray vibrating parallel to the c-axis is most strongly absorbed. A reddish brown pigment is arranged in zones parallel to the base and to the traces of the rhombohedral faces. These zones alternate with nearly colourless ones. Sections parallel to the base through the end portions of the crystal are straw-yellow and homogeneous, showing a regular p o s i t i v e axial image with the coloured rings close to one another. A similarly oriented section through the central portion of the crystal, on the other hand, shows the reddish brown pigment in hexagonal zones. The axial image is less distinct, and the coloured rings lie less closely, though the plate has the same thickness as the preceding one.

For the determination of the indices of refraction of the mineral a prism was ground with the refracting edge parallel

to the c-axis of the crystal[1]). Though the mineral transmits but little light, the indices of refraction could be determined with great accuracy. From the values of angles that were obtained the following figures are calculated

	Green	Yellow	Red
ω	1,6767	1,6742	1,6718
ε	1,7729	1,7701	1,7664
$\varepsilon—\omega$	0,0962	0,0959	0,0946.

For the parisite from Muso the indices of refraction have been determined by Senarmont, whose values are quoted by Des Cloizeaux. These values are as follows

ω	ε	$\varepsilon—\omega$
1,569	1,670	0,101.

The Greenland mineral consequently has a considerably stronger refraction than the American mineral. The strength of the double refraction, on the other hand, is about the same in the two minerals.

Before the blowpipe in the forceps the mineral is infusible and emits an intense white light. Splinters that have been ignited are of a light liver-brown colour and traversed by cracks. The mineral is fairly easily soluble in acids, with the evolution of carbon dioxide.

Of the analysis made by me the following account may be given. Pure material for analysis has by no means been wanting, and the values obtained could therefore be verified by duplicate determinations. Both the carbon dioxide and the fluorine were determined directly. The carbon dioxide was

---

[1]) All prisms and plates cut for the axial angle determinations, and microscopical preparations used in this investigation have been made by Mr. A. R. Andersson, •Preparator• at the Geological Institution of the University of Upsala, with his well-known skill and care. They are deposited, together with the rest of the material of investigation, in the Mineralogical Museum of Copenhagen.

driven off by boiling with dilute hydrochloric acid and collected in a potash apparatus. The fluorine was expelled as silico-fluoride, was collected in a soda solution and then precipitated as fluoride of calcium. The precipitate obtained by ammonia from the mineral solution was dissolved in hydrochloric acid, and the solution was saturated with potassium sulphate, by which the cerium earths were thrown down. The slight amount of precipitate obtained by ammonia from the filtrate was attributed to yttria. The cerium oxide was separated from the lanthanum and didymium oxides by leading chlorine for some time into potash solution in which the oxides were suspended. The undissolved residue was taken to be oxide of cerium. The values thus found are given below under I. Those obtained by D a m o u r and D e v i l l e from the mineral from Muso are given under II.
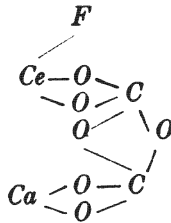
	I.		II.	
		Molecular ratios.		Molecular ratios.
CO_2	26,54	. . . 0,6032—2	23,48	0,5337—3
Ce_2O_3	28,14 ⎫		44,17 ⎫	
La_2O_3 ⎱ . .	22,88 ⎬ . . 0,3221—1		8,05 ⎬ . .	0,3702— 2
Di_2O_3 ⎰	⎪		9,98 ⎭	
Y_2O_3	1,23 ⎭		. . . .	
CaO	17,13 ⎫		10,11	0,1808—1
Na_2O	0,19 ⎬ . . 0,3103—1		. . . .	
K_2O	0,12 ⎭		. . . .	
F	5,82	. . . 0,3068—1	5,55	0,2921—2
	102,05		101,34	
$-O$	2,45		2,34	
	99,60		99,00.	

For the mineral from Narsarsuk the chemical formula thus becomes

$$Ce\,F\,Ca\,C_2O_6,$$
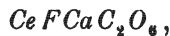
in which Ce indicates all metals of the rare earths contained in the mineral, and Ca stands for calcium together with the small

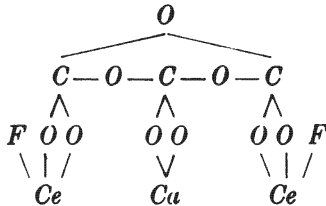quantities of alkali metals. This composition may be denoted by the following structural formula:

$$
\begin{array}{c}
F \\
\diagup \\
Ce-O \\
\searrow O \diagdown C \\
O \diagdown \\
\diagdown O \\
\searrow \\
Ca \diagup O - C \diagup \\
\diagdown O \diagup
\end{array}
$$

For the mineral from Muso the formula would be somewhat more complicated, viz.

$$Ce_2F_2CaC_3O_9,$$

the structural formula being as follows:

$$
\begin{array}{c}
O \\
\overbrace{\qquad\qquad} \\
C-O-C-O-C \\
\wedge \quad\wedge \quad\wedge \\
F\ O\ O \quad O\ O \quad O\ O\ F \\
\diagdown\,|\diagup \quad \vee \quad \diagdown\,|\diagup \\
Ce \quad Cu \quad Ce
\end{array}
$$

The values found by Damour and Deville do not, however, quite correspond to the latter formula. The quantity of fluorine indicated is too small. Further, the analysis shows a loss of 1 per cent. If this loss is assumed to be fluorine (or hydroxyl), the agreement with the proposed formula is somewhat better. The difference in composition between the two minerals would then lie in the fact that the Narsarsuk mineral consists of equivalent quantities of fluorcarbonate of earths and of calcium carbonate, while in the mineral from Muso these substances are presumed to enter in the proportion of 2 to 1.

In the foregoing it has been stated that the two minerals differ from each other with regard to several of their most important characters. To facilitate the comparison these characters are collected together in the following table.

Parisite from Muso.	Mineral from Narsarsuk.
Composition: $Ce_2 F_2 Ca C_3 O_9$	$Ce F Ca C_2 O_6$
Cleavage: Distinct basal	No distinct true cleavage
Sp. Gr.: 4,364	3,902
Refractive indices: $\omega = 1,569$	1,6742
$\varepsilon = 1,670$	1,7701
Crystallization: Hexagonal	Trigonal

These differences are so important that, if all the state-ments could be accepted as correct, the mineral from Narsar-suk which I have here described, and the parisite from Muso should be regarded as two distinct mineral species. The correct-ness of the statements as to the Muso mineral is, however, in my opinion not quite beyond all doubt. The chemical for-mula of the mineral cannot be definitely established, as long as the analyses shows a considerable loss. If this loss represents fluorine, the formula of Damour and Deville will hold good. If, on the other hand, the loss consists, for instance, of lime, the composition approaches somewhat more to that of the mineral from Narsarsuk. But in this case no simple relation between the amounts of calcium carbonate and fluorcarbonate of the rare earths is obtained; that these substances should replace each other isomorphously, can hardly be assumed[1]. The discrepancy as to specific gravity may to some extent be explained as due to the fact of the Muso mineral containing a considerably larger amount of the heavy earths than does the other mineral.

----

[1] After the above was written, an article on parisite from Ravalli Co., Montana, has been published by S. L. Penfield and C. H. Warren (Amer. Journ. of Science, 1899, 4 Ser., Vol. 8, p. 21). In this article an analysis made by Warren on parisite from Muso is also given. This analysis agrees very closely with the formula $Ce_2 F_2 Ca C_3 O_9$ given above. This composition also belongs to the recently discovered parisite from Ravalli Co., which has, likewise, been found to be holohedral hexagonal. These facts are of the greatest importance with regard to the position of the mineral from Narsarsuk I hope soon to come back to the question.

It ought, therefore, to be heavier, though one might not have expected to find the discrepancy so great as it really is.

As for the hexagonal crystallization of the original parisite I have already pointed out that it may possibly be only apparent and due to constant twinning parallel to the base.

In other respects there is great agreement between the two minerals, and judging only from the outward appearance one could not consider the Narsarsuk mineral to be distinct from parisite. As, moreover, experience proves the necessity of great caution in announcing a substance as a new mineral species, I desist for the present from claiming for the one here described the position of a new mineral. It may be united to the parisite, and the true explanation of the discrepancies stated may depend on future investigation.

The parisite is of fairly common occurrence on Narsarsuk. At the locality No. 2 it has been found in the greatest quantity. Small crystals are most common here, but also larger individuals have been found in this place. The accompanying minerals here are neptunite, epididymite, ægirine, microcline etc., all of which are older than the parisite. Of more recent or of contemporaneous origin are albite, elpidite, fluorite, cordylite and polylithionite. Also at the localities No. 12 and 13 parisite has been met with tolerably abundantly. At the former locality the largest of the known crystals (see page 31) was found. The best developed, medium-sized crystals were found at the locality No. 17 associated with the same minerals as at the locality No. 2 and, besides, with arfvedsonite, rhodochrosite, and spodiophyllite.

10. Cordylite (Barium-parisite).

The name of this new mineral is derived from the Greek word χορδύλη, a club; the reason is that its crystals often have a club-like form.