

MEDDELELSER OM GRØNLAND

UDGIVNE AF

KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND

Bd. 119 · Nr. 7

WEBERITE, A NEW MINERAL
FROM IVIGTUT

BY

RICHARD BØGVAD

WITH 2 FIGURES IN THE TEXT AND 1 PLATE

KØBENHAVN

C. A. REITZELS FORLAG

BIANCO LUNOS BOGTRYKKERI A/S

1938

The new mineral from Ivigtut in southwestern Greenland has been named

Weberite

after THEOBALD WEBER, who in 1859 founded the factory "Øresund", and who rendered great services to the Cryolite Industry during its difficult start¹⁾.

Anomalies in the results of the analyses at the "Øresunds chemiske Fabriker", where the raw cryolite from Ivigtut is worked up, suggested the present work, and I express my thanks to Mr. C. F. JARL for permission to carry out the investigation which was chiefly made at the laboratory of the factory. I likewise tender thanks to the Directors of the A/S "Kryolith Mine og Handels Selskabet" and to Mr. S. O. CORP for help and hospitality during my stay at Ivigtut.

As is well known, cryolite and many other complex and simple fluorides are dissolved in an aqueous solution of $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$, with which they form complex compounds. The various fluorides, however, do not dissolve with equal readiness; cryolite, for instance, is more easily soluble than chiolite and fluorite. The method is employed at the "Øresunds chemiske Fabriker" for the determination of quartz, topaz, etc. in the various products appearing during the purification of the raw cryolite from Ivigtut. After boiling, the insoluble residue is washed into a filter, and AlCl_3 is washed out, after which the filter is burned away and the insoluble residue is weighed. When this, the bulk of which is usually quartz, is present in greater quantity than expected, it is examined under the polarization-microscope, and an estimate is thus formed of the quantities of quartz, topaz, and fluorite contained in the product in question.

In August 1937 some products appeared, the analyses of which showed 2—3 % of "insoluble residue", while they were expected to contain c. 0.5 %. These samples contained up to 2 % of a biaxial, weakly

¹⁾ C. F. JARL, Fabrikken Øresund, p. 33, Copenhagen 1909.

birefringent compound with an index of refraction slightly above that of cryolite. — The following possibilities were then present as a cause of the high “percentage of insolubility”. a) Part of the cryolite might have been transformed, perhaps only at the surface, by the treatment in the flotation plant of the factory, and had thereby apparently obtained a higher index of refraction and would not dissolve so readily. — b) Part of the cryolite had been wetted with oil, — c) transformed by boiling with AlCl_3 or — d) transformed by heating; e) a new mineral might be present which did not dissolve so readily in $\text{AlCl}_3, 6\text{H}_2\text{O}$ as cryolite.

After various experiments, amongst others with raw material for the flotation, with cryolite treated with hydrochloric acid and ether, with heated cryolite, and with sorted pure cryolite boiled in $\text{AlCl}_3, 6\text{H}_2\text{O}$, the first four possibilities could be eliminated. On heating the cryolite, its index of refraction did, indeed, rise slightly, but in the “insoluble residue” from the raw material, which had been determined without the use of filter paper but by means of a filter crucible, and thus had not been exposed to heat, the unknown compound was also present.

It could now be safely said that a new mineral was present in the products of the factory. — After some futile investigations weberite was finally found in fluorite-containing pieces of raw cryolite from the factory. It was not possible, however, to sort out material for analysis from these, since the weberite was only present in very small pieces. I then tried to isolate the mineral by a very short boiling with $\text{AlCl}_3, 6\text{H}_2\text{O}$ of the products in which it had first been discovered. The result of this separation, however, was a material which besides essentially heavier minerals such as fluorite and topaz contained the new mineral mixed with chiolite and cryolite, from which weberite cannot be separated by means of liquids of high density. — Shortly afterwards I had occasion to visit the Ivigtut Cryolite Quarry and here I found the new mineral in situ especially in the northern part of the western wall. — Finally it turned out, on going through some material the treatment of which had not been finished, that I had already observed it in small quantities in a couple of samples collected at the factory in 1935, and in two cases during the examination of drill core samples at Ivigtut in 1931. — In a previous paper¹⁾ I have mentioned cryolite which seemed to have an abnormally high index of refraction. What was then observed is probably identical with weberite. — Further, I found it at the Mineralogical Museum of Copenhagen in a sample containing fluorite (No. 17) collected by Ussing at Ivigtut in 1900.

¹⁾ R. BØGVAD, *New Minerals from Ivigtut*, Medd, om Grl., Bd. 92, No. 8, p. 8, 1933.

So far weberite has been found in the following places in the quarry:

Northern wall, cote —60	near the big chiolite locality.
Northern wall, — —58	at the foot of the elevator pillar (Plate, fig. 2).
Lower tunnel, — —55/—60	northern side at entrance.
Western slope, — — —	(Plate, fig. 1).
Southern slope, — — —	
Western wall	in the three fluorite areas from cotes —30 to —50 (Plate, figs. 3—6).
Western wall	near the bottom of the present open quarry.
Southern wall	near the bottom of the present open quarry.
Western quarry	below cote —60.
Eastern quarry	western part, cote —54.
Ledge above quartz pillar	
Bottom layer, western quarry, drilling No. 24, (21.5 m).	
Northern quarry, cote —77.5, drilling No. 28, (67.4 m).	

In samples from most of the above-mentioned localities, some of which are seen in fig. 1 in the text, it occurs in small quantities, and it is difficult to find the mineral without the aid of the microscope and an immersion liquid with the same index of refraction as the mineral. In such a liquid it is easily distinguished from cryolite with its lower refractive index and from the uniaxial chiolite, which has approximately the same index of refraction as weberite. Further, it differs from the two aforementioned minerals by its turbid appearance, due to the inclusions mentioned on p. 8—9. — In the locality at the foot of the elevator pillar, and in the two drillings mentioned above, it occurs in larger quantities, and in the two northernmost fluorite areas situated above each other in the western wall (from about cote —30 to —40 and —45 to —50 respectively) it may be taken in fairly large pieces especially together with green mica.

Weberite is found in all the surface occurrences investigated, together with fluorite, cryolite, topaz, and pyrite. In most localities chiolite, "topaz-cryolite"¹⁾, and green mica are also present²⁾. Finally in some of the samples there occurred together with the new mineral milky

¹⁾ "Topaz-cryolite" is the provisional name for a greyish mass, the bulk of which seems to be cryolite, and which contains numerous very small topaz crystals. It nearly always occurs in company with chiolite.

²⁾ See p. 11.

quartz, feldspar, siderite, and hematite¹⁾, sphalerite, chalcopyrite, jarlite, thomsenolite, "hagemannite", and in a single case the first regular mineral?²⁾ In one of the samples with weberite, which was found at the factory in 1935, there occurred in addition to fluorite, green mica³⁾ etc., some prosopite⁴⁾, not previously recorded from Ivigtut but discovered associated with cryolite at Pikes Peak in Colorado.⁵⁾

In thin sections under the microscope (see the plate) it is seen that the weberite areas consist of crystal individuals of different orientation and highly varying size. The large individual in fig. 6 (where nothing is stated to the contrary, the figures refer to the plate), for instance, is about 2.5 mm long.

The boundary planes between the weberite individuals are sometimes quite irregular, sometimes plane and parallel to the two most conspicuous planes of cleavage mentioned on p. 9 (fig. 6, the plate; fig. 2 in the text).

In some few cases the individuals have a certain longitudinal extension and are parallel in such a way that they convey the impression of twinning-lamellæ (particularly fig. 2, at top, in the weberite area).

As already mentioned, in most of the localities weberite is merely sporadically present, often surrounded by fluorite (fig. 1); in other places larger quantities are seen enclosed in cryolite, though it cannot be decided which has crystallized first (fig. 2). Fig. 4 shows a section consisting almost exclusively of weberite.

In some sections the fluorite along the boundary towards the cryolite and weberite has a quite clear, narrow zone, interrupted by an almost opaque zone. Farther from the boundary of the cryolite, the fluorite is very turbid and penetrated by concentric opaque zones, which are much narrower than the outer opaque zone and, like the latter, contain numerous inclusions (fig. 1).

Pyrite is frequently enclosed in the weberite, always in automorphic crystals (fig. 5). Mica occurs both in larger (fig. 3) and in smaller areas, as a rule with a somewhat irregular boundary towards the weberite. Sometimes veins of mica are likewise found (fig. 5).

Several complex fluorides containing Mg have been mentioned in the literature. Thus F. RÖDER⁶⁾ claims to have produced $MgAlF_5$ by the

¹⁾ Siderite and hematite are rather rare in the fluorite areas outside the eastern quarry.

²⁾ BØGGILD, *Zeitschr. f. Kryst.*, 51, p. 607—608, 1913.

³⁾ See p. 11.

⁴⁾ The prosopite from Ivigtut will be treated in a later paper.

⁵⁾ CROSS and HILLEBRAND, *American Journ. of Science*, vol. 26, pp. 288 and 291, 1883.

⁶⁾ Über krystallisirte wasserfreie Fluor-Verbindungen, Dissertation, p. 29—30, Göttingen 1863. (By the courtesy of Mr. A. H. NIELSEN.)

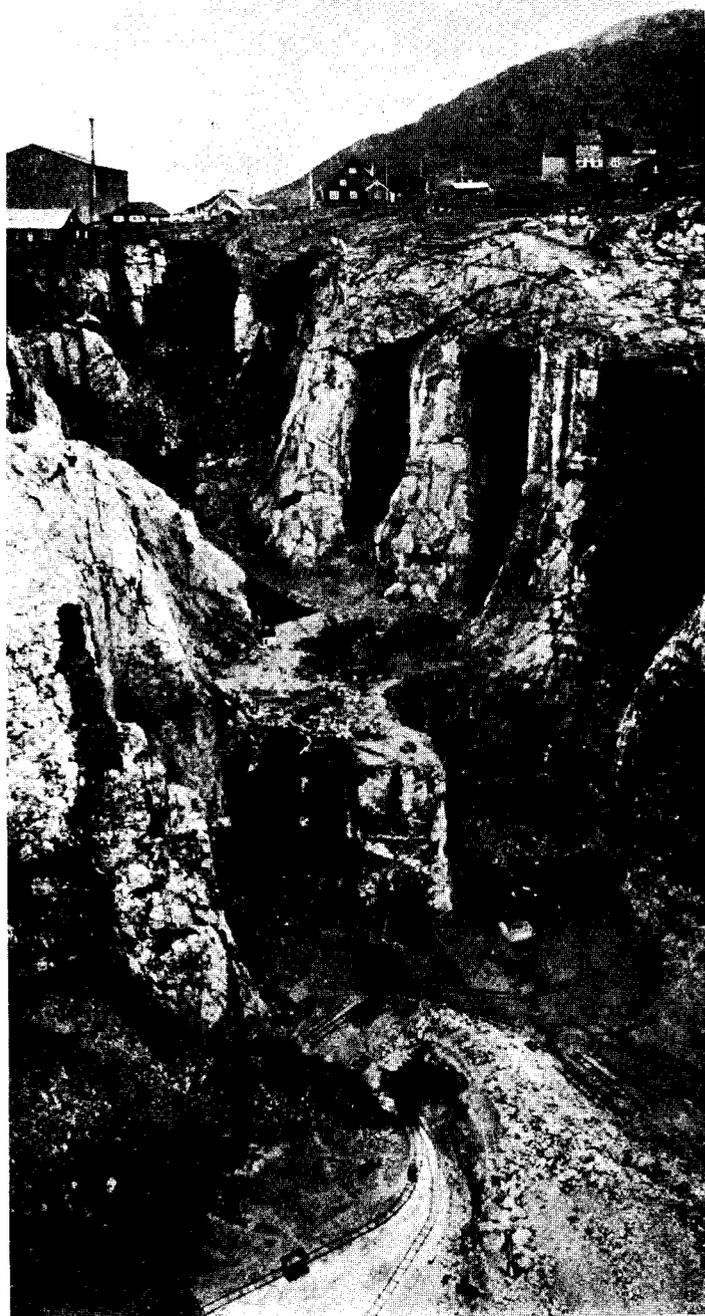


Fig. 1. View of Ivigtut Cryolite Quarry, looking east (autumn 1937). In the left foreground, the foot of the elevator pillar, and, to the right of this, the entrance to the lower tunnel flanked by the area from cote —55 to —60. Above the excavator to the right, the western part of the eastern quarry.

action of magnesium chloride on cryolite; he only ascertained, however, that the theoretical quantity of Mg was present in the substance, and did not determine Al and F.

A. NOELLNER¹⁾ produced amongst other fluorides NaMgAlF_6 , H_2O , likewise by the action of magnesium chloride on cryolite, by six days' treatment at 180°C .

A. H. NIELSEN²⁾ seems to have arrived at the same compound by a quite brief boiling of finely powdered washed cryolite in a magnesium chloride solution. The reaction product was apparently isotropic with a refractive index of about 1.37.

SLARABBA³⁾ erected the mineral zamboninite, CaMg_2F_6 from Etna, but FERRARI and CURTI⁴⁾ showed that it was a mechanical mixture of fluorite and sellaite.

G. CAROBBI⁵⁾ has recently claimed that he could erect a new mineral from Vesuvius with the composition $(\text{Ca.Na}_2)\text{F}_2.\text{MgF}_2 \cdot 2\text{Al}(\text{F.OH})_3$ and n between 1.40 and 1.41. It has been found in stalactites associated with alkalibisulphates, hieratite, and other substances. — The composition has been calculated from the analysis of the whole mixture, deducting the components of the identified compounds.

At Ivigtut magnesium in large quantities is rare. It occurs in rals-tonite and, as shown by H. BUCHWALD²⁾, in one of the regular minerals found by O. B. BØGGILD⁶⁾, which later was separated by the present writer from samples that also contained prosopite. — Further it has been found in impure thomsenolite, the so-called hagemannite by HAGEMANN (BØGGILD⁷⁾ p. 125 and BUCHWALD²⁾). Various authors (see especially BØGGILD⁷⁾) further record small quantities or traces of Mg in siderite, columbite, fluorite, cryolite, chiolite, thomsenolite, gearksutite and jarlite from Ivigtut.

In solid pieces weberite is light grey, but white in the powdered condition. — It is translucent and has a vitreous lustre.

The specific gravity was determined on the material for the analysis by means of a pycnometer and an air-pump:

$$D = 2.96.$$

This value is possibly a little too low owing to inclusions, of which there are usually many in the mineral. These consist in part of up to 20μ

¹⁾ Zeitschr. Deutsch. geolog. Ges., 33, p. 152, 1881.

²⁾ From personal information.

³⁾ Boll. Soc. Geol. Ital., 46, p. 259, 1929. (Ref. Neues Jahrb. I, p. 142, 1932.)

⁴⁾ Periodico di Mineralogia, p. 465—472, 1933. (Ref. Neues Jahrb., p. 143—144, 1934.)

⁵⁾ Atti (Mem) Accad. Sci. Lett. Arti, ser. 5, vol. 1, p. 33—42, Modena 1936.

⁶⁾ Zeitschr. f. Kryst., 51, 6. Hft., p. 607—608, 1913.

⁷⁾ Mineralogia Groenlandica, Medd. om Grønland, 32, 1905.

sized, irregular, slightly rounded cavities filled with gas; they are either quite irregularly placed or arranged in parallel rows like strings of pearls. — Further there occur cavities filled with liquid, occasionally enclosing a bubble of gas, — and finally a number of inclusions with a much higher index of refraction than weberite, probably green mica and topaz. At the boundary between two differently orientated crystal individuals the inclusions are often present in large quantities.

The hardness is 3.5. — The fracture is uneven. — No distinct cleavage is seen macroscopically in pieces of weberite, but in thin sections

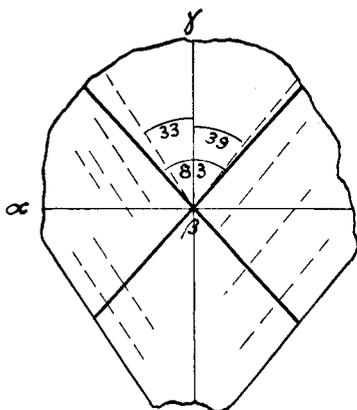


Fig. 2. Sketch of a weberite individual. The plane of the paper is the axial plane. The continuous lines represent the optic axes, the stippled lines, the most conspicuous planes of cleavage.

several planes of cleavage may be observed under the microscope. The two most conspicuous directions are perpendicular to the axial plane, forming angles of about 33° and about 39° respectively with the β - γ -plane (fig. 2 in the text). — A third less conspicuous plane of cleavage seems to be parallel to the axial plane. — These measurements were made by means of the universal stage.

No crystals of the mineral have been found. From the direction of the cleavage planes it seems to be monoclinic. The mineral is optically positive.

The indices of refraction were determined on orientated grains of the mineral by the immersion method, with a series of liquids, mixtures of glycerol and water, whose refractive indices differed < 0.001 from each other:

$$\begin{aligned} \alpha &= 1.346 \\ \beta &= 1.348 \\ \gamma &= 1.350^1) \end{aligned}$$

¹⁾ Natrium light with a Lifa light filter.

As a check the average index of refraction was calculated on the basis of the specific refractive energies, $\frac{n-1}{D}$, from NaF, MgF₂ and AlF₃¹⁾, according to GLADSTONE'S and DALE'S law²⁾: $n = 1.343$.

The strength of the birefringence was found by means of BEREK'S compensator:

$$\gamma - \alpha = 0.003^3).$$

The axial angle was determined on the universal stage. The average of 11 determinations of the acute and obtuse axial angles respectively was

$$2V_\gamma = 83^\circ \pm 3^\circ.$$

(The great difference between the refraction of the mineral and the glass hemispheres rendered possible the direct determination of the obtuse axial angle on the outer east-west horizontal axis of the universal stage.)

Before the blowpipe the mineral turns white and swells up, but it will not fuse to a drop, as for instance cryolite. — After ignition it shows an alkaline reaction, and with cobalt nitrate an Al reaction. — On heating in a closed tube, a small quantity of white solid sublimate is deposited while acid vapours are given off and the glass is corroded.

100 c. c. of water dissolves 0.02 g of the mineral. The determination was made by boiling finely powdered material with water for 10 minutes and afterwards cooling to room temperature, filtrating and evaporating in a drying box (2 determinations). — The evaporated material consisted of apparently isotropic particles with a refractive index of about 1.35 and a size of about 1μ . — Na, Mg, and Al were shown to be present in the material. — Further I have let a saturated aqueous solution of weberite evaporate at room temperature in the course of 1 $\frac{1}{2}$ months so as to obtain crystals of the mineral, if possible. — This proved impossible, the compound having evidently been split, so that two components had been formed. One of these consisted of apparently isotropic particles with an index of refraction of about 1.37. The other was made up of rhombic positive crystals with a refractive index of about 1.32. The former component is probably an aqueous Na-Mg-Al-fluoride (see p. 8); the latter component must, judging by the very low index of refraction, contain much Na and F.

As already mentioned, weberite is further soluble in an aqueous solution of AlCl₃·6H₂O, but only after boiling for a longer time than cryolite.

¹⁾ The specific refractive energy of AlF₃ was calculated from cryolite and chiolite.

²⁾ See LARSEN and BERMAN, *The Microsc. Determin. of the nonopaque Minerals*, p. 30, Washington 1934.

³⁾ Natrium light with a Lifa light filter.

The material for the analysis, about 5 g, was taken from samples collected in the west wall of the western quarry in Ivigtut. The impurities were separated off by means of methylene iodide and bromoform.

The analysis was made by Mr. H. BUCHWALD:

	Analysis	Theoretical after $\text{Na}_2\text{MgAlF}_7$
Al.....	11.65	11.71
Fe	0.37	—
Ca	0.08	—
Mg.....	10.43	10.56
Na.....	19.08	19.97
K.....	1.19	—
F	57.58	57.76
Remainder.....	0.16	—
	100.54 %	100.00 %

H. BUCHWALD gives the following information: "The analysis was made on air-dried material. Fluor was determined after the method of HAWLEY (fluoride is precipitated as PbClF and the quantity of Cl equivalent to F is titrated with 0.1 N. AgNO_3); this method is apt to give somewhat too high results. — In determining the iron it was disregarded whether this was found as Fe^{++} or Fe^{+++} . — The analysis gives the composition



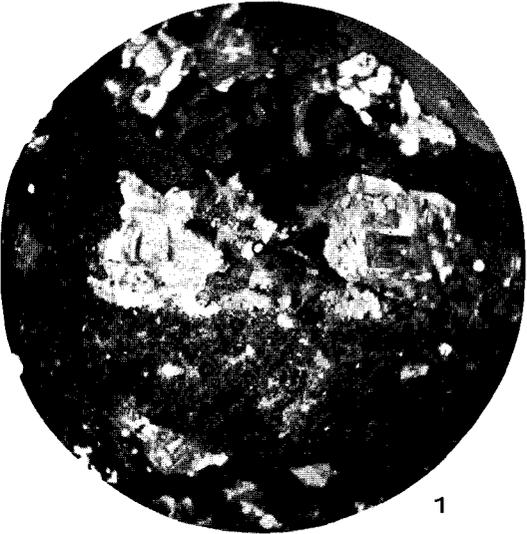
in which part of the Na has been replaced by K."

The 0.16 % found as the residue after decomposition with H_2SO_4 , turned out to consist of mica¹) and topaz. There must, however, have been more than the 0.16 % of impurities in the material for analysis, since a determination with $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$ gave 0.80 % of "insoluble" (H. BUCHWALD), which consisted in the main of mica¹). Part of this enters into the analytic results, and thus the Al-, Fe-, and K-values are a bit too high. — The 0.08 % Ca is in all probability derived from fluorite; the 0.37 % Fe probably replaces some of the Al or Mg in the molecule.

¹ The green mica which accompanies weberite, and which has been mentioned several times in the preceding part, has been provisionally analysed by H. BUCHWALD. It contains Al_2O_3 , c. 6 % Fe_2O_3 , K_2O and a little Na_2O .

Explanation of the Plate.

- Fig. 1. The nicols form an angle of about 80° with each other. — $\times 8$. — Ivigtut cryolite quarry, western slope, cote — 55/—60. A cryolite area runs through the middle of the figure from left to right. — Above and below this, fluorite. — The two small individuals lying near a gas bubble almost in the centre of the picture are weberite, as is also part of the very light-coloured area above to the right. — In the upper fluorite area, in particular, along the boundary towards the cryolite, is seen an opaque zone formed of numerous inclusions. Adjacent to this are seen thinner concentric rings further inside the fluorite.
- Fig. 2. Nic.+ . — $\times 9$. — From the foot of the elevator pillar. Fluorite above, adjacent to cryolite with twinning-lamellæ. In the cryolite, a little to the right of the perpendicular centre line, is seen an area of weberite, with twinning-lamellæ next to the fluorite.
- Fig. 3. Nic.+ . — $\times 27$. — Upper fluorite area in the west wall. Weberite to the left, fluorite in the middle, and mica to the right.
- Fig. 4. Nic.+ . — $\times 20$. — Lower fluorite area in the west wall. Weberite (nearly the whole figure) with a little mica (the three light-coloured triangular areas below to the right). A little to the left of the quadratic weberite individual in the centre of the figure, cleavage planes of weberite.
- Fig. 5. Nic.+ . — $\times 17$. — Lower fluorite area in the west wall. Weberite in the middle of the figure. Mica at the edge to the left and below to the right (southeast), as also in a vein to the right of the perpendicular centre line. Three automorphic pyrite crystals near centre.
- Fig. 6. Nic.+ . — $\times 17$. — Lower fluorite area in the west wall. Weberite with a little mica. Two planes of cleavage are seen in the large weberite individual.



1



2



3



4



5



6