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NEW MINERALS FROM IVIGTUT, SOUTHWEST GREENLAND

BY

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WITH 1 FIGURE IN THE TEXT AND 2 PLATES

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The Columnar Aggregates.

In the spring of 1929 a columnar aggregate not formerly closely examined was discovered at Øresunds Chemiske Fabriker (C. F. JARL). The preliminary mineralogical examination showed i. a. the presence of a new fluoride (for the present denoted mineral X) and a relatively highly refractive mineral which was determined as baryte, a mineral which had not previously been recorded from Ivigtut.

In a collection which Mr. SVEND JARL had brought home from Ivigtut about the year 1920 and handed over to Øresunds Chemiske Fabriker, I found a piece of the same characteristic appearance. Similar samples had been supplied to the Mineralogical Museum by Dr. ØDUM after a journey to Ivigtut.

The colour of the rock is greyish-green or brownish, later reddish varieties have been found as well. The brownish variety seems to be in a more weathered state than the greyish-green, and the rocks contain cavities with partially dissolved remnants of cryolite and presumably gearksutite, partly with mm-large crystals of thomsenolite and the new mineral described below as jarlite.

The columnar aggregates (Pl. II, fig. 11) consist of a mixture of thomsenolite, fluorite, spherulitic topaz, baryte, and a new fluoride (mineral X). Pyrite and small quantities of chalcopyrite are dispersed throughout the mass. A green mineral, probably identical with ivigtite, is likewise represented in the rock, and quartz occurs here and there. Chiolite was not observed.

A more detailed account of the relation between the above-mentioned fluoride (mineral X) and the two new minerals jarlite and meta-jarlite, as well as a thorough description of the columnar aggregates will follow in a later paper.

Jarlite.

As stated above, the mineral occurs together with thomsenolite in cavities in the columnar aggregates. The free crystals very rarely exceed a length of 1 mm. The crystals are usually orientated in such a way as to form fans or spherulites.

The mineral has been named jarlite, after Mr. C. F. JARL, by whose courtesy I have been enabled to carry out the present investigations in

addition to permanent observation of all the interesting minerals that are brought back from Ivigtut.

I also owe a great debt of gratitude to Professor O. B. BØGGILD for much help and guidance during the work.

The crystals are colourless or slightly brownish, due to a thin coating of rust which under the microscope resolves itself into small, very refractive particles. The crystals often enclose oblong air-bubbles, which may be orientated in three different directions ≠ conspicuous edge directions. Further, interpositions of solid particles may sometimes occur.

The hardness of the small crystals cannot be stated with certainty. Probably it is 3—4.

It has been extremely difficult to find material for measurement by goniometer. Many cavities have been searched for free, well-developed crystals. In by far the majority of cases, several individuals, as already stated, are densely fused so as to form fans. Hence faces from other crystals will always be included in the measurements, and the free crystals often have curved faces which give quite indistinct reflections. — Gradually I succeeded in finding and measuring about twenty crystals, fourteen of which were rather good.

The measurements were made on the two-circle goniometer, and by comparison of the results from the fourteen crystals it will be seen that

5	forms	occur	in	8—9	crystals
1	—	—	-	4	—
3	—	—	-	2—3	—
and 6	—	—	-	1	—

Thus the ten last forms only occur in a few crystals, and as further the parameters do not correspond with the parameters of the most frequently occurring faces, they are omitted, and only the five forms that are of most frequent occurrence, and even in 3—4 cases are the only faces measured, are considered as certain. On account of the poorly developed faces the picture of the crystals should only be considered a preliminary result.

The crystals (fig. 1) are monoclinic and elongated along the Y axis with the following faces, enumerated in the table below together with the approximate position values for an arrangement with (010) as a polar plane:

		ς	φ
a	(100)	90°00′	0°00′
c	(001)	—	69°20′
r	($\bar{1}$01)	—	146°30′
m	(110)	36°10′	0°00′
b	(010)	0°00′	

(100) is, as a rule, the greatest.

The ratio c: a was found by means of (101) to be 1.7665, and b: a by means of (110) to be 0.6840:

$$a : b : c = 1.46 : 1 : 2.58. \quad \beta = 69°20'$$

The refraction was determined by the method of immersion:

$$\alpha = 1.427$$
$$\beta = 1.432—1.433$$
$$\gamma = 1.435$$

The axial angle was measured by placing the crystals between glass hemispheres, and by six measurements the following values were arrived at:

1) 2 V_a .....78°10′
2) — .....79°10′
3) — .....80°00′
4) 2 V_o .....91°40′
5) — .....92°00′
6) — .....92°30′

With the normal to (100) the bisectrix observed forms an angle of:

2) c. 16°
4) - 16°
5) - 24°15′

1, 2, and 3 are optically negative, 4, 5, and 6 optically positive. The majority of the crystal fragments observed, however, are optically negative.

Whether the values enumerated are all of them referable to the same mineral, which may possibly by minor changes in the chemical composition exhibit variations of the axial angle, or whether they belong to two different substances, cannot be decided until better material is available. (The possibility seems to be present that 4, 5, and 6 are crystals of metajarlite). All the crystals had a refraction of about 1.43. (In this connection it may be mentioned that an axial angle of 2 V = 41°—43° was occasionally ascertained in crystals among the material from the cavities in the columnar aggregates (possibly mineral X). The refraction of these crystals is likewise c. 1.43).

The specific gravity was determined as stated below under metajarlite. On account of the inclusions of both air-bubbles and solid particles even in selected material, only two decimals are given:

$$D = 3.93$$

Before the blow-pipe the mineral easily melts, showing effervescence, and after heating gives an alkaline reaction. Like cryolite it is soluble

in aluminum chloride, with which it forms complex combinations. (Boiling with a solution of $AlCl_3$, 6 H_2O is an excellent method for the isolation of certain minerals that occur together with fluorides. Thus cryolite, chiolite, thomsenolite, jarlite, etc., are dissolved in that way but after different periods of exposure to this action, and barite, quartz, topaz, etc., are not affected at all.)

In 1931 I found columnar aggregates with jarlite in situ in several places in the cryolite quarries by Ivigtut. Thus southwest of the mouth of the tunnel in the western part of the quarries on cote ÷ 60 they were

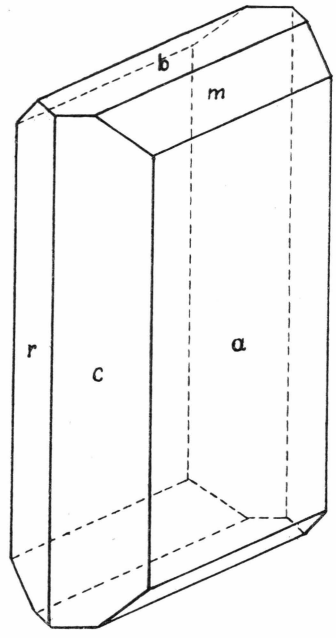


Fig. 1. Jarlite.

found as a dyke-like formation, which has connection with another area south of the shaft leading down from ÷ 55 to ÷ 60, where the rock occurs i. a. in connection with violet fluorite and black cryolite; this area extends towards the southwestern corner of the quarry on cote ÷ 55, where the samples found in 1929 were mined. In 1932 the above-mentioned reddish variety was further discovered in the large magazine in the north-western corner of the quarry.

The purest possible material for analysis, determinations of refraction, etc., has been obtained in the following way. The thomsenolite was removed by means of methylene-iodide, which is easier and cheaper to employ than Clerici's solution. The remaining impurities were removed by means of Clerici's solution, the only common heavy liquid that is heavier

than the mineral. By repeated centrifuging with a hand-centrifuge (maximum about 2000 rotations a minute) and decantation of the lightest material a comparatively pure product can be obtained.

The analysis of the mineral is dealt with after meta-jarlite.

Meta-Jarlite.

In the autumn of 1930 at Øresunds Chemiske Fabriker my attention was caught by some greyish inclusions in chiolite. A provisional examination, especially as to the refraction, showed that a fluor mineral not previously described was present. Macroscopically, especially in wet pieces, the mineral may be confounded with dark-coloured cryolite, but on looking through the chiolite material of the factory several pieces with the new mineral were found.

The mineral has been named meta-jarlite, since both as regards refraction and its chemical composition it comes close to jarlite.

In thin sections under the microscope meta-jarlite proves to be composed of delimited areas or blocks, which are usually very differently orientated in relation to each other (Pl. 1, figs. 1—2 and 6). The individual blocks are composed of sometimes highly bent, elongated individuals, which cause the greatly undulating extinction in the blocks. The meta-jarlite individuals may be up to 5 mm long. Some few blocks are composed of quite small individuals, apparently placed at random (Pl. 1, fig. 5), yet a certain regularity in the extinction from one individual to the other within the blocks is noticeable. Sometimes several fan-shaped or pinnate blocks of meta-jarlite are seen, arranged in the same direction one beside the other, the individuals being orientated in such a way that on rotation of the the microscope-stage the undulating extinction begins at the same side of all the blocks and moves across them almost simultaneously, from which a pinnate arrangement of the minor individuals may be inferred (Pl. 1, fig. 4). — Here and there, especially at the middle of the meta-jarlite masses, there occur veins consisting of up to 100 μ big meta-jarlite individuals; — from the veins, and almost vertical to them, there often issue long rays of the mineral (Pl. 1, fig. 3.)

The chiolite which surrounds the meta-jarlite is easily distinguishable from this latter, it being extinguished simultaneously over large areas, which are sharply marked off from other parts of the chiolite with a different orientation (Pl. 1, figs. 1—2). In the chiolite cleavage systems parallel to the direction of extinction (basal cleavage) are seen (Pl. 1, fig. 2), and the mineral may contain needles (up to 1 $\times$ 30 μ) presumably of topaz. In sections normal to the main axis of the chiolite these needles are sometimes orientated in two main directions at an interval of 45° (probably along the pyramidal planes), while a small number of them are more casually arranged. — Often the meta-jarlite fans protrude far into

the chiolite areas, and the individuals may then terminate in points; in continuation of these, fragments of meta-jarlite may sometimes be found in the chiolite. These have as a rule the same optic orientation as the apices of the fans, which thus seem to have been connected with the fragments outside the plane of the section (Pl. 2, fig. 7). In the meta-jarlite, however, there may often be found, among the long individuals, rows of very small particles, no doubt consisting of chiolite, and sometimes wedge-shaped fragments of chiolite which as regards orientation do not correspond to the surrounding areas of chiolite (Pl. 1, fig. 2). Thus it must be assumed that the chiolite, at any rate in several areas, is older than the meta-jarlite.

The meta-jarlite and the chiolite are often intersected by up to 80 μ broad beds of cryolite, which may develop into larger cavities and frequently penetrate the meta-jarlite blocks transversally (Pl. 2, fig. 9). In places the cavities with cryolite are intersected by the same cryolite veins that may also form the boundary between meta-jarlite and chiolite. Among these there sometimes occur large areas of cryolite which send off dykes into the surrounding minerals and which seem to have absorbed some meta-jarlite, the boundary of which has thus become more rounded than usual (Pl. 2, fig. 8). In some few cases this cryolite that occurs at the boundary between meta-jarlite and chiolite, seems to have a somewhat higher refraction than the normal cryolite from Ivigtut. — The afore-mentioned cryolite beds are younger than the meta-jarlite and the chiolite, and the cryolite sometimes contains rounded fragments of meta-jarlite, the presence of which may indicate the same age relation; however, part of the cryolite is older than the beds, and the age relation of this part to the meta-jarlite and the chiolite could not be decided on account of the irregular boundaries. A single graphic-granite-like area with chiolite-cryolite was observed in the preparations, but this area may also be interpreted as a section through an uneven boundary plane between the minerals.

The boundary area between the meta-jarlite and the chiolite sometimes consists of a very irregular mixture of meta-jarlite, fluorite, cryolite, chiolite, and topaz. The areas of fluorite present fairly rounded boundaries towards the other minerals (Pl. 2, figs. 7 and 10). In some few places they follow the curvation of the meta-jarlite individuals. The fluorite is penetrated in all directions by dark, ribbon-like areas and by thin fissures, which seem to contain cryolite. These fissures sometimes run along the boundary of the fluorite (Pl. 2, fig. 10), and many of them are connected with the areas of cryolite. — Spherulites of topaz with a needle-length of up to 150 μ occasionally occur, bounding the fluorite and enclosed in the cryolite (Pl. 2, fig. 10).

Pyrites with well-developed crystal faces occur in the meta-jarlite as well as in the adjoining chiolite and fluorite.

Even without a microscope, especially on ground surfaces, one may observe the radiating structure of the meta-jarlite, which extends in "bays" into the chiolite. The rays issue like pinnæ from the middle of these to the boundary of the chiolite, and here, too, one receives the impression that the meta-jarlite is the youngest. The pyrite is at times concentrated round an axis in the middle of these "bays" and occurs more sparsely towards the boundary of the chiolite. The cryolite that accompanies the meta-jarlite is faintly smoke-coloured, and occurs in areas up to 1 cm in size. — The largest piece of meta-jarlite observed measures c. 20 × 20 × 10 cm.

As will be seen from the above, the meta-jarlite occurs enclosed in chiolite together with cryolite, fluorite, topaz, and pyrite. The pyrite has been formed first everywhere, and the chiolite seems to be older than the meta-jarlite. A part of the Cryolite is absolutely younger than the meta-jarlite-chiolite-fluorite, while it is difficult to determine the relative age of other areas.

As stated above, the colour of the mineral is grey.

The hardness of the mineral is 4—4.5.

Crystals of meta-jarlite were not found; no cavities occur in the mineral. The meta-jarlite is biaxial, the axial angle is nearly 90°, and even on the basis of the extinction of the elongated but bent individuals the crystal system cannot be more accurately determined. On account of the large axial angle the sign is difficult to determine; however, the mineral is probably optically positive.

The refraction was determined by the method of immersion. As a result of repeated determinations only an average refraction value can be given:

$$n = 1.432 \pm 0.004$$

The double refraction is almost as in quartz, or possibly slightly higher.

The specific gravity was determined by centrifuging of the mineral in Clerici's solution. The pulverised material is placed into the liquid and during repeated centrifugings the liquid is adjusted until the powder keeps suspended, after which the specific gravity of the liquid is determined by means of a Westphal balance.

$$D_{21\text{-}23}{}^{\circ} = 3.780—3.781 \text{ (five determinations).}$$

The mineral easily melts, showing effervescence, and after heating gives an alkaline reaction. Like jarlite it is soluble in aluminum chloride.

Despite careful search, outcrops of meta-jarlite have not yet been

observed in the Ivigtut cryolite quarry, whereas several samples, as stated above, have been found at Øresunds Chemiske Fabriker. In the quarry it should probably be searched for in the chiolite in the western quarry. During Miss CALLISEN's investigation journey to Ivigtut in 1931, in which H. GRY and myself took part, we made a mineralogical examination of the drill cores, and found the meta-jarlite in the western part of the quarry, near the pumping well on cote ÷ 35 and west of Niche 1 in the south wall.

The mineral powder employed for the analysis etc. was purified by means of methylene-iodide and Clerici's solution, the pyrite, however, was first floated off by means of a xanthate and pineoil.

Analysis of jarlite and meta-jarlite.

The chemical analyses have been executed by Dr. RAGNAR BLIX, Stockholm.

Jarlite.

	Weight %	mol. quot.	
H_2O — 105°	0.08		
H_2O + 105° 1.54 %, i. e. OH:	2.91	0.171	2.446
F	43.23	2.275	
Li	0.08	0.011	0.152
Na	3.23	0.141	
Mg	0.90	0.037	0.464
Ca	0.55	0.014	
Sr	35.60	0.406	
Ba	0.99	0.007	
Al	12.16	0.450	0.453
Fe	0.17	0.003	
	99.90 %		

Meta-jarlite.

	Weight %	mol. quot.	
H_2O — 105°	0.08		
H_2O + 105° 1.14 %, i. e. OH:	2.14	0.126	2.521
F	45.50	2.395	
Li	0.04	0.006	0.160
Na	3.54	0.154	
Mg	1.38	0.057	0.481
Ca	3.20	0.080	
Sr	28.70	0.328	
Ba	2.25	0.016	
Al	12.49	0.463	0.469
Fe	0.31	0.006	
	99.63 %		

The molecule quotients are thus

for jarlite: (Na, Li) : (Sr, Mg, Ca, Ba) : (Al, Fe) : (F, OH)
= 1.00 : 3.05 : 2.98 : 16.1 = 1 : 3 : 3 : 16

and for meta-jarlite: (Na, Li) : (Sr, Mg, Ca, Ba) : (Al, Fe) : (F, OH)
= 1.00 : 3.01 : 2.93 : 15.8 = 1 : 3 : 3 : 16

and the formula of the minerals will be: $Na\ Sr_3\ Al_3\ F_{16}$, in which

	Li	partially	replaces	Na,
Mg, Ca, and	Ba	—	—	Sr,
	Fe	—	—	Al, and
	OH	—	—	F.

The formula $Na\ Sr_3\ Al_3\ F_{16}$ can (likewise according to information furnished by Dr. R. Blix) be explained as a combination of salts of the acids $H\ Al\ F_4$ and $2\ H_3\ Al\ F_6$, viz. $Na\ Al\ F_4 + Sr_3Al_2F_{12}$.

In their chemical composition the two minerals are closely related, but the meta-jarlite contains more magnium, calcium, and baryum and less strontium than the jarlite.

The formula $Na\ Sr_3\ Al_3\ F_{16}$ corresponds to

Na	3.43	per cent.
Sr	39.17	- -
Al	12.11	- -
F	45.29	- -
	100.00	per cent.

In spite of several common features jarlite and meta-jarlite are erected as two different minerals, partly on account of divergent optic conditions, partly owing to the different specific gravity, which is highest in jarlite; this also agrees with the higher Sr-Ba-content of that mineral. Further it should probably be taken into consideration in this connection that the meta-jarlite occurs in compact masses in chiolite, while the jarlite occurs in cavities in the columnar aggregates, where chiolite has not been found.

EXPLANATION OF PLATES

Plate 1.

Fig. 1. Nic.+, × 42.
Blocks of meta-jarlite in different orientation, surrounded by chiolite (below, right, and at the top).

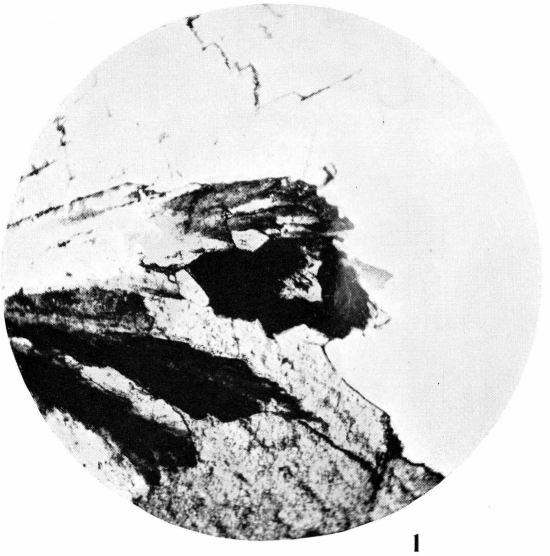
- 2. Nicols in parallel position, × 42.
Same area as in fig. 1. — The light area indicates meta-jarlite with fragments and "Schlieren" of chiolite, the greyish area represents chiolite with cleavage systems.

- 3. Nic.+, × 42.
Meta-jarlite penetrated by a vein containing comparatively small meta-jarlite individuals (up to 100 μ in size). Individuals up to 5 mm long radiate from the vein almost perpendicular to this.

- 4. Nic.+, × 42.
Fan-shaped meta-jarlite blocks in parallel orientation.

- 5. Nic.+, × 42.
Irregularly orientated meta-jarlite individuals.

- 6. Nic.+, × 42.
Meta-jarlite fans (the greater part of the picture) with chiolite (at the top, almost in the middle of the picture).



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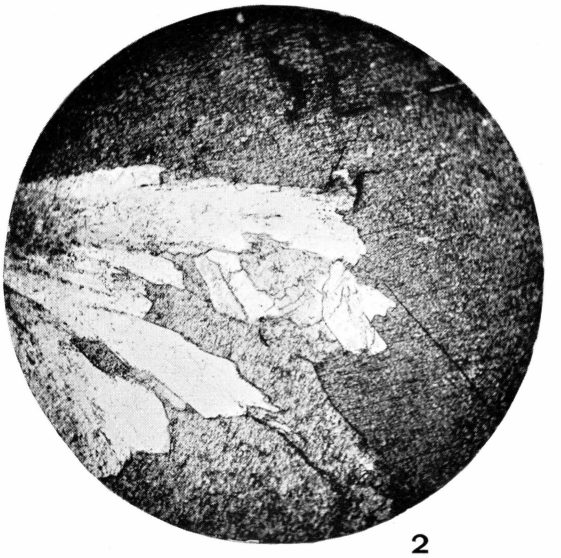

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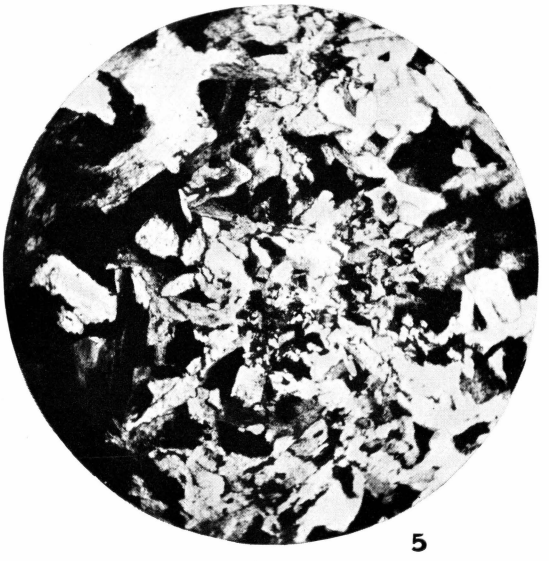

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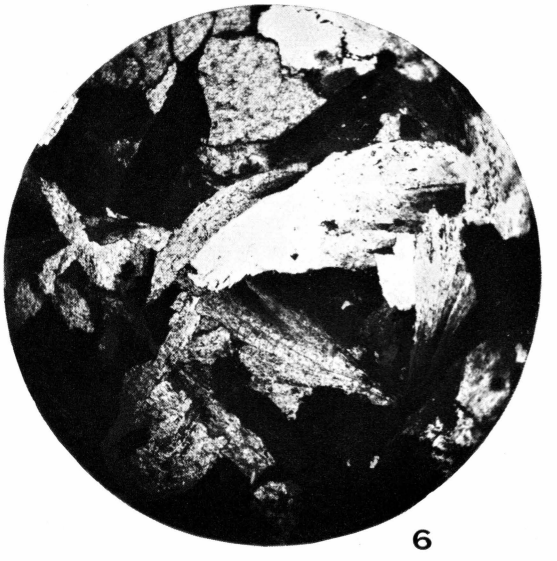

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Plate 2.

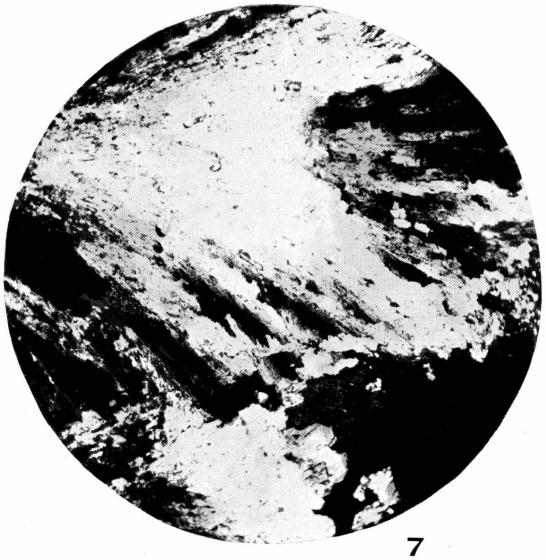
Fig. 7. Nic.+, × 42.
Relatively big fan of meta-jarlite (the greater part of the light-coloured area). The black, sharply delimited area in the left side of the picture is fluorite; the dark-grey area slightly below the middle to the right is chiolite with "fragments" of meta-jarlite.

- 8. Nic.+, × 42.
Meta-jarlite (below, left) separated from chiolite (top, right) by cryolite (the black area), which sends off veins into the surrounding minerals.

- 9. Nic.+, × 42.
Meta-jarlite with cryolite veins (the most conspicuous is c. 80 μ broad). About the middle of the picture there occur three fairly rounded black areas. The two uppermost of these consist of cryolite, the lowermost of pyrite.

- 10. Nic.+, × 42.
Boundary area between meta-jarlite and chiolite. Fluorite with cryolite veins (the black area to the right), topaz spherulites (especially in the middle of the picture), cryolite, and meta-jarlite. Cryolite veins are seen along the boundary of the fluorite.

- 11. Nic.+, × 42. The columnar aggregate.
Matrix of "mineral X" with barite (the light parallelograms, which are most conspicuous in a belt running from left to right nearly through the middle of the picture) and ivigtite? (the light-coloured, fine-grained belt extending from left to right in the upper part of the picture).



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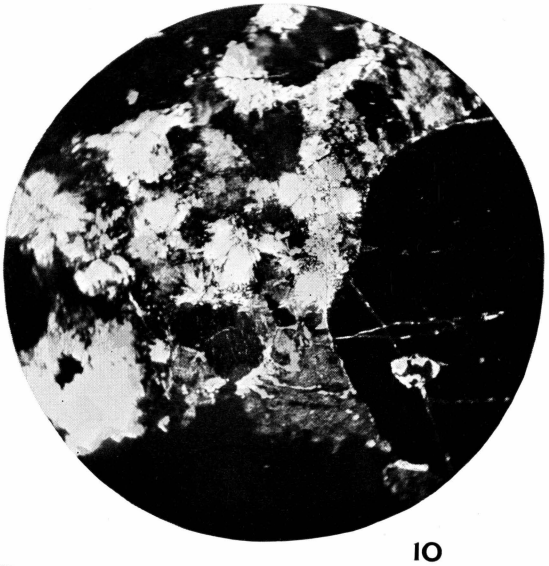

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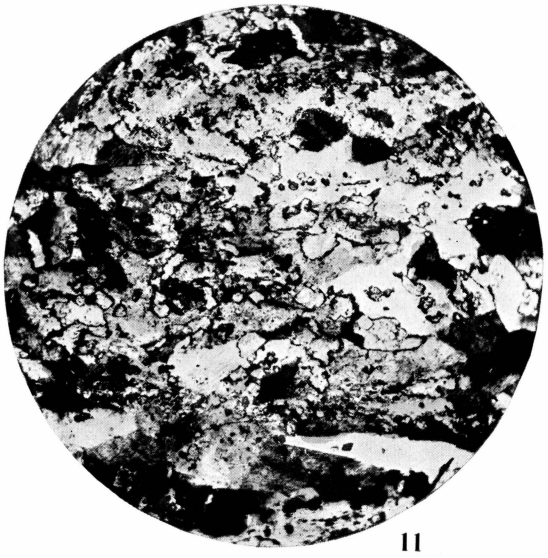

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