MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
BD. 92 · NR. 9

IGALIKITE AND NAUJAKASITE, TWO NEW MINERALS FROM SOUTH GREENLAND

BY

O. B. BØGGILD

WITH 2 PLATES

KØBENHAVN
C. A. REITZELS FORLAG
BIANCO LUNOS BOGTRYKKERI A/S
1933

Among the material brought home from Greenland by former expeditions I found two specimens, each of which consisted mainly of a hitherto unknown mineral. There is the formal similarity between the two occurrences that the specimens in question bear no close relation to the minerals and rocks otherwise known from the same localities, and it is possible, therefore, that the specimens are allochthonous, having been transported by the ice from some other place.

1. Igalikite, from the country East of Igaliko.

The locality was visited by H. Ødum[1]) in 1926, who gives the following description of the place (p. 53): Point 5. The easternmost part of the mountain ridge (a branch from Qôrorssûp iluloqutâ) which separates the two branches of Qôrorssuaq. Point 5 is not indicated on Ødum's map but according to the description it is situated about 35 km East of Igaliko. The surrounding rock is a nepheline syenite belonging to the „Igaliko batholite" described by Ussing[2]) and according to Ødum, the rock at point 5 consists of a „nepheline syenite, rather coarse-grained, very similar to the foregoing [of the „Usuk Type", Ussing p. 236]. Here it contains thin veins with fibrous aegirine and violet fluorite. Locally the rock is developed as pegmatite and contains, besides feldspar, aegirine, arfvedsonite, nepheline, eudialyte, and fluorite". The specimen containing the igalikite is not mentioned by Ødum, but its label is inscribed „Point 5 of Ødum".

To the above description given by Ødum I have but little to add; the pegmatites consist of the same association of minerals which is so common in all pegmatite veins in the Greenland nepheline syenite. The minerals are well known from many former descriptions, especially from that given by Ussing[3]). It should, however, be pointed out that all the

---

[1]) Geologiske Iagttagelser i Landet Øst for Igaliko Fjord. Medd. Grønl. 74, 1927, p. 45—54.

[2]) Geology of the Country around Julianehaab, Greenland. Medd. Grønl. 38, 1911.

[3]) Mineralogisk-petrografiske Undersøgelser af Grønlandske Nefelinsyeniter og beslægtede Bjærgarter. Medd. Grønl. 14, 1898.

pegmatites have formerly been found in the nepheline syenite of the Ilimausak batholite, whereas no pegmatites are mentioned by Ussing from the Igaliko batholite, with the exception only of the well known ones from Narsarsuk, which, however, belong to the augite syenite.

The specimen containing the igalikite had the form of a flat, rounded mass, the weight of which was about 50 gr. It has, probably, been formed as a geode but, as stated above, it is impossible to tell whence it originates or in what rock it may have been formed. An examination of the association of minerals will show that in most respects it differs greatly from that of the pegmatites of the nepheline syenite.

The greater part of the specimen consists of igalikite, which forms a perfectly compact mass, without any cavity. Enclosed in the igalikite are various other minerals, which are distributed in such a way that most of them are found in the outer part of the geode, where they form an almost continuous layer, whereas they become more and more scattered towards the innermost part of the mass, the interior consisting of an almost pure igalikite.

The minerals associated with the igalikite are the following: barkevikite, green augite, feldspar (orthoklase, oligoclase, and perthite), and, in smaller amounts, biotite, magnetite, apatite, and olivine. These minerals are exactly the same as those described by Ussing[1]) as constituents of the augite syenite of the Igaliko batholite, and they possess, in all essentials, the same properties, so that it is unnecessary to give any closer description of them here. Now, in the maps of Ussing and Ødum the augite syenite is undicated only along the western border of the nepheline syenite, but I think that it may very probably also exist along the other borders, and it is possible that the specimen in question originates from such a syenite occurring East of the point in question, whence it may have been transported by the ice.

In some instances the minerals mentioned possess their own crystalline faces towards the igalikite, which shows that they have been formed before the crystallisation of that mineral; mostly, however, the boundaries are rather irregular, and in that case the crystallisation of the igalikite must have begun before the formation of the associated minerals was concluded. A view of the igalikite with the three main included minerals is seen in fig. 1, pl. 1.

At first sight the igalikite itself looks rather uninteresting, mostly resembling some aphanitic substance such as a common limestone. On closer examination in a sharp light, however, it will be seen to reflect in different directions, arranged as a hexagonal prism with a basis, and in the goniometer it is possible to establish the existence of reflections of

---

[1]) 1911, p. 240.

the same four directions. The mineral is, of course, pseudohexagonal and is built up of very small subindividuals, and the apparent cleavage is probably formed by a parting at the boundaries of these subindividuals. Most of them have the form of thin plates and the greater number of them are orientated parallel to the hexagonal prism. In a section in this direction most of the subindividuals will, of course, be seen to be orientated parallel to the hexagonal axis, and if observed between crossed nicols they are seen to be alternately black and white according to their orientation. Each subindividual is optically uniaxial, negative, and it is not possible to decide whether it is hexagonal or tetragonal. The black parts are formed by those individuals which are cut parallel to their own bases, whereas the white ones are cut in some oblique direction. Aspects of this alternation of the individuals are seen in figures 2 and 4. The last-named figure also shows some individuals placed vertically to the former, parallel to the hexagonal basis; these are, generally, rather insignificant and are only seen in some of the sections. It is possible that the weak parting parallel to that face is produced by the existence of these individuals. Besides the two above mentioned orientations we see, in many of the sections, individuals arranged in an oblique direction, forming an angle of almost 45 degrees with the former; these are seen in especially large numbers in figure 3, which represents the same section as that shown in fig. 2, but the section is turned in such a way that all the main vertical individuals are extinguished. These oblique individuals are seen in most sections, but in most instances they are rather small and insignificant.

In a section cut parallel to the hexagonal basis the lamels are seen to be arranged in three directions forming angles of 60 degrees with each other. Such a section is seen in fig. 5; all the lamels of one system, which are arranged vertically, are black, whereas those of the other two systems are white.

On consideration of the figures it will be obvious that the directions of the lamels are very irregular, sometimes deviating many degrees from the mean orientation. At the same time many of the lamels are curved or branched in a feathery manner. The whole structure is not that of a common polysynthetical twin formation, and I have seen no other substance showing a similar structure.

The hardness is $5^1/_2$; the specific gravity was found to be 2.559, as an average of 6 values ranging from 2.549 to 2.568. The colour is rather impure, light brownish, reddish or greyish. The streak is white.

The refraction cannot be determined with any great exactness, first because of the smallness of the subindividuals, which makes it impossible to isolate them, and secondly because of the fact that the refraction is rather variable, so that even in the smallest splinters, the different parts do not possess the same refraction. In a fluid with a refraction of 1.540 we shall find, however, that most of the substance has no distinct margin and that the refraction may be considered as that of the freshest part of the mineral. That part is, however, grown together with particles of much lower refraction, down to a value of 1.519, and we receive the impression that the substance is not homogeneous but partially in a more or less altered state. For the same reasons it is impossible to give an exact value for the double refraction; judging by the interference colour of the small splinters, it is almost of the same dimension as that of quartz or perhaps a little higher. In the rather few instances where it is possible to observe the optic axis, the substance may turn out to be negative. As all the subindividuals have the form of thin plates parallel to the base, it is very characteristic of all sections and small splinters of the mineral that they possess a fine fibrous structure with a positive sign in the direction of the fibres.

Before the blowpipe the igalikite fuses easily (fusibility 2—3) to a colourless glass. It is decomposed by hydrochloric acid with separation of gelatinous silica.

The chemical analysis was made by Mr. Chr. Dethlefsen with the result stated below under I:

	I.	Quot.	Theor.
SiO_2	45.85	0.764	43.0
Al_2O_3	32.60	0.320	36.6
Fe_2O_3	0.92	0.006	..
CaO	1.41	0.025	..
MgO	0.15	0.004	..
K_2O	6.29	0.067	8.4
Na_2O	5.92	0.094	5.6
H_2O	6.80	0.378	6.4
	99.94		100.0

This analysis does not correspond to any simple formula. As stated above, the mineral is mixed with different alteration products and it might, therefore, be expected beforehand that it did not possess a uniform composition. The following formula is that which corresponds best to the analysis:

$$NaKAl_4Si_4O_{15}, 2H_2O.$$

On the basis of this formula the theoretical values stated above have been calculated, but it will be seen that rather considerable differences exist between these values and those of the analysis. The lack of potash may be compensated by the addition of lime and magnesia, but the lack of alumina cannot be accounted for. Any formula corresponding more closely to the analysis will be exceedingly complicated.

The systematical position of the igalikite is extremely doubtful and it is not possible to find any other mineral to which it can be related. Its composition is not so very different from that of the muskovite, but its physical properties by no means agree with those of the mica.

2. Naujakasite from Naujakasik.

Among the minerals collected by G. Flink on his mineralogical journey in 1897[1]) there is a specimen labelled „Chlorite?" by Flink. The locality is stated to be Naujakasik, a well-known place the coast of Tunugdliarfik Fjord, belonging to the nepheline-syenite batholite, described by Ussing[2]). Flink and Ussing do not mention any chlorite-like mineral from that place, which is otherwise rather rich in minerals originating from the many pegmatite veins from the nepheline-syenite.

The specimen containing the naujakasite was probably found loose on the ground and the connection between it and the nepheline-syenite is not clear; it may perhaps have been transported from some other place. The minerals associated with the naujakasite, the arfvedsonite, and the sodalite, are, no doubt, very common in the pegmatites of that region but the aggregation, as a whole, bears no resemblance to any other known rocks or mineral associations found in the country.

The whole material consists of a single piece of the size of a hand; the weight is almost 350 gr. The habit is not that of any pegmatitic material; it mostly resembles a fine-grained rock which is perfectly uniform throughout the whole mass. It is to be hoped that some future expedition may succeed in finding the original occurrence of this peculiar mass.

The mineral aggregation is very simple; more than half of the mass consists of naujakasite, and almost the whole remainder of arfvedsonite. Among the lightest particles of a specific gravity below 2.460 there are found some single-refracting grains of a refraction of 1.485 from which it might be concluded that they consist of sodalite. There may, perhaps, also be smaller amounts of other minerals, which cannot, however, be determined with certainty.

The largest part of the arfvedsonite occurs as granular masses between the crystals of the naujakasite but it also occurs as regularly formed crystals in the naujakasite. The determination of the arfvedsonite is not quite certain because of the great similarity between that mineral

---

[1]) Berättelse om en mineralogisk Resa i Syd-Grønland sommaren 1897. Medd. Grønl. 14, p. 221.

[2]) Geology of the Country around Julianehaab, Greenland. Medd. Grønl. 38, 1911, p. 106 ff.

and riebeckite, in some instances, however, a marked obliquity of extinction may be ascertained, which points decidedly towards the first-named mineral. The absorption colours are the same as those common to the two minerals. The orientation of the crystals of the arfvedsonite in relation to those of the naujakasite is mostly quite accidental; it will be seen, however, that a relatively large number lie in the cleavage plane of that mineral and that a relative large amount of these are orientated in the direction of the axis of symmetry.

The whole material is in a rather crumbled state and is easily crushed and broken with the fingers only. There is a faint trace of banding or schistosity in the rock, as the majority of the shining cleavage faces of the naujakasite are orientated in almost the same direction; however, a very large number of them are orientated in all possible directions.

The crystals of the naujakasite have very roughly the form of hexagonal plates; the diameter mostly ranges from 1 to 3 millimeters, the thickness, in most instances, is less than 1 millimeter. The boundaries towards the neighbouring individuals of naujakasite or arfvedsonite are mostly very irregular, showing that all the grains must have crystallized at nearly the same time. In some instances, however, the outlines of the shining cleavage faces of the naujakasite may be rather regularly hexagonal. It is quite impossible to find such well developed faces that they can be measured with the goniometer.

The naujakasite in so far resembles the micas that it possesses a very strong cleavage in one direction, parallel to the pseudohexagonal basis; the lustre of the cleavage face is strongly pearly, and to a certain degree also metallic; it is possible, however, that this last property is due to the beginning alteration of the substance. There is no trace of any cleavage in other directions, and the small cleavage plates always have perfectly irregular outlines. The plates are quite brittle and cannot be bent without being broken. The cleavage faces are far from plane but irregularly facetted and folded; in most instances it is found, on closer inspection, that they possess a distinct striation or folding in one direction parallel to one of the prismatic faces bounding the crystal, and, as shown by the optical properties, this direction coincides with the monoclinic axis of symmetry.

The colour of the cleavage faces is shining silvery white, while seen from other directions the crystals appear dark greyish. Under the microscope the small leaves are perfectly colourless and transparent, but in many places there occur spots of a faintly translucent, brownish substance, probably an alteration product, and these parts are more or less sharply bounded towards the fresh substance. In some instances the brown parts are more cloud-like and irregularly distributed, but sometimes they are also arranged in very thin lines, the direction of which is parallel to the axis of symmetry.

The hardness is 2—3. The specific gravity of pure, selected pieces was found to be 2.615; the brown substance is lighter, c. 2.46, and all transitions between those values occur.

The optical properties are very characteristic and by them the mineral is easily distinguished from any kind of mica, to which mineral naujakasite may otherwise show a considerable similarity. The naujakasite is optically biaxial, one axis being nearly normal to the cleavage plane. The hyperbole is only very slightly curved so that it is very difficult to decide whether the sign is positive or negative; generally, however, the negative sign is most pronounced. The axial angle cannot, of course, be very far from 90 degrees, and the other axis, which is very difficult to observe, must lie nearly in the cleavage plane. This orientation shows with certainty that the crystals must belong to the monoclinic system, and they are, so far in accordance with the micaceous minerals in that they are monoclinic and pseudohexagonal. The above mentioned brown, altered substance is isotropic but there are, in this respect, all possible transitions between that and the fresh mineral.

Because of the form of the thin leaves it is almost impossible to determine the refraction in other directions than that normal to the leaves, and as one of the optic axes is orientated nearly normally to the cleavage, we only obtain the value of β. For the freshest material it is found to be 1.537, but the altered material has a much lower refraction, c. 1.516, and in this respect too all possible transitions occur.

Before the blowpipe the naujakasite is easily melted (fusibility about 3) to a glass, which is, for the purest mineral, greyish, whereas small amounts of arfvedsonite produce a black glass. Decomposed by hydrochloric acid with gelatinisation.

The analysis was made by Mr. CHR. DETHLEFSEN. In order to procure the purest possible material for analysis the powdered mineral was separated into many parts by means of heavy liquids. Generally the heaviest parts contained most of the arfvedsonite, which mineral, however, will also be found in the lighter parts as small crystals included in the naujakasite. The lightest parts are not, however, suitable for analyses, since they consist mostly of the altered mineral, and I have therefore selected some of the middle parts, the naujakasite of which is mostly in the freshest state, but which, besides that, also contains many of the altered parts with included arfvedsonite crystals. A more perfect separation is quite impossible since the material can never be ground down to such small dimensions that the two minerals will not be found in the same pieces.

The result of the analysis is stated below (under I):

	I.	Quot.		Theor.
SiO_2	50.95	0.849		53.64
Al_2O_3	20.63	0.202	0.219	22.79
Fe_2O_3	2.76	0.017		..
FeO	5.25	0.072	0.333	5.70
Na_2O	14.51	0.234		15.86
K_2O	0.80	0.008		..
MnO	0.57	0.008		..
CaO	0.55	0.010		..
MgO	0.10	0.002		..
H_2O (100°)	1.02	..		..
H_2O (ign.)	2.60	0.144		2.01
	99.74			100.00

It might be expected beforehand that a material of this kind would not give any good values, and we shall see, too, that no simple formula corresponding to the analysis can be found. It is not possible to estimate how much of the arfvedsonite is mixed in the naujakasite analysed, and it is, of course, impossible to subtract the arfvedsonite from the analysis, all the more so because the composition of that mineral is rather variable and we cannot determine with certainty whether the mineral inclosed is arfvedsonite or riebeckite. The theoretical values given above correspond to a composition like the following:

$$H_2O,\ 3(Na_2, Fe)O, 2Al_2O_3,\ 8SiO_2$$

but, as will be seen, there are rather large differences between the analysed values and the theoretical ones. If we disregard the iron, the formula may be written in a simpler way as:

$$HNa_3Al_2Si_4O_{13}.$$

The systematical position of the naujakasite is quite uncertain, and there is no other mineral with which it is closely related. As stated above, there is a superficial similarity to the micas, but both the optical properties and the composition show that it has nothing to do with them, and the same is proved by the röntgenographical properties. The röntgenographical examination was kindly undertaken by Professor B. Gossner and Dr. O. Krauss of Munich with the following result:

Über die Kristallform von Naujakasit. Für die goniometrische Messung haben sich die Kristalle als ungeeignet erwiesen. Nachdem aber einerseits hinreichend grosse Blättchen ausgesucht werden konnten u. anderseits die Kenntnis der optischen Eigenschaften eine geometrische Orientierung ermöglichte, erschien der Versuch einer röntgenographischen Untersuchung nicht aussichtslos. Die Vermutung hat sich bestätigt. Es stehen uns ein recht befriedigendes Laue-Diagramm u. vor allem zwei Drehspektrogramme von wider Erwarten guter Beschaffenheit zur Ermittlung geometrischer Eigenschaften der Kristalle zur Verfügung.

Gemäss der Lage der Ebene der optischen Achsen folgt zunächst mit grosser Wahrscheinlichkeit die Zugehörigkeit zum monoklinen System u. zugleich die Lage der Symmetrieebene. In der Blättchenebene, die mit (001) zu bezeichnen ist, bestimt sich in der Richtung senkrecht zur Spur der Ebene der optischen Achsen die b-Achse = [010]. Eine zweite Richtung, senkrecht zu dieser in der Ebene des Blättchens, ergibt die a-Achse = [100].

Das Kristallblättchen, mit seiner Ebene senkrecht zum einfallenden Strahl gestellt, ergab zunächst das in Fig. 1 wiedergegebene Laue-Diagram. Man erkennt darin die Spur der Symmetrieebene, parallel der Ebene der optischen Achsen, während senkrecht dazu sich die Richtung [010] bestimmt. Es weist also auch das Laue-Diagram mit seiner Symmetrie, vor allem in seiner Orientierung gegenüber den auf optischen Wege erkennbaren Hauptrichtungen des Kristalles, deutlich auf die Zugehörigkeit zum monoklinen System hin.

Nachdem die beiden Richtungen [010] u. [100] in der Ebene des Blättchens somit nicht bloss auf Grund der optischen, sondern auch der röntgenographischen Untersuchung festgelegt waren, führte der Versuch, Drehspektrogramme für diese Richtung als Drehungsachsen zu erhalten, bald zu einem befriedigenden Ergebnis.

Fig. 2 ist das Drehspektrogramm mit [010] als Drehungsachse, wobei (001) als Grundfläche für die Schwenkung des Kristalles eingestellt war. Aus Schichtlinienabständen ergibt sich b = 7,9 Å.

Fig. 3 ist das Drehspektrogramm mit [100] als Drehungsachse u. (001) als Grundfläche. Aus Schichtlinienabständen folgt a = 15,06 Å.

Die beiden Drehspektrogramme zeigen auf der Nullschichtlinie in grösserer Anzahl die Reflexe von (001), welche es ermöglichen, den Netzebenenabstand $d_{(001)}$ zu ermitteln. Es ist $d_{(001)} = 9,58$ Å. Mit Rücksicht auf den Habitus der Kristalle ist man aber berechtigt anzunehmen, dass man in d = 19,16 Å den Abstand zweier nächster identischer Ebenen vor sich hat. Es fallen somit die ungeraden Ordnungen aus u. die beobachteten Reflexe sind 004, 006(st), 008, 0.0.10, 0.0.12(st), 0.0.14, 0.0.16(st).

Nicht möglich war es, den Winkel β zu ermitteln. Es fehlt somit auch die Kenntnis des genauen Wertes der Kante c des Elementarparallelepipedes, welcher sich mit Hilfe von d u. β berechnen würde. Es ist wahrscheinlich, dass β nicht allzuweit von 90° abweicht. Für letztere Neigung $\beta = 90°$ ist c = 19,16 Å; zu $\beta = 100°$ würde der Wert c = 19,8 Å gehören. Ein mittlerer Wert c ∾ 19,5 Å dürfte von der wahren Länge der Kante nicht allzu weit sich unterscheiden.

Die Kanten des monoklinen Elementarparallelepipedes sind also gegeben in

$$a = 15{,}06\,\text{Å} \qquad b = 7{,}98\,\text{Å} \qquad c \backsim 19{,}5\,\text{Å}$$

bei einer mutmasslich von 90° nur mässig abweichenden Neigung β.

Die c-Achse kommt dem entsprechenden Werte von Muskovit, mit c ∾ 20,0 Å, nahe. Die beiden andern Konstanten sind beim Glimmer a = 5,2 Å u. b = 8,94 Å. Es zeigen hierin die beiden Silikate einen wesentlichen Unterschied. Die äussere Ähnlichkeit des Naujakasites mit dem Glimmer wiederholt sich also nicht in den Dimensionen des Elementarkörpers.

Dessen Inhalt lässt sich durch das Produkt z × M kennzeichnen, wobei z die Anzahl der Moleküle mit dem Molekulargewicht M bedeutet. Es ist z × M = 3627 für β = 90° u. c = 19,16 Å; das Produkt erhält natürlich für c = 19,8 Å und β = 100° einen ganz ähnlichen Wert. Der wahre Wert dürfte davon sich nur wenig unterscheiden. Angesichts der Tatsache, dass eine befriedigende Analyse nicht vorliegt, bietet der Versuch einer weiteren Auswertung des Ergebnisses mit dem Ziele einer Ermittlung von z u. M wenig Aussicht auf Erfolg.

Aus den Gitterkonstanten leitet sich für den Naujakasit das Achsenverhältnis

$$a : b : c = 1{,}887 : 1 : 2{,}44 \; (= 15{,}06 : 7{,}98 : 19{,}5)$$

ab, mit nicht näher bekannten, aber mutmasslich von 90° sich nur mässig unterscheidenden Winkel β. Die Parameter a u. b sind mit der üblichen Genauigkeit bestimmt, c dagegen nur mit jenem Grad der Annäherung, der in dem Mangel der Kenntnis von β bedingt ist.

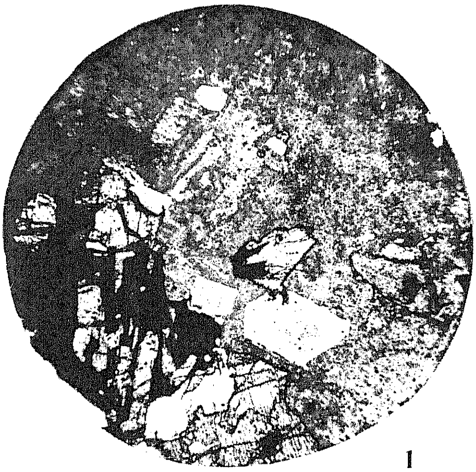
PLATES

Plate 1.

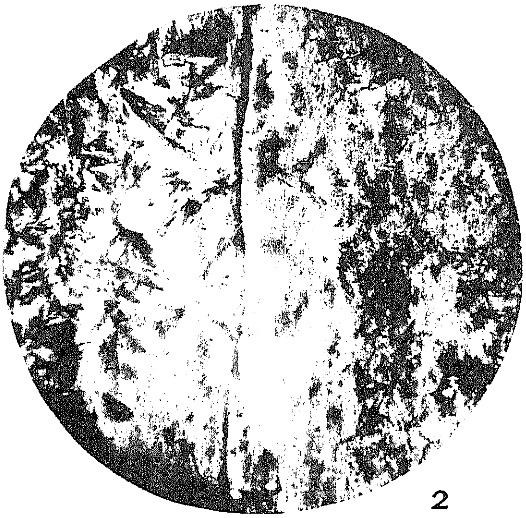
Fig. 1. Igalikite with the most commonly included minerals. The igalikite is the impure, grey substance which includes barkevikite (black), augite (grey) and feldspar (white). Enlargement c. 16.

\- 2-5. Microstructure of the igalikite, see p. 5. Nicols crossed. Enl. c. 140.

\- 6. Mixture of naujakasite (white) and arfvedsonite (mostly black). In the naujakasite are seen small crystals of the arfvedsonite of which some are transparent, grayish. One of the large individuals of the naujakasite is cut normally to the cleavage. Enl. c. 30.

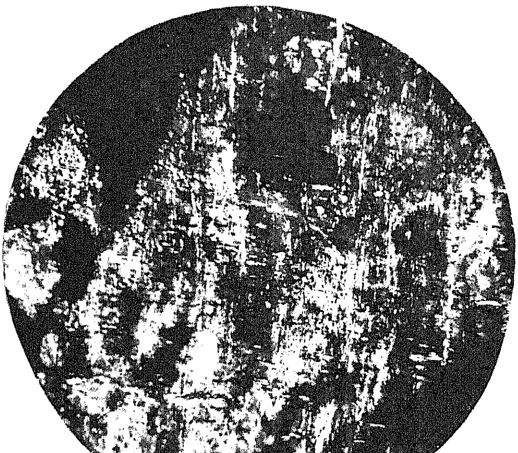


1



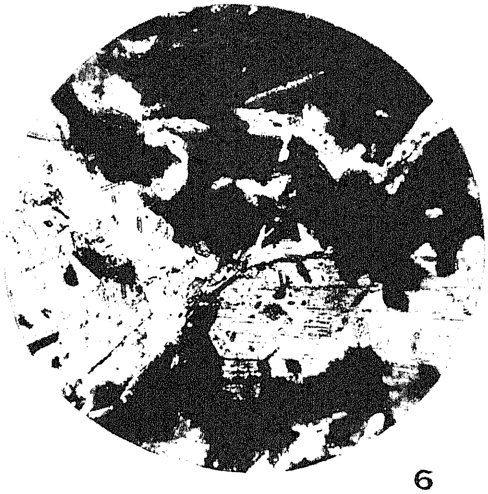
2

3



4

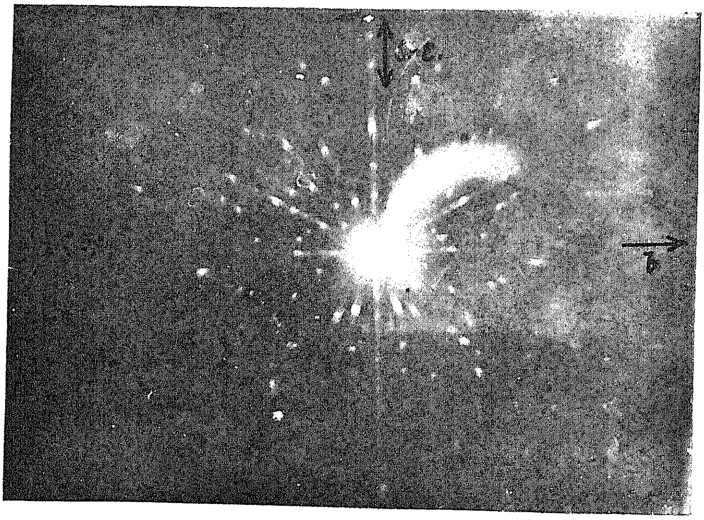
5



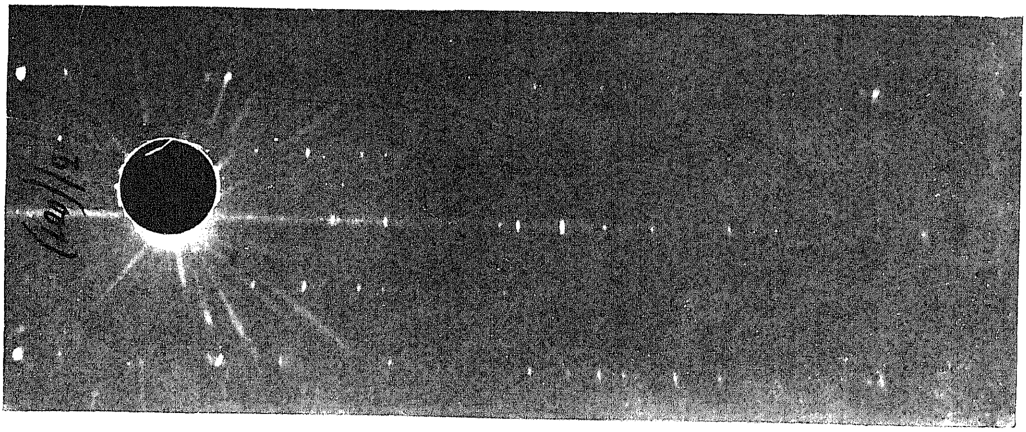
6

Plate 2.

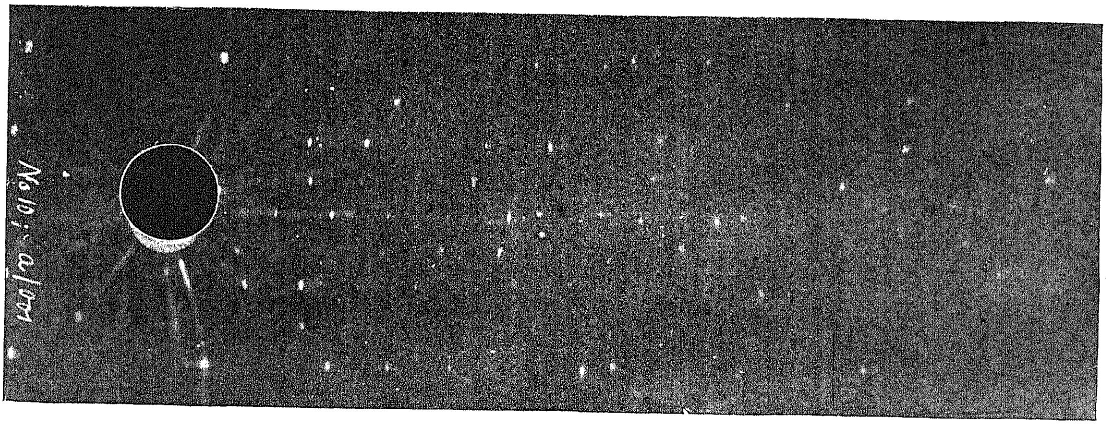
Fig. 1-3. Röntgenograms of naujakasite. See p. 11.



1



2



3