Det Kgl. Danske Videnskabernes Selskab.
Mathematisk-fysiske Meddelelser. **VI,** 3.

ON THE LABRADORIZATION OF THE FELDSPARS

BY

O. B. BØGGILD

WITH ONE PLATE

1742

KØBENHAVN
HOVEDKOMMISSIONÆR: ANDR. FRED. HØST & SØN, KGL. HOF-BOGHANDEL
BIANCO LUNOS BOGTRYKKERI
1924

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The peculiar property of some varieties of feldspar which is here called labradorization, and which consists in a peculiar reflection of the light from certain planes in the interior of the substance has been well known from the oldest times and has been the object of many investigations. What has been stated, however, about the position of the reflecting planes, especially in the plagioclases, is very little, and I have tried in the present paper to bring full light about that question. The whole phenomenon is still rather enigmatic and it embraces many points of which it is quite impossible to give any explanation, but I hope, however, that my investigations will bring forth some point of interest.

For the phenomenon I have found no proper term in the English literature. In the mineralogy of Dana, for example, are used such different terms as "satin-like luster or schiller", "reflections", "play of colors", "pearly opalescence", "iridescence" and "change of colors", and no one of these can be said to be specially characteristic of the phenomenon in question as all of them are commonly used to signify quite differing properties. As the phenomenon itself is, in all essential respects, of a rather uniform character it ought to have a special name, and I therefore propose to use the name "labradorization" for the property which may be defined in the following manner:

Labradorization is the peculiar reflection of the light from submicroscopical planes orientated in one direction (rarely in two directions); these planes have never such a position that they can be expressed by simple indices, and they are not directly visible under the microscope. A typical labradorization is not known from other minerals than the feldspar, with the exception, perhaps, of the gedrite which will be mentioned later on. As will be seen in the following, only the labradorizing plagioclases possess the abovenamed qualities to a full degree while the orthoclases are in some respects diverging.

Totally different from labradorization is the phenomenon which is called aventurization and which has recently been exactly described by Andersen[1]. It is characteristic of aventurization that the reflection is caused by distinctly bounded and easily visible particles which are orientated after different planes which can be referred to faces with rather simple symbols although in most cases they play a very insignificant role in the outer termination of the crystals.

As material for the examination I have had representatives from a very large number of occurrences. The museum of Copenhagen especially possesses many rare Greenlandic occurrences, and furthermore I have got many excellent specimens from the Museums in Washington, Kristiania, Stockholm and Helsingfors from which places we must expect beforehand to get the best representatives of most of the pegmatites of the Precambrian formation. To my colleagues from these museums I hereby express my most cordial thanks.

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[1] Amer. Journ. Sci. 40, 1915, p. 351.

Methods of Examination.

For the methods formerly used the reader is referred to the papers cited later on. Where the labradorization can be observed through a natural cleavage face, as is the case in most plagioclases, this face has been used in the manner described by Reusch and Andersen, and I do not find it necessary to repeat the method here. In those instances where that is not the case, the former observers have gone different ways; sometimes they have used a ground and polished face of an exactly determined position in the symmetrical zone of the orthoclase, and sometimes the reflexion has been measured in such a manner that the light passes in through one face and out through another opposite to the former (dioptric schiller, Viola). As for the orthoclase the position of the reflecting lamellae has in many cases been determined not by observation of the reflected light but by measurement of the plane of parting in many cases connected with the labradorization of that mineral.

In my measurements I have mostly used quite another method. As the only cleavage face through which the labradorization can be observed in the common (catoptric) manner, is the face (010) of the plagioclases, and as this face, in most cases is of a rather imperfect nature, it is not very apt for exact measurements. It is necessary, of course, to use the cleavage faces for the orientation of the crystal on the goniometer, but the inaccuracy will be multiplied if the light is observed after having passed an uneven face twice. If the labradorizing lamellae form a rather large angle (20° or more) with the face (010), the measurement will in all cases be very inexact. Therefore I have only made use of that face in such cases when it was especially well developed and when the said angle was rather small.

In all other cases I have ground a face at random, the only condition required being that it must form an angle of ca. 5—15° with the labradorizing plane. A too small angle will cause the reflection from the ground face and from the labradorizing lamellae to be visible at the same time, and hence the latter, which is the weaker of the two, will be difficult to observe. It is not necessary that the face be polished as we shall always get excellent reflections by placing a piece of glass by means of a small drop of canada balsam which fluid, having almost the same refraction as the crystal, will cause no measurable deviation of the light.

The crystal is, thereafter, placed on the two-circled goniometer and orientated in the common manner either with one of the faces as polar face or with both in the equatorial zone. For the perfect orientation it will almost in all cases be possible to find some trace of a prismatic cleavage. The position of the ground face and of the labradorization are determined, and the whole is drawn on the gnomonical projection as shown in figure 1 which represents an orthoclase where, for the sake of orientation, are drawn, also, the positions of the common faces of that mineral. The circle is the common fundamental one (45°). The point *F* represents the ground face and *L* the observed place of the labradorization.

For the determination of the actual position of the labradorizing lamellae we must know the aperture of the instrument, the angle between the collimator and the telescope. On my instrument this angle is always 60°, and if therefore we draw two points, R_I and R_{II}, lying on the meridian of L and at a distance of 30° from that point, we shall get the directions of the rays of light outside the crystal. We thereafter draw the lines $R_I F$ and $R_{II} F$ and on these the two points r_I and r_{II} in such a manner that $\sin R_I F : \sin r_I F = \sin R_{II} F : \sin r_{II} F = \beta$, the points r_I and r_{II} will represent the directions of the rays in the crystal. The reflecting face must, consequently, be represented by the point l which we get by bisecting the angle between r_I and r_{II}. If we want to obtain the position of the point l with absolute exactness, it will be necessary to perform the whole operation by calculation which will in every single case take rather a long time. I have, therefore, preferred to use a graphical method which can be made rather exact if we use a large scale with a fundamental circle of about 15 cm. The determination will not, of course, be absolutely exact, but it will certainly be more exact than the measurement itself as neither the cleavage faces nor the labradorization give very good reflections, the last named being only a rather indistinctly bounded spot. As a control for correct drawing it is known that the point l must be situated on the line FL, and for the sake of control I have in some instances made different constructions from the same observed angles, and I have always found that the

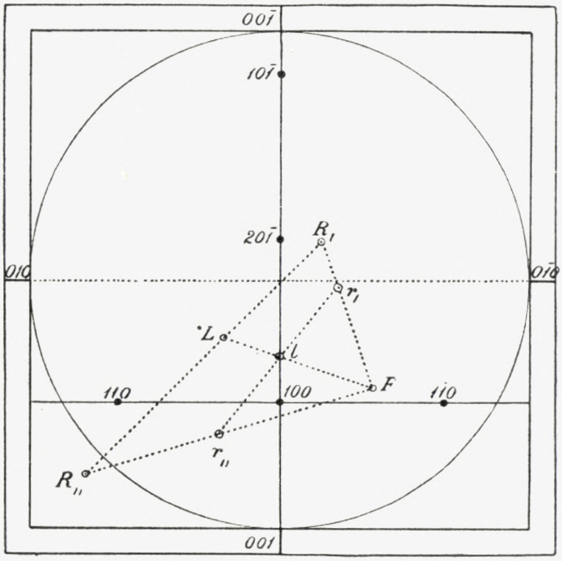

Fig. 1. For explanation, see the text.

variations in the results thereby obtained are smaller than those which we find if we measure different specimens of the same feldspar or even if we measure the same specimens several times.

For the point *l* the values x and y are directly read on the gnomonic projection paper (in the orthoclases the last named value will, of course, be = 0), and also the values φ and d are easily seen, and from the last of these the value of ϱ may be calculated.

I. Orthoclase.

The orientation of the labradorizing plane of that mineral has been described by different authors and I have no essentially new facts to add to what is formerly known. I believe, however, that it will be of some interest to collect all that can for the present be stated about that matter.

In his Manuel de Minéralogie, I, 1862, Descloizeaux, in different places, gives the position of the labradorizing plane or of the parting connected with it. For the moonstone the angle for the parting is stated (p. 329) to be either 64—65° or 68° 40′ (here, as in the following, the angle given is always the acute one between *l* and (001)). For the mineral from Frederiksvärn he has found the angle of the labradorization to be 68° 30′; he states here that he has never been able to observe the plane of parting which, according to other authors, should form an angle of 74° with the base. For the murchisonite from Dawlish and Heavitree he gives for the parting the angle 73° 10′ corresponding to the form ($\bar{7}01$) for which is calculated the angle 73° 17′, and in a later paper[1] he states almost the same angle (73° 13′) for the murchisonite and for an orthoclase from Elba.

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[1] Ann. Chim Phys. 5 sér. IX, 1876, p. 42.

By measurements of the light reflections which seem to be very exactly performed REUSCH[1] obtained the angles 74° 24′ and 74° 18′ for the adulare, and 73° 51′ and 73° 53′ for the moonstone; for the last named he obtained a slightly smaller angle by measuring the fine striations on (010) under the microscope. For the feldspar from Frederiksvärn he obtained the not very exact value of 74°.

A somewhat diverging value of 68° 50′ is given by JEREMEJEW[2] for the parting of an orthoclase from the uralite-syenite from Turgojak.

In a sanidine in rhyolite from Chalk Mountain CROSS[3] obtained the angle for the parting of 72° 53′ which he refers to the form $(\overline{15}.0.2)$ which would require an angle of 72° 40′. It is very characteristic that that parting is confined to those feldspar individuals which possess a brillant satiny luster, while those which are more transparent and have a faint bluish luster show no parting at all.

Another instance of parting is described by GRAEFF[4] in a feldspar from an eleolite syenite from Serra de Tingua. The angle is here found to be ca. 73° and the parting is referred to the form $(\overline{7}01)$, nothing being stated about any kind of labradorization accompanying this parting.

The cryptoperthite from Frederiksvärn has been described by BRÖGGER[5] who for the first time clearly shows the close connection, formerly suggested by ROSENBUSCH, between the labradorization and the perthitic structure. The

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[1] Pogg. Ann. 118, 1863, p. 260.

[2] Neues Jahrb. Min. 1872, p 405.

[3] Bull. U. S. Geol. Surv. 20, 1885, p. 77.

[4] Neues Jahrb. Min. 1887, 2, p. 226.

[5] Zeits. f. Kryst. 16, 1890, p. 524.

common blue variety possesses a parting after (100) while a yellowish labradorization found in some specimens is connected with a parting forming 72° 1′ and 72° 8′ with (001); this parting is referred to the form ($\bar{8}01$) for which the angle calculated is 72° 2 ½′.

While all the said observations have given rather similar results, Viola[1] obtains quite diverging positions for the labradorizing planes in the moonstone; it seems that he must have made a mistake in determining the orientation of the face of parting. He finds that this forms an angle of 81° with (001), and therefore concludes that it must lie near the form ($\bar{2}01$), and he states that the acute bisectrix is almost normal to that face. I think, therefore, that the face in question must have been a steep orthodome lying between the common plane of parting and (100), and that the angle obtained between the labradorizing plane and (001) which is said to be almost 69° (over ($\bar{1}01$)) must be incorrect. Another plane of labradorization, observed in "dioptric schiller", and lying at a distance of almost 16° from (001) (in the same direction) I cannot in any way identify as I have never observed more than one plane of labradorization in the moonstone or in any other orthoclase. Viola has also examined an adulare, in one instance by means of a ground and polished face of a very oblique position (almost lying in the zone [001]), while in another he has used two faces of the form (310) which otherwise is one of the rarest and most insignificant in orthoclase. It seems that these faces have not been correctly determined as the plane of labradorization lies quite differently in relation to the two symmetrical faces and consequently the position obtained of that plane cannot be relied upon.

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[1] Zeits. f. Kryst. 34, 1901, p. 171.

Description of the Specimens.

Narsarsuk.

Among the many different minerals from the pegmatite veins from Narsarsuk in South Greenland[1] the Museum in Copenhagen has obtained a few specimens of a soda orthoclase which is one of the finest of all the labradorizing feldspars. The substance is semitransparent, of a brownish color; the cleavage after (010) is very weak. Where the labradorization is strongest there is often found a parting which can be very marked and gives rather good reflections; it is obvious, however, that it is not quite parallel to the labradorizing plane. The angle between the parting face and (001) is found to be 76° (varying from 75° to 78°), and the parting is also in most cases rather unsymmetrically orientated, forming an angle of 85° to 87° with (010). The parting cannot, therefore, be produced by the labradorizing lamellae. These are quite symmetrically orientated (which is always the case in the orthoclase) and for the angle to (001) I have found the value 72° 18′ (72° 15′ — 72° 20′). The color of the labradorization is a brillant blue; in sections after (010) there are no labradorizing lamellae visible.

The main part of the mineral is perfectly homogeneous with an extinction angle on (010) of $10^1/_2$° (10—11°).

Kunak.

From the mountain of Kunak near Ivigtut the Museum in Copenhagen possesses a few specimens of a greyish or

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[1] It is probably the same feldspar which has been described by Ussing (Medd. om Grønl. 14, 1898, p. 60), but the locality is here stated to be Siorarsuit. Later specimens of the same kind have in all probality come from Narsarsuk. In the same paper (p. 53) Ussing describes another labradorizing feldspar, a cryptoperthite, from Narsasik (= Narsarsuk), this is, however, quite a different variety to that examined here.

brownish orthoclase with a rather weak blue labradorization. There is no distinct parting found; the angle of the labradorization is 72° 40′ (72° 15′—73°). The mineral may be quite homogeneous, or it may be penetrated by bands of a perthitic structure. The angle of extinction on (010), in two different specimens, was found to be 13° ($12^1/_2$—$13^1/_2$°) and 11° ($10^1/_2$—$11^1/_2$°), respectively.

Aliortok.

From the island of Aliortok in the district of Godthaab, Greenland, we have an orthoclase, which in most respects much resembles that from Kunak. For the labradorization I have found the angles 72° 40′ and 72° 47′, and for the angle of extinction on (010) a mean value of 12° 50′ (12° 15′ —13° 15′).

Frederiksvärn.

As regards that commonly known feldspar I have very little to add to the description given by Brögger; at my disposal I have only had material of the blue variety, and for the angle of the labradorization I have found the value of 72° 27′ (72° 15′—72° 40′).

Arendal.

From Arendal the Museum in Copenhagen possesses a small specimen of yellowish color and yellow labradorization. The reflecting lamellae form an angle with the base of 72° 27′ (72° 3′—72° 48′) and after the same direction there is a rather marked parting. Microscopically the whole structure is regularly perthitic with the lamellae in the above-named direction; the thickness of the lamellae is very variable but most of them are extremely fine and here it seems that the labradorization is caused by visible lamellae, although this is rather difficult to state with certainty. The angle of extinction on (010) of the whole complex is found to be 12° (11$^1/_2$—12$^1/_2$°), that of the albite alone is 18°, but it is impossible to measure that of the orthoclase.

Besides the above-mentioned perthitic lamellae of the more ordinary nature there is in this feldspar another system of albitic lamellae which is, as I think, quite unique and which I shall, therefore, describe here although it has certainly nothing to do with the labradorization. The lamellae are rather thin and very regular, and their orientation is quite unsymmetrical. In basic sections they are seen as striae in one direction forming an angle of ca. 15° with the trace of (010) while in sections normal to (001) and (010) they form an angle of ca. 7° with the same trace. From these angles we may conclude that the lamellae are orientated after a prismatic face forming an angle of ca. 16$^1/_2$° with (010) which value corresponds mostly with a form (160) which is, however, not known in the feldspars, but the determinations are not exact enough to insure this symbol. In connection with the unsymmetrical orientation of the lamellae stands the fact that the albite in all of them belongs only to one individual, and the extinction on the base shows that the lamellae are orientated after a left-sided prism ($\bar{1}60$) in relation to the albite.

Fig. 1 on the plate shows this peculiar structure with the two kinds of lamellae.

St. Gotthard.

The well known adulare from St. Gotthard and other localities in many instances possesses a rather weak labradorization which is generally of a bluish white color. In most instances the entire section is not labradorizing, but only some parts of it which have often the form of irregular striae. In many instances there are found spots of a brilliant white micaceous luster which, however, reflect in the same direction as the main part of the labradorization. The orientation of both kinds of lamellae is 74° 3′ (73° 43′—74° 20′) and is of course distinctly different from the common value. In sections after (010) the extinction angle is 6° (5½—6½). In the labradorizing parts of the section it is possible to see very fine lamellae which, after the analogy of other occurrences, must be considered perthitic, but it is not possible to determine the albite by means of extention angle measurements. Only in a few cases is there any parting parallel to the lamellae.

Ceylon.

The moonstone from Ceylon is so well known that it needs no special further description. The whole substance possesses a bluish white labradorization, the direction of which is found to be 73° 5′ (72° 47′—73° 18′). The parting is mostly very irregular, in some instances, however, it is so even, that it can be measured, and I have found it in possession of an unsymmetrical orientation similar to that from Narsarsuk, lying at a distance from the symmetrical zone from 0° up to 10° while the angle with the base varies from 65° (as given by Descloizeaux) to c. 60°. In thin section the structure is absolutely homogeneous without visible lamellae of any kind or other inclusions. The angle of extinction on (010) is found to be 10° 35′ (10—11°).

Mursinsk.

A feldspar from this locality is in possession of a rather peculiar and complicated structure. The feldspar is light flesh red with perfect cleavage faces, and on these is seen a rather coarse, more or less regular, structure caused by an alternation between lighter opaque, and darker transparent parts. In sections it is seen that the former consist of perthitic intergrowths, while the latter are homogeneous[1]. The perthitic portions are of two kinds, the alternating lamellae being in some instances very regular and orientated in the common manner, while in other instances they have only very roughly that orientation, but are mostly quite irregularly bounded and anastomosing. The more homogeneous feldspar is only by high magnifying seen to be composed of very fine lamellae which are probably also perthitic; these lamellae, however, are mostly confined to the inner parts of it, while the outer rim, bordering on the opaque substance, is perfectly homogeneous.

The feldspar, in accordance with the structure described, possesses two kinds of labradorization, a more typical one of bluish-white color, caused by the last named fine lamellae and a more micaceous luster caused by the first mentioned regular lamellae. Curiously enough the two kinds of lamellae are not quite parallel, the first forming an angle of 75° 32′ with the base, while for the other kind the angle is somewhat more normal, viz. 73° 50′. Both kinds of lamellae produce a weak parting along the above-mentioned directions. The angle of extinction on (010) for the inner parts of the homogeneous substance is found to be ca. 9° 48′ (9—10½°) while the outer, not labradorizing parts, are easily seen to possess a more parallel extinction, the mean value being here ca. 7°.

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[1] When Warren (Proc. Amer. Acad. Arts and Sci. 51, 1915, p. 130) says that he »doubts if there is such a thing as a pegmatitic perthite which contains orthoclase«, that is not absolutely true for that feldspar and the following where the orthoclase shows only weak traces of microcline structure in a narrow zone at the boundaries against the albite.

Jekaterinburg.

From that locality I have at my disposal two specimens. The first of them is a common perthite with broad lamellae of albite which are rather irregularly bounded but orientated nearly after (100). But here and there we find small flakes where the lamellae are narrow and very regularly orientated in the direction common to the labradorizing orthoclase. These flakes produce a strong micaceous luster, but in the feldspar in question no trace is found of the more typical labradorization described from the former locality. The angle of the reflecting lamellae to the base is 74°28′ (74°21′—74°35′) and the lamellae produce a parting in the same direction. The angle of extinction on (010) for the orthoclase is found to be 6°22′ (6—7°): for the mixture of orthoclase and albite in the lamellae it is not directly determinable.

The other specimen in its outer appearance much resembles the former, and in sections after (010) they can hardly be distinguished from each other; in sections after (001) this feldspar, however, shows quite another picture. Most of the orthoclase substance consists of a single individuum of microcline, the extinction of which is almost 15°, but where it borders on the broader, more irregular albitic lamellae it passes gradually into an orthoclase with parallel extinction. Of the common microcline structure there are only small traces, and the opposite individual is only in a few instances developed independently. The more regular reflecting albitic lamellae are always situated in the single microcline, and we have here, consequently, the only known instance of labradorizing microcline. In accordance with that we find that the place of the labradorization on the drawing (fig. 1) is unsymmetrically orientated.

While in all orthoclases the value of y is almost 0 we find here a mean value of 1.6 (1.3—1.8) mm and hence the angle between the labradorizing lamellae and (010) can be calculated to be approximately 88°10′ and we see, consequently, that the labradorization in microcline is orientated in the zone [010] which, in the vicinity of (100) forms almost the above mentioned angle with (010)[1]. The angle between the labradorization and (001) is found to be 74°0′ (73°46′—74°9′).

The figures 2 and 3 in the plate show the coexistency of coarser, more irregular albitic lamellae and finer, more regular ones in the feldspar from Jekaterinburg.

Elba.

The white orthoclase crystals from St. Piero on Elba contain numerous fine reflecting albite lamellae, while the coarser, more irregular lamellae, described from the former occurrences, are not found here. For the orientation of the lamellae I have found the value 74°20′. G. v. Roth[2] finds that the lamellae form an angle with the base (over $\bar{1}01$)

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[1] As to the elements of microcline there seems to reign some confusion. The author (Zeits. f. Kryst. 48, 1910, p. 466) has in the best possible material, crystals of single microline from Ivigtut, found the values $\alpha = 89^\circ 18^{1}/_{2}{}'$ and $\gamma = 92^\circ 9^{1}/_{2}{}'$ and for the angle (010):(001) the value 89°43′ which is in good accordance with most of those formerly given by other authors (cited in the Mineralogy of Hintze, 1897, p. 1338). But in the »Mikroskopische Physiographie« of Rosenbusch (1905, I, 2. p. 315) were given quite different values viz. $\alpha = 94^\circ 40'$ and $\gamma = 90^\circ$ ca., but he does not mention where he obtained these elements which seem to be in contradiction to all observations, and on the same page is furthermore given for the angle (010):(001) the common assumed value of 89°30′ ca., which is, as will be seen without difficulty, absolutely incompatible with the above named values. The same confusion recurs in most of the modern handbooks f. i. those of Niggli (1920) and Groth (1921) where the wrong values for the angles α and γ are cited together with the correct one for (010):(001).

[2] Zts. d. d. geol. Ges. 22, 1870, p. 656.

of 94$^3/_4$—96$^3/_4$°, but he states that their position is not quite constant. How he has made these measurements, the results of which are rather divergent trom those obtained by me, is not mentioned. The labradorization is of the white, micaceous kind. The angle of extinction on (010) is found to be 7°30′ (7—8°), while for the same angle Kloos[1] found the values 6°25′ and 6°40′.

Colorado.

From the U. S. National Museum I obtained specimens of the "Hinsdale Rhyolite" from Uncompahgre Quadrangle, Co. and it contains small phenocrysts of a transparent orthoclase with a brillant blue luster. For the orientation of the reflecting plane I have found the angle 72°34′; any further examination of the feldspar I have not undertaken because of the smallness of the individual.

The examples described will give a general impression of the many varying features accompanying the labradorization of the orthoclases and I shall, in the following, give a summary of those features.

As to the outer appearance of the phenomenon there is a gradual transition from those instances where we have a deep blue reflection homogeneously scattered throughout the whole substance to such where we see only single spots reflecting with a micaceous luster. The first-named form of reflection is by no means to be distinguished from the labradorization of the plagioclases and I find, therefore, that it must be convenient to use the same name in both instances although the origin is probably rather different. From the blue reflection there are all transitions to such instances where the reflection is bluish white or pure white or, in

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[1] N. J. Min. 1884, 2, p. 117.

some instances (the murchisonite) yellow and with those colors is sometimes connected the phenomenon that the reflection is not uniform over the whole substance but confined to certain spots which are, however, rather indistinctly bounded. From this type there are again all transitions to such instances where the reflection is confined to distinctly bounded leaves of a micaceous appearance. That reflection is in its common appearance very different from the typical labradorization and has more resemblance to the avanturization, but the orientation of the lamellae in the common orthodomatic position and the gradual transition to the typical labradorization shows that it must be an essentially similar phenomenon.

The orientation of the reflecting lamellae is very uniform in the orthoclases although the differences between the single occurrences are so large that they cannot be due to errors in observation, and it will not, of course, be possible to ascribe a single symbol to the direction in question. The angle with the base for the occurrences examined is the following:

Narsarsuk	72°18′	Ceylon	73°5′
Frederiksvärn	72°27′	Mursinsk[1]	73°50′
Arendal	72°27′	St. Gotthard	74°3′
Colorado	72°34′	Elba	74°20′
Kunak	72°40′	Jekaterinburg	74°28′
Aliortok	72°43′	Mursinsk[2]	75°32′

We see that there is a difference of more than 3 degrees between both extremes, and it will be obvious that the more typically labradorizing occurrences mostly have

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[1] The coarser, micaceous lamellae.

[2] The finer, labradorizing lamellae.

the smaller values and those with coarser, micaceous lamellae mostly the larger ones, but the rule is not without exceptions. St. Gotthard and Mursinsk 2, for instance, which possess the finer lamellae, have some of the largest angles. The most simple symbols of the orthodomes which fall in the vicinity of the lamellae are those given below together with their angles to basis:

$(\bar{8}01)$	72°3′
$(\bar{7}01)$	73°17′
$(\bar{6}01)$	75°0′

It is easily seen that none of these values are preferred by the lamellae and there is of course no reason for giving them those or any other special symbols.

As the lamellae are, in all probability, produced by a regular intergrowth of albite and orthoclase, it would be of interest if we could determine their crystallographical position in relation to the first named mineral. Directly it is not possible to do so as we never find a perfect crystal or even a cleavage piece of albite possessed of the lamellae in question and we must therefore go a more indirect way. If we consider a common, rather coarse perthite, we shall see that the reflection of the albite is always orientated in such a manner that the base of that mineral is somewhat declined in relation to that of the orthoclase and the inclination is always directed towards (100). If we observe the perthite on the goniometer, we shall see that the reflection of the base of the orthoclase is not placed exactly between the two of the albite but at a distance of nearly 55′ behind the zone connecting these reflections. This value I have found rather uniform in different perthites, and we must consequently conclude that the axes a of the two minerals form the said angle with each other, whereof we shall find by calculation[1] that the axes *c* of both minerals form an angle of $19'$ with each other. If we calculate the positions of the steep orthodomes of the albite we shall get the following values for their angles with the base of the orthoclase:

$(\bar{8}01)$	$72^\circ 5'$
$(\bar{7}01)$	$73^\circ 16'$
$(\bar{6}01)$	$74^\circ 54'$

and on comparing these values with those given above for the orthoclase we shall find a very near coincidence, and the values will show, furthermore, that if we go to other faces in the same zone the differences between the two series will be larger in both directions. The two minerals are, consequently, grown together after a steep orthodoma which is common to both and that face is the only one in the whole zone of the orthodomes which is parallel in both feldspars. The cause of that peculiar parallelism I can, not, however, imagine; beforehand we should expect that some of the important faces of the zone, especially (001) would be orientated in parallel position.

A special interest is connected with the occurrence of labradorization in the single microline from Jekaterinburg described above. As long as that phenomenon was only known in the homogeneous orthoclase it was not possible to tell if it was bound to the face $(\bar{h}01)$ itself or to some pyramidal face $(\bar{h}kl)$, as we must expect, in the last case, that the lamellae in two symmetrical directions produced by the fine twin structure of the microline, which is com-

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[1] For the albite are used the elements of DREYER and GOLDSMIDT: Medd. om Grønl. 34, 1910. S. 43; and: N. Jahr. Min. Beilageband 29, 1910, p. 577.

monly supposed to result in the orthoclase, should produce lamellae in a single orthodomatic direction. The observations in the single microcline show distinctly that the lamellae are orientated after an orthodomatic face, and that the labradorization in the orthoclase is in so far essentially different from that of the plagioclase that in the last named it is neither bound to any distinct face nor zone, while in the orthoclase it is bound to the zone [010] but to no distinct face in that zone.

The coarser of the reflecting lamellae are plainly seen to consist of albite. Their dimensions are, however, never very large, their breadth being in most cases under 0.005 mm, while all essentially broader lamellae are of the common irregularly bounded type. In thin sections it looks as if the reflecting lamellae are in most cases not very pure and as if there must be a stratum of some foreign substance inserted between the orthoclase and the albite. What that substance is, cannot be directly stated but it is most probably air, which will be in good accordance with the fact that these lamellae produce a very strong micaceous luster which could not be caused alone by the rather few alternating lamellae of the two feldspars. This type of reflection is in all instances confined to rather small spots of the feldspar and is in most cases found in such feldspars as possess the common, coarser perthitic structure. In some instances (St. Gotthard, Mursinsk) the same feldspar may contain both these lamellae and those of the next type, but in that case the two kinds of lamellae are distributed in different parts of the feldspar.

The second type af lamellae, which are, however, not sharply distinguished from the first, are such as are so narrow that they can only with difficulty be observed by high magnification and, it is not possible, then, to determine the albite more directly by its angle of extinction. These lamellae give the bluish white or yellowish luster.

The third type of lamellae are so fine that they cannot be directly observed in sections and they are, consequently, only visible by their reflections. We can here only by analogy conclude that they consist of albite. These lamellae produce the most typical, blue labradorization which is always homogeneously distributed over the whole substance and is never connected with the existence of coarser perthitic structures.

A very obvious phenomenon which is in most cases connected with the labradorization, is the parting. The two first types of lamellae mostly produce a parting in the same direction as the lamellae themselves, but the parting may be more or less prominent. In those instances where the lamellae are confined to certain parts of the feldspar the parting will, of course, not be very distinct. The feldspars belonging to the third type behave very differently in that respect in so far as they never show any parting exactly in the direction of the reflecting lamellae, and it is very doubtful if the parting found in some instances has anything to do with the labradorization. Most regular is the feldspar from Frederiksvärn which possesses a parting after (100); this parting may, however, also be found in those parts of the feldspar which show no labradorization and must, consequently, be assumed to have no nearer connection with that property. The feldspars from Narsarsuk and Ceylon are more doubtful in that respect; they possess very irregular partings which have no distinct orientation, and on both feldspars I have measured angles with basis which correspond neither with that for (100) nor with that for the common orthodoma, and furthermore the parting is unsymmetrically orientated lying several degrees from the zone of the orthodomes.

As the labradorization of the orthoclases is, in all probability, caused by a regular lamellation of both components, we should expect, beforehand, that this property was confined to those members of the series where there is no possibility of a homogeneous mixture, viz. the large, midmost part of the whole series. The exact boundaries of this is not known, but according to the investigations of Vogt and Warren[1] it is most probable that those orthoclases which contain less than c. 8 p. ct. of potassium feldspar or more than c. 90 p. ct. of the same constituent are perfectly homogeneous and can, of course, show no labradorization. The rest of the series is inhomogeneous and may be labradorizing if the lamellae are of proper dimensions. If they are too large they will almost always get more irregular and in that case we have the common perthite which gives no reflections at all. If, on the other side, they are so small that their thickness is below the wave length of the common light, every reflection of the light is equally impossible.

Because of the great similarity between orthoclase and microcline on the one side and albite on the other it is very difficult to determine a member of the potash-soda feldspar series more exactly. The property which gives the best result is certainly the angle of extinction on (010) but the variation in the whole series is only ca. $15^1/_2°$ (from 4° to $19^1/_2°$) while in the plagioclases the variations of the same angle goes up to a value of c. 55°. On the

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[1] Proc. Amer. Acad. Arts and Sci. 51, 1915, p. 148.

other side the cleavage faces of the orthoclases are commonly more regular than those of the plagioclases and, of course, we more easily get perfectly orientated sections of the orthoclases.

For the labradorizing orthoclases the following angles of extinction on (010) are determined:

St. Gotthard	6°	Kunak	11°
Elba	7°30′	Aliortok	11°50′
Mursinsk	9°48′	Arendal	12°
Narsarsuk	10°30′	Frederiksvärn[1]	12°-14°38′
Ceylon	10°35′		

The table shows that the labradorizing menbers of the alkali feldspar series may have a very variable composition and it is also seen clearly that both ends of the series are wanting in accordance with what was explained above. I shall not try to calculate the composition of the feldspars mentioned by means of their angle of extinction, partly because of the small variation of that angle from the one end of the series to the other, and partly because of the circumstance that the amount of lime feldspar, which is in no instance known, may cause feldspars with different ratios of the main components to have the same angle of extinction.

In the following table I have tried to collect the existing analyses of labradorizing alkali feldspars. Naturally such a list can never be complete as it is in many cases not stated if the feldspar analysed possesses labradorization. That, for instance, is the case with adulare, of which mineral there exists many analyses, but where in no instance anything is stated about the labradorization. In

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[1] After Brögger: Zts. Kryst. 16, 1890, p. 524 ff.

the first three columns are given the percentages of potash, soda and lime and in the last three the percentages of the main components calculated by means of the amounts of the oxides mentioned.

	K_2O	Na_2O	CaO	*Or.*	*Al.*	*An.*
Ceylon (moonstone)......	14.81	0	0.42	97.7	0	2.3
— —	13.50	0	0.50	97.0	0	3.0
— — [1]	12.06	2.62	0.49	74.4	23.1	2.5
Dawlish (murchisonite)..	14.80	0	0	100	0	0
Exminster — ..	12.43	1.44	0.33	84.2	13.9	1.9
Limonest	11.69	2.58	0.62	73.7	23.0	3.3
Elba	11.23	3.40	0	69.4	30.6	0
Korea (moonstone)[1]	9.63	3.52	0.99	62.3	32.6	5.2
Narsarsuk	8.66	5.61	0	51.9	48.1	0
Frederiksvärn	7.38	7.25	0	41.5	58.5	0
—	7.03	7.08	0.48	42.3	57.7	2.3
—	7.68	6.54	0.37	44.2	54.0	1.8
Larvik	5.75	6.11	1.64	35.4	55.9	8.7
Ula......................	5.84	7.26	1.19	33.9	60.3	5.8
—	5.32	7.48	1.38	31.0	62.3	6.5
Byskoven	4.42	6.48	3.23	27.0	56.5	16.5
Svenør...................	4.97	6.59	4.66	26.4	50.1	23.5

From the above list we get the impression that the composition of the labradorizing alkali feldspars varies from the pure potash feldspar to a feldspar containing the ratio of c. 1 *Or.* to 2 *Al.* That a pure potash feldspar should be able to labradorize is beforehand highly improbable as it is almost certain that this property is caused by a fine lamellation of orthoclase and albite and we are, therefore, almost forced to assume that the three analyzes showing no Na_2O cannot be correct. Now these analyses are rather old and the total equivalents of K_2O and CaO are so small in them that these oxides are not sufficient to form feldspars of normal composition together with the amounts

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[1] Analysed by Seto: Sci. rep. Tohoku imp. Univ. Vol 1, No. 1, 1921. The other analyses are cited from the handbooks of Hintze and Doelter.

found of Al_2O_3 and SiO_2. These analyses cannot, of course, be considered very trustworthy and perhaps the same is the case with the feldspar from Axminster the analysis of which shows a similar great want of oxides; this feldspar, however, does not fall outside the assumed range of compositions of the non-homogeneous orthoclases.

With the exceptions mentioned all the analyses show a composition as we should expect it theoretically, lying between a ratio of $Or:Al$ of almost 6 : 1 and of almost 1 : 2. If we compare the variation of the compositions of those feldspars with the variations found in the angles of extinction, we find good agreement in most instances. In the feldspar from Korea where the ratio $Or:Al$ is almost 2 : 1 the angle of extinction is stated to be 8°, and in the feldspar from Elba where the amount of orthoclase is a little larger, the angle of extinction is found to be 7° 30′. The feldspar from Narsarsuk which has almost the same amount of the two main components has an angle of extinction of 10° 30′, while the feldspar from Frederiksvärn where the ratio $Or:Al$ is almost 2 : 3 has an angle of extinction of 12° and that from Ula where the same ratio is ca. 1 : 2 has an angle of 14° 38′. The only feldspar which forms an exception from the common rule is the moonstone from Ceylon where the amount of *Or*, according to the analysis of Seto, is almost 75 p. ct., and for that feldspar I have found an angle of extinction of 10° 35′ which should correspond to a much more sodic orthoclase. The only explanation seems to be that the moonstone may be rather variable in composition.

Of special interest are those instances where we have in the same feldspar both labradorizing and not labradorizing parts, and where this difference is connected with variations in the angle of extinction or in the chemical composition. In such instances we obtain the impression that the feldspar in question is situated just at the boundary between the homogeneous and the heterogeneous parts and that a small variation in composition will be sufficient to bring it from the last to the first-named region where there is no possibility of labradorization.

The potassic boundary for the labradorizing alkali feldspars is found in the orthoclase from Mursinsk where, as told above (p. 15), the more homogeneous parts mostly possessed a very fine labradorization while those parts of them which bordered on the opaque substance were perfectly homogeneous without any trace of labradorization. For these two parts were found the angles of extinction of respectively 9° 48′ and 7°, and it seems, consequently, that the boundary for the labradorizing part in this feldspar would correspond to an angle of extinction lying between these two values. Now it is not possible to calculate the exact composition of the feldspar by means of the angle of extinction, and it is not possible from this feldspar to get material for analysis of the two parts in question.

A better value for the potassic boundary we obtain from the adulare from St. Gotthard which, as well known, sometimes possesses a brillant luster and sometimes none. There is, however, never any distinct boundary between the two parts, but in some of the larger crystals we may find parts, where most of the substance is labradorizing and others where only some small spots show that property. For these two parts I have found almost the same angle of extinction, c. 6°, but as it is not possible from that clue to conclude anything more exactly about the composition I thought it best to get a partial chemical analysis of the two varieties of adulare. This was undertaken by the chemist Max Möller and showed that the weakly labradorizing adulare contained 14.15 (as the mean of two determinations 14.15 and 14.16) p. ct., K_2O, and 1.24 (1.23—1.25) Na_2O, while the more strongly labradorizing one contained 14.05 (14.03—14.07) K_2O, and 1.35 (1.35—1.36) Na_2O. To these percentages the ratios 88,9 *Or.* : 11.1 *Al.* and 87,9 *Or.* : 12,1 *Al.* correspond. According to the thorough investigations of Warren[1] the amount of $Ab + An$ in the microcline ranges between 7.0 and 11.5 p. ct., and as we must assume that the same is the case with the monoclinic orthoclase, we shall see that there is a good congruence between the results obtained above and those obtained by Warren by means of analyses of the microclines of the perthites.

The sodic boundary for the labradorizing orthoclases is seen very distinctly in the feldspar from Frederiksvärn and Larvik. It is a rather common phenomenon in the rock called larvikite, which is well known because of its content of labradorizing feldspar, that the larger grains of that constituent often possess a zonar structure that is labradorizing only in the outer rim, and in such instances we shall see in these sections that the angle of extinction in that rim is smaller than in the colorless interior which signifies that the inner part of the feldspar grain is more rich in soda than the outer rim and that, consequently, the constituent most rich in soda has crystallized first, being in excess over the eutectic composition. When the boundary for the labradorizing (or inhomogeneous) feldspar is reached this property comes into existence. Now it is impossible to obtain such good material of these grains that their exact composition can be determined, but in the large

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[1] Proc. Amer. Ac. Arts and Sci. 51, 1915, p. 141.

pegmatite masses of the same rock we may find specimens of which one part is strongly labradorizing while another is quite colorless, and of such a specimen I have undertaken a closer examination. The boundary between two parts is here, in opposition to what was the case in the adulare, quite distinct, and there is no immixture of the one substance in the other. On measuring the angle of extinction I found for the labradorizing part as mean value 11°, and for the corlorless part 11° 45′ which value is, indeed smaller than those found by Brøgger for the labradorizing varieties. The chemical analysis, undertaken by Max Möller, shows the same irregularity. For the labradorizing parts were found 7.37 K_2O (7.36—7.39) and 5.48 Na_2O (5.47—5.50), and for the corlourless one 7.26 K_2O (7.25—7.27) and 5.69 Na_2O (5.67—5.72). Thereof we obtain the compositions of the two parts of respectively 48.4 *Or*, 51.6 *Al* and 47.1 *Or*, 52.9 *Al*. If we take into consideration that other labradorizing feldspars from the same localities possess a ratio of $Or:Al$ of almost 1:2 we do not feel convinced that we have in that instance found the sodic boundary for the labradorizing orthoclases, or that boundary must have a very variable position in every single instance.

It is, after all, highly probable that there exists a sodic boundary for the labradorizing orthoclases, but it is not possible to determine it more exactly if not by means of rhöntgenographic examination. This has, indeed, been performed by various authors but what has been published about the structure of the alkali feldspars is not very much. It is shown that some of them contain a double arrangement of the atoms but until now only few such feldspars have been examined.

II. Plagioclase.

The brilliant labradorization which is so characteristic for many plagioclases has been mentioned by many earlier authors but most of the properties are still rather imperfectly described. Especially of the direction of the lamellae there exist only few descriptions which are mostly quite contradictory. The earlier investigations will be mentioned in the following under the single occurrences.

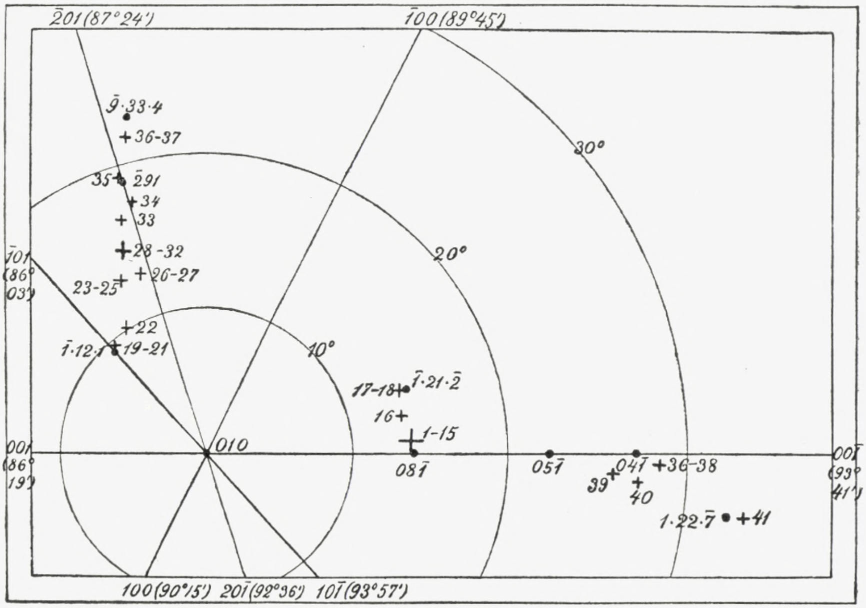

Fig. 2. Position of the labradorizing lamellae in the peristerites (Nos. 1—18), the labradorites of the group *a* (19—37) and those of the group *b* (36—41). For further explanation see the text.

As most of the plagioclases possess a labradorization which is visible through the face (010) it is natural to draw the results on a projection with that face as pole, as will be seen in fig. 2. As the zone [010] is not quite normal to that face it will not be situated exactly in the equatorial zone of the projection. Its faces have, however, been drawn in the border, and at each of them is given their angle with (010). As first meridian is chosen the zone from (010) to $(00\overline{1})$ (the acute angle between both cleavage faces) and the values φ and ϱ are used in the common manner. The scale, which is essentially larger than that commonly used, is given by the three circles. The crosses signify the positions of the labradorizing lamellae and the numbers annexed refer to the occurrences described in the text; in many instances the positions for different localities lie so close together that they cannot be distinguished with the scale used. The round spots give the indices for certain faces lying in the close vicinity of the reflections; as these indices are mostly rather large it will be seen that it is mostly quite accidental which symbols we shall draw. All positions and angles given for the faces belong to the albite and it is clear that the values will not be exactly the same for the plagioclases in question. It is, however, impossible to get these values exactly, and for the sake of orientation those of the albite will be quite sufficient.

All labradorizing plagioclases belong to one of two groups: the first has a composition between albite and oligoclase (albite-oligoclase, peristerite) and the second mostly belongs to the labradors proper, confined, however, to those most rich in soda.

A. Albite-oligoclase.

1. Hvidehald.

In a pegmatitic vein at Hvidehald on Bornholm there are small, inconspicuous grains of a colorless feldspar giving a bright, skye-blue luster. For the lamellae have been found the positions: $\varphi = \div 1^\circ\,10'$ $(1^\circ\,0'—1^\circ\,30')$, $\varrho = 14^\circ\,4'$ $(13^\circ\,44'$

—14° 31′) the angle of extinction on (010) is found to be ca. $12^3/_4$°.

2. Klippegaard.

This locality, also situated on Bornholm, is very similar to the former; the feldspar grains are larger (up to 3 cm in diameter) and grey, semitransparent. The following angles have been found: $\varphi = \div 3° 45'$ (3° 0′—4° 30′) $\varrho = 13° 45'$ (13° 30′—13° 58′). The angle of extinction is c. 14° (13—15°).

3. Aliortok.

The albite-oligoclase from here is reddish grey and rather impure, with a weak, bright sky-blue luster. For φ is found 0°, for ϱ 14° 16′; the angle of extinction is c. 12°.

4. Kanajorsuit.

From this place, which like the former is situated in Greenland, the Museum in Copenhagen possesses a specimen of graphic granite with a white, semitransparent feldspar giving a rather weak luster of the common appearance. φ is found to be $\div 4° 0'$ (3° 30′—4° 30′) and for ϱ is found 13° 40′ (13° 24′—13° 58′); the angle of extinction is c. $12^1/_2$°.

5. Greenland.

From Greenland without other locality given we have a small specimen of a rather transparent feldspar producing a fine, bright blue luster. $\varphi = \div 6° 0'$, $\varrho = 13° 30'$, the angle of extinction = c. 13° 30′.

6. Ljoselandsknipan.

This locality, which is situated in Iveland, is known as a place for various rare minerals, especially the Thortveitite described by SCHETELIG[1]. The oligoclase is said to

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[1] Kristiania, Videnskabsselskapets Skrifter, I. Mat.-naturv. Klasse, 1922, Nr. 1, p. 51.

occur in large individuals (up to 0.5 m in diameter) together with microline perthite and quartz, partially grown together as graphic granite. The oligoclase is whitish, with rather irregularly curved cleavage faces; it is only partially labradorizing with a rather weak luster of the common color. $\varphi = \div 5^\circ 10'$ (4°—$6^\circ 30'$), $\varrho = 13^\circ 22'$ ($13^\circ 18'$—$14^\circ 14'$), the angle of extinction is c. $15^1/_2{}^\circ$.

7. Urstad.

From this locality, situated on Hitterö in Norway, I obtained from Kristiania a rather large specimen of a reddish-white oligoclase enclosing some particles of a dark garnet. The cleavage faces are even more irregularly curved than those from the former locality, the luster is mostly of the common kind but sometimes passes into a darker blue or into a greenish, yellowish or brownish color. $\varphi = \div 4^\circ 45'$ ($3^\circ 30'$—6°), $\varrho = 13^\circ 19'$ ($13^\circ 16'$—$13^\circ 22'$); the angle of extinction = c. 16° ($15^1/_2$—$16^1/_2{}^\circ$).

8. Malmberget.

From the Museum in Stockholm I obtained a specimen of this interesting feldspar described by Flink[1]. It is greyish white and semitransparent and the cleavage faces are very perfect; the labradorization is strong and even more variable than in the former feldspar. The colors form a regular series, as will be described later on for the labrador: when we begin with the non-reflecting parts we first come to a deep blue zone and thereupon to a bright sky-blue and a greenish one, while other, more irregularly distributed parts are

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[1] Arkiv f. Kemi, Min. och Geol. Upsala and Stockholm. Vol. 5. Nr. 10, p. 179.

brown or yellow. The said series of colors is not, however, connected here with any variation in the angle of extinction and consequently not in the composition of the feldspar, as is so distinctly seen in the labrador. For the reflecting lamellae I have found: $\varphi = \div 1^\circ 50'$ ($0^\circ 40'$—$3^\circ 0'$), $\varrho = 13^\circ 47'$ ($13^\circ 41'$—$14^\circ 0'$). The angle of extinction I have found to be $15^1/_2{}^\circ$ (15—16°). FLINK gives many different values, varying from 13 to 20°, but as he does not state if the feldspars examined are labradorizing or not, these values have no interest for the present purpose, and the same is the case with the analysis cited, which gives 0.51 p. ct. CaO and 10.06 Na_2O.

9. Bersbo.

The feldspar from this locality has also been described by FLINK[1]; in its outer appearance it is very different from all others belonging to that group as the color is a dark leek-green. The cleavage faces are rather imperfectly developed, the labradorization is weak, of the common, bright blue color. $\varphi = \div 1^\circ$ (0—2°), $\varrho = 13^\circ 26'$ ($13^\circ 22'$—$13^\circ 31'$). The specific gravity was determined by FLINK to be 2.648 and 2.652 and the extinction on (010) to be $5^1/_4{}^\circ$ and $3^1/_2{}^\circ$, whereof was obtained the composition $Ab_3 An_1$. In different sections I have found for the extinction the angle 13° ($12^1/_2$—$13^1/_2{}^\circ$), and it is possible that the divergence between the measurements can be explained thereby that the material used by FLINK was, perhaps, not identical with mine as FLINK does not mention any labradorization in his feldspars. For the well labradorizing varieties I have found the specific gravity = 2.620 to 2.629.

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[1] l. c. p. 135 and 137.

10. Perth.

The peristerite from this well-known locality is grey, semitransparent with good cleavage and a sky-blue luster. $\varphi = \div 3^\circ 10'$ $(2^\circ - 4^\circ 10')$, $\varrho = 14^\circ 30'$ $(14^\circ 14' - 14^\circ 47')$; the angle of extinction is determined to be $11^\circ 45'$ $(10^{1}/_{2} - 12^{1}/_{2}{}^\circ)$ while for the same angle Descloizeaux[1] gives the value of c. 16°.

11. Bathurst.

From the Museum in Washington I obtained from that locality a specimen which was of a whitish color and gave a blue or, sometimes greyish or brownish reflection. $\varphi = \div 3^\circ 15'$ $(3^\circ - 3^\circ 30')$ and $\varrho = 13^\circ 39'$ $(13^\circ 36' - 13^\circ 42')$. The angle of extinction is $16^{1}/_{2}{}^\circ$ $(16 - 17^\circ)$. This feldspar is unique among all labradorizing plagioclases in that it contains small flakes giving a strong micaceous luster exactly in the same direction as the labradorization and giving rise, furthermore, to a parting in that direction. In sections normal to (001) and (010) we also see distinctly a striation forming an angle of $13^{1}/_{2}{}^\circ$ with the trace of basis. We get the impression that there exist small lamellae, containing air, in the direction of the labradorization, but we obtain no real solution, thereby, of the enigmatic problem what is the cause of the labradorization of the plagioclases. We saw, in the orthoclases, that the broader, regular albitic lamellae could be accompanied by similar, strongly reflecting strata (p. 19). That phenomenon is, however, in all probability secondary in relation to the labradorization and not the cause of it.

12. Lanark.

From this locality the museum in Copenhagen possesses a large specimen of a graphic granite, the feldspar component

[1] Bull. Soc. Min. France, 6, 1883, p. 100.

of which is a peristerite with the common, bright blue luster. Because of the intimate mixture with quartz the structure of the feldspar is rather irregular and the values obtained cannot be considered very good. $\varphi = \div 2° 14'$ (1—4°), $\varrho = 14° 3'$ (13° 58'—14° 14'); angle of extinction c. $12^1/_2$°.

From a fourth place in Canada, Burgess, DESCLOIZEAUX[1] describes a peristerite and he states that the labradorization is orientated in a direction situated between ($0\bar{2}1$ and ($0\bar{6}1$). As the direction for most of the peristerites is very near the face ($0\bar{8}1$) the observation of DESCLOIZEAUX, cannot in all probability be correct. The angle of extinction is stated to be 15—16°.

13. Macomb.

From this place the museum in Copenhagen possesses a specimen with rather large crystals of a greyish, transparent peristerite giving a rather strong, blue luster. $\varphi = \div 6°$, $\varrho = 14°$; the angle of extinction = $15^1/_2$°.

14. Valhalla.

From this locality, situated in New York, I obtained from the museum in Washington a specimen of a white peristerite showing a blue labradorization. $\varphi = 4°$, $\varrho = 13° 58'$. The angle of extinction = $14^1/_4$°.

15. Amelia Court House.

The labradorization of this feldspar has been examined by VIOLA[2]; his methods are, however, very complicated and his results, cannot, in my opinion, be correct as he

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[1] l. c. p. 106.

[2] Zeits. f. Kryst. 34, 1901, p. 181.

obtains a position for the labradorization which lies rather far from the zone (010) : (001) while it is easily seen, on observing a specimen of the mineral, that it must be orientated in the close vicinity of that zone. As was the case with the moonstone from Ceylon, Viola also finds for the feldspar from Amelia a "dioptric shiller" in another direction. This I have not been able to observe, and I do not understand what can be the cause of that observation.

Most of the feldspar from Amelia is an almost pure albite which is perfectly transparent and which shows no trace of labradorization. For this feldspar I have determined the angle of extinction to be 20° and the specific gravity to be 2.624—2.627. From the museum in Washington I obtained a fine specimen of the labradorizing variety which is white and semitransparent and gives a rather strong luster of the common bright blue color. $\varphi = \div 5° 25'$ (5°—5° 50′), $\varrho = 13° 37'$ (13° 30′—13° 45′). The angle of extinction is $15^1/_2°$ and the specific gravity 2.631—2.634.

16. Hult.

This feldspar which, as described by Flink[1], is very remarkable by containing some lamellae of a perfectly doubtful nature is yellowish white with a weak, blue luster. $\varphi = \div 10° 30'$ (9° 30′—11° 30′), $\varrho = 13° 22'$ (12° 30′—13° 30′). The angle of extinction is stated by Flink to be $16^1/_2°$ while I have in several different sections obtained the value 15° ($14^1/_2$—$15^1/_2°$).

17. Seiland.

The feldspar from that locality was described by Hoel and Schetelig[2]; it forms large and well developed crystals

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[1] l. c. p. 153.

[2] Festskrift til Prof. Amund Helland, 1916, p. 122.

of a dark grey color, varying, however, according to the quantity of the inclusions from almost black to almost white. The cleavage faces are very perfect, especially those after (010) which in the lighter parts possess a very strong nacreous luster parallel to the face itself, while in the darker, transparent parts they mostly show labradorization which is, however, in most cases rather weak. The color of the labradorization is very variable, passing from blue to green, violet or brown, or in some instances grey or silvery white. $\varphi = \div 17^\circ 40'$ (16°—$19^\circ 30'$), $\varrho = 13^\circ 10'$ (13°—$13^\circ 30'$). HOEL and SCHETELIG only loosely gave as the direction for the labradorizing lamellae a face near (010) and lying in the zone (010) : $(1\bar{1}2)$ which, as seen on fig. 2, is quite correct, the face lying very near $(1.\overline{21}.2)$. The angle of extinction on (010) was by the said authors determined to be $16^1/_2{}^\circ$ (16—17°), while I have found the mean value $17^\circ 48'$ ($16^1/_2$—$18^1/_2{}^\circ$).

18. Mineral Hill.

This is one of the finest peristerites of a whitish grey color and with a strong blue luster. $\varphi = \div 18^\circ 30'$ (18—19°), $\varrho = 14^\circ 16'$ ($14^\circ 5'$—$14^\circ 27'$). Under the microscope we see that it is an antiperthite with lamellae of orthoclase, mostly orientated after (100). The angle of extinction is 16° ($15^1/_2$—$16^1/_2{}^\circ$) but as the structure is very irregular it is not possible to make exactly orientated sections.

The labradorizing albite-oligoclases (the peristerites) as a whole form a very uniform group. As regards the outer appearance they are mostly semitransparent, whitish grey with very small variations, and only two occurrences (Bersbo and Seiland) are exceptional in that respect. The color of the labradorization is also in most instances very uniform, blue varying from a dark blue, which color is mostly developed where the labradorizing part of the crystal is bounded by a not labradorizing part, to a light sky-blue which is the main color. Sometimes this, on the other side, passes into a greenish blue, but other colors are confined to a few instances (Urstad, Malmberget, Bathurst and Seiland). In one respect the peristerites differ from all other labradorizing feldspars, viz. in giving much better reflections. While, in the other feldspars, the reflection of the labradorization is a rather large and indistinct spot, it is here very small, and in some instances the cross-formed signal is directly seen. Because of this concentration of the luster in one small spot it is often possible to observe the phenomenon in the goniometer where it is so weak that it cannot be seen otherwise, while in the other feldspars the opposite is the case. The values given for the position of the labradorizing lamellae are, of course, here much more exact than otherwise, and the exactness of the measurements is mostly only limited by the circumstance that the cleavage faces are in many instances not very even, so that it is impossible to place the whole specimen in an exact position.

The positions of the labradorizing lamellae together with the angles of extinction on (010) are given in the following table:

	φ (÷)	ϱ	ext.
1. Hvidehald	1° 10′	14° 4′	12° 45′
2. Klippegaard	3° 45′	13° 45′	14°
3. Aliortok	0°	14° 16′	12°
4. Kanajorsuit	4°	13° 40′	12° 30′
5. Greenland	6°	13° 30′	12° 30′
6. Ljoselandsknipan	5° 10′	13° 22′	15° 30′

	φ (÷)	ϱ	ext.
7. Urstad	4° 45′	13° 19′	16°
8. Malmberget	1° 50′	13° 47′	15° 30′
9. Bersbo	1°	13° 26′	13°
10. Perth	3° 10′	14° 30′	11° 45′
11. Bathurst	3° 15′	14° 39′	16° 30′
12. Lanark	2° 14′	14° 3′	12° 30′
13. Macomb	6°	14°	15° 30′
14. Valhalla	4°	13° 58′	14° 15′
15. Amelia Court House	5° 25′	13° 37′	15° 30′
16. Hult	10° 30′	13° 22′	15°
17. Seiland	17° 40′	13° 10′	17° 48′
18. Mineral Hill	18° 30′	14° 16′	16°

As will be seen the 15 first feldspars labradorize in almost the same direction; the differences are, it is true, so large that they cannot be caused by errors in the measurements, but the positions lie so near each other that it is not possible to distinguish between them on a projection in the scale of fig. 2 for which reason they have been represented by one cross. The difference between the two outermost values of ϱ is only 1° 20′, and the larger difference between the values of φ, viz. ÷ 6°, is only apparent, the real angle correspondent to that value being only ca. 1° 25′. The three last-named occurrences diverge more from the main part, especially the two last which lie rather near each other. The difference in angle between the outermost ones on both sides is c. 4° 20′. As regards the crystallographical orientation of these positions we shall see from the figure that the main part falls in the close vicinity of the face $(08\bar{1})$ for which the position, with the projection used, is (for the albite): $\varphi = 0°$, $\varrho = 14° 13'$. The feldspars no. 17 and 18 lie rather near the face $(\bar{1}.21.\bar{2})$ for which the theoretical position is: $\varphi = \div 18^\circ 10'$, $\varrho = 13^\circ 36'$. It is clear that the position of the labradorizing lamellae cannot well be expressed by any simple symbol.

The composition of the feldspars cannot be determined very exactly if not by means of a good chemical analysis and experience always shows that, by using different other methods, we mostly get rather contradictory results. The specific gravity can be measured with great exactness but this property is so largely affected by foreign inclusions that we cannot very well rely upon that. The indices of refraction can also be determined rather exactly in small splitters, but the exact orientation of these is so difficult to ascertain that it does not seem probable that the best results can be obtained in this manner. The determination of the angles of extinction on the two cleavage faces has the advantage that the orientation of the section can be made rather exact if, by cementing the piece to the glass, we ascertain that reflection from the upper cleavage face is parallel to that from the glass, and I have therefore preferred this method to the others. Of the two cleavages, that after (010) gives an angle of extinction which is much more variable with the composition of the feldspar, especially for the more acid plagioclases, and I have therefore in most cases tried to determine this value as exactly as possible, especially by making many different sections of each feldspar. If the section consists of two or more individuals after the albite law we can mostly observe a labradorization in two directions, and in these instances we have an excellent control for the orientation of the section if we place it on the goniometer and see if the two reflections are symmetrical.

If we consider the extinctions given in the table, we shall see that most peristerites are in that respect rather uniform, and only one of them (Seiland) stands rather apart from the others. There is no certain difference between the tree last named, which stand apart as regards the position of the labradorizing lamellae, and the main part of the occurrences, with the exception, perhaps, that they belong to the most acid. The composition which we obtain from the extinctions given passes from 85.6 to 92.5 *Al.* or from 14.4 to 7.7 *An.*), and we may conclude, of course, that all labradorizing plagioclases of that group have a composition lying in that vicinity[1].

Of analyses of the feldspars in question I have not been able to find more than the following 6 for which are given the amounts of the oxides of *K*, *Na* and *Ca* together with the percentages of three components, *Or*, *Al* and *An*, calculated therefrom[2]:

	K_2O	Na_2O	CaO	*Or.*	*Al.*	*An.*
Stromay........	1.23	9.55	2.04	7.4	82.3	10.3
Mineral Hill....	1.36	8.86	1.47	8.8	83.1	8.1
— —	0	8.90	2.50	0	86.4	13.6
Canada........	0.58	7.00	2.52	4.5	78.9	16.6
Koromandel....	0.94	9.38	1.96	5.8	84.0	10.2
Seiland........	1.05	10.27	1.04	6.3	88.4	5.3

If we consider the amount given above for *Al.* and *An.* we will see that they agree rather imperfectly with those obtained from the angle of extinction; the amount af *Al.* is too small in most instances, and especially in the feld-

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[1] The numbers have been taken from the graphical projection given by BECHE (Denks. d. k. Akad. d. Wiss. Wien. Mat.-naturw. Kl. Bd. 75, p. 106); for the sake of easier comparison with the results of the analyses the values, given by BECHE as molecular percentages, are recalculated to weight percentages.

[2] With the exception of Seiland (l. c. p. 126) the analyses have been cited from the handbooks of HINTZE and DOELTER.

spar from Canada, and that of *An.* is too small from Seiland. Now we do not know exactly what role the potash feldspar component plays in the plagioclases. If the results obtained by Alling[1] are correct, it is most probable that it works together with the anorthite and that, consequently, the value of the *Al.* will be the most correct. If that is the case, we shall see that the feldspar from Canada forms the largest discrepancy between the analyses and the values obtained from the angles of extinction. The old analysis (by Hunt) of the peristerite from Canada cannot, however, be fully relied upon, as the total amount of the equivalents of the metal oxides (= 0,173) is much smaller than that of the Al_2O_3 (= 0,214). The boundaries for the percentages of albite obtained from the five other analyses (83.0—88.4) are somewhat smaller than those obtained by me (85.6—92.3), and I cannot see if the discrepancy is caused by an inexact determination of some kind, or by an incorrect correlation between the angle of the extinction and the composition, or by the fact that some of the orthoclase ought, perhaps, to be added to the albite to give the extinction found. If one half of the orthoclase were added to the albite and the other to the anorthite, the five analyses would be in perfect accordance with my determinations.

B. Labradorite.

On observation of the labradorites we shall soon see that the reflecting lamellae are orientated in three essentially different directions and thus for those feldspars we obtain three groups, which are, however, not totally separated from each other as some of the feldspars may labradorize in two of the said directions.

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[1] Journ. of Geol. 29, 1921, p. 250.

Group a.

The main part of the labradorites belong to this group which will, therefore, be treated in the first place.

19. Kijew.

The well known feldspar from Kamenoi Brod has been described by many previous authors as regards which I may refer to the handbook of HINTZE. A special decription of the colors of labradorization has been given by SCHRAUFF but I do not think that his descriptions or drawings of the series of colors can be correct as they are too much in contradiction to what I have found to be the general rule in that feldspar and in all others of that group. SCHRAUFF has especially observed that the green colors form the border of the labradorizing parts, but I have always found that there is a very small border of a blue color outside the green part.

The specimen, which I have had at my disposal, is a gabbro, or perhaps a labradorite rock consisting for the main parts of large individuals of a greyish black labradorite; most of these are labradorizing in the inner part and not in the outer and the labradorizing parts often form very regular figures which are, however, in many instances interrupted by strata of the non-labradorizing substance. This is without any exception bordered by a deep blue color from which we pass to a light blue and further to a green and, more rarely, further to a yellow or reddish color. This series of colors, which is the normal one for the labradorites of group a, is mostly connected with a variation in the compositions of the substances in such a manner that the colorless feldspar bordering on the deep blue color is the most acid and that the labradorizing substance gets more and more basic as we pass further up in the series of colors. The orientation of the labradorizing lamellae is the same for the different colors: $\varphi = \div 132^\circ 50'$ (129°—$135^\circ 30'$), $\varrho = 9^\circ 23'$ ($9^\circ 17'$—$9^\circ 34'$). The angle of extinction cannot be determined very exactly as the cleavage faces are very irregular but in all sections we shall see that it varies with the labradorization. For the labradorizing substance I have found $\div 19^\circ$ for the deep blue, and $\div 21^\circ$ for the light blue and green colors, while for the colorless substance I have found values from $\div 18^\circ$ down to $\div 10^\circ$.

20. Vågefjärden.

From this locality, which is situated near Nordingrå in Ångermanland, I obtained from the Museum in Stockholm a small specimen of which only a small spot was labradorizing with a blue color. $\varphi = \div 130^\circ$, $\varrho = 9^\circ 35'$. For the angle of extinction, which cannot be determined very exactly, I have found the value of $\div 20^\circ$ and I have not been able to state any difference between the labradorizing and the non-labradorizing part of the feldspar.

21. Ingermanland.

From this province of Russia without special locality the museum in Copenhagen possesses some specimens of a gabbro, the labradorites of which are partially labradorizing with a blue color. The feldspar is of the common greyish black colour. $\varphi = \div 129^\circ$, $\varrho = 9^\circ 15'$. The extinction, which cannot be determined very exactly, is found to be $\div 18^\circ$ ($17^1/_2$—$18^1/_2{}^\circ$); there is no distinct difference between the different parts of the feldspar.

22. Labrador.

The many specimens from that locality which the museum in Copenhagen possesses are in many respects rather variable. The specimen in question is a gabbro with the feldspar individuals partly labradorizing with a blue color. $\varphi = \div 122° 30'$ $(121° 30'—123° 30')$, $\varrho = 10° 8'$ $(9° 51'—10° 25')$. The angle of extinction for the labradorizing parts is $\div 20°$ $(19—20^1/_2°)$ for the deep blue color, and $\div 21°$ $(20^1/_2—22°)$ for the light blue and green colors, for the colorless parts it varies from $\div 18°$ in the parts next to the labradorizing parts to c. 0°.

The labradorization of the feldspar from Labrador has been described by various previous authors. Descloizeaux[1] determines the position of the reflecting lamellae for a labradorite, which is probably from that locality; his methods are not very clearly stated, but, if we try to express his results in the manner commonly used here, we obtain the values $\varphi = \div 105°$ and $\varrho =$ ca. 13° which pair of values does not correspond very well with any of those obtained by me. Reusch[2] has undertaken very exact measurements of the position of the reflecting lamellae in the labradorite from Labrador; he obtains the following corresponding values (expressed in the manner used here):

$\varphi = \div 115°$	$\varrho = 12^1/_2°$
$\div 110°$	$14° 45'$
$\div 105° 20'$	$18° 6'$

These values are in very good accordance with some of those found by me (vide numbers 23, 31 and 34), but the symbols (4. 31. 3), (3. 18. 2) and (5. 25. 3) given

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[1] Man. de Min. I, 1862, p. 304.

[2] Pogg. Ann. 120, 1863, p. 95.

by Reusch for the reflecting faces cannot be correct in that they have only positive indices. All observations, and also the figures of Reusch show, that the projection of the labradorization on (010) falls in the acute angle β and the orientation of that phenomenon must, consequently, be parallel to a face $(\bar{h}kl)$.

23. Labrador.

This specimen is a rather large cleavage piece of a grey color and rather impure; it shows a brilliant luster which is distinctly confined to some irregularly bounded parts while the surrounding substance is absolutely without any labradorization. The series of colors is very marked, passing from colorless to deep blue, light blue, green, yellow, red and violet, and there is a marked difference in the direction of labradorization for the different colors. For the main part of the labradorization, the red and violet colors, we have: $\varphi = \div 116°$, $\varrho = 12° 50'$, while for the blue $\varphi = \div 120°$, $\varrho = 16° 40'$. The difference in composition between the different parts is, however, still more marked, as is shown by the angle of extinction which for the colorless parts is c. ÷ 13—17°, while for the blue border it is c. ÷ 18° and for the violet part c. ÷ 20°.

24. Russia.

From Russia, without any other locality given, the museum in Copenhagen possesses some specimens of a labradorite of a dark grey color from earlier times. It is partly labradorizing with the common colors ranging from blue next to the non-labradorizing parts to green. $\varphi = \div 117° 15'$ ($114^{1}/_{2}°$—120°), $\varrho = 13° 18'$ (13° 11'—13° 25'). The angle of extinction on (010) is c. ÷ 16° (15—17°), and there is no distinct difference between the labradorizing and the non-labradorizing parts, which is, perhaps, due to the circumstance that the last-named are very impure and consist, in a very peculiar manner, of a perthite-like intergrowth of the common labradorite with a much more basic one. As this phenomenon, as far as I know, is quite unique in the plagioclases, I have tried to establish it by the following measurements: the angle of extinction on (010) for the first labradorite is c. ÷ 16°, for the second c. ÷ 26°; on (001) for the first c. ÷ 6°, for the second c. ÷ 12°. We have here, consequently, in the labradorite which forms the largest parts of the specimens, and the composition of which is almost 52 % An, inclusions of another labradorite of a composition of almost 67 % An. The boundaries between the two feldspars are rather sharp and distinct, and we can distinctly observe the difference in refraction between them by means of Beche's line.

25. Siberia.

In the Museum of Copenhagen we have from earlier times a specimen of a gabbro from Siberia without other locality. The labradorite is of the common, dark grey color and is remarkable by the fact, that it possesses, sometimes, a perfect series of colors of reflection in such a manner that the inner, basic, part of the individuum is colorless, and around that we find a perfect ring of the different colors arranged in such a manner that from the inner to the outer side we pass from violet over red, yellow and green to blue, while the outer, acid, part of the individuums is colorless. In most individuums, however, the inner colorless part is wanting, and the colors in most cases form a rather irregular figure. $\varphi = \div 115°$, $\varrho = 13° 11'$.

The angle of extinction I have determined to be ÷ 18° for the labradorizing, blue substance and for the red substance to ÷ 20°, while for the colorless, acid substance I have found ÷ 15 to ÷ 17° and for the colorless, basic one ÷ 22° to ÷ 24°.

26. Labrador.

A cleavage specimen of the common dark grey color. The color of labradorization is mostly brownish (an impure variety of the common red) or green. $\varphi = 110^\circ$ (117—123°), $\varrho = 12^\circ\, 25'$ (11° 15′—13° 58°); the angle of extinction = c. ÷ 20°.

27. Labrador.

A cleavage specimen of grey color showing, in some parts, a fine labradorization with the blue and green colors arranged as in no. 23 as regular rings around a yellowish or reddish interior. $\varphi = \div 109\,{}^1/_2{}^\circ$ (109—110°), $\varrho = 13^\circ\, 11'$ (12° 55′—13°28′). The angle of extinction = ÷ 18°; because of the irregular structure of the substance there is no marked difference between the different parts of the feldspar.

28. Egersund.

From the Museum in Bergen I obtained from that locality a specimen of a labradorite rock with phenocrysts of a grey labradorite showing mostly a deep blue color of labradorization. $\varphi = \div 114^\circ\, 10'$ (113° 30′—115° 30′) $\varrho = 14^\circ\, 32'$ (14° 16′—15° 4′). The angle of extinction, which cannot be determined exactly because of the irregular structure, was found to be c. 16—20°.

29. Kasigianguit.

From this Greenlandish locality the Museum in Copenhagen possesses a small specimen of a dark grey color.

The series of colors of labradorization is here quite abnormal, the colorless parts being bordered by a rim of deep blue whereupon follows an impure reddish and a yellow band while the main part of the labradorizing substance gives an intensive green color which is very marked in comparison with the common green lying between the blue and the yellow. $\varphi = \div 112^\circ 30'$ (111—114°), $\varrho = 14^\circ 40'$ (14° 32′—14° 48′). The angle of extinction is found to be ÷ 18°, for the green, labradorizing substance for the blue c. ÷ 16° and for the colorless substance ÷ 14°.

30. Labrador.

A light grey feldspar, only partly labradorizing with a weak blue color. $\varphi = \div 112\,{}^1/_2{}^\circ$, $\varrho = 14^\circ 48'$; angle of extinction = 17°.

31. Labrador.

A grey feldspar with a strong labradorization showing the usual series from the colorless through blue and green to yellow. $\varphi = \div 110^\circ 40'$ (108—113°), $\varrho = 14^\circ 37'$ (14° 14′—14° 48′). The angle of extinction for the labradorizing substance is ÷ 18 ¹/₂°, for the colorless one it varies from ÷ 16 to ÷ 3.

32. Labrador.

This feldspar has a dark grey color with a strong blue or green luster without non-labradorizing parts. $\varphi = \div 110^\circ 30'$ (109° 30′—111° 30′), $\varrho = 14^\circ 40'$ (14° 16′—15° 4′). Angle of extinction = ca. ÷ 18°.

33. Sjösa.

From this locality I obtained from the Museum in Stockholm a small specimen of the material examined by Flink[1]. It is of the common dark grey color and shows a strong,

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[1] l. c. p. 69.

deep blue labradorization over the whole substance. $\varphi = \div 110°$, $\varrho = 16° 38'$; the angle of extinction was given by Flink as ÷ 18° and I have found the same value (17—19°). The specific gravity was determined by Flink to be 2.776.

34. Labrador.

A grey feldspar partly labradorizing with the common series of colors, from blue to green. $\varphi = \div 106° 30'$ (105—108°), $\varrho = 17° 40'$; the angle of extinction for the labradorizing substance is ÷ 16° 30′ (16—17°), for the colorless one (12—15°).

35. Ojamo.

This, the most resplendent among all labradorizing feldspars, has been described by various previous authors. Senff[1] describes the polygonally arranged colors, of which he gives a list containing 57 numbers which shows that the same series must recur many times and the feldspar, consequently, must consist of many strata of a somewhat differing composition. The measurements of the position of the labradorization have not, in my opinion, much value. Nordenskiöld[2] gives drawings of two plates, of which the one (fig. 1) shows a section of a crystal regularly built up of an inner, more basic part and an outer, more acid, with the labradorizing parts arranged in zones between these parts. Fig. 2 shows a crystal, where both the inner and outer parts seem to be acid, the basic substance being found in the middle parts of the ring system (the white zone f). Nordenskiöld has observed the very important property that this feldspar is labradorizing in two different directions, as will be described later on. The posi-

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[1] Pogg. Ann. 17, 1829, p. 352.

[2] Pogg. Ann. 19, 1830, p. 179.

tion of the labradorizing lamellae, found by this author, cannot, according to my measurements, be correct. For the angle which is here called φ he finds a value of $\div 96°$ which is c. 12° smaller than the value found by me, and the angle ϱ is by Nordenskiöld determined to be 32° 46′, which value is also too large. Here it must be remarked, however, that Nordenskiöld is of opinion that the reflection is produced by some lamellae in the surface of the substance, and if by means of that value we calculate the position of the lamellae in the interior of the substance, we shall obtain the true position.

As material for my examination I had a large specimen from the Museum in Copenhagen which showed the labradorization rather indistinctly with irregularly arranged colors. Afterwards I obtained from the Museum in Helsingfors a cleavage piece where the colors showed more regular figures, and in which it was possible to examine the phenomenon in more details. What is essential is not the arrangement of the colors in more or less regular figures, but the series of colors, which is here more complicated than in any other feldspar. In sections nearly parallel to (010) we see as the first color, bordering the acid colorless substance, a green (sometimes a yellow), whereas the common blue colors are wanting. On closer observation we shall see that the blue ring really exists, but the lamellae producing it are turned round in such a manner that the blue (in some instances also the green) reflection is seen in a direction normal to both cleavage faces, as will be described later on under group c. On (010) we pass from the initial green color as usual to a yellow and thereupon to a red and violet color, but while the series of colors stops here in the feldspar from Siberia which is the only one of the other labradorites which possesses a colorless basic part, the violet color in the feldspar from Ojamo is continued by a new series rather similar to the colors of the 3rd order of the Newton's rings, comprising a pure blue, a yellow, a green and a reddish one, before we reach the basic, colorless part. The position of the labradorizing lamellae is a little variable with the color, but as mean value I have found $\varphi = \div 107° 17'$ (103—111½°) and $\varrho =$ 19° 18′ (17° 40′—20° 43).

The angle of extinction on (010) was determined by Descloizeaux[1] to be ÷18° 30′—20° 10′, and by Schuster[1] to be ÷15°—÷17°. In spite of the long series of colors there is by far not so marked a difference between the angle of extinction in the different parts of the feldspar as is commonly the case. For the labradorizing part I have found ÷16½ on the acid side and ÷18° on the basic side, while for the colorless, acid substance I have found ÷13° to ÷15° and for the colorless, basic one ÷18°, there being no visible difference between that and the adjoining part of the labradorizing substance.

36. Mountmoniahme.

In the Museum of Copenhagen we have a specimen of a gabbroid rock for which the old label gives the said locality as situated in New York. I have not been able to find that place in the maps or in the literature, and the great similarity which exists between that feldspar and the following makes it probable that they may be identical. The labradorite, which forms large phenocrysts, is of a greyish black color and possesses a rather weak, blue labradorization in two different directions, which makes this

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[1] Cited after the Handbook of Hintze, p. 1438 and 1439.

feldspar belong both to the group in question and to group b. In contrast to what was the case in the feldspar from Ojamo it is quite certain here that the same part of the substance labradorizes in both directions. If we observe a plate of the mineral, we see the two reflections forming quite irregular figures which are similar for both but not identical. There can be certain spots of the feldspar where one or the other of the two reflections are specially intensive, with a light greenish blue color, but for no of them is there any distinct series of colors. The measurements give very large variations because of the irregular structure of the feldspar substance and because of the weak and indistinct reflections which we obtain from the labradorizing lamellae. For the labradorization in question I have found: $\varphi = \div 105^\circ 52'$ (99—117°) and $\varrho = 21^\circ 6'$ (18° 40′—54° 44′). For the angle of extinction I have found the value of ÷ 18°, and there is no visible difference in that respect between the labradorizing and the non-labradorizing parts of the substance.

37. Sanarac Lake.

From the Museum in Washington I obtained a specimen from that locality situated in New York. As mentioned before, there is in all respects an almost perfect similarity between this feldspar and the former, and we have here the same labradorization in two directions. $\varphi = \div 103^\circ$, $\varrho = 21^\circ 20'$; the angle of extinction = ÷ 18° (17—18 ½°).

The labradorites of group a are in most instances of a rather uniform outer appearance. The color is mostly dark grey or almost black, and only some few occurrences (Ojamo and some of the specimens from Labrador) have an essentially lighter grey color. Most of the feldspars are only imperfectly transparent and include impurities of many different kinds, mostly in the form of crystals or leaves of foreign minerals, as was especially described by Schrauff, which often produce an avanturization in different directions besides the labradorization. In other instances there seem to be included lamellae of other feldspars in the substance, which is especially distinct in the case of the feldspar from Russia which consists, in some parts, of a perfect perthite-like intergrowth of two different labradorites.

The colors of labradorization are, in that group, more variable than in any of the other groups of feldspar, and it is only in that group that we have a distinct connection between the the color of labradorization and the composition of the feldspar. In some instances we have, it is true, only a single color, mostly the blue, which shows nothing of special interest, but mostly we see a quite distinct series of colors, the arrangement of which is very variable. Sometimes they are arranged in very regular, crystallographical figures, and sometimes these are quite irregularly curved, but in all instances every color forms a perfect, closed ring, in such a manner that we can only pass from one color to another in a distinct order. The common system of colors is almost identical with the colors forming the second order of Newton's rings, viz:

colorless, acid substance
deep blue
light blue
green
yellow
reddish
violet
colorless, basic substance

The basic end of the series is, however, only found in the feldspar from Siberia, while the others mostly begin with the acid end and stop somewhere in the series.

An exception from the common rule is formed by the feldspar from Kasigianguit which has rings of reddish and yellow color intercalated between the blue and the green. The feldspar from Ojamo is, however, much more divergent from the others, as described above, the perfect series from that locality being the following:

colorless, acid substance
deep blue
light blue
the reflecting lamellae for these colors are turned round from the usual orientation to that of group c.
green
yellow
reddish
violet
blue
green
yellow
reddish
basic, colorless substance.

The position of the labradorizing lamellae cannot, in most cases, be determined very exactly as the cleavage faces are not very perfectly even and the reflection of the labradorization always forms a rather large, indistinctly bounded spot. It is very obvious, however, that there exist very characteristic differences between the positions of the different feldspars, and that in the projection (fig. 2) they form a rather regular line or zone of large extension, the difference between the two outermost feldspars (Kijew and Sanarac Lake) being c. 13° 45′. In most instances the place of the labradorization is not exactly the same for the different colors, the outermost blue especially diverging from the others as was mentioned for the feldspar no. 23 from Labrador where the difference is most marked. In the other feldspars it is, however, so small that it can be neglected, and in the following list we only give the place of the labradorization for the main colors, together with the angle of extinction on (010) for the labradorizing parts of the substance.

	φ (÷)	ϱ	ext. (÷)
19. Kijew	132° 50′	9° 23′	19—21°
20. Vågefjärden	130°	9° 35′	20°
21. Ingermanland	129°	9° 15′	18°
22. Labrador	122° 30′	10° 8′	20—21°
23. Labrador	116°	12° 50′	18—20°
24. Russia	117° 15′	13° 18′	16°
25. Siberia	115°	13° 11′	18—20°
26. Labrador	110°	12° 25′	20°
27. Labrador	109° 30′	13° 11′	18°
28. Egersund	114° 10′	14° 32′	16—20°
29. Kasigianguit	112° 30′	14° 40′	16—18°
30. Labrador	112° 30′	14° 48′	17°
31. Labrador	110° 40′	14° 37′	18$^{1}/_{2}$°
32. Labrador	110° 30′	14° 40′	18°
33. Sjösa	110°	16° 38′	18°
34. Labrador	106° 30′	17° 40′	16$^{1}/_{2}$°
35. Ojamo	107° 17′	19° 18′	16$^{1}/_{2}$—18°
36. Mountmoniahme	105° 52′	21° 6′	18°
37. Sanarac Lake	103°	21° 20′	18°

The positions of the list are given in fig. 2 in such a manner that those which lie rather near are drawn together to one cross which represents the mean position of them.

We see that the locality of Labrador, which is the only one of all from which I have had many specimens at my disposal, is rather variable, the total difference between the two outermost specimens (nos. 22 and 34) being c. 9°. It is probable, of course, that a richer material from the other localities would give somewhat more variation in the results, but we should probably, however, not get very far from the line shown in the figure. As is commonly the case it is quite impossible here to express the positions of the labradorizing lamellae by any simple symbols. The line begins near the important zone $(010):(\bar{1}01)$ in the vicinity of the face $(\bar{1}.12.1)$, afterwards it passes the other important zone $(010):(\bar{2}01)$ in the vicinity of the face $(\bar{2}91)$ and ends near a face $(\bar{9}.33.4)$ which lies in the same zone as the two other faces. For the three faces mentioned the following positions are calculated given in the projection used here:

	Albite		Anorthite	
	φ (÷)	ϱ	φ (÷)	ϱ
$(\bar{1}.12.1)$	127° 41′	9° 16′	128° 33′	9° 27′
$(\bar{2}91)$	107° 44′	19° 4′	108° 49′	19° 33′
$(\bar{9}.33.4)$	103° 43′	22° 47′	104° 48′	23° 24′

The angles of extinction given in the above list show that the whole range of feldspars which belong to group a have compositions which fall within rather limited boundaries. The angle of extinction varies from ÷ 16° to ÷ 23°, to which would correspond a composition varying from 50 to $39^{1}/_{2}$ molecular percent or from $48^{1}/_{2}$ to 38 weight percent of albite ($51^{1}/_{2}$ to 62 anorthite). A comparison between these values and those obtained from the existing analyses will be given later on in connection with the feldspars of the two other gronps. There is no indication of any relation between the orientation of the labradorizing lamellae and the composition of the feldspar, as will be seen from the list above, where the values of the angle of extinction are quite irregularly distributed.

For those feldspars which have their labradorizing parts bounded by a colorless acid or basic part, the angles of extinction on (010) are given in the following list.

	colorless,	labradorizing part:			colorless,
	acid part	blue	green	violet etc.	basic part
19. Kijew......	÷ 10—18	÷ 19	÷ 21	—	—
22. Labrador ..	0—18	20	21	—	—
23. Labrador ..	13—17	18	—	÷ 20	—
25. Siberia	15—17	18	—	20	÷ 22—24
29. Kasigianguit	14	16	18	—	—
31. Labrador ..	3—16	$18^{1}/_{2}$	—	—	—
34. Labrador ..	5—12	$16^{1}/_{2}$	—	—	—
35. Ojamo.....	13—15	—	$16^{1}/_{2}$	18	18

The other feldspars of that group have mostly only one color of labradorization over the whole substance, and if they have colorless parts besides, they are not so perfectly developed that it is possible to ascertain any difference in extinction between the different parts. It seems to be probable, however, that the typical rule for those feldspars is that they possess a certain range of composition for every color, and that they will show no labradorization if they get more acid or basic. We most directly obtain the impression, that the feldspars, the composition of which is too acid or basic, are not able to labradorize at all. It seems, however, that the boundaries for the compositions which give the possibility for labradorization are not exactly the same in all instances, and there must, consequently, exist other factors than the composition which may play a role in producing these boundaries.

Group b.

To this rather small group belong the following feldspars:

36. Mountmoniahme.

This feldspar was described more closely under group 1 (p.). The labradorization in question is blue in different shades; $\varphi = 2^\circ 40'$ (2—3°), $\varrho = 28^\circ 11'$ ($26^\circ 40'$—$29^\circ 30'$). The angle of extinction is ÷ 18°.

37. Sanarac Lake.

This feldspar, which is perhaps identical with the former, was described p. . $\varphi = 1^\circ 40'$ ($1^\circ 30'$—2°), $\varrho = 28^\circ 50'$ ($28^\circ 40'$—29°). The angle of extinction is ÷ 18°.

38. Stansvik.

The labradorite from Stansvik near Helsingfors was described and analysed by Lemberg. From the Museum in Helsingfors I obtained a large specimen of that very interesting feldspar. It is of a reddish grey color and shows labradorization in two directions of which especially that normal to both cleavage faces, which will be treated later on, under group c, is very fine and possessed of almost all colors. The labradorization in the direction here in question is mostly rather weak, and is in a very regular manner connected with the other labradorization, so that only those parts of the substance which are possessed of that, also show the weaker reflection, but in many instances this is, certainly, so weak that it can hardly be observed. Where both reflections are seen, it is an absolute rule that they possess complementary colors, mostly in such a manner that those parts which give the strong yellow reflection give a rather weak blue in the other direction, but other combinations are also sees in some instances. For the labradorization in question I have found the following position: $\varphi =$ 1° 8′ (0° 30′—1° 40′), $\varrho =$ 29° 35′ (28° 45′—30° 6′). The angle of extinction which does not vary with the color of labradorization, is found to be c. ÷ 16° but the determination is rather inexact as the structure of that feldspar is very irregular.

39. Keeseville.

From that locality, situated in New York, I obtained from the Museum in Washington a specimen of a labradorite rock, the larger individuals of which showed a rather weak, blue labradorization. It is not possible to get larger cleavage pieces, and the whole structure is very irregular, with curved cleavage faces, so that we cannot expect to obtain very good measurements. The feldspar is grey, the labradorization, as said, blue, and is found only in some parts. For φ I have found the value of 3°, for ϱ 26°. The angle of extinction is found to be ca. ÷ 19° (16—20°), and there is no visible difference between the labradorizing and the colorless parts.

40. Ekalugsuit.

From this locality, situated in the district of Egedesminde in Greenland, the Museum in Copenhagen possesses a small specimen of a labradorite which is mostly clear and transparent but sometimes also rather impure and differently colored. Besides the two common cleavage faces it possesses a very marked parting after a face which can easily be confounded with (010) as it forms almost the same angle with the base. On the goniometer we see, however, that the face in question mostly gives very bad reflections, and if parts of it sometimes give single reflections we shall find that the positions of those are exceedingly variable. For the angle to basis I have found all values between 80 and 90°, and for that to (010) I have found values from 60 to 75°. To find the crystallographical symbol for such a face must beforehand be considered hopeless; the face $(\bar{7}42)$ is the one which falls most closely in the region given by the above numbers, its angles to basis being 83° 51′ and to (010) 68° 32′ (for the albite).

The labradorization of this feldspar is one of the most brilliant and intensive of all known feldspars, and we have here the same series of colors, as was commonly found in the former group, viz. a dark blue, bounded by a colorless part, and thereupon a light blue and a green. For φ I have found the value 4° 15′ (4°—4° 30′) and for ϱ 27° 15′ 27° 10′—27° 20′). The angle of extinction of the labradorizing part I have determined to be ÷ 19° (18—20°); the colorless part is distinctly more acid, the angle of extinction going down, in some places, to values from ÷ 5 to ÷ 10°.

41. Søndeled.

From this Norwegian locality I obtained from the Museum in Kristiania a large cleavage specimen of a labradorite of a greyish white color. As regards labradorization this feldspar forms an analogy to that from Stansvik, as both of them labradorize in the direction here in question and in the direction of group c, and in both instances the color in one direction is complementary to that in the other. But while the feldspar from Stansvik showed a strong labradorization in the direction of group c and a rather weak in that of the group here treated, the opposite is the case with the feldspar from Søndeled. Here the labradorization seen on (010) is very intensive, and the other is mostly very weak and is in many instances hardly observable. The color of the labradorization in question is in most instances greenish, yellowish or reddish, the blue color being essentially weaker than the others and forming only a narrow border between the green and the colorless. Besides these colorless parts there are, however, others which border directly on the green, yellow or red parts. $\varphi = 7° 5'$ ($7°$—$7° 15'$), $\varrho = 32° 52'$ ($32° 7'$—$33° 40'$). The angle of extinction of the labradorizing parts I have found to be ÷ 17° (16—$17^1/_2°$); the colorless parts bordering on the blue parts have an extinction of ÷ 13—16°, the other colorless parts have their extinction exactly together with the labradorizing ones.

The labradorites of group b are in most respects very variable. The color may be dark grey or lighter grey to almost white, or in one instance reddish grey and the degree of transparency may also be very different. The color of the labradorization is mostly blue, but in other instances it may be very variable; the series of colors is almost the same as that which was typical for the former group, but it is not so pronounced. The orientation of the labradorizing lamellae is given in the following list together with the angle of extinction on (010):

	φ	ϱ	ext. (÷)
36. Mountmoniahme	2° 40′	28° 11′	18°
37. Sanarac Lake.............	2° 40′	28° 50′	18°
38. Stansvik	1° 8′	29° 35′	16°
39. Keeseville	3°	26°	18°
40. Ekalugsuit	4° 15′	27° 15′	19°
41. Søndeled	7° 5′	32° 52′	17°

The picture given by these positions and drawn in fig. 2 is rather similar to those obtained by the former groups; we see the crosses scattered over a small area, the five first lying nearer together and the sixth more apart. It is, as otherwise, quite impossible to give these positions any simple symbols; the first of them are not very far from the face $(04\bar{1})$, while the last cannot be expressed otherwise than by the complicated symbol $(1.22.\bar{7})$. For the two said faces are calculated the following positions:

	Albite		Anorthite	
	φ	ϱ	φ	ϱ
$(04\bar{1})$	0°	27° 15′	0°	27° 37′
$(1.22.\bar{7})$	6° 48′	32° 8′	6° 43′	32° 32′

The list of the angles of extinction show that the feldspars of the group b have almost the same composition as those of the main group, as they fall perfectly within the boundaries obtained for that group. There is no visible difference between the angles of extinction of the differently colored parts, the only rule being that the colorless part sometimes bordering on the extreme blue ring is distinctly of a more acid composition than the labradorizing part.

It is characteristic that only two of the labradorites of that group (Keeseville and Ekalugsuit) possess labradorization in only one direction; of the rest two (Mountmoniahme and Sanarac Lake) also possess the labradorization of group a, while two (Stansvik and Søndeled) labradorize in the direction of group c.

Group c.

While all the plagioclases hitherto considered possess a labradorization which is visible through the face (010), and the position of which can, consequently, be drawn on the projection fig. 2, I have found four labradorites which give a reflection in a direction very near normal to both cleavage faces and which can not, therefore, be seen through any of them. They form the third group of the labradorites the numbers of which are, however, partially identical with some of the two former groups.

The measurement of the labradorization of these feldspars must of course be made by means of a ground face orientated nearly normal to both cleavages. The piece is placed on the goniometer in such a manner that the cleavage faces fall in the equatorial zone, and for the first meridian is chosen a face of (010). The more exact orientation is given on fig. 3 which also gives the signification of the values for φ and ϱ used in the following. The scale of the projection is the same as that of fig. 2.

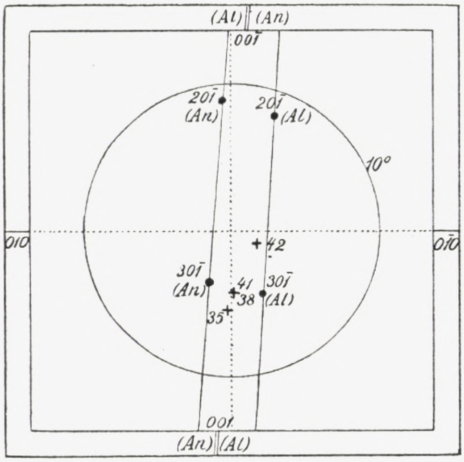

Fig. 3. Position of the labradorizing lamellae in the labradorites of group c. For further explanation see the text.

35. Ojamo.

As said above (p. 53) the feldspar from Ojamo shows the peculiar phenomenon that the blue ring which commonly, in the feldspars of group a, borders the acid colorless part, is not seen in the common direction, but the lamellae producing that color, and sometimes also those producing the green one, are turned round in such a manner that this feldspar also becomes a member of the group here treated. The labradorization in question is mostly rather weak and for the orientation I have found the following values: $\varphi = 95°$ (84—100°), $\varrho = 5° 3'$ (4° 30′—5° 55′). The angle of extinction of the labradorizing part of that feldspar is, as stated above, $\div 16^1/_2°$ to $\div 18°$; for the narrow band which labradorizes in the direction here in question and which is situated on the acid side of the system, the angle of extinction will probably be c. 16°.

38. Stansvik.

Characteristic of the feldspar which was described above (p. 61) is the peculiar phenomenon that it possesses labradorizations in two directions, and that the colors of both of them are complementary to each other. We find, in both directions, a rather complete series of colors, but while these were very weak for the labradorization after group b, that in question in most instances shows intensive and brillant colors. In some instances there is an arrangement of these colors in the common order (blue, green, yellow, red), but just as often the order of colors is quite irregular, and we can find instances where two colors, which commonly lie far from each other, border immediately on each other. And the irregularity is still greater if we consider the colorless parts which here in many places interrupt the colored parts and border soon on one and soon on another of the colors. For the orientation of the labradorization I have found the values: $\varphi = 84°$ (74—93°), $\varrho = 4° 14'$ (2° 56′—5° 31′). The angle of extinction is, as stated above, $\div 16°$, and there is no visible difference in this respect between the differently colored and the colorless parts.

41. Søndeled.

The feldspar from Søndeled, as described on p. 63, in most respects forms an analogy to the former, being in possession of the same two labradorizations with complementary colors. But here the labradorization in the direction of group b is very intensive and possesses all colors, while the labradorization in question is mostly very weak and only shows violet, blue or greenish blue colors. It is, of course, rather difficult to find specimens suited for measurements. I have found: $\varphi = 88^\circ$ (87—90°), $\varrho = 4^\circ 14'$ (3° 26'—4° 49'). The angle of extinction of the labradorizing part is, as formerly stated, ÷ 17°.

42. Skottvång.

This feldspar, which is perhaps the most brillant of all labradorizing feldspars, was described by Flink[1]. There exists only very little of it, but otherwise it would form an excellent gem. It is almost pure and transparent, colorless if seen through the cleavage faces and yellow if seen in the normal direction; the cleavages are very good. The labradorization is pure blue, in some parts rather weak but in others most intensive. $\varphi = 30^\circ$ (10—60°), $\varrho = 1^\circ 55'$ (1° 35'—2° 15'); the value of φ must, of course, be very inexact here because of the small value of ϱ.

Flink determined this feldspar to be an andesine of composition $Al_4\,An_3$ (= 57 Al), and his determination is based upon the following data: the specific gravity is found to be 2.698, the angle of extinction on (001) is ÷ $4^1/_4$° and that on (010) is ÷ $11^3/_4$°. I can confirm the measurements of Flink concerning the specific gravity and the extinction on

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[1] Arkiv f. Kemi, Min. och Geol. Upsala and Stockholm. Vol. 5, Nr. 10, p. 75.

(001), but none of these properties is very good for an exact determination of the feldspar, and I have therefore used the very scanty material for making three sections after (010), and in these I have found the following angles of extinction ÷ 15° 5′, 15° 30′ and 16°, as mean value nearly ÷ 15° 30′.

The four feldspars of group c have very little in common with the exception alone of the direction of the reflecting lamellae. The outer appearance of the feldspars is exceedingly variable and the color and intensity of the labradorization vary equally. In the following table are given the positions of the reflecting lamellae together with the angle of extinction on (010).

	φ	ϱ	ext. (÷)
35. Ojamo	95°	5° 3′	16°
38. Stansvik	84°	4° 14′	17°
41. Søndeled	88°	4° 14′	17°
42. Skottvång	30°	1° 55′	$15^1/_2$°

As regards the position of the lamellae we see the same phenomenon as in the other groups that they are distributed over a small area which is shown on the projection, fig. 3. The three first feldspars have positions which lie very near to each the other and to the face $(30\bar{1})$ for which the following positions are calculated (in the projection used here):

Albite		Anorthite	
φ	ϱ	φ	ϱ
64° 39′	4° 47′	113° 39′	3° 35′

For the labradorite itself the exact position cannot be calculated, as we have no good elements. The point lying halfway between the two given above will have the following position:

$$\varphi = 85° 29' \qquad \varrho = 3° 50'$$

and we see, consequently, that the feldspars from Stansvik and Søndeled have very nearly that position. The feldspar from Ojamo differs a little more, but the measurements for that feldspar are not very good, and if we had only these three examples of that group, we should conclude that the labradorization took place after the face $(\bar{3}01)$ which is the most simple of all found for any labradorization, although it is not known as outer face in any plagioclase. But the feldspar from Skottvång has a position which differs rather markedly from that face, and for ascertaining that I have measured 7 different specimens of that excellent feldspar, and I have obtained rather concordant values, as stated above. We must conclude, of course, that the lamellae of that feldspar cannot be orientated after $(\bar{3}01)$ but must be ascribed to some other face with very complicated indices, and the group of labradorites here treated must, consequently, follow the common rule that the labradorization is orientated after directions which cannot be expressed by any simple symbol.

The angles of extinction of the feldspars of group c are not very variable and show that they mostly fall inside the same boundaries for composition as were obtained for the other groups. The only one of these feldspars which belongs to that group alone, that from Skottvång, is perhaps a little more acid than any other and will, consequently, cause the acid boundary for the labradorizing labradorites to pass a little more to the albite side than that formerly obtained, and this class of feldspars would, consequently, have a composition lying between 49 and 38 weight percent of albite or between 51 and 62 percent of anorthite.

All the chemical analyses of the labradorizing labradorites which I have been able to find, are collected in the following list[1].

	K_2O	Na_2O	CaO	*Or.*	*Al.*	*An.*
1. Labrador	1.04	4.89	12.11	5.7	38.4	55.9
2. —	0.32	4.83	11.40	1.9	41.1	57.0
3. —	0.48	4.87	11.26	2.8	41.3	55.9
4. —	0.43	4·76	11.20	2.5	40.9	56.6
5. —	0	13.7	11.14	0	17.3	82.7
6. —	0.63	48.1	11.16	3.7	40.8	55.5
7. —	0.53	51.3	10.60	3.1	43.8	53.1
8. —	0.36	51.7	10.33	2.1	45.0	52.9
9. —	0.40	50.0	10.10	2.3	44.9	52.8
10. —	1.25	75.3	9.58	6.2	53.7	40.1
11. —	0.65	61.3	8.55	3.9	52.6	43.5
12. Kijew	0.71	44.1	11.37	4.1	38.1	57.6
13. —	0.42	46.2	11.23	2.5	40.2	57.3
14. Ojamo	0	55.0	9.87	0	48.7	51.3
15. —	0	62.5	8.48	0	55.7	44.3
16. Helsingfors	0.92	54.3	9.14	5.6	47.5	46.9
17. Egersund	0.60	3.90	11.70	3.8	35.4	62.0
18. Drummond	0.23	2.44	11.42	1.8	26.2	72.0
19. Mt. Marcy	0.92	4.37	10.80	5.6	38.5	55.9

On considering the table we shall see that most of the analyses given are in good accordance with the results obtained by the extinction. 12 of the 19 analyses fall within the boundaries for the composition given above, while the others are more or less divergent from it either to the acid or to the basic side. Of these the two, nos. 16 and 17, stand rather near to the composition given above, and by addition of the orthoclase to one or the other of the

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[1] Cited after the handbooks of Hintze and Doelter.

main components the accordance will be still closer. The five remaining feldspars, nos. 5, 10, 11, 15 and 18, are so divergent from the others that no addition of the orthoclase will bring any closer accordance. On considering the analyses of them it will be obvious, that most of them, which are rather old, cannot be correct, as they give a composition impossible for any feldspar, the total equivalents of the oxides of *Na*, *K* and *Ca* being often very different from that for Al_2O_3. This is especially the case with the analyses nos. 5, 10 and 18, which may, therefore, be neglected in the following.

As regards the locality of Labrador the table of the extinctions given on p. 58 showed all values between $\div 16^1/_2°$ and $\div 21°$ whereto correspond compositions of from c. $47^1/_2$ to 38 percent of albite ($52^1/_2$ to 62 anorthite). We see that 8 of the analyses are in perfect accordance with that result, and that only one of the more reliable analyses, no. 11, shows an essentially more acid composition. It is, however, not stated by Lemberg[1], who has made that analysis, that the feldspar in question is in possession of labradorization, and in that case there is no contradiction, as many of the specimens from Labrador consist, for a large part, of the acid, colorless substance.

The feldspar from Kijew belongs to the most basic of all the labradorizing feldspars, the composition obtained from the extinction being from c. 43 to 38 percent of albite (57 to 62 anorthite). The analyses give rather exactly the same composition, and the accordance would be still closer if we calculated the composition as a percentage of the two main components alone without considering the orthoclase, or if

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[1] Zts. d. geol. Ges. 40, 1888, p. 645.

which is almost the same, we add half of the orthoclase to the albite and half to the anorthite.

For the feldspar from Ojamo the angle of extinction suggests a composition of the labradorizing part lying between c. 49 and 45 1/2 percent of albite (51—54 1/2 anorthite). There exist two old analyses by BONNSDORFF and LAURELL[1], and of these one shows this composition, while the other is essentially more acid. The analyses, however, do not seem to be very reliable with their want of potassium and their excess of silica, as was pointed out by DESCLOIZEAUX[2]. If there exists any real difference between the two feldspars analysed, we must assume that the abnormal one (no. 15) belongs to the colorless, acid part of the crystal.

The feldspar from Helsingfors, which is, in all probability identical with that which was described above as originating from Stansvik, should according the extinction have a composition of c. 48 1/2 albite (51 1/2 anorthite); the analysis shows a little more acid composition which depends, however, to a rather large degree upon the placement of the potash component.

For the feldspar from Egersund we obtain from the angle of extinction, which cannot be determined very exactly, a composition of from c. 48 1/2 to 40 1/2 albite (51 1/2—59 1/2 anorthite). The analysis gives the result that the feldspar is essentially more basic, but it is very doubtful if we can rely upon this very old analysis[3] in which the amounts of SiO_2 and Al_2O_3 are too large in proportion to the oxides of K, Na and Ca to give the feldspar composition.

Of the two last feldspars in the list on p. 71, of which I

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[1] Vet. Akad. Handl. Stockholm. 1853.

[2] N. Jahrb. Min. 1876, p. 711.

[3] By KERSTEN: Pogg. Ann. 63, 1844, p. 123.

have had no specimens for examination, that from Drummond has, as stated above, a composition quite impossible for any feldspar; the other, that from Mt. Marcy, has the normal composition of a rather basic, labradorizing feldspar.

The general result, which we obtain from the analyses cited, is, that they do not absolutely contradict the result obtained from the angle of extinction, that all the labradorizing feldspars for that class have a composition lying between c. 49 and 38 albite. These boundaries are, of course, not absolute, and may be moved a little in one direction or other but there seems necessarily to exist such boundaries, outside of which we have no labradorization.

The examination of the labradorization in plagioclases has given the result that this phenomenon is found only in two groups of them, having the composition of from c. 92$^1/_2$ to 85$^1/_2$ and from c. 49 to 38 weight percent of albite (7$^1/_2$—14$^1/_2$ and 51—62 anorthite). It is not, of course, possible to prove that other plagioclases are not able to labradorize, but there seems to be very small probability of that being the case. It is not possible for me to imagine what may be the cause of that peculiar restriction of the phenomenon to two rather small classes of the whole series, as the members of it are in all other respects essentially alike, the different physical properties varying gradually with the composition.

As regards the labradorization itself it is a much more uniform phenomenon in the plagioclases than in the orthoclase; the reflecting lamellae are in no instance directly visible under the microscrope, and there is, of course, no transition to essentially coarser lamellae. Only in one instance (11. Bathurst) do we find lamellae of some foreign substance, possibly air, in the same direction as the labradorizing lamellae, but there is no transition between both and we get no explanation hereby of the labradorization itself with which the said lamellae seem to have nothing directly to do. The only means by which we can get to know something about the nature of the reflecting lamellae is an examination of the colors of labradorization.

In the foregoing we have described both all the different colors of labradorization found for the single occurrences and groups of the plagioclases and the more or less regular order in which they are arranged. Although the most common, blue colors of the plagioclases and the orthoclases have a certain resemblance to each other there is, however, one difference between both feldspars in that the colors of the plagioclase are more pure in so far as they never show that mixture with white which is so common in the orthoclase. And if we examine the colors by flat incidence of the light we will see that they are of an essentially different nature. The colors of the orthoclase will not undergo any visible alteration thereby, and we may conclude from this that they are not interference colors but of a more complicated nature. The colors of the plagioclases, on the contrary, by flat incidence in the common manner are altered to colors of an inferior order and they must, of course, be regarded as interference colors. They however, always, show, the peculiar phenomenon that the series of colors stop at the same deep blue which may, perhaps, be identical with the blue of the 2nd order, whereas we never see any trace of the colors of the first order.

If we observe the labradorization through a ground and polished face, we shall see only a slight alteration of the color by using flat incidense, whereas we obtain the great alteration if we observe the colors through a thin section normal to the lamellae, or, what gives the best result, through a glass prism placed upon the face of the feldspar ground almost in the direction of the lamellae, and with a drop of oil between the prism and the feldspar. By these means we effect that the light passes through the feldspar in a direction very nearly parallel to the lamellae, and the circumstance that such a direction is necessary for obtaining an essential reduction of the colors of interference makes it most probable that the reflecting lamellae consist of a substance of nearly the same reflection as the feldspar itself. It is, at all events, certain that the lamellae cannot consist of air, but I do not think it possible to ascertain anything more about their consistency by observation and all conclusions which we may draw concerning the matter are, indeed, very uncertain.

The most improbable seems to be that the inclosed lamellae should consist of some foreign mineral. Such inclusions are very common and produce the phenomenon called avanturization, and we might, of course, very well imagine that the same inclusions could be of essentially smaller dimensions, but, as mentioned in the beginning, these inclusions are orientated quite differently from the lamellae producing the labradorization, as they have mostly, in every single feldspar, several different directions which are mostly parallel to rather simple symboled faces, and the existence of the avanturization is not at all confined to a small part of the whole series of the plagioclases. On the other side it is very difficult to imagine how any regular intergrowths of different feldspars would be able to produce the phenomenon in question, and especially what the feldspars could be. We are accustomed to consider the whole plagioclase series as perfectly isomorphous, and there are no other properties which give us any sign of the opposite. The circumstance that some of the labradorites possess a regular series of colors of labradorization with the higher interference colors towards the basic side of the labradorizing region would suggest, perhaps, that the reflecting lamellae consisted of the more basic feldspar and were wedge-shaped, getting gradually broader towards the basic side, but we would in that manner obtain equally wedge-shaped lamellae of the more acid feldspar getting broader towards the acid side, and these would very probably produce a series of colors in the opposite direction.

That the labradorization should be produced by an immixture of some other feldspar than the main components themselves is still more improbable. There is in most plagioclases a rather small amount of potash, and perhaps it would be found in all, if the analyses were quite correct, but the amount of that component is almost always so small that we must assume that it may be perfectly soluble in the main components. Furthermore we find no more potash in the labradorizing feldspars than in the others, and in such instances where we find the potash feldspar as visible intergrowths in the plagioclase as in the antiperthites, we find the lamellae mostly orientated in the same manner as in the perthites themselves, after the same steep orthodoma. And it seems to be still more improbable that the lamellation should be produced by some of the rarer forms of feldspar, as the baryum feldspar or the carniegiegite, as the analyses only in a few instances give any indication of the existence of them.

It must, of course, be considered perfectly enigmatic what can produce the labradorization in the plagioclases, and equally impossible to explain is the peculiar orientation of the lamellae which produce that phenomenon. As shown above there are four main directions, one for the peristerites and three for the labradorites, and everyone of these main directions consists of a group of rather close lying single directions which are, however, mostly so far distant from each other that they may be distinguished with certainty. In no instance is it possible to ascribe the position of the lamellae to any simple symbol although they are, in some instances, rather near to such a face. It is characteristic, that the lamellae are in most instances orientated in such a manner that the labradorization is visible through (010) but there are some few feldspars (group c) which labradorize in a direction almost normal to that face. It is not possible to find any cause for the orientation of the lamellae in these peculiar directions, and there is no other property, neither crystallographical nor optical, which can be connected with them.

While the peristerites all belong to the same system, labradorizing in the same main direction, we have in the labradorites three groups with three essentially different directions. Most of the labradorites only possess a labradorization after one of these directions, but there exist some feldspars which labradorize after two of them and all possible combinations of the three are found. Each of these combinations behaves in a very characteristic manner, differently from the others: in the feldspars belonging at the same time to groups a and c it is different parts of the substance which possess the two labradorizations in such a manner that that part of the feldspar which shows the usual blue color in the begining of the series has its lamellae turned in another direction than those giving the other colors, but in the two other combinations the same parts of the substance show both labradorizations. There is however, the essential difference between them that the feldspars possessing labradorization in the directions of groups a and b show the same, blue color in both directions, while those belonging at the same time to groups b and c show complementary colors in both directions.

Among all other minerals I have not succeeded in finding any instance of labradorization which was in all essential respects identical with that of the feldspars. Only in one mineral the phenomenon has a rather great similarity to that of the feldspars. This is the gedrite from Avisiarfik in Greenland[1]. This mineral possesses a luster of a fine blue, or sometimes yellowish or reddish color, and the substance is perfectly homogeneous as it is not possible to observe any reflecting intercalations under the microscope. The lamellae are orientated exactly to the face (010) and that is the essential difference from the labradorization of the feldspars, which are always orientated after a direction to which no simple symbol can be given. As the gedrite is rhombic we shall see, however, that there is no other possibility for the orientation of one system of lamellae than in the direction of one of the three pinacoids.

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[1] Described in "Mineralogia Groenlandica," Medd. Grønl. 32, 1905, p. 400.

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Fig. 1.

Fig. 2.

Fig. 3.

MATHEMATISK-FYSISKE MEDDELELSER

UDGIVNE AF

DET KGL. DANSKE VIDENSKABERNES SELSKAB

3. BIND (Kr. 13,75):

		Kr. Ø.
1.	Thorkelsson, Thorkell: Undersøgelse af nogle varme Kilder paa Nordisland. 1920	1.00
2.	Pál, Julius: Über ein elementares Variationsproblem. 1920	1.15
3.	Weber, Sophus: Et Metals Fordampningshastighed i en Luftart. 1920	0.50
4.	Weber, Sophus: Note om Kvægsølvets kritiske Konstanter. 1920	0.40
5.	Juel, C.: Note über die paaren Zweigen einer ebenen Elementarkurve vierter Ordnung. 1920	0.50
6.	Juel, C.: Die Elementarfläche dritter Ordnung mit vier konischen Doppelpunkten. 1920	0.50
7	Rørdam, H. N. K.: Benzoe- og Toluylsyrernes absolute Affinitet overfor een og samme Base. 1920	1.00
8.	Mollerup, Johannes: Une méthode de sommabilité par des moyennes éloignées. 1920	1.00
9.	Brønsted, J. N.: On the Applicability of the Gas Laws to strong Electrolytes, II. 1920	0.75
10.	Nielsen, Niels: Note sur une classe de séries trigonométriques. 1921	0.50
11.	Hansen, H. M. und Jacobsen, J. C.: Ueber die magnetische Zerlegung der Feinstrukturkomponenten der Linien des Heliumfunkenspektrums. Mit 1 Tafel. 1921	1.40
12.	Hevesy, G.: Über die Unterscheidung zwischen elektrolytischer und metallischer Stromleitung in festen und geschmolzenen Verbindungen. 1921	0.75
13.	Hevesy, G.: Über den Zusammenhang zwischen Siedepunkt und Leitfähigkeit elektrolytisch leitender Flüssigkeiten. 1921	0.60
14.	Fogh, I.: Über die Entdeckung des Aluminiums durch Oersted im Jahre 1825. 1921	0.60
15.	Fogh, I.: Zur Kenntnis des Aluminiumamalgams. Mit 1 Tafel. 1921	0.75
16.	Nielsen, Niels: Sur la généralisation du problème de Fermat. 1921	0.80
17.	Larsen, Valdemar: Bertrands Problem. 1921	1.25
18.	Weber, Sophus: En Luftstrøms Indflydelse paa et Legemes Fordampningshastighed. 1921	0.60
19.	Weber, Sophus: Psychrometrets Teori. 1921	0.50
20.	Faurholt, Carl: Über die Prozesse »$NH_2COONH_4 + H_2O \rightleftarrows (NH_4)_2CO_3$« und »$CO_2 + H_2O \rightleftarrows H_2CO_3$«. 1921	3.75

4. BIND (Kr. 13,20):

		Kr. Ø.
1.	Nielsen, Niels: Recherches sur l'Équation de Fermat. 1922	5.75
2.	Jacobsen, C. & Olsen, Johs.: On the Stopping Power of Lithium for α-Rays. 1922	0.60
3.	Nørlund, N. E.: Nogle Bemærkninger angaaende Interpolation med æquidistante Argumenter. 1922	1.10
4.	Brønsted, J. N.: The Principle of the Specific Interaction of Ions. 1921	1.15
5.	Pedersen, P. O.: En Metode til Bestemmelse af den effektive Modstand i højfrekvente Svingningskredse. 1922	0.70
6.	Prytz, K.: Millimètre étallonné par des interférences. 1922	0.75
7.	Pedersen, P. O.: On the Lichtenberg Figures. Part II. 1. The distribution of the velocity in positive and negative figures. 2. The use of Lichtenberg figures for the measurement of very short intervals of time. With two plates. 1922	2.15
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9.	Wiedemann, E. und Frank, J.: Über die Konstruktion der Schattenlinien auf horizontalen Sonnenuhren von Ṯâbit ben Qurra. 1922	0.75
10.	Pedersen, P. O.: Om elektriske Gnister. I. Gnistforsinkelse. Med 2 Tavler. 1922	3.25

5. BIND (Kr. 13,10):

		Kr. Ø.
1.	Nielsen, Niels: Recherches sur les Équations de Lagrange. 1923	3.20
2.	Kampé de Fériet, J.: Sur une formule d'addition des Polynomes d'Hermite. 1923	0.50
3.	Hansen, H. M., Takamine, T., and Werner, Sven: On the Effect of Magnetic and Electric Fields on the Mercury Spectrum. With two plates and figures in the text. 1923	2.25
4.	Nielsen, Niels: Recherches sur certaines Équations de Lagrange de formes spéciales. 1923	3.00
5.	Nielsen, Niels: Sur le genre de certaines Équations de Lagrange. 1923	2.25
6.	Kloosterman, H. D.: Ein Satz über Potenzreihen unendlich vieler Variabeln mit Anwendung auf Dirichletsche Reihen. 1923	1.00
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9.	Gjaldbæk, J. K.: Über das Potential zwischen der 0.1 n und 3.5 n Kalomelelektrode. 1924	0.60
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11.	Bjerrum, Niels, Unmack, Augusta und Zechmeister, László: Die Dissoziationskonstante von Methylalkohol. 1924	1.10
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