8. On the contact features of the Nordingrå massive.

By

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(With a map, Pl. 7.)

Introductory.

LUNDBOHMS investigations [1] in the post-Archean igneous area of the coast of Ångermanland (the Nordingrå massive) have given as result a good geological survey map whereby further studies are much facilitated.

His geological survey is based on the map of the Topographic Corps, made in the twenties of the past century, which was not distinguished for its accuracy. For to understand the geology of the massive it is, naturally, of much importance to study its limits at the surrounding older formations. Hitherto that has not been done; thus, when, recently, the General Staff published maps on the scale of 1 : 50 000, having conferred with Professor HÖGBOM, to whom I am very thankful for much good advice, I decided to go to Ångermanland to study these limits between the young eruptives and the Archean formation. Besides this, I have studied the contacts with the younger diabase. In this preliminary note, I will describe only the contact between these eruptives and the Archean rocks, from Grönsvik, in the south, to the Firth of Nätra, in the North and, give an account of the contact features between the diabase and the granite on the Ulf-islands, and, further, I will treat succinctly some questions of the genesis of the massive. These questions will be treated in detailed form in a future contribution where also the petrography of the Nordingrå rocks will be described.

Contacts between the Nordingrå massive and the Archean.

The formation which, south of the Ramsta bay, borders upon the post-Archean eruptive on the western side, is a hornblende granite of Archean age.

On the eastern shore of the Firth of Grönsvik, in the immediate neighbourhood of the contact with the diabase, the hornblende granite is crossed by irregular dykes of a very fine-grained diabase, and, besides, by veins of a red granite. The Archean granite, in its turn, contains xenolites of a black rock, which probably derive from the leptite of the neighbourhood.

The red granitic veins are, in some places, very numerous and have a secondary origin as have those which are to be seen at the contact between the diabase and the granite at the Ulf-islands and in many other localities of this district.

This red granite, which is younger than the diabase, has been observed very often, as LUNDBOHM has already noticed in his work, above cited.

South of the village of Grönsvik, a stratum of sandstone of the thickness of about two meters appears under the diabase, and in many places this sandstone is covered by a talus of fragments of diabase.

To the north of the village the sandstone disappears, and the diabase shows itself again in contact with the Archean granite. The diabase is fine-grained at the contact and sometimes crossed by veins of the above mentioned red granite.

On the southern shore of the Ramsta bay I have not seen a definite limit between the hornblende granite (Archean) and the rock that LUNDBOHM, on his map, classifies as »gabbrogranite».

This rock is crossed by innumerable veins and dykes of red granite, which are only occasionally sharply limited from the invaded rock.

From Ramsta bay to Norasundet the boundary between the Archean formation and the young eruptive passes through a cultivated valley, which is rather narrow north of Allsta and which opens out widely at Östanö and Ramsta. It seems that in this region have taken place dislocations, which run along the boundary of both formations.

From Ramsta towards the north as far as Nätra, the Archean formation that borders upon the eruptives in question, consists of leptites.

Between Ramsta and Allsta is to be found gabbro similar to that of Nordingrå, »gabbrogranite», and in the neighbourhood of the latter village I have seen three varieties of granitic rock. One of these varieties, of grey color, has a special interest, as a very similar kind has been observed in other parts of the contact region.

From Norasundet to the Firth of Ullånger extends the gabbro massive of Nordingrå. The rock of this region varies from a fine-grained gabbro to labradorite-rock. In the places which I have studied I have found all sorts of transitions.

Ulandsberget, the mountain situated north-west of the village of Eden, is about 150 meters in height. On its southern side (west of Eden) it is covered by great patches of Archean rock, and its north-western slope is covered by a cap of the same rock.

An analogous phenomenon is to be noticed on the mountain situated north of Gavik, Grönberget.

On the western side of this mountain there is a little hill of gabbro isolated by the Archean formation from the above-mentioned mountain.

From Grönberget to Öfver Veda it is impossible to study the contact, which runs in a row of narrow valleys with abrupt and craggy sides, whose bottoms are in general occupied by fens, peat-bogs and small lakes; sometimes the valleys are rather broad and covered with cultivated land and picturesque villages, as in the neighbouring region of Dalberget and that of Salsåker further to the north.

On Dalberget radial dislocations seem to have taken place.

West of the Veda lake and of Fröstvik there is a region where the younger rocks are covered by great patches of leptite, which appears to be what is left of the cap of old rock that formerly covered the gabbro and the granitic rocks.

South of Salsåker is to be noticed a grey granite similar to that of Allsta, and west of the landing-stage of that village, the same rock is found in contact with leptite, which has been intensely metamorphosed.

On the northern shore of the Firth of Ullånger, to the east of the little village of Knäppa, there is a mountain which demands attention. It is divided into two parts by a gorge, not very deep, and through this passes, in a north-northeasterly direction, the contact between the old formation and the post-Archean eruptive, which in this case consists of granite.

The part situated north-west of the gorge is of leptite, that to the south-east is of granite. But the top of the latter part is covered by a cap of leptite. This cover can not be considered as a fragment of the Archean rock broken by the eruptive. It is the remainder of a cover of wider extension, that has been isolated by denudation.

The contact between the granite and the Archean formation runs in a regular line, and the first-mentioned rock seems to have dissolved foreign materials.

South of Sätra, beside the road, there are two hills about 80 meters in height that consist of granite. Between these hills and the limit of the Archean the distance is less than two kilometers; in this stretch are to be found many different rocks, mixed, as it appears, without regularity, for instance gabbro, fine-grained like that of Nordingrå, as well as an intermediate form between this rock and the labradorite-rock.

The granite crosses this rock in all direction, sometimes in rather narrow dykes, but in dykes of various breadths, and sometimes even in small stocks.

The intermediate form between gabbro and granite exists too, and moreover a grey granite, which seems to be intimately related to the granite of the massive. This grey granite I have observed at Skofed and on the mountain west of Magdbäcken, south of Bergs »fäbodar» (mountain dairies).

In general, it is porphyritic, and in the latter place it is full of fragments which seem to originate from the leptite of the neighbouring country.

LUNDBOHM has observed a grey granite south and north-west of the rectory of Vibyggerå, on the slopes of Skuleberget, on Värnsberget, north of Värns, on the cape of Farnö, and in many other places south of the Norra and Södra firths.

The same geologist has noticed, on Trollarviksberget, east of Breviken, red medium- and fine-grained granite of the same type as that of Ulf-islands and a third variety which crosses them in dykes.

In these rocks there are fragments of leptite, of a length that varies between a few centimeters and some meters. These fragments are now and then surrounded by a wide zone of grey granite, which sometimes shows definite boundaries against the red granite, but sometimes there are intermediate forms between them.

As is shown, this grey granite always appears in connection with the granite of the massive and, in general, it follows the region of the limit of the Archean from Magdbäcken to Allsta.

Perhaps it is a modification of the granite caused by the assimilation of foreign rocks. The observations made by LUNDBOHM on Trollarviksberget give support to this opinion.

In some parts of the contact region — for instance north-east of the little lake of Sätra, as well as in the neighbourhood of Högsvedjeberget and of Magdbäcken — I have seen a kind of eruptive breccias where the fragments were of Archean rock.

North of the farm situated to the north of Magdbäcken there is a hill whose base consists of post-Archean rock, but whose top part is a cap of Archean rock.

This part has been strongly metamorphosed by the young eruptive and in some parts a complete melting has taken place.

In the vicinity of Högsvedjeberget it is possible to study the rocks of intermediate composition between the gabbro and the granite, which are mixed rocks due to assimilation, as Professor HÖGBOM has remarked [2]. The mixture has not taken place in situ everywhere; sometimes it has gone on under the surface of the earth.

An interesting locality of this region is the hill of Nylands »fäbodar», where there are to be found gabbro and intermediate rocks separated from the granitic hill by a peat-bog.

Between Nylands fäbodar and the lake of Skule it is very difficult to investigate the contact, because the ground is covered by brushwood and fens, but it seems that it follows a direction coinciding with that given on LUNDBOHM's map. According to this map, the region enclosed between lake Skule and the Firth of Näske (through which flows the rivulet that serves as the outlet of lake Skule) should be of diabase. I followed the rivulet in its whole length and, as it was possible to examine many parts of its bed, I could verify that it belongs entirely to the Archean formation.

The diabase extends probably to the south of the rivulet, bordering upon the granitic rocks, but on the northern side I have found diabase only west of Ytterböle and at Näske on a farm situated by the side of the road, to the north of the Sawmill.

Contacts between the granite and the diabase of the Ulf-Islands.

The post-Jotnian olivine-diabase is of relatively wide extent on the coast of Ångermanland, especially south of the Firth of Omne. In this region, as at Skrubban and on Trysunda-island, it is met with covering and invading the sandstone. As professor HÖGBOM has pointed out the diabase has probably erupted in connection with dislocations. The majority of the small lakes on the Ulf-islands are to be found at the contact between the diabase and the granite, and it seems that their origin has to do with dislocations.

The contacts between the diabase and the granite are very interesting. I have had the opportunity of studying them, besides, at the Ulf-islands, also in the region situated between the Firths of Näske and Nätra. On the Ulf-islands the diabase is micro-crystalline at the contact and its crystals increase in proportion as one retires from the contact.

The granularity of the granite is the same at the contact as at a distance from it; consequently the diabase is younger than the granitic rock.

South of Sandviken on Norra Ulfön, the diabase near the contact is crossed by a net of very irregular and fine-grained granitic veins, which have the appearance of originating from the granite of the massive. Besides, in some parts, it is possible to find granitic dykes up to 15 centimeters in breadth, whose structure and composition are equal to those of the older granite that the massive consists of.

On the sea coast, between the fishing-village of Sandviken and the contact, there are three dykes of a basic rock that cross the granite. This rock is microcrystalline and it has not been examined microscopically.

Two of the dykes are about 1,15 m. in breadth; the third is much narrower.

The metamorphic effects, perceptible to the unaided eye, which have been caused by the dykes in the granite consist in decoloration.

On Norrtaskberget, north-west of Sörby, there is a dyke of a dense rock that macroscopically is equal to the former and that also crosses the granite.

West of Sörsand the diabase of the contact is crossed by dykes and veins of granite.

On the northern shore of Svartbergsviken the contact is visible. This is one of the most accessible places.

South of Svartbergsviken and in the neighbourhood of Kvarnsviken granitic dykes are to be found in the diabase, and a little more towards

the south, at a little cape called by the fishermen Korsudden, the diabase is mixed with granite.

This makes it likely that the granitic rock east of Ulföhamn and that of Åskäret stretch out under the sea towards the north.

East of the fishing-village of Ulföhamn the granite and the diabase are mixed in about the same way as at Korsudden.

The diabase is in both cases very fine-grained. At the ascent of Hamnberget (west of Ulföhamn), on its eastern side, one observes a granitic dyke in the diabase. In many places on these islands granitic dykes are to be found in the diabase as well as in the granite of the massive.

In the vicinity of Långviken (on the eastern shore of the S. Ulfö, there is also a mixture of these two rocks crossed by small granitic dykes. In this place LUNDBOHM has noticed that »the granite forms a body 4—5 meters broad in the diabase, which is aphanitic at its limits while the granite has its normal appearence. From the latter rock a multitude of fine veins and dykes run out in the diabase which in its turn contains small grains of granite».

Probably the just named occurrence, as well as several dykes in the region south of Sandviken (N. Ulfö), are fragments detached and partially melted by the diabase.

The veins and dykes that seem to emanate from that granite will have their origin in melting of this granite by the influence of the diabase magma.

The diabase, in making eruption, has melted the granite and mixed with it in many other localities (to the east of Ulföhamn, at Korsudden, west of Svartbergsviken, at Långviken etc.).

The granitic veins and dykes that cross the diabase (south of Sandviken, at Korsudden etc.) are of secondary origin, that is to say, it is the granite regenerated by the diabase that has erupted after the diabase.

Whether the mixture is homogeneous or not, depends chiefly on the rate of cooling. Thus, to the south of Alviken, on Vårdkasberget (the parish of Nätra) the diabase has not only mixed very intimately with the granite, but it seems, too, that it has regenerated the granite on a certain area contiguous to that of the mixture. In this case the temperature of the diabasic magma fell relatively slowly.

In this place I have not found fine-grained diabase, and the rock that I suppose to be regenerated, is a little more fine-grained than the remainder of the granitic rock that composes Vårdkasberget.

At the N. Ulfö (east of the hotel of Ulföhamn and at Korsudden) the mixture is not intimate, and the diabase is almost microcrystalline. This is the result of a rapid cooling. In such cases it seems that the rate of cooling has depended chiefly on the distance between the contacts in question and the focus of the intrusion. It is natural that the temperature of the rocks in places near to the conduits through which the diabase made intrusion, was much higher than in regions more remote

from those openings, but that even they were influenced by the diabasic magma.

The mixed rocks of this massive are abnormal, because of the little depth at which the mixture has taken place. Many geologists are of opinion that rocks arising from mixtures are not normal. HARKER calls them hybrids.

This author declares that »by averaging, e. g. the analyses of a peridotite and a granite, we obtain a result much richer in magnesia and poorer in lime and alumina than any natural intermediate rock».

HARKER [3] supposes consequently, that a mixed rock has a composition that can be calculated by the analyses of the constituents in the state of crystallisation. This seems to be erroneous, since the chemical composition of rocks is not the same in the state of crystallisation as in the magmatic state.

There are many constituents in the magma which are eliminated before the solidification, and there is no doubt that these have influenced the composition of mixed rocks.

Moreover, it is not right to generalize the results obtained in volcanic studies, and in studies of intrusive bodies that have been solidified near the surface, and to apply them on great plutonic massives.

Some theoretical remarks about the genesis and the classification of the Nordingrå massive.

We have seen that at the western limit of the massive the Archean formation covers the young eruptive as a cap in some parts, in a way comparable with the boundaries of the Ragunda massive. It is very probable that this Archean cap once covered the whole massive and that the denudation has only uncovered its higher part.

If we admit this hypothesis to be true, the consequence would be that the rocks that compose the massive are to be considered as intrusive; but it would be a kind of intrusive difficult to class because it is not known how it penetrated the old rocks.

The fact that the magma has been crystallized under a cap of rock is common to all intrusives; that is just what is natural to them.

In this case the intrusion has taken place in Archean crystalline rocks: granites and leptites. This is important for the classification of the intrusive mass, for the form of the same depends, to a large extent, on the physical properties of the invaded rocks and of the magma, and, too, on its living force, but my view of the matter is that of the causes mentioned the first has the greatest influence.

Other analogous intrusive bodies in Fenno-Scandia have been classed as laccoliths. I am, however, convinced that the post-Archean massive of the coast of Ångermanland is not at all of laccolithic character.

The base of a laccolith ought to be the invaded rock, and the laccolith ought to be in communication with the magma at greater depths, by means of rather narrow conduits.

Of this massive we only know the upper part, and it is probable that it is nothing else but a ramification of a very great batholith, from which also the analogous massives in Ragunda, at Rödön and in Finland are likely to have originated.

From the works of the Americans GILBERT, CROSS, WEED, PIRSSON, JAGGAR, and others in the Rocky Mountains, it may be concluded that the laccolith is an intrusive form connected with stratified formations whose strata are of easy separation.

GILBERT [4], in his classical work on the Henry Mountains, says that: »all the determined laccolites are inclosed by soft beds. They have been intruded into the shales, but not the sandstones. They cluster about the Henry's Fork conglomerate, but none of them divide it. This selection of matrix is confined, however, to the laccolites and is not exercised by sheets and dikes».

The formations of shale that contain laccoliths are separated by strata of sandstone of some thickness. Blue Gate shale and Tununk shale are separated by Tununk sandstone; Tununk shale and Flaming Gorge shale by Henry's Fork conglomerate.

CROSS [5] declares that the igneous masses of the Carriso mountains »are apparently thick sheets rather than laccoliths, and this form is no doubt connected with their occurrence in sandstones in the Trias and Jura».

PIRSSON [6] says that »the base of the Mesozoic is not only a horizon in which laccoliths occur, but to a very large extent one in which intrusive sheets are also found. This is well illustrated around the outer flanks of the Elk Peak dome, where not only do sheets occur, but these swell out, in places, into thick lenticular masses, which might well be classed as small subordinate laccoliths. It is very clear that these horizons have been selected by the ascending and invading magmas because of their fissile character and ready penetrability.

It is in such shaly horizons that the vast majority of intruded sheets occur, not only here, but in other localities as well, and an intruded sheet is the first (and necessary) stage of a laccolith».

Besides, it is to be noticed that in the regions where the sedimentary formations have been subjected to considerable tectonic movements the laccoliths lose their symmetry and tend to form irregular bodies which are not laccoliths.

Consequently, the laccoliths are the ordinary intrusive forms in sedimentary formations whose strata are banked or have a distinct layer structure and have not been subjected to considerable movements of folding.

In the same class of formations, when they are not of distinctly stratified or when the formations have been subjected to folding, the magma

finds a more easy way in other directions, giving rise to the formation of Stocks and other intrusives e. g. Chonoliths.

Many intrusives classed as »irregular laccoliths» and as »asymmetrical laccoliths» are not laccoliths but probably chonoliths, as DALY has noticed.

DALY [7] defines the chonolith as an igneous body injected into dislocated rock of any kind, stratified or not; of shape and relations irregular, in the sense that they are not those of a true dyke, vein, sheet, laccolith, bysmalith or neck; and composed of magma either passively squeezed into a subterranean orogenic chamber or actively forcing apart the country rocks.

For these reasons, and taking the nature of the invaded rocks into consideration, I am of the opinion that the massive of the coast of Ångermanland may be of chonolithic character, but most probably it is batholithic.

It is possible that previous to the formation of the post-Archean massives a batholith of great extent, which — in order to fix ideas — I call principal, has been formed at a great depth under a part of the northern region of Fenno-Scandia.

I am inclined to think that the magma of this batholith was gabbroid. At the formation of this batholith, the part of the earth crust that covered it may have been subjected to dislocations, which, in causing the breaking of the rocks at certain weak points, gave birth to openings that got enlarged gradually. Thus it is easy to conceive, that tangential dislocations in a certain direction can cause an aperture more or less perpendicular to that direction.

At the same time as the aperture of the rocks has arisen, the gabbro may have erupted, filling the cavity and forming a subordinate batholith.

The gabbroid magma, being at a very high temperature, has melted the invaded formation in the inferior parts of the cavity.

I believe that the country rocks were granites and, because of their great depth, they had probably a high temperature already before the intrusion of the gabbro.

It seems to me that the melting of the country rocks was hydrotermical.

If we suppose an interruption of the tangential dislocations, in the inferior parts of the subordinate laccolith, the gabbro would be surrounded by an envelope of regenerated granitic magma. At the contacts, mixtures would arise, and the granitic magma, on account of its lover sp. gr. would always tend to rise to levels superior to those occupied by the gabbro.

The movements of dislocation have continued to enlarge the volume of the cavity, and then the regenerated magma has erupted, filling it. The zone of mixtures between the two magmas has attained considerable extension at great depths, gradually getting smaller towards the top of the eruptive.

For these reasons and since, according to my supposition, the respective magmas have had different origins, this igneous body, which ori-

ginates from a batholith of great dimensions and is composed of materials intruded during more than two periods of intrusion, may beclassed as a separate subordinate composite batholith [7].

As a consequence of the phenomenon of melting I consider it as probable that the magmas of this massive have been solidified in subjacent conditions.

That means that the cavity where these magmas have been solidified owes its origin, not only to tangential movements, but also to the fact that, in the inferior parts, the cavity got enlarged by the melting of the country rocks, caused by the gabbro.

In 1906 DALY [8] expressed the opinion of »a cooling earth superficially composed of a relatively thin crust overlying a fluid gabbroid substratum of unknown thickness».

In 1909, RAMSAY [9] writes in his text-book of geology that »the superior strata of magma may afterwards have solified and come to belong to the crust of the earth, while, next inferior to it, gabbroid and peridotitic masses have remained in a fluid state».

My hypothesis of a great batholith of gabbroid magma does not imply the supposition that the magmasphere is gabbroid, even in its superior regions.

These are regions of assimilation, and as the lithosphere, in consequence of its proper genesis is of heterogeneous composition, it is impossible that they are gabbroid.

For this to have been the case, it would have been necessary that the parts of the lithosphere assimilated by the magmasphere, should also been gabbroid.

In the massive in question we find, that first a gabbroid magma erupts and that a granitic one follows afterwards. After the deposition of the Jotnian Sandstone something analogous takes place: first appears the olivine diabase, and then a granitic magma.

The succession of eruptions observed by BRÖGGER is first a basic magma, afterwards more and more acid, and finally once more basic.

To make our case in accord with the observations of BRÖGGER would need that last basic eruption.

It is not at all impossible that the dykes of a basic rock that cross the granite at the Ulf-islands belong to an eruption posterior to the diabasic one. But I think that even if that should be so in this case, this fact would not give any support to a generalization of the succession of eruptions given by BRÖGGER. Il is sufficient to run through what is written on the petrology of different regions, to see their discordance from such a theory of the succession of eruptions.

IDDINGS finds that »the general succession is from a rock of average composition through less silicious and more silicious ones to rocks extremely low in silica, and others extremely high in silica that is, the series commences with a mean and ends with extremes». This law, says IDDINGS, is very widely applicable.

And finally MICHEL LÉVY, basing his opinion upon observations made on the Plateau central of France, remarks that the succession of eruptions in that country is in complete discordance from the ideas expressed by BRÖGGER and IDDINGS.

This is the result when quoting only three eminent geologists.

It is easy to imagine, especially when it is not a question about phenomena of differentiation, that the succession of eruptions varies according to circumstances, and that it may be sometimes a basic magma, sometimes a magma of intermediate composition, and sometimes an acid magma that make the first eruption.

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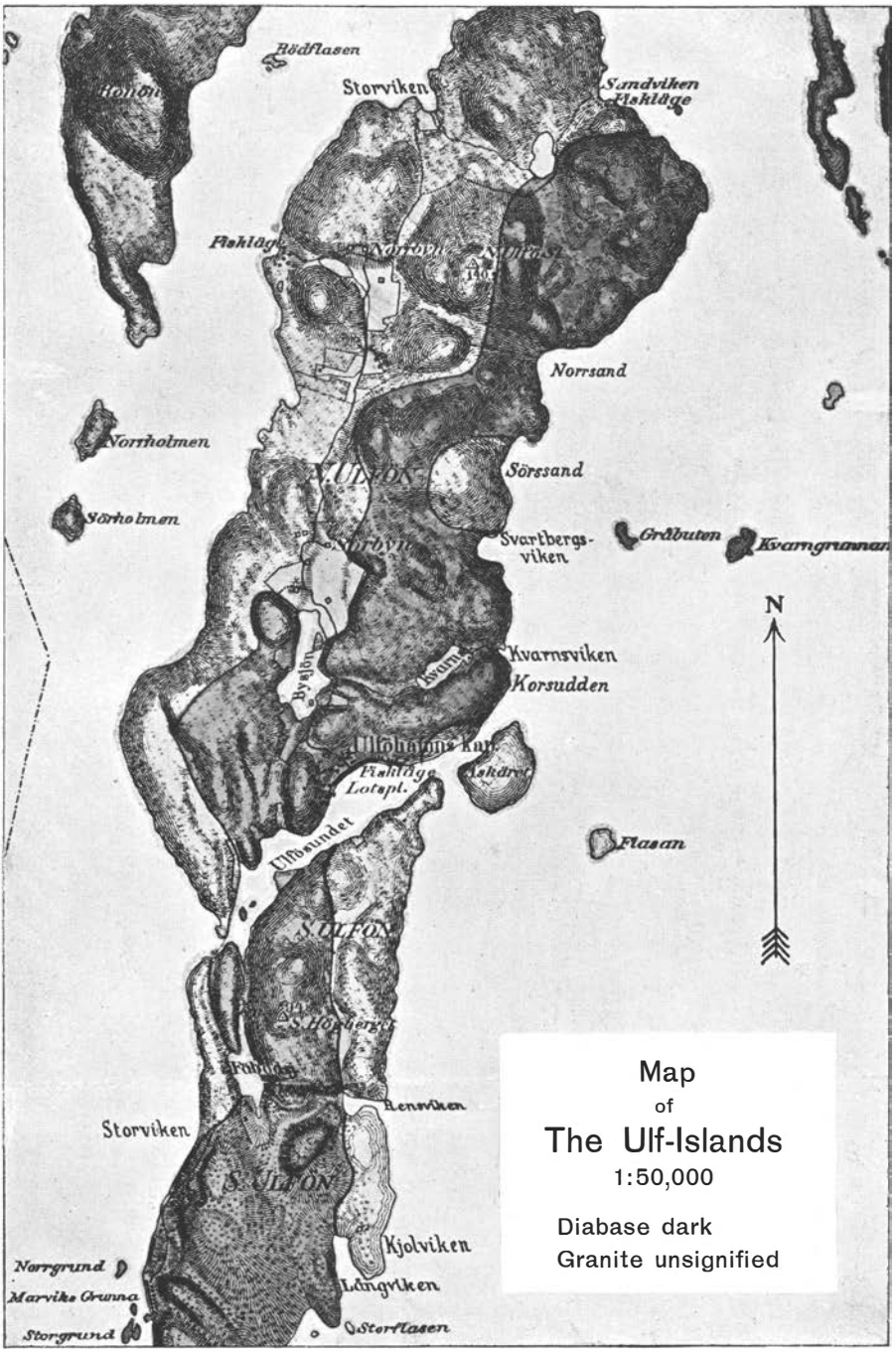
Rödflasen
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Marvike Grunna
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Diabase dark
Granite unsignified