SUOMEN GEOLOGINEN TOIMIKUNTA || GEOLOGISKA KOMMISSIONEN I FINLAND

BULLETIN
DE LA
COMMISSION GÉOLOGIQUE
DE FINLANDE

N:o 91

PRE-QUATERNARY ROCKS OF FINLAND

EXPLANATORY NOTES TO ACCOMPANY A GENERAL GEOLOGICAL MAP OF FINLAND

BY
J. J. SEDERHOLM

WITH A MAP AND 40 FIGURES IN THE TEXT

HELSINKI — HELSINGFORS
AUGUST 1930

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INTRODUCTION.

Nearly twenty years have elapsed since the publication of the last edition of a general map of the ancient rocks of Finland. This map in 1 : 2 000 000 was compiled for the second edition of the Atlas of Finland 1910, published by the Geographical Society, and was also printed with accompanying text for this Bulletin as No. 28.

A new edition of the same Atlas was a long time in preparation, and appeared in 1928. For this Atlas a revised edition of the geological map was compiled.

At the time of the publication of the preceding edition in 1910, considerable parts of the country, especially along the coast of the Gulf of Bothnia and in central Finland, had not yet been mapped, but now all the country has been geologically surveyed, with the exception of an insignificant portion of the central granitic area and a part of the Petsamo region on the Arctic coast. It is, however, necessary to make a re-survey of those parts of south-western Finland which were mapped more than half a century ago. In certain other regions, too, as in Inari (Enare) and north-eastern Sodankylä in Lapland, a revisional survey is still necessary. Among those regions which have been surveyed in greatest detail are the tracts between Lake Ladoga and the north-eastern shore of the Gulf of Bothnia, but these regions present some of the most difficult geological problems, and the survey must therefore be continued there also.

The greatest part of the rocks of Finland are crystalline and pre-Cambrian in age. Rocks which are younger than these occur only to a less extent.

The ancient rocks which constitute the substructure of Finland form a peneplain that is on the whole smooth, although it shows many shallow furrows and small protuberances. In southern Finland, S. of Lake Oulujärvi, only small areas lie at a level higher than 150 m., and the highest hills attain heights varying between 200 and 300 m. In the northern and north-eastern parts of the country, larger

areas lie at levels above 300 and 400 m. The highest peaks are between 500 and 800 m. in height, and a few even higher. Besides the differences of level which are visible on a hypsometrical map of small scale, there are almost everywhere in the country innumerable small hills and ridges many of which consist of or contain a core of crystalline rock.

By far the greatest part of the rocks is, however, hidden under a cover of glacial or post-glacial deposits. The map of the ancient rocks shows their composition and boundaries as they would appear if the loose deposits covering them were removed. As the rocks are also visible in the numerous islands of the lakes and along the coasts, it is quite possible to map them where they are partly covered by water, indeed it is often easier than where they are hidden by thick Quaternary deposits. The map therefore does not show the lakes, and extends over the archipelagoes skirting the coasts.

This procedure has the further advantage of showing more clearly the main features of the geological structure, which would appear disunited and ragged if the numerous lakes were shown as spaces. There are in any case a great number of essential details which unavoidably detract from the clearness of the whole.

The colours of the map have been chosen, as in the previous editions, especially to show the petrological character of the rocks. The geological age is indicated by varying the shade. Those rocks which are younger, and in many cases have also better preserved their primary characters, are shown by more distinct, darker colours, and the comparatively older rocks have been allowed to sink into the background by being given a lighter shade.

Most of the colours are identical with those of earlier maps, with however some slight modifications.

For pelitic sediments, as phyllite and mica-schist, a grey colour has been introduced. For greenstones, including diabases, gabbro, anorthosite, ossipite, peridotite etc., which on the earlier maps were partly indicated by brown colours, only green in different tinges and shades has now been used. For the oldest gneissose granites, a very light pink shade has been introduced, in order to emphasize the difference between the monotonous gneissose area in eastern Finland and the region with more complicated structure to the west of it.

When publishing the last general geological map, the present author made the following remark which may be here repeated in English: It has always been thought that the mapping of a pre-Cambrian area presents such great (in part almost insuperable) difficulties that it is never possible to regard it as definite. Each new

endeavour however may serve for a certain time as a summary of the knowledge hitherto won of the pre-Quaternary geology of the country. Further, it was stated, at the end of the description of the sketch-map of Fenno-Scandia published in the same Atlas: One of the greatest difficulties in studying Archæan rocks is the fact that we are here forced, even more than in studying other geological problems, to develop the methods of research during the progress of the survey. Possibly it is only after having once mapped all the region in question, that we shall know how it ought to have been done: — and, only after a second survey, based on uniform principles, all over the region, shall we be able to draw a more definite geological map. Both these remarks may be applied also to the present map.

Most of the geological mapping of the present area has been done according to the following method. The rock masses have been subdivided in the field into different formations mainly on petrological grounds, and then traced from point to point. Their relative age has been determined chiefly through the study of their contact relations. The relations of the sedimentary rocks to the granites have been of special importance, because the latter have a wide extension and their intrusion has in many cases been connected with mountain-building movements affecting large areas. During these movements, the sedimentary rocks were subject to metamorphism and this process often acted in a rather uniform way over extensive areas. The degree of metamorphism may therefore in some cases be used for determining the relative age of the rocks, although this method ought to be used with great caution. Many of the mistakes which have been made in the study of the pre-Cambrian, even in the present area, are due to an indiscriminate use of this criterion.

During recent years, it has become evident that the geotectonic methods which have been used with so much success in the study of younger mountain chains, as, e. g., the Alps of Switzerland, France and Austria, have a wide application also in the study of the deeply eroded ancient mountain chains of the territory under consideration.

The geotectonic researches of recent years according to such methods, using very largely stereographic plottings, have thrown much light on the structure of the ancient rock masses. Several questions which have long been mooted have received a more definite answer than before, while other new problems have arisen, the solution of which may be reached by continued geotectonic research. The results of these studies may be of interest not only for the local geology, but also in general for the conception of the geotectonics of deeper parts of the earth's crust, both as to the movements of the sedimentary and the eruptive rock masses.

It has, however, not been possible to take into account the result of these latest geotectonic studies in the drawing of the present map, because it was printed in 1927 and had been practically ready for publication a couple of years earlier, after which time only changes of minor importance could be introduced.

This map may therefore be regarded as embodying the result of the geological study of Finland until the end of the fifth lustrum of this century. In a future edition it will be possible to emphasize certain structural features more, and the shades indicating the age will in some cases be changed. The contours and the colours of the petrological indications on the map will of course in most cases be only slightly modified.

In some areas, especially in Lapland and the southernmost part of Finland, which have been only summarily mapped, in part long ago, more radical changes will be necessary.

In writing this explanation of the map the results of latest research have been taken into consideration. This circumstance accounts for some discrepancies between the present text and that accompanying the map in the Atlas of Finland 1925.

MAIN FEATURES OF THE GEOLOGICAL STRUCTURE.

A first glance at the map shows a marked difference in the character of the rocks in different regions.

In the easternmost region, on the boundary of East Carelia, a zone of very ancient g n e i s s o s e g r a n i t e s appears, and other rocks occur only to a small extent. This zone continues north of the Kuusamo region, in Kuolajärvi and Inari in Lapland, and stretches to the coast of the Arctic Sea. In Inari we find, instead of gneissose granites, a broad belt of peculiar schistose rocks rich in garnet which have been called g r a n u l i t e s or l e p t y n i t e s.

Immediately west of the largest areas of gneissose granites, there are zones of schists, such as mica-schists and phyllites, quartzitic schists, limestones etc., and of metabasites or greenstones. These zones of schists are especially well developed in the neighbourhood of Lake Oulujärvi (Ule träsk). Their strike is here in an N.—S. or N.N.W., whereas in Lapland it is mainly in an N.W. direction. West of these zones of schistose rocks, great areas of so called p o s t - K a l e v i a n g r a n i t e occur in Lapland. In the Kemi and Kuusamo regions, and also more to the north, there are zones in which q u a r t z i t i c rocks prevail which preponderantly strike in an E.—W. direction. To the south, the zones of mica-schists, quartzites, etc.,

which follow the western boundary of the gneissic area become broader and some of them strike in more N.W. directions. There is no distinct boundary between these rocks and those of southwestern Finland, i. e., the peninsula-like territory between the Gulf of Bothnia on the one hand, the Gulf of Finland and Lake Ladoga on the other.

The main part of this latter region is occupied by a confused mixture of different rocks, in part granites, in part schists of varying composition. One of the most prominent features is a large c e n t r a l g r a n i t i c a r e a along whose boundaries are zones of s c h i s t s, especially at the southern side, where they strike in E. — W., partly and S.E. — N.W. directions. Areas of »m i g m a t i t e s», rocks which have in large measure been mixed up with granitic veins, are common, especially in the southernmost part of the country. In them a predominant E.N.E. strike may be recognized; the schists of the regions around Lake Saima, where a strong admixture of granitic veins is also very common, strike in N.W. and N.N.W. directions. To the S.E. of Vaasa (Vasa), the strikes are arcuate, in middle Ostrobothnia again mainly follow N.W. directions.

On the map of southern Finland we notice large areas of so called r a p a k i v i g r a n i t e s, in connection with which s a n d s t o n e and d i a b a s i c rocks occur. All these rocks are unrelated to the surrounding Archæan rocks. There are also, besides the rapakivi, other granites in the same region which form well defined smaller areas, as if holes had been punched in the Archæan rocks and filled by the granitic magma.

The rocks of Finland may for descriptive purposes be subdivided into three greater groups which it is, however, possible further to subdivide.

The oldest group, comprising rocks which are almost everywhere crystalline and have in great measure been mixed up with veins of granitic rocks, has been designated as A r c h æ a n. Rocks of a similar petrological character occur, however, also in the younger groups (cf. the remarks on pp. 35—36). The A r c h æ a n C o m p l e x may be subdivided into two minor groups. The O l d e s t A r c h æ a n R o c k s are the crystalline schists, sedimentary and volcanic, of south-western Finland which have been penetrated by the oldest gneissose granites of this region and also intruded by granites and associated plutonic rocks belonging to a younger group. The oldest gneissose granites and associated schists of eastern Finland may be referred to the same complex. As y o u n g e r A r c h æ a n R o c k s may be designated another sub-group of old crystalline schists, volcanic and sedimentary, which differ from the aforemention-

ed in their primary petrological characters and also as it seems in their relations to the oldest plutonic rocks. Though they are intimately penetrated by the younger Archæan granites and over large areas also highly metamorphic, there are places, in regions where they are better preserved, where their contact relations seem to prove that they are later than a part of the oldest gneissose granites.

The Middle Group of Pre-Cambrian Rocks comprises sedimentary and volcanic rocks of eastern and northern Finland which are obviously younger than the gneissose granites of eastern Finland and associated rocks of other parts of Finland, as well as the supercrustal rocks referred to the Archæan. Possibly also certain younger Archæan granites are older than the sedimentary rocks in question. These rocks of the middle group possess in part the character of feebly metamorphic sediments, such as sandstone-like quartzites, etc. They have, however, everywhere taken part in mountain building movements which have affected all the territory in question. In some regions they are more crystalline than elsewhere and have been penetrated by granites which are not very different in character from those of the Archæan.

The third group comprises the Youngest Pre-Cambrian, Paleozoic and Later Rocks which have not, or at least only locally, taken part in mountain building movements and are never intimately penetrated by granites. Most of these rocks are therefore devoid of any signs of metamorphism.

THE ARCHÆAN COMPLEX.

OLDEST ARCHÆAN ROCKS.

In south-western Finland a great part of the oldest supercrustal rocks are similar to the rocks which have been called leptites in Sweden. They are fine-grained schistose rocks rich in feldspar. These rocks, the layers of which are generally nearly vertical, are intercalated with crystalline limestones or marbles.

In Sweden, the leptites are associated with magnetite iron ores. On the Finnish side this is the case only in a few places, and the ores in question have no great importance. The crystalline limestones occur in some places as thick layers and form the raw material for the cement industry, etc. In spite of the very strong folding which these limestones have undergone (Fig. 1), in connection with the intrusion of granites, their geotectonic structure may locally be unravelled and then shows much analogy to that of younger strongly folded sediments.

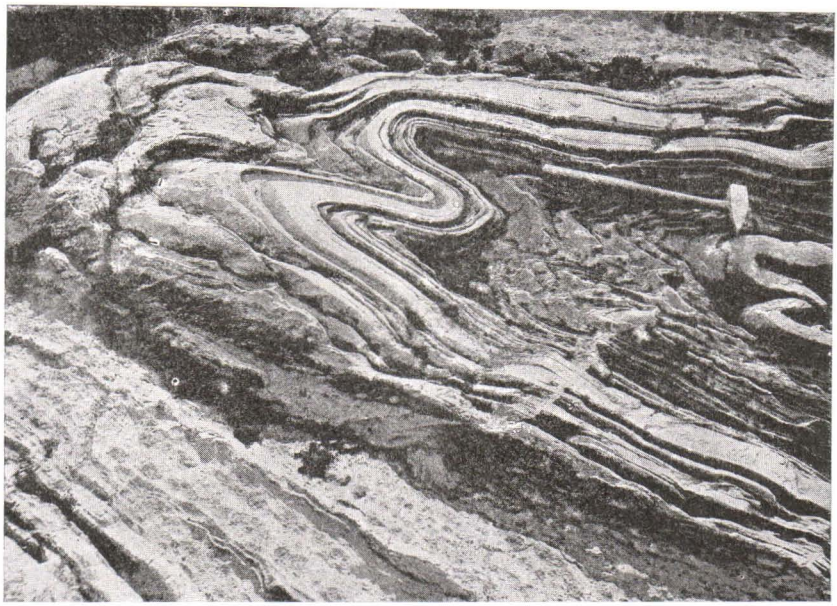

Fig. 1. Strongly folded crystalline limestone alternating with calcitic schists. Kirmoudd (Kirmonniemi), island of Ovensor in Korpo, Abo-Aland archipelago.

The most typical area of leptitic rocks in southern Finland (Fig. 2), and that where the primary characters of the rocks are best preserved, is the Orijärvi area which is also that which has been described most thoroughly.

Fig. 2. Leptite showing an alternation of layers of different composition. Kullajärvi S. of Skogböle in Tenala in the Orijärvi area in southern Finland.
Photo P. Eskola.

The prevailing rocks among the typical leptites of Sweden are strongly metamorphic volcanic rocks, with associated tuffs, of acid composition. They grade into feebly metamorphic hälleflints and metarhyolites. In some cases, these rocks are uncommonly rich in potash, but others are rich in soda. In Finland too, acid volcanic rocks, metarhyolites, occur among these oldest schists, but volcanic rocks and tuffs with a more basic composition, hornblende schists, meta-andesites (Fig. 3), etc., seem to be more common. In general, rocks rich in soda prevail here. Rocks with the composition of mica-schists also occur. Some quartzitic schists, which were originally sandstones, have been found both in Finland and Sweden, in association with these oldest schists.

Fig. 3. Meta-andesite belonging to the leptite formation. Äggh-hällan in Pernå in the Pellinge area on the southern shore of Finland. 1 : 4.

In the last mentioned case, the rocks were no doubt originally normal sediments, the material of which had been formed by the weathering of older rocks. This fact seems to indicate that the same processes of sedimentation as are now in operation were active already at that early epoch. Also many of the leptitic rocks of volcanic origin have obviously been formed under conditions not very different from those under which later volcanic rocks originated. For these oldest rock formations for which the name Svionian has been proposed, an origin under more exceptional conditions has, however, also been assumed, especially by Swedish geologists.

Most of the schists of this oldest formation are highly metamorphic, and they have commonly been intimately mixed with granites (Fig. 4). This process has also influenced the composition of the schists (Fig. 5).

Fig. 4. Gneissose granite containing fragments of basic rocks and older schists. Bågaskär in Ingå at the southern shore of Finland.

In some cases, these schists are rich in cordierite which has originated by the contact action of the granites (Fig. 6). Hybrid rocks, so called veined gneisses, and othet kinds of migmatites, (cf. Figs. 4—5, 16—19) are especially common in the archipelagoes of the southwest and the adjacent parts of the Finnish mainland, and also in the regions around Lake Saïma.

The oldest, gneissose granites are preponderantly grey in colour, and they are more often rich in soda-lime feldspar than in potash feldspar, and pass by gradations into diorites and gabbros.

The gneissose granites, or granitic gneisses, of the great eastern area (as well as those of the similar area in western Sweden) differ in their unvaried character and very wide extension from most younger granites. As they were also for a time thought to be the oldest rocks of the regions in question, they have by several geologists been regarded as »crustal» rocks, i. e., as parts of the original crust formed by the

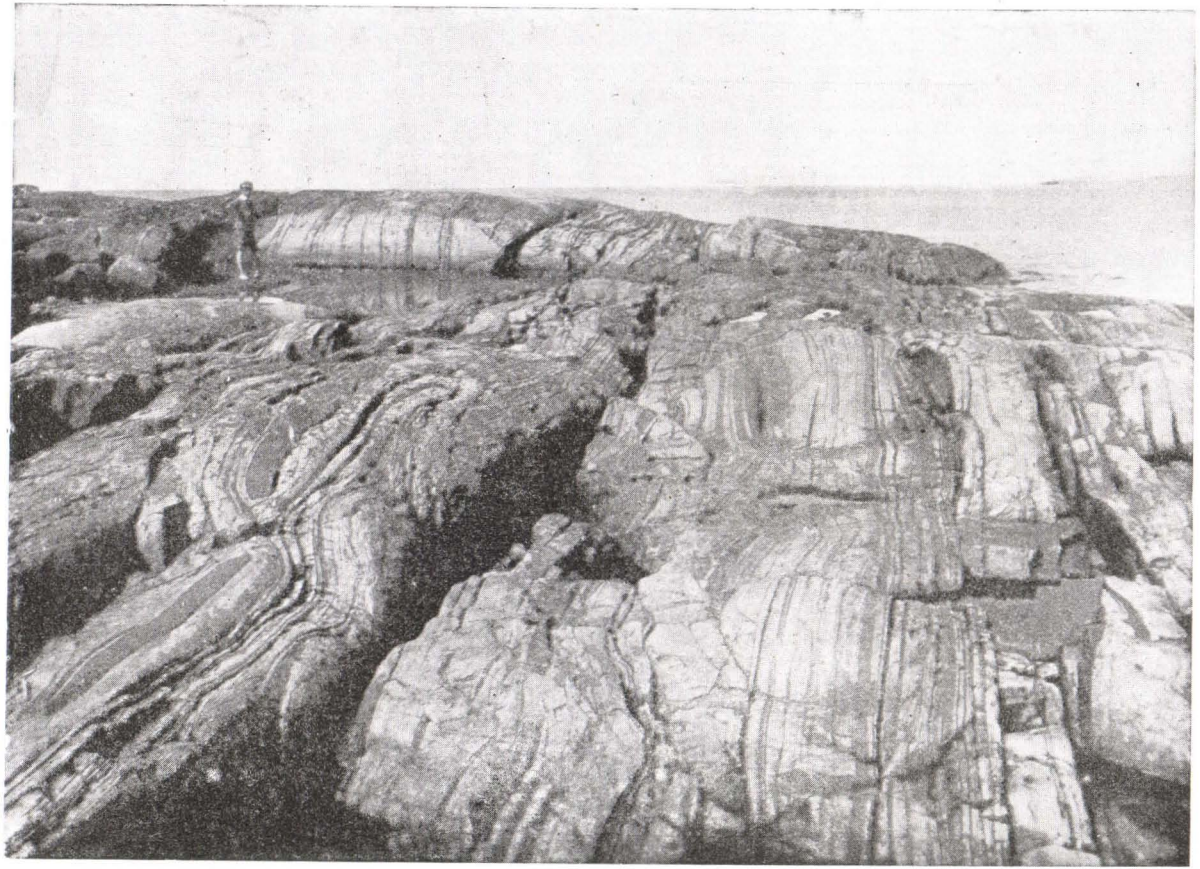

Fig. 5. Leptitic schists mixed up with gneissose granite. Bålaskär in Ingå at the southern shore of Finland.

Fig. 6. Cordierite-antophyllite-gneiss near Perheentupa in the Orijärvi area in southern Finland. 1 : 5.

Photo P. Eskola.

solidification of the molten globe. To that idea is to be traced the name »K a t a r c h æ a n» which was earlier used for these rocks.

The oldest gneissose granites can, however, hardly be described as belonging to the »o r i g i n a l crust», since they penetrate in an eruptive way certain schists of sedimentary origin which also occur, although to a smaller extent, in the regions where the gneissose granites prevail.

There seems to be, in some parts of Fennoscandia, a genetic connection between the old gneissose granites and the effusive acid rocks of the leptite formation. Although a direct gradation between them has only in few cases been ascertained, and the intrusion of the granites has, as a general rule, ended later than the eruption of the volcanics, both seem to belong to the same epoch of diastrophism.

YOUNGER ARCHÆAN ROCKS.

In western Finland, supercrustal rocks belonging to the Archæan complex occur which have a rather different character from that prevailing in the »Svionian» formations above described. Such are the B o t h n i a n schists which occur in most typical form at Lake

Näsijärvi near the town of Tampere (Tammerfors). Although the layers of the sedimentary rocks in question are nearly vertical, they are in fact not very strongly metamorphic. Fine-grained phyllites and mica-schists (Fig. 7) occur which were originally alternations of silts and clays, showing very regular bedding (in part also cross-bedd-

Fig. 7. Phyllite showing an alternation of meta-psammitic and meta-pelitic beds. Messukylä at Lake Näsijärvi in south-western Finland, 1:3.

ing). This bedding reminds one of the varved structure of glacial clays, although the individual layers are often rather thick. These phyllites occasionally contain peculiar sausage-shaped accumulations

of carbonaceous matter which are no doubt of primary origin and have been interpreted as fossils *(Corycium enigmaticum)*, possibly algæ (Fig. 8). Intercalated with the phyllitic schists metamorphic volcanic rocks occur, ranging in composition between metarhyolites, meta-andesites and metabasalts. Basic volcanic rocks are most com-

Fig. 8. *Corycium enigmaticum* Sederholm, in a phyllite from Kuvinniemi in Messukylä at Lake Näsijärvi in south-western Finland. Ca. 1 : 5.

mon. The northernmost (upper) part of the formation consists of metamorphic tuffs (tuff schists) and conglomerates, (Fig. 9) in zones some of which attain a breadth of 700 m. Most of the pebbles consist of effusive and sedimentary rocks belonging to the same series, and of hypabyssic rocks associated with the former.

The total breadth of these zones of supercrustal rocks in the Tampere area is several thousand metres.

Similar rocks have a wide extension also in Ostrobothnia where they form smaller areas surrounded by younger granites. Also here conglomerates are common.

In the southernmost part of Finland volcanic rocks occur which have been included in the Bothnian rocks because very similar to those intercalated with the sedimentary rocks of the typical areas. They are basaltic in composition and texture, locally only slightly metamorphic, but in most cases uralitized (uralite-porphyrites or metabasalts). Pillow lavas are rather common among them (Fig. 10). They are associated with amygdaloid varieties and with tuffs (Fig. 11), and have everywhere the character of true

Fig. 9. Conglomerate alternating with beds of tuff. Island of Vähä-Lima in Lake Näsijärvi in south-western Finland.

Fig. 10. Pillow lava from Enklinge in Kumlinge in the archipelago of Aland.

Fig. 11. Agglomeratic metabasaltic tuff. Island of Stor-Brändholm in the Pellinge area, south Finland. 1 : 7.

volcanic surface rocks. Conglomerates have also been found intercalated, or else in near connection with them.

In the formations of Bothnian character, iron ores and, in most areas, limestones, are conspicuous by their absence and quartzites are very rare. The volcanic rocks are mainly basic, and we do not here observe the abundance of peculiar acid volcanic rocks which is so characteristic of the Svionian. There is thus a great difference in petro-chemical character between the two formations.

The rocks of the typical leptite formation are always penetrated by the oldest gneissose granites of the same regions. The question of the relations of the Bothnian schists of the typical area to rocks which could certainly be proved equal in age with the gneissose granites of the southern coast regions has long been mooted, but is not yet decided with certainty. Where the schists are in contact with mylonitized porphyritic granites S. of them, it may in places look as if they were sharply separated (Fig. 12), but the same granites have been shown to be indubitably younger than the schists. Other granites and granodiorites, again, occur as pebbles in conglomerates intercalated with the Bothnian schists and must thus have been exposed at the surface at the time of the deposition of these sediments. Porphyritic basic rocks outcropping S. of the schists also occur as pebbles.

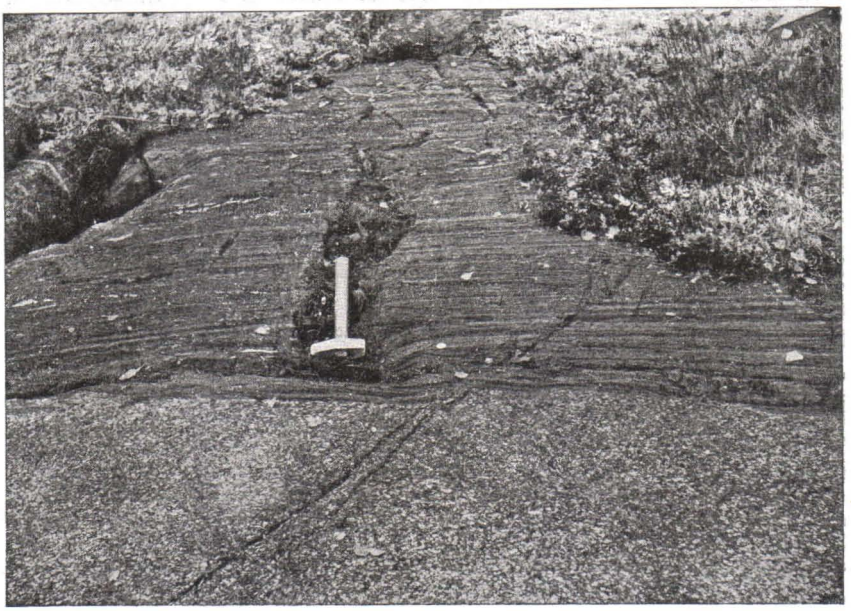

Fig. 12. Contact between Bothnian schists and mylonitized porphyritic granite. Matalajärvi in Kangasala, E. of Tampere (Tammerfors). 1 : 10.

As to certain metabasalts of the archipelago of south-western Finland, dykes which are connected with metabasalts occurring as sheets and which have everywhere the character of true volcanic fissure dykes, penetrate the gneissose granites, often at right angles to their parallel texture, showing that the volcanic activity by which these metabasalts were formed was later than the mountain building processes by which the granites received their gneissose structure. In one area, a conglomerate has been found, in association with metabasaltic rocks, at the base of sediments next to their contact with gneissose granites, and this conglomerate (Fig. 13—14) contains pebbles of the same granite which is thus obviously older.

Metabasaltic rocks and associated basic tuffs are common also in the typical areas of Bothnian sediments. All the facts mentioned seem to indicate that these sediments are not strictly conformable to the oldest schists, but separated from them by an epoch of mountain building, associated with the intrusion of granites, part of which were brought to the earth's surface by erosion before the younger series was deposited. The Bothnian period was, however, also a time of volcanic activity and unrest which may have been a continuation of that of the foregoing period.

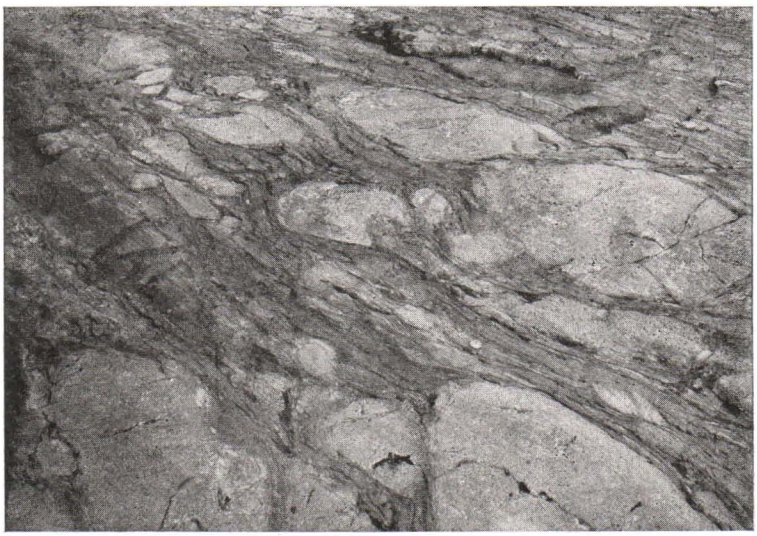

Fig. 13. Conglomerate containing pebbles of the gneissose granite which outcrops near to the conglomerate. Bockholm near Enklinge in Kumlinge in the archipelago of Aland. 1 : 10.

Among the post-Bothnian granites of southern and middle Finland, two different varieties exist which occasionally are well separated from each other, but at other places do not show any sharp delimitation. In one of these sub-groups, grey granites predominate which are often rich in mica or hornblende and in many cases have the character of striped gneissose rocks. This seems to be due to two different causes; in part they have assimilated schistose rocks or older gneissose granites, in part they have undergone pressure caused by movements which have taken place in the molten masses before their complete solidification or, in some cases, later. In the second subgroup, where the rocks are in general somewhat younger, massive granites prevail which are rich in potash feldspar and are more commonly reddish than grey. Porphyritic granites are common in this sub-group (Fig. 15), but also occur in the first mentioned group.

Dioritic varieties occur in both groups, but more often in the first mentioned sub-group.

Probably these granitic formations blend into each other at a greater depth. Closely connected with them occur also metabasites, i. e. different varieties of basic rocks, gabbros, etc. These have in most cases solidified earlier than the granites.

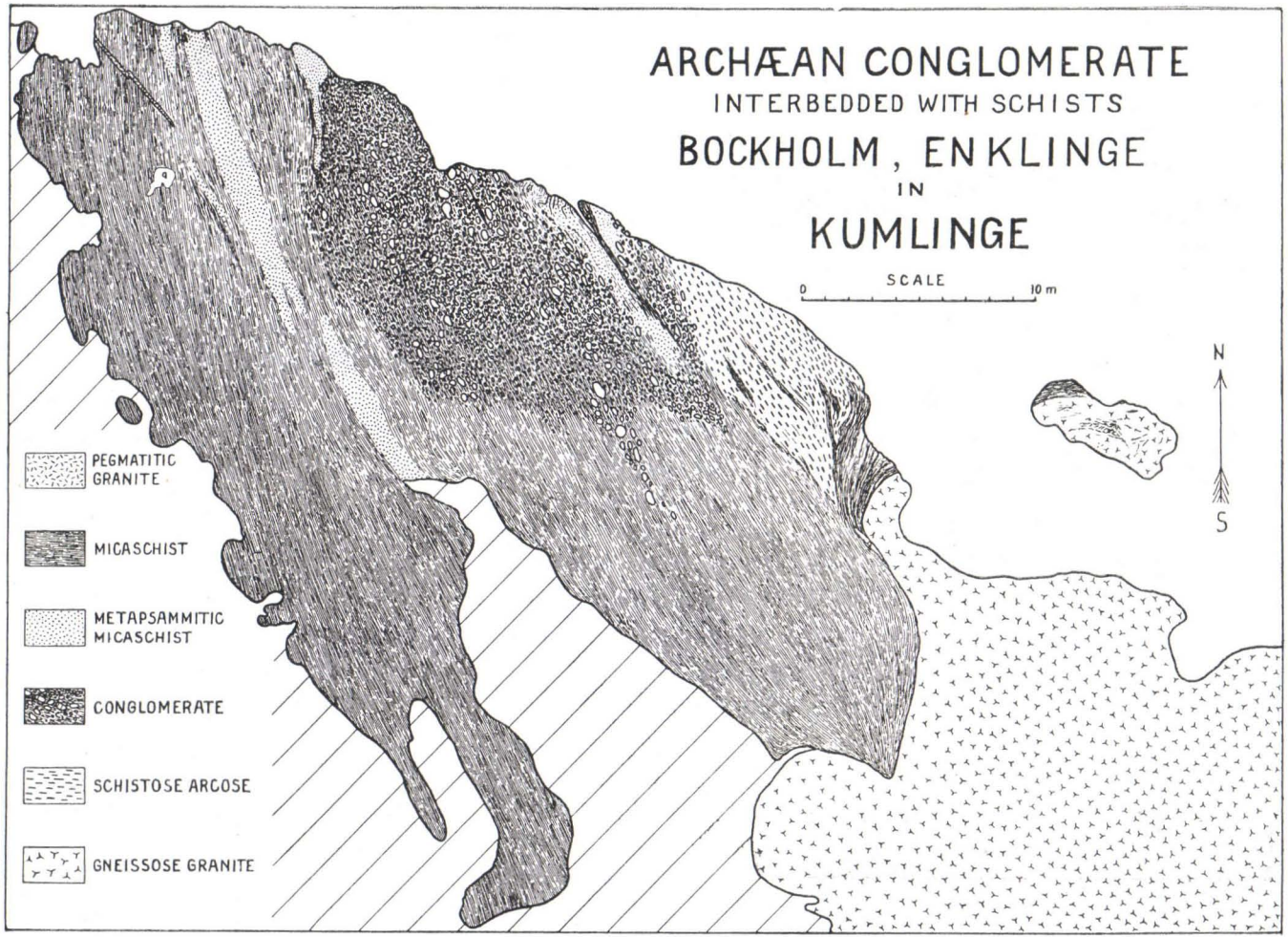

Fig. 14. Map showing the relation of the conglomerate of Bockholm to the adjacent gneissose granite.

Fig. 15. Porphyritic post-Bothnian granite from Lavia in south-western Finland. 1 : 5.

Especially in the coast regions of the Baltic and the Gulf of Finland, the penetration of granites into the schists of different ages is very intimate. A great part of the rock masses here consist of such migmatitic rocks (Figs. 16—19; cf. Figs. 4—6).

In the northernmost part of Finnish Lapland rocks occur which have been designated g r a n u l i t e s or l e p t y n i t e s. Although in general a little coarser than the typical granulites of Saxony, they are otherwise very similar to them. Most of these gneissose or schistose rocks (Fig. 20), which have a very varying chemical composition, are rich in garnet which is commonly a variety rich in magnesia. Most of the granulites are no doubt magmatic rocks which have been highly changed by mechanical action, accompanied by processes of recrystallization. In some cases metamorphic sedimentary rocks seem to be intercalated with the eruptives.

MIDDLE GROUP OF PRE-CAMBRIAN ROCKS.

In eastern Finland certain sedimentary rocks are common which present a strong contrast to the supercrustal rocks hitherto described. As mentioned above, they occur in zones which stretch almost continuously — interrupted only in the region N.W. of Lake

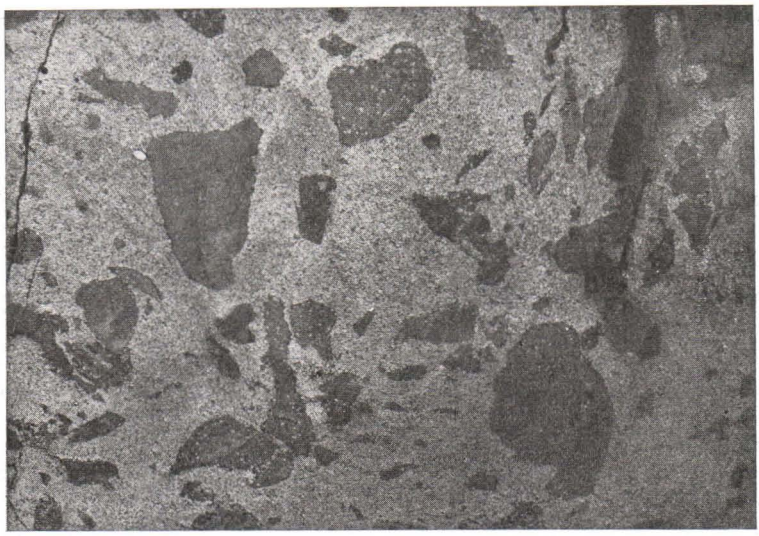

Fig. 16. Migmatite (agmatite) with fragments of schists. Islands of Ytterholmarna near Enklinge in Kumlinge archipelago of Aland.

Fig. 17. Arteritic migmatite showing ptygmatic folding of the veins. Island of Stickellandet in Sjundeå, W. of Helsingfors. 1 : 10.

Fig. 18. Arteritic migmatite from the island of Sottunga in the archipelago of Aland. 1 : 10.

Pielisjärvi — from Ladoga to the region around Lake Oulujärvi, and further to the north, to the Kuusamo region. In northern Finland and Lapland similar rocks have a wide extension along the lower course of the river Kemijoki and in Kittilä, Sodankylä and Kuolajärvi. There are also smaller areas within the great territory of gneissose granites that lies at the Russian boundary.

Many of these rocks possess a character which is similar to that of the unmetamorphic rocks of younger, fossiliferous series. Among them quartzites are common which show a clastic, sandstonelike texture and distinct ripple marks (Fig. 21), and there are conglomerates (Fig. 22), dolomites and fine-grained mica-schists and phyllites, in part quartzitic (Fig. 23). These seidmentary rocks are intercalated with beds of metabasites (metadiabases and metabasalts) which also occur alone over large areas.

Some of the conglomerates lie at the contacts with the gneissose granites which form the basement of the sediments and contain pebbles of these granites.

In the dolomites a structure has been found which has been regarded as a fossil organism, *Carelozoon jatulicum* Metzger (Fig. 24), possibly belonging to some class of animals related to the Tabulatæ.

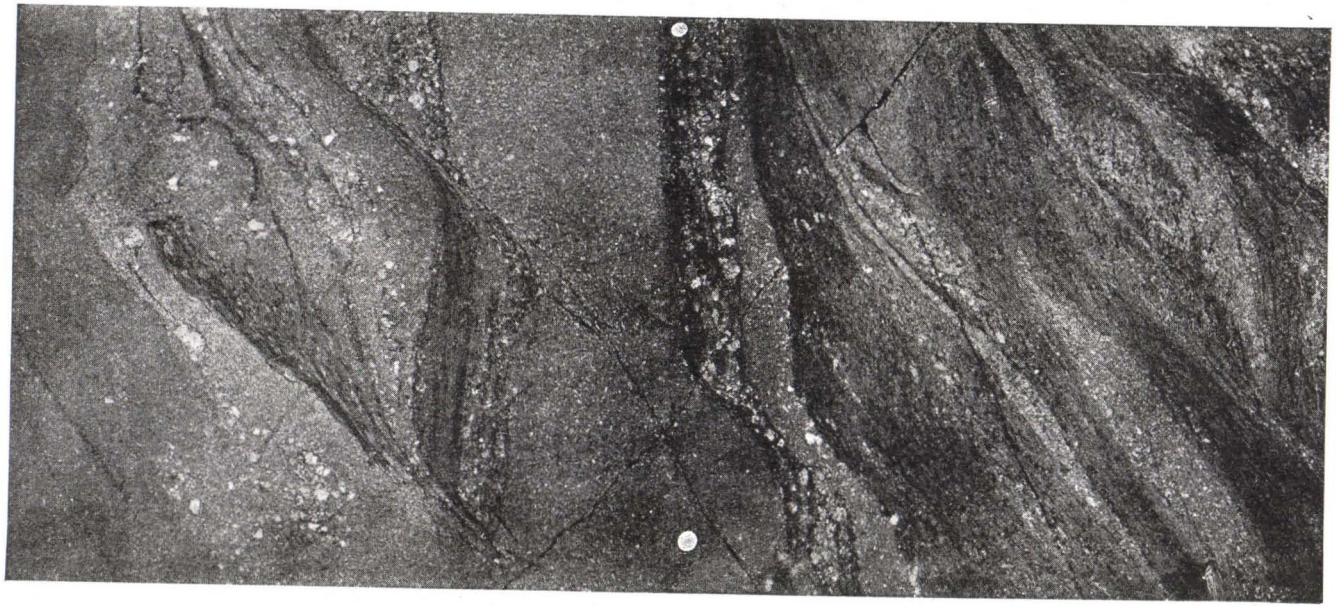

Fig. 19. Nebulitic migmatite (post-Bothnian granite with highly assimilated fragments of older rocks) from an island near Hangö at the southern shore of Finland. 1 : 10.

Fig. 20. Leptynite (granulite) from the river Ivalojoki in Lapland. 2 : 3.

Fig. 21. Sandstone-like quartzite from the Jatulian formation showing ripple marks. Kallinkangas in Kemi in northern Finland. 1 : 8.

Photo H. Berghell.

Fig. 22. Conglomerate from the Jatulian formation. Raatevaara in Kiihtelysvaara in eastern Finland. Photo W. W. Wilkman.

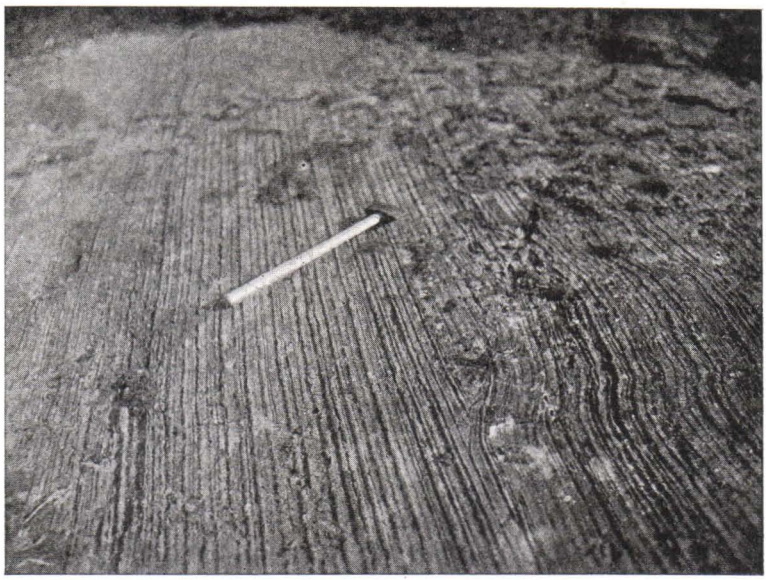

Fig. 23. Fine-grained quartzitic mica-schist. Naatselkä in Pälkjärvi in eastern Finland. Photo H. Hausen.

Fig. 24. *Carelozoon jatulicum* Metzger, in a Jatulian dolomite at the northern shore of Lake Suojärvi in eastern Finland. 5 : 6.

Thin layers of carbonaceous matter, so called s c h u n g i t e, have been found intercalated with the Jatulian schists which outcrop at the Schunga river in Russian Carelia and as numerous blocks, obviously derived from near-lying rock masses, at Suojärvi in Finland.

Besides the varieties of these sedimentary rocks which are only slightly metamorphic, there are others which gradually become more highly changed in composition and texture. The quartzites grade into q u a r t z i t i c s c h i s t s (Fig. 25), the dolomites become crystalline and the phyllites pass by gradations into coarser-grained mica-schists.

The sedimentary rocks of the areas where the primary sedimentary character and the stratigraphical features are best preserved, have been referred to a subdivision called J a t u l i a n. These rocks have for a long time been held to be younger than all the granites of the same areas (the youngest so called rapakivi granites excepted) and this view is still shared by some geologists. Those sedimentary rocks of the same regions which are more highly crystalline, penetrated by granites, sometimes even intimately injected with them so as to form migmatitic mixtures, have, again, been designated K a l e v i a n, and the granites penetrating them have accordingly been termed p o s t -

Fig. 25. Kalevian schistose quartzite (quartzitic schist) dipping at a low angle. Petrovaara in Juuka in eastern Finland.
Photo W. W. Wilkman.

K a l e v i a n g r a n i t e s. These granites form great areas in northern Finland and also occur in the region near Lake Oulujärvi and farther to the S.E. Among the rocks of Kalevian type phyllites and mica-schists, which are metamorphic slates and greywackes, are more common than in the Jatulian areas. Conglomerates (Fig. 26), quartzites and dolomites sometimes also occur in association with these schists. A valuable deposit of copper pyrites has been discovered at Outokumpu, W. of Joensuu, in a quartzite of Kalevian type. At other places, iron pyrites have been found.

There are, further, metamorphic sediments, outcropping near to Lake Ladoga, which in character are not very different from the Kalevian schists, but show a different succession of layers. Especially near to the shore of Lake Ladoga this succession is very regular, with dolomitic limestones, intercalated with layers of amphibolitic schists, next to the granitic basement, and phyllites, mica-schists (cf. Fig. 27) and quartzites higher up. These schists have been designated L a d o g i a n and have been regarded by some writers as older then the Kalevian; others have referred both of them to one and the same subdivision.

Fig. 26. Kalevian conglomerate containing pebbles of gneissose granite (in part migmatitic), quartzite and metabasite. S. of the parish church, Tohmajärvi in eastern Finland. 1 : 6.

Fig. 27. »Ladogian» mica-schist from the island of Tulolansaari in Lake Ladoga. 1 : 9.

In the areas where schists of Ladogian and Kalevian types outcrop, smaller areas of gneissose granites occur which are surrounded on all sides by the schists. The granites never penetrate the latter and their parallel texture has originated previously to the eruption of the metabasaltic dykes of the same regions (Fig. 28). The cases where intrusive contacts with the sediments have been indicated have been proved to be due either to the occurrence of granites belonging to a separate, younger group, or to a mechanical mixing up, caused by geotectonic movements, of both rocks at the contacts. It seems as if a considerable number of these contacts are in fact mechanical and do not possess a primary character.

Fig. 28. Pre-Ladogian migmatitic gneissose granite cut by a dyke of metabasalt which intersects the gneissose texture. Near the railroad station in Sortavala.

In the sedimentary areas of northern Finland, quartzites of Jatulian type occur, closely associated with more highly crystalline quartzites which have been referred to the Kalevian. It has lately been made clear, after a long-continued discussion of these relations, that there is, in these regions, and especially in Kuusamo, no unconformability between the two formations of quartzites, but that they gradually pass into each other. In general, the rocks of Kalevian type occur nearer to the penetrating granites which explains their

more metamorphic character. The so-called post-Kalevian granites must therefore also be post-Jatulian.

In Lapland a series of rocks exists, in Kittilä and Sodankylä, which are separated by a distinct unconformability, marked by basal conglomerates containing pebbles of all the underlying rocks, from sediments and basic eruptives of Kalevian type. The younger series has been included in the Jatulian. Now, however, it seems more probable that it is somewhat younger, since the quartzites which outcrop among the rocks unconformably underlying them have been found to grade into quartzitic sandstones of Jatulian type.

The relation of the youngest series to the »post-Kalevian granites» is not yet quite clear.

The large area of schists N. and N.W. of Lake Ladoga, is that to which the name Kalevian was first applied. At the eastern boundary of this area, rocks of Jatulian type outcrop next to the eastern contact of the schists, apparently overlaid by them. This has been interpreted, by different writers, either as a regular superposition of younger schists upon older quartzites or as due to overthrusts. The latter assumption has lately been proved to be correct. The schists were originally deposited much farther to the west upon an underlying complex of gneissose granites, and have arrived at their present position, in contact with the quartzites and associated dolomites, by overthrust movements of wide range. The age relations of both formations are therefore difficult to unravel in the regions in question.

The rocks of Jatulian type have the general character of sediments laid down upon a continental shelf. The schists again, which are extremely thick, probably 20,000 m, seem to have been deposited in a geosyncline.

It will be necessary to pursue the geotectonic study of the sedimentary rocks of eastern Finland in great detail, so as to show which of the rock masses really belong together, before we shall be able to arrive at a definite conception of the age relations. Although it seems probable, as already remarked, that the Jatulian and a great part of what has been called Kalevian are more closely associated than has been earlier thought by many authors, there are, on the other hand, certain facts that seem to indicate a relationship between schists of the Lake Ladoga region referred to the »Ladogian» and rocks of Bothnian type in western Finland.

It is in the easternmost part of Fenno-Scandia, in Russian Carelia where the sedimentary rocks are much less disturbed than in Finland and therefore their stratigraphical relations clearer, that

the final solution of many of the stratigraphical problems now under discussion will be reached. During the last few years, this region has not been accessible to geologists from the western parts of Fenno-Scandia.

It has been proposed to unite provisionally the rocks which have been called Jatulian, Kalevian and Ladogian, under the common name of K a r e l i a n rocks. According to another proposal the same word should designate the epoch of diastrophism during which the sediments in question were folded and the post-Kalevian granites intruded. The now levelled old mountain chains which originated at that epoch should thus be called K a r e l i d e s (the name L a p p o-K a r e l i d e s has also been used). Their geotectonic study has shown that they possess a structure entirely analogous to that of younger mountain chains — as e. g., the Alps of southern Europe — being composed of a number of rather flat-lying sheet-like blocks which have been thrust over each other (Fig. 29). During these movements, the underlying gneissose granites, in part also the sedimentary rocks, have been mylonitized and stretched.

The strikes of the arcuate zones that mark the site of the old Karelidic mountain chains, follow in the southernmost part directions from S.S.E. to N.W., more to the north from S. to N., while they possess in northern Finland more east-westernly directions. In Russian Carelia, the strikes of similar sedimentary rocks are in general in a N.W. direction.

Besides the variations in the dips of the sedimentary rocks, great differences in the pitch of the axes of the folds are conspicuous. Consequently, we find in this old mountain chain, an alternation of portions where the granitic basement forms culminations and others where it forms depressions.

During the epoch of mountain building, basic eruptive rocks were intruded, and finally the intrusion of great masses of »post-Kalevian granites» took place.

Among these post-Kalevian granites of northern Finland reddish varieties rich in microcline prevail. Both equigranular and, more rarely, porphyritic rocks occur. The quartz is often bluish, the plagioclase has a yellowish tint. In the region S. of Lake Oulunjärvi, and in Carelia, grey granites intruded in schists of Kalevian type also occur.

In certain regions, these post-Kalevian granites are clearly separated from the post-Bothnian granites of the type prevailing in the large central area of Finland and on the southern coast. In the last mentioned region some granites (Fig. 30—31) occur which

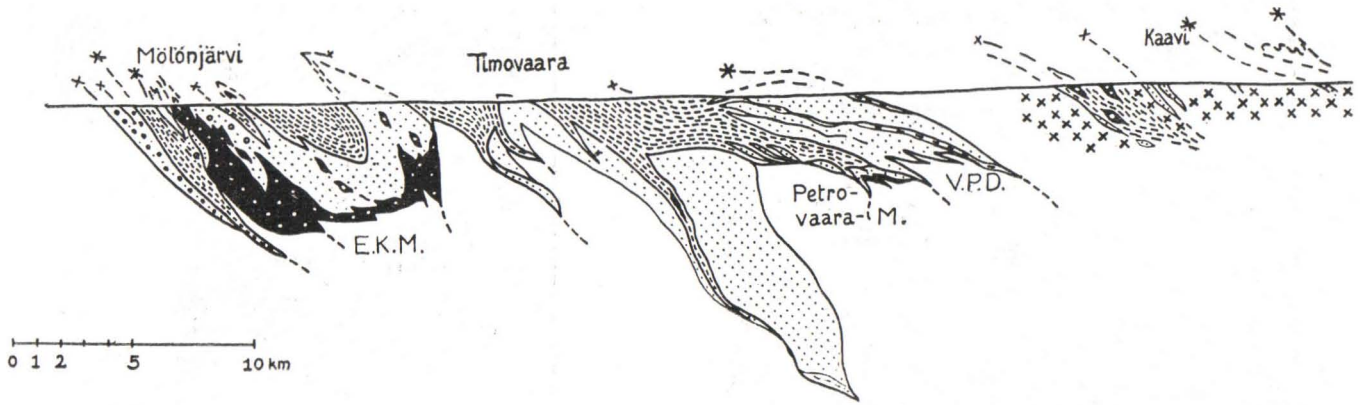

Fig. 29. Diagram section to show the geological structure of the schists of eastern Finland, from Mölönjärvi in Juuka eastwards to Kaavi. Drawn by Eug. Wegmann.

Explanation of the signs:
White: Gneissose granites.
Smaller and larger dots: Quartzites of the Jatulian zone.
Small dots: Quartzites of the Kalevian zone.
Short lines: Phyllites and mica-schists.
Black with white dots: Greenstones.
Crosses: Younger granites.
E. K. M.: Massif of Eno-Kontiolahti.
Petrovaara-M.: Massif of Petrovaara.
V. P. D.: Wedges of Vesivaara and Nappe of Paltamo.

Fig. 30. Granite of the third group, containing a basic fragment, from the Obbnäs area in southern Finland. 1 : 12.

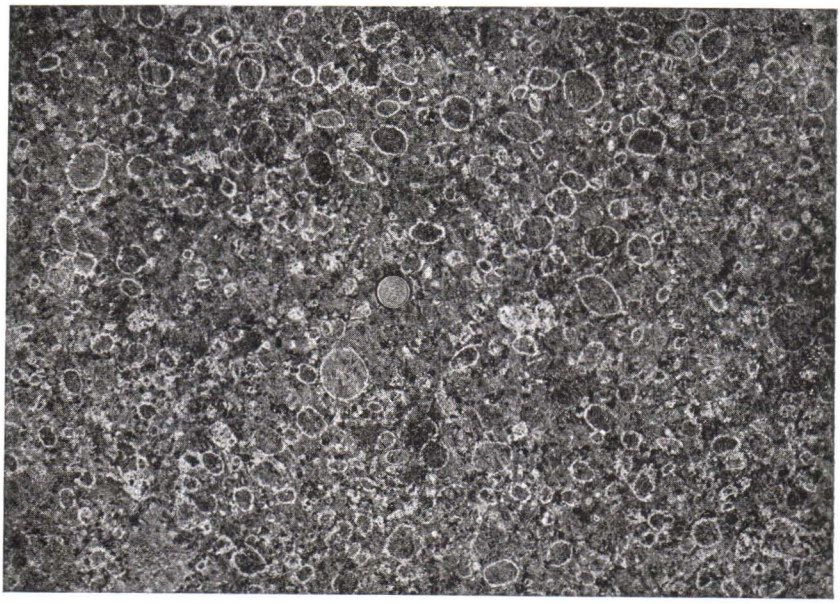

Fig. 31. Typical rapakivi from the area of Viipuri (Viborg). 1 : 5.

show a certain resemblance to the post-Kalevian granites of northern Finland and are very clearly intrusive in those of the second group in which are included the post-Bothnian granites.

It can only be shown by continued geotectonic and petrological study, to what extent the mountain-making movements that have created the Karelides have affected the structure of the central parts of Fenno-Scandia. In any case, here also traces of mountain-making processes are visible that are certainly older. The strikes in the Sveco-Fennian range, which continue from middle Sweden over southern Finland, preponderantly follow directions from W.S.W. to E.N.E. We observe schists with similar strikes also in areas lying between zones with strikes in N.W. directions belonging to the Karelides. The mountain chains characterized by the older strikes have been designated S v e c o - F e n n i d e s.

The unconformebility between the Kalevo-Jatulian deposits and those older sediments which are penetrated by the oldest, gneissose granites is certainly very great, because large masses of the oldest granites have been entirely uncovered by erosion before the deposition of the younger series.

As to the nomenclature, it has long appeared a difficult question to decide whether the sediments belonging to the younger of the groups mentioned should be referred to the »Archæan» or to a later »Proterozoic» group. Most of the Jatulian and large parts of what has been called Kalevian have a character very similar to that of the Huronian formations of Canada which have long been included in a post-Archæan group. Other portions, again, of the sedimentary deposits in question of Fenno-Scandia which are more highly metamorphic and mixed up with granitic veins, decidedly possess the character which we commonly observe among »Archæan» rocks.

In the light of the results of research in different parts of Fenno-Scandia, it seems obvious that the occurrence of such highly metamorphic and strongly granitised pre-Cambrian rocks of Archæan type is by no means restricted to a certain oldest period. As is well known, similar crystalline rocks occur in various parts of the world within restricted areas which have undergone diastrophism during post-Cambrian times, and it is equally possible that the pre-Cambrian sediments have locally been much more changed than in adjacent regions.

As the mountain building processes in early post-Jatulian time seem to have been entirely similar in character to those which have taken place in the latest times of geological history, we are able to conclude that the geophysical conditions in the earth's crust were

the same at that early epoch as they were later. Areas of lability and of greater resistance obviously existed simultaneously already then. The mountain building has not been ubiquitous during the epoch of diastrophism following the deposition of the Jatulian and the Kalevian. In the same way, the granites of this epoch are obviously restricted to certain zones. On the whole, the prevalent belief that a universal mountain building and folding was going on all over the earth's crust during Archæan time, seems to have little foundation in established facts. It is much more probable that diastrophism at all geological epochs has been restricted to narrow belts of the earth's crust.

In any case it is evident that the crystalline schists of Finland form a series in which sediments and other supercrustal rocks of very different ages are represented, and that this area has seen many vicissitudes even during the earliest epochs of its history. Periods of erosion and calm sedimentation have several times been interrupted by epochs of orogenetic folding and intrusion of granites, in the same way as in Canada and other countries of the world whose rocky substructure, like that of Finland, consists in great part of pre-Cambrian crystalline rocks.

YOUNGEST PRE-CAMBRIAN, PALEOZOIC AND LATER ROCKS.

Towards the end of the pre-Cambrian era, the mountain ranges formed during this era were destroyed by weathering and other erosion processes, and a land surface appeared which was in the main horizontal. The protuberances which were formed later have in the same way been obliterated, so that the land surface retained its character of a peneplain.

Lying upon the fundamental complex of ancient rocks or, in some cases, sunk in their upper parts, younger sedimentary deposits occur in a few places. Well defined areas of younger eruptive rocks exist also, which have erupted through the older rocks.

The most important among the latter are the »r a p a k i v i» g r a n i t e s which are characteristic of Finland. They occur in some rounded areas in southern Finland. One of these, lying near Viipuri (Viborg) is one of the largest areas of eruptive rocks existing. It seems probable that these rocks occur as eruptive sheets which have been formed near to the earth's surface under a thin cover of overlying rocks. In part the same magma has formed effusive sheets, consisting of q u a r t z - p o r p h y r i e s, upon the earth's surface. Outcrops of such rocks, associated with tuffs, occur, e. g., in the island

of Suursaari (Hogland) in the Gulf of Finland. Between the quartz-porphyry and its basement, a layer of conglomerate with quartzitic pebbles is intercalated.

All the granitic rocks in question are characterized by their massive (never gneissose) structure, their deep red or brownish red colours, commonly an easy weathering (rapakivi = weathered stone) and their peculiar textures. They show gradations between quartz-porphyries and coarse-grained porphyritic granites in which rounded crystals of potash feldspar are surrounded by covers of plagioclase that appear as lighter rings in the surface of the rock (Fig. 31). In chemical composition they are rather uniform and rich in potash.

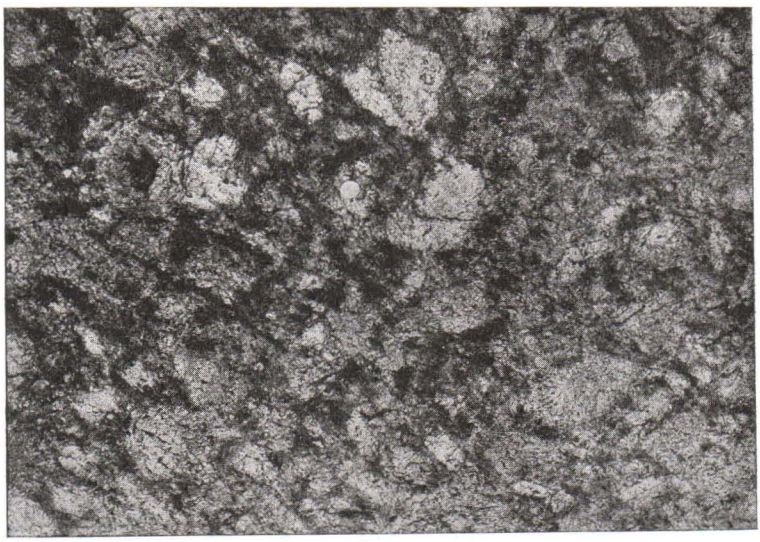

Fig. 32. Ossipite. Höggrund, Eckerö, Aland Islands. 1 : 6.

At Pitkäranta, at the shore of Lake Ladoga, ores connected with the rapakivi have been mined.

Closely connected with the rapakivi granites in distribution, but somewhat older than these, are the basic rocks which on the map have been designated as anorthosite, ossipite (Fig. 32) and diabase. The term ossipite is here used in the sense proposed by Niggli and refers only to the chemical composition. An area of anorthosite occurs at the river Tenojoki (Tana) near the Norwegian boundary, in association with the leptynites. Its age is probably much greater than that of the above mentioned rocks.

Younger than the rapakivi is the »Jotnian» sandstone in Satakunta (Fig. 33), and the Jotnian olivine-diabase, which is younger than the sandstone of the same region, and probably also the diabases which occur on islands in Lake Ladoga.

The white quartzitic sandstone (Fig. 34) in the region S. of Vaasa (Vasa) is probably of Cambrian age, since it entirely

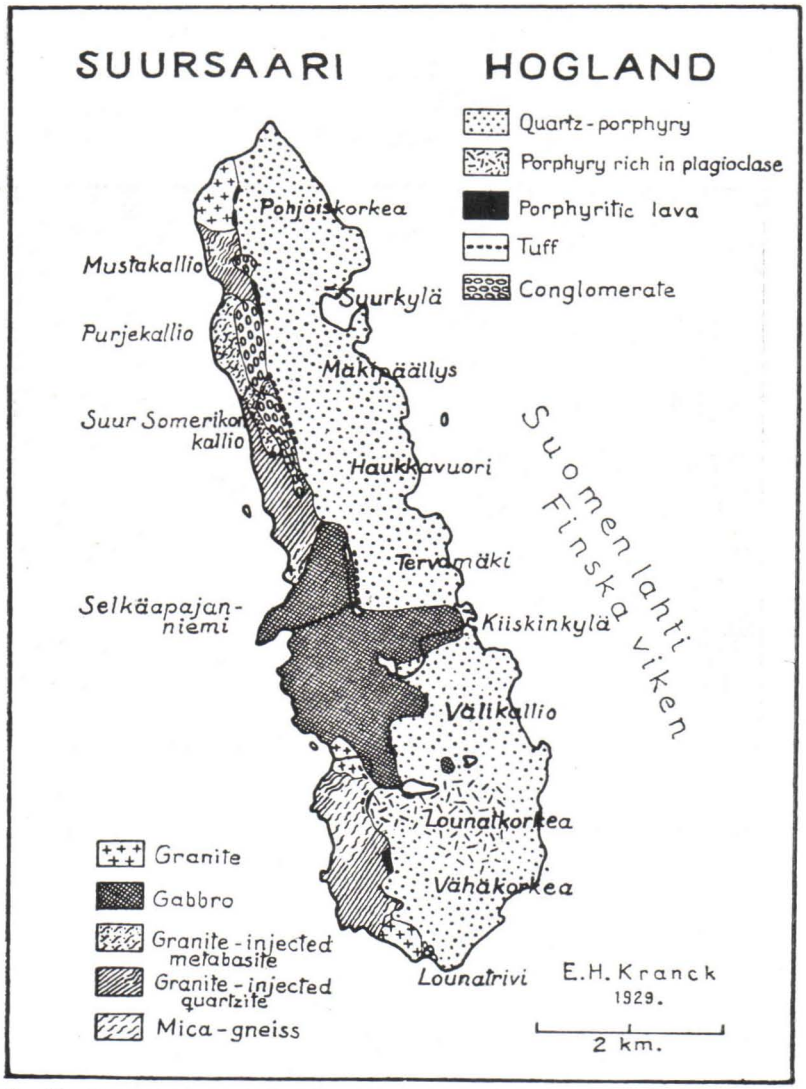

Fig. 33. Geological map of the island of Suursaari (Hogland) in the Gulf of Finland. Drawn by E. H. Kranck.

Fig. 34. Sandstone, probably of Cambrian age, from Kauhajoki in western Finland. 1 : 4.

resembles the fossiliferous sandstone which occurs as dykes on the southern coast and in Aland. Further, a bluish grey Cambrian clay is found on the isthmus between Lake Ladoga and the Gulf of Finland. It is in great part covered by Quaternary deposits, and its extension is therefore difficult to determine.

Paleozoic schists (of Cambrian age) also occur in the Scandinavian mountain range in the N.W. part of Enontekiö in Lapland.

In the Petsamo area, in the Fisher's Peninsula, on the coast of the Arctic Sea, sandstones, conglomerates (Fig. 35), slates and schists occur which are probably of Cambrian age. Overthrusts have taken place in these formations in connection with the Caledonian folding; they are directed from north to south. Along these thrust planes the conglomerates have been strongly brecciated (Fig. 39; cf. the stereogram in Fig. 40).

In the mountain range which is called Petsamon Tunturit, metabasaltic rocks, showing pillow lava structure, metadiabases and serpentinized peridotites occur, in association with conglomerates, arkoses, quartzites, dolomites and schists. In the peridotites, ores with fairly high contents of nickel and copper have been found. The rocks of Petsamon Tunturit have been indicated by the colours of Paleozoic rocks. The near-lying sedimentary rocks of Petsamo and the Varan-

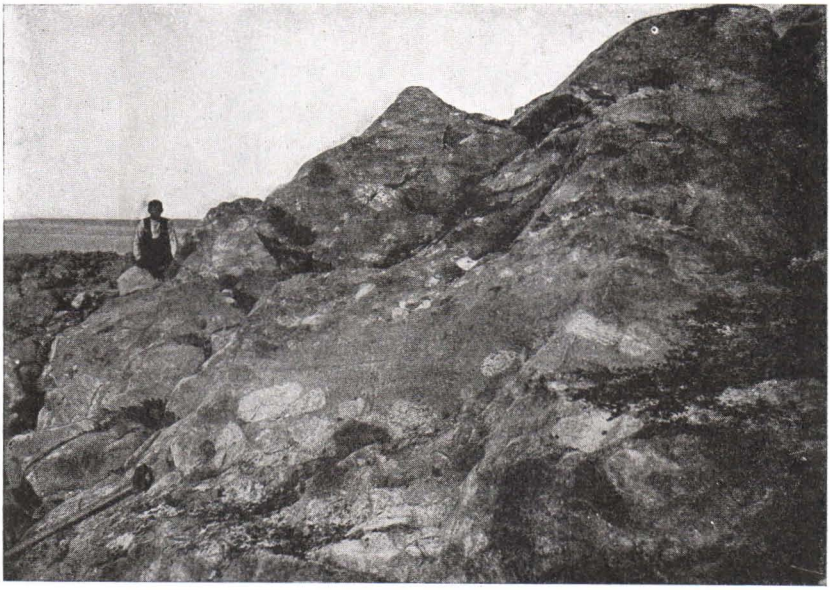

Fig. 35. Conglomerate. Peninsula of Väliniemi in the Pummanki Fiord.

Fig. 36. Brecciated conglomerate from a thrust plane N. of Pummanki at the Fisher's Peninsula.

ger Peninsula however show a different sequence. The previously mentioned rocks have been rather strongly dislocated by overthrust movements from east to west, which are different in character and direction from those which the Cambrian rocks experienced later. It therefore now seems more probable that the rocks of Petsamon Tunturit are older than the Cambrian. If this assumption is correct, we must conclude that a mountain building activity of local extension took place in late pre-Cambrian time.

A couple of years ago an outcrop of Ordovician limestone was discovered at very low water in the bay Lumparen, which is situated in the rapakivi area of the Aland Islands. Numerous blocks found in the neighbourhood also indicate that Paleozoic rocks, possibly also Jotnium, occur here at the bottom of the bay. No doubt, encroachments of the sea over great parts of south-western Finland took place at different epochs in Jotnian, Cambrian and Ordovician time.

Nepheline-bearing rocks (ijolite and nepheline porphyry), probably genetically connected with the similar rocks in the Peninsula of Kola, and Devonian in age, occur in a few small areas in Kuusamo and Kuolajärvi in northern Finland.

At some places in eastern and northern Finland, small deposits of impure kaolin have been found which seem to have been formed by the weathering of the older rock masses, possibly in Mesozoic time.

Volcanic andesite, partly quartziferous (dacite), occurs at two places, in Lake Lappajärvi in the province of Vaasa (Vasa), and in Lake Jänisjärvi in Carelia. This rock is of very late, possibly Tertiary, age. Another andesitic rock occurs associated with the metadiabases of the Petsamo region. It has been indicated by the same colour as the above mentioned younger andesites.

The colour table given with the map shows the sequence in age of the rocks there enumerated, beginning from the youngest and ending with the oldest, as was thought probable at the time when the map was compiled.

The character of the rocks has in some degree determined their topography and vegetation. The predominating granites generally form small, rounded hills, while the schists are often found as elongated ridges, in Finnish called vaaras, especially where the movement of the ice has been parallel to the strike of the rocks. The quartzites, which have better resisted the influence of eroding agencies because of their hardness, ; form the highest mountains in every region. The vegetation on them is often very poor whereas the rocks consisting of schists and basic rocks offer a better soil for the plants.

THE MAP OF THE ROCKS OF FENNOSCANDIA.

The small map of the rocks of northern Europe, which is annexed to the map of the rocks of Finland, can, because of its small scale, give only a very summary idea of the geology of Fennoscandia. We may therefore refer to the map of Fennoscandia on a somewhat larger scale, which was published in Atlas de Finlande (1910), and also appeared, with accompanying notes in French, as No. 24 of the present bulletin.

Even the small map now published shows how sharply Fennoscandia is marked off from the surrounding sedimentary areas, in which the crystalline rocks are completely covered by younger fossiliferous sedimentary deposits.

It also shows how great is the similarity between the general geological structure of Finland and that of the adjacent regions in the west and the east.

Certain zones of rocks continue over the political boundaries or under the water of the separating seas.

Thus, we find, in the region N.W. of Lake Onega, formations of Jatulian type which are in great part surrounded by gneissose granites. Younger granites and different schists, however, also occur, but the details of the older rocks are little known.

Along both shores of the Gulf of Bothnia and the northern Baltic, granitic areas exist which closely correspond to each other. Thus, the granites of the central area of Finland and the granites of »Revsund type» in the Skellefteå region in Sweden are very similar to each other. There are rapakivi granites on both sides of the sea. The youngest among the granites of southern Finland which chronologically immediately precede the rapakivi, seem further to be correlated with the Småland granites of southern Sweden.

There is, however, still controversy about the relative age of the granites of post-Kalevian type and those of the central area and associated granites which have been designated post-Bothnian. In Sweden it has long been thought that there is only one group of late Archæan or, as they have also been called, ser-Archæan granites. The rocks here referred to the third group are thus included in a subgroup of the second group. The granites of Bohus Län in southwestern Sweden are, however, regarded as rather definitely younger than some of the granites here referred to the second, or even to the third group.

Certain zones of Archæan schists continue under the sea. For instance the Bothnian zones in Ostrobothnia have a continuation

in the schists of the Skellefteå area at the Swedish side. They form together what may be called the trans-Bothnian zone.

At the northern boundary of this zone there is an abrupt change in the directions of the strikes of the Archæan rocks which north of this line are from north to south, a fact which obviously has a great geotectonic importance.

The leptites of southern Finland have also a continuation in the leptitic zones of middle Sweden. Both form together the Sveco-Fennian zone.

Those formations of schists which have the widest distribution in Finland, especially in the eastern and northern parts, seem to occupy a much smaller area in Sweden, where the greatest part of the schists belongs to the oldest leptitic formations. The zone in northern Sweden which is rich in iron ores does not continue to the Finnish side, but strikes in a north-southerly direction, parallel to the boundary.

In western Sweden, uniform areas of granitic gneisses exist which are analogous to those of eastern Fennoscandia. The regions which lie between these gneissose areas have a much more complicated geological structure in both countries.

Overthrusts have obviously taken place not only along, or in the neighbourhood of the boundaries between the central regions and the peripheral gneissose areas, but also within the latter areas which are thus geotectonically less simple than they appear at the first glance.

The Paleozoic areas of Sweden have few representatives in Finland, and the broad zone of folded Paleozoic sediments which forms the main part of the rock masses of the Scandinavian mountain range, passes through Finnish territory only in Enontekiö.

The sandstone formations of the Fisher's Peninsula in the Arctic Sea, may be correlated with the Norwegian formations in which the well known tillite of Varanger Fiord (Fig. 37) is intercalated. Similar rocks have lately been found although in small measure, also on the Finnish side of the fiord (Fig. 38), intercalated between psammitic and pelitic sediments. The iron ores, alternating with thin layers of a finegrained quartzite (Fig. 37), which occur in Norway at the southern coast of Varanger Fiord, do not continue to the Finnish side of the boundary, because the Petsamon Tunturit formation has been deposited unconformably upon these older sedimentary rocks, with which conglomerates are also associated, and the granites penetrating them. Quite similar banded iron ores occur in Finland in the Kittilä area, in the Karelidic mountain chain.

Fig. 37. Morainic conglomerate (tillite), lying upon sandstone showing glacial striæ. (Dr H. Reusch's classical locality), between Bigganjarga and Rappanjoaske at the shore of the Varanger Fiord in Norway.

Fig. 38. Psammitic and pelitic sediments, probably Cambrian in age, containing an intercalated layer of morainic conglomerate. Northern shore of the Pummanki Fiord at the Fisher's Peninsula in Petsamo, Finland.

Fig. 39. Magnetite iron ore alternating with quartzitic layers. Northern shore of Lake Björnevand in Syd-Varanger in Norway. 1 : 6.

The relations between the Paleozoic sediments of northern Norway and the Fisher's Peninsula, which have taken part in the Caledonian foldings, the formation of Petsamon Tunturit, which has undergone movements in a different direction and earlier than the epoch mentioned, and the oldest ore-bearing granite-injected crystalline schists, are shown by Fig. 40. Three intersecting mountain chains of different ages and different types here occur in a restricted area.

The geological unity of Fennoscandia is everywhere obvious. More details may be found in the explanatory text to the map of Fennoscandia in the Atlas de Finlande 1910 and Bull. Comm. géol. Finl. No. 24.

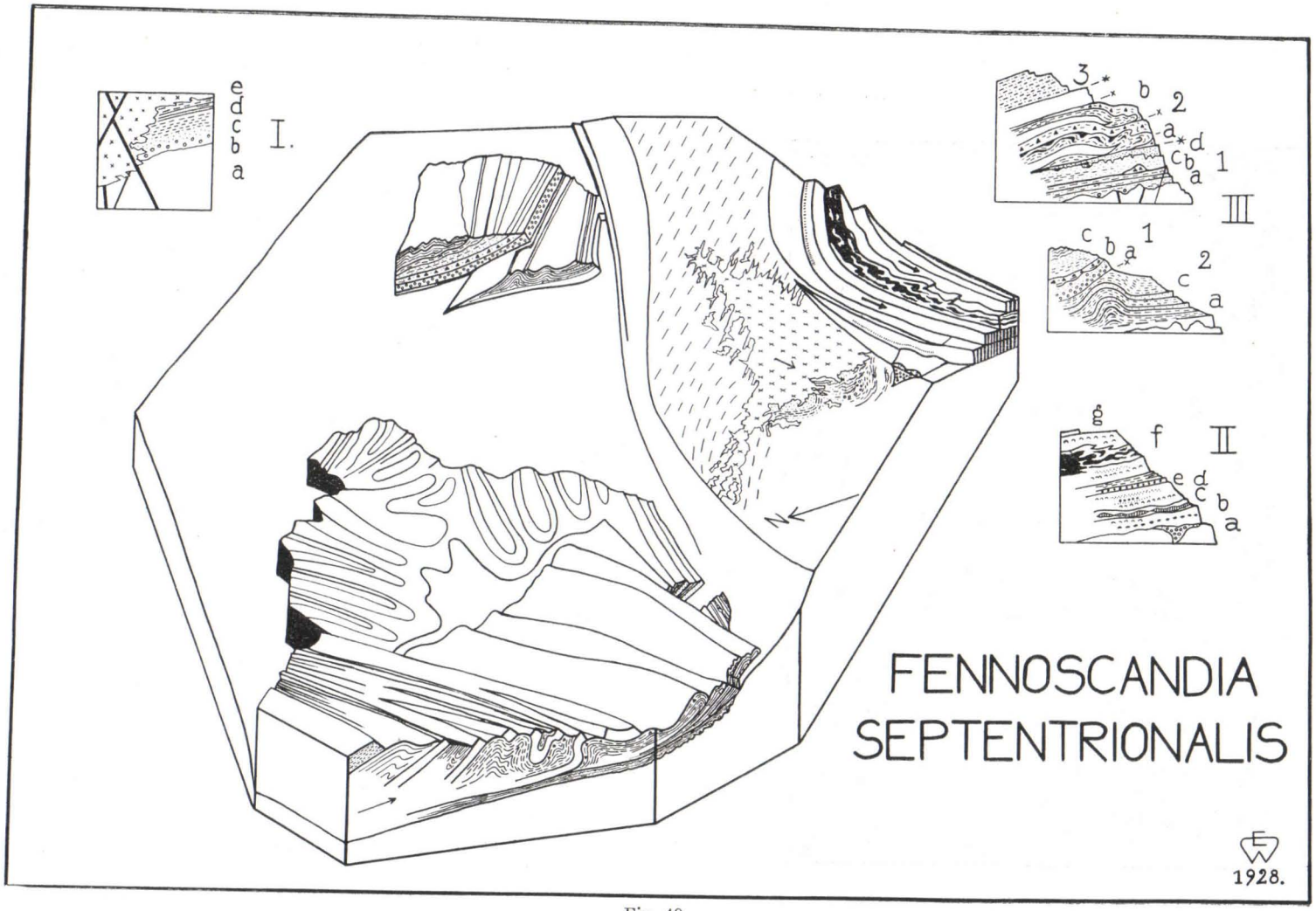
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Fig. 40.

Fig. 40. Stereogram showing the geotectonic structure of the region around Varanger Fiord at the Arctic Sea: Fennoscandia Septentrionalis. Drawn by Eug. Wegmann, 1928.

To the right: the crystalline rocks of Syd-Varanger and Petsamo, (section I) overlain by the sediments and basic eruptive rocks of Petsamon Tunturit (section II).

To the left, below: Paleozoic sediments of the Varanger Peninsula (III, upper section) and above: similar rocks of the Fisher's Peninsula (III lower section).

I. Crystalline rocks of Syd-Varanger and Petsamo.
   - a Gneissose granite.
   - b Conglomerate.
   - c Quartzite and mica-schist.
   - d Iron ore.
   - e Younger granite.

II. Formation of Petsamon Tunturit.
   - a Töllevi-Næverskrug conglomerate.
   - b Diabase and amygdaloid rocks.
   - c Quartzite and dolomite.
   - d Diabase with agglomerates, conglomerates and pillow lavas.
   - e Arkose and schist.
   - f Schist with serpentine and nickel ore.
   - g Andesitic rocks.

III. Paleozoic rocks of the Varanger Peninsula (upper section) and the Fisher's Peninsula.

1. a Basal conglomerates, sandstones and marls.
   - b Tillite (morainic conglomerate), Bigganjarga type.
   - c Sandstones overlying the tillite.
   - d Dolomitic conglomerate and sandstones.
2. Red and green schists with dolomite (in the core of the folds light quartzites).
   - f Tillite, Maartensnes type.
   - c Sandstones and schist.
3. More or less metamorphic schists.

In Varanger (III, upper section) is 1 autochtonous, 2 parautochtonous and 3 allochtonous, forming part of the Caledonian mountain chain proper.

In the Fisher's Peninsula is 1 overthrust and 2 autochtonous.

Fascicules parus du Bulletin de la Commission géologique de Finlande.

N:o 1. Cancrinitsyenit und einige verwandte Gesteine aus Kuolajärvi, von Wilhelm Ramsay und E. T. Nyholm. Mit 4 Figuren im Text. Maj 1896 ..... 15: —

N:o 2. Ueber einen metamorphosirten präcambrischen Quarzporphyr von Karvia in der Provinz Åbo, von J. J. Sederholm. Mit 12 Figuren im Text. Dec. 1895 15: —

N:o 3. Till frågan om det senglaciala hafvets utbredning i Södra Finland, af Wilhelm Ramsay, jemte Bihang 1 och 2 af Victor Hackman och 3 af J. J. Sederholm. Med en karta. Résumé en français: La transgression de l'ancienne mer glaciaire sur la Finlande méridionale. Febr. 1896 ..... 25: —

N:o 4. Ueber einen neuen Kugelgranit von Kangasniemi in Finland, von Benj. Frosterus. Mit 2 Tafeln und 11 Figuren im Text. April 1896 ..... 20: —

N:o 5. Bidrag till kännedomen om Södra Finlands kvartära nivåförändringar, af Hugo Berghell. Med 1 karta, 1 plansch och 16 figurer i texten. Deutsches Referat: Beiträge zur Kenntnis der quartären Niveauschwankungen Süd-Finnlands. Mai 1896 ..... 30: —

N:o 6. Über eine archäische Sedimentformation im südwestlichen Finnland und ihre Bedeutung für die Erklärung der Entstehungsweise des Grundgebirges, von J. J. Sederholm. Mit 2 Karten, 5 Tafeln und 96 Figuren im Text. Febr. 1899 75: —

N:o 7. Über Strandbildungen des Litorinameeres auf der Insel Mantsinsaari, von Julius Ailio. Mit 1 Karte und 8 Figuren im Text. April 1898 ..... 25: —

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N:o 10. Les dépôts quaternaires en Finlande, par J. J. Sederholm. Avec 2 figures dans le texte et 1 carte. Nov. 1899 ..... 25: —

N:o 11. Neue Mitteilungen über das Ijolithmassiv in Kuusamo, von Victor Hackman. Mit 2 Karten, 12 Figuren im Text und 4 Figuren auf einer Tafel. März 1900 25: —

N:o 12. Der Meteorit von Bjurböle bei Borgå, von Wilhelm Ramsay und L. H. Borgström. Mit 20 Figuren im Text. März 1902 ..... 20: —

* N:o 13. Bergbyggnaden i sydöstra Finland, af Benj. Frosterus. Med 1 färglagd karta, 9 taflor och 18 figurer i texten. Deutsches Referat: Der Gesteinsaufbau des südöstlichen Finland. Juli 1902 ..... 70: —

N:o 14. Die Meteoriten von Hvittis und Marjalahti, von Leon. H. Borgström. Mit 8 Tafeln. April 1903 ..... 25: —

N:o 15. Die chemische Beschaffenheit von Eruptivgesteinen Finlands und der Halbinsel Kola im Lichte des neuen amerikanischen Systemes, von Victor Hackman. Mit 3 Tabellen. April 1905 ..... 30: —

N:o 16. On the Cancrinite-Syenite from Kuolajärvi and a Related Dike rock, by I. G. Sundell. With one plate of figures. August 1905 ..... 15: —

N:o 17. On the Occurrence of Gold in Finnish Lapland, by Curt Fircks. With one map, 15 figures and frontispiece. Nov. 1906 ..... 20: —

N:o 18. Studier öfver Kvartärsystemet i Fennoskandias nordliga delar. I. Till frågan om Ost-Finmarkens glaciation och nivåförändringar, af V. Tanner. Med 23 bilder i texten och 6 taflor. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fenno-Scandia. I. Sur la glaciation et les changements de niveau du Finmark oriental. Mars 1907.. 50: —

N:o 19. Die Erzlagerstätten von Pitkäranta am Ladoga-See, von Otto Trüstedt. Mit 1 Karte, 19 Tafeln und 76 Figuren im Text. November 1907 ..... 120:—

N:o 20. Zur geologischen Geschichte des Kilpisjärvi-Sees in Lappland, von V. Tanner. Mit einer Karte und zwei Tafeln. April 1907 ..... 15: —

* Epuisée.

N:o 21. Studier öfver kvartärsystemet i Fennoskandias nordliga delar. II. Nya bidrag till frågan om Finmarkens glaciation och nivåförändring ar, af V. Tanner. Med 6 taf.or. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fenno-Scandia. II. Nouvelles recherches sur la glaciation et les changements de niveau du Finmark. Juni 1907.... 50: —

N:o 22. Granitporphyr von Östersundom, von L. H. Borgström. Mit 3 Figuren im Text und einer Tafel. Juni 1907 ..... 15: —

N:o 23. Om granit och gneis, deras uppkomst, uppträdande och utbredning inom urberget i Fennoskandia, af J. J. Sederholm. Med 8 taflor, en planteckning, en geologisk öfversiktskarta öfver Fennoskandia och 11 figurer i texten. English Summary of the Contents: On Granite and Gneiss, their Origin, Relations and Occurrence in the Pre-Cambrian Complex of Fenno-Scandia. With 8 plates, a coloured plan, a geological sketch-map of Fenno-Scandia and 11 figures. Juli 1907 ..... 50: —

N:o 24. Les roches préquaternaires de la Fenno-Scandia, par J. J. Sederholm. Avec 20 figures dans le texte et une carte. Juillet 1910 ..... 25: —

N:o 25. Über eine Gangformation von fossilienführendem Sandstein auf der Halbinsel Långbergsöda-Öjen im Kirchspiel Saltvik, Åland-Inseln, von V. Tanner. Mit 2 Tafeln und 5 Fig. im Text. Mai 1911 ..... 15: —

N:o 26. Bestimmung der Alkalien in Silikaten durch Aufschliessen mittelst Chlorkalzium, von Eero Mäkinen. Mai 1911..... 10: —

* N:o 27. Esquisse hypsométrique de la Finlande, par J. J. Sederholm. Avec une carte et 5 figures dans le texte. Juillet 1911..... 20: —

* N:o 28. Les roches préquaternaires de la Finlande, par J. J. Sederholm. Avec une carte. Juillet 1911 ..... 20: —

N:o 29. Les dépôts quaternaires de la Finlande, par J. J. Sederholm. Avec une carte et 5 figures dans le texte. Juillet 1911..... 20: —

N:o 30. Sur la géologie quaternaire et la géomorphologie de la Fenno-Scandia, par J. J. Sederholm. Avec 13 figures dans le texte et 6 cartes. Juillet 1911.... 30: —

N:o 31. Undersökning af porfyrblock från sydvästra Finlands glaciala aflagringar, af H. Hausen. Mit deutschem Referat. Mars 1912 ..... 20: —

N:o 32. Studier öfver de sydfinska ledblockens spridning i Ryssland, jämte en öfversikt af is-recessionens förlopp i Ostbaltikum. Preliminärt meddelande med tvenne kartor, af H. Hausen. Mit deutschem Referat. Mars 1912 ..... 20: —

N:o 33. Kvartära nivåförändringar i östra Finland, af W. W. Wilkman. Med 9 figurer i texten. Deutsches Referat. April 1912..... 25: —

N:o 34. Der Meteorit von St. Michel, von L. H. Borgström. Mit 3 Tafeln und 1 Fig. im Text. August 1912 ..... 25: —

N:o 35. Die Granitpegmatite von Tammela in Finnland, von Eero Mäkinen. Mit 23 Figuren und 13 Tabellen im Text. Januar 1913 ..... 30: —

N:o 36. On Phenomena of Solution in Finnish Limestones and on Sandstone filling Cavities, by Pentti Eskola. With 15 figures in the text. February 1913 .. 25: —

N:o 37. Weitere Mitteilungen über Bruchspalten mit besonderer Beziehung zur Geomorphologie von Fennoskandia, von J. J. Sederholm. Mit einer Tafel und 27 Figuren im Text. Juni 1913 ..... 35: —

N:o 38. Studier öfver Kvartärsystemet i Fennoskandias nordliga delar. III. Om landisens rörelser och afsmältning i finska Lappland och angränsande trakter, af V. Tanner. Med 139 figurer i texten och 16 taflor. Résumé en français: Études sur le système quaternaire dans les parties septentrionales de la Fennoscandia. III. Sur la progression et le cours de la récession du glacier continental dans la Laponie finlandaise et les régions environnantes. Oktober 1915 ..... 150:—

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N:o 40. On the Petrology of the Orijärvi region in Southwestern Finland, by Pentti Eskola. With 55 figures in the text, 27 figures on 7 plates and 2 coloured maps. October 1914 ..... 75: —

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N:o 42. Über Camptonitgänge im mittleren Finnland, von Victor Hackman. Mit 3 Figuren im Text. Aug. 1914 ..... 15: —

* Epuisée.

N:o 43. Kaleviska bottenbildningar vid Mölönjärvi, af W. W. Wilkman. Med 11 figurer i texten. Résumé en français. Januari 1915 ..... 20: —

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N:o 46. Le gisement de calcaire cristallin de Kirmonniemi à Korpo en Finlande, par Aarne Laitakari. Avec 14 figures dans le texte. Janvier 1916..... 20: —

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N:o 54. Über die Petrographie und Mineralogie der Kalksteinlagerstätten von Parainen (Pargas) in Finnland, von Aarne Laitakari. Mit 3 Tafeln und 40 Abbildungen im Text. Januar 1921 ..... 30: —

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N:o 73. Über das jotnische Gebiet von Satakunta, von Aarne Laitakari. Mit einer Karte und 14 Abbildungen im Text. Juli 1925 ..... 30: —

N:o 74. Die Kalksteinlagerstätten von Ruskeala in Ostfinland, von Adolf A. Th. Metzger. Mit 9 Abbildungen und 2 Karten im Text. Aug. 1925..... 20: —

N:o 75. Ueber die kambrischen Sedimente der karelischen Landenge, von Benj. Frosterus. Mit 1 Figur und 9 Tabellen im Text. Sept. 1925..... 30: —

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N:o 82. Über Wiikit, von Lauri Lokka. Mit 12 Abbildungen und 21 Tabellen im Text. März 1928 ..... 30: —

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N:o 88 et N:o 89. Paraîtront prochainement.

N:o 90. Geologie des Soanlahtigebietes im südlichen Karelien. Ein beitrag zur Kenntnis der Stratigraphie und tektonischen Verhältnisse der Jatulformation, von H. Hausen. Mit 23 Figuren im Text, 12 Figuren auf 4 Tafeln und einer geologischen Übersichtskarte im Masstab 1:80 000. ..... 50: —

N:o 91. Pre-Quaternary rocks of Finland. Explanatory notes to accompany a general geological map of Finland, by J. J. Sederholm With a map and 40 figures in the text. August 1930. 30: —

Kallioperä
Ancient rocks
Berggrunden

Fennoscandia

1: 15.000.000

Kvartääriä
Quaternary
Kvartär

Tertiääriä
Tertiary
Tertiär

Mesozooisia muodostumia
Mesozoic
Mesozoikum

Permia ja karbonia
Permian and Carboniferous
Perm och karbon

Devonia
Devonian
Devon

Nefelinikivilajeja
Nepheline-bearing rocks
Nefelinbergarter

Paleozooista graniittia
Paleozoic granite
Paleozoisk granit

Paleozooisia ja vanhempia diabaaseja ja gabbroja
Paleozoic and older diabases and gabbros
Paleozoiska och äldre diabaser och gabbror

Paleozooisia kivilajeja tunturijuonossa
Paleozoic rocks in the Scandinavian mountain chain
Paleozoiska bergarter i fjällkedjan

Kambro-siluurilaisia muodostumia
Cambro-Silurian rocks
Kambrisk-siluriska bergarter

Jotuunilaista hiekkakiveä
Jotnian sandstone
Jotnisk sandsten

Rapakivigraniitteja
Rapakivi granites
Rapakivigraniter

Kvartsiporfyyriä
Quartz-porphyry
Kvartsporfyr

Postkalevalaista graniittia
Post-Kalevian granite
Postkalevisk granit

Metadiabaaseja ja -gabbroja
Metadiabases and -gabbros
Metadiabaser och -gabbror

Jatulilaista kvartsiittia
Jatulian quartzite
Jatulisk kvartsit

Kalevalaisia liuskeita ja kvartsiitteja
Kalevian schists and quartzites
Kaleviska skiffrar och kvartsiter

Postbotnialaisia graniitteja, massamaisia
Post-Bothnian granites, massive
Postbottniska graniter, strimmiga

Postbotnialaisia graniitteja, juovaisia
Post-Bothnian granites, gneissose
Postbottniska graniter, strimmiga

Botnialaisia ja laatokkalaisia liuskeita
Bothnian and Ladogian schists
Bottniska och ladogiska skiffrar

Vanhimpia liuskeita ja suonigneissejä
Oldest schists and veined gneisses
Äldsta skiffrar och ådergneiser

Vanhimpia gneissigraniitteja
Oldest gneissose granites
Äldsta gneisgraniter

Värien selitys
Explanation of the colours
Färgschema

Kvartääriä, joka kokonaan peittää kallioperän
Quaternary, entirely hiding the ancient rocks
Kvartär, h. o. h. skylande berggrunden

Andesiittia ja dasiittia
Andesite and dacite
Andesit och dacit

Nefeliini-kivilajeja
Nepheline-bearing rocks
Nefelinbergarter

Paleozooisia diabaaseja ja oliviinikiviä
Paleozoic diabases and peridotites
Paleozoiska diabaser och olivinstenar

Paleozooisia liuskeita, kambrilaista savea
Paleozoic schists, Cambrian clay
Paleozoiska skiffrar, kambrisk lera

Paleozooisia hiekkakiviä
Paleozoic sandstones
Paleozoiska sandstenar

Jotuunilaisia diabaaseja
Jotnian diabases
Jotniska diabaser

Jotuunilaista hiekkakiveä
Jotnian sandstone
Jotnisk sandsten

Rapakivigraniitteja
Rapakivi granites
Rapakivigraniter

Kvartsiporfyyriä
Quartz-porphyry
Kvartsporfyr

Anortosiittia, ossipiittia ja diabaasia
Anorthosite, ossipite and diabase
Anortosit, ossipit och diabase

Postkalevalaista graniittia
Post-Kalevian granite
Postkalevisk granit

Migmatiittia, jossa suonet ovat postkalevalaista graniittia
Migmatite with veins of post-Kalevian granite
Migmatit med ådror av postkalevisk granit

Jatulilaista ja kalevalaista metabasiittia
Jatulian and Kalevian metabasite
Jatulisk och kalevisk metabasit

Eri-ikäisiä kalkkikiviä ja dolomiitteja
Limestones and dolomites of various ages
Kalkstenar och dolomiter av olika åldrar

Fylliittiä ja kiilleliusketta, etupäässä kalevalaista
Phyllite and mica-schist, mainly Kalevian
Fyllit och glimmerskiffer, företrädesvis kalevisk

Jatulilaista kvartsiittia
Jatulian quartzite
Jatulisk kvartsit

Kalevalaista ja laatokkalaista kvartsiittia
Kalevian and Ladogian quartzite
Kalevisk och ladogisk kvartsit

Postbotnialaisia graniitteja, enimmäkseen massamaisia
Post-Bothnian granites, mainly massive
Postbottniska graniter, företrädesvis massformiga

Postbotnialaisia graniitteja, enimmäkseen juovaisia
Post-Bothnian granites, mainly gneissose
Postbottniska graniter, företrädesvis strimmiga

Botnialaisia ja postbotnialaisia metabasiitteja
Bothnian and post-Bothnian metabasites
Bottniska och postbottniska metabasiter

Migmatiitteja, joissa suonet ovat postbotnialaista graniittia
Migmatites with veins of post-Bothnian granite
Migmatiter med ådror av postbottniska graniter

Laatokkalaista fylliittiä ja kiilleliusketta
Ladogian phyllite and mica-schist
Ladogisk fyllit och glimmerskiffer

Laatokkalaista sarvivälkeliusketta
Ladogian hornblende-schist
Ladogisk hornblendeskiffer

Botnialaista metabasalttia
Bothnian metabasalt
Bottnisk metabasalt

Botnialaista tuffiliusketta
Bothnian tuff-schist
Bottnisk tuffskiffer

Botnialaista fylliittiä ja kiilleliusketta
Bothnian phyllite and mica-schist
Bottnisk fyllit och glimmerskiffer

Gneissigraniittia, jossa on suonina nuorempaa graniitia
Gneissose granite with veins of younger granite
Gnejsgranit med ådror av yngre granit

Granuliittia
Granulite (leptynite)
Granulit

Vanhimpia gneissigraniitteja
Oldest gneissose granites
Äldsta gnejsgraniter

Vanhimpia gabbroja ja metabasiitteja
Oldest gabbros and metabasites
Äldsta gabbror och metabasiter

Vanhimpia kvartsiittiliuskeita
Oldest quartzitic schists
Äldsta kvartsitskiffrar

Vanhimpia sarvivälkeliuskeita
Oldest hornblende-schists
Äldsta hornblendeskiffrar

Vanhimpia kiilleliuskeita ja kiillegneissejä
Oldest mica-schists and mica-gneisses
Äldsta glimmerskiffrar och glimmergnejser

Eri ikäisiä konglomeraatteja
Conglomerates of various ages
Konglomerat av olika åldrar

0 10 20 30 40 50 60 70 80 90 100 200 km
1: 2000 000

N:o 8

Maanmittaushallituksen kivipaino, Helsinki 1926