8. A Study in a Caledonian Mayor Thrust Plane

By

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Introduction

In the last twenty years the geology of the Caledonian highland border of Sweden has been subject of considerable interest. Chiefly owing to the work of ASKLUND and THORSLUND many stratigraphical and tectonical problems of importance have been solved. Thus, in Jämtland and Västerbotten, the ideas of TÖRNEBOHM were again put to the fore and confirmed on essential points. A typical feature of the border region in this middle Scandinavian section is the narrowing northwards of the belt in which nappes of the Jämtland-type are met with. Moreover the Cambro-Silurian of easterly facies in these nappes below the great Seve-thrust, is subsequently substituted first by Eocambrian (upper Pre-Cambrian) quartzites in the Strömsquartzite nappes of northern Jämtland and KULLING's (1) Blaik-nappe in Västerbotten. Then increasingly sparagmitic sediments and crystalline basement rocks occur. In the northern parts of Västerbotten these rocks are dominating in KULLING's Stalon-nappe. These conditions clearly indicate a change of level of the shear plane at which these nappes were released from the substratum and it seems likely that this development also indicates a certain change in tectonics of the range as a whole, perhaps not in type of deformation, but markedly in intensity. From a more northerly district G. KAUTSKY (2) presents a section, which gives a lucid picture of this development, carried to the utmost. In this region, i.e. the middle part of Norrbotten, he demonstrates a very great Seve-thrust and below that a series of minor nappes emanating from a fractured Fennoscandian continent.

At first sight the conditions in the highland border of southern Norrbotten immediately north of the frontier of Västerbotten do not fit well in the general scheme. A map by F. KAUTSKY (3) shows a reduction of the lower minor nappes and the appearence again of quartzite-nappes. As will be set forth below, all lower nappes are practically absent in the vicinity of Laisvall; the Seve-thrust comes to rest directly on autochthonous Cambrian sediments. In the Laisvall region these sediments are partly lead bearing (4, 5) for which reason extensive investigations have been carried out there by the Boliden Mining Company. More than 300 bore-holes have been sunk in the area. E. LJUNGNER (6) made use of these borings for a study on the deformation of the surface of the crystalline basement. I have undertaken an investigation from a different point of view, recorded in the title of the present paper. My purpose is to throw some light upon Caledonian thrust mechanics.

The foundation on which all further work in the Laisvall region has to rest, is the work of F. KAUTSKY (3). Most of his mapping has now been revised by himself, LJUNGNER and the present author, and certain corrections will be necessary. For further information concerning the Laisvall area in a broader sense I refer to his stimulating paper. Many facts from the Laisvall area proper are also published in papers of LJUNGNER (6) and GRIP (4, 5).

I. The Autochthonous

In the works already referred to, much rather detailed information is given about the basement and its autochthonous sedimentary mantle. According to GRIP (5) the following formations can be distinguished in the lower part of the series in descending order:

Cambrian transgression conglomerate	1 m
Upper sandstone	5 »
Quartz-quartzite conglomerate	0.1 »
Middle sandstone	8 »
Quartz-quartzite conglomerate	0.1 »
Lower sandstone	20 »
Mudstone	10 »
Conglomerate (tillite?)	about 0.5 »
Arkoses	usually several metres
Archaean granite	

As mentioned by GRIP, the sandstone series and its foundation has been only slightly affected by the overthrust tectonics, but the strata following thereupon, consisting of shales, are deformed in a very instructive manner and in order to elucidate this, a new and more detailed subdivision has been worked out for them.

Fig. 1 gives the Cambrian sequence in one of the bore-holes of the region. The hole is situated west of the Storlaisan Lake on the southern slope of the Nadok Hill.

The section begins with the conglomerate which rests upon the Eocambrian sandstone series. Then follow rather light claystones with but a faint bedding. There is often a strong intermixing of a coarser quartz phase leading to a siltstone. One metre above the conglomerate comes a horizon, one metre thick, chocolate-brown and green in colour, consisting of a rather

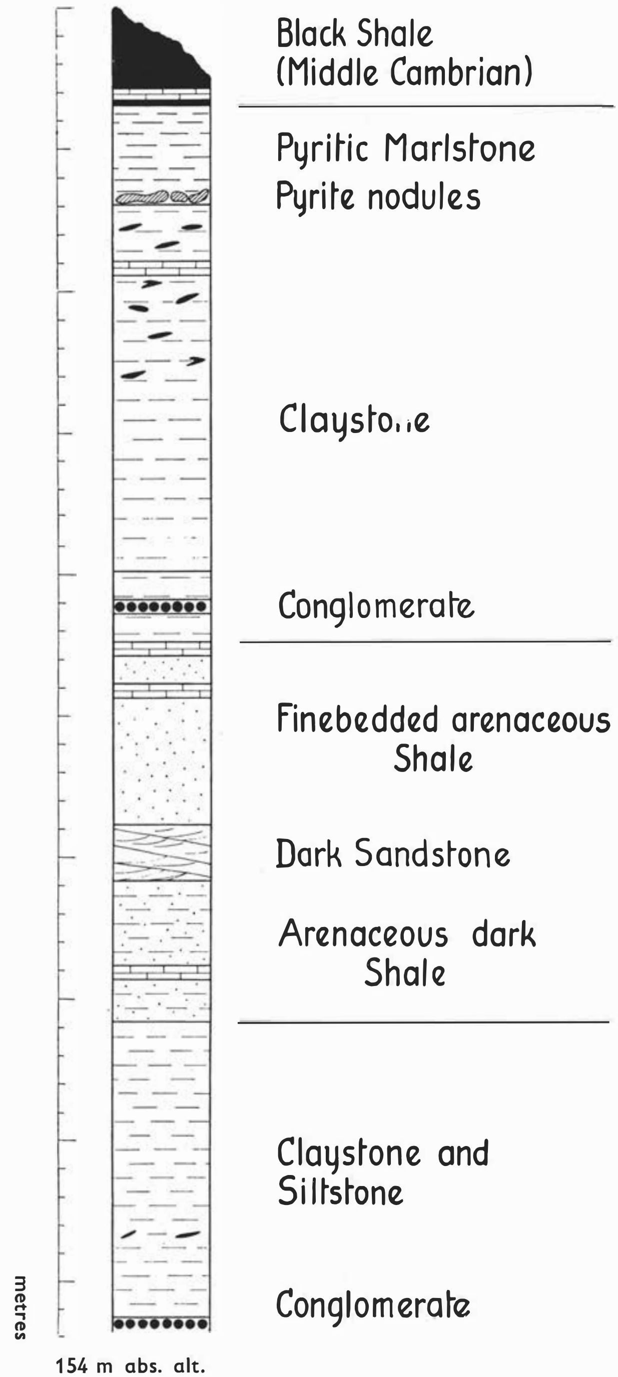

Fig. 1. Shales above the Eocambrian sandstone in Laisvall. Based on bore-hole Laisvall No. 279.

fine-grained ($< 10\ \mu$) claystone. Higher up the shale holds dark, often somewhat angular, distinctly delimited pelitic fragments. They are particularly frequent just above the coloured section. The claystones and siltstones, reaching a thickness of about 10 m in the Laisvall region, constitute a well defined lower part of the sequence in question, being followed by a strikingly different type of sediment.

The new development starts with coarsening and calcification, and at the same time appearance of bitumen gives the sediment a dark lustre. The lime-content is, especially at the base, concentrated to thin layers of limestone or calcareous sandstone, which in addition to small but numerous pelitic fragments evidently also contain fragments of fossils which as yet have not been closer investigated. Upwards the sedimentation grows still more agitated and finally results in a fine-grained dark psammite, the polymict material of which indicates that it belongs to the graywacke suit. It is, however, characterized by beautiful current bedding and small intraformational conglomerates often resembling the Cambrian transgression conglomerate but of smaller pebbles. Such structures are not normally attributed to gray-wackes so the more neutral designation 'dark sandstone' has been used preliminary.

Also the next stratum is for the present considered as belonging to the same sedimentary group as the dark sandstone. It is a flat, thin-bedded arenaceous shale, in its upper part containing a layer of limestone, 20 cm thick. This limestone is found in several bore-holes. The thickness of the arenaceous shale is in Laisvall 6 m. The dark strata have maximum total thickness of 25 m.

Starting with a thin calcareous layer the dark psammites are succeeded by very fine-grained, non-calcareous light bluegray claystones, practically devoid of bedding. About one metre above its base a conglomerate suddenly appears in the claystone. It measures 20 cm and contains small pebbles usually well rounded, which originate from different horizons of the subjacent sequence. Pebbles resembling the siltstone above the sandstone series have also been observed. The conglomerate displays a sharp green colour owing to a glauconitic matrix and the claystone of the next two metres also presents a tint of green or chocolate. Higher up the claystone contains several thin calcareous layers, and dark, rounded pelite pebbles also become frequent.

The claystone is succeeded by a marlstone. Its boundary is distinctly marked by a layer of pyrite nodules. The marlstone itself is then sprinkled by this mineral. This horizon would correspond to the fossiliferous one of Aistjakk, determined by F. KAUTSKY as uppermost Lower Cambrian. The claystone and marlstone measure together 20 m.

The autochthonous sequence is then concluded with black shales. They are always more or less disturbed and usually phyllitized. It is believed that their original thickness was at least 10 m. A gray sandstone 30 cm thick is intercalated at the bottom of the shales. Greater thickness (up to 1 m) has been observed in other bore-holes. F. KAUTSKY assigns the shales to Middle Cambrian. Some new fossil finds north of the Laisvall region seem to bring that out rather clearly.

The strata above the sandstone series can thus be subdivided lithologically into five well-defined zones.

5. Black shale (Middle Cambrian).
4. Pyritic marlstone (uppermost Lower Cambrian).
3. Pelitic zone dominated by pure, poorly bedded claystones.
2. Psammitic zone with dark strata and agitated sedimentation.
1. Pelitic zone with mixed sediments.

II. The Thrust Masses

A. Borehole Number 279, upper part

The black shale terminating the Autochthonous measures 2 m and though strongly flattened and showing horizontal minor slip planes, it is not much faulted or brecciated. A sheared slate, 5 metres in thickness, follows above. Most of the core is lost in this zone. Proceeding upward we find that we have just passed a thrust plane, for next we meet with 20 m of crystalline rocks. They are syenitic to gabbroid in type. Some of the syenitic types are nearly monomineralic, the main constituent being a peculiar perthitic feldspar much resembling so called Jotun-perthite as shown in the microphotograph Fig. 2. The rocks are deformed, and the general mode of deformation is crushing. Fig. 3 is a photograph of a polished syenitic core-specimen five metres above the top of the brecciated slate. It shows a fine net-work of fissures filled with a bituminous paste derived from the Cambrian black shales below. A closer examination of the core reveals an ultracataclastic shearing zone, one metre thick, in the middle of the crystalline complex. Below, the rocks are purely syenitic; above, there is much gabbro. It looks as if the cataclasite has been derived mainly from gabbroid material, for it contains minerals of the chlorite group abundantly.

The crushing of the crystalline rocks under consideration is somewhat stronger than usual at the base, but no formation of new minerals is noticed except very little chlorite. Calcite is introduced in joints and fissures. At the top of the complex, on the other hand, we find a zone where the crystalline rocks pass into phyllonites within a very short distance. These are mostly very fine-grained, but there are numerous relics to show that the parent rock belonged to the crystalline rocks. Fig. 4 shows a phyllonite from this zone. We have now arrived at a division of the column where a pronounced recrystallization of the rocks has taken place. The phyllonites are just a few metres thick and grade rapidly into blastophyllonites with

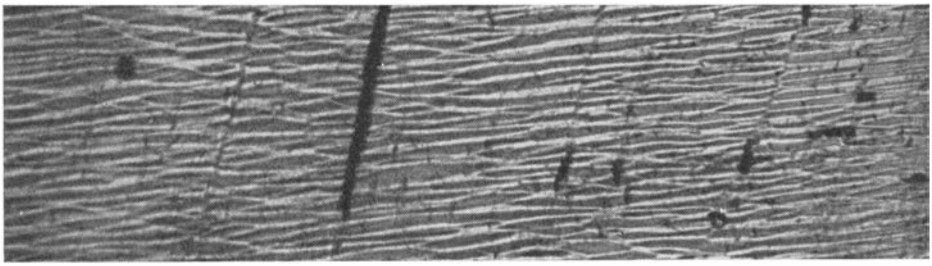

Fig. 2. Perthitic feldspar. Laisvall Bh 279. Nicols parallel. × 35.

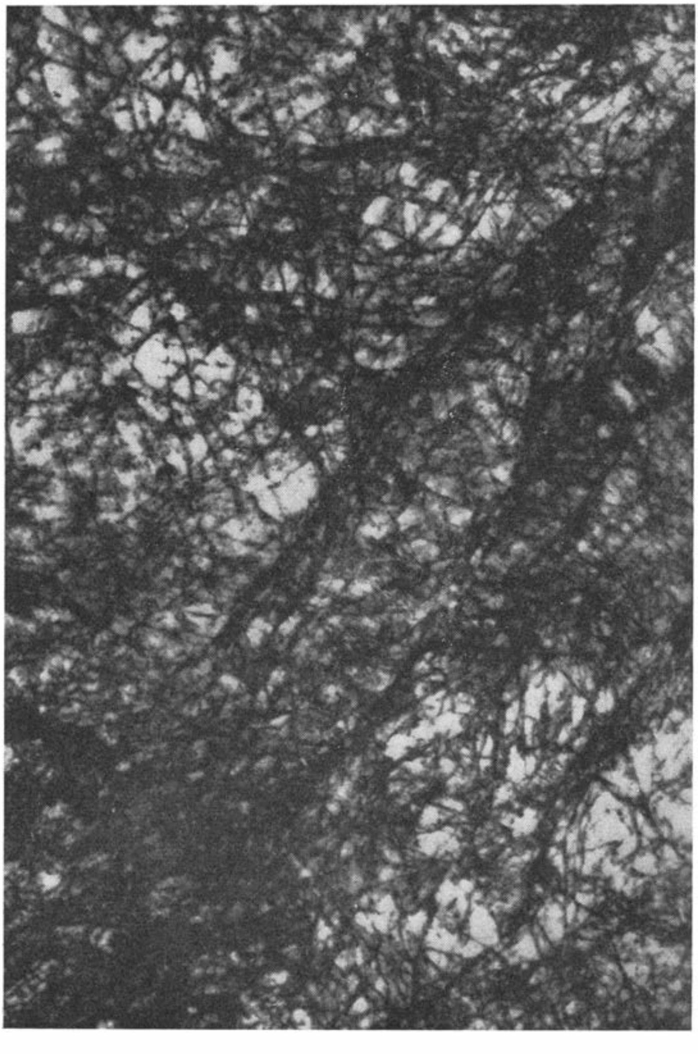

Fig. 3. Mylonite. Laisvall Bh 279. Polished core-specimen. × 3.

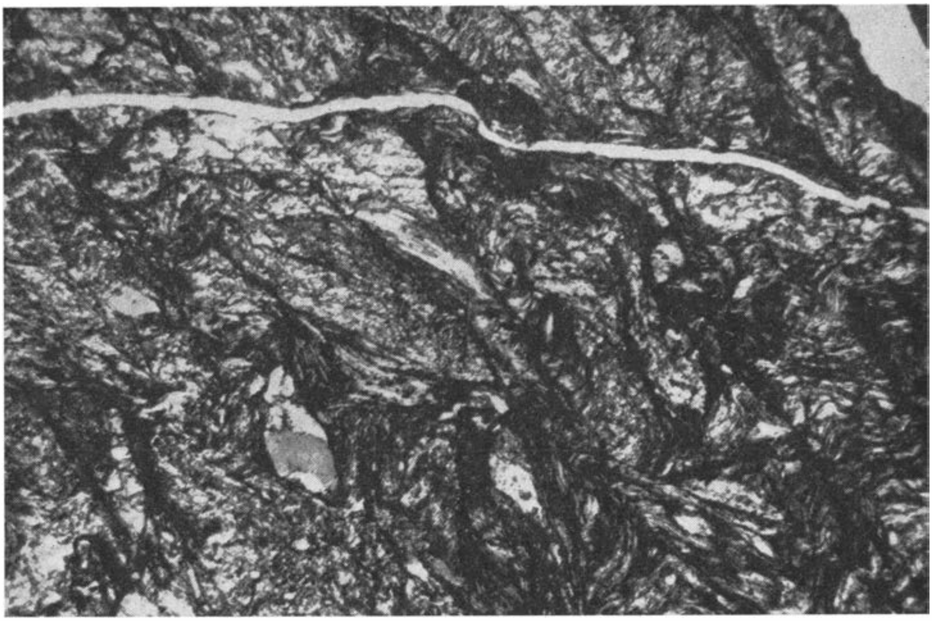

Fig. 4. Phyllonite. Laisvall Bh 279. Nicols parallel. × 35. Sharp-edged rock fragments in a brecciated fine-grained groundmass (grey) of sericite and chlorite. Black is bituminous matter.

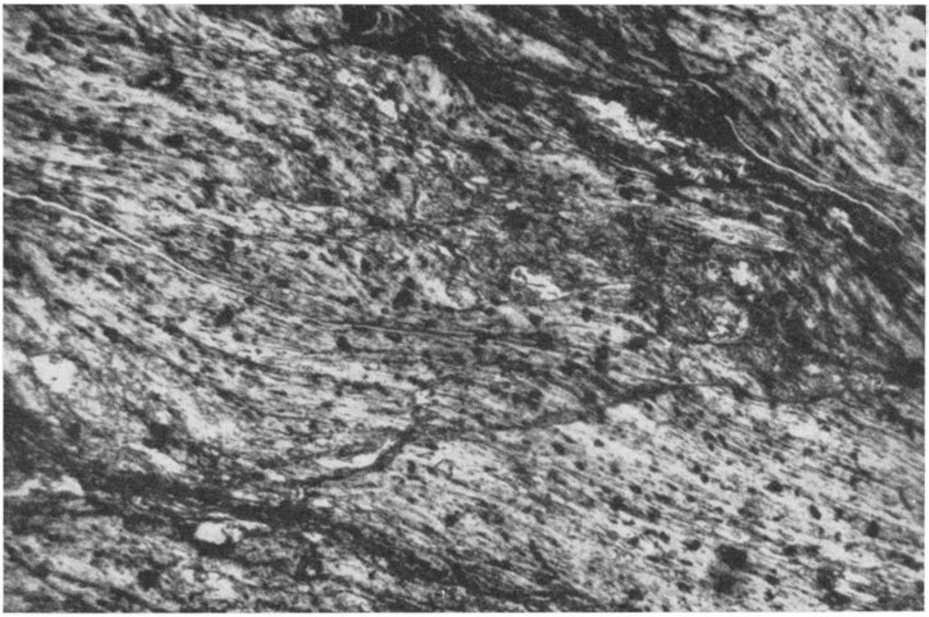

Fig. 5. Chlorite-sericite-schist (blastophyllonite). Laisvall Bh 279. Nicols parallel. × 35. Diagonally in the central part and over the whole picture part of a single large sericite aggregate. The chlorite is more greyish. Dark spots are zircon, titanite etc.

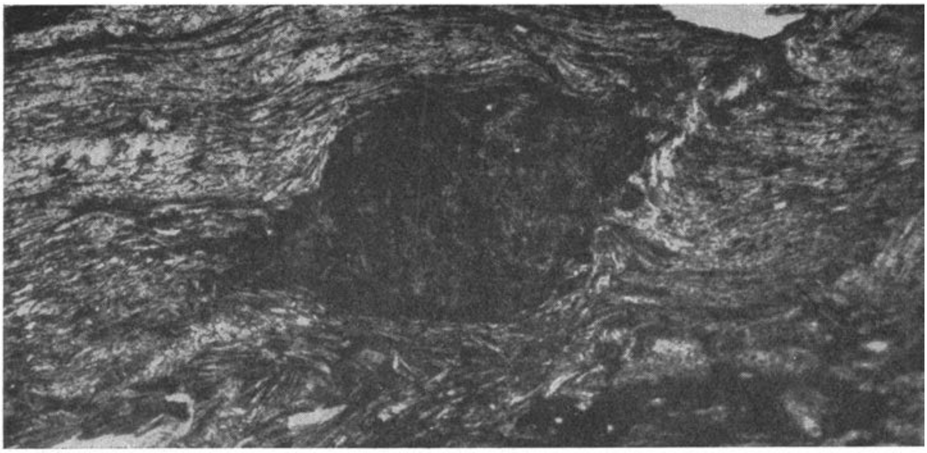

Fig. 6. Diaphthoritic schist with a garnet converted into a felted chloritic mass. Laisvall Bh 279. Nicols parallel. ×35.

a development of large aggregates of micaceous minerals and chlorite. Such rocks constitute the rest of the core up to the surface, a vertical distance of 85 m. As to my present knowledge, part of the blastophyllonites have beenderived from crystalline rocks over mylonites and phyllonites, but to a certain extent they are old sediments now converted into silicious schists, banded schists or pure chlorite-sericite schists, the latter sometimes containing bituminous matter (Fig. 5). In other bore-holes of the Laisvall region the section upwards reaches the basal parts of a new complex, the Yraf Complex, showing high grade metamorphism, succeeded by one of retrograde order. But for some relics, such as chlorite pseudomorphs after garnet and scattered biotite remnants, these schists would be difficult to distinguish at a glance from some types of the blastophyllonites, which now belong to the same mineral facies as the diaphthoritic schists. When mapping the central shaft of the Laisvall mine, which cuts through all rocks mentioned here, GRIP observed a conspicuous stress zone which later turned out to be the boundary between diaphthoritic and blastophyllonitic schists and which can often be located very sharply in the bore-holes. The diaphthoritic schists (Fig. 6) which, in the surroundings, attain a thickness of about 150 m are then followed by various garnet-micaschists, presumably of great thickness.

B. The tectonic units

As already mentioned, F. KAUTSKY has worked out an accurate tectonic division in the Laisvall region. During my own mappings I have found it convenient to distinguish the blastophyllonites as a separate complex. This has been even more necessary after a comparative study of the results of

Photo Erik Ljungner

Fig. 7. The Nebsuort Hill. View from E.N.E. The thrust plane of the Kaskajaure Complex is situated below the precipices half-way up the mountain. The rigid masses above are crystalline Archaean rocks and the slopes below are built of parautochthonous quartzite nappes. At the shore of the lake the Autochthonous is outcropping.

the borings. The blastophyllonites are sharply delimited and presumably indicate a distinct phase in the tectonic evolution. After the typomorphic minerals I have named the blastophyllonites the Chlorite-sericite schist Complex, since Kautsky's method with local names for several reasons has had some disadvantages. The tectonic division of the rocks in bore-hole No. 279 and its surroundings should then be the following (Table I):

Table I

~150 m	Diaphthoritic Schists	Yraf Complex
	Thrust	
85 m	Blastophyllonites	Chlorite-sericite-schist Complex
	Thrust	
20 m	Cataclastic Crystalline Rocks	Kaskajaure Complex
	Thrust	
5 m	Sheared Slate	Parautochthonous Nappe
	Thrust	
120 m	Lais-series Crystalline basement	Autochthonous

Now, in this section the Kaskajaure Complex and the Parautochthonous nappes are exceedingly thin. Bh 279 is situated south of the Nadok Hill near the north-western termination of the profile which on the map, Plate II, is drawn west of Storlaisan (in the south-eastern parts the map is based on an unpublished map of LJUNGNER, in the north-western and western parts on my own mappings). The map shows that the Kaskajaure Complex wedges out in vicinity of Bh 279. The parautochthonous nappes are also thin here, and east of Storlaisan they are partly lacking. Southwards, beyond Garbmadak, they both rapidly gain in thickness, especially the Kaskajaure Complex, thereby proving to be not just a more or less incidental tectonic constituent between the Yraf Complex and the Gautojaure Complex, but a tectonic unit of a special significance. Fig. 7 is a photograph from a point east of Storlaisan in the W.S.W. direction towards the Nebsourt Hill which is situated just south of the south-western corner of the map, Plate II.

III. The Influence of the Thrust Masses on the Autochthonous

The influence of the thrust movements upon the Autochthonous is partly great. LJUNGNER showed in 1945 that there is a marked Caledonian deformation even of the surface of the crystalline basement and that Caledonian tectonics are responsible for the settling of ore in the Laisvall sandstone series (GRIP 1948). Even stronger disturbances are to be noted in slates above the sandstone series and the establishment of the detailed column of Chapter I made it possible to follow them from bore-hole to bore-hole.

Only the sandstone series and parts of the lower claystone are preserved under the lowermost thrustplane over large areas within a radius of several kilometres and mainly east of Storlaisan. Such conditions are also met with in the south-eastern part of the section, Plate I b, marked with a line south of the Nadok Hill on the map, Plate II. Proceeding N.W., that is opposite the direction of tectonic transport, we find preserved some higher strata in Bh 165, which are clearly recognizable though strongly fractured. In Bh 167 more of the series is still better preserved. Then, in Bh 169, the shales suddenly get much thicker, as a result of repetition of parts of the series. Here the birth of a minor parautochthonous nappe is clearly demonstrated. We must now consider the fact, that the appearance of this nappe not only means the entrance of a new tectonic unit, but also that the distance between the two principal tectonic complexes, the Yraf Complex and the Autochthonous, has been enlarged. Now the question arises: what is the cause and what the effect? Before we try to make a statement, there are some other facts to be considered. The drillings namely permit the drawing of one section similar and parallel to the section, Plate I a,

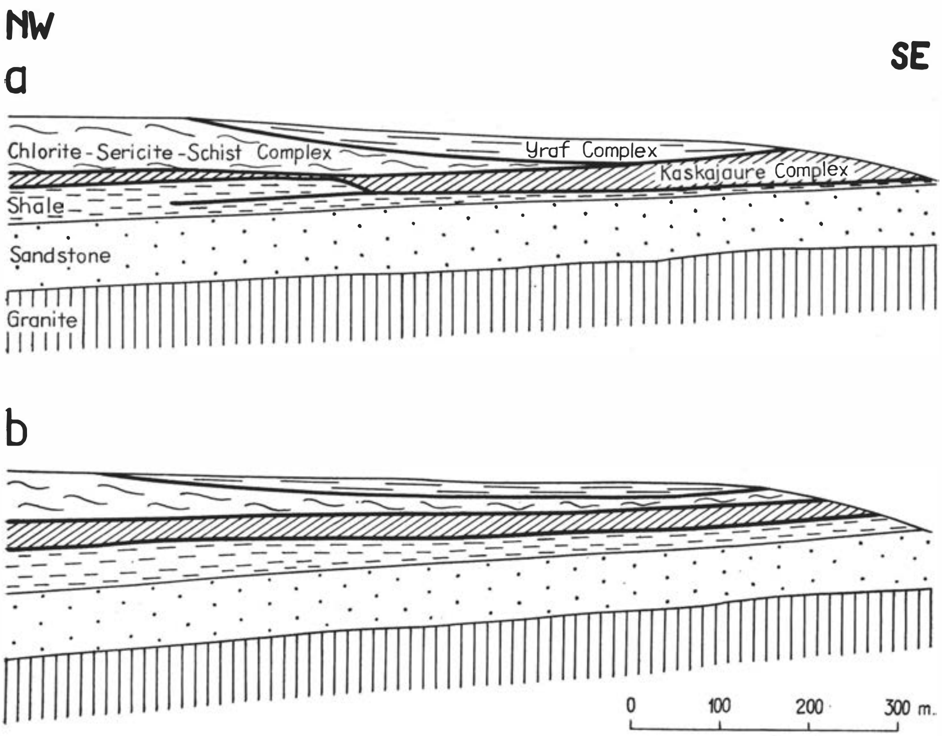

Fig. 8. Diagrammatic sections W. of Lake Storlaisan. *a* is the section plate I b, *b* is situated 150 m S.W. of the foregoing.

south-east of it and several northwest of it. Thus a three-dimensional picture of the whole structure can be obtained and has also been worked out. For the present purpose I have prepared the schematic free-hand sketches of Fig. 8 in order to illustrate the main points. The section, Fig. 8 a, is a simplification of Plate I b. Sections N.E. of and parallel to this one show the same structure. Fig. 8 b, however, showing a section 150 m S.W. of the foregoing one, is different. Starting in N.W. in the section, Fig. 8 b, we first find the Autochthonous fully developed and apparently practically undisturbed. South-eastwards it becomes more and more fractured but there are no signs of tectonic transport within it, except in the black shales. Finally, at the extreme south-east all shales above the lower claystone are entirely brecciated and cannot be separated from another macroscopically. The lowermost thrust plane, however, is here situated 15 metres higher than in the corresponding parts of the section, Fig. 8 a. It seems most likely that the section, Fig. 8 b, indicates that in this region the thrust masses have met the substratum with a certain inclination. The section, Fig. 8 a, shows, that this has, locally, resulted in a tearing away of parts of the substratum. The small parautochthonous nappe of Fig. 8 a has evidently advanced in the space behind a flexure in the higher thrust masses; this flexure originated when these masses sunk down to replace the parts of the substratum previously torn off. The marked differences between sections Fig. 8 a and Fig. 8 b indicate that a steep fault line in the thrusted units separates them. It runs somewhat more westerly than the direction of the sections. To the S.E. some bore-holes, for instance Bh 162, ought to stand very near the fault as indicated by a strong brecciation and a conspicuous settling of minerals belonging to the Laisvall ore suit. When mapping the highland border at lake Hornavan north of the Laisvall region, I found another very fine example of a similar process. There, over a large area, all of the autochthonous sedimentary series except the basal conglomerate was removed by a flat movement which could be proved on the basis of field measurements and from the fact that the dislocated series is to be found outcropping in an outlier east of the highland border. Thus, in this region lower nappes have originated solely through a tangential influence of the higher nappes.

The section, Plate I a, illustrating conditions east of Storlaisan, shows the same tendencies, though less pronounced, as the section, Fig. 8 b.

IV. Structures in the Thrust Zone

In the area of the Laisvall borings all Caledonian tectonic complexes below the Yraf Complex are thin and constitute together a complicated thrust zone.

A. The Kaskajaure Complex

In the south-western parts of the map, Plate II, the Kaskajaure Complex consists at the base of a single crystalline sheet at least 100 m thick. On the crest it supports parts of the Eocambrian Sparagmite Series, for instance in Garbmadak a well-known conglomerate. As mentioned above the complex wedges out northwards, and in the section, Plate I b, it enters with a thickness varying between 0 to 50 m. It is strongly deformed cataclastically in its upper parts. Its subsurface is practically all over clothed with a film 10 to 20 cm thick, consisting of a dark mudstone with sparse feldspar fragments and now strongly silicified. I have not been able to explain this phenomenon satisfactorily. Most of all the sediment resembles the mudstone below the Autochthonous sandstone series. In the section, I have marked its occurrence with open triangles.

Plate I a shows a section through the Kaskajaure Complex just at its northern fringe. There it is disrupted into a series of elongated flat slabs immersed in a mass of brecciated shale. The individual slabs are different in composition. Some consist of syenite or porphyry, in neighbouring sections there are others derived from the Sparagmite Series and quartzites.

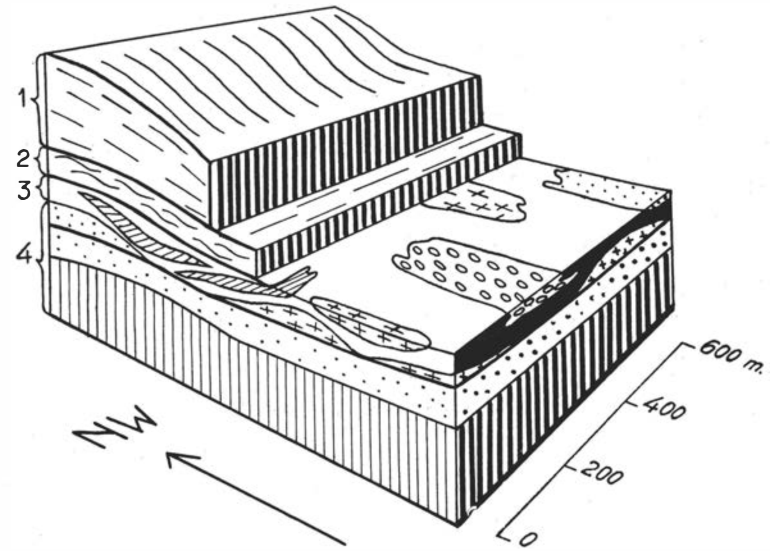

Fig. 9. Block-diagram showing the Caledonian mayor thrust zone E. of Lake Storlaisan. The S.W.-wall of the diagram is a simplification of Plate I a. 1. Yraf Complex. 2. Chlorite-sericite-schist Complex. 3. Disseminated Kaskajaure Complex. 4. A parautochthonous nappe to the N.W. and lowermost Autochthonous.

This indicates a certain transport of each slab individually, and thus the fact can be ascertained that they have a definite orientation. The borings are especially dense in this area and a rather detailed picture of the architecture is obtainable. The block-diagram, Fig. 9, affords a schematic illustration of the structure. It is generally agreed that the main tectonic transport in the Caledonians of Scandinavia is from the north-west. Then the orientation of the units in this area is after the tectonic a-axes. Such an orientation is reported from other parts of the Caledonians, and recently discussed by ANDERSON (7). In the Laisvall region it is apparently developed on a very large scale. It is not possible to get orientated samples from the old drilling cores, but in shafts and adits of the mine, rock specimens are now being collected, which will permit a petrofabric analysis of this structure. The connection between these formations and the typical Kaskajaure Complex consists of an enlargement and thickening of the slabs toward the section, Plate I b. Further to the south the Complex seems to become entirely consolidated, and as already mentioned, its thickness increases to about 200 m. It is hard to avoid the impression that the Yraf Complex in this area has carried out a movement relatively to the Kaskajaure Complex.

B. The Chlorite-Sericite-Schist Complex

The Chlorite-sericite-schist Complex has not yet been examined in detail. In the section, Plate I b, an attempt is made to separate pure Chlorite-sericite schists from banded and siliceous schists. A kind of imbricationstructure seems to be the result. No doubt this complex is extremely dynamic, and it has been traced along the highland border both north and south of the Laisvall area. Particularly interesting is the fact, that to the north, where this complex rests not on the Kaskajaure Complex with its crystalline rocks, but on nappes consisting of Eocambrian-Cambrian sediments, it still contains much material, that ought to have been crystalline. Most likely this complex includes large parts of the primary sedimentary mantle of the Kaskajaure Complex together with some of its crystalline rocks. It is to be considered as the thrust zone of the Yraf Complex, which constitutes a thrust mass of very high order.

V. Concluding Remarks

In the Laisvall region two very large structural units can be distinguished namely 1) the Fennoscandian basement, peneplaned and covered with a relatively thin Eocambrian-Cambrian mantle of sediments, and 2) resting flat on them a heavy series of rocks, which were deformed, recrystallized and thrusted in Caledonian time. The units are termed the Autochthonous and the Yraf Complex respectively. The principal tectonic process is the motion of these two complexes in relation to each other. The Autochthonous can be followed in the direction of its persistent north-westerly dip far below the Yraf Complex. There are no signs, that this dipping will soon come to an end towards the west. The Yraf Complex in the border region also dips to the west but at a much lower angle than the Autochthonous, and if a broader area is considered, for example that between Laisvall and the lake Gavasjaure 45 km N.W. of Laisvall, we would find that it is just horizontal and lying in a great flat syncline between Laisvall and Gavasjaure. Thus, between the two complexes an interspace develops in the border region which widens to the west. Within this interspace nappes of a lower order have developed. In the section, Plate I b, the birth of such a nappe has been demonstrated, and to my knowledge this ought also to be the general mode of formation of all lower-order nappes in the vicinity. It seems, indeed, very probable that a hypothesis of underthrusting could be applied in this case, the minor nappes originating in the space between a large Caledonian thrust mass and a Fennoscandian continent dragged down to depths below it. To give a clearer picture of how such a process may have worked, I have drawn the simplified sections of Fig. 10. The uppermost section shows a stage when just one nappe lies between the Yraf- and Gautojaure Complexes. The following sections show the addition of new nappes, which are released from the top of the Autochthonous. But these sections were also prepared to show, that tectonic evidence would possibly allow an explanation of the much debated problem of the Seve metamorphism, which is mainly concentrated to the

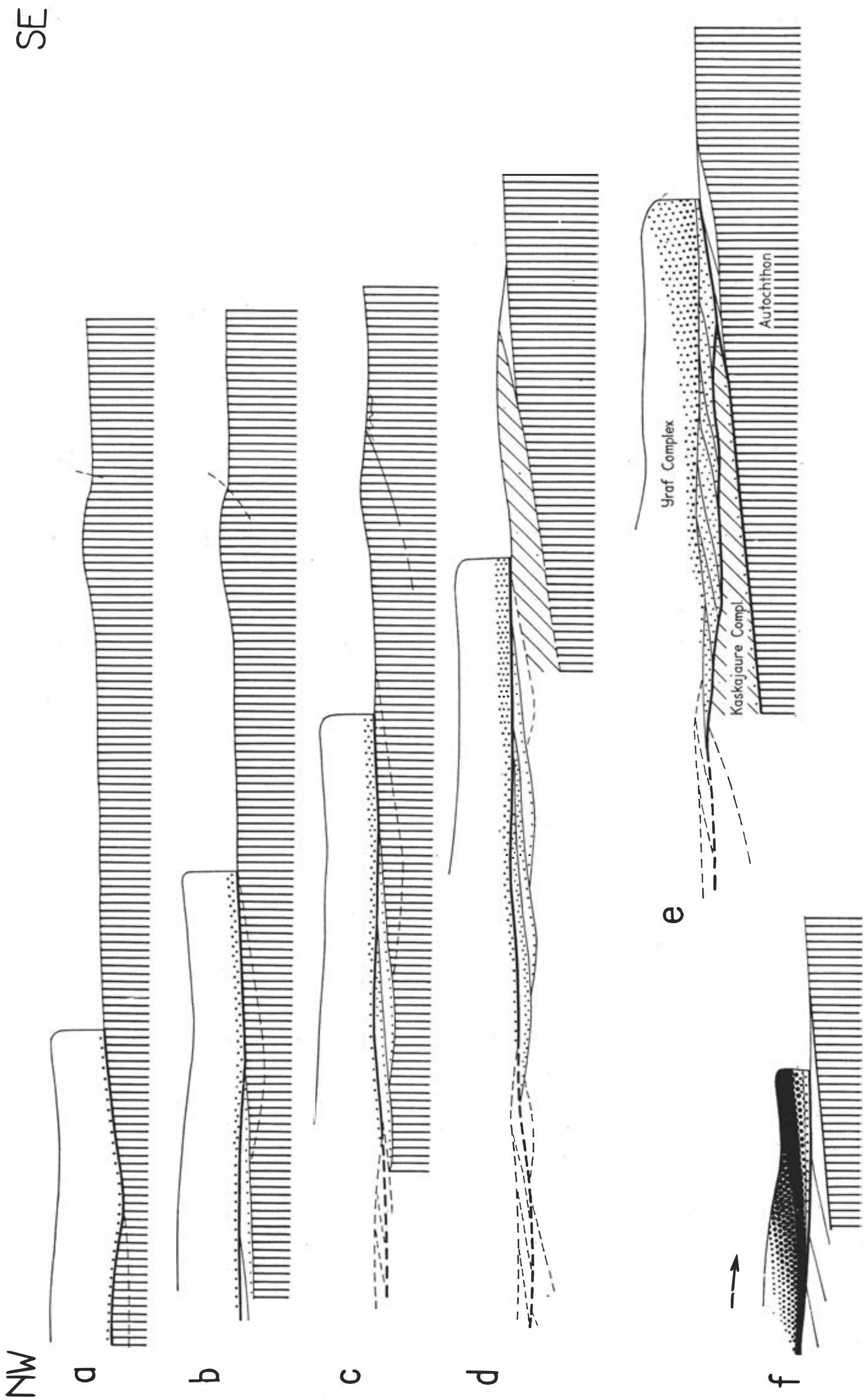

Fig. 10.

eastern front of the great Seve Thrust Sheet (part of which is the Yraf Complex). It is evident with the explanation here offered, that in the front of the thrust mass the entire frictional energy has been set free within a rather narrow zone, namely where the thrust mass has struck the continent. Further to the west, the motion has been more differentiated beneath the great thrust mass and divided on many secondary thrust planes. Thus, the accumulation of frictional energy in the front of the great thrust mass might well be the source of heat of the Seve metamorphism. And as to the source material of the metamorphic schists, the conditions at Laisvall indicate, that a great part of it may have been derived from easterly mantle rocks. At a first stage they are picked up as parautochthonous nappes below the Seve thrust plane; then they have become mylonitized, phyllonitized, recrystallized and finally assimilated with the great thrust mass. In this way the confusing picture of a low grade metamorphism at the base of the thrust mass rising to a high grade metamorphism higher up and then sinking again in the uppermost parts of the thrust mass, can be explained without resorting to deep burial or injected rock masses. The injection metamorphism would rather itself be an advanced result of the tectonical processes. This is merely a hypothesis which is by no means proved. It is put forward here because the author has made several other observations pointing in the same direction.

The costs of printing of this preliminary report have been carried by the Boliden Mining Company. I am specially indebted to its Chief geologist, Dr. ERLAND GRIP, who always took a keen interest in the work. Discussions with above all Dr. FRITZ KAUTSKY has contributed very much to my interest in and acquaintance with the problems here dealt with. Professor ERIK LJUNGNER introduced me in the field in 1943—1945 when I had the pleasure to assist him in his work. He has kindly furnished me the photo of Fig. 7 and permitted me to use his unpublished maps of the surroundings of Laisvall. The material has been worked up at the Mineralogical-Geological Institute of the University of Uppsala under the guidance of Professor ERIK NORIN. I wish to express my sincere gratitude to Professor NORIN for freely placing his experience and knowledge at my disposal.

The micrographs are prepared by Mr. LARS FINN, the drawings by Mr. ERHARD KÖSTER and Mr. OLLE SPARRMAN.

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Explanation to Fig. 10

Fig. 10 intends to show the character of the tectonic events, which are supposed to have taken place during a horizontal displacement of about 50 km of the Seve thrust mass in relation to Fennoscandia. Thicknesses of the thrust complexes are strongly exaggerated.

a. A situation resembling that of Plate I b. Stippling at the base of the thrust mass indicates the zone where frictional energy has been set free to a larger extent. In the sections a—e the stippled areas are built up through adding at each section new rows of points corresponding to a continued production of frictional heat. The line of short dashes under the great thrust marks the part of the Autochthonous which will start to travel on further thrusting. In S.E., a small dome represents a buried Eocambrian land rising through the revival of precaledonian faults (6).

b. The front of the thrust mass has travelled a certain distance. Behind the front the motion is partly on a secondary thrust plane. A new small nappe is indicated.

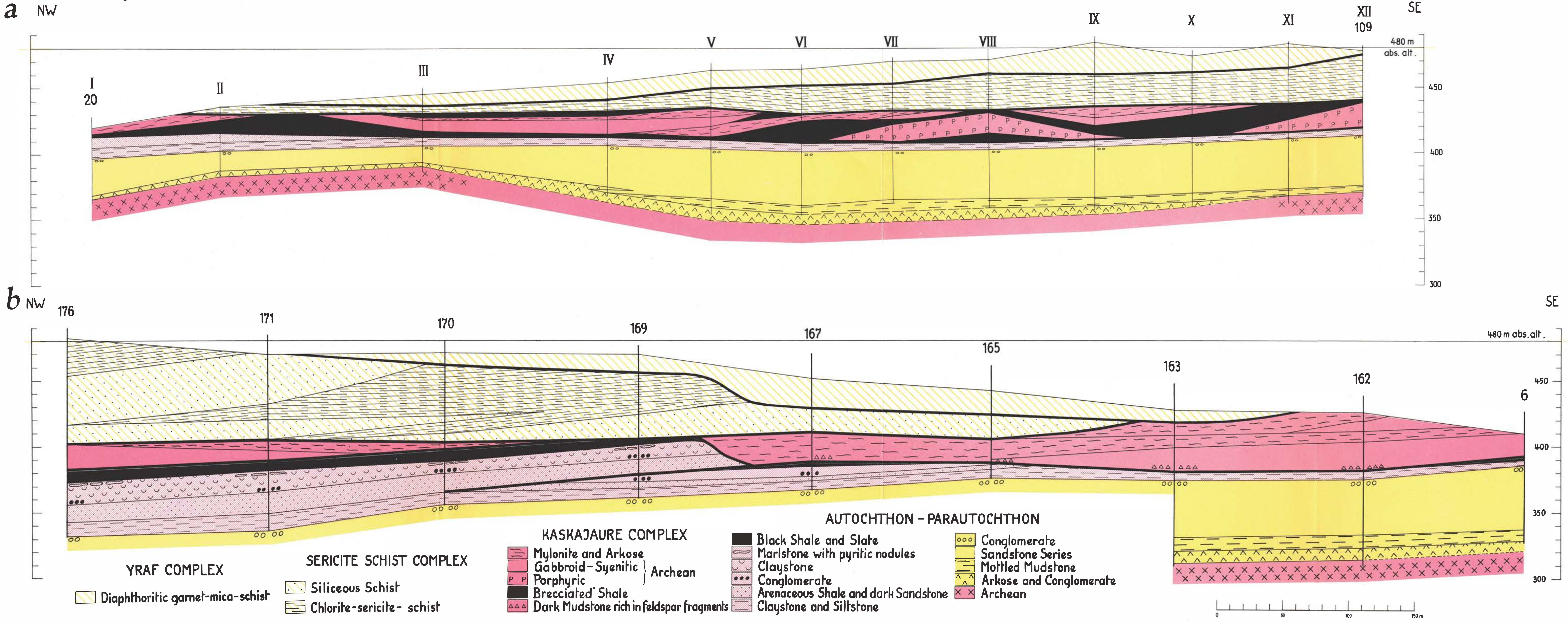
c. Movement in one mayor and two minor thrust planes. A shear plane develops in the old fault-zone in S.E. In N.W. is indicated, with dashed lines, a former thrust zone now incorporated with the Seve thrust sheet. To avoid confusion stippling of these parts of the sections is omitted.

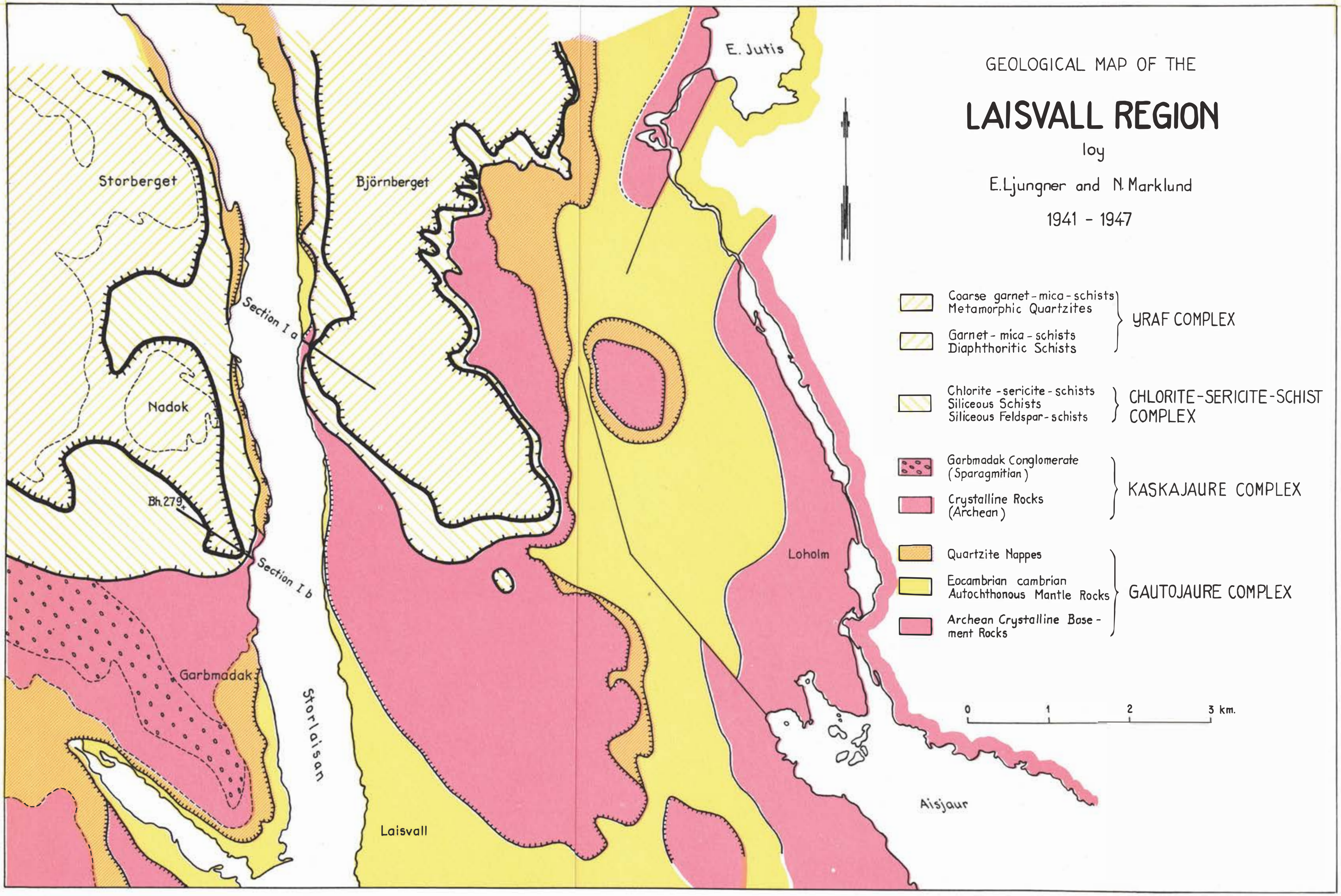
d. Movement in one mayor, one semimayor and three minor thrust planes. The semimayor plane has developed from the precaledonian fault zone. South-east of the semimayor thrust the Autochthonous becomes partly faulted and thrusted.

e. After several steps equalling them between the foregoing sections, this is the section from the highland border at Laisvall to a point about half-way to the Norwegian frontier in N.W. The Seve thrust mass (Yraf Complex) has overridden the Kaskajaure Complex. The Chlorite-sericite-schist Complex, situated between the Kaskajaure- and Yraf Complexes has been cut off at the base by a new mayor thrust plane and incorporated with the great thrust mass.

f. In this section the actual distribution of the metamorphic intensity within the Seve thrust mass of section e is illustrated. Black indicates highly metamorphic rocks.

The sections give an exaggerated picture of discontinuity inasmuch as the tectonic transport is considered to be restricted to a limited set of planes. The amount of internal gliding and translation within the units is, however, considerable especially in the Yraf Complex and exerts a very strong modifying influence upon tectonics and metamorphism.


a
NW
SE
I
20
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
109
480 m
abs. alt.
450
400
350
300
b
NW
SE
176
171
170
169
167
165
163
162
6
480 m abs. alt.
450
400
350
300
YRAF COMPLEX
Diaphthoritic garnet-mica-schist
SERICITE SCHIST COMPLEX
Siliceous Schist
Chlorite-sericite- schist
KASKAJAURE COMPLEX
Mylonite and Arkose
Gabbroid-Syenitic
Porphyric
Archean
Brecciated Shale
Dark Mudstone rich in feldspar fragments
AUTOCHTHON - PARAUTOCHTHON
Black Shale and Slate
Marlstone with pyritic nodules
Claystone
Conglomerate
Arenaceous Shale and dark Sandstone
Claystone and Siltstone
Conglomerate
Sandstone Series
Mottled Mudstone
Arkose and Conglomerate
Archean
0
50
100
150 m


GEOLOGICAL MAP OF THE
LAISVALL REGION
by
E. Ljungner and N. Marklund
1941 - 1947
Coarse garnet-mica-schists
Metamorphic Quartzites
Garnet-mica-schists
Diaphthoritic Schists
YRAF COMPLEX
Chlorite-sericite-schists
Siliceous Schists
Siliceous Feldspar-schists
CHLORITE-SERICITE-SCHIST COMPLEX
Garbmadak Conglomerate (Sparagmitian)
Crystalline Rocks (Archean)
KASKAJAURE COMPLEX
Quartzite Nappes
Eocambrian cambrian Autochthonous Mantle Rocks
Archean Crystalline Basement Rocks
GAUTOJAURE COMPLEX
0 1 2 3 km.
E. Jutis
Storberget
Björnberget
Nadok
Section I a
Bh. 279
Section I b
Garbmadak
Storlaisan
Laisvall
Loholm
Aisjaur