

MIDDLE CAMBRIAN STRATIGRAPHY IN THE RØYKEN AREA, OSLO REGION

BY

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Abstract: The Middle Cambrian beds, which are the oldest ones in this area, are described from a number of localities. The basal beds are of different age in the different localities and the facies change rapidly. This is explained by a marked topography in the basement, probably due to Precambrian faulting along a system of fractures which were active also in the Permian. In other areas of the Oslo region the change in facies in the Middle Cambrian can probably be explained in the same way, and not by Caledonian thrust faulting.

Introduction.

The Røyken area lies on the western side of the Oslo fjord, about 30 km SW of Oslo. The area mainly consists of Precambrian rocks, dissected by numerous faults. Cambrian and Ordovician sediments are preserved on some of the subsided Precambrian blocks.

The geology of the area has been dealt with by BRØGGER (1882),

who described the stratigraphy and palaeontology of the Cambrian and Lower Ordovician, and also made some notes on the Permian eruptives. Later BRØGGER (1886) also mentioned some general (tectonic) features of the area. STRAND (1929) described some Middle Cambrian fossils and mentioned localities at Slemmestad. GLEDITSCH (1944, 1952) has studied the Precambrian rocks of the area, and also mentioned the occurrence of Cambrian basal sediments at several localities.

The author is deeply indebted to Prof. L. STØRMER and Dr. G. HENNINGSMOEN for valuable advice and discussions in connection with this paper.

Description of Localities.

Slemmestad. There are several Middle Cambrian localities in or near Slemmestad (text fig. 1, loc. 1—4).

In the road section just south of the centre of Slemmestad, on the road to Nærnes, the basal beds of the Cambrian are well exposed, resting on the Precambrian. (text fig. 1, loc. 2, text fig. 2). The latter is represented by a deeply weathered granite, which contains some scattered quartz pebbles in its upper part. On top of this conglomeratic arkose we find a thin layer (2—6 cm) of light, tough fragment limestone, followed by 30—40 cm of bedded, arenaceous dark limestone. Above this is a thin arkosic layer (3—10 cm) followed by unfossiliferous, dark carbonaceous shale (alum shale), of which up to 1 m is exposed.

The arkosic layer converges towards the basal arkose, which has a slightly steeper slope towards the north. All beds between the two arkose layers seem to thin out gradually, with no signs of squeezing. This indicates that the basal limestones were not deposited on a horizontal surface. The angle between the arkose beds possibly corresponds to the slope of the original Precambrian surface. The upper arkose probably represents an outwash of coarse sediment over the limestone. It mainly consists of angular fragments of the local granite. However, we also find an abundance of other rocks, such as quartz and fragments of dark shale and limestone. The thickness varies, and the lower surface is undulating (text fig. 2).

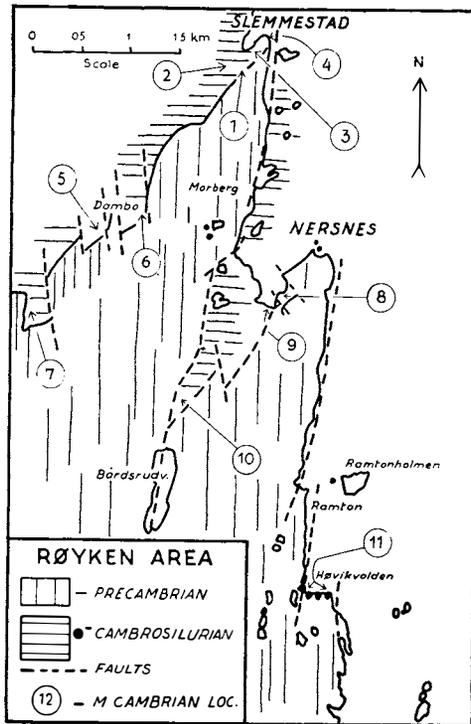


Fig. 1. Map of localities in the Røyken district. The map is slightly modified from GLEDITSCH 1952. Localities: 1) Road section just south of the centre of Slemmestad. 2) Lortbekken (not exposed at present). 3) Section south of the road from Slemmestad to the public harbour. 4) Exposure just south of the public harbour, Slemmestad. 5) Section of a brook near Dambo. 6) Section of the road between Dambo and Morberg about 900 m SE of Dambo. 7) Large exposures of conglomerate between Dalbø and Auke. 8) Old quarry at Nærnes. 9) Section along the brook by the football field, Nærnes. 10) Small section near the road from Nærnes to Bårdsrudvann. 11) Numerous small exposures at Høvikvolden.

In the lower limestone we find the following fossils:

<i>Ptychagnostus</i> (<i>Triplagnostus</i>) <i>gibbus</i>	few specimens
<i>Solenopleura parva</i>	not common
<i>Solenopleura munsteri</i>	common
<i>Paradoxides paradoxissimus</i>	very common
<i>Hyolithes</i> spp	few specimens
Inarticulate brachiopods.	

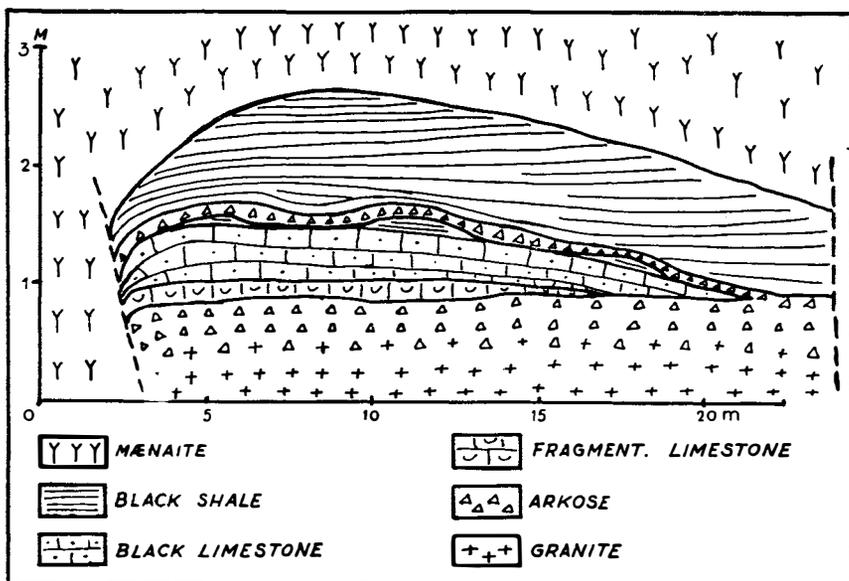


Fig. 2. Section of the locality just south of the centre of Slemmestad (text fig. 1, loc. 1). The height in the figure is exaggerated three times in proportion to the length.

One finds the same fossils in the dark limestone, *Ptychagnostus* (*Triplagnostus*) *gibbus* is, however, dominating, in some cases preserved as complete specimens. In the upper arkose layer the only determinable fossil to be found is a pygidium of *Paradoxides paradoxissimus*. As mentioned above, the shale is unfossiliferous in this locality.

All the Middle Cambrian beds at this locality are preserved in a lens of sediments below a sill of Permian mænaite (see text fig. 2). Generally the sills occur close to the Precambrian surface, altering the Cambrian sediments, and thus obscuring the contact between the Cambrian and the Precambrian.

We find a large number of individual sills with thin layers or lenses of Middle Cambrian sediments in between. Most of the sills are of mænaite type, light, finegrained rocks consisting chiefly of plagioclase feldspar, others are camptonites, dark porphyric rocks, and others again resemble diabases (cf. BRØGGER 1882).

The present material of observation indicates that there is a dif-

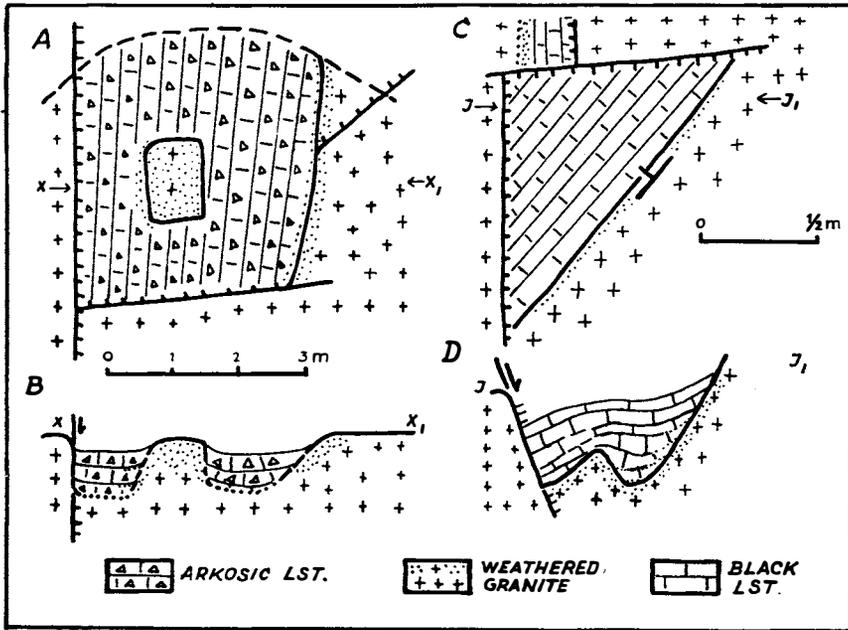


Fig. 3. Sketch maps (A, C) and vertical sections (B, D) of two exposures from Høvikvolden. The first one (A, B) yielded *Hyagnostus parvifrons mammilatus* and other fossils, the latter (C, D) *Ptychagnostus atavus* and other fossils. Faults are indicated by indentated lines and arrows.

ference in the degree in metamorphism caused by the various types of sills. The metamorphism seems to be stronger below the dark sills than below the mænaites. The diabase often occurs as more or less vertical dikes and as a combination of sills and dikes.

Fossils are found between the sills at Slemmestad. The locality lies by the road from the centre of Slemmestad to the public harbour. In this locality (text fig. 1, loc. 3) we find *Ptychagnostus punctuosus* in large stinkstone lenses in black shale. In layers further down there are indeterminable agnostids in similar stinkstone lenses and in the black shale. It is very difficult to estimate the total thickness of the Middle Cambrian because of the numerous sills and the intense faulting.

There is another Middle Cambrian locality on the shore just south

of the public harbour (text fig. 1, loc. 4). The rocks are brecciated by a large permian fault, and the surface of the rocks is covered with cement dust from the large factory at Slemmestad. It is, therefore, difficult to interpret the geological structure correctly.

Fossils have been found in a small lens of sediments between two thick sills. The lens is only exposed at low tide with calm weather. The sequence is the same as in the road section at Slemmestad. At the base fragment limestone with *Paradoxides paradoxissimus*, *Solenopleura parva* and *Ptychagnostus (Triplagn.) gibbus* followed by dark bedded limestone with abundant *Ptychagnostus (Triplagn.) gibbus* and a thin (5 cm) layer of arkose. There are black unfossiliferous shales between the arkose and the upper sill. In this case the lower sill was evidently injected into the basal arkose below the fragment limestone. The persistence of the thin arkose layer is remarkable. The distance between the two localities (text fig. 1, loc. 2 and 4) is about 500 m, and they are almost in the line of the strike of the beds. This fact corroborates the author's hypothesis that the basal beds were deposited on a hill sloping towards NNW.

An old locality was Lortebekken (text fig. 1, loc. 2). Here the Cambrian basal layers were developed as a calcareous conglomerate with numerous fossils in the matrix. The locality is no longer accessible due to housebuilding, and much of the material collected has been lost.

The locality was partly exposed for a short time in October 1953. The sequence was similar to that found in the road section (loc. 1, see below). On top of the precambrian there is a conglomeratic, light limestone with *Paradoxides paradoxissimus*, *Solenopleura* spp. and *Ptychagnostus (Triplagnostus) gibbus*, a dark limestone with abundant *Ptychagnostus (Triplagnostus) gibbus*, underneath unfossiliferous, black shales. There is no upper arcose layer in this locality. The basal beds are more conglomeratic than in the road section, containing numerous quartz pebbles and phosphate nodules. (The conglomerate was not accessible in October 1953, and the description is based on specimens preserved in Paleontologisk Museum, Oslo, collected by Prof. L. STØRMER).

In Paleontologisk Museum, Oslo, there are specimens of *Hypagnostus parvifrons* preserved in shale from Slemmestad. They are

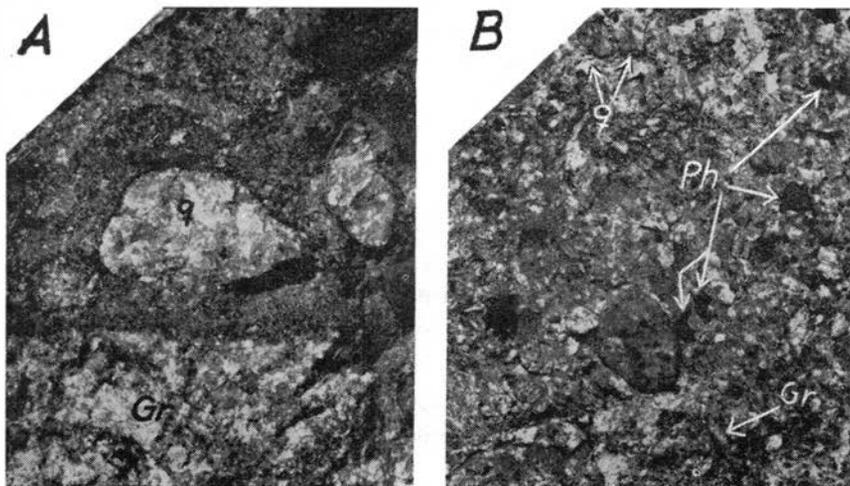


Fig. 4. Types of basal beds from the Røyken district. A is from loc. 6 (text fig. 1), showing quartz pebbles (q), and the sharp contact with the Precambrian granite. (Gr) B. is from Høvikvolden, showing angular fragments of granite (gr), rounded quartz pebbles (q) and black phosphatic rocks (Ph). Both figures are about 9/10 natural size. Photo. B. Mauritz.

referred to as «*Agnostus laevigatus*» by BRØGGER (1882, p. 202). However, he used that term in rather a wide sense.

A fairly complete section of the Middle Cambrian is exposed in a brook near Dambo, about 2½ km SW of Slemmestad (text fig. 1, loc. 5). The rocks are altered, possibly by a thick camptonite sill, and no fossils have been found. (The metamorphism might, in this case also be due to the Permian Drammen Granite, which is exposed about 3 km to the west).

The basal beds are like those found at Slemmestad. They rest upon an arkose with very little foreign material. The lower light limestone (10 cm) and the upper, dark limestone (40 cm) are altered into hornfels. In this locality there is none of the upper arkose found in localities 2 and 3.

Above the lower ½ m there is 8—9 m of black shale with a few, large stinkstone lenses, interrupted by the sill about 5 m above the base.

Between Dambo and Morberg, the basal beds are exposed in a locality on the southern side of the road (text fig. 1, loc. 6). A conglomerate rests upon a smooth, but slightly irregular surface of fresh, unweathered granite.

The grain-size varies considerably, ranging from a coarse sandstone to pebbles more than 15 cm in diameter. The coarse conglomerate appear as lenses wedging out towards the south (against the slope of the Precambrian surface). In the opposite direction the lenses grade into finer conglomerate. This indicates that also in this locality the basal sediments were deposited on a hill sloping towards the north.

The pebbles are generally well rounded, and consist mainly of quartzites and other hard rocks, most of which do not appear in the local bedrock. (text fig. 4 A). A few pebbles of light limestone and sandy to conglomeratic carbonaceous rock have also been found. Due to the metamorphosis, however, it was impossible to find fossils in these pebbles. Quartz, probably pegmatite quartz, dominates among the smaller pebbles (2—5 cm).

Resting on the conglomerate, which is 25 to 40 cm thick, is an arkose, similar to that found at Slemmestad (in the upper layer). It is dark, probably coloured by carbonaceous matter, and mainly consist of angular fragments. The percentage of local material seems to be lower than in Slemmestad. The thickness of the arkose is up to 75 cm. No younger beds are preserved in this locality.

The beds slope slightly towards the north. The Precambrian rock rises steeply above this plane of bedding just south of the locality. No fault line has been observed along the angular junction, and this indicates that the locality is a fraction of one of the Cambrian shore-lines. This is corroborated by the wedging out of the conglomerate towards the south.

At Dalbø, and north of Auke, the basal beds are exposed over a large area. (GLEDITSCH, 1952), (text fig. 1, loc. 7). They vary to a certain degree. Generally an arkose consisting of granitic detritus rests upon the Precambrian with a more or less sharp border. In some cases the arkose was deposited on a comparatively unweathered granite, and in other cases there is a gradual transition from deeply weathered granite to arkose. Above the arkose there is a conglomerate

with boulders of various rocks, granite, quartz, quartzite and conglomerate or arkose. The thickness of the arkose and the conglomerate is up to 1½ m. On top of the conglomerate there is a thin, light limestone (5—10 cm) followed by dark limestone and black shale. The sediments have been extensively altered by the Drammen Granite, and there are no fossils. The conglomerate from this locality was described by REUSCH (1884), who especially mentioned the presence of pebbles of conglomerate in the conglomerate. It is not unusual to find such boulders together with pebbles of sandstone, arkose and phosphates, even if they only make up a minority of the pebbles of the conglomerate. The pebbles of this type are angular, and do not differ visibly from the sediment underneath. This indicates that the final conglomerate was formed by erosion of older, probably local sediments.

There is a considerable amount of galena and other sulphides in the coarse sediments in the Røyken district. They also appear in veins in the Precambrian rocks. The localities at Slemmestad and Dalbø are specially rich on sulphides. On the latter area some mining of argentiferous galena has been done. (cf. REUSCH 1884). One has found galena in Cambrian basal sediments in Sweden, too, and it is supposed to be of sedimentary origin. In contrast to the Swedish deposits, the galena in the Røyken distrikt is accompanied by quantities of pyrite and zinc-blende. The presence of this paragenesis might indicate a pneumatolytic origin of the sulphides in connection with the numerous Permian eruptives of the region. However, this is probably not the case at Slemmestad, where the arkose is very rich on sulphides, while the unmetamorphic limestones are practically devoid of ore minerals. The sulphides in the fine sediments (mainly in the black shale, and a little in the dark limestone) are arranged in bands parallel to the bedding. Generally these bands also contain a large amount of sand or silt. The sulphide grains are of silt size, too, or smaller, except for some recrystallised clusters which probably are of secondary origin. The sulphide grains found in the arkose are more irregular both as to shape and size, indicating that the ore minerals were deposited as heavy minerals in the sediments.

In the Nærnes district (for geological description, see BRØGGER 1882 and GLEDITSCH 1924, 1952), the Middle Cambrian rocks are

exposed over a comparatively large area. The geological structure is similar to that found at Slemmestad, a faulted block of Precambrian sloping N—NNW, covered with Cambrian and Ordovician sediments, with the oldest beds at the southern margin of the area. The Middle Cambrian rocks are penetrated by numerous sills, some of them of different types to those found at Slemmestad. BRØGGER (1882) has given a description of some of the types, which occur both as sills and dikes. The tectonics of the oldest beds are therefore very complicated, and in the same way as at Slemmestad, no exact figures of the thickness of the beds can be given.

In spite of the widespread occurrence of Middle Cambrian sediments in Nærnes, determinable fossils have only been found in two localities. In the first one, an old quarry on the southern side of the Nærnes bay, (text fig. 1, loc. 8) we find *Hypagnostus parvifrons* in a black stinkstone lens, and about 2—4 m higher there is *Peronopsis fallax ferox* in altered shale. The latter form is represented by specimens intermediate between this subspecies and *Peronopsis fallax fallax*, like those figured by WESTERGÅRD (1946, pl. 3 figs. 1—2) from the zone of *Ptychagnostus punctuosus*. It is therefore taken for granted that both this zone, and that of *Hypagnostus parvifrons* occur in this locality. Besides the other fossils, indeterminable agnostids (*Ptychagnostus* sp. ?) occur in masses in the shale in both zones.

The basal beds are exposed on the road along the southern side of the bay. No fossils have been found here. The rocks are an arkose, consisting mainly of detritus of the local granite, mixed with a few pebbles of quartz. The thickness of the arkose, which grades into the granite, is up to one meter. The contact surface between the arkose and the granite, which has been studied in detail, is very irregular, indicating a smallscale relief of the Precambrian surface. The «topography» consists of domeshaped areas of granite, a couple of meters broad and less than one meter high. In the granite there are irregular steep-sided furrows filled with arkose.

In this locality the arkose is followed by a sill, obscuring the transition to the black shale. In a small quarry NE of the first mentioned locality, the arkose is found in contact with a small patch of black shale. There is no bedded limestone at the bottom.

In another locality, in the bed of the brook by the football field,

(text fig. 1, loc. 9), the Middle Cambrian shale rests directly upon the irregular, slightly weathered surface of the granite. Here there is no arkose.

The other locality at Nærnes, where fossils have been found, was described by BRØGGER (1882, p. 199) (text fig. 1, loc. 10). It lies in the southwestern part of the Nærnes district. The fossils are found in a dark, slightly metamorphic shale. BRØGGER (l.c.) reported *Paradoxides rugulosus* and «*Agnostus laevigatus*». It is obvious that BRØGGER used the latter term in a much wider sense than *Lejopyge laevigata* of modern authors, e.g. WESTERGÅRD (1946). All the agnostids from this locality, both those collected by BRØGGER, and those found by the author, are undeterminable as to genus and species. Most of them probably belong to *Ptychagnostus*. A few are smooth, but it is impossible to refer them to *Lejopyge laevigata* because of the bad state of preservation. *Paradoxides rugulosus* only appears in fragments, and is identified by the characteristic sculpture, and on a fragmentary pygidium. In addition to the trilobites mentioned by BRØGGER, the author also found *Agraulos* cf. *acuminatus* (BRØGGER). The specimens which were found are transitional forms between the typical *Agraulos acuminatus*, and the type described by BRØGGER (1878 pl. 4 fig. 5) from stage 1 c. The two types differ considerably in the development of the prelabellar field, which is large and triangular in front, in *acuminatus*, and smaller and evenly rounded in the older type. The specimens from Nærnes are closer to the typical form than to the older one, which, according to oral communication with dr. G. HENNINGSMOEN, might be a separate species.

The fauna, therefore, indicates that the layers belong to the lowest part of stage 1 d, or to the transitional beds between 1 d and 1 c. It is the only locality in the Røyken district, where the stage 1 d is found.

The author's interpretation on the geology of the Nærnes area slightly deviates from that expressed in the earlier maps and descriptions (BRØGGER 1882, GLEDITSCH 1944, 1952). The border between the Cambrian and the older rocks is a fault line. (cf. text fig. 1). In some places there are large diabase dikes along this line. In the locality mentioned above, (loc. 10), the geological structures are obscured by heavy vegetation. However, it seems to be evident that there are Precambrian rocks on both sides of the brook, and that there is no

conglomerate in this place. Therefore there is probably a faultline on the northern side of the stream, a few meters south of the exposure where the fossils have been found. (Compare BRØGGER 1882, text fig. on p. 199).

At Høvikvolden (text fig. 1, loc. 11) the basal layers of the Middle Cambrian are exposed as a thin crust of calcareous conglomerate sloping to the north or north-west (cf. GLEDITSCH 1944). We find the conglomerate in a large number of presumably original depressions in the Precambrian surface. The dimensions of these depressions vary from less than 10 cm to more than 50 m. They are generally limited by straight lines, corresponding to joints in the Precambrian granite. (text fig. 3). Movements have taken place along some of these lines in Permian time, this being indicated by small friction breccias. We also find a number of large breccias and quartz-filled veins between the depressions. In some cases, however, the Cambrian basal beds show grading along the steep walls of the depressions, indicating that the conglomerate and limestone originally were deposited in cavities formed by erosion in the jointed Precambrian rock. In this area we come across many depressions of similar size and shape, now filled with pleistocene or recent gravel.

There are two different types of Cambrian basal sediments at Høvikvolden. In most cases the rock consists of an arkose or conglomerate cemented with a grey limestone. The fragments, which are of an angular shape (text fig. 4 B), chiefly come from the granite underneath and from other local rocks. There are also a good deal of more rounded pebbles of quartz and quartzites. We find large pebbles (up to 15 cm in diameter) of a black, unmetamorphic sediment, probably a phosphatic sandstone with wellrounded quartz grains. In the depressions there are several subangular horsts of the Precambrian basement, and these reflect the irregular surface on which the Cambrian beds were deposited (text fig. 3).

The Precambrian granite is strongly weathered, and at times brecciated. However, the decomposed layer is rather thin, 5—15 cm, except in the horsts mentioned above, which are deeply weathered.

The limestone is fossiliferous, and contains the following fossils:

Hypagnostus parvifrons mammilatus.

Paradoxides paradoxissimus.

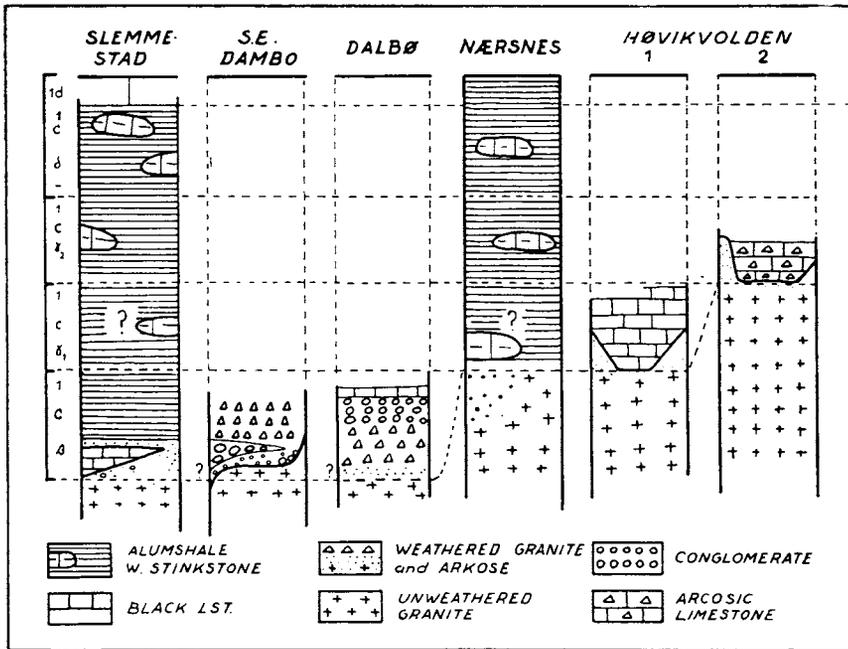


Fig. 5. Diagrammatic section of the Middle Cambrian sequence in some localities in the Røyken district. The scale is not the thickness of the beds, only the zones present. The Slemmestad and Nærnes sections are combined from localities 1—4 and 8—10 respectively, and specimens found in the collections of Paleontologisk Museum, Oslo.

Solenopleura parva.

Hyalolithes sp.

In some of the depressions there are plenty of fossils, and in others there are none or very few. The quantitative composition of the fauna also varies. *Hypagnostus parvifrons mammilatus* is the most common species everywhere. *Paradoxides* can be found in most places, but in rather small amounts. There is a great deal of *Solenopleura* and *Hyalolithes*, but they are not found in all localities.

We find the other type of sediments in two deep, triangular depressions. In one of them (text fig. 3 C—D) all the sediment was taken out in order to study the contact with the basement. The granite appears to be only slightly weathered. The sediment consists of dark,

carbonaceous limestone with considerable quantities of sand and silt, and some thin fragment layers. The lowest layers are lightcoloured and marly. The bedding and the topography of the bottom of the depression, clearly indicate that the sediments were deposited in an original depression in the granite.

The fauna in this place consists of:

Ptychagnostus atavus.

Hypagnostus parvifrons mammilatus.

Paradoxides paradoxissimus

Solenpleura parva

Hyalolithes sp.

The agnostides are evenly distributed in the layers, with *Ptychagnostus atavus* in majority. The other fossils are found in the fragment layers, or in between them in the lowest beds of the depression. The total thickness of the layers of this type is 75 cm, the other depressions seem to be less than 40 cm deep. It is probable that the two types of sediment belong to two different zones. The first one, with numerous *Hypagnostus parvifrons mammilatus* probably belong to the zone of *Hypagnostus parvifrons*. However, the subspecies *mammilatus* is also reported to have been found in the zones of *Ptychagnostus atavus* and *Ptychagnostus punctuosus* (WESTERGÅRD 1946), but it is not common in these zones. The other type evidently belongs to the zone of *Ptychagnostus atavus*, the guide fossil being the most abundant. The layers of these two types are certainly not contemporaneous. The latter (with *Ptychagnostus atavus*) was deposited under euxinic conditions, whereas the first, in spite of containing some carbon, seems to have been deposited under ventilated conditions. Because of the intense faulting of the district, it is impossible to find the original vertical distance between the depressions. They are now all found at, or near sea level.

Correlation.

The faunal zones and subzones in the Middle and Upper Cambrian are remarkably constant all over Scandinavia. The difference between the regions lies in the lithology and the number of zones present. In the Røyken district the lowest zone found in the Middle Cambrian

is that of *Ptychagnostus (Triplagnostus) gibbus*, just as in the typical section at Krekling, in Scania and in some of the northern districts in the Oslo region.

The table below shows the stages found in Norway, and their Swedish equivalents. The table is based mainly on data given by WESTERGÅRD (1946) and STRAND (1929, 1946). The symbols applied to the Norwegian zones are partly new and are the result of a cooperation between Dr. G. HENNINGSMOEN and the author.

Stage of	Zone of	Swedish symbol	Norwegian symbol	Thickness at Krekling ¹
Paradoxides forchammeri	<i>Lejopyge laevigata</i>	C 3	1 d γ	ca. 11 m
	<i>Solenopleura brachymetopa</i>	C 2	1 d β	
	<i>Ptychagnostus lundgreni</i> & <i>Goniagnostus nathorsti</i> ..	C 1	1 d a	
Paradoxides paradoxis-simus	<i>Ptychagnostus punctuosus</i> (= z. of <i>Par. rugulosus</i>) . . .	B 4	1 c δ	ca. 8 m
	<i>Hypagnostus parvifrons</i> ..	B 3	1 c γ_2	» 1,5 m
	<i>Tomagnostus fissus</i> and <i>Ptychagnostus atavus</i> . . .	B 2	1 c γ_1	» 2,5 m
	<i>Ptychagnostus (Tripl.) gibbus</i> (= z. of <i>Ctenocephalus exulans</i>)	B 1	1 c β	» 5 m
Paradoxides ölandicus	<i>Paradoxides pinus</i>	A 2 }	1 c a	not developed
	<i>Paradoxides insularis</i>	A 1 }		

¹ from BRØGGER 1878.

The *Paradoxides ölandicus* zone, which is not developed in the Røyken district, is found in Norway in the Mjøsa district, and in Rogaland (STRAND (1929, 1948) and HENNINGSMOEN (1952).

In the Røyken district, the Middle Cambrian sedimentation started at different times at the various localities. At Slemmestad, the zone of *Ptychagnostus (Triplagn.) gibbus* is the lowest. At Nærnes, the basal layers are unfossiliferous. The oldest datable zone is that of *Hypagnostus parvifrons* developed as a black shale with stinkstone lenses. At Høvikvolden both the zone of *Ptychagnostus atavus* and

that of *Hypagnostus parvifrons* are represented in the basal layers. We find the latter zone in a facies quite different to that at Nærnes. This difference in facies in this comparatively small district, indicates that the Precambrian surface must have had a marked topography, even if the variations as to altitude were not so large.

In the basal beds, phosphatic rocks are common in most localities. The rounded quartz grains in these rocks form a striking contrast to the generally sharply angular material which we find in the basal beds. At Dalbø one can also find pebbles of conglomerate in the conglomerate. However, the pebbles and the matrix are similar in this locality.

The phosphatic rock is rather soft and fragile and can hardly have endured long transport. The older Cambrian rocks were therefore probably sedimented in this area before the time of the zones of *Ptychagnostus (Triplagn.) gibbus*, and were eroded before this zone was deposited.

In the rest of the Oslo region, two facies of the Middle Cambrian have been found. In the first one, the sequence starts with 1 c β , and in the latter with 1 c α . (subzone of *Paradoxides pinus*, the lower subzone of *Paradoxides insularis* is not reported from Norway). The second type of facies is regarded as being allochthonous, and is found in the Mjøsa district, and in parts of Hadeland. (STRAND 1929, 1948). In the latter district we do not find any Lower Cambrian layers, and the *Paradoxides ölandicus* beds were regarded as belonging to a nappe because they are found 10 and 20 km respectively from two localities in which the Middle Cambrian have the first («autochthonous») development. In the Røyken district, however, we find changes in facies of the same order of size within a much smaller area.

Therefore it must be stressed that change in facies of the Middle Cambrian, even in a small area, generally is no proof of tectonical displacement of the beds.

Since no tectonical evidence for a nappe at Hadeland has been procured, it seems reasonable to conclude that the *Paradoxides ölandicus* beds in this district probably are autochthonous.

The Precambrian topography in the Røyken district was possibly determined by faults running NE—SW. Fault breccias in this direction have been described by BRØGGER (1886) and GLEDITSCH (1943,

1952). The faulting is regarded as being of Permian age only. However, both authors mention that there are at least two zones of breccia, of different age. The youngest one is dark-coloured by carbonaceous matter from alum shales, while the older ones are devoid of such material. Both BRØGGER and GLEDITSCH indicate the possibility of the older breccias being Precambrian. If this is correct, the Precambrian topography can easily be explained, even if the breccias are much older than the Middle Cambrian. Selective erosion of the rock on both sides of the faults, and along the faultlines themselves would have produced a marked relief. Another fact that must be mentioned, is that the *Paradoxides ölandicus*-locality at Røykenvik, Hadeland lies near one of the large faultlines bordering the Oslo region.

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