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ON THE MIDDLE CAMBRIAN OF HADELAND (OSLO REGION, SOUTHERN NORWAY)

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With 2 figures in the text.

Abstract. Two Middle Cambrian sections in Hadeland, 11 km apart, show considerable differences in lithology and fauna. In one of the sections the rocks are strictly autochtonous, in the other they are strongly folded. In view of the facies differences the rocks in the latter section are interpreted as belonging to a thrust-sheet.

Good sections of fossiliferous Middle Cambrian rocks are known in two localities only in Hadeland. One of these is a railway section north of the railway station of Hennung, about 11 km north of Brandbu[1]. The section is at the northern boundary of the outlier of Hennungsbygda of Cambrian alum shales on surrounding Archean rocks. The other locality is at the shore of Lake Randsfjord to the west and south-west of the church of Nes, west of Røykenvik. The locality near Hennung is 11 km to the north-east of the locality west of Røykenvik. A comparison of the stratigraphy of the two sections brings out differences of great interest, and both of them are described here. The description of the section north of Hennung is based upon recent field work by the writer, while the stratigraphy of the locality west of Røykenvik is based mainly on the collections of fossils from this locality preserved in Paleontologisk Museum, Oslo, collected at different dates by Mr. Ths. Münster, Professor Olaf Holtedahl and the writer. In prevous litterature the alum shale area of Hennungsbygda was described by Andresen (1891) and Holtedahl (1911), while fossils from the locality west of Røykenvik were listed by the present writer (Strand 1929, p. 328).

The railway section north of Hennung is represented in fig. 1. The exposed sequence with its Archean substratum dips about 5

[1] For topographical and geological orientation the geological map Gran (Holtedahl and Schetelig 1923) may be used.

degrees in a south-westerly direction, probably due to faulting, there is no folding or crumpling of the shales. The section consists of alum shale intruded by sills of mænaite. At the boundary between the Archean gneiss and the alum shales a conglomerate is exposed. Parts of this are rather rich in quartz-pebbles, while in other parts, where a calcareous matrix completely prevails, the rock is a light coarse-grained limestone. A closer inspection of the outcrop shows this conglomerate to occur as a sedimentary dyke, filling a cleft in the substratum, 2 to 3 dm wide, and not as a continuous layer beneath the alum shale. The conglomerate was not searched through for fossils, as this would involve a destruction of the outcrop. There is no doubt, however, that it is the same conglomerate, which, at near-by localities, has yielded *Torellella lævigata* (Linrs.), thus of Lower Cambrian age. At the eastern boundary of the Hennungsbygda outlier Holtedahl (1911, p. 9) found boulders consisting in some parts of quartz conglomerate, in other parts of light and grey coarsely crystalline calcite, in which *Torellella lævigata* was found. Further localities for the Torellella conglomerate are a spot near the railway station of Bleiken and farther south at Bjerke near Brandbu, where the conglomerate was discovered by W. C. Brøgger in 1894.

The Torellella conglomerate of Hadeland is not a basal conglomerate of the overlying Middle Cambrian alum shales, but was deposited by a separate transgression in Lower Cambrian time. A disconformity between the conglomerate and the overlying alum shales is clearly shown at the locality Risbekken in the Toten District, 25 km north-east of Hennung (Strand 1929, p. 324).[1]

[1] When discussing the Torellella conglomerate of Hadeland, Kiær (1916, p. 101) considered it a basal conglomerate of the overlying Middle Cambrian alum shales of the Paradoxides tessini division. As a logical consequence the conglomerate itself was considered as of Middle Cambrian age. In this connection Kiær referred to a faunule collected from loose boulders at Tømten, Ringsaker, in which *Torellella lævigata* was found together with trilobite fragments, with a sculpture reminiscent of that of *Paradoxides*, and listed by Kiær as *Paradoxides* sp. (Kiær 1916, p. 99). This assemblage was claimed to represent a transition fauna with a mixture of Lower and Middle Cambrian species. It must, however, be strongly emphasized, that the trilobite fragments in question (figured by Strand 1929, pl. 1, figs. 17, 18) are wholly indeterminable, as a similar sculpture may be found in many genera other than *Paradoxides*. There is thus nothing to indicate the presence of a transition fauna between the Lower and the Middle Cambrian, as claimed by Kiær.

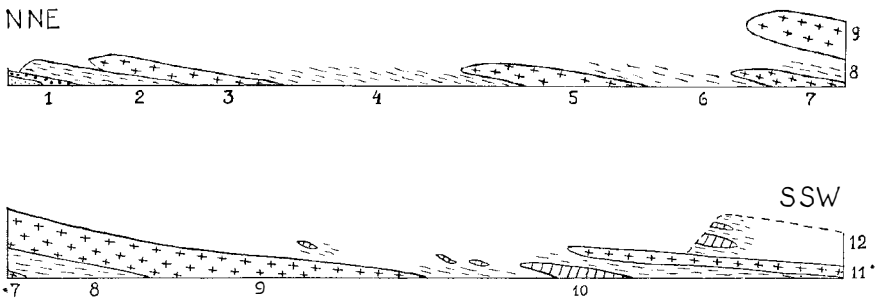

Fig. 1. The railway section north of Hennung. 1. Archean basement with Torellella conglomerate and the basal conglomerat of the alum shale. 3, 5, 7, 9, 11. Mænaite sills, thickness in metres 1,1, 0,8, 0,6, 1,2 and 0,3 respectively. 2, 4, 6, 8. Alum shale between the sills, thickness in metres 0,7, 1,3, 1,5 and 1,0, respectively. 10, 12. Alum shale with fossiliferous stinkstone, thickness in metres 1,1 and 1+, respectively. The whole thickness of the sediments in the section is 6,5 to 7 metres.

Beneath the alum shales in the railway section, in the parts not occupied by the conglomerate described above, there is a dark grey micaceous rock with an almost vertical schistosity, evidently inherited from the gneiss, which probably is a weathering product *in situ*. In the upper part, below the alum shale, it contains quartz-pebbles. This is the basal deposit of the alum shale formed at the Middle Cambrian transgression, and it has evidently no sharp boundary to the underlying gneiss.

No fossils were found in the shales in the section, but in the upper part there are lenses of the usual black limestone (stinkstone). In a lower horizon of stinkstone (10 in fig. 1) were found a great number of specimens of

Hypagnostus nepos (Brøgger),
Goniagnostus nathorsti (Brøgger),

which species were also cited by Holtedahl (1911). In the upper horizon with stinkstone (12 in fig. 1) the following fauna was collected:

Paradoxides sp., fragments with a sculpture of *forchhammeri* type.
Agraulos difformis (Ang.).
Acothele sp.
Hyolithus sp.

Higher horizons are not exposed in this section.

About a hundred metres to the south of the locality just described the railway crosses a brook, running down in a westerly direction; just to the south of the brook there is a small bridge carrying a

road across the railway. In the railway section at this place there are alum shales with a rather high southern dip intruded by thick lenses of mænaite, in limestone lenses in the shale a cranidium or a *Hypagnostus* sp. was found. There should be little doubt that this corresponds with the lower horizon of limestone in the section just described. About 5 metres, by estimation, higher than the railway alum shales with thin layers of stinkstone with *Olenus* sp. are exposed at the road at the east side of the line. In this horizon of the sequence folding is perceptible by gentle waves in the shales. Upwards along the brook, further east, crop out highly folded and contorted alum shales, which did not yield any fossils.

At the locality at the lake shore west of Røykenvik the exposures are mostly very low, and a great part of the material from here has certainly been taken from loose pieces of limestone in the beach. At a visit last autumn the writer found the greater part of the locality inaccessible due to high water of the lake. Among the material from this locality, the limestone with fossils from the Paradoxides oelandicus stage, discovered and collected by Professor Holtedahl on a students' excursion in 1922, is of special interest. The rock is a grey to black fine-grained tough limestone, similar to the limestone in the same zone in Ringsaker at Lake Mjøsa. Also the preservation of the fossils with a black glistening surface of the shell is similar. The material contains numerous *Paradoxides* cranidia of *oelandicus* type, a pygidium of *Paradoxides* cf. *pinus* Holm and a pygidium of an unnamed *Paradoxides* (brief description in Strand 1929, p. 350).

There is, further, a great material of fossils occurring in black stinkstone of the usual type, representing two main horizons.

1. *Ptychagnostus (Triplagn.) hybridus* (Brøgger)
   Hypagnostus parvifrons (Linrs.)
   "Liostracus" linnarssoni Brøgger.

It may by noted that the two agnostids have not been found together, except for dubious specimens of *Hypagnostus?* sp. together with *Pt. (Tr.) hybridus.*

2. *Peronopsis fallax* (Linrs.), some specimens near to subsp. *ferox* Tullberg.
   Ptychagnostus (Triplagn.) lundgreni (Tullberg)[1]
   Doryagnostus incertus (Brøgger)

[1] By Strand 1929 erroneously identified with *Ptychagn. atavus* (Tullberg). Specimens from this locality were figured l. c. pl. 1 fig. 20.

Phalacroma sp.
"*Liostracus*" *linnarssoni* Brøgger
Paradoxides cf. *rugulosus* Corda.

The species in this assemblage have been found associated, if yet not all of them in each of the collections under one label.

In the south-eastern part of the locality black shale with large lenses of limestone are exposed in a low cliff in the beach, separated by a covered interspace of about 50 metres to the south-east from a small promontory with Orthoceras Limestone. The shales dip at a high angle to the north and are very fissile, due also to their jointing perpendicularly to the bedding. The limestone lenses are also full of joints, indicating a rather great tectonical influence. The limestone lenses here are uncommonly large in size, up to 2 metres wide, and consist of a tough but generally coarse-grained black limestone with irregular inclusions of pyrite. In the central parts the lenses have veins filled with crystalline calcite, the so-called septaria. The lenses contain the following fauna:

Phalacroma sp.
Paradoxides cf. *forchhammeri* Ang. (fragments)
Agraulos difformis (Ang.)
Solenopleura cf. *brachymetopa* Ang.

In his recent paper on the Agnostidea of the Middle Cambrian of Sweden, Westergård (1946, p. 8) puts forth the following stratigraphical scheme for the Middle Cambrian Paradoxides beds of Sweden, which ought to be adaptable also for Norway:

C. Paradoxides forchhammeri stage.
3. Zone of Lejopyge lævigata
2. - - Solenopleura brachymetopa (Andrarum Limestone)
1. - - Ptychagn. (Triplagn.) lundgreni and Goniagnostus nathorsti

B. Paradoxides paradoxissimus (tessini) stage
4. Zone of Ptychagn. (Pt.) punctuosus
3. - - Hypagn. parvifrons
2. - - Tomagn. fissus and Ptychagn. (Pt.) atavus
1. - - Ptychagn. (Tr.) gibbus, exsulans limestone

A. Paradoxides oelandicus stage
2. Zone of Paradoxides pinus
1. - - Paradoxides insularis.

In fig. 2 the two sections are represented diagrammatically, irrespective of the possible differences in thickness, and the fossiliferous horizons have been inserted in the above scheme of Westergård. As the section at Hennung has yielded no fossils from its basal part, we can not determine directly at which horizon the transgression took place. The nearest autochtonous sections of the Middle Cambrian in which the basal parts can be dated by fossils is that at Risbekken, 25 km to the north-east, and that of Slemmestad, south-east of Oslo, 80 km to the south. At Risbekken *Ptychagn. (Triplagn.) gibbus* was found half a metre above the Torellella conglomerate, at Slemmestad the same species occurs in a basal limestone with embedded quartz-pebbles (Strand 1929, p. 324, p. 328). The Middle Cambrian transgression in Southern Norway seems to have taken place in the upper part of the gibbus zone (B 1) of Westergård, and, as indicated in the figure, this is most probably also the case in the present section.

By a comparison between the two sections in fig. 2 we note for the first that the Paradoxides oelandicus beds are absent from the section of Hennung, if the above conclusions are accepted. In any case the fossiliferous limestone of this zone is absent.

In the Røykenvik section the Hypagnostus parvifrons zone is represented by fossiliferous stinkstone, in the section at Hennung the zone is most probably represented, but only by shale without limestone. The zone of Ptychagn. (Tr.) lundgreni and Goniagn. nathorsti is represented by fossiliferous stinkstone in both sections, but here the faunas found are wholly different. In the zone of Solenopleura brachymetopa (C 2) the fauna is the same in both sections, but here there are lithological differences. The stinkstone lenses in the section at Hennung are much smaller and different from the large lenses with septaria west of Røykenvik.

In the Hennung section the rocks are autochtonous in the strictest sense of the word, while west of Røykenvik they have been torn away from their original place of deposition. This circumstance in itself only tells that folding has acted at a lower stratigraphical level in the section west of Røykenvik, and is no proof or indication of allochtonity. But when considering the faunistical and lithological differences between the two sequences, the best interpretation, in the author's opinion, is to consider the sequence west of Røykenvik as belonging to a nappe that has been thrust a considerable distance to the south or the south-east. We know from all stratigraphical

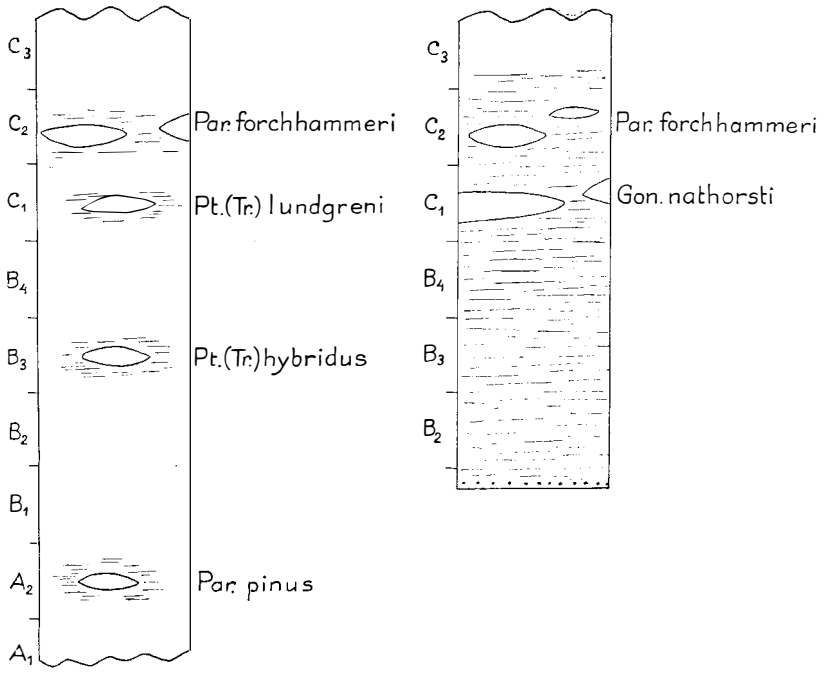

Fig. 2. Diagrams of the sections west of Røykenvik (to the left) and north of Hennung (to the right).

experience that epicontinental deposits, like those here considered, usually retain their faunal and lithological facies over long distances, and the many differences noted between the two sections described, makes a deposition in areas only 11 km remote from each other very unlikely.

The great difference in facies development of the Middle Ordovician (Chasmops Series) between the southern and the northern parts of the Cambro-Silurian area of Hadeland has been known for many years. Størmer (1942, 1945) showed that there is no transition, but a marked boundary, between the two facies. He interpreted the northern facies as belonging to a nappe, but as no thrust-plane could be found in that heavily covered area, he took a cautious attitude to the nappe interpretation. When now similar indications are found in other parts of the sequence in the same area, there should no longer be any reason to doubt the presence of allochtonous Cambro-Silurian in Hadeland.

When dealing with nappes in the central parts of a mountain-chain, it is usually impossible to make any precise statement as to where an allochtonous rock mass had its origin. In the present case there are, however, rather good indications as to this point. To the north and north-west of Hadeland, at the northern part of Lake Randsfjord (Holtedahl 1915) and further north and west in the Valdres valley district, there is found a thin cover of Cambrian shales, often less than 10 metres thick, above the Archean substratum, which is again covered by overthrust Sparagmitian rocks. What may have existed of higher Cambro-Silurian deposited in these areas has been stripped off the substratum and is most probably now to be sought in the nappes of Hadeland.

Future research will probably show the existence, in other parts of the sequence in the northern parts of the Oslo Region also, of facies differences which may serve to distinguish between nappes, as has been done for Jämtland by Asklund (1938) and Thorslund (1940). In this connection attention may be called to the facies differences of the Orthoceras Limestone at Hamar and in Helgøya in the Mjøsa district, a brief account of which has been published by the present writer (Strand 1929, p. 327).

REFERENCES

Andresen, J. C. 1891. Norges Geol. Unders. No. 1 (aarbog 1891), p. 19.
Asklund, B. 1938. Sveriges Geol. Unders. ser. C No. 417.
Holtedahl, O. 1911. Norsk Geol. Tidsskr. **2**, no. 6.
— 1915. Norges Geol. Unders. No. 75, I.
— and J. Schetelig. 1923. *Ibid.*, No. 97.
Kiær, J. 1916. Vid.-Selsk. Skr. I. M.-N. Kl. 1916. No. 10.
Strand, T. 1929. Norsk Geol. Tidsskr. **10**.
Størmer, L. 1942. *Ibid.* **22**.
— 1945. *Ibid.* **25**.
Thorslund, P. 1940. Sveriges Geol. Unders. ser. C No. 436.
Westergård, A. H. 1946. *Ibid.*, ser. C. No. 477.