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WIESŁAW BEDNARCZYK

The Ordovician in the Koszalin-Chojnice region (Western Pomerania)

ABSTRACT: Within the strongly tectonically disturbed region of Koszalin-Chojnice, fragments of Ordovician sediments have been found in 12 boreholes drilled by the Oil Research Survey and in two other ones drilled by the Geological Institute. On the presence of graptolites these sediments, developed in a silty facies, have been referred to the Llandellian and Caradocian including the *Dicranograptus clingani* Zone. In the SE part of the above region the occurrence has been noted of tuffite layers.

INTRODUCTION

Data regarding the occurrence of Ordovician sediments in Western Pomerania are given by Dadlez (1967) and Modliński (1968) as well as by Teller & Korejwo (1967).

In concurrence with the above authors, Ordovician deposits have been found in boreholes both of the Geological Institute (Jamno *IG-1* and Jamno *IG-2*) and of the Oil Research Survey of Piła (Miastko *1* and Nowa Karczma *1*). These boreholes, drilled in an area strongly tectonically disturbed, and extending from Chojnice in the SE to Koszalin in the NW, did not pierce the Ordovician (Modliński 1968). During the last few years several new boreholes were drilled by the Oil Research Survey, ten of which (Fig. 1) reached Upper Ordovician siltstones underlying Permian, Carboniferous or Devonian deposits (Fig. 2).

In the present paper are given the results of the stratigraphic investigations of the Ordovician sediments from these ten boreholes with reference to the data obtained by the authors mentioned above. All the columns have been described by the writer in the core storage room at Piła, while the samples have been worked out in the Laboratory of

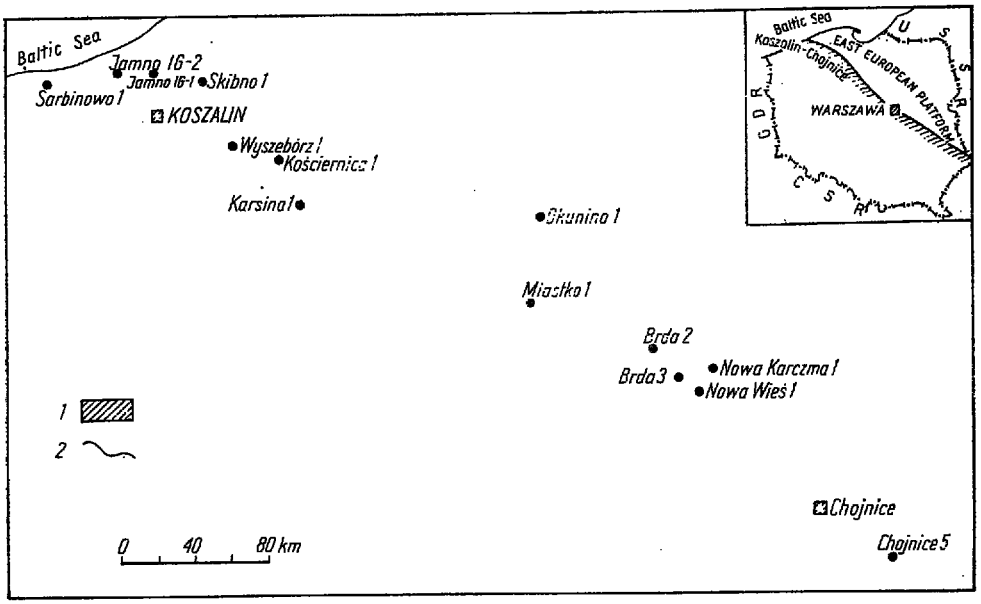


Fig. 1

Sketchmap of the Koszalin-Chojnice area showing boreholes in which the Ordovician has been reached

Stratigraphy of the Institute of Geological Sciences of the Polish Academy of Sciences in co-operation with the Union for Oil Mining. The Ordovician documentary materials are kept in the above named Laboratory.

The writer's most cordial thanks are due to the Head Geologist of the Union for Oil Mining for the access to materials, also to B. Sikorski, M. Sc., from the Oil Research Survey at Piła for friendly help.

LITHOLOGO-FAUNISTIC CHARACTERISTICS OF ORDOVICIAN DEPOSITS

The following are descriptions of the Ordovician sediments reached in boreholes drilled by the Oil Research Survey, going NW-SE.

Borehole Sarbinowo 1

As is shown by electric logging analysis, the Ordovician in this column directly underlies the Carboniferous sediments from a depth of 2796.0 m. It is represented by darkgrey siltstones, sometimes dolomitic with pyrite concentrations and muscovite flakes. The whole series is strongly slickensided and tectonically disturbed. The fauna (Table 1) is

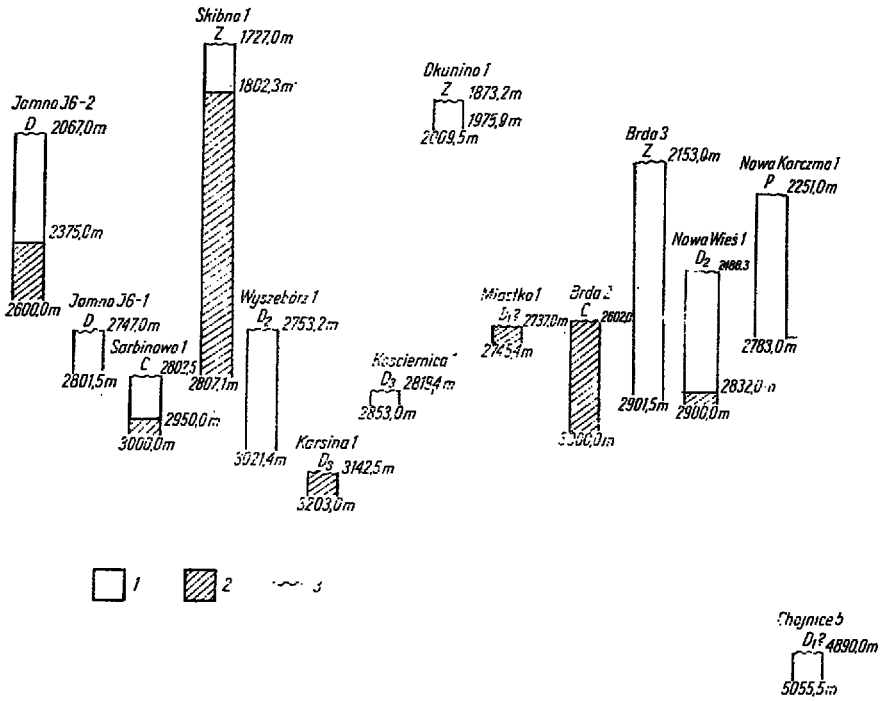


Fig. 2

Correlation of zones differentiated in the columns of the Koszalin-Chojnice area
1 — Climacograptus bicornis — Orthograptus truncatus Zone, *2 — Glyptograptus teretiusculus — Orthograptus acutus* Zone, 3 — erosional boundary between the Ordovician and the late Paleozoic sediments

Table 1

FAUNA \ DEPTH in m	2950.0–2954.0	2912.0–2914.0	2887.0–2891.0	2844.0–2847.0
Paterula cf. portlocki /Gein./				+
Amplexograptus? sp.	+			
Climacograptus cf. brevis E. & W.				+
C. cf. tuberculatus Nich.				+
Climacograptus sp.	+	+	+	+
Orthograptus acutus /Lapw./	+			
Tomaculum problematicum Groom			+	+

composed chiefly of graptolites, together with which have been sporadically found isolated brachiopod shells from the Inarticulata group, also coprolites of mud-eaters.

The drilling was stopped at a depth of 3000.0 m without piercing the Ordovician sediments.

Borehole Skibno 1

Here the Ordovician sediments have been found at a depth of 1727.0 m directly underlying Zechstein conglomerates beginning the Werra cyclothem. Lithologically the Ordovician series may be divided into three parts:

the lower part between 2807.0 m (the final depth) and 1882.6 m consists of darkgrey siltstones with abundant fine muscovite flakes and with pyrite which is dispersed or occurs in concentrations;

the middle part from 1882.6 to 1802.3 m is represented by dolomitic darkgrey siltstones;

the upper part is composed of dolomitic darkgrey greenish-tinted siltstones intercalated in the top by darkgrey mudstones and red dolomitic siltstones.

The whole series is strongly slickensided, steep dips dominate to a depth of 2386.4 m, higher up being from 10 to 50°.

The relatively abundant fossil remains are shown in Table 2.

Table 2

FAUNA \ DEPTH in m	2799.1–2818.8	2652.0–2655.3	2590.6–2599.0	2528.0–2533.0	2386.4–2391.2	2330.7–2336.7	2110.5–2114.0	2037.6–2041.0	1992.7–1996.0	1949.3–1954.0	1879.0–1882.6	1838.4–1841.0	1795.0–1802.3	1745.0–1751.0	1730.0–1737.4	1728.0–1725.0
Paterula cf. portlocki /Gein./															+	
Leptograptidae indet.					+											
Nemagraptus? sp.										+						
Dicellograptus cf. sextans exilis /Z. & W./							+					+				
Dicellograptus sp.														+		
Amplexograptus cf. perexcavatus /Lapw./						+										
Amplexograptus? sp.				+												
Climacograptus cf. brevis Z. & W.	+															
C. cf. minimus /Carr./				+										+		
Climacograptus sp.	+	+	+			+		+		+	+	+	+			
Pseudoclimacograptus cf. scharenbergi Lapw.			+													
Orthograptus cf. acutus /Lapw./								+								
Glyptograptus teretiusculus /His./		+		+			+	+								
G. cf. teretiusculus /His./							+									
Graptolita indet.																+
Tomaculum problematicum Groom	+						+	+	+	+	+	+	+	+		+

Borehole Wyszebórz 1

On electric logging data, the Ordovician sediments occur here under the Middle Devonian from a depth of 2724 m. The drilling was stopped at 3046.3 m without piercing the Ordovician.

Lithologically, the Ordovician is represented in this column by darkgrey siltstones with fine muscovite flakes; in places it is intercalated and laminated by dolomitic mudstones or greish-beige dolomite. From 2869.3 m upwards the mudstones intercalations grow in number and pyrite concentrations make their appearance. The whole series is strongly tectoni-

cally disturbed and it is characterized by dips ranging from 50 to 90 degrees.

The stratigraphic positions of this series are indicated by graptolites found between 2869.3 and 2873.3 m, namely *Pleurograptus?* sp., *Climacograptus* cf. *bicornis* (Hall), *C.* cf. *caudatus* Lapw., and *Orthograptus* cf. *calcaratus* Lapw. Besides these coprolites of mud-eaters of *Tomaculum problematicum* Groom have been found between 2865.4—2869.3 m also between 2879.4—2891.3 m.

Borehole Karsina 1

As is shown by electric logging data the Ordovician sediments occur here beginning at 3142.5 m and are represented by darkgrey siltstones occasionally green tinted and with pyrite concretions. The siltstones are strongly slickensided and the dips range from 40 to 60 degrees. In the top the Ordovician series is in contact with Upper Devonian sediments, its bottom is not known since the drilling was stopped at 3203.0 m without piercing the Ordovician.

At a depth from 3166.4 to 3169.1 m have been found: *Dicellograptus* cf. *sextans exilis* E. & W., *Pseudoclimacograptus* cf. *scharenbergi* Lapw., *Orthograptus* sp. and *Glossograptus* cf. *hincksii* (Hopk.), but only *Climacograptus* sp. between 3142.5 and 3143.0 m.

Borehole Kościernica 1

According to the electric logging data the Ordovician occurs in this column underlying the Middle Devonian from a depth of 2818.4 m. The drilling was stopped at 2853.0 m without piercing this system.

The Ordovician sediments are represented by darkgrey siltstones containing pyrite concentrations, fine muscovite flakes and browngrey dolomitic concretions in the top. The siltstones are strongly slickensided, the dips being c. 70 degrees. At a depth between 2850.0—2853.0 m have been found *Climacograptus* cf. *brevis* E. & W., *Glyptograptus* cf. *teretiusculus* (His.) and *Tomaculum problematicum* Groom, and *Climacograptus* cf. *minimus* (Carr.) and *Tomaculum problematicum* Groom between 2820.0 —2824.0 m.

Borehole Okunino 1

The Ordovician here directly underlies the basal conglomerate of the Zechstein (Werra cyclothem) and was pierced by drilling from 1873.2 to 2009.5 m. It is represented by grey-green siltstones, spotted in the top and containing fine muscovite flakes, thin anhydrite veinlets and pyrite concentrations. The dips are of c. 20°. A fragment of *Dicellograptus* sp. has been found in the top part and coprolites of *Tomaculum problematicum* Groom at the bottom.

Borehole Brda 2

According to electric logging data the Ordovician here occurs from 2576.5 m underlying the Lower Carboniferous (Tournaisian ?). It is developed as darkgrey brown-tinted siltstones with pyrite concentrations, in the bottom part locally with a darkbrown limestone intercalations and with mudstone interbeddings in the top. The whole series is strongly slickensided and cracked. The fissures in the cracks are filled in with white calcite. Dips vary from 30 to 90°. Drilling was stopped at 3000.0 m without piercing the Ordovician. *Amplexograptus* cf. *perexcavatus* Lapw., *Glyptograptus* cf. *teretiusculus* (His.) and *Tomaculum problematicum* Groom have been found in fair abundance but only between 2727.0 and 2733.0 m.

Borehole Brda 3

Ordovician sediments have been differentiated under the Zechstein anhydrites (Werra cyclothem). The electric logging data show their presence down to a depth of 2133.0 m. Down to the final depth of the borehole (2902.5 m) the Ordovician is developed as darkgrey siltstones, occasionally greenish-tinted, towards the top with thin beds of black mudstones containing fine muscovite flakes, and with pyrite dispersed or in concentrations. Tuffite has been differentiated between 2641.0 and 2647.0 m [1]. It occurs as intercalations distinguishable by a lightgrey bluish-tinted colouration against the darkgrey colour of the siltstones. The whole series is strongly slickensided and folded. The dips range from 30 to 80 degrees.

Climacograptus sp., *Glyptograptus* sp., *Orthograptus truncatus* Lapw., *O.* cf. *truncatus* Lapw. and *Tomaculum problematicum* Groom have been found between 2355.0 and 2361.0 meters.

Borehole Nowa Wieś 1

The electric logging analysis shows the Ordovician series to occur here under the deposits of the Late Paleozoic (Devonian or Carboniferous) from a depth of 2417.5 m. It is represented by darkgrey siltstones, in the bottom laminated by darkgrey mudstones containing minute muscovite flakes. Higher up in the column, the siltstones is sporadically brown coloured and contains numerous, irregularly shaped pyrite concretions. In the top part, between 2496.5 and 2488.3 m, lightgrey tuffite intercalations have been observed in the darkgrey dolomitic siltstones. The series is throughout slickensided, cracked and folded; the fissures of cracks are filled in by white calcite; the dips range from 40 to 80 degrees.

The fossil remains found in this column are shown in Table 3.

[1] The tuffite has been identified by Dr Roman Chlebowski from the Institute of Geochemistry, Mineralogy and Petrography of the Warsaw University.

Table 3

FAUNA \ DEPTH in m	2893.0–2900.0	2832.0–2836.0	2755.0–2760.0	2708.0–2714.0	2590.0–2596.0
Amplexograptus sp.	+				
Climacograptus cf. brevis E. & W.		+			
C. cf. caudatus Lapw.			+		
C. minimus /Carr./					+
Climacograptus sp.				+	
Orthograptus truncatus Lapw.			+		
Orthograptus sp.		+	+		
Glyptograptus euglyphus /Lapw./		+			
G. cf. teretiusculus /His./		+			
Glyptograptus sp.					+
Tomaculum problematicum Groom				+	

Borehole Chojnice 5

In this column the presence of the Ordovician has been ascertained under the Middle Devonian which the electric logging data show to occur down to a depth of 4890.0 m. The darkgrey neatly black siltstones, with numerous pyrite concretions and dips varying from 10 to 50 degrees, have been observed to the final depth of the borehole (5055.5 m). The graptolites found in fair abundance in the column are shown in Table 4.

Table 4

FAUNA \ DEPTH in m	5048.0–5055.5	5006.0–5008.0	5000.0–5006.0	4956.3–4958.0	4895.1–4967.1
Climacograptus bicornis /Hall/			+		
C. brevis E. & W.		+			
C. cf. brevis E. & W.			+		
C. minimus /Carr./		+	+		
C. cf. minimus /Carr./	+				
C. cf. wilsoni Lapw.		+			
C. tubuliferus Lapw.			+		
Climacograptus sp.	+	+	+	+	+
Pseudoclimacograptus cf. scharenbergi Lapw.	+				
Orthograptus truncatus Lapw.			+		
O. truncatus pauperatus Lapw.		+			
Orthograptus sp.		+			
Glyptograptus sp.	+	+			
Lasiograptus sp.	+				
Aniscochilina? sp.	+				

STRATIGRAPHY OF THE ORDOVICIAN SERIES

The lithological characteristics of the Ordovician series within the Koszalin-Chojnice area show its monotonous development and strongly disturbed tectonics. Its correct differentiation is moreover impeded by extremely meagre coring. In column Brda *3* it amounts to c. 4 per cent, the maximum coring figure being 17 per cent in the Wyszebórz *1* column. Neither do the rather scarce and poorly preserved fossil remains help more accurately to determine the stratigraphy of the Ordovician.

In spite of these difficulties the writer believes it reasonable to differentiate, on the basis of graptolite assemblages, at least two local assemblage Zones, namely (going from bottom):

Glyptograptus terestiusculus — Orthograptus acutus Zone
Climacograptus bicornis — Orthograptus truncatus Zone

Glyptograptus teretiusculus — Orthograptus acutus Assemblage Zone

Sediments representing this Zone have been found in columns from five boreholes, namely:

Borehole	Sarbinowo *1*	Depth of	3000.0—2950.0 m
„	Skibno *1*	„	2807.0—1802.3 m
„	Karsina *1*	„	3203.0—3142.0 m
„	Brda *2*	„	3000,0—2602.0 m
„	Nowa Wieś *1*	„	2900.0—2832.0 m

The graptolite assemblage on which the above Zone has been determined is as follows:

Dicellograptus cf. *sextans exilis* Elles & Wood (Pl. 1, Figs 7—8),
Climacograptus cf. *brevis* Elles & Wood,
Pseudoclimacograptus cf. *scharenbergi* Lapworth,
Orthograptus acutus (Lapworth) (Pl. 1, Fig. 3),
Glyptograptus euglyphus (Lapworth),
G. teretiusculus (Hisinger) (Pl. 1, Fig. 2),
G. cf. *teretiusculus* (Hisinger),
Glossograptus cf. *hincksi* (Hopkinson) (Pl. 2, Fig. 6),
Amplexograptus cf. *perexcavatus* Lapworth.

The most representative lithological column for this Zone is Skibno *1*. It is composed of darkgrey siltstones, occasionally dolomitic, intercalated by rare mudstones of the same colour with numerous concentrations of pyrite and fine muscovite flakes. In other columns the siltstones have a greenish hue (Karsina *1*) or darkbrown one (Brda *2*). Sporadical intercalations of darkbrown limestones have been observed in the siltsto-

nes (Brda *2*). In view of the variability of the dips which range from 10 to 90 degrees, as well as the fact that the sediments here considered have not been pierced it is hardly possible to determine their real thickness.

Climacograptus bicornis — Orthograptus truncatus assemblage Zone

This Zone is represented by deposits ascertained in columns of the eight following boreholes:

Borehole	Sarbinowo *1*	Depth of	2950.0—2802.5 m
„	Skibno *1*	„	1802.3—1727.0 m
„	Wyszebórz *1*	„	3021.4—2753.2 m
„	Kościernica *1*	„	2853.0—2818.5 m
„	Okunino *1*	„	1975.9—1873.2 m
„	Brda *3*	„	2901.5—2153.0 m
„	Nowa Wieś *1*	„	2832.0—2488.3 m
„	Chojnice *5*	„	5055.5—4890.0 m

Its paleontological documentation is based on:

Paterula cf. *portlocki* (Geinitz),
Anisochilina? sp.,
Nemagraptus? sp.,
Pleurograptus? sp.,
Dicellograptus sp.,
Climacograptus bicornis (Hall) (Pl. 2, Fig. 2),
C. cf. *bicornis* (Hall),
C. brevis Elles & Wood,
C. cf. *brevis* Elles & Wood (Pl. 2, Fig. 8),
C. cf. *caudatus* Lapworth (Pl. 2, Fig. 5),
C. minimus (Carruthers) (Pl. 2, Figs 7, 9),
C. tubuliferus Lapworth,
C. cf. *tuberculatus* (Nicholson),
C. cf. *wilsoni* Lapworth,
Pseudoclimacograptus cf. *scharenbergi* (Lapworth),
Orthograptus cf. *calcaratus* Lapworth,
O. truncatus Lapworth (Pl. 1, Fig. 5: Pl. 2, Fig. 3),
O. cf. *truncatus* Lapworth,
O. truncatus pauperatus Lapworth (Pl. 1, Fig. 1),
O. cf. *truncatus pauperatus* Lapworth (Pl. 1, Fig. 4),
Glyptograptus cf. *teretiusculus* (Hisinger) (Pl. 2, Fig. 1),
Lasiograptus sp.,
Tomaculum problematicum Groom (Pl. 2, Fig. 6).

The *C. bicornis — O. truncatus* Zone within the Koszalin-Chojnice area is characterized by its strongly differentiated lithological development. Skibno *1* is the typical column for the north-western part of this area. It is represented by dolomitic siltstones, darkgrey, greenish-tinted

and intercalated by mudstones of the same colour in the lower part and by red siltstones with pyrite concentrations in the upper part. Here and there it shows intercalations of beige-coloured dolomite (columns Wyszebórz *1* and Kościernica *1*).

In the south-eastern part of the Koszalin-Chojnice area column Nowa Wieś *1* is the representative one for the Zone here discussed. It is composed of darkgrey siltstones, occasionally green or brown tinted, with numerous pyrite concentrations and minute muscovite flakes, also with intercalations of lightgrey bluish tinted tuffite.

In the most south-eastern borehole Chojnice *5*, sediments from the *C. bicornis — O. truncatus* Zone differ from those already described in their darkgrey, nearly black colouration, greater degree of schistosity, abundance of graptolites and the absence of coprolites of mud-eaters so common throughout the Koszalin-Chojnice area.

Similarly as in the case of the *G. teretiusculus — O. acutus* Zone it is hardly possible to determine the thickness of the Zone under discussion because of the great dip variability (from 20 to 90 degrees), and of the erosional contacts with sediments of the Late Paleozoic.

The distribution of sediments belonging to the zones distinguished in the Koszalin-Chojnice area is suggested in a paper by Modliński (1968) giving data on the Ordovician yielded by the two northernmost boreholes: Jamno *IG-1* and Jamno *IG-2*.

In column Jamno *IG-2*, the siltstones from a depth of 2600.0—2375.0 m, identical with those throughout the area here considered, correspond to the *G. teretiusculus — O. acutus* Zone. They bear *Nemagraptus gracilis remotus* Elles & Wood, *Dicranograptus nicholsoni* Hopkinson, *Climacograptus* cf. *bicornis* (Hall), *Orthograptus acutus* (Lapworth) and *Glyptograptus teretiusculus* (Hisinger).

On the other hand, siltstones with *Dicellograptus* sp., *Pseudoclimacograptus scharenbergi* (Lapwroth), *P. modestus* (Ruedeman), *Climacograptus brevis* Elles & Wood, *Orthograptus apiculatus* Elles & Wood, *O. truncatus intermedius* Elles & Wood, and *Glyptograptus teretiusculus* (Hisinger) occurring in the same column between 2375.0—2096.0 m correspond to the *C. bicornis — O. truncatus* Zone.

In column Jamno *IG-1*, analogous sediments found between 2801.5—2747.0 m are probably referable to the same Zone, as is resonably suggested by such forms as *Paterula* sp., *Dicranograptus nicholsoni* Hopkinson, *Climacograptus bicornis* Hall, *Orthograptus* sp., and *Amplexograptus arctus* Elles & Wood.

It is hardly possible to determine the stratigraphic position of the Ordovician sediments reached in boreholes Miastko *1* and Nowa Karczma *1*, because of the lack of adequate paleontological documentation. The subgenus *Pseudoclimacograptus angulatus sebyensis* Jaanusson, identified

by Modliński (1968) from the siltstones of column Miastko *1*, is known from the limestones of Seba and Folkesunda on the island of Oeland. These limestones correspond to the top members of the *Didymograptus murchisoni* Zone, also to beds transitional to the *Glyptograptus teretiusculus* Zone (Jaanusson 1973). The Ordovician siltstones from column Miastko *1* are included by the present writer in the newly established *G. teretiusculus — O. acutus* Zone. The accurate stratigraphic division and correlation of the siltstone-mudstone series from column Nowa Karczma *1* (Teller & Korejwo 1967) will remain an open question until the time when some reliable indices (microorganisms?) have been found.

CORRELATION OF THE DIFFERENTIATED ZONES

Seven taxons are of particular value in the graptolite assemblage of the *G. teretiusculus — O. acutus* Zone. Their presence allows to correlate this Zone with the corresponding graptolite zones from the more important Ordovician profiles of Europe, North America, Asia and Australia (Elles & Wood 1904—1906, Ruedemann 1947, Harris & Thomas 1955, Jaanusson 1960, Obut 1960, Thomas 1960, Berry 1964, Obut & Sobolevskaya 1964, Havliček & Vaněk 1966, Toghill 1970, Nikitin 1972, Williams & *al.* 1972, Bouček 1973).

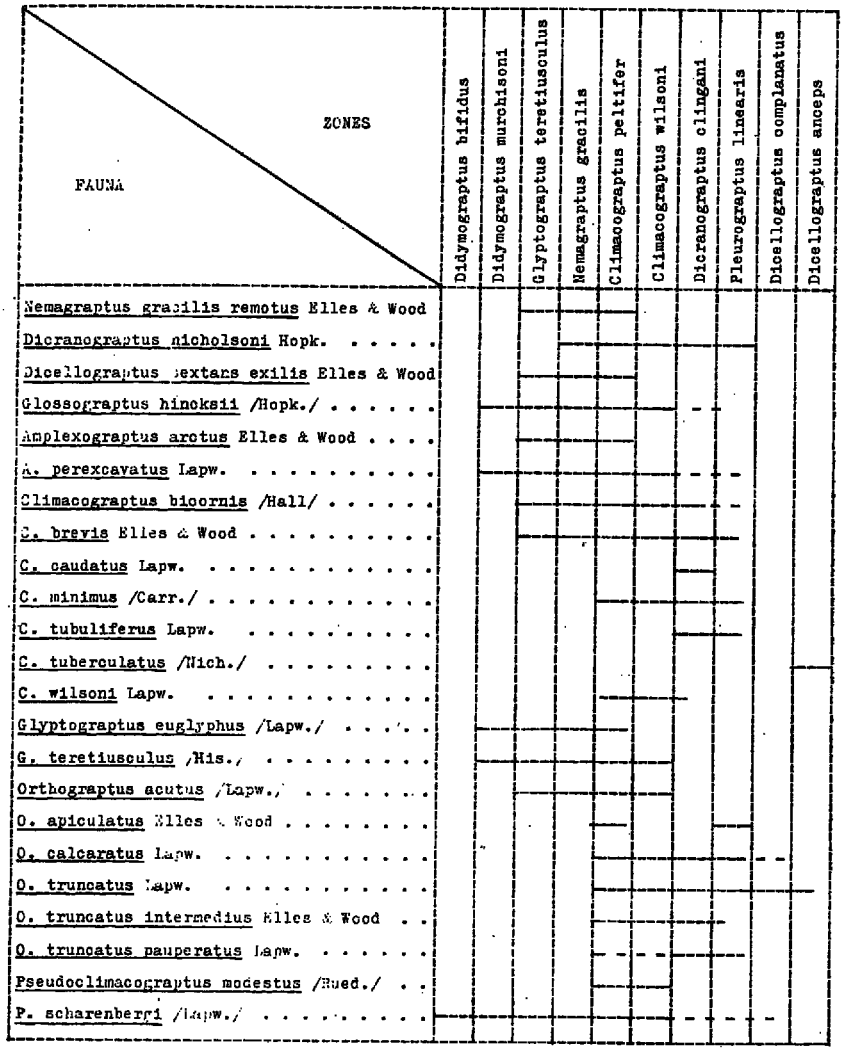
As may be supposed from Table 5, the vertical range of the form *Pseudoclimacograptus scharenbergi* (Lapw.) indicates its appearance at the beginning of the *Didymograptus bifidus* Zone. Such forms as *Glyptograptus euglyphus* (Lapw.) and *G. teretiusculus* (His.) make their appearance from the *Didymograptus murchisoni* Zone while *Nemagraptus gracilis remotus* E. & W. and *Orthograptus acutus* (Lapw.) occur beginning with the *Glyptograptus teretiusculus* Zone. *Dicranograptus nicholsoni* Hopk. is an exception not being noted before the *Nemagraptus gracilis* Zone.

Most of the taxons mentioned above do not overlap the *Climacograptus peltifer* Zone, less often the *Climacograptus wilsoni* Zone (Table 5).

Hence, it may be reasonably concluded that our *G. teretiusculus — O. acutus* Zone ought to be correlated with the *G. teretiusculus — C. peltifer* Zones of the standard British subdivision (Table 6). Moreover, it is not excluded that the boundaries of the Zone here discussed may overlap the lower parts of the *C. wilsoni* Zone. Such a correlation seems also to be confirmed by the other taxons included in the assemblage of our Zone. Namely: *Dicellograptus* cf. *sextans exilis* Elles & Wood, *Amplexograptus* cf. *perexcavatus* Lapw., *Climacograptus* cf. *bicornis* (Hall), *C.* cf. *brevis* Elles & Wood and *Glossograptus* cf. *hincksi* (Hopkinson).

Table 5

Stratigraphic ranges of the Ordovician graptolites in the Koszalin-Chojnice region and their relation to the standard British subdivision



The *C. bicornis* — *O. truncatus* Zone is determined by a graptolite assemblage consisting of 17 taxons. Only eight of them, however, are of help in the correlation of the zones. Five of them: *Climacograptus wilsoni* Lapw., *Orthograptus truncatus* Lapw., *Orthograptus truncatus intermedius* Elles & Wood, *O. truncatus pauperatus* Lapw. and *Pseudoclimacograptus modestus* (Rued.) are known beginning with the *C. peltifer* or *C. wilsoni* Zone; two: *Climacograptus caudatus* Lapw. and *C. tubuliferus* Lapw. make their appearance in the *Dicranograptus clingani* Zone, and one —

Table 6

Stratigraphic position of the established graptolite zones in the Koszalin-Chojnice region and their comparison with the standard British subdivision

Stages	British graptolite zones /Williams & al. 1972/	Zones accepted in this paper
Ashgill	D. anceps D. complanatus	
Caradoc	P. linearis	- - - - - - - ? - - - - - - -
	D. clingani	C. bicornis – O. truncatus
	C. wilsoni	
	C. peltifer	- - - - - - - ? - - - - - - -
Llandeilo	N. gracilis	G. teretiusculus – O. acutus
	G. teretiusculus	- - - - - - - ? - - - - - - -

Orthograptus apiculatus Elles & Wood not before the *Pleurograptus linearis* Zone (Table 5).

On the basis of the taxons here mentioned, as well as on the other identified forms it may be reasonably supposed that the writer's *C. bicornis — O. truncatus* Zone is to be correlated with the *C. wilsoni* to *D. clingani* Zones. It is not excluded, however, that it also involves the lower parts of the *P. linearis* Zone as may perhaps be suggested by the presence of *Orthograptus apiculatus* Lapw., as well as by the uppermost parts of the *C. peltifer* Zone (Table 6).

PALEOGEOGRAPHIC-FACIAL DEVELOPMENT

The Ordovician sediments have been formed in a marine basin along the south-western margin of the East European platform. In the SE this basin extended to the vicinity of Rawa Ruska (Teller 1969) while in the NW it covered the area of Rugia (Jaeger 1967).

The existence of a Caledonian geosynclinal basin, similarly directed, has previously been suggested by Znosko (1964, 1965), while the first boreholes which reached Ordovician and Silurian sediments in Western Pomerania (Modliński 1968, Teller & Korejwo 1968) have confirmed these suppositions.

The rather great thickness of the tectonically disturbed Llanvirnian and Llandellian sediments in Rugia (c. 1,000 m.; *cf.* Franke 1967, Jaeger 1967), also the some hundred meters thick Llandellian and Caradocian sediments in Western Pomerania with tuffite intercalations, indicate the

miogeosynclinal character of sedimentation. Precambrian and early Paleozoic sediments in southern Norway (Størmer 1967, Strand & *al.* 1972) are their facial equivalents.

Thus it may be concluded that, during the Ordovician, the zone of epicontinental sedimentation in Baltoscandia (Fig. 4) was surrounded in the NW and SW by a sedimentary area of considerably thick miogeosynclinal deposits. The direction of this area, north of Rugia and west of Oslo and Västergotland (Fig. 3) is not clearly known, but it should be noted that this problem is generally connected with the question of the western boundary of the East European platform (*cf.* Bailey 1928; Bogdanov & *al.* 1964; Gaertner 1960; Pożaryski 1969; Størmer 1967; Znosko 1964, 1965).

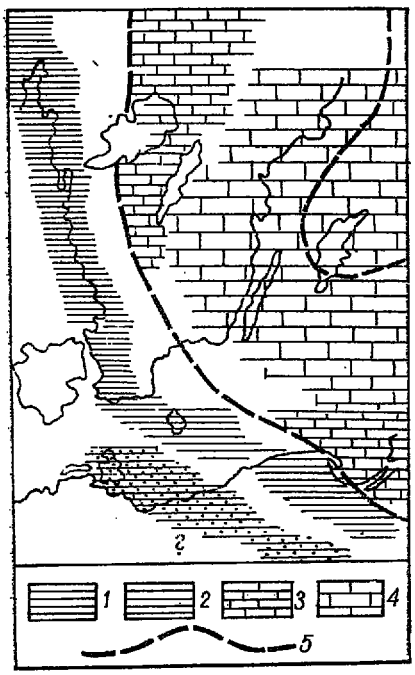


Fig. 3

Chief lithofacial types in the western part of Baltoscandia during the Llandellian (after a diagram by Jaanusson, 1973, supplement by the writer)

1 — siltstones interbedded by greywackes (Rugia) and sandy-muddy-clayey sediments (Koszalin-Chojnice area); *2* — siltstones interbedded by mudstones and with concretions and intercalations of calcilutites in the Oslo-Scania-Łeba area; *3* — facies of grey calcilutites in the Swedish-Latvian area; *4* — facies of grey calcarenites in the same area; *5* — hypothetical limits of the Swedish-Latvian area

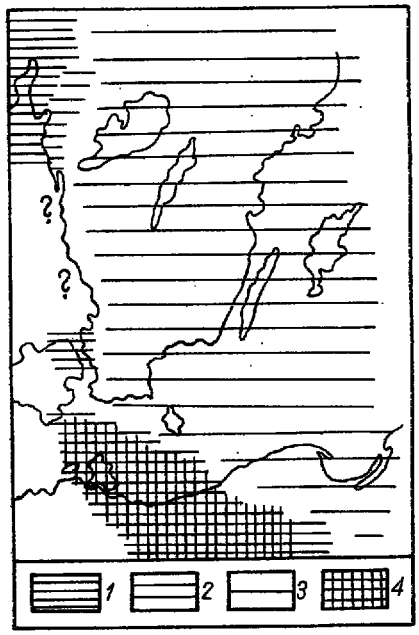


Fig. 4

Thickness variability of the Middle Ordovician sediments (Viruan, graptolite zones *D. murchisoni* to *D. clingani*) of the western part of Baltoscandia and the neighbouring areas (after a diagram by Jaanusson, 1973, supplemented by the writer)

1 — 200—300 m, 2 — 100—200 m, 3 — 100 m, 4 — 300 m

In order to present a more accurate paleogeographic picture it seems advisable to describe the characteristics of the lithofacies within the area of epicontinental sedimentation (Baltoscandia). Thus, in agreement with Jaanusson (1973), the distribution of the Viruanu lithofacies (*i.e.* of sediments corresponding in age to those in Rugia and the Koszalin-Chojnice area) is as follows (going W-E):

1. Terrigenous coarse-grained sediments (mudstones, sandstones, greywackes and conglomerates) from the geosynclinal zone and the adjacent regions (including the Rugia-Koszalin-Chojnice area [2]).

2. Shales, frequently graptolithic or mudstones with concretions and calcilutite interbeddings (area of Scania sedimentation west of the lake Väner) into which should also be added the area of the Łeba elevation.

3. Carbonate clays mixed with calcarenite calcilutites (area east of lake Väner) of the Swedish-Latvian facial area (Männil 1966) or the central facial area of Baltoscandia (Jaanusson 1973).

4. Oolitic-calcite calcarenites and micritic calcarenites with chamosite or limonite ooids (area of the Swedish-Latvian facial zone also including the areas of the peribaltic syneclise (Männil 1966, Bednarczyk 1968, Modliński 1973).

5. Sandstones and calcareous sandstones, as a rule scarce and sporadical.

In Jaanusson's (1973, pp. 17, 94) opinion the sequence of the here mentioned lithofacies displays symmetry in what regards the distribution of grain-size, since the fraction of grains of greater diameter decreases towards the middle of the basin. In the case of geosynclinal sediments, however, the sequence of epicontinental lithofacies is asymmetric, since the middle and western lithofacial belts are not parallel to the axis of the geosyncline (Fig. 3). The sedimentation of fine-grained terrigenous deposits in the western part of the epicontinental basin took place along a belt running N–S of the geosyncline. In the north this belt of sedimentation turned to the NE, overlapping the margin of the geosyncline at least as far as northern Jämtland. In this belt sediments accumulated with greater intensity, probably in connection with the increased rhythm of subsidence. The alimentary areas for this belt as well as for the miogeosynclinal area were probably situated in the island archipelago lying within the geosyncline (Jaanusson 1973). From there the material was transported farther to the foothills and only scanty amounts of it penetrated to the centre of the sedimentary basin of Baltoscandia where they were mixed up with the carbonate clays. In what concerns the area Rugia-Koszalin-Chojnice, an analogy may reasonably be supposed with

[2] With the writer's necessary supplements.

the sedimentary conditions in the Norwegian arch of the Caledonian geosyncline. Since N and NE of this area there stretched a region of clayey-carbonate sedimentation of the Scania type, and farther on the Swedish-Latvian (Fig. 3) facial zone, the alimentary areas could have been situated only in the south. An analysis of the distribution of the coarse-grained fraction of the sediments in Rugia shows that the material was transported over a rather small distance (Jaeger 1967). Hence, it may be supposed that the terrigenous material brought into the miogeosyncline also came from the island archipelago of the southern arch of the Caledonian geosyncline.

The description of the characteristics of the marine basin within the Koszalin-Chojnice region are supplemented by paleontological observations. From them it is seen that the fauna of the area under discussion is scarce and relatively monotonous as compared with the epicontinental one of Baltoscandia. The development of the organic world here may have been affected by the unfavourable life conditions in the marine basin. The presence of pyrite in the Ordovician of the area here considered, dispersed or in concentrations, reliably indicates the reduced conditions of the sedimentary environment which must have affected the development of the organic world.

Neither is it excluded that the here discussed part of the geosynclinal basin had, to a certain extent, been isolated from the epicontinental sea of Baltoscandia. This is reasonably suggested by the limited range of the traces of activity of the mud-eaters *Tomaculum problematicum* Groom. This type of coprolites is often found outside the Koszalin-Chojnice region in many other Ordovician profiles in England, Spain (Radig 1964), north-western (Brittany) and southern (Montagne Noire, the Voges Mts) France (Ross 1964), the Rheinische Schiefergebirge, Thuringia, Bohemia (Richter 1939a, b, 1941) and Rugia (Jaeger 1967). No information is, however, available regarding their occurrence in the Ordovician profiles of Scandinavia, NE Poland, the Holy Cross Mts and farther east outside the Polish territory. Upon accepting Størmer's (1967) conception of the existence of an intracratonic syneclise stretching from Oslo across Scania in the direction of the peribaltic areas east of Łeba it will be reasonable to suppose that, west and parallel to the hypothetical syneclise, submarine barriers were formed handicapping faunal migration from the marine basin of the Koszalin-Chojnice area to the epicontinental sea of Baltoscandia. However, in order more reliably to justify this supposition, a more thorough geological study is needed of the relations between the structural area here considered and the Łeba elevation.

Laboratory of Stratigraphy
Institute of Geological Sciences
Polish Academy of Sciences
02-089 Warszawa, Al. Żwirki i Wigury 93
Warsaw, December 1973

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W. BEDNARCZYK

ORDOWIK W STREFIE KOSZALIN—CHOJNICE NA POMORZU ZACHODNIM

(Streszczenie)

W pracy przedstawiono wyniki badań biostratygraficznych osadów ordowickich, pochodzących z 10 wierceń wykonanych przez Przemysł Naftowy w NW Polsce (fig. 1).

W oparciu o graptolity (tab. 1) wyodrębniono na badanym obszarze dwie lokalne zony zespołowe (od dołu): *Glyptograptus teretiusculus — Orthograptus acutus* i *Climacograptus bicornis — Orthograptus truncatus.*

Obecność zony *G. teretiusculus — O. acutus* ustalono w profilach wierceń na głębokościach: Sarbinowo *1* (3000—2950 m), Skibno *1* (2807—1802,3 m), Karsina *1* (3203—3142,5 m), Brda *2* (3000—2602 m), Nowa Wieś *1* (2900—2832 m), Miastko *1* (2745,4—2737,0 m), Jamno *IG-2* (2600—2375 m) (fig. 2). Reprezentowana jest ona przez iłowce ciemnoszare niekiedy z odcieniem zielonawym z lokalnie występującymi wkładkami mułowców i wapieni ciemnobrunatnych. Miąższość osadów wydzielonej zony, ze względu na zmienne upady wahające się w granicach od 10 do 90°, nie może być ustalona.

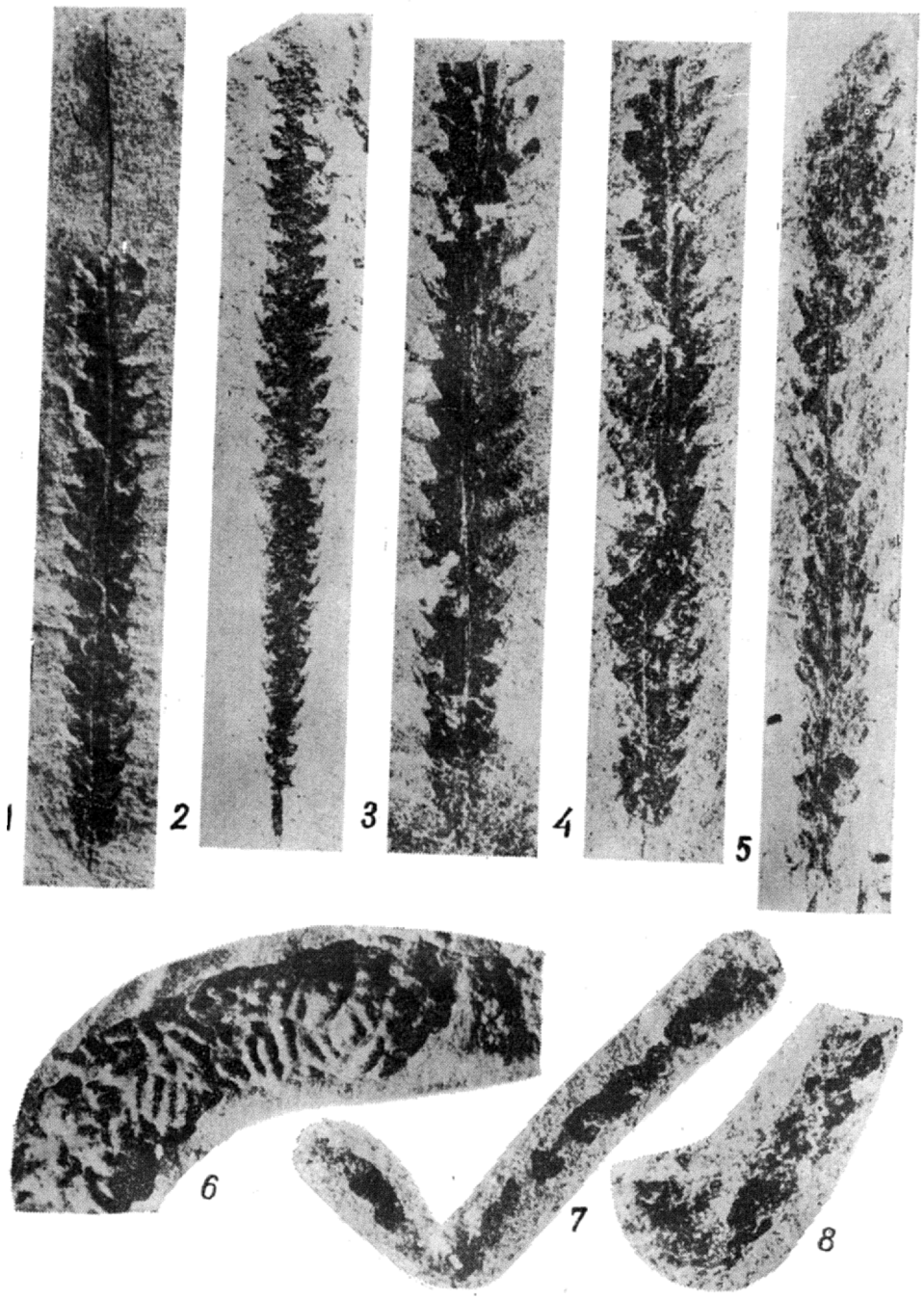
Zonę *C. bicornis — O. truncatus* udokumentowano w profilach ośmiu wierceń na głębokościach: Sarbinowo *1* (2950—2802,5 m), Skibno *1* (1802,3—1727 m), Wyszebórz *1* (3021,4—2753,2 m), Kościernica *1* (2853—2818,4 m), Okunino *1* (1975,9—1873,2 m), Brda *3* (2901,5—2153 m), Nowa Wieś *1* (2832—2488,3 m), Chojnice *5* (5055,5—4890,0 m), Jamno *IG-1* (2801,5—2747,0 m), Jamno *IG-2* (2037,5—2096,0 m), Nowa Karczma *1* (2783—2251 m) (fig. 2). Reprezentowana jest ona przez iłowce dolomityczne ciemnoszare z odcieniem zielonawym, w górnych partiach czerwone ze skupieniami pirytu. W iłowcach często występują wkładki mułowca lub dolomitu, a w profilach Brda *3* i Nowa Wieś *1* wkładki tufitu. Silne zlustrowania, lokalne sfałdowania i zmienne upady od 20 do 90° uniemożliwiają ustalenie miąższości.

Zasięgi stratygraficzne zidentyfikowanych w poszczególnych profilach graptolitów umożliwiają korelację wydzielonych zon z ich wiekowymi odpowiednikami w klasycznych profilach Europy, Ameryki i Azji (tab. 1). W odniesieniu do podziału brytyjskiego (Williams & *al.* 1972) można przyjąć, że wydzielona zona *G. teretiusculus — O. acutus* odpowiada górnej części zony *G. teretiusculus* aż po zonę *Climacograptus peltifer*, a zona *C. bicornis — O. truncatus* zonom *Climacograptus wilsoni* i *Dicranograptus clingani* (tab. 2). Z analizy paleogeograficzno-facjalnej i porównań ordowiku obszarów sąsiadujących ze strefą Koszalin-Chojnice wynika, że osady ordowickie badanej strefy tworzyły się w zbiorniku morskim rozciągającym się wzdłuż południowo-zachodniej krawędzi platformy wschodnioeuropejskiej. Zbiornik ten na południowym wschodzie sięgał aż po granicę Polski, przedłużając się ku Mołdawii (Teller 1969), a na północnym zachodzie obejmował wyspę Rugię (Jaeger 1967).

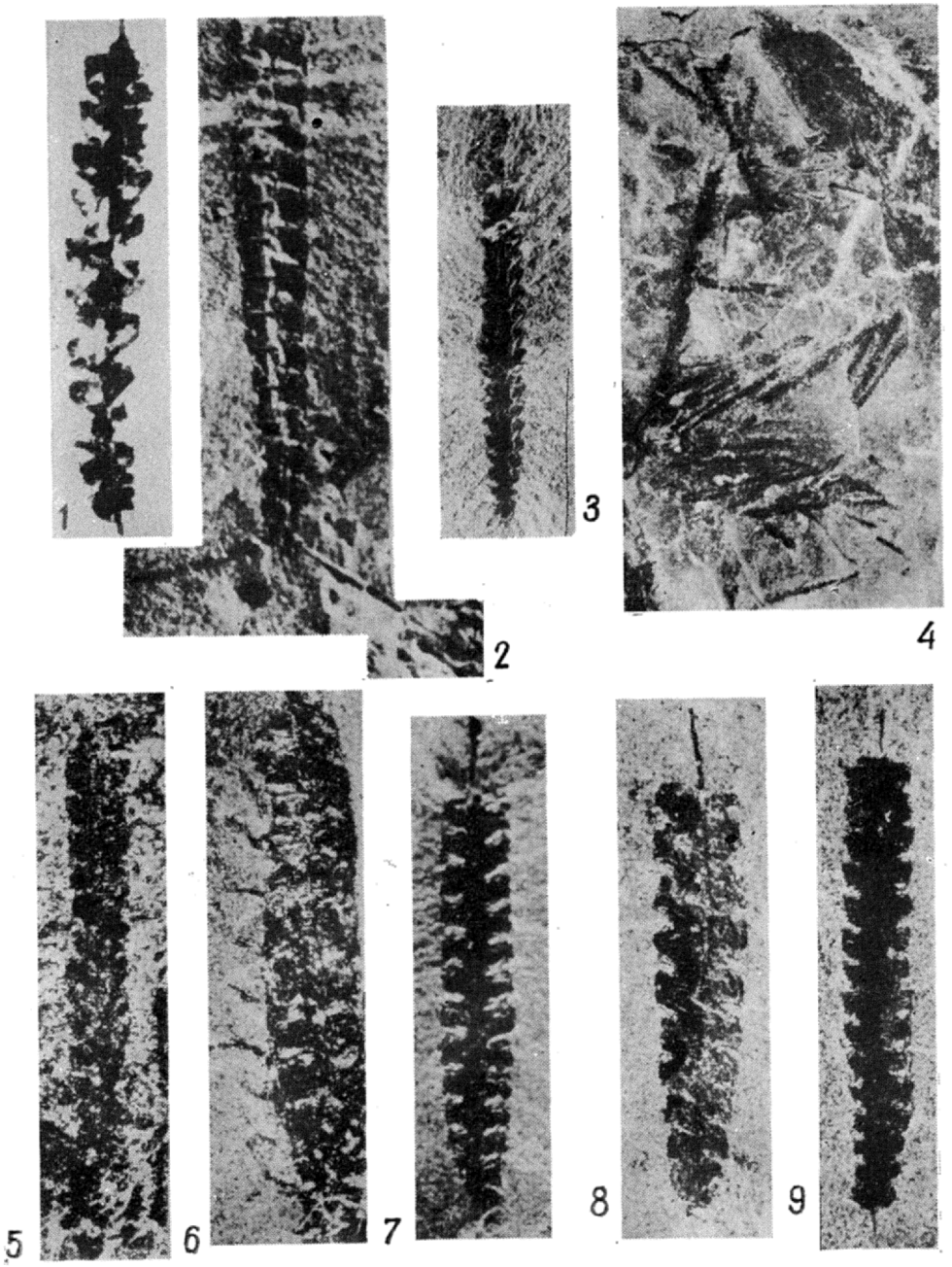
Znaczne miąższości silnie zaangażowanych tektonicznie osadów lanwirnu i landeilu na Rugii (ok. 1000 m — *por.* Franke 1967, Jaeger 1967) oraz kilkusetmetrowej miąższości osady landeilu i karadoku na Pomorzu Zachodnim, zawierające wkładki tufitów, wskazują na miogeosynklinalny charakter sedymentacji. Ich odpowiednikami facjalnymi są osady prekambru i starszego paleozoiku w południowej Norwegii (Størmer 1967). Z powyższego wynika, że strefa sedymentacji znacznej miąższości osadów miogeosynklinalnych otaczała od północnego i południowego zachodu obszar epikontynentalnej sedymentacji Bałtoskandii (fig. 4, Ja-

anusson 1973). Niejasna jest sytuacja geologiczna w obszarze na północ od Rugii i na zachód od Oslo i Västergötlandu (fig. 3). Problem ten wiąże się jednak z zagadnieniem zachodniej granicy platformy wschodnioeuropejskiej (Gaertner 1960; Bogdanov & *al.* 1964; Znosko 1964, 1965; Størmer 1967). Znaczne miąższości ordowickich osadów terrygenicznych w strefie Rugia-Koszalin-Chojnice w porównaniu z niewielkimi miąższościami osadów ilasto-węglanowych ordowiku Bałtoskandii skłaniają do wniosku, że obszarem alimentacyjnym dla omawianej strefy mogły być, co już wcześniej zauważył Jaeger (1967), jedynie tereny leżące na południe od niej. Nie wykluczone, że materiał terrygeniczny dostarczany był również z archipelagu wysp południowego łuku geosynkliny kaledońskiej.

Pracownia Stratygrafii
Zakładu Nauk Geologicznych PAN
02-089 Warszawa, Al. Żwirki i Wigury 93
Warszawa, w grudniu 1973 r.



— *Orthograptus truncatus pauperatus* Lapworth; otwór (borehole) Chojnice 5, głębokość (depth) 5007.45 m; × 6.
— *Glyptograptus teretiusculus* (Hisinger); Skibno 1 (2110.3 m); × c. 4.
— *Orthograptus acutus* Lapworth; Sarbinowo 1 (2953.45 m); × 6.5
— *Orthograptus* cf. *truncatus pauperatus* Lapworth; Chojnice 5 (5007.0 m); × 6.5.
— *Orthograptus truncatus* Lapworth; ibidem (5052 m); × c. 6.
— *Tomaculum problematicum* Groom; Skibno 1 (1734.8 m); × c. 3.
— *Dicellograptus sextans exilis* Elles & Wood; ibidem (1839.7); × 0.5.
— *Dicellograptus* cf. *sextans exilis* Elles & Wood; Karsina 1 (3167.4 m); × 11.



1 — *Glyptograptus* cf. *teretiusculus* (Hisinger); otwór (borehole) Kościernica 1, głębokość (depth) 2850.0—2853.0 m; × 10.
2 — *Climacograptus bicornis* (Hall); Chojnice 5 (5008.5 m); × 3.
3 — *Orthograptus truncatus* Lapworth; ibidem (5006.65 m); × 3.
4 — *Amplexograptus* cf. *perexcavatus* Lapworth; Skibno 1 (2330.7—2336.7 m); × 1.5
5 — *Climacograptus* cf. *caudatus* Lapworth; Wyszebórz 1 (2869.3—2873.3 m); × 7.
6 — *Glossograptus* cf. *hincksi* (Hopkinson); Karsina 1 (3168.0 m); × 7.5.
7 — *Climacograptus minimus* (Carruthers); Chojnice 5 (5004.0 m); × 3.
8 — *Climacograptus* cf. *brevis* Elles & Wood; Nowa Wieś 1 (2832.0—2836.0 m); × 7.
9 — *Climacograptus minimus* (Carruthers); Nowa Wieś 1 (2590.0—2596.0 m); × 7.