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The Ordovician acritarchs of the Pomeranian Caledonides and their foreland — similarities and differences

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Ordovician acritarch assemblages of the West Pomeranian Caledonides and their platformal foreland in the Peribaltic Syneclise immediately adjoining the T-T Zone were investigated. Material come from the Ordovician section of the Kościerzyna IG 1, Lębork IG 1 and Gdańsk IG 1 boreholes drilled in the marginal part of the East European Craton, though acritarchs were found only in two samples from the Gdańsk IG 1 borehole. In general, microflora was abundant and the investigations supported current ideas on the stratigraphical level of these rocks. The acritarch assemblages from the Gdańsk IG 1 borehole, found at a depth of 3214.8 m, contain species of *Baltisphaeridium*, characteristic of the Llanvirn and described by Górka from the eastern part of the Peribaltic Syneclise and the Podlasie Depression. The abundant microflora from West Pomerania contains index taxa of the uppermost Llanvirn (Llandeilo) and Caradoc. Numerous palynomorph associations from the Ordovician rocks of the Koszalin–Chojnice Zone can be divided into three local microfloral zones, using quantitative data, and these may be useful for local stratigraphical correlations. Acritarch assemblages on either side of the T-T Zone show many similarities and suggest that, in the late Llanvirn and Caradoc, there was little palaeogeographic separation between the sedimentary basins of Baltica and West Pomerania; at least, their palaeolatitudinal positions were similar. The thermal maturity of Ordovician organic matter (low and moderate) is also similar in both these areas. The highest heat flow values seem to be characteristic of the western part of the Peribaltic Syneclise, adjoining the T-T Zone. The degree of their thermal alterations in the West Pomeranian Caledonides is surprisingly low when the strong tectonic deformation and considerable depth of the Ordovician rocks are taken into account. The high morphological diversity of the acritarch assemblages, the presence of *Baltisphaeridium* and *Ordovicidium*, and especially of abundant *Veryhachium*, suggest that microflora from the Koszalin–Chojnice Zone represents an open-marine depositional palaeoenvironment, distant from the coast.

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Key words: Peribaltic Syneclise, West Pomeranian Caledonides, Ordovician, acritarchs stratigraphy, thermal maturity.

INTRODUCTION

The Ordovician rocks of northern Poland are known from two structurally contrasting areas: the West Pomeranian Caledonides and the Peribaltic Syneclise, located in their foreland (Fig. 1). The latter is a tectonic element of the East European Craton (Dadlez *et al.*, 1994). These Ordovician deposits have been explored to different degrees. The Lower Palaeozoic deposits of the East European Craton are well known, as numerous boreholes have been drilled by the Polish Geological Institute as well as by oil and gas companies (mainly the Petrobaltic Company). In the western part of the Peribaltic Syneclise alone, over 40 boreholes were drilled, both offshore and onshore. They have yielded over 8000 m of lithological profiles, including 2909 m of core (Modliński and Szymański, 1997). This material has allowed the resolution of many bio- and lithostratigraphical questions concerning the Ordovician deposits in this area. The investigations culminated in a formal lithostratigraphical subdivision, proposed by Modliński and Szymański (1997). The Lower Palaeozoic deposits of West Pomerania are poorly explored by comparison. Ordovician deposits were encountered in several boreholes drilled by oil and gas companies and the Polish Geological Institute in the 1960s. But, until now, there was no comprehensive study of these.

This paper compars the Ordovician acritarchs from the West Pomeranian Caledonides and the Peribaltic Syneclise. So far, microfloral investigations have been performed neither in West Pomerania (except for some preliminary information from the Skibno IG 1 borehole: Bednarczyk *et al.*, 1999) nor in the western part of the Peribaltic Syneclise. The nearest described occurrences of palynomorphs were recorded from the eastern part of the Peribaltic Syneclise and the Podlasie Depres-

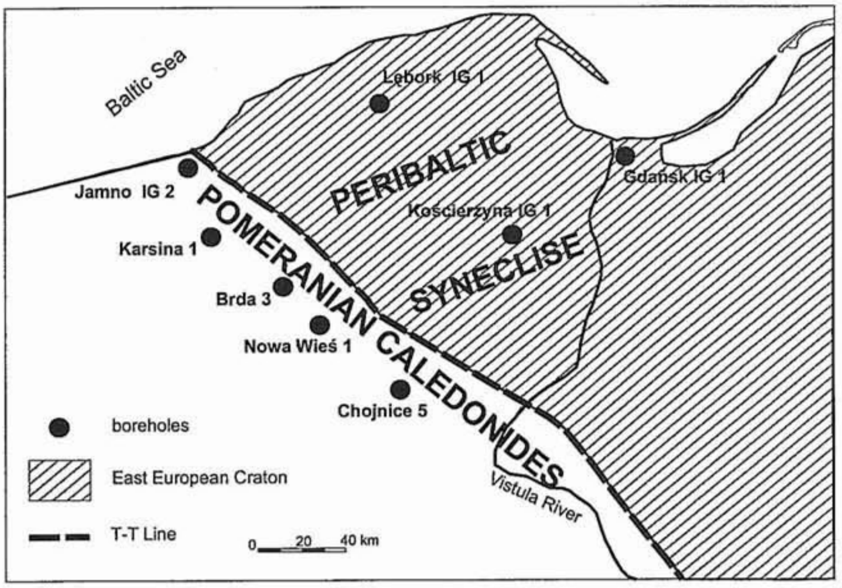


Fig. 1. Location sketch of boreholes studied

sion (Górka, 1979, 1980), Scandinavia (Kjellström, 1971, 1976; Górka, 1987) and Rügen (Servais and Katzung, 1993).

LITHOLOGY OF THE ORDOVICIAN ROCKS

PERIBALTIC SYNECLISE

Ordovician deposits, occurring east of the T-T Zone, are of typical platformal character. Their total thickness reaches up to 65 m in the sections studied. In general, the Ordovician succession is composed of several different lithological assemblages subdivided by Modliński and Szymański (1997) into formal lithostratigraphical units.

The Piaśnica Black Bituminous Shale Formation (Modliński and Szymański, 1997) (Fig. 2) represents the Cambrian/Tremadoc transitional deposits. They conformably overlie Upper Cambrian rocks, and are structurally contiguous with them.

The Słuchowo Shale with Glauconite Formation (Fig. 2), unconformably overlying eroded Cambrian or Tremadoc rocks, ushers in a younger structural element of the Peribaltic Syneclise. The basal conglomerates are overlain by clay shales, locally interbedded with grey-green shales and black limestones. These deposits are Early Arenig in age and occur in the Kościerzyna IG 1 borehole.

The Kopalino Limestone Formation (Modliński and Szymański, 1997) (Fig. 2) is represented by marly limestones with thin interbeds of marly claystones. Trilobites, brachiopods, cephalopods and conodonts document their Late Arenig and Llanvirn age. Deposits of this formation are known from all the boreholes studied in the Peribaltic Syneclise.

Upper Llanvirn (Llandeilo) and Caradoc strata are represented by the Sasino Shale Formation (Modliński and Szymański, 1997) (Fig. 2) developed largely as graptolitic clay shales, commonly strongly bituminous. The base of this formation is diachronous (Llanvirn-Caradoc). Its maximum thickness does not exceed 70 m. This formation is known from all the boreholes studied in the East European Craton.

The Ordovician succession of the western part of the Peribaltic Syneclise is terminated by the Prabuty Marl and Shale Formation (Modliński and Szymański, 1997) (Fig. 2) represented by grey and dark grey, occasionally black, marls intercalated with marly limestones and fine-grained sandstones. These deposits are Ashgill in age.

The Ordovician deposits in this area are characterized by a condensed section, a relatively shallow-marine sedimentary setting and quiescent tectonics. Therefore, they show features typical of a cratonic sedimentary basin.

POMERANIAN CALEDONIDES

Ordovician deposits have been encountered in more than ten drillholes in West Pomerania. Five of these were examined in the present study. These deposits are represented mainly by dark grey and greenish claystones. Intercalations of pyroclastic material occur in a few boreholes (Brda 3, Nowa Wieś 1). The apparent thickness of the Ordovician rocks exceeds 1000 m; the strong tectonism renders accurate estimation impossible (Bednarczyk, 1974). Their age is limited to the latest Llanvirn (Llandeilo) and Caradoc (Modliński, 1968; Bednarczyk, 1974).

The strong folding of the rocks, their large thicknesses and sedimentary features suggest deposition in a deep basin, and in-

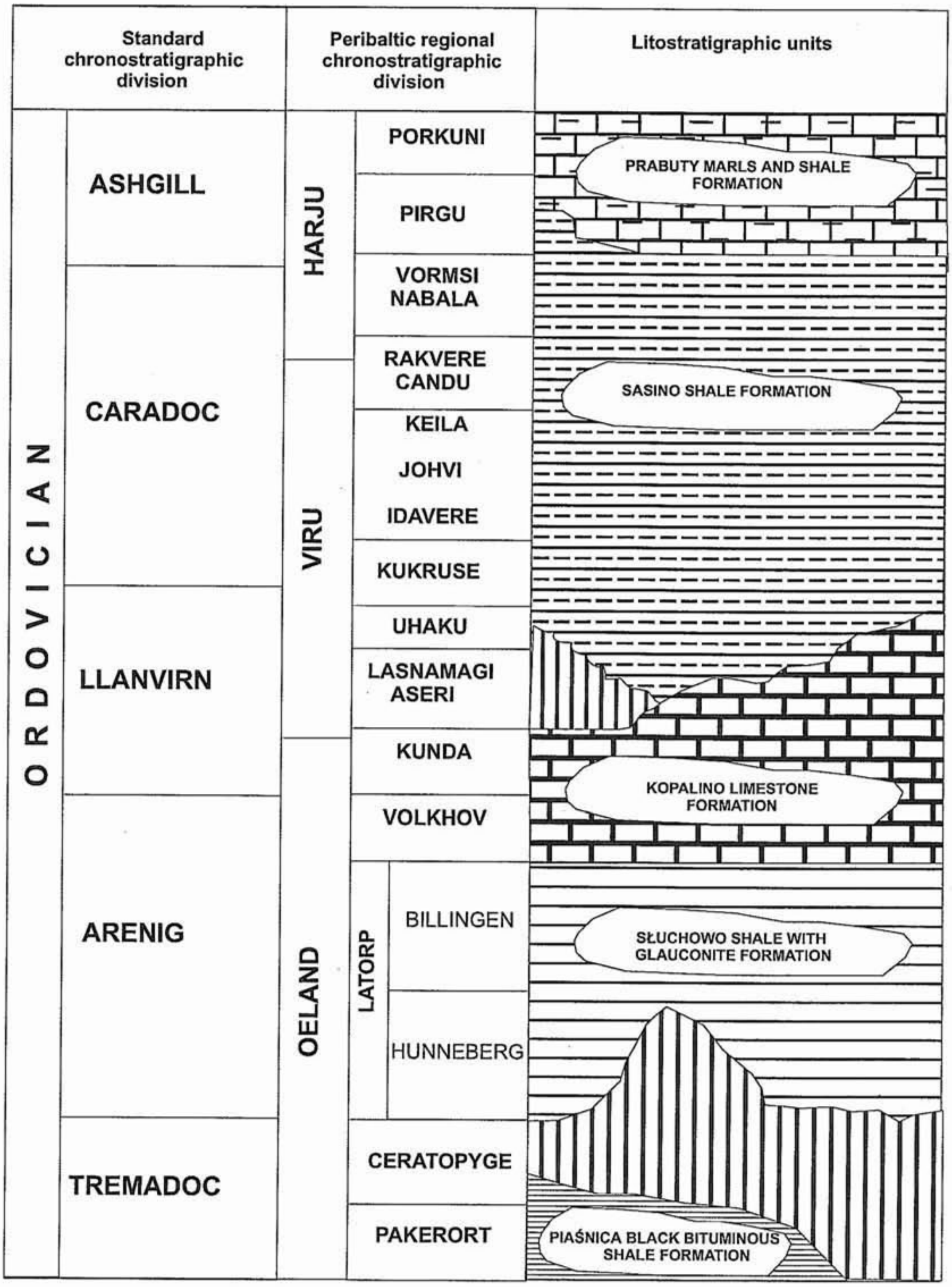


Fig. 2. Ordovician lithostratigraphical scheme in the western part of the Peribaltic Syneclise, after Modliński and Szymański (1997), simplified

dicate a "geosynclinal" character of this Early-Palaeozoic basin (Modliński, 1968; Bednarczyk, 1974).

Although the lithology, thickness and tectonics of the Ordovician deposits differ between the two areas described above, the graptolite and brachiopod faunas do not show such marked differences. Some graptolite and brachiopod taxa are common to both the Caradoc-Llandeilo deposits of the Koszalin–Chojnice Zone and the Sasino Shale Formation (Bednarczyk, 1974; Modliński, 1982, 1989; Modliński and Szymański, 1997).

Table 1

Ordovician acritarchs from boreholes drilled in the East European Craton

Acritarchs	Lębork IG 1	Kościerzyna IG 1		Gdańsk IG 1	
	3276.0	4425.0	4423.5	3090.5	3114.8
Acritarcha gen. et sp. ind.		+			
Aremoricanium sp.					+
?*Baltisphaeridium* sp.		+	+		+
?*Coryphidium* sp.					+
?*Goniosphaeridium* sp.					+
?*Cheleutochroa* sp.	+				
?*Micrhystridium* sp.		+	+		
Baltisphaeridium annelienae (Kjellström)					+
Baltisphaeridium aspersilumiferum Loeblich et Tappan					+
Baltisphaeridium cf. *hirsutoides* (Eisenack)					+
Baltisphaeridium cf. *vieslavi* Górka					+
Baltisphaeridium digitiformae Górka					+
Baltisphaeridium hamatum (Downie)					+
Baltisphaeridium hirsutoides (Eisenack)					+
Baltisphaeridium lancettispinae Górka					+
Baltisphaeridium longispinosum Eisenack				+	
Baltisphaeridium multipilosum (Eisenack)					+
Baltisphaeridium plicatispinae Górka	+				
Baltisphaeridium sp.					+
Cymatiosphaera sp.					+
"Goniosphaeridium" mochtense (Górka)					+
"Goniosphaeridium" sp.		+	+		+
Leiosphaeridia sp.		+	+		+
Peteinosphaeridium bergstromi Staplin, Jansonius et Pocock					+
Polygonium gracile Vavrdová					+
Polygonium sp.				+	+
Tasmanites sp.		+			
Veryhachium sp.	+				
Veryhachium trispinosum (Eisenack)				+	

MATERIAL AND RESEARCH METHODS

Microfloral studies were performed on material from the Jamno IG 2, Karsina 1, Chojnice 5, Brda 3 and Nowa Wieś 1 boreholes drilled in the Pomeranian Caledonides zone. Ordovician deposits from the Peribaltic Syneclise were sampled for microflora in the Kościerzyna IG 1, Lębork IG 1 and Gdańsk IG 1 boreholes (Fig. 1). 58 samples were macerated using the standard palynological method of treatment with strong acids, and subsequenty filtration and flotation.

Acritarchs were found in 6 boreholes. Analysis of many samples failed to reveal any acritarchs in the Ordovician deposits of the Kościerzyna IG 1 borehole (only redeposited microflora was recorded at its base) (Table 1) and the Lębork IG 1 borehole (except for 3 specimens in the uppermost part of the section). Only 2 samples of 20 yielded acritarchs in the

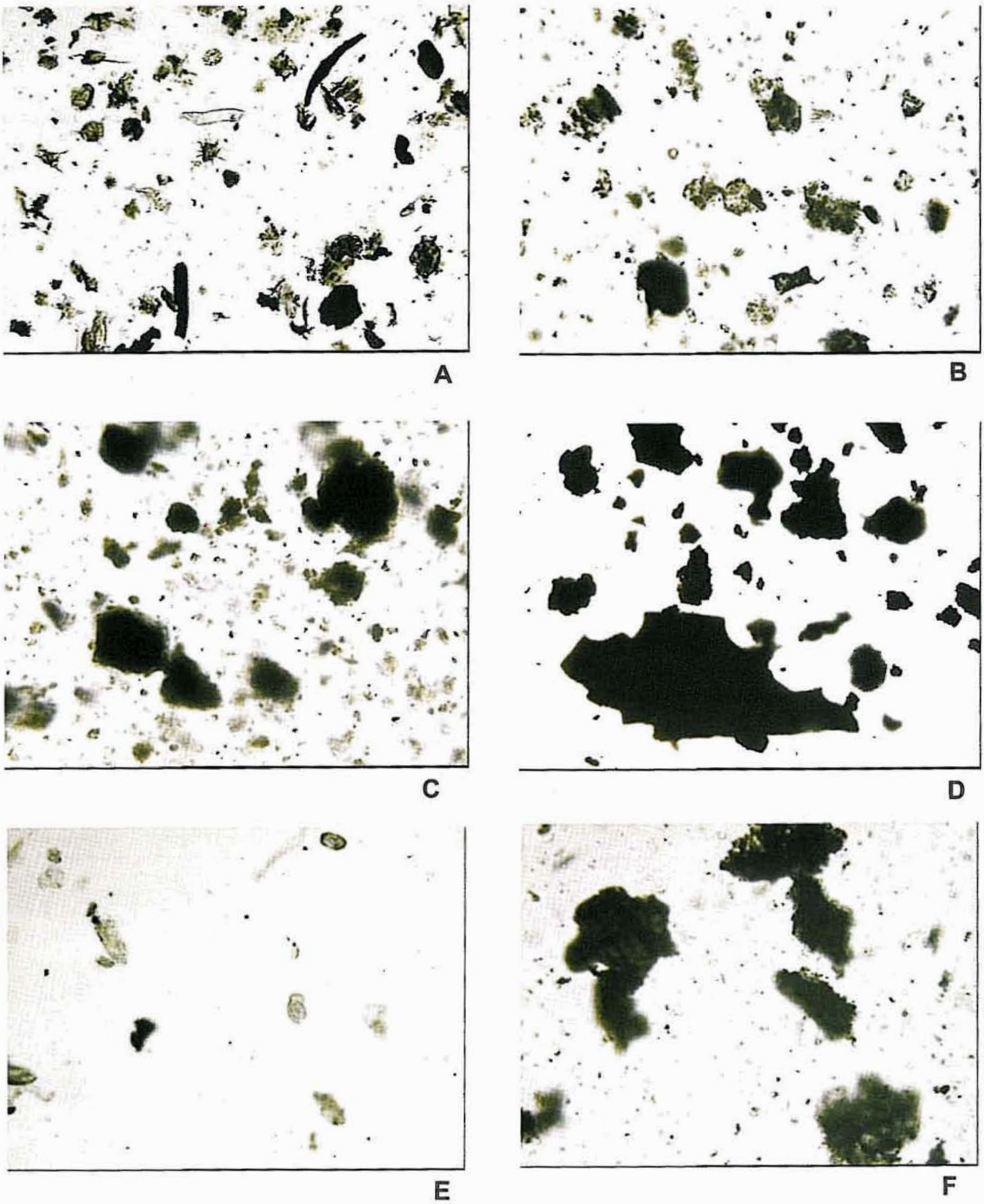


Fig. 3. Types of organic matter in the Ordovician rocks

Table 2

Acritarchs from the Chojnice 5 borehole

Acritarchs	4713.0	4715.0	4725.0	4782.0	5000.0	5043.0
?*Baltisphaera* sp.						+
?*Cheleutochroa* sp.			+			
?*Cymatiogalea* sp.				+		
?*Dasydiacrodium* sp.			+			
?*Veryhachium* sp.	+	+	+	+		+
Baltisphaeridium cf. *plicatispinae* Górka			+			
Baltisphaeridium sp.			+			
Estiastra sp.				+		
"Goniosphaeridium" sp.	+		+			
"Goniosphaeridium" sp. 1		+	+		+	+
?*Multiplicisphaeridium* sp..	+	+			+	
Pirea sp.	+	+			+	
Polygonium sp.	+		+	+		
?*Orthosphaeridium* sp.	+					
Polygonium sp. 1		+				+
Tylotopalla sp.					+	
Veryhachium cf. *hamii* Loeblich			+			
Veryhachium cf. *lairdii* (Deflandre)			+		+	+
Veryhachium hamii Loeblich			+			
Veryhachium lairdii (Deflandre)				+	+	+
Veryhachium reductum (Deunff)		+		+	+	+
Veryhachium sp.	+	+				
Veryhachium trispinosum (Eisenack)	+	+	+	+	+	+
Veryhachium trispinosum ssp. *geometricum* Deflandre				+	+	

Gdańsk IG 1 borehole drilled farther to the east (Table 1, Fig. 1). Much better results were obtained in the West Pomeranian Caledonides. All the boreholes studied in this area yielded acritarchs, locally in great numbers (many thousands of specimens per sample). Precise count cannot be made but estimates showed one kilogram of rock yielding over one million microfloral specimens. Samples with huge amounts of acritarchs are most frequently dominated by morphologically diverse forms of the genus *Veryhachium*. The microflora is well to very well preserved in most of the samples. Processes are usually not crumbled, and the organic substance shows no signs of abrasion. Disruption of walls by crystallized pyrite is sporadic. This state of preservation indicates an autochthonous character for the assemblages. An exception is a 4-metre cored interval, Arenig in age, from the Kościerzyna IG 1 borehole, which contains severely damaged acritarchs showing features suggesting their redeposition (crumbled crests, rubbed surfaces).

Six types of organic matter have been distinguished on the basis of microfloral studies and the character of the kerogen.

Type A (Fig. 3A). Organic residue composed mostly of palynomorphs, fragments of palynomorphs, membranes and other floral elements. Both black detrital and brownish amorphous kerogen are practically absent. Several samples contain huge amounts of microflora, in the boreholes Jamno IG 2, Karsina 1 and Nowa Wieś 1.

Type B (Fig. 3B). This type is characterized by relatively equal contributions of floral fragments and amorphous kerogen

Table 3

Acritarchs from the Jamno IG 2 borehole

Acritarchs	2111.0	2113.0	2139.7	2141.0	2428.0	2520.7	2595.4	2597.3
?*Multiplicisphaeridium* sp.	+							
?*Orthosphaeridium* sp.			+					
?*Polygonium* sp.								
?*Veryhachium* sp.	+		+				+	
Baltisphaeridium annelienae (Kjellström)	+		+					
Baltisphaeridium bramkaense Górka								+
Baltisphaeridium cf. *bramkaense* Górka								+
Baltisphaeridium calicispinae Górka					+			
Baltisphaeridium lancettispinae Górka						+	+	
Baltisphaeridium longispinosum (Eisenack)	+							
Baltisphaeridium plicatispinae Górka						+		
Exculibranchium sp.	+						+	
"*Goniosphaeridium*" cf. *smedsbiense* Górka				+				
"*Goniosphaeridium*" sp.	+		+					
Multiplicisphaeridium sp.	+		+				+	+
Ordovicidium elegantulum Tappan et Loeblich			+					
Orthosphaeridium vibrissiferum Loeblich et Tappan	+		+					
Peteinosphaeridium sp.				+				
Peteinosphaeridium trifurcatum (Eisenack)								+
Polygonium gracile Vavrdová	+		+			+	+	
Polygonium sp.	+							
Veryhachium cf. *hamii* Loeblich		+						
Veryhachium cf. *lairdii* (Deflandre)	+							
Veryhachium hamii Loeblich	+							
Veryhachium reductum (Deunff)	+	+	+					
Veryhachium sp.	+							
Veryhachium trispinosum (Eisenack)	+		+				+	

(largely brown in colour). Acritarchs are fairly abundant but their quantity is only a few percent of that recorded in type A. These types of macerals are common in Ordovician deposits from the Koszalin–Chojnice Zone, except in the boreholes Chojnice 5 and Nowa Wieś 1 (uppermost part).

Type C (Fig. 3C). Amorphous organic matter with a considerable admixture of dark detritus is dominant here. Acritarchs are present only in some of the samples. This type of organic matter occurs in the Chojnice 5 borehole.

Type D (Fig. 3D). Organic matter composed solely of large black, frequently angular, detrital fragments. Acritarchs are absent. Such macerals are characteristic of Caradoc and Llandeilo deposits of the East European Craton (Kościerzyna IG 1 and Gdańsk IG 1). There is a strong correlation between the occurrence of these assemblages and the abundance of graptolites. Locally, brownish amorphous and flocky kerogen occurs together with detrital material.

Type E (Fig. 3E) contains the smallest amount of organic matter. Samples with very rare organic fragments were found

Table 4

Acritarchs from the Karsina 1 borehole

Acritarchs	3140.0	3166.0	3201.5
?*Baltisphaeridium* sp.		+	
?*Cymatiogalea* sp.	+		
Baltisphaeridium brevispinosum (Eisenack)		+	
Baltisphaeridium calicispinae Górka		+	
Baltisphaeridium cf. *hirsutoides* (Eisenack)		+	
Baltisphaeridium cf. *lancettispinae* Górka			+
Baltisphaeridium lancettispinae Górka		+	
Baltisphaeridium plicatispinae Górka	+		
Baltisphaeridium sp.		+	
Exculibranchium sp.			+
Gorgoniosphaeridium sp.	+		
Multiplicisphaeridium sp.	+		
Ordovicidium nudum (Eisenack)		+	
Polygonium gracile Vavrdová		+	+

throughout the entire section of the Lębork IG 1 borehole and in the Ashgill deposits of the Kościerzyna IG 1 borehole. The preparations contain concentrations of heavy minerals and insoluble fluorides as products of maceration.

Type F (Fig. 3F). This type was found only in a 4 m-long interval of the Arenig claystones from the Kościerzyna IG 1 borehole which contains a quite different kind of organic matter. Abundant fragments of microfloral origin, strongly degraded mechanically and thermally. Individual fragments show rubbed and corroded surfaces.

Some samples collected from the Pomeranian Caledonides show evidence of moderate stratigraphical condensation. In such condensed deposits, organic detritus that originated from other organisms (e.g. graptolites) frequently dominates the microflora and makes it practically impossible to find acritarchs. A substantial contribution of microplankton indicates little reworking from shallower zones, suggesting a distal setting.

Samples collected from the zone located east of the T-T Line (Peribaltic Syneclise) show a different character. Kerogen is more abundant here. Both large fragments of black opaque structural matter and minute brown fragments of type C (Fig. 3C) are plentiful. No acritarchs were found in this type of material. It probably indicates much stratigraphical condensation of the deposits and a high concentration of other organic fragments (?graptolites). Marly-argillaceous deposits contain much rarer biogenic detritus — type E (Fig. 3E). These macerals usually contain small amounts of organic matter, though, and microfloral assemblages have been sometimes found there (Gdańsk IG 1).

RESULTS OF PALYNOLOGICAL INVESTIGATIONS

PERIBALTIC SYNECLISE

Lębork IG 1. Only three acritarch specimens were found throughout the whole section. They indicate an Ordovician age; no further stratigraphical conclusions can be drawn.

Kościerzyna IG 1. Three different types of organic matter were found in this section. Very rare organic detritus (type E), containing no acritarchs, occurs at depths of 4394.5–4398.5 m. Mass concentrations of black and angular kerogen (type D), most probably of graptolitic origin, appears at depths of 4395.5–4421.5 m. The lowermost part of the Ordovician section, below a depth of 4222.5 m, contains largely destroyed organic microfragments (type F), among others acritarchs (Pl. I, Fig. 2). The state of preservation of the microflora does not guarantee its autochthony.

Gdańsk IG 1. A poor microfloral assemblage from a depth of 3090.5 m (Ashgill) is composed of few specimens representing the long-lived genera *Baltisphaeridium*, *Veryhachium* and *Polygonium* which are characteristic of almost all the Ordovician section (Górka, 1990). A rich assemblage of palynomorphs from a depth of 3114.8 m (Llanvirn) is dominated by acritarchs of the genera *Baltisphaeridium* and *Polygonium*. Some of the taxa are guide fossils to the Llanvirn, e.g. *B.* cf. *vieslavi* Górka in the Polish part of the East European Craton (Pl. I, Fig. 11). This assemblage represents the Baltic microfloral province (Vavrdová, 1974), though one specimen of ?*Coryphidium* sp. (Pl. I, Fig. 7), considered a peri-Gondwanan form (Servais, 1995), was found. Organic matter

Table 5

Acritarchs from the Brda 3 borehole

Acritarchs	2153.4	2643.5	2900.5
?*Gorgoniosphaeridium* sp.		+	
?*Multiplicisphaeridium* sp.	+	+	+
?*Veryhachium* sp.	+		+
Actipilon cf. *druggi* Loeblich	+		
Baltisphaeridium annelienae (Kjellström)	+		
Baltisphaeridium brevispinosum (Eisenack)	+		
Baltisphaeridium calicispinae Górka	+		
Baltisphaeridium cf. *hirsutoides* (Eisenack)			+
Baltisphaeridium lancettispinae Górka			
Baltisphaeridium longispinosum (Eisenack)		+	
Baltisphaeridium plicatispinae Górka	+		
Baltisphaeridium sp.	+	+	
Batisphaeridium latiradiatum (Eisenack)		+	
Diexallophasis sp.	+		+
Exculibranchium sp.	+		
Leiofusa sp.	+		+
Multiplicisphaeridium sp.		+	
Ordovicidium heteromorphum (Kjellström)	+		
Petaloferidium sp.	+		
Pirea sp.	+		
Polygonium gracile Vavrdová	+		
Polygonium sp.		+	
Veryhachium cf. *lairdii* (Deflandre)		+	
Veryhachium cf. *oklahomense* (Loeblich)		+	+
Veryhachium lairdii (Deflandre)	+		
Veryhachium oklahomense (Loeblich)	+		+
Veryhachium reductum (Deunff)	+		
Veryhachium sp.		+	
Veryhachium trispinosum (Eisenack)	+		
Veryhachium trispinosum ssp. *geometricum* Deflandre		+	

in the Ashgill deposits is rare (type E). The Caradoc and Llandeilo rocks are characterized by both a huge concentration of black angular microdetritus, probably originating from graptolites (type D), and a lack of microflora. In the Llanvirn and Arenig, the supply of biogenic matter rapidly ceased, with the exception of the sample from a depth of 3114.8 m, which is abundant in acritarchs.

POMERANIAN CALEDONIDES

Chojnice 5. The microfloral assemblage (Table 2) is dominated by acritarchs of the genera *Veryhachium* and *Polygonium*. The acritarchs are fairly numerous but not as much as in other boreholes of this area (type B). This assemblage, with a dominance of *Veryhachium* (including quadran-

Table 6

Acritarchs from the Nowa Wieś 1 borehole

Acritarchs	2404.0	2757.5	2893.0
?*Gorgoniosphaeridium* sp.			+
?*Leiofusa* sp.			+
?*Veryhachium* sp.	+		+
Acritarcha gen. et sp. ind.			+
Aremoricanium sp.			+
Baltisphaeridium calicispinae Górka			+
Baltisphaeridium cf. *bramkaense* Górka		+	
Baltisphaeridium cf. *calicispinae* Górka	+	+	
Baltisphaeridium cf. *hirsutoides* (Eisenack)			+
Baltisphaeridium cf. *longispinosum* Eisenack			+
Baltisphaeridium cf. *plicatispinae* Górka			+
Baltisphaeridium lancettispinae Górka		+	+
Baltisphaeridium plicatispinae Górka			+
Baltisphaeridium sp.			+
Diexallophasis sp.			+
Exculibranchium sp.	+	+	+
"*Goniosphaeridium*" sp.		+	
"*Goniosphaeridium*" sp. 1		+	
Multiplicisphaeridium sp.			+
Petaloferidium sp.			+
Peteinosphaeridium sp.			+
Polygonium gracile Vavrdová			+
Polygonium sp.			+
Veryhachium hamii Loeblich		+	
Veryhachium lairdii (Deflandre)		+	+
Veryhachium reductum (Deunff)			+
Veryhachium sp.	+	+	+
Veryhachium trispinosum (Eisenack)	+		+
Veryhachium trispinosum ssp. *geometricum* Deflandre			+

gular forms), suggests an Upper Ordovician age; there are also a considerable number of seemingly redeposited acritarchs (*Cymatiogalea*, *Acanthodiacrodium*). A similar phenomenon was observed in the Czech Republic, where Ashgill deposits contain very numerous redeposited Lower Ordovician assemblages (Vavrdová, 1982). "Extraneous" microfloral elements were also found in Ashgill deposits of the Holy Cross Mts. (Szczepanik, 1996). Assemblages very similar to those from the Chojnice 5 borehole are characteristic of the Upper Ordovician (Caradoc-Ashgill) in many areas (Jacobson, 1979; Jacobson and Achab, 1985; Hill and Molyneux, 1988).

Jamno IG 2. The assemblages found in this borehole (Table 3) show a twofold character. The upper part of the section (above 2141.0 m) is characterized by a domination of *Veryhachium* species. *Baltisphaeridium* is rare, while *Ordovicidium* and *Polygonium* forms are more frequent. This assemblage slightly resembles the microflora found in the Chojnice 5 borehole, although the spectrum is richer and more diverse here. These Ordovician deposits are slightly older than those drilled in Chojnice (Caradoc). Much richer assemblages occur at depths below 2428.0 m. *Baltisphaeridium* species, including forms described by Górka (1969, 1979, 1980, 1987, 1990) from the Polish part of the East European Craton and Scandinavia, appear in great numbers. Their stratigraphical ranges indicate a time interval from the latest Llanvirn (Llandeilo) to the Caradoc. In the Jamno IG 2 borehole en masse occurrences of acritarchs were found (type A); a few samples contain several tens of thousands specimens.

Karsina 1. The acritarch assemblage (Table 4) contains abundant morphologically diverse specimens (type A) here. The range of taxa indicates the presence of Llandeilo-Caradoc deposits. These assemblages are very similar to those from the bottom part of the Jamno IG 2 borehole. En masse occurrences of *Baltisphaeridium* shows the presence of Lower Caradoc or Llanvirn/Caradoc transition zone deposits (Fig. 3).

Brda 3. Acritarchs are extremely abundant and morphologically diverse here (Table 5). A substantial contribution of *Veryhachium* specimens makes this assemblage similar to that from the Chojnice 5 borehole. However, rare specimens of *Baltisphaeridium*, with forms known from the "lower" microfloral zone (in Karsina 1 and lower parts of the Jamno IG 2 borehole), are also observed here. Thus, any interpretation of the stratigraphical succession is difficult in this section. Tectonic overturning of beds may occur here.

Nowa Wieś 1. Two acritarch assemblages are present here (Table 6). Forms occurring above a depth of 2757.0 m are characterized by numerous taxa of the genus *Baltisphaeridium*, including species typical of the Middle Ordovician of the East European Craton (Górka, 1979, 1980). Diverse microfloral assemblages dominated by *Veryhachium* are observed above. This may point to a slightly younger age of these deposits. Acritarchs are extremely abundant here — type A and B (Fig. 3).

STRATIGRAPHICAL SIGNIFICANCE OF THE ASSEMBLAGES

The results of the investigations show that the Ordovician deposits of West Pomerania, despite their considerable thicknesses, represent a relatively short stratigraphical interval. The stratigraphical ranges of the common *Baltisphaeridium* forms (Górka, 1990) indicate that they correspond to the Llandeilo-Caradoc. This is supported by the abundance of *B. lancettispinae* Górka, an index species of the Caradoc (Górka, 1990). *B. bramkaense* Górka, found at the base of the Jamno IG 2 borehole (Pl. III, Figs. 11, 12), is also of stratigraphical importance as a guide fossil to the Llandeilo. Therefore, the lowermost deposits in the Jamno IG 2 borehole may belong to the Llandeilo. The present author consider that current knowledge of the Ordovician microflora in Poland does not allow unequivocal stratigraphical conclusions. A revision of the ranges of some taxa is probable soon.

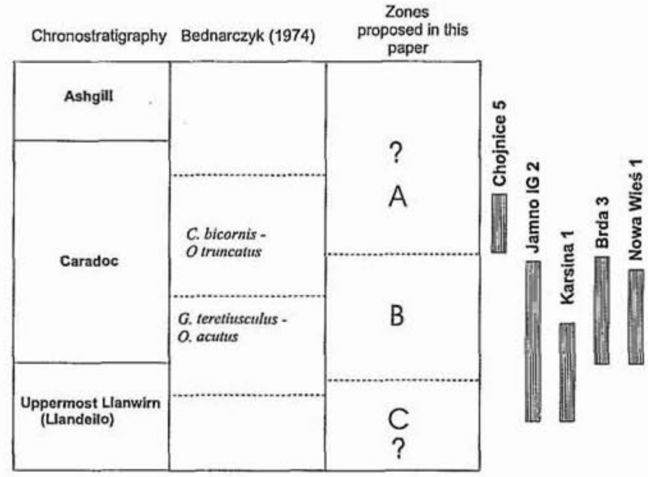


Fig. 4. Correlation scheme of local palaeontological zones in the Ordovician of the Pomeranian Caledonides

The assemblage from the Chojnice 5 borehole shows a different character. Microflora found in this borehole resemble the Upper Ordovician (Caradoc-Ashgill) assemblages known elsewhere in the world (Jacobson, 1979; Jacobson and Achab, 1985; Hill and Molyneux, 1988).

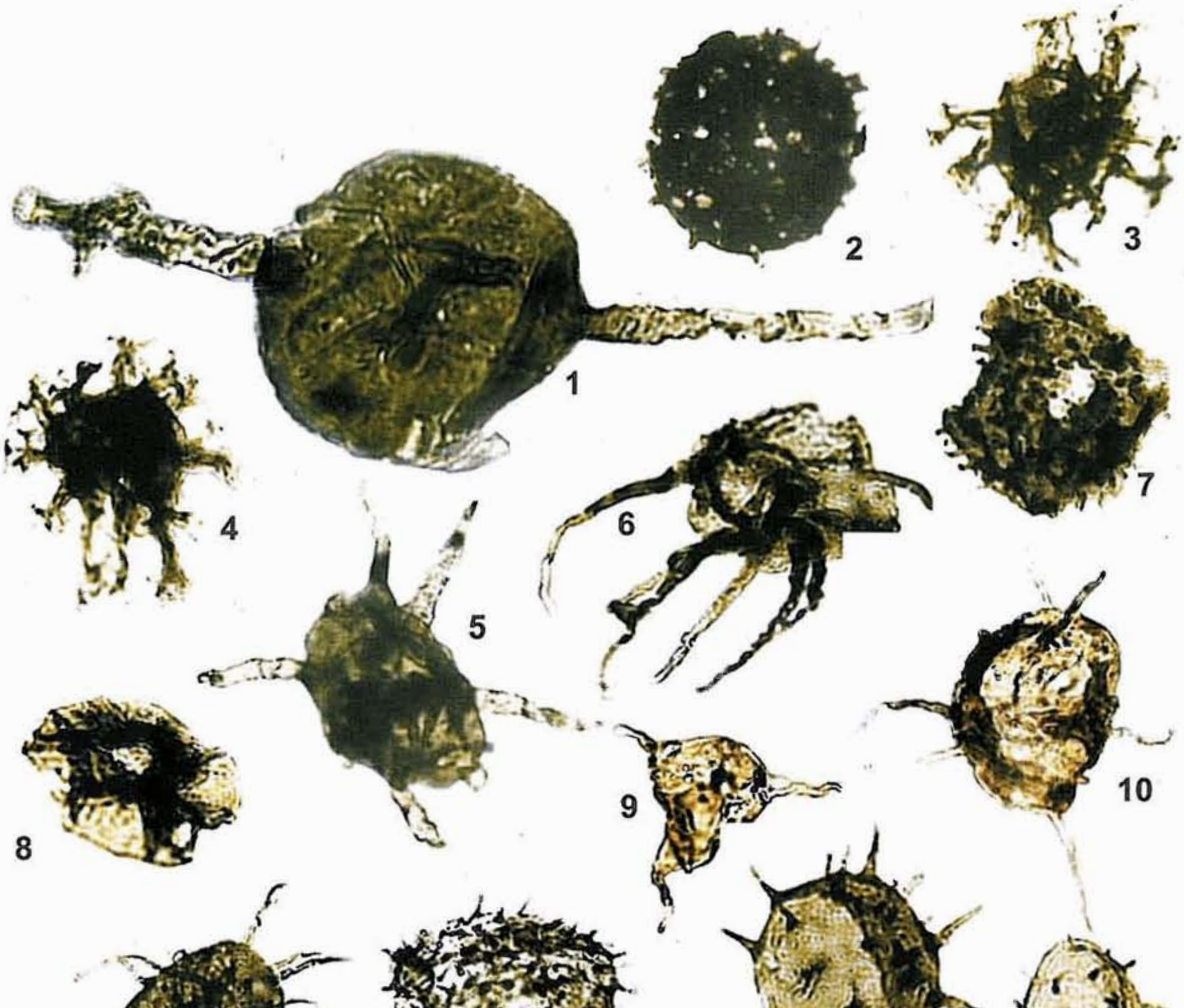
Three local microfloral zones (Fig. 4) can be distinguished. However, their definition is based on a quantitative analysis of palynomorph assemblages rather than on the stratigraphical ranges of individual forms.

The youngest deposits probably occur in the Chojnice 5 borehole. The sparse acritarch population is dominated by various taxa of *Veryhachium*. *Baltisphaeridium* specimens are very rare here, whereas *Ordovicidium* forms, common in other boreholes from this region, are completely absent.

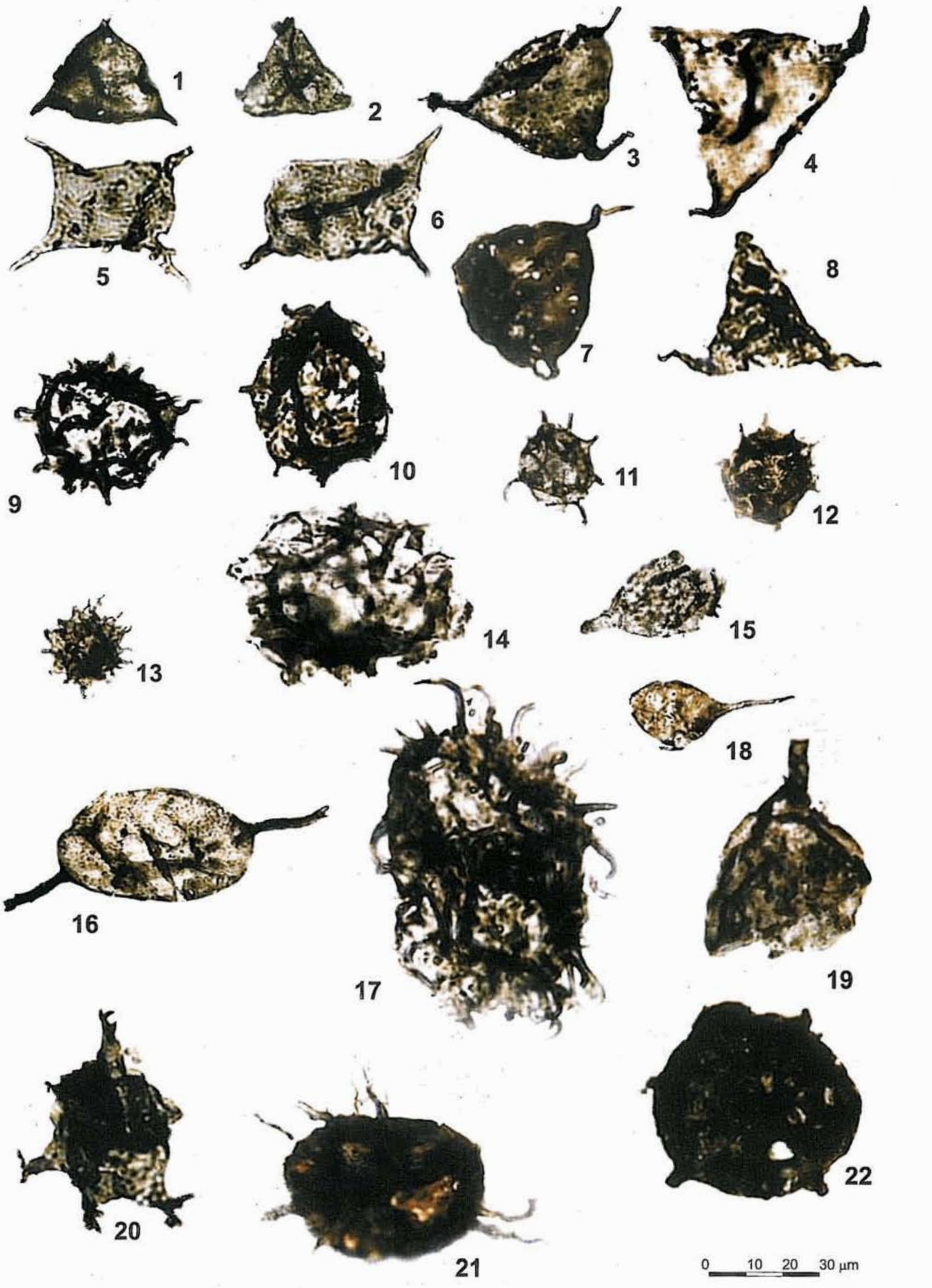
The microflora, found in the upper parts of the Jamno IG 2 borehole and characterized by a very high contribution of minute *Veryhachium* forms (but containing "baltisphaerids"), seems to be slightly older. Such assemblages also occur in the Brda 3 and Nowa Wieś 1 boreholes. A high contribution of taxa belonging to the genera *Ordovicidium* and *Exculibranchium* is characteristic of this assemblage.

The oldest assemblage, with a dominance of *Baltisphaeridium* div. sp., occurs in the Karsina 1 borehole and in the bottom part of the Jamno IG 2 borehole. *Veryhachium* acritarchs are practically absent here.

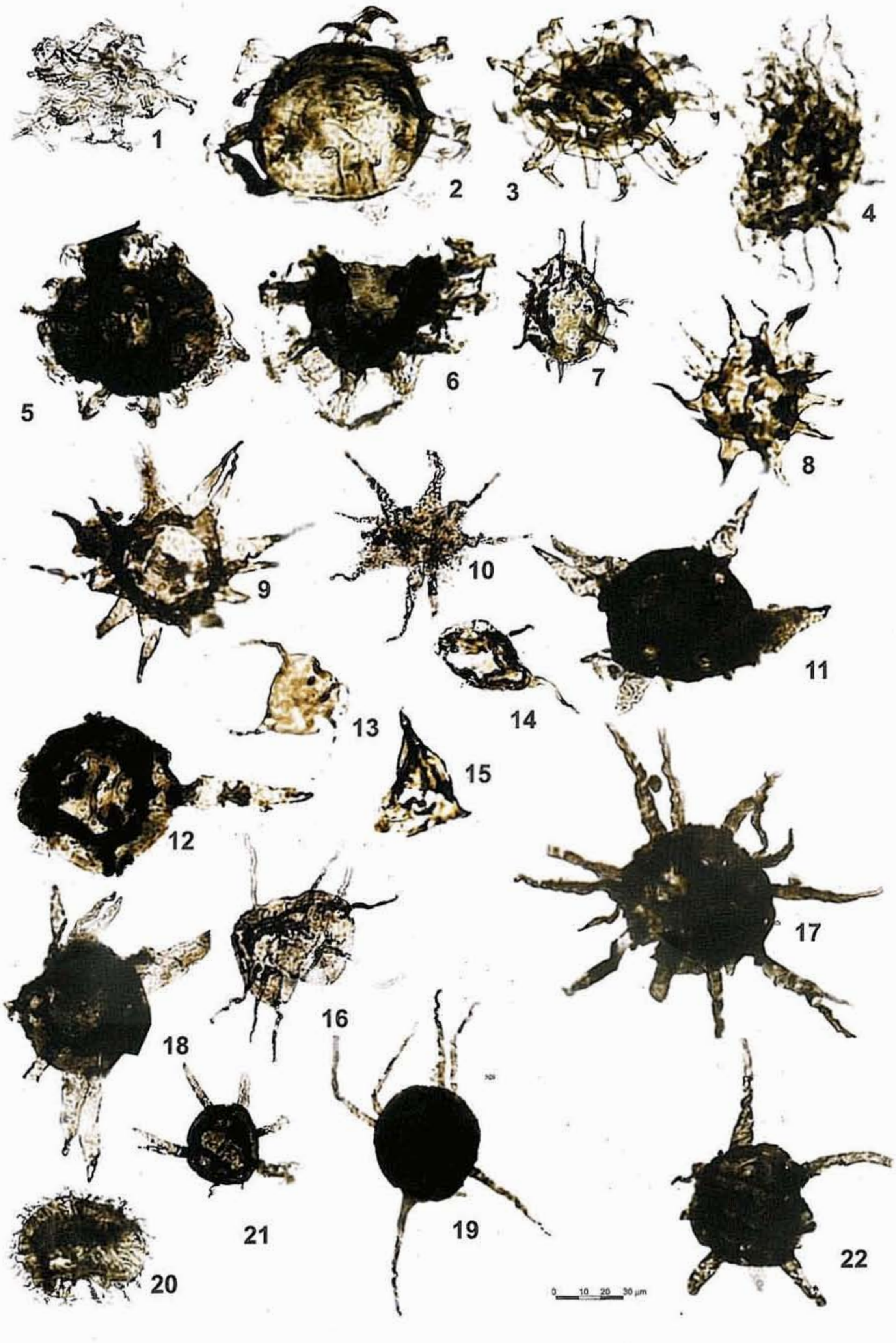
Comparison of these results with the Ordovician stratigraphy of the Pomeranian Caledonides given by Bednarczyk (1974) shows an accord with both the age of the series (Llandeilo-Caradoc) and the position of particular borehole sections in the chronostratigraphic table. The combination of these two methods helps to determine the age of the deposits more precisely. The Ordovician section of the Chojnice 5 borehole probably comprises a higher part of the local graptolite zone of *Climacograptus bicornis–Orthograptus truncatus* than that of the Brda 3 borehole. The deposits from the Karsina 1



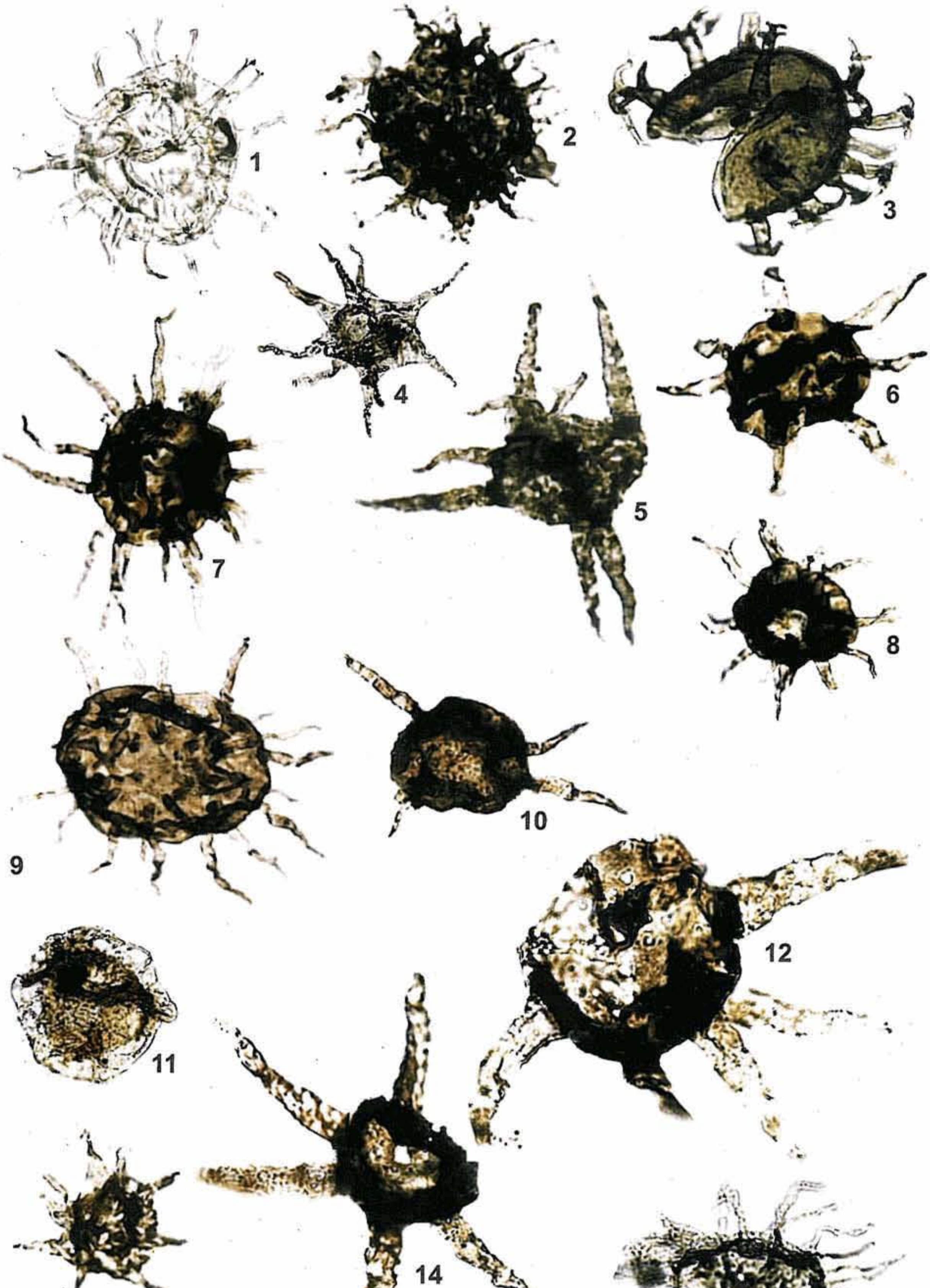
1, 5. Baltisphaeridium plicatispinae Górka, 3276.0 m, Ashgill. *2. ?Baltisphaeridium* sp., 4423.5 m, Arenig. *3, 4. Peteinosphaeridium bergstromi* Staplin, Jansonius et Pocock, 3114.8 m, Llanvirn. *6. Aremoricanium* sp., 3114.8 m, Llanvirn. *7. ?Coryphidium* sp., 3114.8 m, Llanvirn. *8. Cymatiosphaera* sp., 3114.8 m, Llanvirn. *9. Veryhachium trispinosum* (Eisenack), 3090.5 m, Ashgill. *10. Baltisphaeridium longispinosum* Eisenack, 3090.5 m, Ashgill. *11. Baltisphaeridium* cf. *vieslavi* Górka, 3114.8 m, Llanvirn. *12. Baltisphaeridium hamatum* (Downie), 3114.8 m, Llanvirn. *13. Baltisphaeridium hirsutoides* (Eisenack), 3114.8 m, Llanvirn. *14. Baltisphaeridium* cf. *hirsutoides* (Eisenack), 3114.8 m, Llanvirn. *15, 20. Baltisphaeridium* sp., 3114.8 m, Llanvirn. *16. Baltisphaeridium multipilosum* (Eisenack), 3114.8 m, Llanvirn. *17. Polygonium gracile* Vavrdová, 3114.8 m, Llanvirn. *18, 19. Polygonium* sp., 3114.8 m, Llanvirn. *21. Acritarcha* gen. et sp. ind., 3114.8 m. *1, 5* — Lębork IG 1 borehole, *2* — Kościerzyna IG 1 borehole, *3, 4, 6–21* — Gdańsk IG 1 borehole



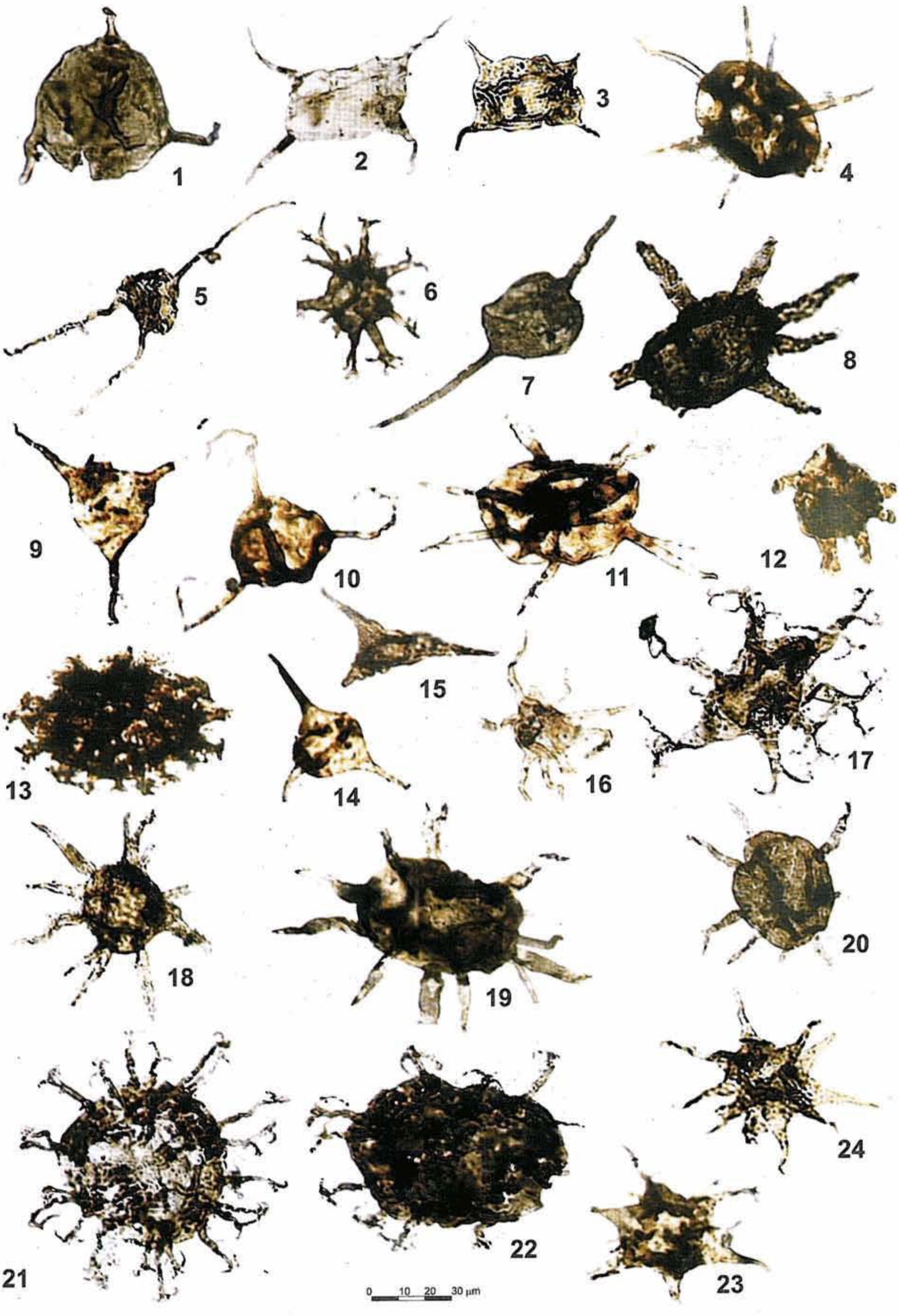
1, 3. Veryhachium trispinosum (Eisenack): *1* — 4713.0 m, *3* — 4715.0 m. *2, 4. Veryhachium reductum* (Deunff): *2* — 4782.0 m, *4* — 4715.0 m. *5, 6. Veryhachium* cf. *lairdii* (Deflandre): *5* — 4725.0 m, *6* — 5043.0 m. *7. Veryhachium* cf. *hamii* Loeblich, 4725.0 m. *8. Veryhachium trispinosum* ssp. *geometricum* Deflandre, 5000.0 m. *9, 10, 14. Polygonium* sp. 1: *9* — 4715.0 m, *10* — 5043.0 m, *14* — 4715.0 m. *11, 12. Polygonium* sp.: *11* — 4713.0 m, *12* — 4725.0 m. *13.* ?*Polygonium* sp., 4725.0 m. *15, 19. Pirea* sp.: *15* — 4715.0 m, *19* — 5000.0 m. *16.* ?*Orthosphaeridium* sp., 4713.0 m. *17. Acanthodiacrodium* sp., 4725.0 m. *18.* ?*Veryhachium* sp., 4782.0 m. *20. Tylotopalla* sp., 5000.0 m. *21. Baltisphaeridium* cf. *plicatispinae* Górka, 4725.0 m. *22.* ?*Baltisphaera* sp., 5043.0 m. Chojnice 5 borehole



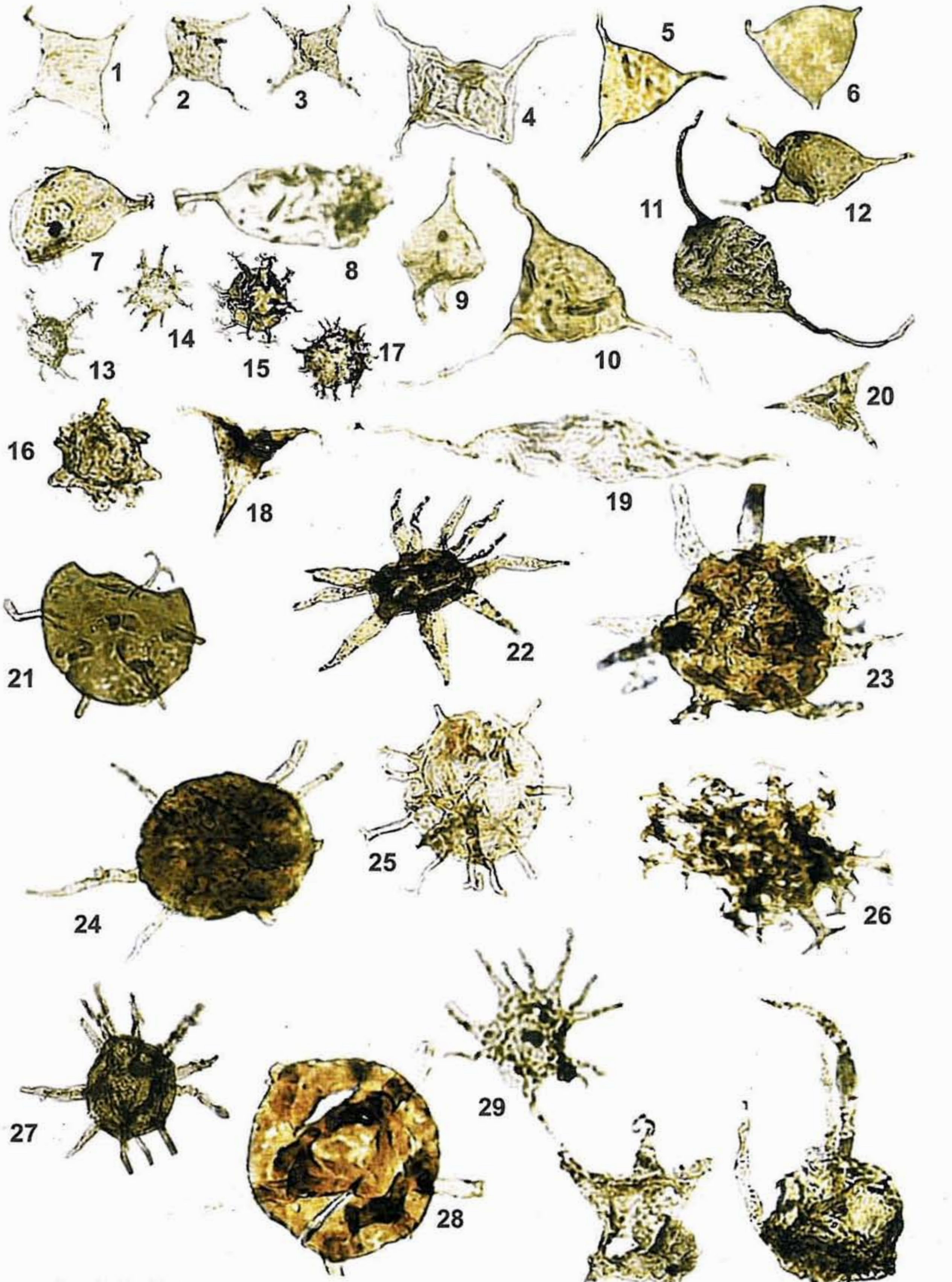
1. Multiplicisphaeridium sp., 2139.7 m. ***2, 3.*** *Ordovicidium elegantulum* Tappan et Loeblich, 2139.7 m. ***4.*** *Baltisphaeridium annelienae* (Kjellström), 2139.7 m. ***5.*** *Peteinosphaeridium trifurcatum* (Eisenack), 2597.3 m. ***6.*** *Peteinosphaeridium* sp., 2141.0 m. ***7.*** "*Goniosphaeridium*" cf. *smedsbiense* Górka, 2141.0 m. ***8, 9.*** *Polygonium gracile* Vavrdová: *8* — 2139.7 m, *9* — 2520.7 m. ***10.*** *Polygonium* sp., 2111.0 m. ***11.*** *Baltisphaeridium* cf. *bramkaense* Górka, 2597.3 m. ***12.*** *Baltisphaeridium bramkaense* Górka, 2597.3 m. ***13.*** *Veryhachium* sp., 2111.0 m. ***14.*** *Veryhachium* cf. *hamii* Loeblich, 2113.0 m. ***15.*** *Veryhachium reductum* (Deunff), 2113.0 m. ***16, 19.*** *Baltisphaeridium longispinosum* (Eisenack), 2111.0 m. ***17, 22.*** *Baltisphaeridium plicatispinae* Górka, 2520.7 m. ***18.*** *Baltisphaeridium lancettispinae* Górka, 2520.7 m. ***20.*** ?*Multiplicisphaeridium* sp., 2111.0 m. ***21.*** *Baltisphaeridium calicispinae* Górka, 2428.0 m. Jamno IG 2 borehole



1. *Exculibranchium* sp., 3201.5 m. *2*. *Multiplicisphaeridium* sp., 3140.0 m. *3*. *Ordovicidium nudum* (Eisenack), 3166.0 m. *4, 13*. *Polygonium gracile* Vavrdová: *4* — 3166.0 m, *13* — 3201.5 m. *5*. *Gorgoniosphaeridium* sp., 3140.0 m. *6*. *Baltisphaeridium lancettispinae* Górka, 3166.0 m. *7, 9*. *Baltisphaeridium plicatispinae* Górka: *7* — 3140.5 m, *9* — 3140.0 m. *8*. *Baltisphaeridium* cf. *hirsutoides* (Eisenack), 3166.0 m. *10*. *Baltisphaeridium* sp., 3166.0 m. *11*. ?*Cymatiogalea* sp., 3140.0 m. *12*. *Baltisphaeridium* cf. *lancettispinae* Górka, 3201.5 m. *14*. *Baltisphaeridium calicispinae* Górka, 3166.0 m. *15*. ?*Baltisphaeridium* sp., 3166.0 m. Karsina 1 borehole



1. ?*Veryhachium* sp., 2404.0 m. ***2, 3***. *Veryhachium lairdii* (Deflandre): ***2*** — 2757.5 m, ***3*** — 2893.0 m. ***4***. *Baltisphaeridium* cf. *longispinosum* Eisenack, 2893.0 m. ***5, 10, 14***. *Veryhachium* sp., 2893.0 m. ***6***. *Diexallophasis* sp., 2893.0 m. ***7***. *Acritarcha* gen. et sp. ind., 2893.0 m; ***8***. *Baltisphaeridium calicispinae* Górka, 2893.0 m. ***9***. *Veryhachium trispinosum* (Eisenack), 2893.0 m. ***11, 19***. *Baltisphaeridium lancettispinae* Górka, 2757.5 m. ***12***. *Petaloferidium* sp., 2893.0 m. ***13***. *Peteinosphaeridium* sp., 2893.0 m. ***15***. *Veryhachium reductum* (Deunff), 2893.0 m. ***16***. *Aremoricanium* sp., 2893.0 m. ***17***. *Multiplicisphaeridium* sp., 2893.0 m. ***18***. *Baltisphaeridium* cf. *calicispinae* Górka, 2757.5 m. ***20***. *Baltisphaeridium plicatispinae* Górka, 2893.0 m. ***21, 22***. *Exculibranchium* sp.: ***21*** — 2404.0 m, ***22*** — 2757.5 m. ***23, 24***. *Polygonium gracile* Vavrdová, 2893.0 m. Nowa Wieś 1 borehole



1, 3, 4. *Veryhachium oklahomense* (Loeblich): ***1, 4*** — 2153.4 m, ***3*** — 2900.5 m. ***2***. *Veryhachium* cf. *oklahomense* (Loeblich), 2900.5 m. ***5, 10***. *Veryhachium trispinosum* (Eisenack), 2153 4 m. ***6***. *Veryhachium reductum* (Deunff), 2153.4 m. ***7, 8***. *Pirea* sp., 2153.4 m. ***9, 12***. ?*Veryhachium* sp.: ***9*** — 2153.4 m, ***12*** — 2900.5 m. ***11, 19***. *Leiofusa* sp.: ***11*** — 2900.5 m, ***19*** — 2153.4 m. ***13, 14, 17***. ?*Multiplicisphaeridium* sp.: ***13*** — 2900.5 m, ***14*** — 2153.4 m, ***17*** — 2643.5 m. ***15, 25***. *Exculibranchium* sp., 2153.4 m. ***16***. *Petaloferidium* sp., 2153.4 m. ***18, 20***. *Veryhachium trispinosum* ssp. *geometricum* Deflandre, 2643.5 m. ***21***. *Ordovicidium heteromorphum* (Kjellström), 2153.4 m. ***22***. *Baltisphaeridium latiradiatum* (Eisenack), 2643.5 m. ***23***. *Baltisphaeridium brevispinosum* (Eisenack), 2153.4 m. ***24***. *Baltisphaeridium calicispinae* Górka, 2153.4 m. ***26***. *Multiplicisphaeridium* sp., 2643.5 m. ***27***. *Baltisphaeridium* cf. *hirsutoides* (Eisenack), 2900.5 m. ***28***. *Actipilon* cf. *druggi* Loeblich, 2153.4 m. ***29***. *Polygonium gracile* Vavrdová, 2153.4 m. ***30***. *Polygonium* sp., 2643.5 m. ***31***. ?*Gorgoniosphaeridium* sp., 2643.5 m. Brda 3 borehole

borehole and the bottom part of the Jamno IG 2 borehole seem to be the oldest ones (Fig. 4).

COLOUR OF ACRITARCHS AS AN INDICATOR OF THERMAL ALTERATIONS

Organic matter grows dark as a result of a relative increase in carbon content due to increased temperature. This process has been proved by experiments and is considered to be common and irreversible. The degree of carbonization is directly dependent on the amount of thermal energy supplied. This, in turn, is related to the temperature attained by the rocks and the duration of heating (Bełka, 1990; Narkiewicz and Nehring-Lefeld, 1993).

Acritarch wall colour can be used to estimate the maximum temperature that affected biogenic matter. Experiments have permitted both determination of temperatures corresponding to particular phases of thermal alteration and creation of a scale (calibrated in degrees centigrade) of thermal alteration of organic matter — Thermal Alteration Index (TAI) (AMOCO, 1992 — unpublished). This scale was created mainly for the needs of oil companies where it is used to determine petroleum generation potential and the migration directions of hydrocarbons.

Colour analysis has been applied to two samples of each borehole from extreme depths. Acritarch assemblages from individual samples are characterized frequently by different colours of individual specimens, and even within different parts of one specimen. This results from many reasons. The specimen becomes darker in transmitted light as its wall thickness increases. Any convexities on the wall surface, or tucks and overlaps of particular wall fragments result in darkening of the surface. Another problem is the subjectivity of the observer. The colour of individual specimens also depends on the quality and kind of the medium surrounding them in the preparation, the light and magnification used, and other factors. Almost all the samples studied contain *Veryhachium trispinosum* (Eisenack). This taxon is characterized by a relatively simple structure, smooth and thin walls lacking any swellings and foldings, and by small species variability. Hence, the colour analysis has been based on this species. The problem of subjective optical impressions of colours has been solved using an experimental method of digital transformations. A selected fragment of the organic surface together with a fragment of the surrounding medium was scanned and input into computer memory as a graphic file. After a digital "homogenization" of the colour, reducing differences of tints of the walls and background within the field of vision, uniform colour samples were obtained. Such standard colours were converted to tints of grey. This enabled a digital estimation of colour intensity (scaled from 0 to 255).

The measure of blackening is not represented by a digital value of the colour but by substraction of the values obtained for the specimen and the background. Tests of measurement values at different intensities of microscopic light and at different magnifications shows that the results of substraction expressed by digital values remain similar, although the tints of the colour are visually different. Hereafter, this index will be called the Blackening Difference Index.

Lębork IG 1. No microflora fragments (except for three specimens — light in colour?!) have been found in the Ordovician deposits of the Lębork IG 1 borehole. Therefore, no palaeothermal investigations have been conducted. Fragments of membranes, sporadically found in the samples, are light in colour suggesting that the palaeotemperatures did not reach high values. The scarcity of material for such analysis as well as doubts about its autochthonous character reduce the reliability of these studies. Investigations of the thermal alteration of conodonts and vitrinite reflectance studies indicate much higher temperatures of up to 190–300°C (Nehring-Lefeld *et al.*, 1997; Grotek, 1999). If the rock was really heated to such high temperatures, the observed lack of acritarchs could result from their graphitization and breakdown. Such palaeotemperatures must have been related to a rapid increase in the palaeothermal gradient up to over 60°C/km.

Kościerzyna IG 1. As in the Lębork IG 1 borehole, no colour studies of organic matter were conducted here due to a lack of Ordovician acritarchs. *Leiosphaeridia* sp., found in the 4423.5 m sample, is probably redeposited. The lack of acritarchs might result from their thermal degradation, though this seems improbable because fairly well preserved acritarchs have been found in the bottom part of the borehole at depths exceeding 5000 m.

Gdańsk IG 1. Determinable microflora was found in two samples collected from marly deposits at depths of 3090.5 and 3114.8 m (Ashgill and Llanvirn in age, respectively). Acritarchs from these samples are orange to light brown in colour corresponding to the phases 4+ and 5 on the AMOCO thermal alteration scale (AMOCO, 1992 — unpublished). The values determined by the method used in the present study fall within a range of 70–95. The stage 4+–5 of the AMOCO scale corresponds to palaeotemperatures not exceeding 90°C. These values are slightly higher that those obtained from studies of both vitrinite-like matter reflectance (Grotek, 1999; Nehring-Lefeld *et al.*, 1997) and CAI (Nehring-Lefeld *et al.*, 1997). Taking into account a relatively thick overburden (over 3000 m) we can infer that the geothermal gradient around Gdańsk has never reached high values. The analysis of total subsidence curves drawn for the Gdańsk IG 1 borehole (Sikorska and Pacześna, 1997) shows that the maximum burial depth of the Ordovician deposits approximates the present depth. Assuming the recent value of the palaeothermal gradient (15–30°C/km), temperatures should not have exceeded 100°C.

Brda 3. Ordovician deposits occur here at depths of 2153.0–2901.5 m. The sample collected from the top of the sequence contains barely altered acritarchs of *Veryhachium trispinosum*. These are light yellow and correspond to the lowest stages of thermal alterations (1–3) using the AMOCO scale, i.e. to temperatures of approximately 50°C. The Blackening Difference Index is 10–15. The acritarch colours are darker (AMOCO 3+–4) at the base of this sequence (2900 m) with a Blackening Difference Index of 25–40. In this case temperatures were slightly higher, although below 80°C.

Karsina 1. A relatively short depth interval (3140.0–3203.0 m) was sampled in this borehole. The degree of thermal alteration is equivalent to stages 3+–5+ that corresponds to the oil window of hydrocarbon generation (AMOCO, 1992 — unpublished). Palaeotemperatures most likely have not reached 90°C. Both the depth to the Ordovician rocks and the degree of their thermal maturity are similar to the Gdańsk IG 1 borehole. This suggests a similar value of heat flow in these two areas despite their different structural setting. The Blackening Difference Index ranges from 60 to 100.

Nowa Wieś 1. Two samples were selected for comparative studies of thermal alteration. The first was collected from a depth of 2416.0 m, the second from the bottom of the borehole at a depth of 2900.0 m. *Veryhachium trispinosum* specimens indicate the stage 3+4 (early oil window) and palaeotemperatures well below 80°C. The Blackening Difference Index is fairly constant within a range of 55–70, i.e. distinctly lower than in the boreholes discussed above. It probably results from a slightly shallower burial.

Jamno IG 2. Acritarchs from the base and top of the Ordovician sequence were analysed (2111.0 and 2597.3 m). In spite of their stratigraphical proximity, the colour gradient between these two samples is high. In the top sample, *Veryhachium* is yellow, occasionally slightly orange, characteristic of stages 3+–4, i.e. similar to those from the Nowa Wieś 1 borehole (Blackening Difference Index < 75). Towards the base acritarchs become more brown (stage 5+) that corresponds to the condensate window and temperatures that may have exceeded 100°C (Blackening Difference Index 100–130). The thermal gradient here is slightly higher than in the other boreholes and suggests the presence of hydrothermal or volcanic processes within the basement of the northern part of the West Pomeranian Caledonides.

Chojnice 5. Acritarchs have been found at depths from 4713.0 to 5055.5 m. Colours of their walls indicate the AMOCO stage 5+–6, i.e. temperatures exceeding 100°C (110–150°C). The Blackening Difference Index ranges between 140 and 190.

These results show that the degree of thermal alteration of organic matter is similar on either side of the T-T Zone. Caledonian tectonic deformation was not accompanied by increased heat flow. Therefore, the geothermal gradient was similar to that characteristic of the East European Craton — 2–2.5°C/100 m (Majorowicz, 1982). Even very deeply lying rocks (Chojnice 5) contain relatively slightly altered acritarchs. It is interesting that Lower Cambrian acritarchs, found at a depth of 5000.0 m in the Kościerzyna IG 1 borehole located east of the T-T Line, are only slightly more altered (Szczepanik, 1999). Therefore, it leads to the conclusion that this is not an area of the West Pomeranian Caledonides which was characterized by an increased palaeothermal gradient in relation to the adjoining areas, but is the marginal, immersed part of the East European Craton. It suggests certain analogies to the palaeotemperature distribution in the Holy Cross Mts. In the Kielce area (south), which underwent Sandomirian, Early Caledonian and Variscan orogenic movements, the degree of thermal alteration of Cambrian deposits is very low (Szczepanik, 1997), while in the Łysogóry area (north), suggested by some research workers to have a platformal structure, the degree of thermal alteration of Cambrian deposits is higher (Moczydłowska in Kowalczewski *et al.*, 1987; Szczepanik, 1997).

PALAEOGEOGRAPHICAL POSITION OF THE AREA

Preliminary information on the distribution of acritarch assemblages in various Ordovician sections suggested a diversity of microfloras characteristic of two palaeogeographical provinces (Vavrdová, 1974). These two provinces are the Baltic Province with a strong dominance of Acanthomorphitae taxa, and the Mediterranean Province where diacrodal Diacromorphitae forms are predominant. The Baltic Province comprises Scandinavian, north German and presumably British acritarchs. The Mediterranean microfloral assemblages have been recognized in Belgium, France, Spain, Czech Republic, south Germany, Balkans and north Africa. Later papers mostly maintained this idea of palaeobiogeographical diversity. Subsequently, there was refinement of the extent of these provinces (Servais and Katzung, 1993; Servais, 1995). The discovery of peri-Gondwanan acritarchs by Servais (Servais and Katzung, 1993) in Rügen (an area very similar to the West Pomeranian Caledonides in terms of its geological structure) was very important for the determination of the palaeogeographical position of the West Pomeranian Caledonides. These acritarchs came from near the Tremadoc/Arenig transition.

The palynological material discussed in this paper contains forms characteristic of the vast Baltoscandia areas (Kjellström, 1971, 1976; Górka, 1979, 1980, 1987; Tynni, 1982), the Holy Cross Mts. (Jagielska, 1962; Górka, 1969; Szczepanik, 1996), Great Britain (Turner, 1984) and North America (Jacobson, 1978).

Baltisphaeridium and *Ordovicidium* taxa, cited and illustrated by Jachowicz (in Buła and Jachowicz, 1996), also show certain similarities to the forms from West Pomerania. The Llandeilo-Caradoc microflora exhibits no differences between the East European Craton and the Pomeranian Caledonides area. This probably results from the unification of Upper Ordovician acritarch assemblages then throughout most of Europe. Some authors (Turner, 1984; Katzung *et al.*, 1995) think that a partial closure of the Tornquist Sea (separating Baltica from "peri-Gondwana") by a shift of the East Avalonia block towards Baltica, took place at that time. However, it should be stressed that geographical proximity is not a precondition for the unification of microfloral assemblages. Similar thermal structures of water masses, usually related to geographical palaeolatitude, may be sufficient reason.

Observations relevant to palaeogeographical interpretation include the recognition of a form similar to the peri-Gondwanan genus *Coryphidium* in Llanvirn deposits of the Gdańsk IG 1 borehole (Pl. I, Fig. 7). It is striking that the Ordovician deposits from the Chojnice 5 borehole contain a few forms representing the Lower Ordovician taxa *Acanthodiacrodium*, *Cymatiogalea* and others. These were probably transported from "peri-Gondwana". Such a phenomenon is also observed in Ashgill deposits of the Holy Cross Mts., where similar forms occur in microfloral assemblages of the Kielce region (Szczepanik, 1996). This may indicate how transport direction within the Late Ordovician sedimentary basin of West Pomerania might be ascertained.

ACRITARCHS AS INDICATORS OF PALAEOBATHYMETRY

Acritarchs as indicators of sedimentary environment have not yet been comprehensively studied. The mode of life of microplanktic forms (free floating in water) causes them to be little controlled by bathymetric factors. Therefore, these organisms can be employed for stratigraphical correlation of deposits representing different sedimentary environments. However, some authors note the presence of certain regularities in the distribution of microfloral assemblages in sedimentary basins. A general trend of decreasing diversity of microplankton is observed towards coastal and deep-water zones. Outer shelf assemblages seem to be most diverse and numerous (Jacobson, 1979). Jacobson (1979) suggests that very shallow zones are dominated by sphaeromorph acritarchs lacking crests; deeper zones are characterized by a greater number of "*Peteinosphaeridium*" acritarchs; whereas the "*Baltisphaeridium–Veryhachium–Polygonium*" type dominates in open-marine areas. Such a distribution of assemblages shows that microflora from West Pomerania resembles the open-marine assemblages of "*Baltisphaeridium–Veryhachium–Polygonium*". The "*Peteinosphaeridium*" type seems to dominate in the Peribaltic Syneclise.

CONCLUSIONS

1. Palynological data show that the Ordovician deposits of the Pomeranian Caledonides are Llandeilo-Caradoc in age. Three local biostratigraphical zones can be distinguished within these deposits.

2. The deposits contain a microfloral assemblage showing close similarities to coeval assemblages from the East European Craton, the Holy Cross Mts., Scandinavia, Upper Silesia, Great Britain and other areas.

3. The degree of thermal alteration of Ordovician organic matter in West Pomerania is low and resembles that from the western part of the Peribaltic Syneclise. It indicates that Caledonian orogenic movements were not accompanied by increased heat flow. This phenomenon is identical to that observed in the southern part of the Holy Cross Mts.

4. The microfloral assemblage from the Ordovician deposits of the Pomeranian Caledonides is characteristic of "open-marine" environments and seems to represent zones more distant from the coast than the analogous Ordovician microfloral assemblages from areas located east of the T-T Zone.

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