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TIMING OF THE ONSET OF DEVONIAN SEDIMENTATION IN NORTHWESTERN POLAND: PALYNOLOGICAL EVIDENCE

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Abstract: Palynomorph assemblages of low taxonomic diversity are recorded from the basal Devonian strata in three boreholes in western Pomerania and Kujawy. The palynoflora is assigned to a younger, autochtonous assemblage, and an older, redeposited one. The composition of the younger assemblage suggests lower to middle Eifelian. The older palynomorphs are derived from (1) Upper Ordovician or Lower Silurian, and (2) probably from Upper Silurian deposits.

Key words: Northwestern Poland, Ordovician, Silurian, Devonian, sporomorphs, stratigraphy, redeposition.

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INTRODUCTION

In the Pomerania–Kujawy region, the subsurface Devonian deposits have been found in approximately hundred boreholes situated mainly within the northeastern zone extending to SE of Koszalin, and along the Baltic coast, west of Koszalin (Fig. 1).

Dadlez (1978) was the first to propose an informal lithostratigraphic division of the Devonian strata into basic units of formation rank, which were termed complexes. This author presented also his opinion on the spatial distribution and correlation of the rock bodies. The scheme was subsequently complemented by Miłaczewski (1986). Only for the well dated and well represented Upper Devonian succession the division has been formalized (Matyja, 1993). The lithology, sedimentary structures and sedimentary environment of these deposits has been discussed recently by Matyja (1998). In the Middle Devonian deposits 2 depositional systems have been distinguished: a fluvio-deltaic one in the Jamno region and clastic/carbonate in the nearshore Miastko—Chojnice—Polskie Łąki area (comp. Fig. 1).

The basal Devonian strata concerned in this paper belong to the Jamno, Studnica, and Tuchola lithostratigraphic units. They have not, so far, been formally defined but in this paper they are termed formations for the sake of simplicity.

The clayey carbonate Upper Devonian succession has been recognized in several tens of wells, and it is well dated (see Matyja, 1993) on conodonts, other faunas, and miospores, contrary to the underlying Devonian clastics which are almost devoid of stratigraphically important fauna. These rocks, often coarse-grained and in many cases occurring at considerable depth are also, in many instances, unfavourable for palynological studies. Because of this, the timing of the onset of Devonian sedimentation in the area under discussion has been, so far, a matter of varying opinions. These were based mainly on lithostratigraphic correlations and on comparisons with other regions. Łobanowski (1968) suggested that the basal Devonian strata from the Miastko 1 borehole represented Lower Devonian or Eifelian. In the opinion of Dadlez (1978), the Devonian sedimentation in the marginal part of the basin, close to the Jamno region (Fig. 1) commenced probably in late Siegenian (Pragian). The age of the Studnica Formation, known only from the Miastko 1 borehole, was suggested by Miłaczewski (1979) to be Early Devonian. In subsequent paper (Miłaczewski, 1986), this age was supposed to be either Emsian or Eifelian. In the opinion of Miłaczewski (1979), to the north from Miastko (the Jamno region), the basal Devonian deposits are not older than the Eifelian, whereas in the Chojnice area, they are even younger (Givetian). In a recent paper, Łobanowski (1990, p. 406, tab. 1) suggested that in the Miastko 1 borehole, the lowermost 60 m of the Devonian sequence represent uppermost Silurian and Lower Devonian. This opinion was based on vertebrates (Thelodonti, Acanthodei) recovered from the basal few metres of this sequence. This fauna was found in pebbles (Łobanowski, personal communication, 1995), so it is reasonable to suppose that it had been redeposited. Some biostratigraphic information on the age of the discussed deposits was provided by spore studies

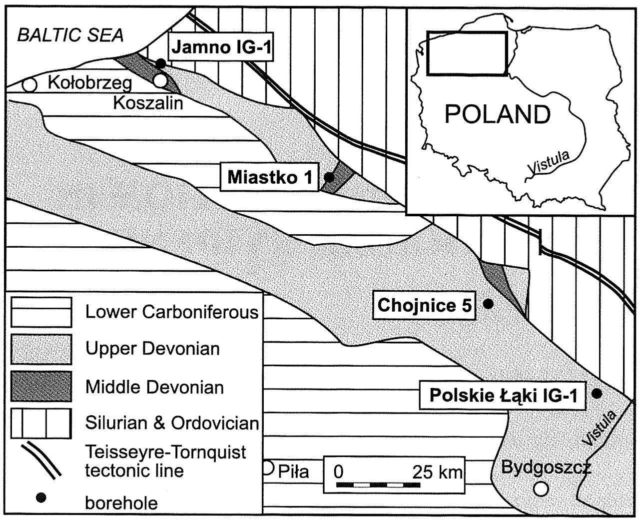

Fig. 1. Location of discussed boreholes against the geological map of pre-Permian deposits in northwestern Poland. Geology after Matyja, 1993, 1998. Insert – position of study area

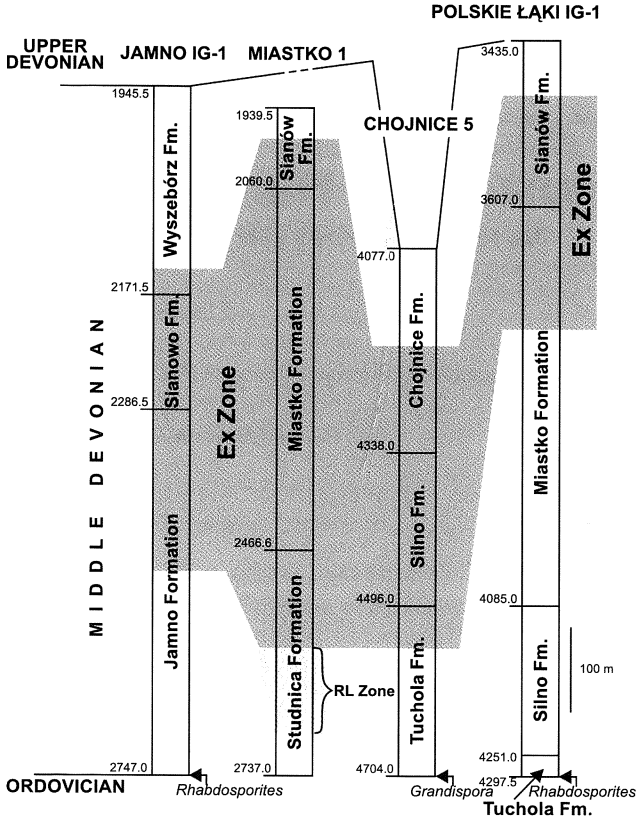

Fig. 2. Age and stratigraphical nomenclature of Middle Devonian formations of boreholes studied. Position of Eifelian miospore assemblages with *Rhabdosporites* and *Grandispora* is shown as well as previously established (Turnau, 1995, 1996) position of Eifelian RL and Givetian Ex Miospore zones (shaded areas)

(Fuglewicz & Prejbisz, 1981; Turnau, 1995, 1996). The Studnica Formation was included in the Eifelian and Givetian, and the Jamno and Tuchola formations in the Givetian. But these results did not concern the lowermost strata (cf. Fig. 2) because either the samples processed were barren or cores were not available.

Recently, another attempt has been made to obtain spores from the basal Devonian strata. The results are discussed below. The four wells which have been chosen are those in which the coring of the relevant parts of the Devonian succession is almost complete. Even more important is the fact that in these sections the Ordovician/Devonian contact is within the cored intervals.

LITHOLOGY AND SEDIMENTARY ENVIRONMENT

The subsurface Devonian deposits of the Pomerania–Kujawy region occur below various subsystems of the Permian or Carboniferous, and they rest discordantly on Ordovician (mostly Caradoc) or Silurian strata. The Caledonian substratum has been reached only in twelve boreholes or so.

Deposits of the **Jamno Formation** occur only in the NE part of western Pomerania. They are known, among others, from the Jamno IG-1 borehole where they overlie discordantly Ordovician (Caradoc) deposits. The formation is developed as a sequence of reddish and mottled, less commonly grey clastics. These are alternating units representing either simple sedimentation cycles of fining upwards grain size or reversed, coarsening up cycles. The former consist of light grey, cross-bedded, coarse and medium-grained quartz sandstones containing layers of well rounded but only moderately sorted quartz pebbles. The sandstones of some intervals of this lithofacies are massive and lack noticeable bedding. This lithofacies passes upwards into medium grained sandstones displaying parallel mudstone bands.

Units of coarsening up grain size include fine-grained quartz sandstones laminated levelly and paralelly with black claystones, and grey, very fine-grained quartz sandstones paralelly intercalated with dark grey mudstones. As a whole, the above formation represents fluvial and deltaic environments, and the lowermost interval concerned in this paper has entirely an alluvial origin (Paczeŝna in Matyja *et al.*, 2000).

The **Studnica Formation**, distinguished by Miłaczewski (1986), has been known, so far, only from the Miastko 1 borehole. These deposits rest discordantly on Ordovician strata. They are reddish and pale grey siliciclastic-calcareous and dolomitic sandstones and mudstones as well as claystones. The lower part of the formation contains mainly coarse-grained sandstones displaying large-scale cross bedding. These are overlain by a sequence of fine grained sandstones with small-scale cross bedding and parallel lamination. Anhydrite nodules and layers occur within middle part of the formation, and the presence of linguloids and ostracods in clayey parts of the formation was noted by Lobanowski (1968), while micro- and megaspores are common in mudstones, except for the 60 lowermost part of the formation (Fuglewicz & Prejbisz, 1981; Turnau, 1995).

The basal part of the formation, from which samples have recently been studied, represents sediments of the lower part of the delta plain, and, higher up, those of the delta front (Paczesna in Matyja *et al.*, 2000)

The deposits of the **Tuchola Formation** have been recognized only in the southeastern part of the study area, among others in the Chojnice 5 and Polskie Łąki IG-1 boreholes (Figs 1, 2) where they rest on Ordovician strata. The unit thickness varies from 40 m in the latter borehole to about 200 m in Chojnice 5.

In the Chojnice 5 section the formation is developed as dark grey marls, marly and organodetritic limestones, the latter with abundant coralloids, remnants of echinoderms, vermicular snails and large oncoids. There are also organogenic limestones with massive stromatoporoids. The marly nature of the sediment, presence of characteristic fossils, large oncoids and vermicular snails suggests an inner carbonate ramp environment partly corresponding to a lagoonal one. In the Polskie Łąki borehole, the formation includes black claystones and fine laminated mudstones with laminite intercalations. The assemblage of fossils is rather poor including ostracods and plant detritus. These are sediments of clastic lagoon.

MATERIAL

The examined material was derived from the basal Devonian strata pierced in the Miastko 1, Jamno IG 1, Polskie Łąki IG 1 and Chojnice 5 boreholes (Figs 1, 2). Twenty-one samples were processed using standard laboratory methods but only eight contained determinable palynomorphs. Samples from the Miastko 1 borehole were barren, most of samples from the other three boreholes contained miospore assemblages.

PALYNOSTRATIGRAPHY

Eight samples yielded spores (see Table 1), few acritarchs, scolecodonts and fragmented chitinozoa. The dominant palynological matter found in the slides was unstructured, and occasionally structured plant detritus supposedly representing in part comminuted spores. The spore preservation was variable, large specimens were often fragmented, small specimens were rather well preserved, though those from the Chojnice 5 borehole were of a high maturation level. The representation of the particular forms was poor hence many taxa are in open nomenclature or are determined to the generic level only. Nevertheless, the stratigraphic conclusions based on the new findings are confident, at least those concerning the Polskie Łąki IG-1 and Jamno IG-1 boreholes.

The spore assemblages contain taxa which have contradicting stratigraphic meaning. Small spores and cryptospores represented by tetrads, diads and monads indicate an older age, while species assignable to *Rhabdosporites*, *Camarozonotriletes*, *Diatomozonotriletes* and *Corystisporites* suggest a much younger age. It is obvious that we deal with autochtonous and reworked palynomorphs. Specimens assigned to *Retusotriletes* sp., *Cymbosporites* sp., *Apiculiretusispora* sp. and *Emphanisporites* sp. may belong either to the autochtonous or to the reworked assemblage. As colour

Table 1

Distribution of spore/cryptospore taxa in samples studied

BOREHOLE	Polskie Łąki IG-1					Jamno IG-1	Chojnice 5	
Depth in m	4273-4274	4272-4273	4270-4271	4269-4270	4226-4227	2742-2743	4701-4702	4689.7-4690.7
Emsian/Eifelian taxa								
Apiculiretusispora brandtii			+					
Apiculiretusispora plicata	+	+		+		+		
Camarozonotriletes cf. *sextantii*	+	+						
Rhabdosporites cf. *parvulus*	+			+		+		
Camptozonotriletes sp.	+							
Retusotriletes sp.	+	+	+	+				
Acinosporites cf. *lindlarensis*	+			+	+			
Retusotriletes cf. *rugulatus*			+		+			
Diatomozonotriletes sp.			+					
Grandispora? sp.			+				+	
Retusotriletes triangulatus				+				
Corystisporites sp.						+		
Silurian taxa								
Archaeozonotriletes chulus v. *chulus*	+	+	+	+		+		
Apiculiretusispora sp.	+			+	+			
Laevolancis divellomedium	+		+	+		+	?	
Cymbosporites sp.	+		+	+	+	+		
Emphanisporites sp.	+			+	+			
Chelinohilates sp.			+					
Hispanaediscus? sp.				+				
Ambitisporites dilutus					+			
Tetrahedraletes medinensis					+			+
Nodospora sp.							+	+
Segestrespora sp.							+	+
Smooth diad/pseudodiad							+	+

indices (TAI) do not show differences in thermal maturity level of spores derived from individual samples, the assignement to one or other assemblage has been made arbitrarily based on spore diameter. Silurian spores are in generall small and the spore diameter increases during the Lower Devonian (Chaloner, 1967; Richardson, 1967). It was thus considered that specimens measuring about 30 μm belong rather to the older assemblage.

Autochtonous assemblage

The composition of the autochtonous assemblage is given in Table 1, and the taxa are illustrated in Figure 3. Stratigraphically most important is *Rhabdosporites* cf. *parvulus* Richardson. *Rhabdosporites* is a very distinctive pseudosaccate genus characterized by a very fine and dense sculpture of rods and grana. Spores of this genus, especially *R. langii* (Eisenack) Richardson, are important constituens of spore assemblages of early (but not earliest) and middle Eifelian age (Richardson & McGregor, 1986; Avkhi-

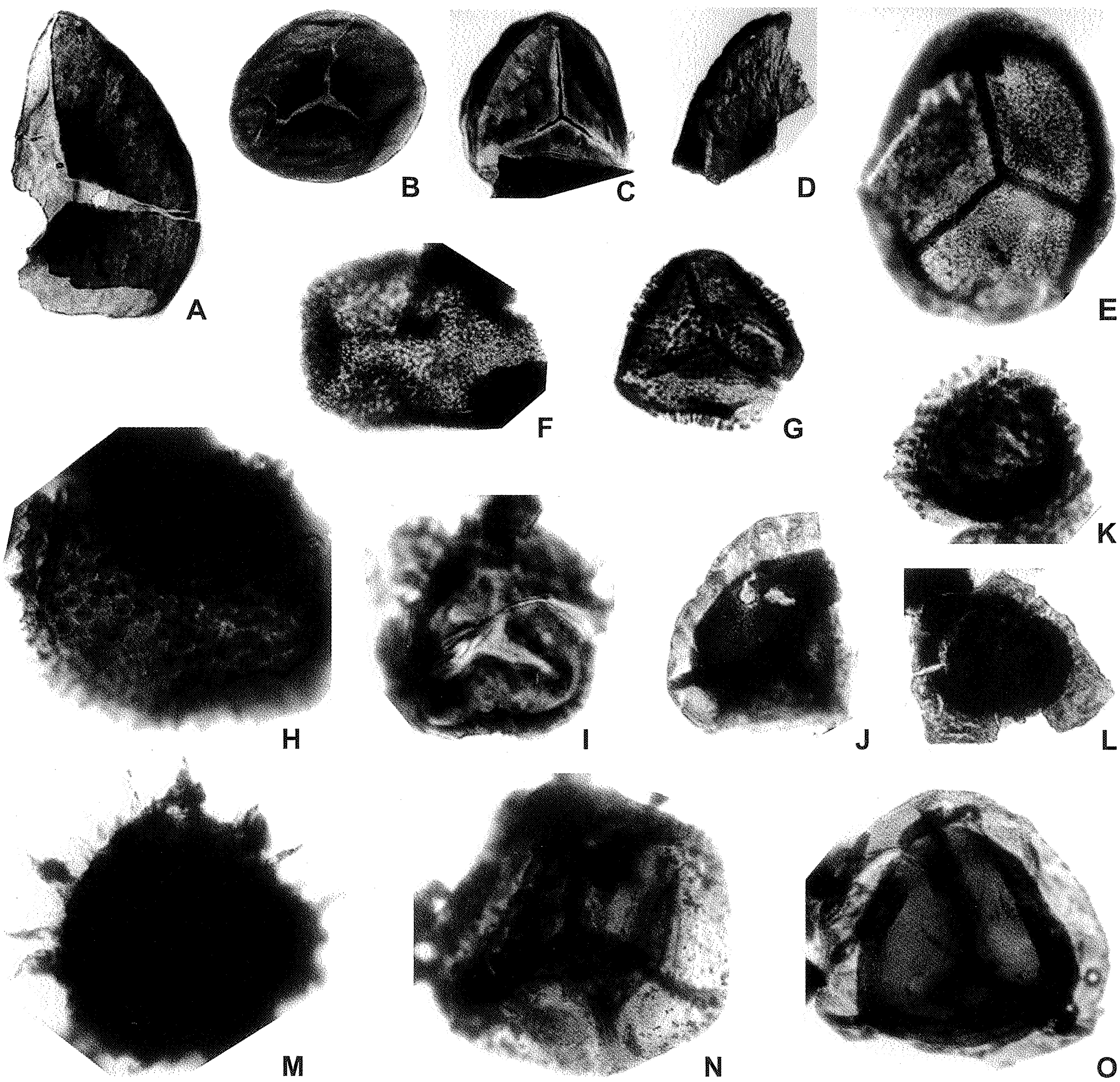

Fig. 3. Eifelian spores. Specimens A, C, D are from Polskie Łąki IG-1, depth 4270–4271 m, slide PZNII/81; specimens B, G, K, ibidem, slide PZNII/79; specimens F, N, M are from Jamno IG-1, depth 2742–2743 m, slide PZN II/6; specimens E, O are from Polskie Łąki IG-1, depth 4269–4270 m, slide PZNI/100; specimen H, ibidem, slide PZNI/99; specimens I, J are from Polskie Łąki IG-1depth 4273–4274 m, slide PZN I/95; specimen L is from Chojnice 5, depth 4701–4702 m, slide PZN II/64. All magnifications × 500 except when stated otherwise; **A-B** – *Retusotriletes triangulatus* (Streel) Streel, **A** – spore fragment; **C** – *Retusotriletes* sp.; **D** – *Retusotriletes rugulatus* Riegel, fragment of proximal face; **E** – *Apiculiretusispora brandtii* Streel; **F** – *Apiculiretusispora plicata* (Allen) Streel; **G** – *Diatomozonotriletes* sp.; **H** – *Acinosporites lindlarensis* Riegel, x 1000; **I** – *Camarozonotriletes* cf. *sextantii* McGregor & Camfield, x 1000; **J, N, O** – *Rhabdosporites* cf. *parvulus* Richardson; **K-L** – *Grandispora*? sp., **M** – *Corystisporites* sp.

movitch *et al.*, 1993). The species *Rhabdosporites parvulus* is known from the Middle Devonian, but it has been also reported from the uppermost Emsian of Canada (McGregor & Camfield, 1976). The earliest record of *Rhabdosporites* is from the Wiltz Beds in the Eifel region, Rheinisches Schiefergebirge. Riegel (1982) reported from these beds the first occurrence of "small *Rhabdosporites*", and Ashraf *et al.* (1991) noted the appearance of *Rhabdosporites minutus* Tiwari & Schaarschmidt in the upper part of this unit corresponding to the *serotinus* Conodont Zone (Weddige & Requadt, 1985). *Rhabdosporites mirus* Arkhangelskaya is typical of assemblages of the latest Emsian *Diaphanospora inassueta* (DI) miospore zone for the central regions of the Russian Platform (Arkhangelskaya, 1985), and was also reported from the DI Zone from Belarus (Obukhovskaya, 1999); the species range extends to the lower Eifelian (Avkhimovitch *et al.*, 1993). Another Emsian record of *Rhabdosporites* is from the Trebotov Limestone, Dalejan (the *serotinus* Conodont Zone), Barrandian region in the Czech Republic (McGregor, 1979). *Rhabdosporites* cf. *parvulus* from our material is quite different from *R. minutus* and *R. mirus*, but is closely comparable to *Rhabdosporites parvulus*, and to *Rhabdosporites* sp. from the Barrandian region (see Section Taxonomic Note).

In the Jamno IG-1 borehole, *R.* cf. *parvulus* was accompanied by *Corystisporites* sp. The oldest specimens assign-

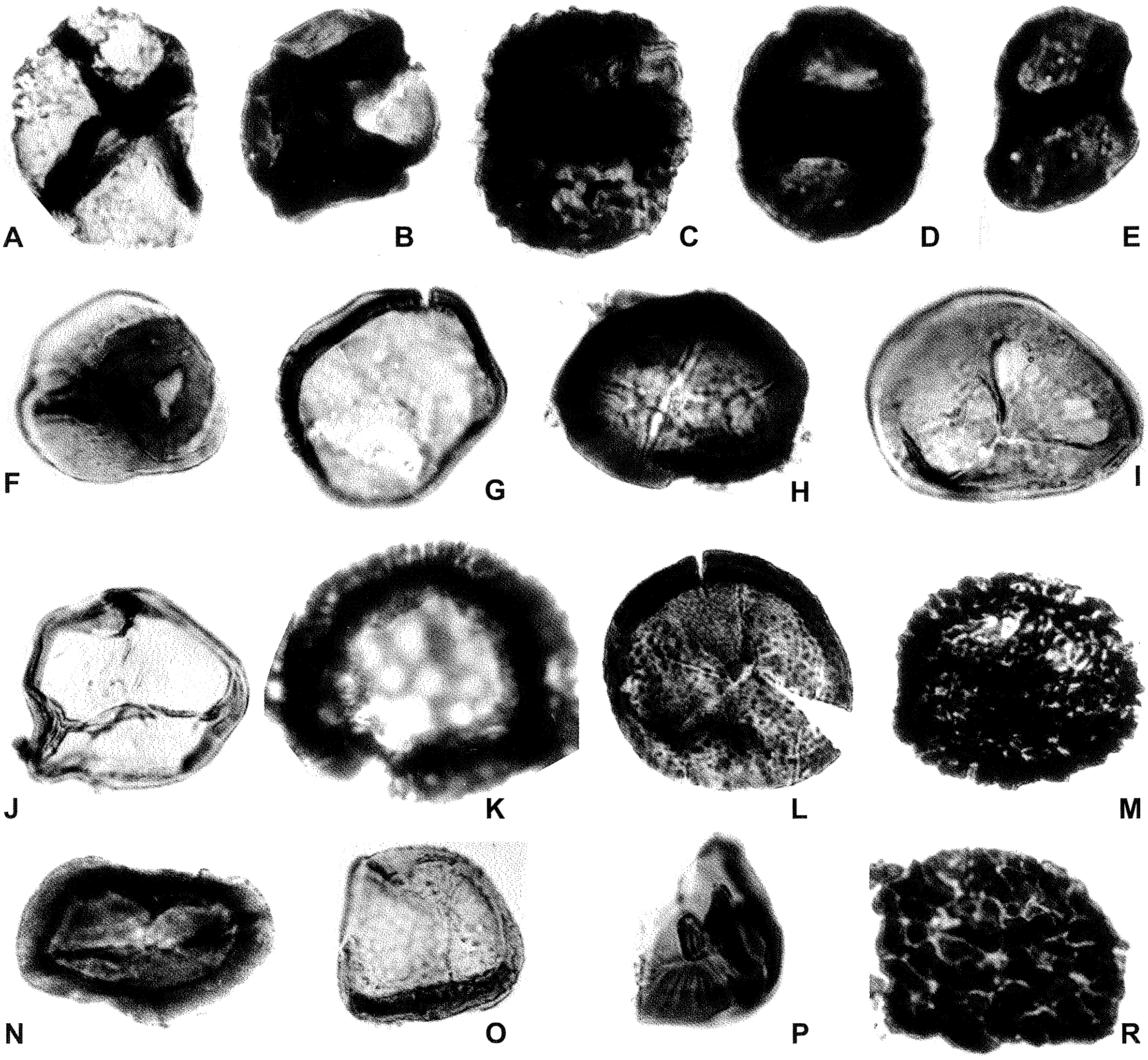

Fig. 4. Silurian or Lochkovian spores. Specimens A, D, E are from Chojnice 5, depth 4701–4702 m, slide PZN II/64; specimens B, C are from Chojnice 5, depth 4689.7–4690.7 m, slide PZN II/61; specimens F, G, I, J, O, P are from Polskie Łąki IG-1, depth 4226–4227 m, slide PZN I/88; specimen H is from Chojnice 5, depth 4701–4702 m, slide PZN II/67; specimens K, R are from Polskie Łąki IG-1, depth 4269–4270 m, slide PZN I/100; specimens L, M are from Polskie Łąki IG-1, depth 4270–4271 m, slide PZN II/81; specimen N, ibidem, slide PZN II/79. All magnifications × 1000: **A** – *Nodospora* sp.; **B, F** – *Tetrahedraletes medinensis* Strother & Traverse; **C** – *Segestrespora* sp.; **D, E** – smooth diad/pseudodiad; **G** – *Laevolancis divellomedium* (Tchibrikova) Burgess & Richardson; **H** – *Laevolancis*? *divellomedium*?; **I** – *Retusotriletes* sp.; **J** – *Ambitisporites dilutus* (Hoffmeister) Richardson et Lister; **K** – undetermined cryptospore; **L** – *Apiculiretusispora* sp.; **M** – *Chelinohilates* sp.; **N** – *Archaeozonotriletes chulus* Cramer; **O** – *Cymbosporites* sp.; **P** – *Emphanisporites* sp., **R** – *Hispanaediscus* sp.

able to this genus have been reported from the upper Emsian Wiltz Beds in the Eifel (Tiwari & Schaarschmidt, 1975).

In the Polskie Łąki IG 1 borehole, *R.* cf. *parvulus* was accompanied by single specimens of *Camarozonotriletes* cf. *sextantii* McGregor & Camfield and *Diatomozonotriletes* sp. The species *C. sextantii* is known from Emsian of Canada (McGregor & Camfield, 1976), Algerian Sahara, Germany and Belgium (see Steemans, 1989), and from the Barrandian region of the Czech Republic (McGregor, 1979). The species is thought to disappear approximately at the top of Emsian (Richardson & McGregor, 1986) but its exact range near the Lower/Middle Devonian boundary has never been traced in a well dated section yielding well preserved and diversified miospore assemblages. Moreover, *C.* cf. *sextantii* from our material may represent *Camarozonotriletes parvus* Owens recorded from the Eifelian and Givetian (McGregor & Camfield, 1982). The species *Apiculiretusispora plicata* Allen, found in the strata under discussion from both Jamno IG-1 and Polskie Łąki IG-1 boreholes is a typical Lower Devonian taxon, but it extends to middle Eifelian (Richardson & McGregor, 1986). Spores of *Diatomozonotriletes* are quite common in the Biya Horizon (uppermost Emsian and lowermost Eifelian) of Bashkirya and western slopes of the Urals (Tchibrikova, 1962), and are found in Middle Devonian of Canada (McGregor & Camfield, 1982) and Belarus (Kedo & Obukhovskaya, 1981).

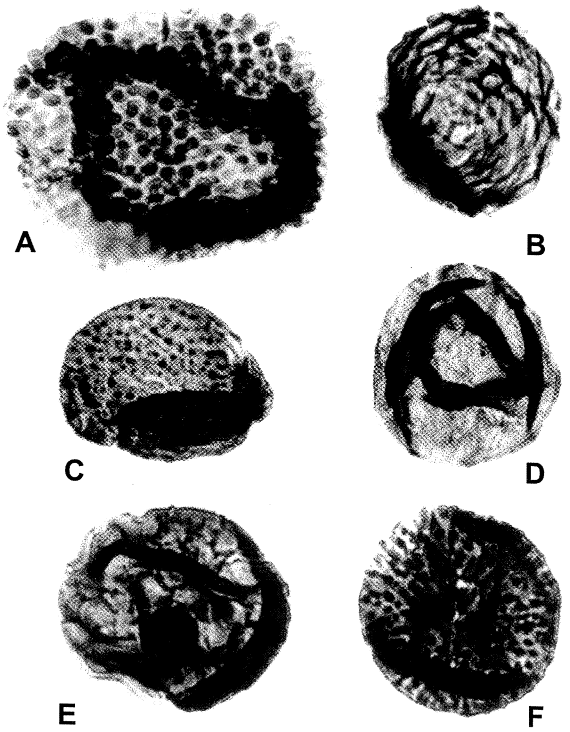

Fig. 5. Silurian acritarchs. All specimens are from Polskie Łąki IG-1 borehole, depth 4270–4271 m, slide PZNII/81. All magnifications × 1000: **A** – *Buedingiisphaeridium* sp.; **B** – *Moyeria cabotti* (Cramer) Miller et Eames; **C** – *Lophosphaeridium* sp.; **D** – *Leiosphaeridia* sp.; **E** – *Dictyotidium dictyotum* Eisenak; **F** – *Gorgonisphaeridium* cf. *bringwoodensis* Dorning

The species *Acinosporites lindlarensis* Riegel appears in uppermost Emsian and extends to the basal Givetian (McGregor & Camfield, 1982; Riegel, 1982), and *Retusotriletes rugulatus* Riegel appears in early (not earliest) Eifelian (Riegel, 1982; Richardson & McGregor, 1986).

It may be thus concluded that the basal Devonian strata from the Polskie Łąki IG 1 and Jamno IG 1 boreholes are not older than the latest Emsian, the *serotinus* Conodont Zone.

In Polskie Łąki IG-1 borehole, a position not below lower Eifelian is indicated by the presence of *Retusotriletes rugulatus* Riegel, but middle Eifelian where spores of the *Rhabdosporites langii* - *R. parvulus* complex are very common can not been ruled out.

Poorly preserved (broken and dark) specimens of pseudosaccate, apiculate spores (*Grandispora*?) were found in the basal strata of the Tuchola Formation from the Chojnice 5 borehole. The presence of spores featuring a spinose zona—pseudosaccus is first noted in Emsian spores (Richardson & McGregor, 1986). Consequently, these strata are not older than Emsian, and they may well be contemporaneous with the basal Devonian deposits from the Polskie Łąki IG-1 and Jamno IG-1 boreholes.

Reworked assemblage

The samples studied yielded also small trilete spores, cryptospores (see Table 1 and Figure 4), and few acritarchs.

Acritarchs occur as single representatives of a few taxa (Fig. 5), of Silurian, Silurian–Devonian or wider ranges.

Cryptospores from the base of the Tuchola Formation in the Chojnice 5 borehole (Tab. 1) may be derived from Upper Ordovician or Lower Silurian rocks which is indicated by the presence of *Segestrespora* sp. (see Burgess, 1991; Wellman, 1996).

The taxa recorded from the basal strata of the Tuchola Formation from Polskie Łąki IG-1 borehole are known to first appear in the Ordovician or Silurian and extend into the Lower Devonian. The presence of *Laevolancis divellomedium* (Tchibrikova) Burgess & Richardson suggests that the assemblages are not older than Wenlock (Richardson, 1996) and the presence of *Emphanisporites* indicates an age not older than Ludlow (Richardson & McGregor, 1986). The species *Tetrahedraletes medinensis* Strother & Traverse emend. Wellman & Richardson is common in Ordovician and Silurian, but has been noted also, though infrequently, from the Lochkovian (Wellman, 1993; Wellman & Richardson, 1996). Thus, the spore/cryptospore data suggest that the reworked palynomorphs are probably derived from Ludlow or Pridoli deposits but Lochkovian strata can not be entirely ruled out. But the composition of the derived acritarch assemblage, which includes *Buedinghiisphaeridium* sp., *Moyeria cabotti* (Cramer) Miller et Eames, and *Gorgonisphaeridium bringewoodensis* Dorning, points to a Silurian age.

The first record of redeposited fossils from the lowermost Devonian deposits in western Pomerania was by Żbikowska (1974) who characterized assemblages of Pridoli ostracods from limestone pebbles derived from the base of the Miastko Formation in the Miastko 1 borehole. This, and the present data show that various Silurian fossils on secondary floor in the lowermost Devonian strata in western Pomerania are not exceptional. It is therefore very likely that the Pridoli–Lochkovian vertebrate fauna reported by Łobanowski (1990) from the Studnica Formation in Miastko 1 borehole section is not autochtonous. It is possible, therefore, that also in this borehole the basal Devonian strata are not older than latest Emsian or early Eifelian. Łobanowski considered these strata as Silurian–Lochkovian transition beds, though the fauna was recovered from pebbles.

CONCLUSIONS

In the Polskie Łąki IG-1 and Jamno IG-1 boreholes, the basal Devonian strata are not older than latest Emsian, and the most likely age is early to middle Eifelian. In Chojnice 5 and Miastko 1 boreholes, these strata are probably of the same age.

The redeposited palynomorphs are derived from Upper Ordovician or Lower Silurian rocks (Chojnice 5 borehole) and probably from higher Silurian strata (Polskie Łąki IG-1 borehole).

The Silurian–Lochkovian vertebrate fauna reported from the Miastko 1 borehole by Łobanowski (1990) is probably also reworked.

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APPENDIX – TAXONOMIC NOTE

Genus *Rhabdosporites* Richardson 1960 emend Marshall et Allen, 1982

Rhabdosporites cf. *parvulus* Richardson 1965

Fig. 3 J, N, O

Description: Cavate, trilete spores. Amb subtriangular, sides convex, apices rounded. Trilete rays obscured by folds extending almost to spore equator. Exoexine detached from intexine distally and in equatorial region forming a bladder. Ratio of intexine to spore radius is 69–79%. Exine ornamented by densely packed, low elements about 1/2 μm in diameter. Distal folds of exoexine present.

Size range: 58–88 μm (5 specimens).

Comparisons: the described specimens are similar to *R. parvulus* Richardson (Richardson, 1965, p. 588-589, pl. 93, figs 5-6) in size and the spore/body ratio but their sparcity and poor preservation do not allow a confident assignment. The species *Rhabdosporites minutus* Tiwari et Schaarschmidt (Tiwari and Schaarschmidt, 1975, p. 39-40, pl. 21, figs 4-6) recorded from the Emsian is smaller (45–57 μm), and has much thicker, rigid exoexine. The species *R. mirus* Arkhangelskaya (Arkhangelskaya, 1985, p. 68, pl. 11, figs 4, 5; pl. XII, fig. 2) known from the uppermost Emsian/lowermost Eifelian is larger, but otherwise similar to the discussed form. A specimen of *Rhabdosporites* was reported (illustrated but not described) by McGregor (1979, pl. 22.3, fig. 87) from the upper Emsian. It appears similar to our specimens in size, spore/body ratio, exine thickness and ornamentation.

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Streszczenie

POCZĄTEK DEWOŃSKIEJ SEDYMENTACJI W PÓŁNOCNO-ZACHODNIEJ POLSCE: PRZESŁANKI PALINOLOGICZNE

Elżbieta Turnau & Hanna Matyja

Wiek klastycznych utworów stanowiących najniższą część sukcesji dewońskiej na Pomorzu zachodnim ma słabą dokumentację biostratygraficzną z powodu ubóstwa skamieniałości, a przyspągowa część tych osadów pozbawiona była do tej pory jakiegokolwiek datowania. Skutkiem tego opinie na temat czasu, w którym nastąpił początek sedymentacji dewońskiej na tym obszarze, wyrażane w ostatnim trzydziestoleciu przez różnych autorów, znacznie się od siebie różniły. Przedmiotem dyskusji były szczególnie obecność lub brak utworów dolnego dewonu.

Badania palinologiczne, których rezultatom poświęcony jest niniejszy artykuł, dotyczyły próbek ze spągowej części formacji tucholskiej z otworów Polskie Łąki IG-1 i Chojnice 5, formacji jamneńskiej z otworu Jamno IG-1 i z formacji studnickiej z otworu Miastko 1 (Fig. 1, 2). Pozytywne wyniki uzyskano z ośmiu próbek pochodzących z trzech otworów wymienionych powyżej w pierwszej kolejności.

Palinomorfy uzyskane z tych próbek można zaliczyć do dwóch różniących się wiekiem zespołów. Zespół młodszy (Tab. 1, Fig. 3) można uznać za autochtoniczny, zespół starszy (Tab. 1, Fig. 4, 5) jest na drugim złożu.

W zespole młodszym z otworów Polskie Łąki IG-1 i Jamno IG-1 napotkano *Rhabdosporites* cf. *parvulus* Richardson, *Acinosporites lindlarensis* Riegel, i *Corystisporites* sp. Formy te nie są znane z utworów starszych od najmłodszego emsu. W próbkach z otworu Polskie Łąki towarzyszą im *Apiculiretusispora plicata* Allen i *Retusotriletes rugulatus* Riegel, z których pierwszy zanika w środkowym eiflu a drugi pojawia się po raz pierwszy w dolnym eiflu. Można zatem twierdzić, że zbadane utwory nie są starsze niż najmłodszy ems a ich najbardziej prawdopodobny wiek to wczesny lub środkowy eifel.

Pojedyncze, słabo zachowane okazy należące prawdopodobnie do rodzaju *Grandispora* (Fig. 3/K) napotkano w jednej z dwóch próbek z otworu Chojnice 5. Spor o takiej morfologii nie notuje się poniżej emsu.

Starszy, redeponowany zespół zawierał małych rozmiarów spory i kryptospory, oraz bardzo nieliczne akritarchy. Kryptospory ze spągu formacji tucholskiej z otworu Chojnice 5 mogą reprezentować górny ordowik lub dolny sylur, o czym świadczy obecność okazów *Segestrespora* sp.

Taksony napotkane w próbkach z otworu Polskie Łąki IG-1 pojawiają się po raz pierwszy w ordowiku lub sylurze. Obecność *Loevolancis divellomedium* (Tchibrikova) Burgess & Richardson sugeruje wiek nie starszy od wenloku a obecność *Emphanisporites* wskazuje na wiek nie starszy od ludlowu. *Tetrahedraletes medinensis* Strother & Traverse jest pospolity w ordowiku i sylurze, rzadziej spotykany jest w lochkowie. Zespol akritarch (Fig. 5), zawierający między innymi *Buedinghiisphaeridium* sp., *Moyeria cabotti* (Cramer) Miller et Eames i *Gorgonisphaeridium bringewoodensis* Dorning sugeruje wiek sylurski.