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Palynostratigraphy of the Mississippian Łobżonka Formation of Western Pomerania (NW Poland)

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Miospore assemblages from the Łobżonka Formation from three boreholes situated in the Laska–Czaplinek zone in Western Pomerania represent the lower part of the *Lycospora pusilla* (Pu) Biozone established for that area. An assemblage from one sample may represent this zone or the preceding *Prolycospora claytonii* (Cl) Biozone. This indicates that the sequences investigated may be attributed to the lower Viséan, and that the lower part of one of these may represent the uppermost Tournaisian. It is suggested that the part of the Łobżonka Formation studied is the lateral equivalent of the lower (but not the lowermost) part of the Drzewiany Formation of the Koszalin–Wierzchowo zone.

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Key words: Pomerania, Tournaisian,Viséan, palynostratigraphy.

INTRODUCTION

In Western Pomerania, the subsurface Mississippian (Lower Carboniferous) deposits occur within two zones separated by an area where these deposits have been eroded and where Devonian rocks are directly overlain by Permian deposits (Fig. 1). The northeastern zone has often been referred to as the Koszalin–Chojnice zone, and here it is called, after Lipiec and Matyja (1998) the Koszalin–Wierzchowo zone. The second area that is situated more to the south-west is called here, after Lipiec and Matyja (*op. cit.*), the Laska–Czaplinek zone.

In the Koszalin–Wierzchowo zone, which has a relatively small extent, the Mississippian deposits have been penetrated in many boreholes. The results of biostratigraphical studies of these strata have been reviewed by Matyja *et al.* (2000). By the contrast, the Mississippian deposits concerned in this paper, of the much larger Laska–Czaplinek zone, have been found, but not completely penetrated, in twelve boreholes only. Their biostratigraphy is incomplete and detailed results of studies on micro- and macrofossils from these deposits have never been published.

The present paper deals with miospore assemblages derived from three boreholes situated in the Laska–Czaplinek zone (Fig. 1). The material was isolated from beds representing the Łobżonka Formation, the lowermost of the four lithostratigraphic units of the Mississippian distinguished in that area. The formation has been considered to belong to the Viséan, and possibly Tournaisian, but few biostratigraphic constraints have been published (see the section Geological setting). Our objective was to establish the stratigraphical position of this formation more precisely than has been done before, and to correlate these deposits with those of the Koszalin–Wierzchowo zone.

GEOLOGICAL SETTING

The Mississippian deposits of the Laska–Czaplinek zone are overlain by Permian, or, locally, by Pennsylvanian strata, and they have not yet been penetrated completely.

The first lithostratigraphic subdivision of the Devonian-Carboniferous succession of Western Pomerania was pro-

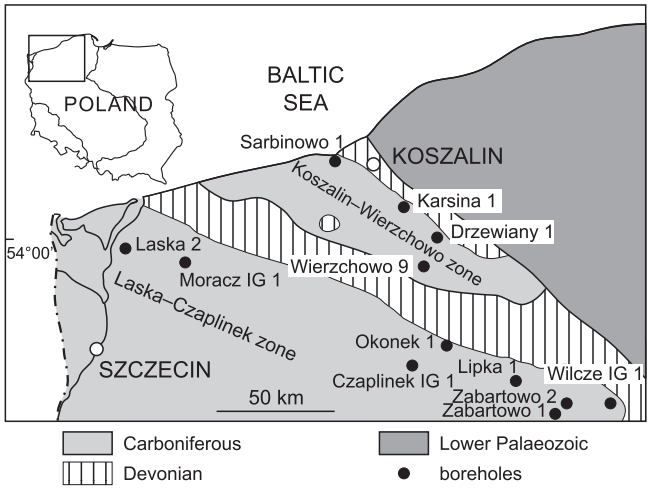
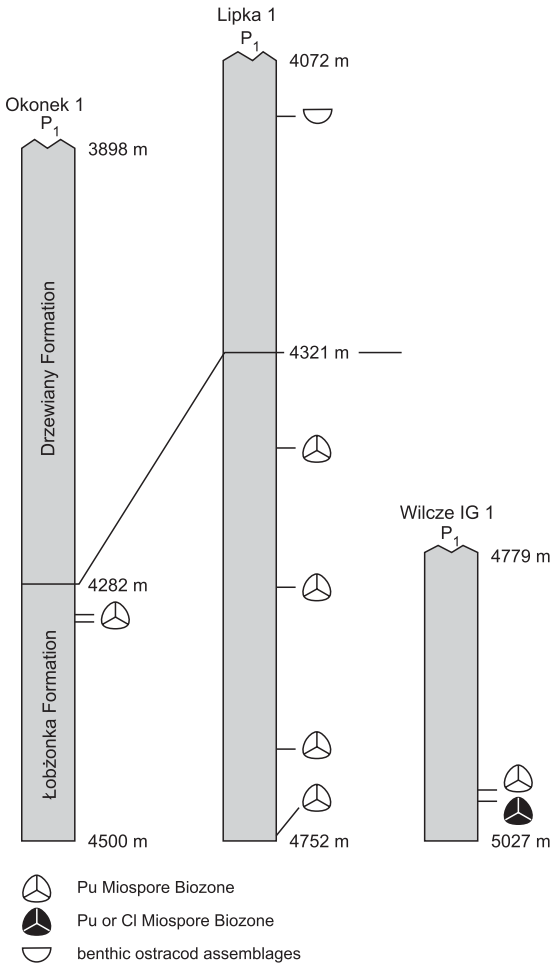


Fig. 1. Geological map of pre-Permian deposits in Western Pomerania showing the location of the boreholes discussed (geology after Matyja, (1993; Lipiec and Matyja, 1998; Matyja *et al*., 2000)



CHRONO-STRATIGRAPHY			MIOSPORE ZONATION BRITISH ISLES		W. POMERANIA	
MISSISSIPPIAN (part)	VISÉAN	BRIGANTIAN	*Bellispores nitidus –Reticulatispores carnosus*	NC	stratigraphic gap	
			Tripartites vetustus –Rotaspora fracta	VF		
		ASBIAN	*Raistrickia nigra –Triquitrites*	NM	*Dictyotriletes pactilis*	Pa
			Perotrilites tessellatus –Schulzospora campyloptera	TC	*Schulzospora campyloptera*	Ca
		HOLKERIAN	*Knoxisporites triradiatus Knoxisporites stephanephorus*	TS	*Lycospora pusilla*	Pu
		ARUNDIAN				
		CHADIAN	*Lycospora pusilla*	Pu		
	TOURNAISIAN	COURCEYAN	*Schopfites claviger Auroraspora macra*	CM	*Prolycospora claytonii*	upper
			Spelaeotriletes pretiosus Raistrickia clavata	PC		Cl
			Spelaeotriletes balteatus Rugospora polyptycha	BP		lower
			Kraeuselisporites hibernicus Umbonatisporites distinctus		*Convolutispora major*	Ma 4 3 2 1
			Vallatisporites vallatus Retusotriletes incohatus	VI	stratigraphic gap	

Fig. 2. Location and biostratigraphy of the palynological samples in the sections studied. The location of the ostracod sample discussed in the text is also shown; table shows the miospore division for the Mississippian in the British Isles and Western Pomerania

P_1 — Lower Permian

posed by Dadlez (1978). Its uppermost Devonian and Carboniferous portion was subsequently modified and supplemented by Żelichowski (1983), and more recently modified and formalized by Lipiec (in Lipiec and Matyja, 1998).

In the Laska–Czaplinek zone, four lithostratigraphical units of the Mississippian have been distinguished. These are, in ascending order: (1) the Łobżonka Formation, (2) the Czaplinek Formation, (3) the Nadrzyce Formation, and (4) the Drzewiany Formation.

The Łobżonka Formation comprises silicified, black claystones, dark grey mudstones and grey or pale grey quartz sandstones, mostly quartz wackes, locally arenites (Lipiec, 1999). In the Czaplinek IG 1 and Zabartowo 1 and 2 boreholes the proportion of sandstones is higher in the upper part of the formation (Żelichowski and Łoszewska, 1987). Carbonates are subordinate, and only occur in some boreholes. Żelichowski and Łoszewska noted the presence of marly intercalations containing sparse foraminifers, brachiopods, goniatites and redeposited ooids. The deposits of the Łobżonka Formation accumulated in basinal to deltaic environments (Lipiec and Matyja, 1998).

The base of the formation is not known. In the area between the Laska 2 and Czaplinek IG 1 boreholes, this unit is overlain by carbonates of the Czaplinek Formation. In the region of Lipka 1 and Okonek 1, it lies beneath the Drzewiany Formation, and in the region of the Zabartowo 1, 2 and Wilcze IG 1 boreholes, the formation is partly eroded, and is overlain directly by Permian strata.

The published information on the biostratigraphy of the Łobżonka Formation is sparse. A Foraminifera assemblage containing *Parathurammina suleimanovi* Lipina, *Endothyra* sp. and *Palaeotextularia* sp. was reported from the lower part of the formation from the Czaplinek IG 1 borehole by Żelichowski and Łoszewska (1987) who suggested assignment to the upper Tournaisian or lower Viséan. Lipiec (1999) recorded Foraminifera belonging to the genus *Tetrataxis* from the lowermost part of the formation and also from the Czaplinek IG 1 borehole. A stratigraphical position not below the upper Ivorian (upper Tournaisian) was suggested by this author. The macrofauna found in the lower part of the formation in the Zabartowo 2 borehole includes chonetid brachiopods, and fragments of ammonoids assignable to *Pericydus* (Żelichowski and Łoszewska, 1987). As in the case of the

Czaplinek IG 1 borehole, an upper Tournaisian and lower Viséan age was suggested for the formation.

The Czaplinek Formation that overlies the Łobżonka Formation in the Czaplinek IG 1 and Moracz 1 boreholes belongs to Viséan; its lower boundary lies within the upper Chadian in the former and in the Arundian in the latter borehole (Lipiec, 1999). This opinion was based on studies of Foraminifera.

No stratigraphically important fauna is known from the Drzewiany Formation in the Laska–Czaplinek zone, with the exception of benthic ostracods and bivalves found near the top of this unit in the Okonek 1 borehole (see Fig. 2). Żbikowska (1995) who determined *Leiopteria* cf. *thompsoni* (Port.), *Glyptopleura ruegensis* Blumenstengel, *Sansabella* sp. 1, *Cavellina* sp. and *Chamishaella* sp. concluded that the fauna is Tournaisian or lower Viséan.

LITHOLOGY AND PREVIOUS BIOSTRATIGRAPHY OF THE SEQUENCES INVESTIGATED

The lithostratigraphy of the strata investigated and the position of palynological samples are shown in Figure 2.

Okonek 1. In this borehole, the Carboniferous succession is 602 m thick. The Łobżonka Formation occurs below the Drzewiany Formation, in the depth interval 4282–4500 m (Lipiec, 1999). It comprises grey claystones, mudstones and fine-grained quartz wackes. Quartz arenites occur at the base of the sequence and mudstones associated with quartz wackes predominate near the top. Ostracods and plant detritus occur throughout the sequence, but no particular taxa have been determined.

Lipka 1. In this borehole, the Carboniferous succession is 680 m thick. The Łobżonka Formation occurs below the Drzewiany Formation in the depth interval 4321–4752 m (Lipiec, 1999). It comprises claystones, mostly variegated in colour, mudstones, and subordinate fine-grained quartz sandstones.

Brachiopods, microfauna and macroplant remnants occur in some places within the sequence, but no species have been determined, except for *Stigmaria undulata* Geoppert found in the depth interval 4402–4416 m. This fossil ranges throughout the Carboniferous (Kuchciński, 1995).

Wilcze IG 1. In this borehole, the Carboniferous deposits penetrated under the Permian are represented by the Łobżonka Formation only. This unit occurs in the depth interval 4779–5027 m. It comprises grey and brownish claystones, grey mudstones and fine-grained, and coarse-grained quartz sandstones. A conglomerate bed including pebbles of sandstone, mudstone and andesite is present near the base of the deposits (Żelichowski *et al*., 1985).

An assignment of these deposits to the lower or middle Viséan was suggested by Jachowicz (1985) while Górecka (1985) implied that they represented the lower Namurian. Both opinions were based on miospore studies.

PALYNOSTRATIGRAPHY

Turnau (1978, 1979) erected a local miospore zonal scheme for the uppermost Devonian and Lower Carboniferous strata of Western Pomerania. Subsequently, the scheme was modified by Avkhimovitch and Turnau (1994) and by Matyja and Stempień-Sałek (1994). The Pomeranian scheme can be correlated at several stratigraphical levels with the zonal scheme for the type regions of the Lower Carboniferous stages in the British Isles. The latter scheme was created by Neves *et al*. (1972, 1973) and later refined by the studies of Clayton (1985) and Higgs *et al*. (1988*a*). The scheme is keyed to the British Isles Carboniferous stages (Higgs *et al*., 1988*b*; Riley, 1993). The local scheme and its correlatives in the British Isles are shown in Figure 2.

The distribution of miospore taxa in the sections investigated is shown in Table 1, and the characteristic assemblage is illustrated in Figure 3. The miospore associations from the Lipka 1 borehole, and from the lower sample from the Wilcze IG 1 borehole show low numbers and diversity due to poor preservation of the spores. Those from Okonek 1 and from the higher sample from Wilcze IG 1 show a higher taxonomic diversity. All assemblages but one include stratigraphically important taxa which allows confident zonal assignment. The most common species are *Anaplanisporites baccatus*, *Colatisporites multisetus* and *Prolycospora claytonii*. They occur in association with *Crassispora trychera*, *Schopfites delicatus* and *S. claviger*. The species *Lycospora pusilla* occurs in most samples (Table 1).

The first appearance of *Lycospora pusilla* defines the base of the *Lycospora pusilla* (Pu) Biozone (in the British Isles and Pomerania). All of the species recorded from the previous zones (the *Schopfites claviger–Auroraspora macra* (CM) Biozone for the British Isles, and the upper *Prolycospora claytonii* (Cl) Subzone for Pomerania) extend up to the Pu Biozone. Therefore, both zones may be distinguished only on the presence or absence of *L. pusilla*. The latter species is very rare near the base of the Pu Biozone, but soon becomes quite common in most samples. Evidence in the British Isles and Falster (Denmark) concerning the age of the base of the Pu Biozone has been discussed by Riley (1993) and by Turnau *et al*. (1997). It appears that this base is clearly close to (slightly below) the Tournaisian/Viséan boundary.

The assemblages from the boreholes discussed can be assigned to the Pu Biozone of Pomerania, except for that from the lower sample from the Wilcze IG 1 borehole (*cf*. Fig. 2, Table 1). This is a very poor assemblage that may represent either the Cl Biozone or the Pu Biozone. In Pomerania, the younger assemblages of the Pu Biozone contain numerous specimens of *Waltzispora planiangulata* (Matyja *et al*., 2000). Therefore, the upper part of the zone can be equated with the *Knoxisporites triradiatus–Knoxisporites stephanephorus* (TS) Biozone of the British Isles (see Fig. 2). The present assemblages do not contain the species just mentioned which suggests that they represent the lower part of the Pu Biozone of Pomerania.

The data discussed above suggest that the part of the Łobżonka Formation penetrated in the three boreholes represents the lower Viséan (Chadian and probably lower Arundian) and possibly also the uppermost Tournaisian. In the assemblages from the Lipka 1 borehole, in spite of the very poor spore preservation, *Lycospora pusilla* is not uncommon (a few specimens per slide in the lowest samples). This suggests that the entire sequence studied from this borehole can be attributed

Fig. 3. Miospore assemblage of the *Lycospora pusilla* (Pu) Biozone from the Laska–Czaplinek zone

a — *Baculatisporites fusticulus*, Wilcze IG 1, depth 4984.80 m, slide I: O 38/2; **b** — *Dictyotriletes membranireticulatus*, Okonek 1, depth 4305.6 m, slide PZIX/62: N 42/1; **c** — *Anaplanisporites baccatus*, Lipka 1, depth 4745.20 m, slide PZIX/82: H 58/2; **d** — *Crassispora trychera*, Okonek 1, depth 4305.60 m, slide PZIX/62: L 36/4; **e** — *Schopfites claviger*, ibidem, slide 63: B 37/2; **f** — *Colatisporites multisetus*, ibidem, slide PZIX/62: F 42/3; **g** — *Verrucosisporites nitidus*, Wilcze IG 1, depth 4984.80 m, slide IV: W 46/3; **h** — *Gorgonispora multiplicabilis*, Okonek 1, depth 4305.60 m, slide PZIX/63: E 33/2; **i**, **j**, **l** — *Lycospora pusilla*: **i** — Wilcze IG 1, depth 4984.80 m, slide IV: J 42/3, **j** — Lipka 1, depth 4411.10 m, slide PZIX/76: J 50/4, **l** — Lipka 1, depth 4745.20 m, slide PZIX/62: L 43/2; **k** — *Auroraspora macra*, Okonek 1, depth 4305.60 m, slide PZIX/62: H 40/4; **m**, **n** — *Prolycospora claytonii*, Lipka 1, depth 4411.10 m, **m** — slide PZIX/76: Y 48/1, **n** — slide PZIX/76: Y 53/2; **o**, **p** — *Auroraspora panda*: **o** — Okonek 1, depth 4305.60 m, slide PZIX/62: K 43/4, **p** — Wilcze IG 1, depth 4984.80 m, slide IV: D 32/4; magn.: **a**, **b**, **d**–**h**, **k**, **o**, **p** × 500; **c**, **i**, **j**, **l**, **m**, **n** × 1250; the palynological slides are housed in the Institute of Geological Sciences, Polish Academy of Sciences, Senacka 1, PL-31-002 Kraków (Okonek 1 and Lipka 1) and in the Polish Geological Institute, Królowej Jadwigi 1, PL-41-200 Sosnowiec

to the Viséan. The presence of *L. pusilla* in all but one sample from Okonek 1 supports the same conclusion. The samples from Wilcze IG 1, where *L. pusilla* is rare or absent, may span the Cl/Pu zonal boundary, which would indicate that the lower part of the sequence from this borehole represents the uppermost Tournaisian. However, here the evidence is not strong, as the assemblage from the lower sample is very poor.

CORRELATION WITH THE KOSZALIN–WIERZCHOWO ZONE

In the Koszalin–Wierzchowo zone, the Pu and Cl biozones have been distinguished within the Drzewiany Formation. The Cl/Pu zonal boundary runs within this for-

Table 1

Distribution of taxa in palynological samples from Wilcze IG 1, Lipka 1 and Okonek 1 boreholes

Borehole	Wilcze IG 1		Lipka 1				Okonek 1				
Depth	4992.15 m	4984.80 m	4745.20 m	4672.20 m	4535.10 m	4411.10 m	4311.30 m	4311.20 m	4311.10 m	4311.00 m	4305.60 m
Miospore Zone	Cl? Pu?	*Lycospora pusilla* (Pu)									
Acanthotriletes persibus Higgs	x	x									
Anaplanisporites baccatus (Hoffmeister, Staplin et Malloy) Smith et Butterworth	x	x	x	x		x	x		x	x	
Apiculiretusispora dominans (Kedo) Turnau	x	x									
Colatisporites multisetus (Luber) Avkhimovitch et Turnau	x	x	x	x		x	x	x	x	x	x
Prolycospora claytonii Turnau	x	x	x	x	x	x	x		x	x	x
Verrucosisporites nitidus Playford	x	x									
Discernisporites micromanifestus (Haquebard) Sabry et Neves	x	x						x		x	x
Lycospora pusilla Somers		x	x	x		x	x		x	x	x
Auroraspora panda Turnau		x	x				x	x	x	x	x
Auroraspora solisorta Hoffmeister, Staplin et Malloy		x					x	x			x
Baculatisporites fusticulus Sullivan		x									
Convolutispora spp.		x	x			x					
Crassispora trychera Neves et Ioannides		x			x			x		x	x
Rugospora minuta Neves et Ioannides		x					x				
Tripartites incisotrilobus (Naumova) Karczewska et Turnau		x									
Rugospora polyptycha Neves et Ioannides		x									
Auroraspora macra Sullivan		x								x	x
Densosporites sp.		x	x							x	
Schopfites claviger Sullivan emend. Higgs, Clayton et Keegan		x								x	x
Bascaudaspora submarginata (Playford) Higgs, Clayton et Keegan		x									
Dictyotriletes sagenoformis Sullivan		x									
Foveosporites parviperforatus Turnau		x									
Gorgonispora convoluta (Butterworth et Spinner) Playford		x									
Grandispora echinata Haquebard		x									
Knoxisporites pristinus Sullivan		x									
Knoxisporites triradiatus Hoffmeister, Staplin et Malloy		x									
Kraeuselisporites cf. *hibernicus* Higgs		x									
Pustulatisporites dolbii Higgs, Clayton et Keegan		x									
Prolycospora rugulosa (Butterworth et Spinner) Turnau			x	x	x						
Gorgonispora multiplicabilis (Kedo) Turnau									x		x
Schopfites delicatus Higgs emend. Higgs, Clayton et Keegan									x	x	x
Dictyotriletes membranireticulatus Bertelsen										x	x

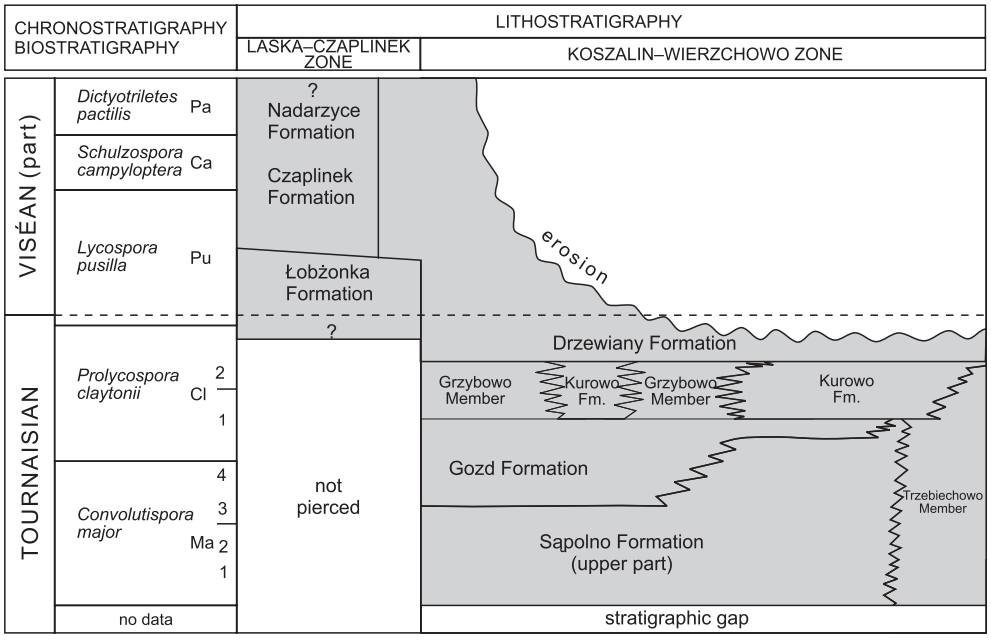


Fig. 4. Biostratigraphical correlation of Mississippian lithostratigraphical units of the Koszalin–Wierzchowo and Laska–Czaplinek zones of Western Pomerania (partly after Matyja *et al.*, 2000)

mation, and the base of this unit corresponds to a stratigraphical level within the upper *Prolycospora claytonii* (Cl 2) Subzone (Avkhimovitch and Turnau, 1994; Matyja *et al*., 2000). In most boreholes, the top of the Drzewiany Formation is erosional, and this boundary is oblique in relation to the spore zones. In the Sarbinowo 1 borehole, the Drzewiany Formation that rests on Caradoc strata belongs to the middle and upper Viséan (the upper Pu, Ca and Pa miospore zones). In the Karsina 1 borehole, the Drzewiany Formation represents the uppermost Tournaisian and lowermost Viséan (Cl 2 and lower part of Pu zones), while in the Wierzchowo 9 and Drzewiany 1 boreholes it belongs to the Tournaisian (Cl 2 zone). Thus, the part of the Łobżonka Formation studied corresponds to a lower, but not the lowest, part of the Drzewiany Formation (Fig. 4). In most boreholes, only this part of the Drzewiany Formation has been removed by erosion.

CONCLUDING REMARKS

This paper provides the first detailed account of miospore assemblages from the Łobżonka Formation in Western Pomerania. Palynological results permit assignment of the deposits studied to Carboniferous series and stages. The presence of the *Lycospora pusilla* (Pu) Biozone (the lower part of this zone distinguished for Western Pomerania) indicates that the strata studied can be ascribed to the lower Viséan-Chadian, and probably the lower Arundian. The miospore assemblage from the lowest sample from the Wilcze IG 1 borehole may represent the top part of the *Prolycospora claytonii* (Cl) Biozone. Thus, this part of the formation may represent the Tournaisian part of the Chadian.

We suggest that the Łobżonka Formation from the sequences studied is the lateral equivalent of a lower (but not the lowermost) part of the Drzewiany Formation from the Koszalin–Wierzchowo zone in Western Pomerania.

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