Geological Quarterly, 2010, **54** (3): 337–356

Complementary data on the palynostratigraphy of the Carboniferous succession of SW Poland

Anna GÓRECKA-NOWAK

Górecka-Nowak A. (2010) – Complementary data on the palynostratigraphy of the Carboniferous succession of SW Poland. Geol. Quart., **54** (3): 337–356. Warszawa.

New palynostratigraphical data concerning the Carboniferous sedimentary succession of SW Poland has been obtained from the Czerńczyce IG 1 borehole and the Brońsko boreholes on the northern slope of the Wolsztyn–Leszno High, where the oldest rocks were expected. The miospore assemblages recovered from the Czerńczyce IG 1 borehole allowed assignment of the interval studied to the Marsdenian (Namurian B) and Yeadonian (Namurian C). These results, supplemented with previous palynostratigraphical data, refute the existence of a stratigraphic gap between the early Namurian and Duckmantian (Westphalian B). The reinterpretation of the unpublished miospore results of Górecka *et al*. (2000*b*, 2001*a*) from the Carboniferous rocks from the Brońsko boreholes, also indicate that they should actually be assigned to the upper Marsdenian and Yeadonian. All analysed miospore assemblages are mixed and contain abundant reworked specimens. The results above complement previous opinions and permit a re-evaluation of the stratigraphy of the Carboniferous siliciclastic succession of SW Poland. Its sedimentation was certainly initiated in the earliest Namurian or earlier and probably lasted without long gaps until the Stephanian. The abundance and common occurence of reworked miospores indicate the age of rocks eroded during Carboniferous deposition. The lithological and palynofacial features of the late Namurian rocks from the Czerńczyce IG 1 borehole may be interpreted as a record of the shallowing of the sedimentary basin, including the possibility that some of the sedimentation occured in continental conditions. This means that the transition from the deep marine environment to shallow-water or even continental habitats likely had already taken place by the late Namurian. This suggestion, together with the tectonic deformation dated as post-Bolsovian, corresponds to the timing of the deposition and deformation in the German part of the Variscan Foreland Basin.

Anna Górecka-Nowak, University of Wrocław, Institute of Geological Sciences, Cybulskiego 30, PL-50-205 Wrocław, Poland, e-mail: anna.gorecka-nowak@ing.uni.wroc.pl *(received: February 02, 2010; accepted: July 08, 2010).*

Key words: Carboniferous, palynostratigraphy, the Variscan Foreland Basin.

INTRODUCTION

The Carboniferous succession of SW Poland, buried under a thick cover of younger rocks of the southern part of the Polish Basin, presents an infill of the Polish part of the European Variscan Foreland Basin (Rheno-Hercynian Zone). The stratigraphy of this succession has been difficult to understand because of the numerous contradictory stratigraphical conclusions previously published, based on macrofaunas and miospore assemblages, as discussed by Górecka-Nowak (2007, 2008, 2009). The results of recent palynological studies enabled a new stratigraphical interpretation to be proposed which takes into account the influence of redeposition indicated by the common occurrence of the reworked fossils and the usually mixed nature of the fossil assemblages. This conclusion is justified by the rejection of previous results based on macrofossils, which are considered as reworked (Górecka-Nowak, 2008, 2009).

Results from the current palynostratigraphical investigations have shown that miospores alone may be useful in solving the stratigraphical problems of this succession (Górecka-Nowak, 2007). The results obtainet indicate the presence of Pendleian to Alportian (Namurian A) and Duckmantian to Asturian (Westphalian B to D) rocks there (Górecka-Nowak, 2008). However, to determine the timing of deposition, certain information was needed (Górecka-Nowak, 2008).

The first yet unsolved question concerns the exact time of the onset of deposition. Wierzchowska-Kicułowa (1984), Żelichowski (1984, 1995) and Parka and Ślusarczyk (1988) had suggested the presence of the Tournaisian and Visean rocks in these Carboniferous succession. Analysis of the biostratigraphic data on which these interpretation had been based, however, (Górecka-Nowak, 2007, 2008, 2009) indicate that there is no reliable biostratigraphical evidence for either the Tournaisian or Visean rocks.

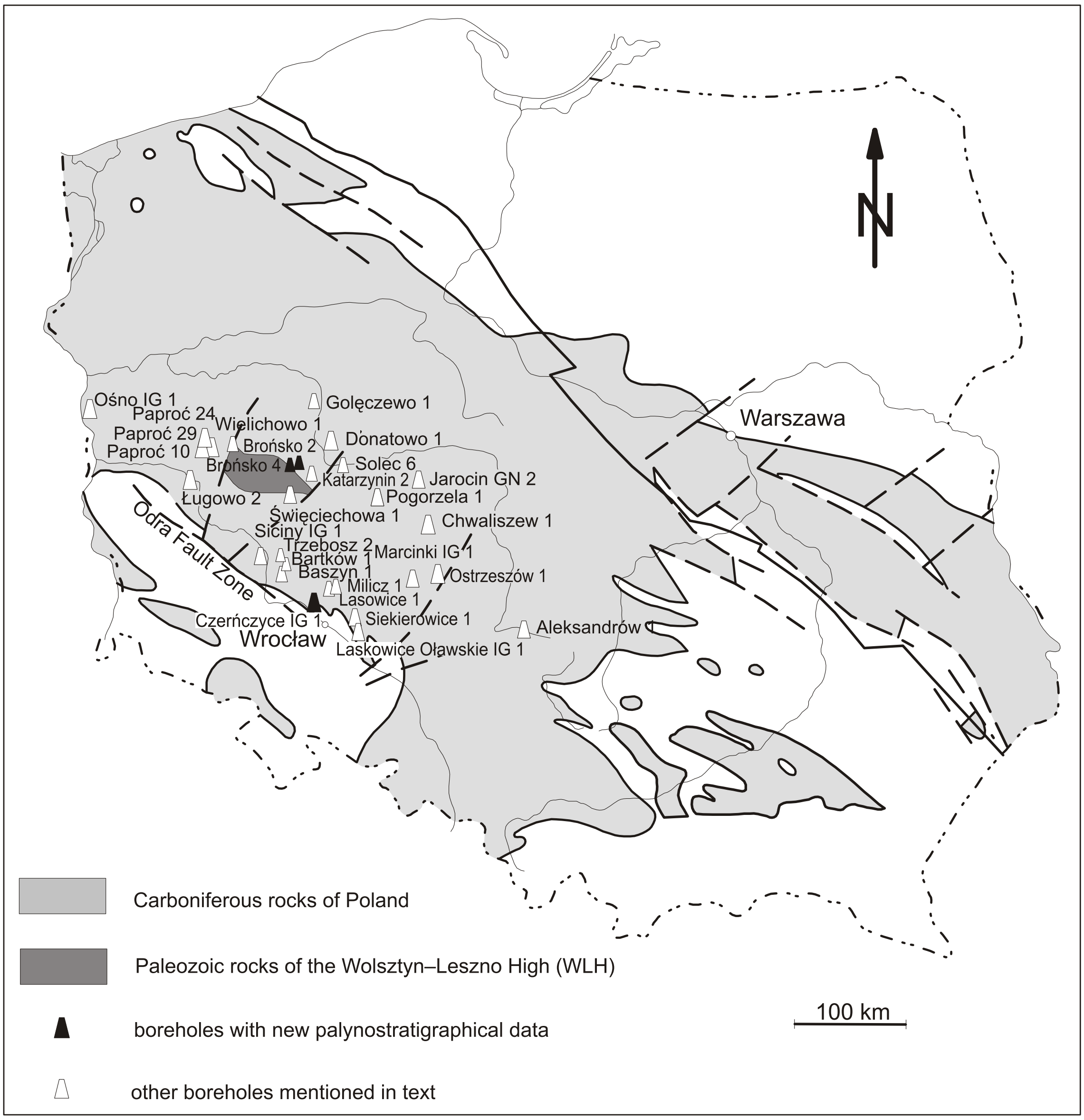

Fig. 1. Map of the Carboniferous rocks in Poland (after Żelichowski, 1984) with location of the boreholes studied and other boreholes mentioned in the text

The determination of the onset of deposition would require the dating of rocks from the basal part of the Carboniferous succession. This is currently impossible because none of the boreholes drilled away from Wolsztyn–Leszno High (WLH), penetrated deep enough. The Carboniferous rocks covering the WLH are relatively thin and their age has been palynologically determined as Carboniferous in general (Święciechowa 1 borehole; Górecka *et al.*, 1977*a*; Parka and Ślusarczyk, 1988) or early Namurian (Wielichowo 1 borehole; Krawczyńska-Grocholska and Grocholski, 1976; Krawczyńska-Grocholska, 1978). These studies did not address the timing of the onset of deposition.

The area where the oldest drilled Carboniferous rocks might occur is the northern slope of the WLH (Fig. 1), where Carboniferous strata are tectonically deformed close to the fault (Mazur *et al.*, 2010). Further investigations of the oldest rocks have focused on this area and some results are given in this paper.

Another stratigraphical problem concerns the possible stratigraphic gap between the two palynologically dated rock sequences in the Carboniferous succession. The existence of a gap between the Alportian and Duckmantian may be tested via current palynostratigraphical studies (Górecka-Nowak, 2008, 2009), previous opinions on the completeness of the Namurian–Westphalian section have been contradictory.

Wierzchowska-Kicułowa (1984) and Parka and Ślusarczyk (1988) suggested that a complete stratigraphic succession from the Tournaisian to Stephanian occurs in the Carboniferous sequence discussed. These interpretations were based on the many palynological dates from the Namurian B and C as well as from the Westphalian A and B deposits (Górecka, 1972, 1991; Górecka *et al.*, 1977*a*, *b*, 1978, 1994; Ślusarczyk, 1980, 1992; Parka and Ślusarczyk, 1988). The richest palynostratigraphical evidence of the late Namurian and the lowermost Westphalian was derived from the Czerńczyce IG 1 borehole, where the Carboniferous age of this succession was established for the first time (Górecka, 1972). The Namurian B and C (depth 1202.0–1165.5 m) and lower Westphalian A (depth 1165.3–1086.5 m) were recognized in this section. These results had been rejected by Żelichowski (1984, 1995) and Kmiecik (2001) who proposed the existence of a gap between the Namurian B and Westphalian B. Bojkowski and Żelichowski (1980) limited the possible stratigraphic gap to the late Westphalian A and Westphalian B.

In order to resolve these contradictory opinions, miospore studies of the Carboniferous rocks from the Czerńczyce IG 1 borehole have been undertaken and correlations proposed with western European reference sections (Clayton *et al*., 1977; Owens *et al*., 2004). The results are presented below, in this, the last part of a series of reports devoted to the stratigraphy of the Carboniferous siliciclastic succession of SW Poland (Górecka-Nowak, 2007, 2008, 2009). It summarizes the results of the current phase of local palynostratigraphical research and dates the important geological events associated with the deposition and deformation of these rocks, which contain a record of the terminal stage of evolution of the Polish part of the European Variscan Foreland Basin.

OBJECTIVES OF THE PALYNOSTRATIGRAPHICAL INVESTIGATION

There are two objectives. The first concerns the Carboniferous rocks from the Czerńczyce IG 1 borehole, which were palynologically studied in order to elucidate the question of the previously inferred stratigraphic gap between the Namurian and Westphalian rocks.

The second objective concerned the Carboniferous rocks of the Brońsko gasfield, located on the northern slope of the WLH (Fig. 1). These are believed to be the oldest penetrated Carboniferous rocks of this succession and so may allow determination of the timimg of the onset of deposition. Detailed palynological data from the unpublished reports of Górecka *et al*. (1999, 2000*b*, 2001*a*, *b*, 2002*a*, *b*, *c*, 2003) appears significant in this context, and has been analysed and stratigraphically reinterpreted.

METHODS

The main purpose of the palynological studies of the Carboniferous deposits from the Czerńczyce IG 1 borehole was stratigraphic interpretation. Additionally palynofacial observations and an assessment of the thermal maturity of the organic matter have been made. Each sample was divided into two parts: one of them was destined for palynostratigraphical studies and another one for palynofacial and thermal maturity observations. Samples for the palynostratigraphical studies were processed in the standard way, using hydrofluoric acid followed by nitric acid and potassium chlorate. The processed sample was cleaned on a 16 μm sieve in an ultrasonic vibrator. Remaining samples for the palynofacies studies were neither oxidized nor sieved.

The assessment of the thermal maturity of the organic matter was made on specimens of *Lycospora*, applying the 7 grades of Batten's scale (1984). The microscopic slides were studied on an *Optiphot* (*Nikon*) microscope and the photomicrographs were taken by a *Cannon Power Shot A 640* digital camera.

In case of the Brońsko boreholes, the palynological data obtained by Górecka *et al*. (1999, 2000*b*, 2001*a*, *b*, 2002*a*, *b*, *c*, 2003) were re-analysed carefully. These reports contain detailed lists of the miospore taxa found in particular samples of each studied section. The recent studies focused on the analysis of the stratigraphic ranges of the miospore taxa listed, which indicated the scope for their reinterpretation.

THE CZERŃCZYCE IG 1 BOREHOLE

The Czerńczyce IG 1 borehole was drilled 15 km NWW from Wrocław, near the Odra Fault Zone (Fig. 1). The Carboniferous rocks, buried under a thick cover of Cenozoic, Mesozoic and Permian rocks, were drilled at a depth of 1088.3–1200.0 m (Fig. 2A).

The Carboniferous section is lithologically bipartite. Its upper part consists of grey conglomerates with sandstone intercalations and its lower part comprises mainly grey sandstones with intercalations of dark grey mudstones. Coal laminae and smudges occur in its lower, fine-grained part. The mudstones and fine-grained sandstones from the entire Carboniferous section were palynologically studied (Fig. 2B).

RESULTS

The miospore assemblages recovered from the samples studied were taxonomically diverse and most of the miospore taxa are listed in Appendix A. Photomicrographs of selected specimens are shown in Figures 3–5.

The miospore preservation is usually good. Many specimens have a fuzzy sculpture, probably caused by the partial gelification of the miospore exines. Colours of *Lycospora* specimens are yellow-orange, orange and orange-brown and their thermal maturity index ranges from 2/3 up to 3/4. It should be noted that abundant, much darker specimens were also recognized among other miospore genera.

Abundant and diverse palynological material, beside miospores, occur in the rocks studied. The main components are black and brown phytoclasts of rectangular, polygonal or oval outline. Cuticules and other fragments of the plant tissues are common. In most samples, small amounts of the amorphous organic matter were found and in some the amorphous matter was more abundant. The miospores are numerous and they are the only group of palynomorphs recorded.

INTERPRETATION

The composition of the miospore assemblage indicates its mixed nature. The youngest miospores consist of taxa which indicate the age of the studied rocks and all older taxa are considered as reworked (Appendix A).

One miospore association of stratigraphic significance consists of *Crassispora kosankei*, *Stenozonotriletes triangulus*, *Apiculatisporis variocorneus*, *Camptotriletes superbus* and *Kraeuselisporites ornatus*. All of these are typically Namurian.

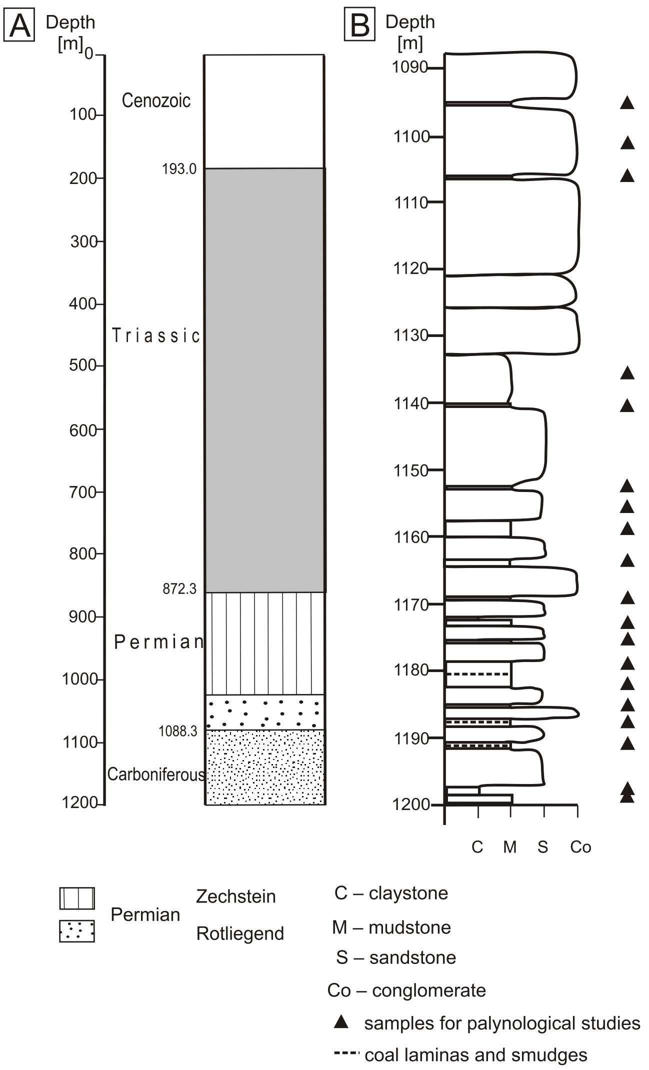

Fig. 2. The Czerńczyce IG 1 borehole

A – geological section, **B** – section of the Carboniferous rocks

The occurrence of *Grumosisporites varioreticulatus* and *Raistrickia fulva*, which were recorded throughout the entire section, indicate that the enclosing deposits are not older than Kinderscoutian (Namurian B), as both these species appear in the upper part of the *Crassispora kosankei–Grumosisporites varioreticulatus* (KV) miospore Biozone. The presence of *Reticulatisporites reticulatus*, which was recorded in the upper part of the section to a depth of 1175.0 m, is very important as it appears at the base of the *Raistrickia fulva–Reticulatisporites reticulatus* (FR) miospore Biozone (Fig. 6). The presence of *Dictyotriletes bireticulatus*, found at a depth of 1170–1176 m by Górecka (1972), confirms that this interval belongs to the upper part of the FR miospore Biozone, corresponding to the Yeadonian (Owens *et al*., 2004). The data above indicate that the lower part of the section, below a depth of 1175 m, should be assigned to the Marsdenian (Namurian B) and its upper part to the Yeadonian (Namurian C). It means that the boundary between the Marsdenian and Yeadonian is located in the lower, sandstone part of the section and entire upper, coarser-grained part should be assigned to the Yeadonian. It is important to note, though, that the miospore assemblage recognized from the Czerńczyce IG 1 borehole does not contain miospore taxa which according to the present palynostratigraphical criteria (Clayton *et al*., 1977; Owens *et al*., 2004) might indicate that the rocks studied belong to the Langsettian (Westphalian A).

All miospore taxa occurring in this assemblage that are older than the FR Biozone, are considered as reworked (Appendix A). Their stratigraphical ranges vary, but they are not older than Famennian. The analysis of their stratigraphical ranges indicate that there are quite numerous late Famennian–Tournaisian taxa: *Auroraspora macra*, *Grandispora echinata*, *Kraeuselisporites hibernicus*, *K. mitratus*, *Lophozonotriletes triangulatus*, *Perotrilites perinatus*, *Prolycospora claytonii*, *Retusotriletes* spp., *Rugospora polyptycha* and *Vallatisporites microspinosus.* Another abundant group of reworked miospores represents typical late Visean–Serpukhovian species including: *Kraeuselisporites echinatus*, *Rugospora* cf. *corporata*, *Verrucosisporites baccatus*, *V. morulatus*, *Raistrickia nigra*, *Microreticulatisporites concavus*, *Dictyotriletes pactilis, D. vitilis*, *Ahrensisporites duplicatus*, *Tripartites distinctus*, *Triquitrites marginatus*, *Potoniespores delicatus*, *Reticulatisporites carnosus*, *Crassispora aculeata*, *C. maculosa*, *Cingulizonates capistratus*, *Grandispora spinosa* and *Schulzospora campyloptera*. The occurrence of these miospores indicates that upper Famennian–Tournaisian and upper Visean–Serpukhovian rocks were eroded during the Marsdenian and Yeadonian. Beside these two groups, miospores of intermediate age and taxa known from the Tournaisian and Visean have also been recognized, for example *Spinozonotriletes uncatus* and S*tenozonotriletes stenozonalis*. Some of the reworked miospores have poorly known stratigraphical ranges. The presence of these taxa, which do not belong to either of the two recognized associations of reworked miospores, indicate a varied stratigraphy for the uppermost Devonian and Carboniferous source rocks.

The colours of the *Lycospora* specimens indicate that the organic matter represents the immature, transitional and early mature stages of thermal maturity. This relatively low thermal alteration is reflected in the diverse composition of the palynological material. The composition of the palynological material reveals domination by humic matter, although small amounts of amorphous organic matter also occur in most samples.

THE BROŃSKO BOREHOLES

The Carboniferous rocks from 10 boreholes located on the Brońsko gas field (the northern slope of the WLH; Fig. 1) have been studied palynostratigraphically by Górecka *et al*., (1999, 2000*b*, 2001*a*, *b*, 2002*a*, *b*, *c*, 2003), who assigned them to the Tournaisian, undivided Visean–Namurian and Namurian. The most interesting results came from the Brońsko 2 and Brońsko 4 boreholes, where the Carboniferous rocks penetrated are about 50 m-thick. The miospore assemblages here are quite diverse and contained some stratigraphically important taxa. The list of recognized miospore taxa (Górecka *et al*., 2000*b*, 2001*a*) is shown in Appendix B.

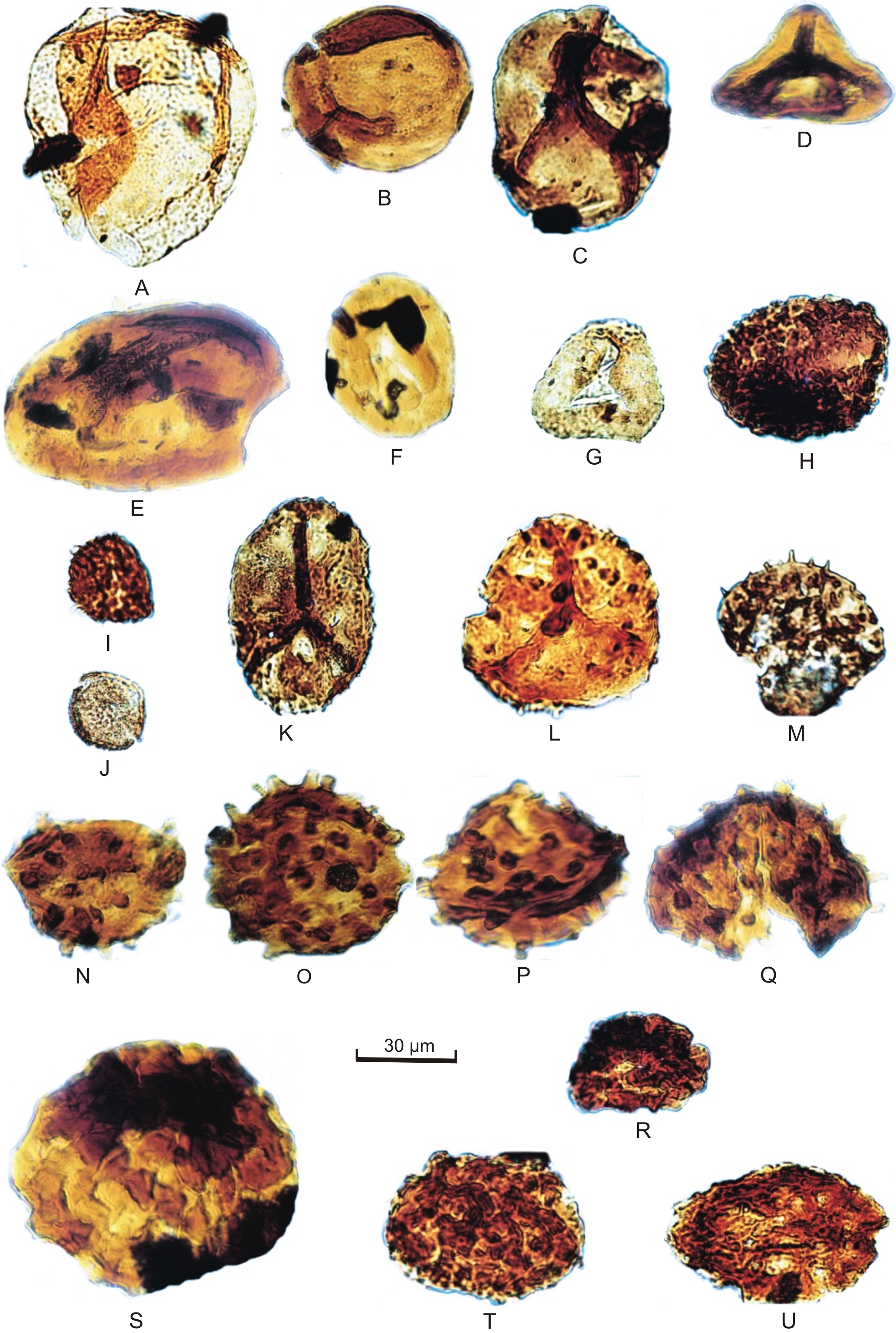

Fig. 3. Miospores from the Carboniferous rocks of the Czerńczyce IG 1 borehole

A – *Calamospora microrugosa*, depth 1190.8 m, sample C 6, slide 1, X 42; **B** – *Calamospora mutabilis*, depth 1190.8 m, sample C 6, slide 1, K 33; **C** – *Calamospora breviradiata*, depth 1129.2 m, sample C 2, slide 1, D27, 2; **D** – *Leiotrilietes tumidus*, depth 1175.5 m, sample C 19, slide 1, K 46, 3; **E** – *Punctatisporites sinuatus*, depth 1179.0 m, sample C 4, slide 1, Y 41; **F** – *Retusotriletes communis*, depth 1179.0 m, sample C 4, slide 2, J 24, 3/4, (r); **G** – *Granulatisporites microgranifer*, depth 1173.3 m, sample C 18, slide 1, L 50, 2; **H** – *Verrucosisporites morulatus*, depth 1136.0 m, sample C 10, slide 1, X 41, 4, (r); **I** – *Acanthotriletes castanea*, depth 1140.5 m, sample C 11, slide 1, S 34, 1; **J** – *Anaplanisporites baccatus*, depth 1136.0 m, sample C 10, slide 1, Y 49, 3; **K** – *Anapiculatisporites* cf. *keikkukensis*, depth 1136.0 m, sample C 10, slide 1, M 61, 1, (r); **L** – *Pustulatisporites pustulatus*, depth 1136.0 m, sample C 10, slide 1, X 33, 3; **M** – *Apiculatisporis variocorneus*, depth 1140.5 m, sample C 11, slide 1, N 22, 1; **N** – *Raistrickia fulva*, depth 1179.0 m, sample C 4, slide 2, T 44, 3; **O** – *Raistrickia fulva*, depth 1197.8 m, sample C 6, slide 1, c6 – J 30, 4; **P** – *Raistrickia fulva*, depth 1179.0 m, sample C 4, slide 2, T 24, 3; **Q** – *Raistrickia fulva*, depth 1136.0 m, sample C 10, slide 1, Q 53, 1/3; **R** – *Secarisporites remotus*, depth 1106.3 m, sample C 9, slide 1,T 2, 2; **S** – *Camptotriletes superbus*, depth 1106.3 m, sample C 9, slide 1, M 27, 1; **T** – *Convolutispora tesselata*, depth 1179.0 m, sample C 4, slide 1, D 21, 1/2 ; **U** – *Convolutispora varicosa*, depth 1106.3 m, sample C 9, slide 1, R 49, 4; (r) – reworked miospore

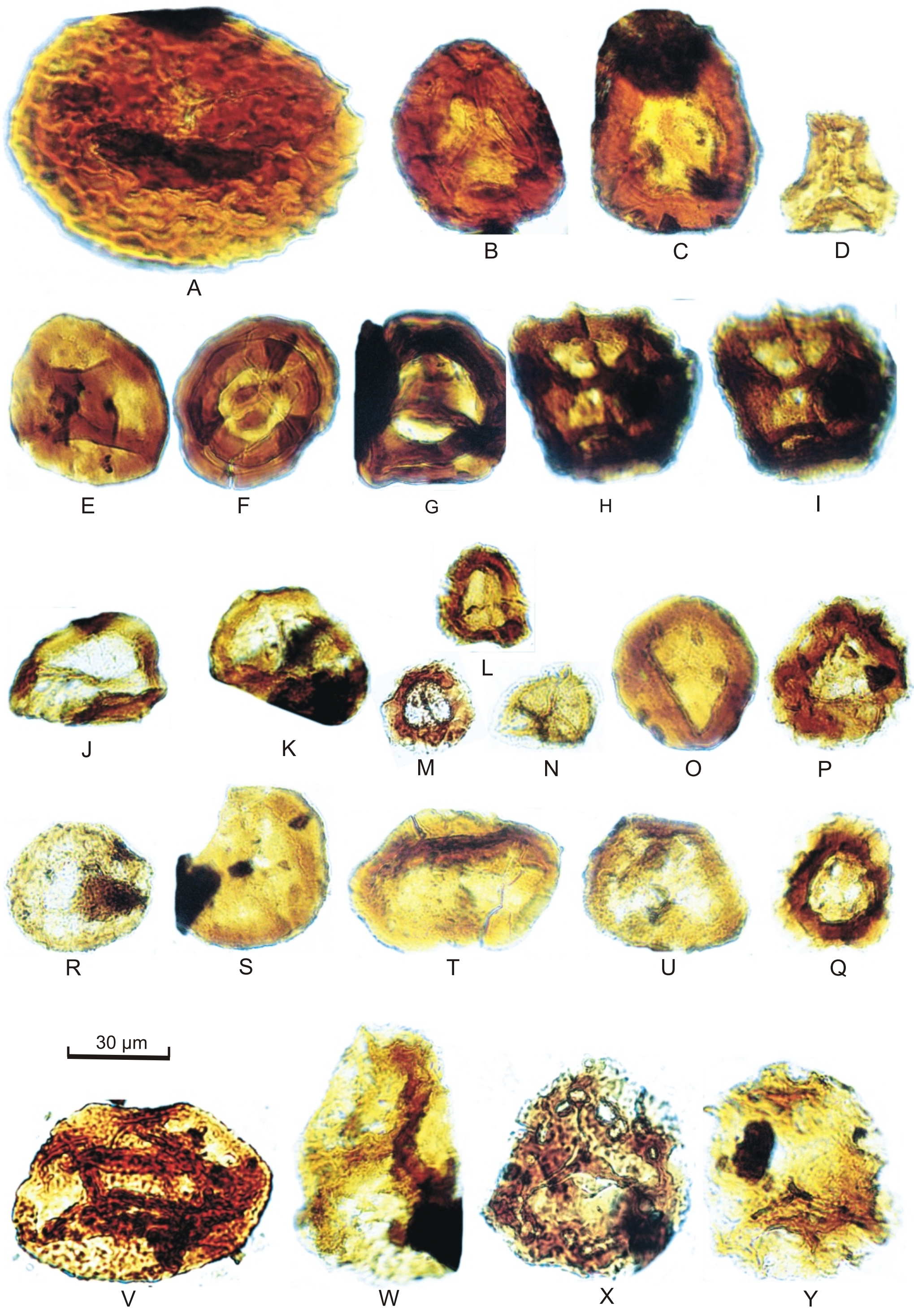

Fig. 4. Miospores from the Carboniferous rocks of the Czerńczyce IG 1 borehole

A – *Grumosisporites varioreticulatus*, depth 1146.6 m, sample C 12, Q 24, 4; **B** – *Murospora dupla*, depth 1175.5 m, sample C 19, slide 1, D 58, 1, (r); **C** – *Murospora aurita*, depth 1173.3 m, sample C 18, slide 1, W 14, (r); **D** – *Ahrensisporites guerickei*, depth 1187.6 m, sample C 5, slide 1, Q 50, 1; **E** – *Knoxisporites hageni*, depth 1197.0 m, sample C 6, slide 1, B 48, 1/2, (r); **F** – *Knoxisporites stephanophorus*, depth 1197.0 m, sample C 6, slide 1, S 40, 3; **G** – *Reticulatisporites carnosus*, depth 1175.5 m, sample C 19, slide 1, Q 40, 4, (r); **H** – *Reticulatisporites reticulatus*, depth 1175.5 m, sample C 19, slide 1, N 14,4; **I** – *Reticulatisporites reticulatus* (the same as H), depth 1175.5 m, sample C 19, slide 1, N 14, 4; **J** – *Stenozonotriletes triangulus*, depth 1190.8 m, sample C 6, slide 1, V 25, 3; **K** – *Stenozonotriletes triangulus*, depth 1190.8 m, sample C 6, slide 1, E 6; **L** – *Densosporites parvus*, depth 1136.0 m, sample C 10, slide 1, D 20, 1; **M** – *Densosporites sphaerotriangularis*, depth 1106.3 m, sample C 9, Q 17, 2; **N** – *Lycospora pusilla*, depth 1179.0 m, sample C 4, slide 1, P 33, 1; **O** – *Tholisporites scoticus*, depth 1197.0 m, sample C 6, slide 1, G 41, 4; **P** – *Cingulizonates bialatus*, depth 1179.0 m, sample C 4, slide 1, E 19, 2; **Q** – *Cingulizonates bialatus*, depth 1106.3 m, sample C 6, slide 1, B 42, 3/4; **R** – *Crassispora kosankei*, depth 1136.0 m, sample C 10, slide 1, Q 57, 2; **S** – *Crassispora kosankei*, depth 1190.8 m, sample C 6, slide 1, C 5, 3/ D 5, 1; **T** – *Crassispora kosankei*, depth 1106.3 m, sample C 9, slide 1, E 62, 2/4; **U** – *Crassispora kosankei*, depth 1187.6 m, sample C 5, slide 1, W 34, 1/3; **V** – *Crassispora maculosa*, depth 1187.6 m, sample C 5, slide 1, F 34, 2; **W** – *Kraeuselisporites ornatus*, depth 1106.3 m, sample C 9, slide 1, K 51, 1; **X** – *Kraeuselisporites ornatus*, depth 1106.3 m, sample C 9, slide 1, K 56, 1/2; **Y** – *Kraeuselisporites ornatus*, depth 1106.3 m, sample C 9, slide 1, U 54, 3; (r) – reworked miospore

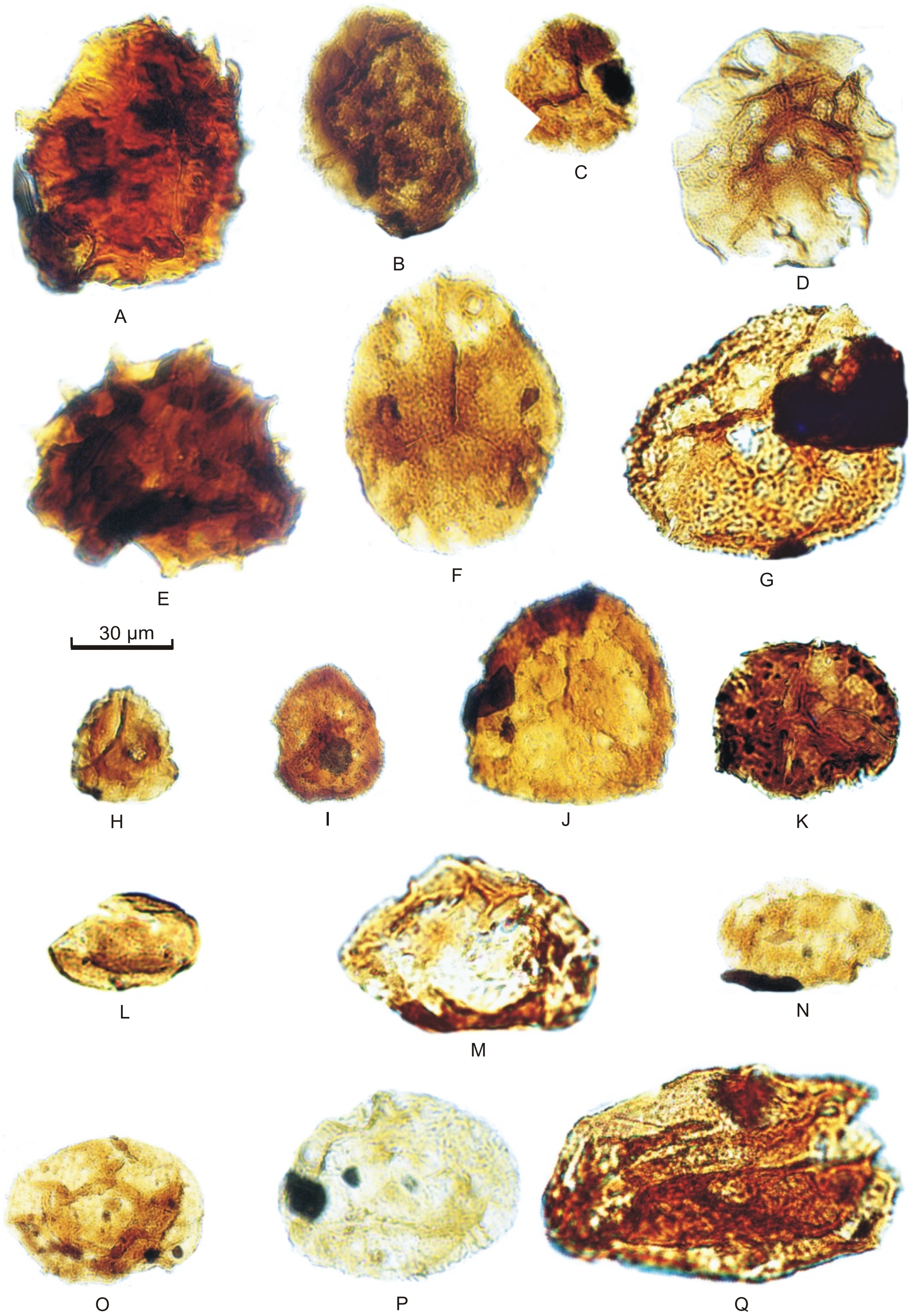

Fig. 5. Miospores from the Carboniferous rocks of the Czerńczyce IG 1 borehole

A – *Kraeuselisporites echinatus*, depth 1146.6 m, sample C 12, slide 1, Q 33, 1, (r); **B** – *Kraeuselisporites hibernicus*, depth 1197.0 m, sample C 6, slide 1, J 29, 4, (r); **C** – *Vallatisporites microspinosus*, depth 1190.8 m, sample C 5, slide 1, L 44, 2/ L 45, 1, (r); **D** – *Discernisporites* sp., depth 1106.3 m, sample C 10, slide 1, E 44, 2; **E** – *Spinozonotriletes uncatus,* depth 1136.0 m, sample C 10, slide 1, X 14, 1, (r); **F** – *Spelaeotriletes arenaceus*, depth 1179.0 m, sample C 4, slide 2, S 33, 1; **G** – *Spelaeotriletes triangulus*, depth 1106.3 m, sample C 9, slide 1, X 64, 3; **H** – *Auroraspora macra*, depth 1136.0 m, sample C 10, slide 1, T 37, 1, (r); **I** – *Grandispora distincta*, depth 1106.3 m, sample C 9, slide 2, H 35, 4; **J** – *Grandispora* cf. *lupata*, depth 1106.3 m, sample C 9, slide 1, N 42, 1/2, (r); **K** – *Grandispora* sp., depth 1106.3 m, sample C 9, slide 2, J 31, 3; **L** – *Laevigatosporites vulgaris*, depth 1190.8 m, sample C 6, slide 1, N 42, 2; **M** – *Schulzospora rara*, depth 1179.0 m, sample C 4, slide 1, S 44; **N** – *Schulzospora plicata*, depth 1187.6 m, sample C 5, slide 1, C 44, 4; **O** – *Florinites mediapudens*, depth 1179.0 m, sample C 4, slide 1, J 32; **P** – *Florinites pumicosus*, depth 1187.6 m, sample C 5, slide 1, B 33, 4; **Q** – *Schopfipollenites* sp., depth 1106.3 m, sample C 9, slide 1, Y 49, 3; (r) – reworked miospore

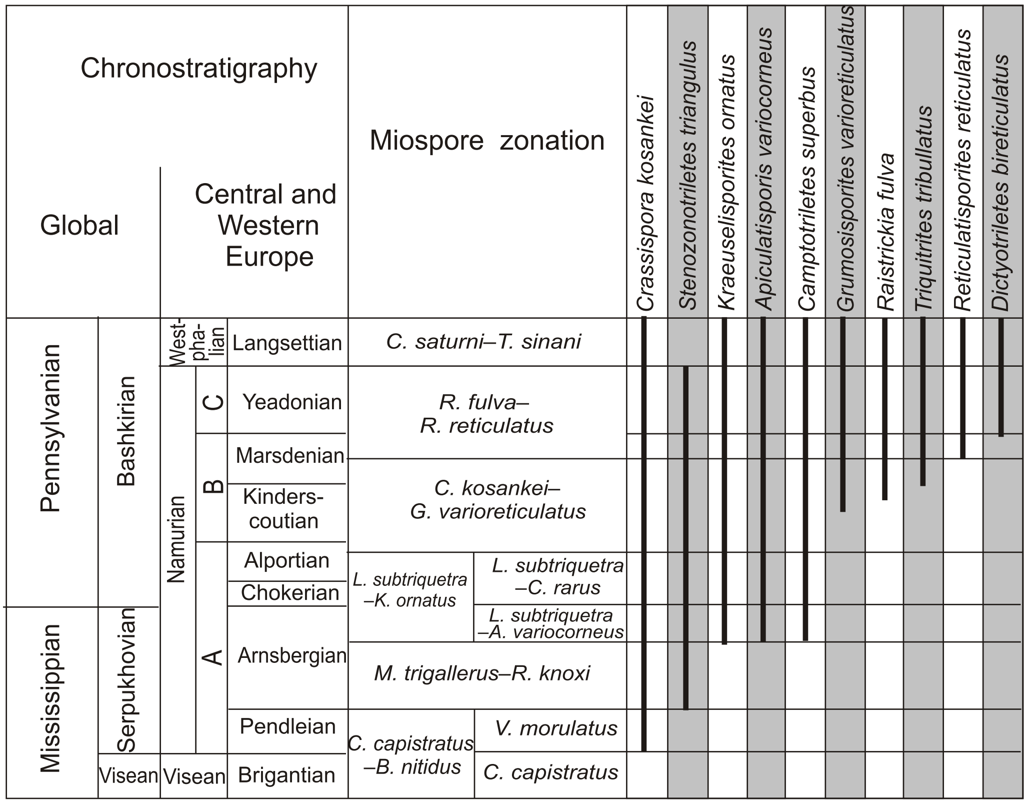

Fig. 6. Stratigraphical ranges of some important miospore taxa (according to Clayton *et al*., 1977 and Owens *et al*., 2004)

In the Brońsko 2 borehole Górecka *et al*. (2000*b*) defined three stratigraphic intervals: undivided Visean–Namurian, which occurs twice in this section (depths 2201.8–2204.6 m and 2245.6–2248.5 m) and the upper Tournaisian, recognized at a depth of 2205.9 m. The entire Carboniferous section from the Brońsko 4 borehole (depth 2191.4–2253.8 m) was assigned to the undivided Visean–Namurian (Górecka *et al*., 2001*a*).

Further analysis of the miospore assemblage compositions (Appendix B) allows alternative stratigraphical interpretations to be made. All these assemblages, which consist of numerous miospore taxa, seem to be mixed, consisting of miospores typical of different time intervals. In such a situation only the youngest miospore taxa have stratigraphical significance and all older ones are considered as reworked.

The miospore assemblages from the Brońsko 2 borehole (Appendix B) contain numerous Famennian–Tournaisian taxa (*Retusotriletes incohatus*, *Verrucosisporites nitidus*, *Raistrickia variabilis*, *R. corynoges*, *Crassispora trychera*), occurring together with taxa appearing in the Visean (*Lycospora pusilla*) and later. The youngest taxa are *Apiculatispores variocorneus*, *A. aculeatus*, *Apiculatasporites spinulistratus*, *Triquitrites* cf. *tribullatus* and *Reticulatisporites reticulatus*, which appeared in the Bashkirian. The occurrence of *R. reticulatus*, as well as *Endosporites globiformis* permit an assignment to the *Raistrickia fulva–Reticulatisporites reticulatus* (FR) Biozone (Fig. 6), correlated with the late Marsdenian and Yeadonian (upper Namurian B and lower Namurian C) (Owens *et al*., 2004). The composition of this assemblage does not reveal the stratigraphically significant vertical diversification. Miospore assemblages derived from different samples contain different numbers of reworked miospores, which are especially abundant in the sample from the depth of 2205.9 m and this probably caused their erroneous assignment to the Tournaisian (Górecka *et al*., 2000*b*).

The miospore assemblage from the Brońsko 4 borehole (Appendix B) consists mainly of Visean–Namurian taxa, but their stratigraphical ranges indicate the mixed nature of this assemblage. The occurrence of *Crassispora kosankei*, appearing at the base of the Serpukhovian, *Apiculatisporis aculeatus* and *Triquitrites* cf. *tribullatus* indicate that the rocks studied are not older than Marsdenian (upper Namurian B) (Owens *et al*., 2004; Fig. 6). Reworked miospores are not frequent but include *Auroraspora* sp.

DISCUSSION, COMMENTS AND CONCLUSIONS

New palynological data, presented in this paper, facilitates new interpretations of the stratigraphy of the Carboniferous succession of SW Poland, which had hitherto been unclear. The stratigraphical reinterpretation of the palynological data of Górecka *et al*. (1999, 2000*b*, 2001*a*, *b*, 2002*a*, *b*, *c*, 2003) from the Brońsko gas field, located on the northern slope of the WLH, gave surprising results. The miospore assemblages recognized there appeared to be mixed and indicate a late Marsdenian and Yeadonian age for the sequence investigated. This conclusion indicates that rocks from this area were wrongly considered as the oldest drilled rocks in this Carboniferous succession.

Thus, the time of the onset of Carboniferous deposition remains unknown. The commencement of deposition may be roughly defined by the rocks underlying this succession and the oldest rocks belonging to it. The basement, elevated and recognized at the WLH (Fig. 1), is composed of the weakly metamorphosed rock complexes. Phyllites occurring there are derived from a Middle?–Upper Devonian protolith (Haydukiewicz *et al*., 1999). Their cooling age was estimated at 358 Ma (Mazur *et al*., 2006) with the termination of metamorphism at 340 Ma (Żelaźniewicz *et al*., 2003). These ages represent of the Late Devonian and early Visean respectively and means that the Carboniferous siliciclastic rock succession has to be younger than early Visean. On the other hand the beginning of the Carboniferous deposition took place probably before the Pendleian (earliest Namurian), when the oldest dated sedimentary rocks, recognized in the Paproć 29 borehole, were deposited (Górecka-Nowak, 2007). This indicates that the onset of deposition was probably in the Visean, although this is still not biostratigraphically confirmed.

In the adjacent parts of the Variscan Foreland Basin Carboniferous siliciclastic deposition also began in the Visean. In the SW part of the Rheno-Hercynian Zone in Germany the oldest siliciclastic Carboniferous rocks accumulated during the deepening of the southern part of the basin in the Brigantian (McCann, 1999; Kornpihl, 2004). In the Czech Culm Basin the initial phase of foreland basin development, connected to the onset of deep marine sedimentation, was even earlier, at the beginning of the Visean (Hartley and Otava, 2001).

The geological recognition of this Carboniferous succession in SW Poland is currently limited to its upper part and there is no possibility to determine the age of rocks from its base. This becomes obvious taking into account that the maximum known thickness of this succession is about 2500 m, which is not great, compared to its huge thickness in the adjacent regions. The thickness of the Carboniferous rocks in the Culm Basin in the Czech Republic exceeds 7500 m (Hartley and Otava, 2001). In SW part of the German Variscan Foreland Basin, where only the upper Visean to Bashkirian rocks occur, their thickness is about 3000 m (McCann, 1999).

The results of the recent phase of palynostratigraphical studies proved the presence of Serpukhovian to Moscovian rocks in the Carboniferous succession of SW Poland (Fig. 7). The oldest dated rocks of this succession have been recognized in the Paproć 29 borehole and assigned to the Pendleian (Górecka-Nowak, 2007). The upper Arnsbergian–Alportian deposits seem to be widely distributed as they have been recognized in the Katarzynin 2, Siciny IG 1 and Marcinki IG 1 boreholes (Górecka-Nowak, 2007, 2008, 2009). The Marsdenian and the Yeadonian rocks probably occur on the northern slope of the WLH and were dated from the Czerńczyce IG 1 borehole. The palynological studies of the strata from the Czerńczyce IG 1 borehole did not confirm the presence of the Langsettian, which had been inferred before from this section by Górecka (1972). The Duckmantian, Bolsovian and Asturian deposits were dated in the Marcinki IG 1, Siciny IG 1 and Września IG 1 boreholes respectively by Górecka-Nowak (2008, 2009).

The above results indicate succession in these Carboniferous rocks is not continuous with no evidence of intervals covering the lower Arnsbergian, upper Alportian–Kinderscoutian and Langsettian. It should be pointed out that during previous palynostratigraphical studies all of these intervals had been identified, although the conclusions were sometimes general and the miospore zonation was not applied. Namurian A deposits had been recognized palynologically in several boreholes i.a. Ośno IG 1 (Krawczyńska-Grocholska, 1975; Krawczyńska-Grocholska and Grocholski, 1976), Milicz 1 (Górecka *et al*., 1977*b*), Jarocin GN 2 (Parka and Ślusarczyk, 1988; Górecka, 1991) and Lasowice 1 (Parka and Ślusarczyk, 1988). Kłapciński and Muszer (1987, 1995) had identified Namurian A rocks from the Chwaliszew 1 and Golęczewo 1 boreholes. Parka and Ślusarczyk (1988) had assigned rocks from the Ostrzeszów 1, Pogorzela 1, Siekierowice 2 and Trzebosz 2 boreholes to the Namurian B and C. Westphalian A rocks had been also recognized from some boreholes, for example Aleksandrów 1 (Górecka, 1991; Ślusarczyk, 1992) and Laskowice Oławskie IG 1 (Górecka and Parka, 1980; Parka and Ślusarczyk, 1988). The occurrence of stratigraphically important taxa, including *Radiizonates aligerens*, found in the Klęka 1 borehole (Parka and Ślusarczyk, 1988), indicative of the upper Langsettian (Clayton *et al*., 1977) indicates that these results seem to be reliable.

The youngest part of the Carboniferous succession probably represents the Stephanian, as Ślusarczyk (1980) and Karnkowski and Rdzanek (1982) recognized mixed miospore assemblages with taxa typical of the Stephanian in rocks from

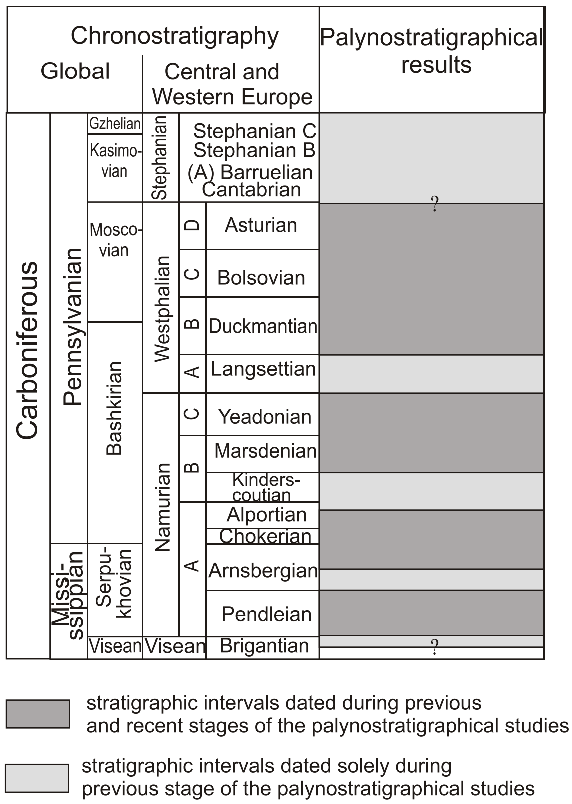

Fig. 7. Stratigraphy of the Carboniferous succession of SW Poland based on palynological results

the Ługowo 2 and Donatowo 1 boreholes. This conclusion is supported by the results from the Bartków 1 and Baszyn 1 (Jerzykiewicz, 1977), Laskowice Oławskie IG 1 (Parka and Ślusarczyk, 1988), Solec 6 (Kłapciński and Muszer, 1995) and Paproć 10 and Paproć 24 boreholes (Górecka *et al*., 2000*a*), where also Stephanian rocks have also been recognized.

The evidence presented here of the presence of Marsdenian and Yeadonian rocks does not support the concept of a stratigraphic gap between the Alportian and Duckmantian. The above review indicates that opinion on the occurrence of two rock successions of different ages in the Carboniferous succession of SW Poland (Górecka-Nowak, 2008, 2009) resulted from the preliminary nature of the studies. On the other hand, the suggestion of a stratigraphic gap between the Namurian and Westphalian has been connected in part with the rejection of earlier palynostratigraphical results by Bojkowski and Żelichowski (1980), Żelichowski (1984, 1995), Kmiecik (2001). Now, however, the presence of rocks of transitional age has been confirmed.

These palynostratigraphical data suggest that the Carboniferous siliciclastic succession of SW Poland consists of rocks from the Pendleian to the Stephanian (Fig. 7). This corresponds to the timing of deposition in the southern part of the Rheno-Hercynian Zone in Germany, which began in the Brigantian and lasted to the Stephanian (McCann, 1999; Kornpihl, 2004). Much older rocks, the Visean and lowermost Namurian, occur in the Culm Basin in the Czech Republic and the Moravo-Silesian Zone in Poland (Hartley and Otava, 2001; Trzepierczyńska, 2003).

The palynofacies observations made for the Marsdenian and the Yeadonian rocks from the Czerńczyce IG 1 borehole indicate that this diverse palynological material differs from the palynofacies from other sections of this succession, which are more monotonous and usually do not contain any amorphous organic matter (Górecka-Nowak, 2007, 2009). The diversity of the organic matter composition from this section, shown also by organic petrological studies (Nowak, 2003), probably reflects lower thermal alteration compared to other Carboniferous sections from this succession (Nowak, *op. cit*., Górecka-Nowak, *op. cit*.).

It is worthy of note that the palynological material from the Czerńczyce IG 1 borehole resembles the palynofacies from the coal-bearing Wałbrzych Formation from the Intrasudetic Basin (Górecka-Nowak and Majewska, 2007). This similarity, associated with the occurrence of coal laminae and smudges in the sandstones from the Czerńczyce IG 1 borehole, may suggest that the sequence investigated accumulated in a continental or at least paralic habitat. Microscope observations of vitrinite laminae, as well as the occurrence of well-preserved sporangia (Nowak, 2003) support this opinion.

This palynofacial observation may indicate that shallowing of the basin and the transition from the deep marine turbidites to shallow-water or even continental deposition took place earlier than in the Westphalian as was suggested by Mazur *et al*. (2010). This change corresponds rather to the palaeogeographic situation in Germany, where the environment of the Carboniferous siliciclastic deposition also evolved from a deep marine to a continental setting, but where the Yeadonian deposits, limited to the basin centre, are consider to have been deposited in a shallow-water to clastic coastal depositional environment (McCann, 1999; Kornpihl, 2004).

The mixed nature of the miospore assemblages from the Marsdenian and Yeadonian complete the observation that these kinds of miospore assemblages are the rule in the siliciclastic Carboniferous rocks of SW Poland (Górecka-Nowak, 2008). The occurrence of reworked miospores indicate that during its deposition the erosion of Upper Devonian–Tournaisian or upper Visean–Serpukhovian (or solely upper Visean) sedimentary rocks took place (Górecka-Nowak, 2007, 2008, 2009). These younger eroded rocks were probably also the source of the reworked marine macrofaunas which had been recorded in some sections of this succession (Górecka-Nowak, 2008, 2009). The evidence of redeposition was also supported by detrital zircon studies. The geochronology of zircons from the upper Arnsbergian–Alportian rocks indicate a Late Devonian and early Carboniferous age although the sources of the zircon detritus from the Asturian were more varied (Mazur *et al*., 2010). Sedimentary detritus, containing miospores and macrofossils, probably transported in blocks, as well as crystalline rocks being the source of the detrital zircons (Mazur *et al*., 2010), supplied to the foreland basin comprise evidence of Devonian and Carboniferous source rocks. Both sets of evidence indicate the important role of intensive redeposition during the sedimentation of the Carboniferous rocks. Mazur *et al*. (*op. cit*.) suggested that the source area was probably in the NE part of the Bohemian Massif, likely in the Sudetes where uplift and its unroofing took place.

The duplication of stratigraphical intervals in some boreholes (Górecka-Nowak, 2008, 2009), associated with the structural record and sediment provenance, determined the time of the late orogenic deformation and uplift as not earlier than Bolsovian. This terminal tectonic paroxysm took place at the same time approximately as the final Variscan tectonism in NW Germany and the British Isles (Mazur *et al*., *op. cit*.).

The data above suggest that the timing of the deposition and deformation, and probably, at least partly, conditions of deposition in the Polish and German parts of the Variscan Foreland Basin were similar. However, the Carboniferous succession of SW Poland requires detailed sedimentological studies, complemented by palynostratigraphical and palynofacial studies, to interpret the evolution of the depositional environment and to construct a palaeogeographical synthesis.

Acknowledgements. The author thanks M. Oliwkiewicz-Miklasińska and B. Owens for their constructive remarks, which allowed to improve this paper.

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APPENDIX A

Composition of the miospore assemblages from the Carboniferous rocks of the Czerńczyce IG 1 borehole

Taxa	Depth [m]															
	1095	1101	1106	1129	1136	1140	1146	1153	1163	1169	1173	1175	1179	1187	1190	1197
Acanthotriletes aculeolatus Kosanke, 1950			x													
Acanthotriletes baculatus Neves, 1961			x		x		x									
Acanthotriletes castanea Butterworth et Williams, 1958			x			x										
Acanthotriletes echinatus (Knox) Potonié et Kremp, 1955													x			
Acanthotriletes falcatus (Knox) Potonié et Kremp, 1955			x													
Acanthotriletes triquetrus Smith et Butterworth, 1967														x	x	
Ahrensisporites beeleyensis Neves, 1961			x													
Ahrensisporites duplicatus Neville, 1973	o														o	o
Ahrensisporites guerickei (Horst) Potonié et Kremp, 1954	x				x							x		x	x	x
Anapiculatisporites minor (Butterworth et Williams) Smith et Butterworth, 1967			x													
Anapiculatisporites cf. *kekiktukensis* Ravn, 1991					o											
Anaplanisporites baccatus (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967	x		x		x	x										
Anaplanisporites globulus (Butterworth et Williams) Smith et Butterworth, 1967			x													
Apiculatisporis abditus (Loose) Potonié et Kremp, 1954			x													
Apiculatisporis latigranifer (Loose) Potonié et Kremp, 1954			x													
Apiculatisporis variocorneus Sullivan, 1964						x						x	x			
Auroraspora macra Sullivan, 1964	o				o						o					
Bascaudaspora canipa Owens, 1983														x		
Bellispores nitidus (Horst) Sullivan, 1964	x		x												x	
Calamospora breviradiata Kosanke, 1950	x			x	x								x			
Calamospora exiqua Staplin, 1960			o													
Calamospora flexilis Kosanke, 1950					x											
Calamospora laevigata (Ibrahim) Schopf, Wilson et Bentall, 1944															x	x
Calamospora microrugosa (Ibrahim) Schopf, Wilson et Bentall, 1944			x	x								x	x		x	x
Calamospora mutabilis (Loose) Schopf, Wilson et Bentall, 1944			x												x	x
Calamospora pallida (Loose) Schopf, Wilson et Bentall, 1944															x	x
Calamospora parva Guennel, 1958	x															x
Calamospora pedata (Loose) Schopf, Wilson et Bentall, 1944	x											x	x	x	x	
Camarozonotriletes cyrenaicus Loboziak et Clayton, 1988															o	o
Camptotriletes bucculentus (Loose) Potonié et Kremp, 1955					x						x	x				
Camptotriletes cristatus Sullivan et Marshall, 1966																o
Camptotriletes superbus Neves, 1961			x										x			x
Cingulizonates bialatus (Waltz) Smith et Butterworth, 1967		x	x		x								x			x
Cingulizonates capistratus (Hoffmeister, Staplin et Malloy) Staplin et Jansonius, 1964					o											
Cirratriradites saturni (Ibrahim) Schopf, Wilson et Bentall, 1944			x										x			

App. A cont.

Taxa	Depth [m]															
	1095	1101	1106	1129	1136	1140	1146	1153	1163	1169	1173	1175	1179	1187	1190	1197
Convolutispora ampla Hoffmeister, Staplin et Malloy, 1955			x													
Convolutispora cerebra Butterworth et Williams, 1958			x													
Convolutispora florida Hoffmeister, Staplin et Malloy, 1955			x										x		x	
Convolutispora jugosa Smith et Butterworth, 1967					x											
Convolutispora mellita Hoffmeister, Staplin et Malloy, 1955															x	x
Convolutispora tessellata Hoffmeister, Staplin et Malloy, 1955													x			
Convolutispora varicosa Butterworth et Williams, 1958			x										x		x	x
Crassispora aculeata Neville, 1968					o											o
Crassispora kosankei (Potonié et Kremp) Bharadwaj, 1957	x		x	x	x							x	x	x	x	x
Crassispora maculosa (Knox) Sullivan, 1964					o										o	
Cristatisporites aculeatus (Hacquebard) Potonie, 1960																
Cyclogranisporites aureus (Loose) Potonié et Kremp, 1955			x										x		x	x
Cyclogranisporites leopoldii (Kremp) Potonié et Kremp, 1954													x			
Cyclogranisporites minutus Bharadwaj, 1957			x										x		x	
Densosporites anulatus (Loose) Smith et Butterworth, 1967	x		x								x	x		x		
Densosporites parvus Hoffmeister, Staplin et Malloy, 1955					x		x									
Densosporites sphaerotriangularis Kosanke, 1950	x		x										x			
Densosporites spinifer Hoffmeister, Staplin et Malloy, 1955					x											
Dictyotriletes cancellatus Potonié et Kremp, 1955			x													
Dictyotriletes castanaeformis (Horst) Sullivan, 1964		x														
Dictyotriletes clatriformis (Artüz) Sullivan, 1964													o			
Dictyotriletes densoreticulatus Potonié et Kremp, 1955								x								
Dictyotriletes insculptus Sullivan et Marshall, 1966			o													
Dictyotriletes pactilis Sullivan et Marshall, 1966	o															
Dictyotriletes vitilis Sullivan et Marshall, 1966			o													
Discernisporites irregularis Neves, 1958			x		x											x
Endosporites sp.																x
Florinites mediapudens (Loose) Potonié et Kremp, 1956													x			
Florinites pumicosus (Ibrahim) Schopf, Wilson et Bentall, 1944														x		x
Florinites visendus (Ibrahim) Schopf, Wilson et Bentall, 1944													x			
Grandispora distincta (Naumova) Avkhimovitch, 1993			o													
Grandispora cf. *lupata* Turnau, 1975			o													o
Grandispora gracilis (Kedo) Higgs, Avkhim., Loboz., Maziane, Stemp. et Streel, 2000																o
Grandispora spinosa Hoffmeister, Staplin et Malloy, 1955																o
Grandispora sp.			x													

Granulatisporites adnatoides (Potonié et Kremp) Smith et Butterworth, 1967													x			
Granulatisporites granulatus Ibrahim, 1933	x		x	x	x							x		x	x	
Granulatisporites microgranifer Ibrahim, 1933	x				x						x	x				
Granulatisporites minutus Potonié et Kremp, 1955												x		x	x	x
Grumosisporites inaequalis (Butterworth et Williams) Smith et Butterworth, 1967	x												x			
Grumosisporites varioreticulatus (Neves) Smith et Butterworth, 1967							x				x					
Grumosisporites verrucosus (Butterworth et Williams) Smith et Butterworth, 1967	x												x			
Hymenospora sp.			x												x	
Ibrahimispores brevispinosus Neves, 1961			x													
Knoxisporites cinctus (Waltz) Butterworth et Williams. 1958					x										x	
Knoxisporites dissidius Neves, 1961																x
Knoxisporites hageni Potonié et Kremp, 1955			x													x
Knoxisporites seniradiatus Neves, 1961																x
Knoxisporites stephanephorus Love, 1960			x													x
Knoxisporites triradiatus Hoffmeister, Staplin et Malloy, 1955.			o							o		o	o		o	o
Kraeuselisporites echinatus Owens, Mishell et Marshall, 1976							o					o				
Kraeuselisporites hibernicus Higgs, 1975			o													o
Kraeuselisporites ornatus (Neves) Owens, Mishell et Marshall, 1976	x		x		x						x	x	x		x	x
Kraeuselisporites mitratus Higgs, 1975			o													
Laevigatosporites perminutus Alpern, 1958															x	x
Laevigatosporites vulgaris (Ibrahim) Alpern et Doubinger, 1973			x		x								x		x	x
Leiotriletes parvus Guennel, 1958			x									x				
Leiotriletes priddyi (Berry) Potonié et Kremp, 1955			x		x											
Leiotriletes inermis (Waltz) Ishchenko, 1952		x	x													x
Leiotriletes sphaerotriangulus (Loose) Potonié et Kremp, 1955	x	x										x	x		x	x
Leiotriletes tumidus Butterworth et Williams, 1958	x		x		x						x	x	x	x		x
Lophotriletes commissuralis (Kosanke) Potonié et Kremp, 1955	x		x												x	x
Lophotriletes gibbosus (Ibrahim) Potonié et Kremp, 1954												x				
Lophotriletes microsaetosus (Loose) Potonié et Kremp, 1955	x															
Lophozonotriletes appendices (Hacquebard et Barss) Playford, 1963					o											
Lophozonotriletes triangulatus Hughes et Playford, 1961			o													
Lycospora noctuina Butterworth et Williams, 1958							x	x							x	
Lycospora orbicula (Potonié et Kremp) Smith et Butterworth, 1967				x	x						x	x	x	x	x	x
Lycospora pusilla (Ibrahim) Somers, 1972	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Microreticulatisporites concavus Butterworth et Williams, 1958	o		o													^
Microreticulatisporites microreticulatus Knox, 1950																x
Microreticulatisporites punctatus Knox, 1950	x		x													
Mooreisporites fustis Neves, 1961					x				x							
Murospora aurita (Waltz) Playford, 1962											o	o			o	
Murospora dupla (Ishchenko) Playford, 1962												o				

App. A cont.

Taxa	Depth [m]															
	1095	1101	1106	1129	1136	1140	1146	1153	1163	1169	1173	1175	1179	1187	1190	1197
Murospora friendii Playford, 1962					o						o					
Neoraistrickia inconstans Neves, 1961			x													
Orbisporis orbiculus Bharadwaj et Venkatachala, 1961			o													
Perotrilites perinatus Hughes et Playford, 1961			o													o
Pilosisporites verutus Sullivan et Marshall, 1966			o													
Planisporites granifer (Ibrahim) Knox, 1950															x	x
Potoniespores delicatus Playford, 1963			o													
Prolycospora claytonii Turnau, 1978					o											
Proprisporites laevigatus Neves, 1961					x											
Punctatisporites aerarius Butterworth et Williams, 1958							x									
Punctatisporites giganteus Neves, 1961												x			x	
Punctatisporites minutus Kosanke, 1950					x					x		x			x	x
Punctatisporites nitidus Hoffmeister, Staplin et Malloy, 1955							x			x						x
Punctatisporites obesus (Loose) Potonié et Kremp, 1955															x	x
Punctatisporites obliquus Kosanke, 1950													x			
Punctatisporites planus Playford, 1962					o											
Punctatisporites punctatus Ibrahim, 1932															x	
Punctatisporites sinuatus (Artüz) Neves, 1961			x		x								x	x	x	x
Punctatisporites stabilis Playford, 1962			o													
Pustulatisporites pustulatus Potonié et Kremp, 1954					x											
Radiizonates striatus (Knox) Staplin et Jansonius, 1964													x			
Raistrickia fulva Artüz, 1957			x		x								x			x
Raistrickia nigra Love, 1960												o				o
Raistrickia superba (Ibrahim) Schopf, Wilson et Bentall, 1944															x	
Reticulatisporites carnosus (Knox) Neves, 1964			o								o	o				o
Reticulatisporites reticulatus (Ibrahim) Ibrahim, 1933			x									x				
Retusotriletes avonensis Playford, 1964					o											
Retusotriletes golatensis Staplin, 1960			o													
Retusotriletes communis Naumova , 1953													o			
Rugospora cf. *corporata* Neves et Owens, 1966					o											
Rugospora polyptycha Neves et Ioannides, 1974					o											o
Savitrisporites nux (Butterworth et Williams) Smith et Butterworth, 1967	x							x							x	x
Schopfipollenites sp.			x									x				
Schulzospora campyloptera (Waltz) Hoffmeister, Staplin et Malloy, 1955										o						^
Schulzospora elongata Hoffmeister, Staplin et Malloy, 1955			x													
Schulzospora plicata Butterworth et Williams, 1958														x		
Schulzospora rara Kosanke, 1950													x			

Secarisporites remotus Neves, 1961			x		x		x									
Spackmanites sp.			x													
Spelaeotriletes arenaceus Neves et Owens, 1966					x								x			
Spelaeotriletes triangulus Neves et Owens, 1966			x		x											
Spinozonotriletes uncatus Hacquebard, 1957					o											
Stenozonotriletes coronatus Sullivan et Marshall, 1966					o											
Stenozonotriletes lycosporoides (Butterworth et Williams) Smith et Butterworth, 1967	x		x					x	x			x				
Stenozonotriletes stenozonalis (Waltz) Ishchenko, 1958			o													
Stenozonotriletes triangulus Neves, 1961					x										x	x
Tholisporites scoticus Butterworth et Williams, 1958			x													x
Triquitrites distinctus Neville, 1973												o			o	
Triquitrites marginatus Hoffmeister, Staplin et Malloy, 1955	o		o													
Triquitrites piramidalis (Kedo et Jushko) Stempień et Turnau, 1988					o											
Vallatisporites microspinosus Higgs, Clayton et Keegan, 1988															o	
Verrucosisporites baccatus Staplin, 1960	o				o		o								o	o
Verrucosisporites cerosus (Hoffmeister, Staplin et Malloy) Butterworth et Williams, 1958					o											
Verrucosisporites morulatus (Knox) Smith et Butterworth, 1967					o											
Verrucosisporites microtuberosus (Loose) Smith et Butterworth, 1967														x		
Verrucosisporites verrucosus (Ibrahim) Ibrahim, 1933		x	x								x	x			x	x
Waltzispora polita (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967		x								x						
Wilsonites delicatus Kosanke, 1950												x	x		x	

x – miospore taxa of stratigraphical value; o – miospore taxa considered as reworked

APPENDIX B

The miospore taxa determined by Górecka (2000*b*, 2001*a*) from the Carboniferous rocks of the Brońsko 2 and Brońsko 4 boreholes

Taxa	Brońsko 2							Brońsko 4							
	Depth [m]							Depth [m]							
	2201.8	2203.5	2204.6	2205.9	2245.6	2247.9	2248.5	2191.4	2192.5	2193.5	2194.4	2199.0	2251.1	2252.3	2253.8
Acanthotriletes persibus Higgs, 1975				+		+									
Acanthotriletes aculeolatus Kosanke, 1950									+						
Acanthotriletes castanea Butterworth et Williams, 1958					+										
Acanthotriletes echinatus (Knox) Potonié et Kremp, 1955				+	+					+					
Acanthotriletes sp.				+											
Anaplanisporites baccatus (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967				+	+	+									
Anaplanisporites globulus (Butterworth et Williams) Smith et Butterworth, 1967						+									
Aneurospora sp.				+											
Apiculatasporites spinulistratus (Loose) Ibrahim, 1933					+										
Apiculatisporis irregularis (Alpern) Smith et Butterworth, 1967					+										
Apiculatisporis variocorneus Sullivan, 1964				+	+	+									
Apiculatisporis aculeatus (Ibrahim) Smith et Butterworth, 1967				+	+	+		+							
Apiculatisporis heteroconus Phillips et Clayton, 1980				+											
Apiculatisporis sp.								+							
Apiculatisporis spinososaetosus (Loose) Smith et Butterworth, 1967									+						
Auroraspora sp.								+					+		
Calamospora microrugosa (Ibrahim) Schopf, Wilson et Bentall, 1944					+	+									
Calamospora minuta Bharadwaj, 1957				+	+										
Calamospora mutabilis (Loose) Schopf, Wilson et Bentall, 1944	+			+											
Calamospora pallida (Loose) Schopf, Wilson et Bentall, 1944					+	+									
Calamospora parva Guennel, 1958				+											
Calamospora pedata (Loose) Schopf, Wilson et Bentall, 1944				+		+		+							
Calamospora straminea Wilson et Kosanke, 1944					+										
Camptotriletes cf. *prionotus* Higgs, 1975				+											
Cirratritadites sp.								+							
Convolutispora cerebra Butterworth et Williams, 1958	+			+											
Convolutispora sp.	+					+									
Crassispora kosankei (Potonié et Kremp) Bharadwaj, 1957									+						
Crassispora sp.			+												
Crassispora trychera Neves et Ioannides, 1974				+											
Cyclogranisporites minutus Bharadwaj, 1957					+										
Cyclogranisporites multigranus Smith et Butterworth, 1967					+										
Cyclogranisporites aureus (Loose) Potonié et Kremp, 1955					+										
Cyclogranisporites minutus Bharadwaj, 1957		+		+											
Cyclogranisporites pressoides Potonié et Kremp, 1955				+											
Cyclogranisporites sp.													+		

Densosporites anulatus (Loose) Smith et Butterworth, 1967				+											
Densosporites solaris Balme, 1952											+				
Densosporites sp.						+		+			+				
Densosporites sphaerotriangularis Kosanke, 1950														+	
Densosporites spinifer Hoffmeister, Staplin et Malloy, 1955					+										
Densosporites spitzbergensis Playford, 1963						+									
Dictyotriletes mediareticulatus (Ibrahim) Smith et Butterworth, 1967				+											
Dictyotriletes castanaeformis (Horst) Sullivan, 1964				+	+				+						
Dictyotriletes sp.						+			+						
Dictyotriletes trivialis Naumova in litt. in Kedo, 1963									+						
Diducites cf. *mucronatus* (Kedo) Van Veen, 1981				+											
Endosporites globiformis (Ibrahim) Schopf, Wilson et Bentall, 1944						+									
Endosporites sp.						+									
Granulatisporites adnatoides (Potonié et Kremp) Smith et Butterworth, 1967		+						+	+						
Granulatisporites granulatus Ibrahim, 1933		+		+								+	+	+	
Granulatisporites microgranifer Ibrahim, 1933					+										
Granulatisporites minutus Potonié et Kremp, 1955								+							
Granulatisporites parvus (Ibrahim) Potonié et Kremp, 1955				+											
Granulatisporites piroformis Loose, 1934															+
Grumosisporites inaequalis (Butterworth et Williams) Smith et Butterworth, 1967				+											
Grumosisporites sp.		+													
Knoxisporites literatus (Waltz) Playford, 1963				+									+		
Kraeuselisporites sp.				+	+			+							
Leiotriletes tumidus Butterworth et Williams, 1958				+											
Lophotriletes granoornatus Artüz, 1957					+			+							
Lycospora granulata Kosanke, 1950					+	+		+							
Lycospora pusilla (Ibrahim) Somers, 1972						+									
Lycospora sp.				+			+					+			
Microreticulatisporites punctatus Knox, 1950					+										
Planisporites sp.				+											
aspnum*Plicatispora scolecophora* (Neves et Ioannides) Higgs, Clayton et Keegan, 1988				+											
Punctatisporites minutus Kosanke, 1950				+											
Punctatisporites obliquus Kosanke, 1950						+									
Punctatisporites planus Hacquebard, 1957				+											
Punctatisporites sp.					+										
Punctatosporites sp.					+			+							
Pustulatisporites cf. *dolbii* Higgs, Clayton et Keegan, 1988				+											
Radiizonates mirabilis Phillips et Clayton, 1980				+											
Radiizonates sp.	+							+							
Raistrickia corynoges Sullivan, 1968				+											
Raistrickia variabilis Dolby et Neves, 1970				+											

App. B cont.

Taxa	Brońsko 2							Brońsko 4							
	Depth [m]							Depth [m]							
	2201.8	2203.5	2204.6	2205.9	2245.6	2247.9	2248.5	2191.4	2192.5	2193.5	2194.4	2199.0	2251.1	2252.3	2253.8
Raistrickia condylosa Higgs, 1975				+											
Raistrickia sp.						+									
Reticulatisporites carnosus (Knox) Neves, 1964				+											
Reticulatisporites reticulatus (Ibrahim) Ibrahim, 1933				+											
Retusotriletes famenensis Naumova, 1953				+											
Retusotriletes incohatus Sullivan, 1964				+											
Rugospora minuta Neves et Ioannides, 1974				+											
Schopfites cf. *claviger* (Sullivan) Higgs, Clayton et Keegan, 1988				+											
Schopfites cf. *delicatus* (Higgs) Higgs, Clayton et Keegan, 1988				+											
Schopfites sp.					+	+									
Schulzospora sp.						+									
Spelaeotriletes sp.	+														
Stenozonotriletes bracteolus (Butterworth et Williams) Smith et Butterworth, 1967					+										
Triquitrites cf. *tribullatus* (Ibrahim) Schopf, Wilson et Bentall, 1944								+							
Triquitrites protensus Kosanke, 1950	+														
Triquitrites sp.					+										
Verruciretusotriletes sp.				+											
Verrucosisporites cerosus (Hoffmeister, Staplin et Malloy) Butterworth et Williams, 1958					+								+		
Verrucosisporites cf. *nitidus* (Naumova) Playford, 1963				+											
Verrucosisporites microtuberosus (Loose) Smith et Butterworth, 1967					+										
Verrucosisporites sp.						+		+			+				