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Palynological data from the Siciny IG 1 and Marcinki IG 1 boreholes and their significance to the interpretation of the Carboniferous succession of SW Poland

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This paper describes in detail palynological data from the Carboniferous siliciclastic rock succession from the Siciny IG 1 and Marcinki IG 1 boreholes (SW Poland), that allow reinterpretation of the local stratigraphy. Two rock series of different ages were recognized. Rocks from the Siciny IG 1 section were assigned to the upper Arnsbergian–Alportian (the *Lycospora subtriquetra–Kraeuselisporites ornatus* (SO) Biozone) and the Bolsovian (the *Torispora securis–Torispora laevigata* (SL) Biozone). In the upper part of the Carboniferous section in the Marcinki IG 1 section the upper Arnsbergian–Alportian and Duckmantian interval (the *Lycospora subtriquetra–Kraeuselisporites ornatus* (SO) and the *Microreticulatisporites nobilis–Florinites junior* (NJ) biozones respectively) were recognized, although the quality of the palynological data from the latter borehole was generally poor. These results conflict with a Viséan age for these rocks interpreted from fossil marine macrofaunas and indicate the reworked nature of the macrofaunas. Possible means of the macrofaunal reworking, sedimentary environment and thermal history, based on the palynological data, are discussed. Repetition of the stratigraphical succession, probably due to tectonic deformation of the rocks in both sections, is demonstrated and indicate a post-Bolsovian age for the deformation event.

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INTRODUCTION

A new interpretation of the stratigraphy of the Carboniferous succession from Polish part of the Variscan foreland basin has resolved previous contradictory interpretations. This interpretation is based on palynological data from several deep boreholes located in the Fore-Sudetic area (Górecka-Nowak, 2007, 2008). The results of palynological studies from two boreholes, Siciny IG 1 and Marcinki IG 1, presented in this paper, have provided much important data towards this interpretation and have a key role in resolving stratigraphical problems.

The Siciny IG 1 and Marcinki IG 1 boreholes (Fig. 1) were drilled in the 1970's. The Carboniferous siliciclastic succession is buried under a thick cover of Permo-Mesozoic and Cenozoic rocks in each of these sections. This succession has usually been sparsely cored and its thickness exceeds 1000 m, although in none of the boreholes was the basement penetrated (Figs. 2A and 3A). Previous palaeontological and palynological studies have provided contradictory results. Late Viséan marine macrofaunas, found in these rocks, have been a basis for the recognition of upper Viséan rocks. A marine origin of these rocks is also supposed mainly on the basis of these fossils. The Marcinki IG 1 borehole is particularly important as it penetrates the maximum known thickness of this sequence (> 2500 m) and includes many late Viséan macrofaunas. The Siciny IG 1 borehole is considered as a section where the entire Lower Carboniferous succession is represented (Żelichowski, 1984, 1995). Previous palynostratigraphical results indicated the occurrence of Westphalian[1] rocks in both these sections (Górecka and Parka, 1980; Parka and Ślusarczyk, 1988), but these results were regarded as less reliable.

[1] The recent Carboniferous subdivision (Heckel and Clayton, 2006) is applied in this paper with regard to the new stratigraphical conclusions. In the parts of the text that deal with eariel results, the traditional names of the stratigraphical units are used

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

The palynological studies of the author have been mainly stratigraphical in nature. An additional purpose of these studies was palynological constraint of the age of the tectonic event which caused deformation of the rock succession studied, as recorded in both boreholes (Mazur *et al*., 2008). The results of the palynostratigraphical studies showed that the macrofaunas found in these rocks have been reworked. A suggestion regarding the probable mechanism of the macrofauna reworking is discussed. The miospore studies were augmented by the palynofacies observations and assessment of thermal maturation of organic matter derived from miospore colour. These studies focused on the identification of source rocks for hydrocarbons (Nowak, 2003), but their results aid stratigraphical interpretation and enabled elucidation of the thermal history of the rocks studied. The palynofacies observations made to establish the reworked nature of the macrofaunas enabled some interpretation of depositional environment.

CARBONIFEROUS OF THE SECTIONS STUDIED AND PREVIOUSLY INFERRED STRATIGRAPHY

SICINY IG 1

The Carboniferous siliciclastic rocks in the Siciny IG 1 borehole occur in the depth interval 2004.5–3000.0 m. They consist of monotonous mudstones and sandstones with intercalations of conglomerate (Fig. 2). Some of these rocks contain volcanogenic fragments. In the upper part of the section, down to 2177.8 m depth, their colour is red-brownish while below this grey rocks occur. The Carboniferous strata are tectonically deformed (Mazur *et al*., 2008). In the upper and lower parts of the log they lie nearly horizontally or dip at a low angle (up to 25°), but within the depth interval 2408.5–2665.1 m strata dip at high angles (up to 90°). The lower and upper contacts of this zone are marked by thrust surfaces while another thrust surface cuts across this zone (Fig. 2).

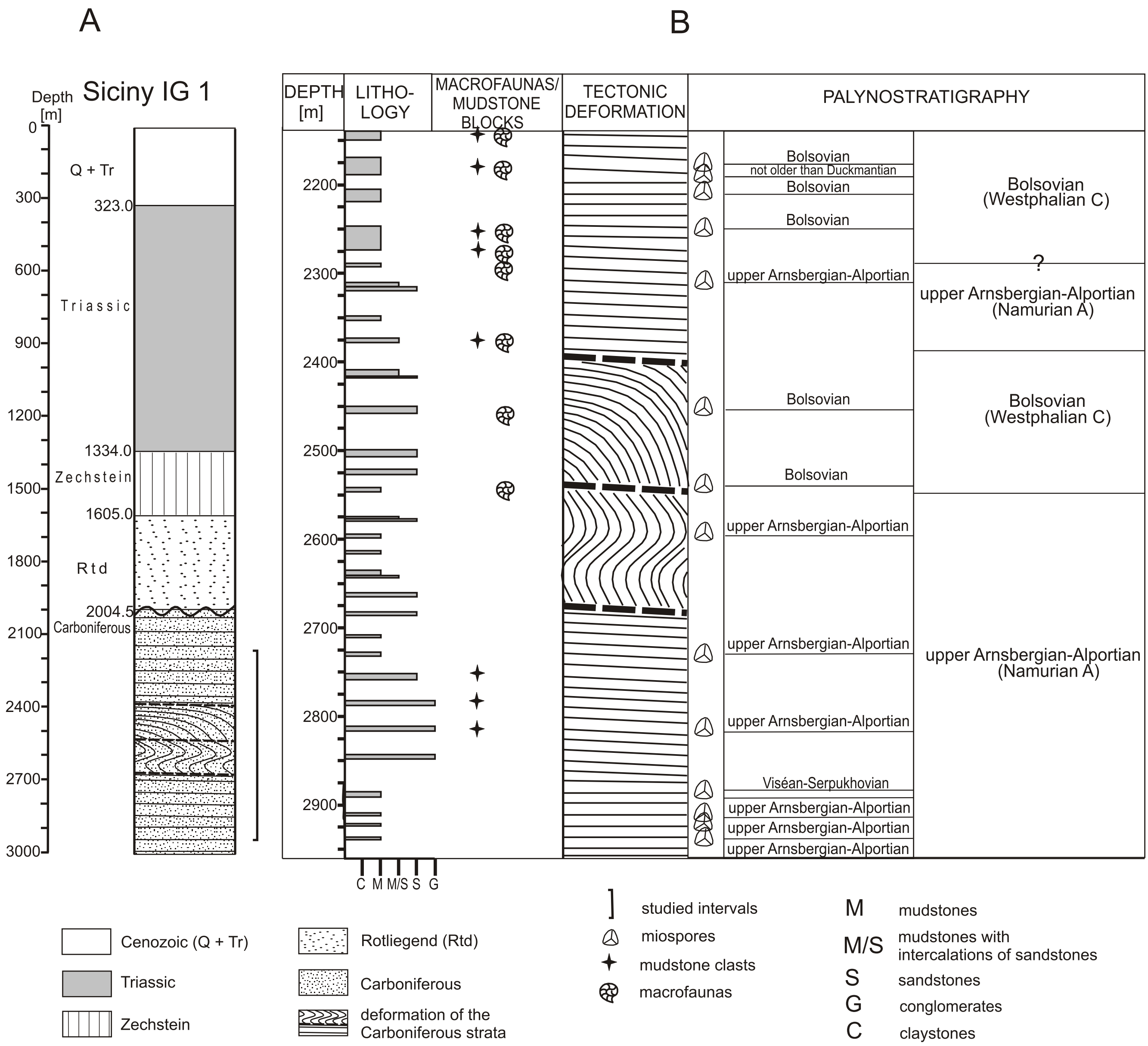


Fig. 2. The Siciny IG 1 borehole

A — geological section, **B** — palynostratigraphy of the Carboniferous rocks (tectonic section from Mazur *et al*., 2008)

Previous stratigraphy was based on macrofossils, found in the upper part of the section, down to a depth of 2545.0 m in red-brownish and grey clastic rocks. Kühn and Paprocka (1979) determined several late Viséan goniatite taxa, including *Nomismoceras vittiger* (Phill.), *Goniatites* ex gr. *striatus* (Roemer), *Goniatites* sp. and bivalves (*Posidonia corrugata* Eth., *Posidonia becheri* Bronn., *Posidonia* ex gr. *corrugata* Eth., *Arciculopecten* sp., *Posidoniella laevis* (Brown). This upper part of the section, in which they had been found, was considered as upper Viséan and about 400 m of palaeontologically barren rocks underlying them was assigned to the Tournaisian and/or lower Viséan (see also Górecka-Nowak, 2008). Thus the Siciny IG 1 borehole had been considered as a complete section through the Lower Carboniferous (Żelichowski, 1984, 1995; Wierzchowska-Kicułowa, 1984).

Therefore, the palynostratigraphical results of Parka and Ślusarczyk (1988) were surprising. These authors determined late Carboniferous miospores from two rock samples from the uppermost part of the section (depth 2018.0–2181.0 m) and assigned them to the upper Westphalian (see also Górecka-Nowak, 2008). Unfortunately, they did not discuss the earlier interpretations and their conclusion was later left out of the account.

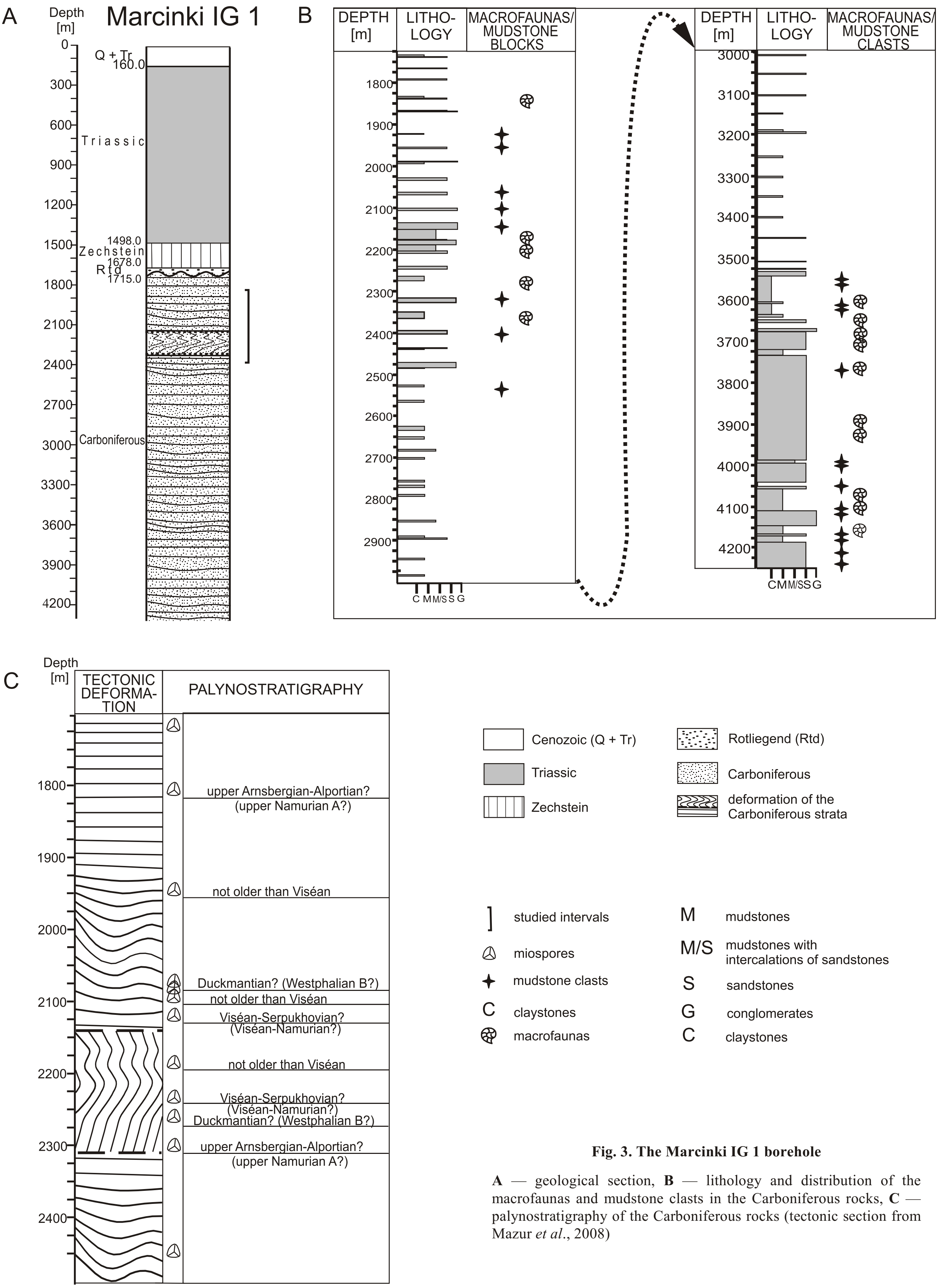


Fig. 3. The Marcinki IG 1 borehole

A — geological section, **B** — lithology and distribution of the macrofaunas and mudstone clasts in the Carboniferous rocks, **C** — palynostratigraphy of the Carboniferous rocks (tectonic section from Mazur *et al*., 2008)

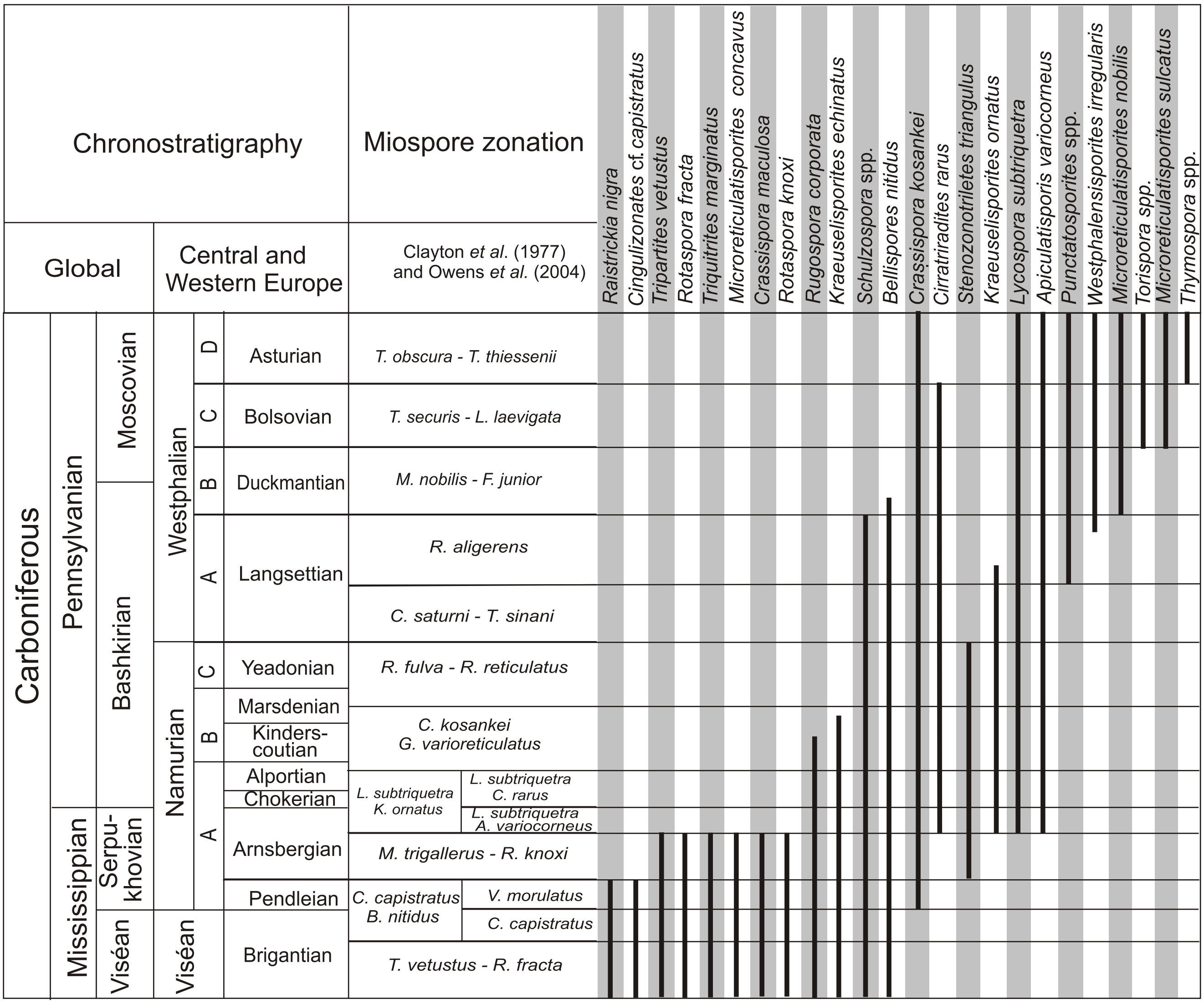


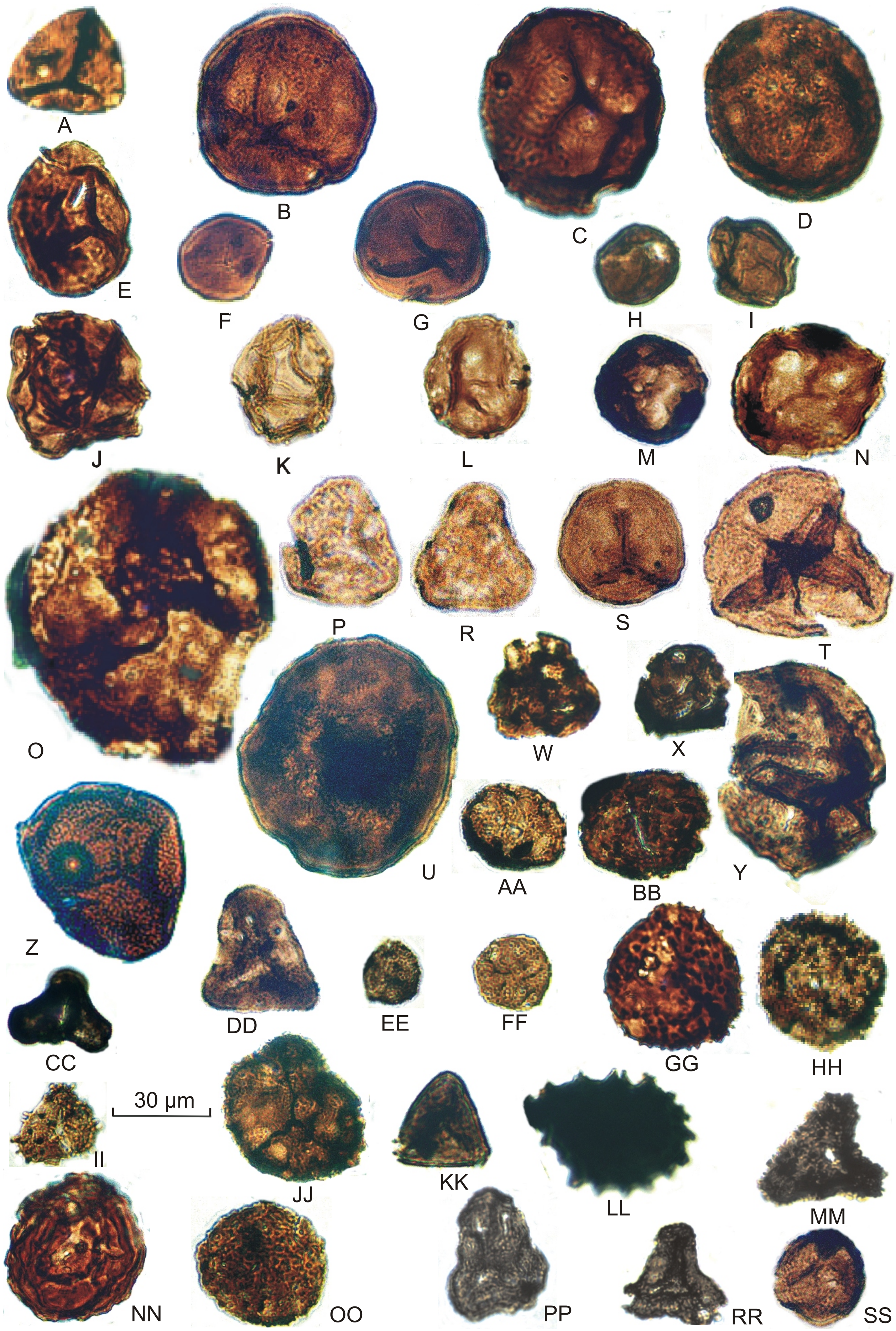
Fig. 4. Stratigraphical ranges of some important miospore taxa
(according to Clayton *et al.*, 1977; Owens *et al.*, 2004, completed by data from Kmiecik, 2001)

MARCINKI IG 1

In the Marcinki IG 1 borehole the Carboniferous strata consist of sandstones, mudstones, claystones and conglomerates, and occur in the depth interval 1715.0–4237.0 m. These strata dip usually at low angles of up to 20° and only in the depth interval 2154.0–2323.0 m, bounded by two thrust surfaces, did they dip at much higher angles, exceeding 90° (Fig. 3; Mazur *et al.*, 2008).

The palaeontological evidence of a Carboniferous age in this section consists of goniatites, bivalves and orthocones, which had been found entire. Rocks containing *Goniatites crenistria* Phill., *Goniatites* cf. *crenistria intermedius* Kobold, *Goniatites* ex gr. *striatus* (Sow.), *Goniatites* cf. *bisati* Moore, *Neoglyphioceras* ex gr. *subcirculare* (Mill.), *Lusitanoceras granosus*, *Posidonia* ex gr. *corrugata* (Ether.), *Dictyodora liebeana* (Geinitz), *Crossopodia moravica* Stur, *Orthoceras* sp. were assigned to the upper Viséan (Goα–Goβ) (Korejwo and Teller, 1973; Bojkowski, 1973; Żelichowski, 1995). In the uppermost part of the section (depth 1832.8–1839.4 m) Korejwo and Teller (1973) found *Dimorphoceras* sp. and included this part within the Namurian (?).

The palynostratigraphic studies provided different results — the lower part of the profile was assigned to the upper Viséan (Górecka and Parka, 1980) or to an undivided Viséan–Namurian interval (Parka and Ślusarczyk, 1988) while rocks from the upper part of the section (above 2945.0 m) were included within the Westphalian (Górecka and Parka, *op. cit.*; Parka and Ślusarczyk, *op. cit.;* see also Górecka-Nowak, 2008). Górecka and Parka (*op. cit.*) suggested that late Viséan macrofaunas found in the Westphalian rocks had been reworked, though Parka and Ślusarczyk (1988) did not discuss the matter. This interpretation was later disregarded.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METHOD

The entire Carboniferous section from Siciny IG 1 was sampled for palynology (Fig. 2). In the Marcinki IG 1 borehole, the sampled interval embraced the zone of the deformed strata as well as rocks occurring above and below it, although sampling was limited to the upper part of the section (depth interval 1832.8–2401.1 m) (Fig. 3).

Samples of fine-grained rocks from both boreholes were processed for palynofossils according to the standard procedure. Each sample was divided during processing into two parts and later only samples for palynology were oxidised (HNO_3, $KClO_3$). The palynofacies observations and thermal maturity assessments were made on unoxidised samples.

The stratigraphical interpretation of the miospore data, based on the occurrence of stratigraphically important taxa, allowed application of the standard miospore zonation of Western Europe (Clayton *et al*., 1977; Owens *et al*., 2004), with reference also to some data from Poland (Fig. 4; Kmiecik, 2001). The classification of palynofacies particles given by Górecka-Nowak and Majewska (2007) was applied in the palynofacies studies. The miospore colour was assessed according to the Batten's scale (1984), using colours of *Lycospora* specimens.

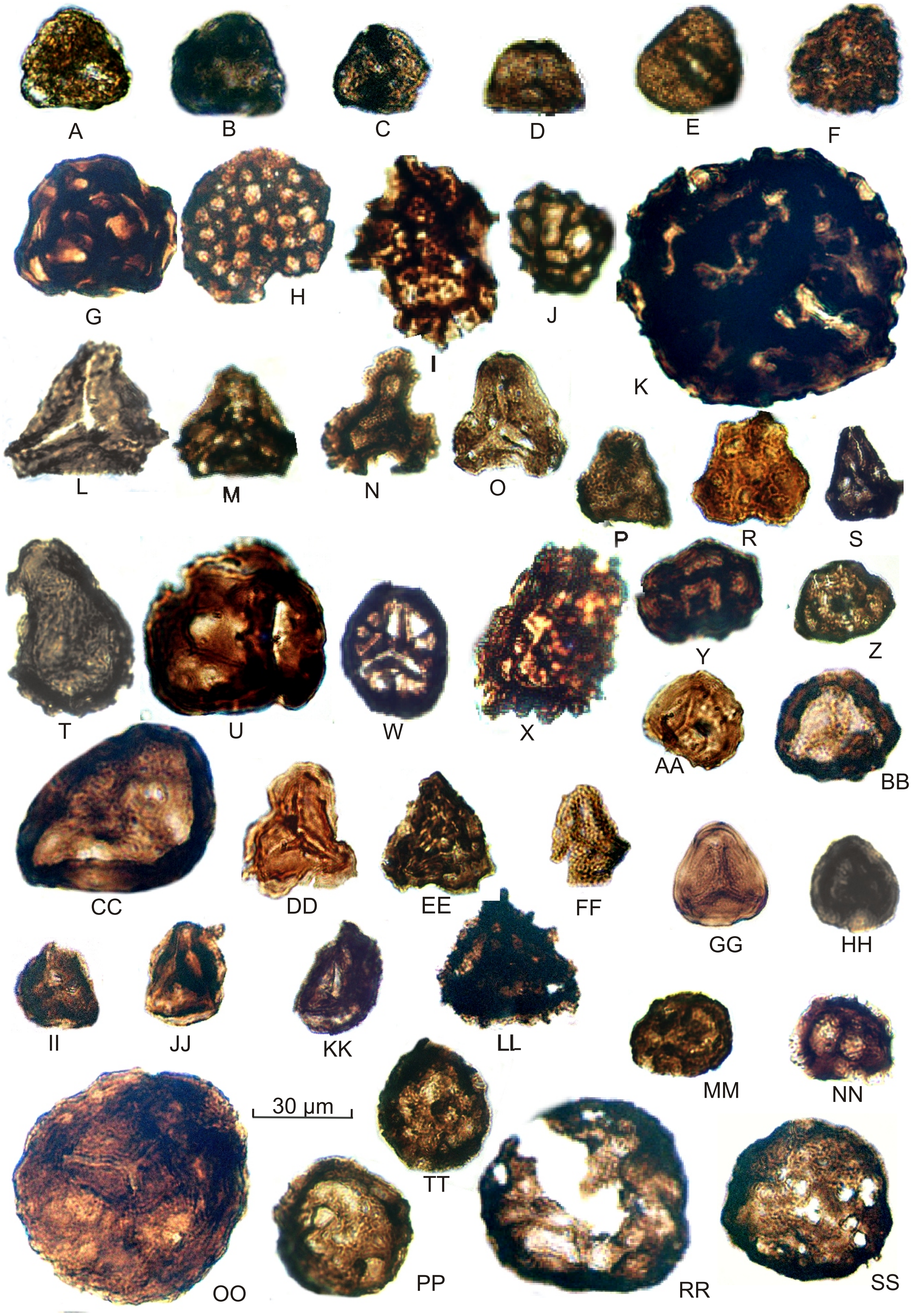
RESULTS

The rocks studied contained abundant miospores, consisting of generally poorly preserved, thermally altered specimens. Representatives of other groups of palynomorphs were not found. The best quality miospore assemblages came from the Siciny IG 1 borehole and were found in grey siliciclastic rocks from the depth interval 2179.2–2939.0 m. Miospore assemblages from this section are well-preserved and are diverse. Assemblages from the Marcinki IG 1 section are poorer, consisting of fewer and less well preserved specimens. In both sections studied over 250 miospore taxa were determined. Most of these are listed in Appendices A, B and some are illustrated Figures 5–8.

The palynofacies material of all samples consists mainly of black, dark brown and brown phytoclasts. These have rectangular or irregular outlines and are of various sizes. In rocks from the Siciny IG 1 borehole these rectangular and irregular phytoclasts are brown and black and occur in various amounts. In samples from the Marcinki IG 1 borehole black phytoclasts dominate. In none of the samples was amorphous organic matter recorded.

Fig. 5. Miospores from the Carboniferous rocks of the Siciny IG 1 and Marcinki IG 1 boreholes

A — *Leiotriletes tumidus* Butterworth et Williams, 1958, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, Q 15, 2; **B** — *Punctatisporites aerarius* Butterworth et Williams, 1958, Siciny IG 1 borehole, depth 2886.0 m, slide 2, V 51, 4; **C** — *Punctatisporites parvivermiculatus* Playford, 1962, Siciny IG 1 borehole, depth 2936.0 m, W 31, 3 (r); **D** — *Punctatisporites punctatus* Ibrahim, 1933, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, Q 22, 1; **E** — *Punctatisporites irrasus* Hacquebard, 1957, Siciny IG 1 borehole, depth 2921.0 m, Q 32 (r); **F** — *Punctatisporites minutus* Kosanke, 1950, Siciny IG 1 borehole, depth 2936.0 m, slide 2, H 30; **G** — *Punctatisporites glaber* (Naumova) Playford, 1962, Siciny IG 1 borehole, depth 2890.0 m, slide 3, T 8, 4; **H** — *Punctatisporites nitidus* Hoffmeister, Staplin et Malloy, 1955, Marcinki IG 1 borehole, depth 1988.3–1994.0 m, sample Mar 9, slide 1, U 32 2; **I** — *Calamospora parva* Guennel, 1958, Marcinki IG 1 borehole, depth 1832.8–1839.4 m, slide 4, V 58, 3; **J** — *Calamospora microrugosa* (Ibrahim) Schopf, Wilson et Bentall, 1944, Siciny IG 1 borehole, depth 2814.0 m, slide 2, K 16, 2; **K** — *Calamospora straminea* Wilson et Kosanke, 1944, Siciny IG 1 borehole, depth 2310.5–2319.5 m, slide 2, Q 19 2; **L** — *Calamospora parva* Guennel, 1958, Siciny IG 1 borehole, depth 2814.0 m, slide 1, B 18, 1, 3; **M** — *Retusotriletes incohatus* Sullivan, 1964, Siciny IG 1 borehole, depth 2936.0 m, sample S 17, slide 2, S 47 (r); **N** — *Retusotriletes communis* Naumova, 1953, Siciny IG 1 borehole, depth 2921.0 m, sample S 15, K 51, 2 (r); **O** — *Retusotriletes avonensis* Playford, 1963, Siciny IG 1 borehole, depth 2936.0 m, slide 1, C 29, 2 (r); **P** — *Granulatisporites adnatoides* (Potonié et Kremp) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, Y 52, 1, 3, **R** — *Granulatisporites microgranifer* Ibrahim, 1933, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, S 59, 3; **S** — *Cyclogranisporites minutus* Bharadwaj, 1957, Siciny IG 1 borehole, depth 2890.0 m, sample S 12, slide 2, S 7, 1; **T** — *Cyclogranisporites aureus* (Loose) Potonié et Kremp, 1955, Siciny IG 1 borehole, depth 2886.0 m, slide 2, O 27, 3; **U** — *Cyclogranisporites palaeophytus* Neves et Ioannides, 1974, Siciny IG 1 borehole, depth 2890.0 m, slide 2, Y 34, 3 (r); **W** — *Converrucosisporites armatus* (Dybova et Jachowicz) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2542.0–2546.7 m, slide 4, L 51, 4; **X** — *Converrucosisporites armatus* (Dybova et Jachowicz) Smith et Butterworth, 1967, Marcinki IG 1 borehole, depth 2135.1–2141.5 m, sample Mar 7, slide 1 dl, V 4, 3; **Y** — *Verrucosisporites baccatus* Staplin, 1960, Siciny IG 1 borehole, depth 2814.0 m, slide 1, H 16, 3, 4 (r); **Z** — *Verrucosisporites donarii* Potonié et Kremp, 1955, Siciny IG 1 borehole, depth 2450.0–2458.0 m, slide 2A, Y 19, 2, 4; **AA** — *Verrucosisporites cerosus* (Hoffmeister, Staplin et Malloy) Butterworth et Williams, 1958, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, Y 16, 1, 3; **BB** — *Verrucosisporites morulatus* (Knox) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2310.5–2319.5 m, slide 2, L 29, 4 (r); **CC** — *Walzispora* sp., Marcinki IG 1 borehole, depth 2348.4–2352.8 m, slide 2 dl, C 10; **DD** — *Tricidarisporites balteolus* Sullivan et Marshall, 1966, Siciny IG 1 borehole, depth 2936.0 m, slide 2, K 41, 1 (r); **EE** — *Anaplanisporites baccatus* (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967, Marcinki IG 1 borehole, depth 2393.3–2401.1 m, slide 1, J 50, 2; **FF** — *Anaplanisporites baccatus* (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, K 31, 4; **GG** — *Pustulatisporites dolbii* Higgs, Clayton et Keegan, 1988, Siciny IG 1 borehole, depth 2936.0 m, slide 1, C 42 (r); **HH** — *Apiculatisporis variocorneous* Sullivan, 1964, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, Y 41, 1, 2; **II** — *Acanthotriletes baculatus* Neves, 1961, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, X 57, 3 (r); **JJ** — *Apiculiretusispora fructicosa* Higgs, 1975, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2; U, 42 (r); **KK** — *Procoronaspora fasciculata* Love 1960, Marcinki IG 1 borehole, depth 2348.4–2352.8 m, slide 2 dl, S 22 2 (r); **LL** — *Raistrickia* sp., Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, O 56, 2; **MM** — *Neoraistrickia inconstans* Neves, 1961, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, H 60, 2; **NN** — *Convolutispora cerina* Ravn, 1979, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, N 51, 1; **OO** — *Convolutispora tessellata* Hoffmeister, Staplin et Malloy, 1955, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, F 57, 3 (r); **PP** — *Microreticulatisporites concavus* Butterworth et Williams, 1958, Marcinki IG 1 borehole, depth 2393.3–2401.1 m, V 42, 1 (r); **RR** — *Microreticulatisporites concavus* Butterworth et Williams, 1958, Siciny IG 1 borehole, depth 2727.4–2731.6 m, slide 1, V, 17 (r); **SS** — *Microreticulatisporites microreticulatus* Knox, 1950, Siciny IG 1 borehole, depth 2886.0 m, slide 2, E 11, 4; (r) — reworked specimen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Miospore colour was diverse, from orange-brown to very dark brown or even black, but dark colours dominate. In many cases the thermal alteration hindered miospore determination.

In all assemblages from the Siciny IG 1 profile miospores of various colour were observed. These differences were particularly significant in rocks from the upper part of this section while in the lower part they are not so marked, but remain noticeable. Specimens of *Lycospora* revealed orange to dark brown colours and their thermal alteration index amounts 3 to 5/6.

Rocks from the Marcinki IG 1 section provided generally much darker miospores, brown to black in colour, so most specimens were difficult to determine or undeterminable. Their thermal alteration index was assessed at level 4/5–7.

DISCUSSION

The results of palynostratigraphical studies of the Carboniferous rocks from the Siciny IG 1 and Marcinki IG 1 boreholes has provided the most important data to data in constaining the timing of deposition and deformation in the Polish part of the Variscan foreland basin (Górecka-Nowak, 2008).

Two rock successions of different ages were recognized in both sections, the upper Arnsbergian–Alportian and the Duckmantian–Bolsovian. The older rock succession, found in the Siciny IG 1 and in the Marcinki IG 1 sections, was assigned to the *Lycospora subtriquetra–Kraeuselisporites ornatus* (SO) Biozone (Owens *et al*., 2004), corresponding to the upper Arnsbergian–Alporitan. The younger rock succession in the Siciny IG 1 profile was constrained to the *Torispora securis–Torispora laevigata* (SL) Biozone, corresponding to the Bolsovian. In the Marcinki IG 1 borehole, where the quality of the palynological data is not satisfactory, this younger rocks were assigned to the Duckmantian (the *Microreticulatisporites nobilis–Florinites junior* (NJ) Biozone).

The results of the palynostratigraphic studies negate the presence of Viséan rocks in these sections, which had been inferred earlier on the basis of the fossil marine macrofaunas. These palynostratigraphical conclusions, though, generally confirm previous interpretations of stratigraphy based on miospores. Parka and Ślusarczyk (1988) recognized upper Westphalian rocks in the top part of the Carboniferous in the Siciny IG 1 section. In the Marcinki IG 1 borehole Górecka and Parka (1980) and Parka and Ślusarczyk (1988), included all these rocks into the Westphalian. They were partly correct, but the stratigraphy of these rocks appears to be more complicated. Their sampling was sparse, and they overlooked the zone of tectonic deformation.

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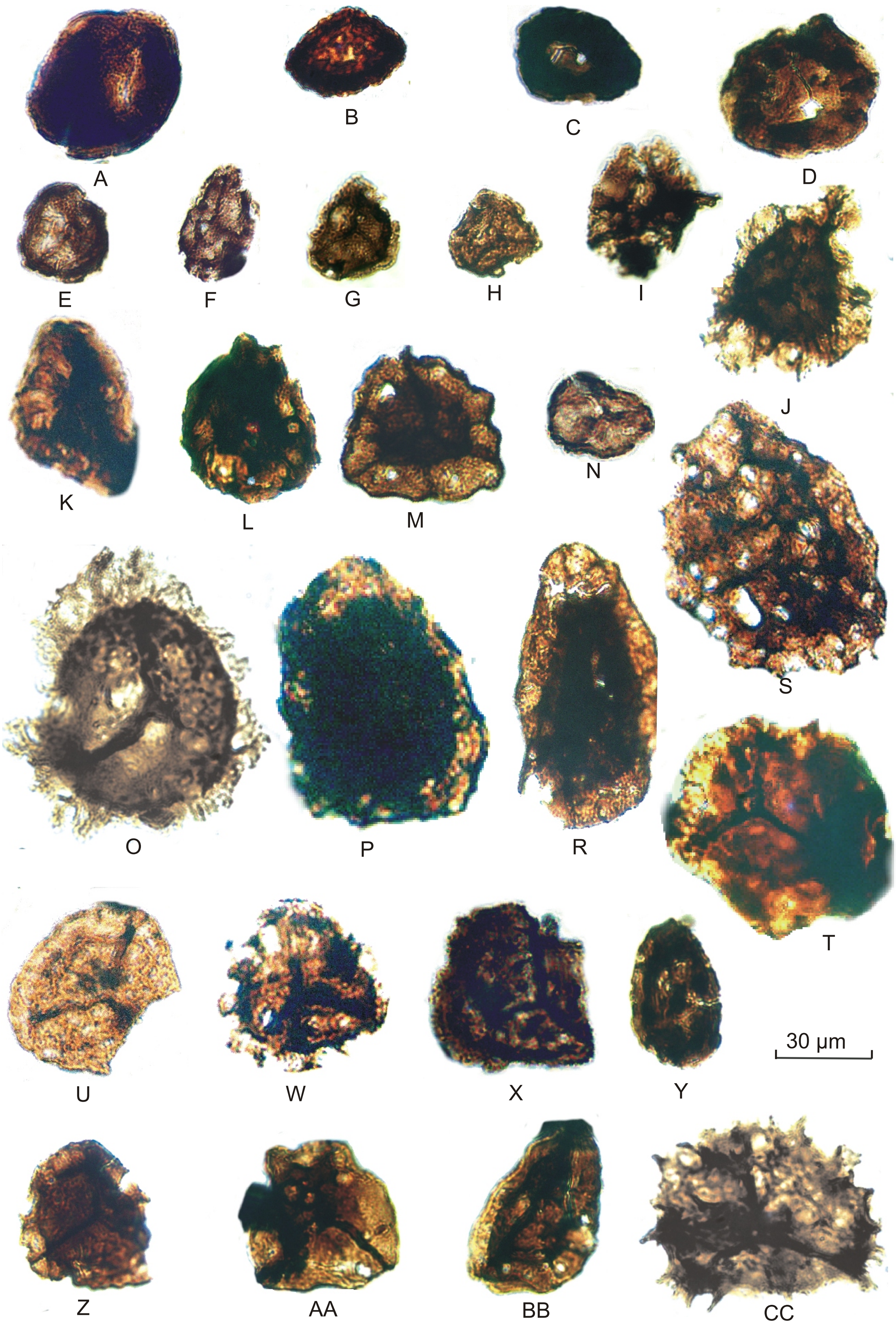
Fig. 6. Miospores from the Carboniferous rocks of the Siciny IG 1 and Marcinki IG 1 boreholes

A — *Microreticulatisporites nobilis* (Wicher) Knox, 1950, Siciny IG 1 borehole, depth 2542.0–2546.7 m, slide 3, G 31; **B** — *Microreticulatisporites nobilis* (Wicher) Knox, 1950, Marcinki IG 1 borehole, depth 2348.4–2352.8 m, slide 1, Y 52; **C** — *Microreticulatisporites nobilis* (Wicher) Knox, 1950, Marcinki IG 1 borehole, depth 2135.1–2141.5 m, slide 3, N 51, 1/3; **D** — *Microreticulatisporites nobilis* (Wicher) Knox, 1950, Marcinki IG 1 borehole, depth 2135.1–2141.5 m, slide 1, X 17; **E** — *Microreticulatisporites nobilis* (Wicher) Knox, 1950, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, H 56, 2/ G, 56, 4; **F** — *Microreticulatisporites sulcatus* (Wilson et Kosanke) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 3, P, 26; **G** — *Dictyotriletes vitilis* Sullivan et Marshall, 1966, Siciny IG 1 borehole, depth 2936.0 m, slide 2, X 33, 3/Y 33, 1; **H** — *Dictyotriletes falsus* Potonié et Kremp, 1955, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1A, N 45, 1, 3; **I** — *Dictyotriletes pactilis* Sullivan et Marshall, 1966, Siciny IG 1 borehole, depth 2936.0 m, slide 1, B, 33, 4 (r); **J** — *Dictyotriletes flavus* Keegan, 1977, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, W 25 (r); **K** — *Corbulispora retiformis* Bharadwaj, 1957, Siciny IG 1 borehole, depth 2814.0 m, slide 1, Q 38, 3; **L** — *Ahrensisporites duplicatus* Neville, 1973, Siciny IG 1 borehole, depth 2814.0 m, slide 1, P 5, 2 (r); **M** — *Ahrensisporites guerickei* (Horst) Potonié et Kremp, 1954, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, B 45, 1; **N** — *Tripartites* sp., Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, G 45, 2, 4; **O** — *Triquitrites* sp., Siciny IG 1 borehole, depth 2727.4–2731.6 m, slide 1, W, 18; **P** — *Triquitrites comptus* Williams, 1973, Marcinki IG 1 borehole, depth 1832.8–1839.4 m, slide 1, Q 23 (r); **R** — *Triquitrites sculptilis* (Balme) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2450.0–2458.0 m, slide 3, Z 52, 3; **S** — *Triquitrites marginatus* Hoffmeister, Staplin et Malloy, 1955, Marcinki IG 1 borehole, depth 2393.3–2401.1 m, slide 5, N 43, 4 (r); **T** — *Bascaudaspora canipa* Owens, 1983, Siciny IG 1 borehole, depth 2921.0–2923.5 m, slide 2, S 23, 4/T 23, 2; **U** — *Knoxisporites stephanophorus* Love, 1960, Siciny IG 1 borehole, depth 2921.0 m, slide 1, Y 43, 3; **W** — *Knoxisporites* sp., Marcinki IG 1 borehole, depth 2321.8–2325.9 m, slide 4, R 50, 4; **X** — *Lophozonotriletes triangulatus* Hughes et Playford, 1961, Siciny IG 1 borehole, depth 2921.0–2923.5 m, slide 1, L 47, 3/M 47, 3 (r); **Y** — *Lophozonotriletes tuberosus* Sullivan, 1964, Siciny IG 1 borehole, depth 2814.0 m, slide 1, U 18 (r); **Z** — *Stenozonotriletes coronatus* Sullivan et Marshall, 1966, Marcinki IG 1 borehole, depth 1832.8–1839.4 m, slide 3, C 41 1/3 (r); **AA** — *Stenozonotriletes lycosporoides* (Butterworth et Williams) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2814.0 m, slide 2, F 8, 3; **BB** — *Stenozonotriletes bracteolus* (Butterworth et Williams) Smith et Butterworth, 1967, Siciny IG 1borehole, depth 2246.5–2255.5 m, slide 1A, G 43, 3 (r); **CC** — *Stenozonotriletes triangulus* Neves 1961, Siciny IG 1 borehole, depth 2936.0 m, slide 2, N 43, 2; **DD** — *Westphalensisporites irregularis* Alpern, 1958, Siciny IG 1 borehole, depth 2246.5–2255.5 m, sample Sic 7, slide 2, K 9, 2, 4/K 10, 1, 3; **EE** — *Savitrisporites nux* (Butterworth et Williams) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2542.0–2546.7 m, slide 6, R 16; **FF** — *Bellispores nitidus* (Horst) Sullivan, 1964, Siciny IG 1 borehole, depth 2814.0 m, slide 2, K 31, 1; **GG** — *Rotaspora* sp., Siciny IG 1 borehole, depth 2886.0 m, slide 3, W 18 (r); **HH** — *Rotaspora knoxi* Butterworth et Williams, 1958, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, Y 62, 2 (r); **II** — *Rotaspora knoxi,* Marcinki IG 1 borehole, depth 1832.8–1839.4 m, slide 1, B 44, 3 (r); **JJ** — *Rotaspora knoxi* Butterworth et Williams, 1958, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1A, H 47, 2/G 47, 4 (r); **KK** — *Rotaspora* sp., Marcinki IG 1 borehole, depth 2348.4–2352.8 m, slide 1, A 17, 2/A 17, 1 (r); **LL** — *Tumulispora dentata* (Hughes and Playford) Turnau, 1975, Siciny IG 1 borehole, depth 2727.4–731.6 m, slide 3, Y 48, 2, 4 (r); **MM** — *Tumulispora malavkensis* Hacquebard, 1957, Siciny IG 1 borehole, depth 2542.0–2546.7 m, slide 5, A 17, 3/B 17, 1 (r); **NN** — *Potonispores delicatus* Playford, 1963, Siciny IG 1 borehole, depth 2921.0–2923.5 m, slide 2, S 40 (r); **OO** — *Grumosisporites* sp., Siciny IG 1 borehole, depth 2886.0 m, slide 2, L 16, 3; **PP** — *Crassispora kosankei* (Potonié et Kremp) Bharadwaj, 1957, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, P 46; **RR** — *Crassispora kosankei* (Potonié et Kremp) Bharadwaj, 1957, Siciny IG 1 borehole, depth 2727.4–2731.6 m, slide 3, K 26, 3; **SS** — *Crassispora kosankei* (Potonié et Kremp) Bharadwaj, 1957, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, O 23, 2; **TT** — *Crassispora kosankei* (Potonié et Kremp) Bharadwaj, 1957, Siciny IG 1 borehole, depth 2727.4–2731.6 m, slide 3, C 24, 4; (r) — reworked specimen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In the Siciny IG 1 and Marcinki IG 1 cores both of the rock successions recognized are duplicated. In the Siciny IG 1 borehole the upper Arnsbergian–Alporitan succession occurs at depth intervals of 2310.5–2319.5 m and 2594.5–2939.0 m while the younger unit was recognized in depth intervals of 2179.2–2255.5 m and 2450.0–2546.7 m. A comparison of palynostratigraphic and tectonic data (Mazur *et al*., 2008) revealed close correspondence. It allowed establishing boundaries of stratigraphic sequences using thrust surfaces. Only the boundary between the Bolsovian and the upper Arnsbergian–Alporitan rocks, set at a depth of 2300.0 m, has been established arbitrarily (Fig. 2). A similar, though less well documented, geological situation was observed in the Marcinki IG 1 profile, where the Duckmantian deposits occur twice in the section (depth intervals of 2135.1–2141.5 and 2348.4–2352.8 m) amid the older strata. The distribution of these stratigraphical intervals in this section may also corresponds to the tectonic reflect of the rocks (Fig. 3).

The tectonic repetitions of these stratigraphical intervals provide evidence of post-Bolsovian thrusting or faulting in the Polish part of the Variscan foreland basin. This deformation event, representing the final Variscan tectonism, appears to be younger then supposed earlier (Oberc, 1978, 1991; Karnkowski and Rdzanek, 1982*b*, Wierzchowska-Kicułowa, 1984; Żelichowski, 1984; Pożaryski *et al*., 1992). Tectonism of this age has also been shown in other parts of the Variscan foreland basin system (i.e. British Isles, Germany) (Mazur *et al*., 2008).

The fossil assemblages occurring in these rocks in both sections studied are complex and consist of mixed miospore associations and macrofossils (Górecka-Nowak, 2008). The stratigraphical ranges of the reworked miospores from the Siciny IG 1 section indicate that Famennian–Tournaisian and upper Viséan–lower Serpukhovian rocks were eroded and the rock material, containing miospores, was redeposited during the sedimentation of the rocks studied. The detrital zircon geochronology from the upper Arnsbergian–Alporitan rocks in this section also indicates Upper Devonian and Lower Carboniferous source rocks (Mazur *et al*., 2008).

Rocks from the Marcinki IG 1 borehole also revealed a record of the redeposition of upper Viséan–lower Serpukhovian rocks during late Arnsbergian–Alporitan and Duckmantian time. The high thermal alteration that caused the poor preservation of miospores from this section is probably responsible for the lack of older reworked miospores, which may though be represented among the black unidentified specimens.

The occurrence of younger miospores in rocks where older marine macrofaunas had been found earlier means that the macrofossils are reworked. This explanation holds for the Siciny IG 1 and Marcinki IG 1 boreholes, and also for other sections (Fig. 1), in which both biostratigraphical methods were applied and provided contradictory results (Górecka-Nowak, 2008). The macrofaunas were probably derived from the same upper Viséan–lower Serpukhovian rocks that were the source rocks of reworked miospores. Elucidation of the possible mechanism of the macrofaunal redeposition is not easy. Macrofossils are usually preserved as moulds and impressions and most have been found in the dark gray mudstones (Cebulak and Dembowski, 1973; Kühn and Paprocka, 1979). It is interesting that in the Siciny IG 1 and Marcinki IG 1 sections, macrofaunas were found in the same depth intervals as contain clasts of dark grey claystone and mudstone, occurring in grey mudstone or sandstone beds (Figs. 2 and 3). These clasts are abundant and of various size. The smallest of them are easy to recognize in the core, but blocks larger than the diameter of the core may also occur and could be erroneously considered as beds. It is possible that the macrofaunas came from just such larger blocks. However, this suggestion is difficult to verify as macrofaunas have been taken from the cores and only future drilling might solve this problem.

The reworked nature of the macrofaunas has ecological and stratigraphical consequences. The latter were discussed by

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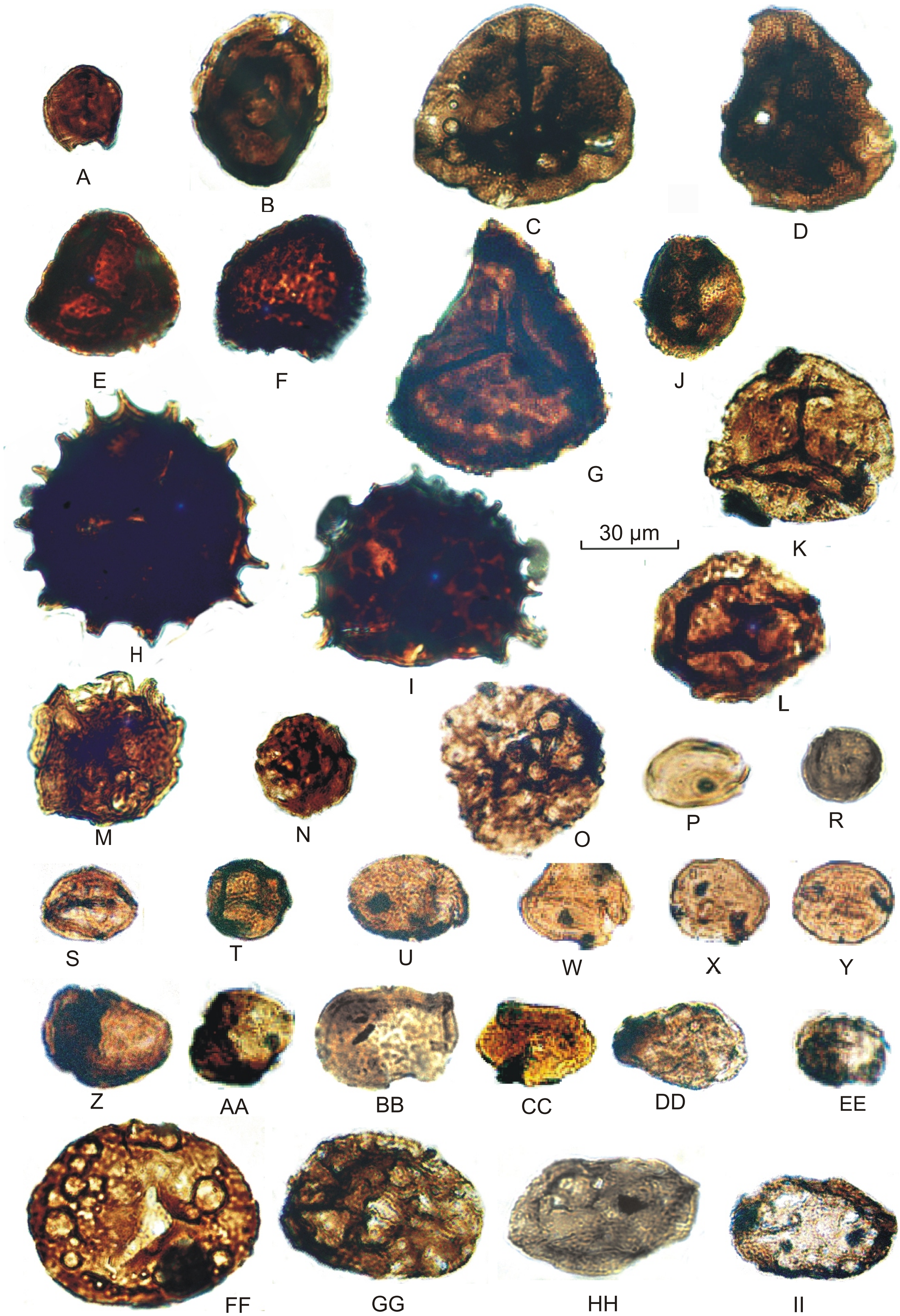
Fig. 7. Miospores from the Carboniferous rocks of the Siciny IG 1 and Marcinki IG 1 boreholes

A — *Tholisporites* sp., Siciny IG 1 borehole, depth 2886.0 m, slide 3, W 18; **B** — *Densosporites gracilis* Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2211.0–2211.3 m, slide 1, N 39, 4; **C** — *Densosporites* sp., Marcinki IG 1 borehole, depth 1832.8–1839.4 m, slide 1, Z 51, 1; **D** — *Densosporites intermedius* Butterworth et Williams, 1958, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, Q 20, 4/Q 21, 3; **E** — *Lycospora pusilla* (Ibrahim) Sommers, 1972, Marcinki IG 1 borehole, depth 1832.8–1939.4 m, slide 4, G 43, 4; **F** — *Lycospora pusilla* (Ibrahim) Sommers, 1972, 1972, Marcinki IG 1 borehole, depth 2159.7–2165.1 m, slide 3, N 24; **G** — *Lycospora pusilla* (Ibrahim) Sommers, 1972, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, U 19; **H** — *Lycospora subtriquetra* (Luber) Potonié et Kremp, 1956, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, A 10; **I** — *Cingulizonates capistratus* (Hoffmeister, Staplin et Malloy) Staplin et Jansonius, 1964, Siciny IG 1 borehole, depth 2921.0–2923.5 m, slide 1, Z 61, 3; **J** — *Cirratriradites rarus* (Ibrahim) Schopf, Wilson et Bentall, 1944, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, Y 24 2/Y 25, 1; **K** — *Radiizonates tenuis* (Loose) Smith et Butterworth, 1967, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1A, O 57; **L** — *Radiizonates mirabilis* Phillips et Clayton, 1980, Siciny IG 1 borehole, depth 2921.0–2923.5 m, slide 2, Q 53, 1/3 (r); **M** — *Radiizonates mirabilis* Phillips et Clayton, 1980, Siciny IG 1 borehole, depth 2727.4–2731.6 m, slide 1 C 19 (r); **N** — *Prolycospora claytonii* Turnau, 1978, Siciny IG 1 borehole, depth 2814.0 m, slide 1, Y 32, 3 (r); **O** — *Kraeuselisporites ornatus* (Neves) Owens, Mishell et Marshall, 1976, Siciny IG 1 borehole, depth 2939.0 m, slide 1, Y 39; **P** — cf. *Kraeuselisporites,* Marcinki IG 1 borehole, depth 1832.8–1839.4 m, slide kr, C 55, 2/C 56, 1; **R** — *Kraeuselisporites ornatus* (Neves) Owens, Mishell et Marshall, 1976, Marcinki IG 1 borehole, depth 1832. 8–1839.4 m, slide 2, Y 44, 4; **S** — *Kraeuselisporites ornatus* (Neves) Owens, Mishell et Marshall, 1976, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, K 62, 3; **T** — *Kraeuselisporites ornatus* (Neves) Owens, Mishell et Marshall, 1976, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, P 35, 4; **U** — *Vallatisporites ciliaris* (Luber) Sullivan, 1964, Siciny IG 1 borehole, depth 2246.5–2255.5 m, N 50, 4/O 50, 2 (r); **W** — *Vallatisporites ciliaris* (Luber) Sullivan, 1964, Siciny IG 1 borehole, depth 2727.4–2731.6 m, sample Sic 5, slide 3, C 12, 3 (r); **X** — *Vallatisporites verrucosus* Hacquebard, 1957, Siciny IG 1 borehole, depth 2814.0 m, sample S 10, slide 1, D 42 (r); **Y** — *Vallatisporites* sp., Marcinki IG 1 borehole, depth 1832.8–1839.4 m, Mar 8 sample, slide 4, Y 34, 2 (r); **Z, AA, BB** — *Discernisporites micromanifestus* (Hacquebard) Sabry et Neves, 1971, Siciny IG 1 borehole, depth 2921.0–2923.5 m, slide 2; 24. B 45, 1; 25. F 53, 1; 26. J 59, 3 (r); **CC** — *Spinozonotriletes uncatus* Hacquebard, 1957, Siciny IG 1 borehole, depth 2939.0 m, slide 1, F 32, 1; (r) — reworked specimen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Górecka-Nowak (2008). The occurrence of these marine macrofossils had been regarded as proof of the marine origin of these Carboniferous rocks. As the macrofaunas is reworked, this argument is negated. The palynofacies observations reveals that the organic material occurring in the rocks studied is of terrigenous origin. Neither amorphic organic matter of aquatic origin, nor marine palynomorphs were found. The results of the palynofacies studies did not provide proof of the marine origin of these rocks, although they can not exclude it as terrigenous material may also dominate in marine sediments. The lack of palaeontological indicators of a marine origin of these rocks should be noted in future sedimentological studies.

The observations of miospore colour have provided data on regional changes in thermal maturity and on the thermal history of the organic matter. They revealed that miospores from the Siciny IG 1 borehole are generally paler than those from the Marcinki IG 1 borehole. This means that rocks in the Marcinki IG 1 borehole are more thermally altered than those in the Siciny IG 1 borehole. These data as well as data from some other boreholes (Górecka-Nowak, 2007) were used to analyse the regional variations in thermal maturity of these Carboniferous rocks (Nowak, 2003).

In the Siciny IG 1 borehole the thermal history of the organic matter is recorded in the colour of miospores occurring in mixed assemblages, as the stratigraphically older specimens reveal a generally darker colour. In the Serpukhovian rocks, where Late Devonian to Alportian miospores occur, these differences are less prominent and all miospores reveal an overmature stage of thermal alteration. This probably means that all these miospores, Serpukhovian and older, had a similar thermal history and the differences in colour depends on the duration of heating. This is unlikely in the case of the Bolsovian assemblages. These assemblages consist of Pennsylvanian miospores of orange colour and overmature, brown to black, reworked specimens. The majority of the reworked miospores represent Late Devonian to Serpukhovian taxa. This may be evidence of thermal regime changes in time. Probably constant or at least similar thermal conditions occurred in the Late Devonian to the Alportian time interval. Later, between the Alportian and Bolsovian, the heating effect became weaker. This weaker heating in the Bolsovian caused miospores of this age to show a mature stage of thermal alteration.

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Fig. 8. Miospores from the Carboniferous rocks of the Siciny IG 1 and Marcinki IG 1 boreholes

A — *Auroraspora asperella* (Kedo) Van der Zwan, 1980, Siciny IG 1 borehole, depth 2923.0 m, slide 1, Z 45, 3 (r); **B** — *Auroraspora panda* Turnau, 1978, Siciny IG 1 borehole, depth 2727.4–2731.6 m, slide 1, Q 53, 3 (r); **C** — *Spalaeotriletes arenaceous* Neves et Owens, 1966, Siciny IG 1 borehole, depth 2921.0–2923.5 m, slide 1, U 55, 3; **D** — *Spalaeotriletes arenaceous* Neves et Owens, 1966, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, V 46, 1; **E** — *Grandispora lupata* Turnau, 1975, Siciny IG 1 borehole, depth 2814.0 m, slide 1, C 22 (r); **F** — *Grandispora lupata* Turnau, 1975, Siciny IG 1 borehole, depth 2909.0 m, slide 2,V 20, 3/4 (r); **G** — *Grandispora lupata* Turnau, 1975, Siciny IG 1 borehole, depth 2814.0 m, slide 1, U 19, 4 (r); **H** — *Grandispora cornuta* Higgs, 1975, Siciny IG 1 borehole, depth 2211.0–2211.3 m, slide 2, B 52, 1 (r); **I** — *Grandispora cornuta* Higgs, 1975, Siciny IG 1 borehole, depth 2909.0 m, slide 2, M 47, 1 (r); **J** — *Grandispora* cf. *gracilis* (Kedo) Higgs, Avkhim., Loboz., Maziane, Stemp., Streel, 2000, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 2, O 56 (r); K — *Grandispora spinosa* Hoffmeister, Staplin et Malloy, 1955, Siciny IG 1 borehole, depth 2310.5–2319.5 m, slide kr, M 52, 3/N 52, 1; **L** — *Grandispora* sp., Siciny IG 1 borehole, depth 2936.0 m, slide 1, C 38; **M** — *Perotrilites tessellatus* (Staplin) Neville, 1973, Siciny IG 1 borehole, depth 2921.0 m, slide 1, E 6 (r); **N** — *Rugospora minuta* Neves et Ioannides, 1974, Siciny IG 1 borehole, depth 2909.0 m, slide 2, X 5, 2/4 (r); **O** — *Rugospora* sp., Siciny IG 1 borehole, depth 2936.0 m, slide 1, T 48, 1/3 (r); **P** — *Laevigatosporites perminutus* Alpern, 1958, Siciny IG 1 borehole, depth 2181.2–2188.5 m, slide 3, P 32, 2; **R** — *Punctatosporites minutus* (Ibrahim) Alpern et Doubinger, 1973, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, P 50, 4; **S** — *Punctatosporites granifer* (Potonié et Kremp) Alpern et Doubinger, 1973, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 2, N, 6; **T** — *Punctatosporites granifer* (Potonié et Kremp) Alpern et Doubinger, 1973, Siciny IG 1 borehole, depth 2181.2–2188.5 m, slide 1, M 16, 2; **U** — *Punctatosporites granifer* (Potonié et Kremp) Alpern et Doubinger, 1973, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 3, Y 20, 2; **W** — *Punctatosporites minutus* (Ibrahim) Alpern et Doubinger, 1973, Siciny IG 1 borehole, depth 2181.2–2188.5 m, slide 3, Q 16, 1; **X** — *Punctatosporites minutus* (Ibrahim) Alpern et Doubinger, 1973, Siciny IG 1 borehole, depth 2208.0–2208.2 m, slide 2, A 11, 4/B 11, 2; **Y** — *Punctatosporites minutus* (Ibrahim) Alpern et Doubinger, 1973, Siciny IG 1 borehole, depth 2208.0–2208.2 m, sample S 7, slide 2, B 11, 2; **Z** — *Torispora securis* (Balme) Alpern, Doubinger et Horst, 1965, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1A, H 57, 1, 3; **AA** — *Torispora securis* (Balme) Alpern, Doubinger et Horst, 1965, Siciny IG 1 borehole, depth 2542.0–2546.7 m, slide 5, O 38, 4; **BB** — *Torispora securis* (Balme) Alpern, Doubinger et Horst, 1965, Siciny IG 1 borehole, depth 2181.2–2188.5 m, slide 1, M 21, 4; **CC** — *Torispora securis* (Balme) Alpern, Doubinger et Horst, 1965, Siciny IG 1 borehole, depth 2181.2–2188.5 m, slide 1, M 12, 4; **DD** — *Torispora securis* (Balme) Alpern, Doubinger et Horst, 1965, Siciny IG 1 borehole, depth 2450.0–2458.0 m, slide 3A, U 19, 1; **EE** — *Torispora securis* (Balme) Alpern, Doubinger et Horst, 1965, Siciny IG 1 borehole, depth 2450.0–2458.0 m, slide 3A, T 39, 4; **FF** — *Schulzospora rara* Kosanke, 1950, Siciny IG 1 borehole, depth 2936.0 m, slide 1, H, 43; **GG** — *Schulzospora ocellata* (Horst) Potonié et Kremp, 1955, Siciny IG 1 borehole, depth 2450.0–2458.0 m, slide 3, O 19, 1 (r); **HH** — *Schulzospora elongata* Hoffmeister, Staplin et Malloy, 1955, Siciny IG 1 borehole, depth 2909.0–2912.0 m, slide 1, D 27; **II** — *Schulzospora elongata* Hoffmeister, Staplin et Malloy, 1955, Siciny IG 1 borehole, depth 2246.5–2255.5 m, slide 1, T 24, 3 (r); (r) — reworked specimen

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APPENDIX A

Occurrence of miospore taxa in rocks from the Siciny IG 1 borehole

Taxa	2179.2 m	2180.0 m	2181.2–2188 m	2208.0 m	2211.0 m	2246.5–2255 m	2310.5–2319 m	2450.0–2458 m	2542.0–2546 m	2594.5–2598 m	2727.4–2731 m	2814.0 m	2886.0 m	2890.0 m	2909.0–2912.0 m	2921.0–2923.5 m	2936.0 m	2939.0 m
Acanthotriletes baculatus Neves, 1961						Δ												
Acanthotriletes falcatus (Knox) Potonié et Kremp, 1955				Δ		Δ										•		
Acanthotriletes echinatus (Knox) Potonié et Kremp, 1955						•					•							
Acanthotriletes hastatus Sullivan et Marshall, 1966						Δ									•	•		
Acanthotriletes triquetrus Smith et Butterworth, 1967						•												
Ahrensisporites duplicatus Neville, 1973												Δ			Δ			
Ahrensisporites guerickei (Horst) Potonié et Kremp, 1954						•									•		•	•
Anaplanisporites baccatus (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967		•	•	•		•	•	•			•	•	•		•	•		
Anaplanisporites denticulatus Sullivan, 1964						Δ					Δ							
Anaplanisporites globulus (Butterworth et Williams) Smith et Butterworth, 1967																•		•
Apiculiretusispora fructicosa Higgs, 1975															∇			
Apiculiretusispora multiseta (Luber) Butterworth et Spinner, 1966																∇		
Apiculatisporis irregularis (Alpern) Smith et Butterworth, 1967				•		•												
Apiculatisporis variocorneus Sullivan, 1964					•	•												
Auroraspora asperella (Kedo) Van der Zwan, 1980											∇				∇	∇		
Auroraspora macra Sullivan, 1964						∇						∇			∇			
Auroraspora panda Turnau, 1978								∇				∇			∇			
Bascaudaspora canipa Owens, 1983						Δ						•				•		
Bellispores nitidus (Horst) Sullivan, 1964						Δ						•						
Calamospora microrugosa (Ibrahim) Schopf, Wilson et Bentall, 1944												•	•			•	•	
Calamospora parva Guennel, 1958												•				•		
Calamospora straminea Wilson et Kosanke, 1944			•				•		•									
Camptotriletes bucculentus (Loose) Potonié et Kremp, 1955					•													
Cingulizonates capistratus (Hoffmeister, Staplin et Malloy) Staplin et Jansonius, 1964						Δ										Δ		
Cirratriradites rarus (Ibrahim) Schopf, Wilson et Bentall, 1944															•			
Converrucosisporites armatus (Dybova et Jachowicz) Smith et Butterworth, 1967						•			•									
Convolutispora cerina Ravn, 1979					Δ										•			
Convolutispora jugosa Smith et Butterworth, 1967						Δ												
Convolutispora cf. *punctatimura* Staplin, 1960			Δ															
Convolutispora tessellata Hoffmeister, Staplin et Malloy, 1955						Δ												
Corbulispora retiformis Bharadwaj, 1957												•						
Crassispora kosankei (Potonié et Kremp) Bharadwaj, 1957		•		•		•	•		•	•	•	•			•	•	•	•
Crassispora maculosa (Knox) Sullivan, 1964															Δ	Δ		
Cribrosporites cribellatus Sullivan, 1964												Δ						
Cyclogranisporites aureus (Loose) Potonié et Kremp, 1955						•		•					•					
Cyclogranisporites minutus Bharadwaj, 1957						•		•						•				
Cyclogranisporites palaeophytus Neves et Ioannides, 1974														∇				

Appendix A continued

Taxa	2179.2 m	2180.0 m	2181.2–2188 m	2208.0 m	2211.0 m	2246.5–2255 m	2310.5–2319 m	2450.0–2458 m	2542.0–2546 m	2594.5–2598 m	2727.4–2731 m	2814.0 m	2886.0 m	2890.0 m	2909.0–2912.0 m	29210.–2923.5 m	2936.0 m	2939.0 m
Densosporites gracilis Smith et Butterworth, 1967		•		•	•													
Densosporites intermedius Butterworth et Williams, 1958						•												
Densosporites pseudoannulatus Butterworth et Williams, 1958								•	•									
Densosporites simplex Staplin, 1960									Δ									
Densosporites sphaerotriangularis Kosanke, 1950						•									•			
Densosporites variomarginatus Playford, 1963									Δ							Δ		
Dictyotriletes equigranulatus Neville, 1968								Δ										
Dictyotriletes falsus Potonié et Kremp, 1955						•												
Dictyotriletes flavus Keegan, 1977															Δ			
Dictyotriletes muricatus (Kosanke) Smith et Butterworth, 1967	•		•															
Dictyotriletes pactilis Sullivan et Marshall, 1966																	Δ	
Dictyotriletes vitilis Sullivan et Marshall, 1966																•	•	
Discernisporites micromanifestus (Hacquebard) Sabry et Neves, 1971											Δ					Δ		
Grandispora echinata Hacquebard, 1957																	∇	
Grandispora cf. *gracilis* (Kedo) Higgs, Avkhim., Loboz., Maziane, Stemp., Streel, 2000															∇			
Grandispora cornuta Higgs, 1975					∇							∇		∇				
Grandispora lupata Turnau, 1975												∇						
Grandispora spinosa Hoffmeister, Staplin et Malloy, 1955							•											
Granulatisporites adnatoides (Potonié et Kremp) Smith et Butterworth, 1967		•				•												
Granulatisporites microgranifer Ibrahim, 1933						•		•										
Granulatisporites minutus Potonié et Kremp, 1955					•			•						•				
Grumosisporites sp.													•					
Knoxisporites stephanophorus Love, 1960															•	•		•
Kraeuselisporites hibernicus Higgs, 1975											∇							
Kraeuselisporites ornatus (Neves) Owens, Mishell et Marshall, 1976											•			•		•		•
Laevigatosporites perminutus Alpern, 1958			•															
Laevigatosporites vulgaris (Ibrahim) Alpern et Doubinger, 1973			•		•													
Leiotriletes tumidus Butterworth et Williams, 1958						Δ		Δ				•			•	•		
Lophotriletes granoornatus Artüz, 1957						•												
Lophozonotriletes triangulatus Hughes et Playford, 1961											∇					∇		
Lophozonotriletes tuberosus Sullivan, 1964												∇						
Lycospora pusilla (Ibrahim) Sommers, 1972	•	•		•		•					•	•	•		•	•	•	•
Lycospora subtriquetra (Luber) Potonié et Kremp, 1956				•			•				•				•		•	
Microreticulatisporites concavus Butterworth et Williams, 1958						Δ	Δ				Δ	Δ				Δ	Δ	Δ
Microreticulatisporites microreticulatus Knox, 1950						Δ	•	Δ					•			•		
Microreticulatisporites nobilis (Wicher) Knox, 1950	•		•		•	•		•	•									
Microreticulatisporites punctatus Knox, 1950						Δ	•				•		•		•	•		
Microreticulatisporites sulcatus (Wilson et Kosanke) Smith et Butterworth, 1967				•		•												
Murospora margodentata Beju, 1970			Δ															

Appendix A continued

Taxa	2179.2 m	2180.0 m	2181.2–2188 m	2208.0 m	2211.0 m	2246.5–2255 m	2310.5–2319 m	2450.0–2458 m	2542.0–2546 m	2594.5–2598 m	2727.4–2731 m	2814.0 m	2886.0 m	2890.0 m	2909.0–2912.0 m	2921.0–2923.5 m	2936.0 m	2939.0 m
Neoraistrickia inconstans Neves, 1961															•		•	
Orbisporis orbiculus Bharadwaj et Venkatachala, 1961														Δ				
Perotrilites tessellatus (Staplin) Neville, 1973																Δ		
Potoniespores delicatus Playford, 1963						Δ										Δ		
Procoronaspora serrata (Playford) Smith et Butterworth, 1967						Δ												Δ
Prolycospora claytonii Turnau, 1978												∇						
Punctatisporites aerarius Butterworth et Williams, 1958													•				•	•
Punctatisporites glaber (Naumova) Playford, 1962														•				
Punctatisporites irrasus Hacquebard, 1957												Δ			Δ	Δ		
Punctatisporites minutus Kosanke, 1950												•					•	
Punctatisporites nitidus Hoffmeister, Staplin et Malloy, 1955						•		•	•			•				•		
Punctatisporites parvivermiculatus Playford, 1962															Δ		Δ	
Punctatisporites punctatus Ibrahim, 1933			•		•	•		•										
Punctatosporites granifer (Potonié et Kremp) Alpern et Doubinger, 1973			•		•	•		•										
Punctatosporites minutus (Ibrahim) Alpern et Doubinger, 1973		•	•	•	•	•												
Punctatosporites punctatus (Kosanke) Alpern et Doubinger, 1973						•		•										
Punctatosporites sp.						•			•									
Pustulatisporites dolbii Higgs, Clayton et Keegan, 1988																	∇	
Pustulatisporites papillosus (Knox) Potonié et Kremp, 1955															•			
Radiizonates mirabilis Phillips et Clayton, 1980											∇					∇		
Radiizonates tenuis (Loose) Smith et Butterworth, 1967						•		•										
Raistrickia nigra Love, 1960								Δ							Δ			
Raistrickia saetosa (Loose) Schopf, Wilson et Bentall, 1944								•										
Retusotriletes avonensis Playford, 1963																	∇	
Retusotriletes communis Naumova, 1953															∇	∇		
Retusotriletes incohatus Sullivan, 1964																	∇	
Rotaspora fracta (Schemel) Smith et Butterworth, 1967																Δ		
Rotaspora knoxi Butterworth et Williams, 1958						Δ	Δ						Δ		Δ			
Rotaspora sp.						Δ	Δ					Δ	Δ		Δ	Δ		
Rugospora minuta Neves et Ioannides, 1974														∇	∇		∇	
Rugospora sp.																	•	
Savitrisporites cingulatus (Alpern) Laveine, 1965						•												
Savitrisporites nux (Butterworth et Williams) Smith et Butterworth, 1967			•			•	•		•		•							
Schulzospora campyloptera (Waltz) Hoffmeister, Staplin et Malloy, 1955																Δ		
Schulzospora elongata Hoffmeister, Staplin et Malloy, 1955						Δ					•				•			
Schulzospora ocellata (Horst) Potonié et Kremp, 1955								Δ			•						•	
Schulzospora plicata Butterworth et Williams, 1958				Δ														•
Schulzospora rara Kosanke, 1950											•					•	•	
Schulzospora sp.	Δ		Δ	Δ		Δ				•	•					•		•

Appendix A continued

Taxa	2179.2 m	2180.0 m	2181.2–2188 m	2208.0 m	2211.0 m	2246.5–2255 m	2310.5–2319 m	2450.0–2458 m	2542.0–2546 m	2594.5–2598 m	2727.4–2731 m	2814.0 m	2886.0 m	2890.0 m	2909.0–2912.0 m	2921.0.–2923.5 m	2936.0 m	2939.0 m
Secarisporites remotus Neves, 1961																•		
Spelaeotriletes arenaceous Neves et Owens, 1966							•								•	•		
Spinozonotriletes uncatus Hacquebard, 1957																		•
Stenozonotriletes bracteolus (Butterworth et Williams) Smith et Butterworth, 1967						Δ	•											
Stenozonotriletes coronatus Sullivan et Marshall, 1966													Δ			Δ	Δ	
Stenozonotriletes lycosporoides (Butterworth et Williams) Smith et Butterworth, 1967	Δ		Δ					Δ				•			•			
Stenozonotriletes triangulus Neves, 1961																	•	•
Tetraporina sp.					∇													
Tholisporites sp.													Δ					
Torispora securis (Balme) Alpern, Doubinger et Horst, 1965	•		•		•	•		•	•									
Torispora sp.	•		•															
Tricidarisporites balteolus Sullivan et Marshall, 1966																	Δ	
Tripartites trilingulis (Horst) Smith et Butterworth, 1967						Δ												
Triquitrites marginatus Hoffmeister, Staplin et Malloy, 1955						Δ												
Triquitrites sculptilis (Balme) Smith et Butterworth, 1967						•		•										
Triquitrites tribullatus (Ibrahim) Schopf, Wilson et Bentall, 1944						•												
Triquitrites sp.						•					•					•		
Tumulispora dentata (Hughes and Playford) Turnau, 1975											∇							
Tumulispora malavkensis Hacquebard, 1957									∇									
Waltzispora planiangulata Sullivan, 1964						Δ												
Waltzispora polita (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967						Δ												
Westphalensisporites irregularis Alpern, 1958			•			•												
Vallatisporites ciliaris (Luber) Sullivan, 1964						Δ					Δ						Δ	
Vallatisporites verrucosus Hacquebard, 1957												∇						
Verrucosisporites baccatus Staplin, 1960												Δ			Δ			
Verrucosisporites cerosus (Hoffmeister, Staplin et Malloy) Butterworth et Williams, 1958			Δ			Δ										•	•	
Verrucosisporites donarii Potonié et Kremp, 1955						•		•										
Verrucosisporites irregularis Phillips et Clayton, 1980																∇		
Verrucosisporites microtuberosus (Loose) Smith et Butterworth, 1967						•						•						
Verrucosisporites morulatus (Knox) Smith et Butterworth, 1967							Δ											
Verrucosisporites nodosus Sullivan et Marshall, 1966									Δ									
Vestispora costata (Balme) Spode, 1968									•									
Vestispora laevigata Wilson et Venkatachala, 1963						•												

• — taxon belonging to the youngest miospores, having stratigraphic value; Δ — taxon characteristic of the Viséan and/or early Serpukhovian; ∇ — taxon characteristic of the Fammennian and/or Tournaisian; the gray shade indicates the Bolsovian rocks and the unshaded area indicates samples assigned to the upper Arnsbergian–Alporitan

APPENDIX B

Occurrence of miospore taxa in rocks from the Marcinki IG 1 borehole

Taxa	1832.8–1839.4 m	1988.3–1994.0 m	2135.1–2141.5 m	2159.7–2165.1 m	2159.7–2165.1 m	2190.1–2197.5 m	2321.8–2325.9 m	2348.4–2352.8 m	2393.3–2401.1 m
Anaplanisporites baccatus (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967	•	•				•			•
Anaplanisporites globulus (Butterworth et Williams) Smith et Butterworth, 1967	•	•			•				•
Calamospora parva Guennel, 1958			•				•		
Converrucosisporites armatus (Dybova et Jachowicz) Smith et Butterworth, 1967			•						
Crassispora kosankei (Potonié et Kremp) Bharadwaj, 1957	•								•
Densosporites pseudoannulatus Butterworth et Williams, 1958	•						•		
Kraeuselisporites ornatus (Neves) Owens, Mishell et Marshall, 1976	•								•
Microreticulatisporites concavus Butterworth et Williams, 1958	Δ					Δ		Δ	Δ
Microreticulatisporites microreticulatus Knox, 1950	•							Δ	•
Microreticulatisporites nobilis (Wicher) Knox, 1950			•					•	
Microreticulatisporites punctatus Knox, 1950	•								•
Procoronaspora fasciculata Love, 1960								Δ	
Procoronaspora sp.								Δ	
Punctatisporites cf. *sinuatus*									•
Punctatisporites nitidus Hoffmeister, Staplin et Malloy, 1955		•							
Punctatosporites sp.			•						
Rotaspora knoxi Butterworth et Williams, 1958	Δ							Δ	
Rugospora corporata Neves et Owens, 1966		•							
Schulzospora rara Kosanke, 1950	•								
Stenozonotriletes bracteolus (Butterworth et Williams) Smith et Butterworth, 1967									•
Stenozonotriletes lycosporoides (Butterworth et Williams) Smith et Butterworth, 1967		•							
Stenozonotriletes coronatus Sullivan et Marshall, 1966	Δ								
Triquitrites comptus Williams, 1973	Δ								
Triquitrites marginatus Hoffmeister, Staplin et Malloy, 1955								Δ	Δ
Walzispora polita (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967		•							
Walzispora sp.	•	•						•	
cf. *Westphalensisporites irregularis* Alpern, 1958								•	
Verrucosisporites donarii Potonié et Kremp, 1955								•	

• — taxon belonging to the youngest miospores, having stratigraphic value; Δ — reworked miospores; the gray shade indicates the Bolsovian rocks and the unshaded area indicates all the remaining samples