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Remarks on palynostratigraphy of the Namurian Wałbrzych Formation in the northern part of the Intrasudetic Basin (SW Poland)

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Rich assemblages of the Namurian miospores were recorded in the deposits of the Wałbrzych Formation from the northern part of the Intrasudetic Basin. One hundred twenty five miospore taxa were determined and two miospore zones were distinguished. Deposits from Konradów and Biały Kamień belong to the *Stenozonotriletes triangulus-Rotaspora knoxi* (TK) Zone, correlated to the middle Namurian A. Deposits from Szczawno Zdrój appeared to be younger, because they represents the *Lycospora subtriquetra-Kraeuselisporites ornatus* (SO) Zone (late Namurian A).

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Key words: Instrasudetic Basin, Namurian, palynostratigraphy, miospores.

INTRODUCTION

The Upper Carboniferous[1] deposits of the Intrasudetic Basin are of continental origin, which limits the possibilities to date them. The lack of marine horizons with fauna means that the age of these deposits may be determined only on the basis of the fossil flora. Initial macrofloral stratigraphical studies were undertaken at the beginning of the 20th century. Palynological studies of the Namurian deposits (the Wałbrzych and Biały Kamień formations) made in the 1960's allowed precise conclusions on the age of these units to be drawn, simultaneously solving some local stratigraphical problems.

It should be pointed out here that the palynological studies of these deposits had been done before many stratigraphically important taxa were described and accepted as markers of particular biozones. Palynological data in older publications are thus hardly comparable to those from the commonly used miospore zonation method, or to local palynostratigraphic divisions made for other areas where Namurian deposits occur. Undertaking palynostratigraphic studies of the Wałbrzych Formation now, after so many years, was due to the authors' interest in correlating results from this area with more recent results of such studies from other areas.

In the Intrasudetic Basin, there are certain difficulties with the stratigraphical correlation of the Namurian deposits because of their monotonous character. Lithological criteria are commonly used for this purpose, but sometimes they may be deceptive. The only effective and usable method of correlation seems to be palynostratigraphy.

The results of recent palynostratigraphical studies of the Wałbrzych Formation provided rich and interesting data. Many miospore taxa, important for age determination, were found and this allowed precise detailed stratigraphy to be done, using miospore zonation criteria from Western Europe. Conclusions on the age of particular parts of the studied profile indicate that revision of former opinions on their stratigraphy is necessary. Deposits of the Wałbrzych Formation from Szczawno Zdrój, which had been believed to be older than the strata of this formation from Konradów and Biały Kamień, appeared to be in fact younger.

[1]Term "Upper Carboniferous" is applied in this paper in the traditional meaning, used in Central Europe. It is also shown in the stratigraphical tables, where is compared with a new, global stratigraphical division of the Carboniferous (Menning *et al*., 2000; Remane, 2000) (Figs. 2 and 4).

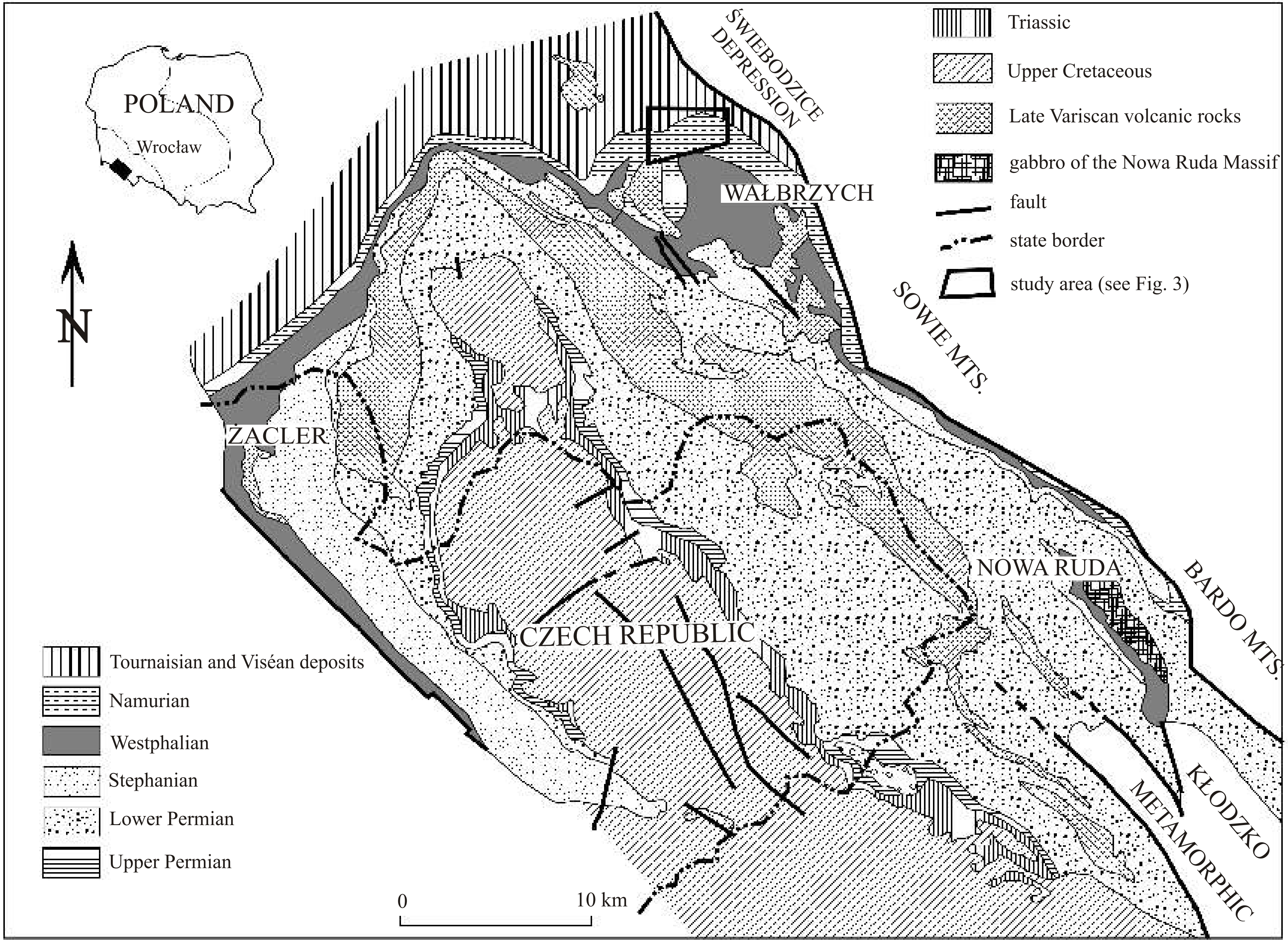

Fig. 1. Geologic map of the Intrasudetic Basin (from Teisseyre *et al*., 1957)

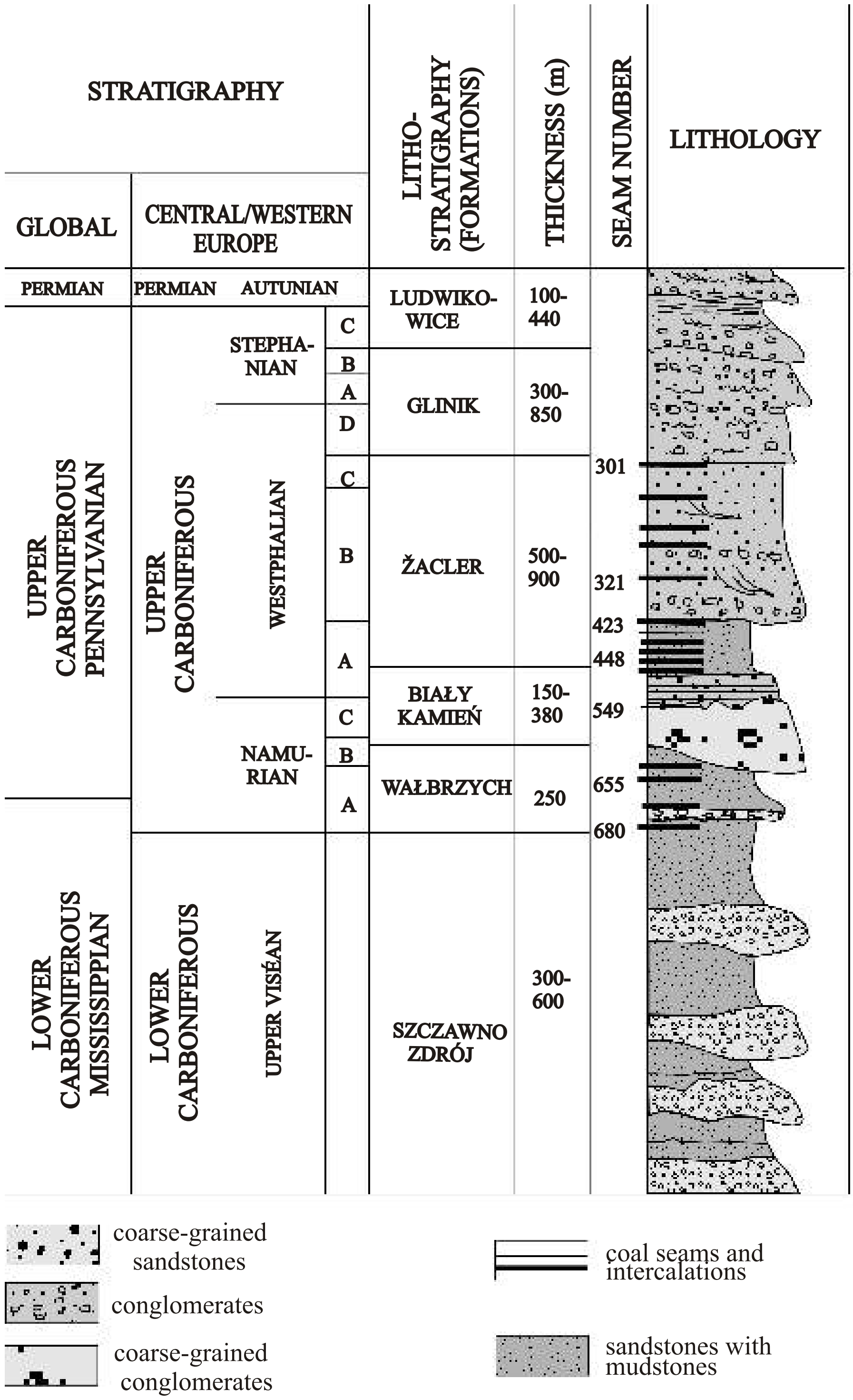

Fig. 2. Stratigraphy of the Carboniferous deposits of the Intrasudetic Basin

LITHOSTRATIGRAPHY OF THE UPPER CARBONIFEROUS DEPOSITS OF THE INTRASUDETIC BASIN

The Intrasudetic Basin is a NW–SE elongated synclinorial structure, located in the central Sudetes. It is filled by thick deposits of the Carboniferous, Permian, Lower Triassic and Upper Cretaceous (Fig. 1). In the Late Carboniferous sedimentation took place in two local basins, which are now marked by a more complete profile of the Carboniferous deposits than is present in other areas. One of them was the Wałbrzych Basin and another was the Nowa Ruda Basin (Augustyniak and Grocholski, 1968). The Upper Carboniferous deposits are of clastic character and continental origin. Their lower part consists of coal-bearing deposits — grey sandstones, mudstones and conglomerates with coal seams and intercalations. In the upper part of the succession, barren, reddish-brown sandstones,

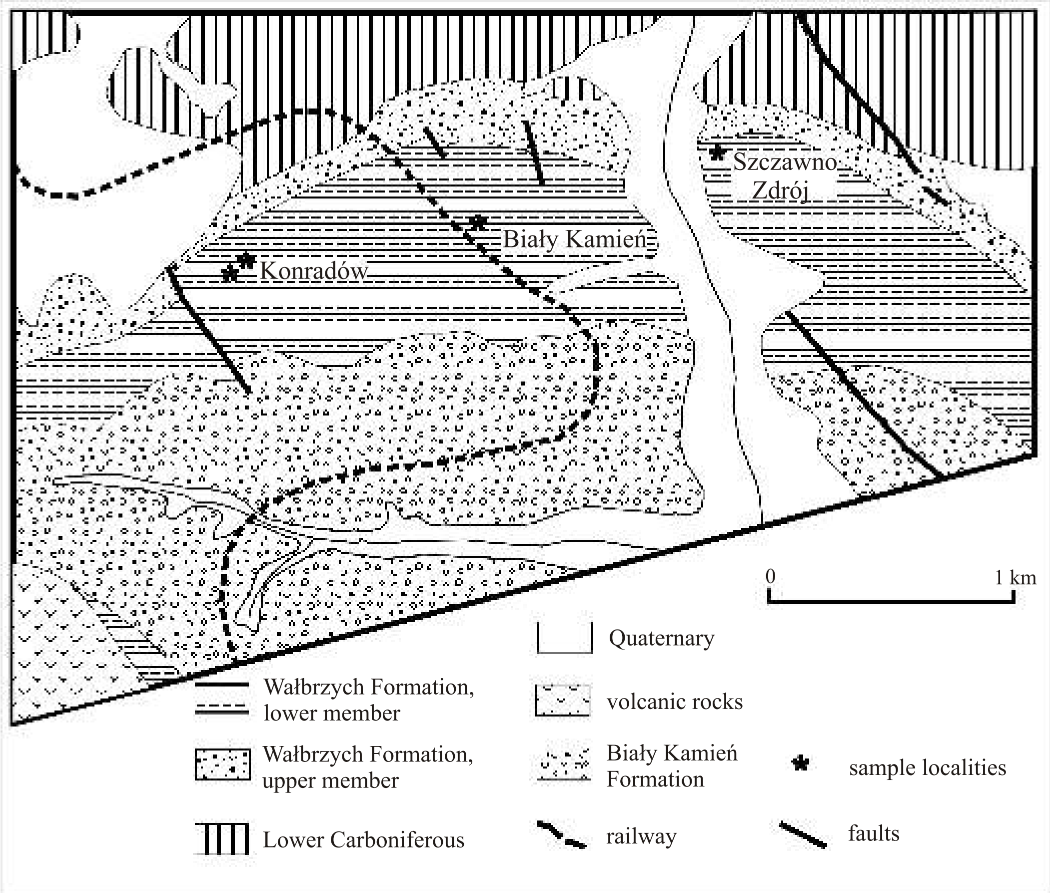

Fig. 3. Geological sketch of the studied area

conglomerates and mudstones occur. Five lithostratigraphical units were distinguished in the Upper Carboniferous profile: the Wałbrzych, Biały Kamień, Žacler, Glinik and Ludwikowice formations (Augustyniak and Grocholski, 1968; Dziedzic, 1971; Nemec *et al.*, 1982) (Fig. 2).

THE WAŁBRZYCH FORMATION IN THE WAŁBRZYCH BASIN

The lowest lithostratigraphical unit of the Upper Carboniferous deposits is the Wałbrzych Formation, which is thickest (about 300 m) in the Wałbrzych Basin. Deposits of this formation in the vicinity of Wałbrzych consist of texturally diverse sandstones — mainly lithic and sublithic arenites or wackes and associated mudstones, siltstones and quartz conglomerates. The conglomerates are usually fine-grained and well sorted. They are characteristic for the lower part of the section and constitute the lower member of the formation. The upper member of the formation consists of mudstones and siltstones, which occur both as thin intercalations between sandstones and far more commonly as beds up to several metres thick. These deposits are associated with numerous coal seams (seam numbers 650–680, counting from the top) and intercalations of coaly shales (Nemec, 1984).

Sedimentation of the deposits of the Wałbrzych Formation commenced with a system of meandering rivers and their flood plains, the rock material being transported northwards. Such a palaeoenvironment existed in this area for a long time, with the river channels migrating repeatedly (Nemec, 1984). In the next stage of the sedimentation of these deposits the rivers in the western part of the Wałbrzych Basin were relatively straight and they transported mainly gravelly material. With time, the sedimentation rate decreased, because meandering rivers gradually occupied this area, and out of channel sedimentation became more widely developed (Mastalerz and Kurowski, 1989).

The fluvial environment and hot, wet climate were conducive to the development of Carboniferous vegetation. The coal seams in the lowest part of the formation are not numerous and their origin is connected with the development of forest mires in widespread areas over former Late Viséan delta. The upper part of the Wałbrzych Formation (higher than coal seam 676–675) consists mainly of fine-grained sediments and coal. Plant sedimentation then took place on the mires which developed on flood plains (Nemec, 1984).

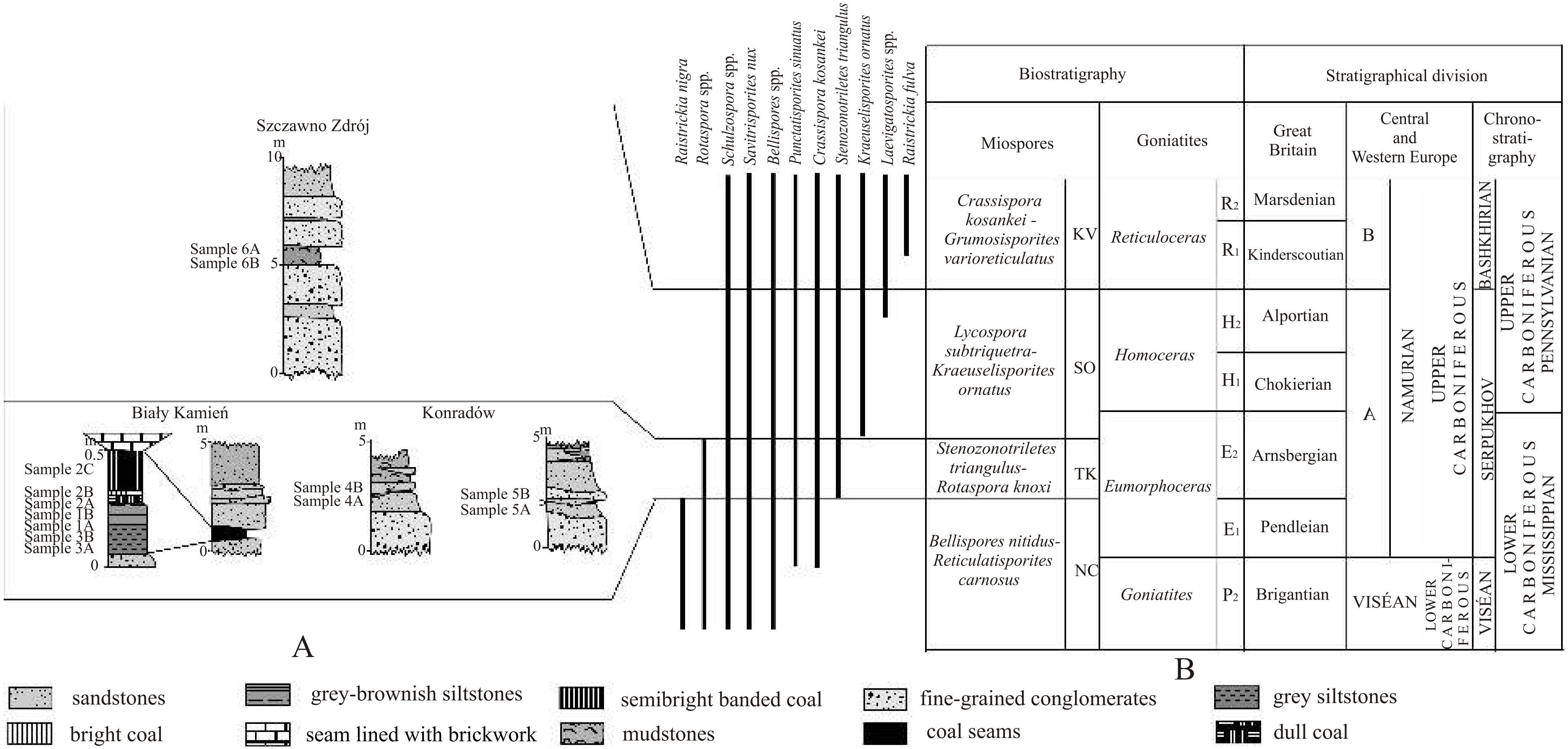

Fig. 4. Lithological profiles of the studied deposits and stratigraphical ranges of characteristic Namurian miospore taxa (Clayton *et al.*, 1977)

PREVIOUS WORK ON BIOSTRATIGRAPHY OF THE WAŁBRZYCH FORMATION

The continental origin of the Wałbrzych Formation deposits limits the potential methods applicable for their dating. The only fossils occurring in them are floral remnants, which were found in both the Wałbrzych and the Nowa Ruda regions. On the basis of macroflora (nearly 50 species), the stratigraphical position of the Wałbrzych Formation was determined as early Namurian A (Gothan and Gropp, 1933; Gothan and Fricke, 1937).

Palynological studies confirmed the early Namurian age of these deposits, but their results indicated that the stratigraphic range of the Wałbrzych Formation deposits in the Wałbrzych Basin should be widened to include the whole Namurian A (Górecka, 1962, 1969; Górecka-Nowak, 1987, 1988). The age of the equivalent of the top part of the Wałbrzych Formation in the northwestern part of the Intrasudetic Basin, the so-called "Przedwojów horizon", was determined as early Namurian B (Górecka, 1969). The results of palynostratigraphical studies of the Wałbrzych Formation deposits obtained by Krawczyńska-Grocholska (1960, 1966) indicated that these rocks also accumulated in the Nowa Ruda Basin throughout Namurian A.

Palynological data obtained from the lower part of the Wałbrzych Formation and the underlying deposits from the Dzikowiec IG 1 borehole (the Nowa Ruda region) were more recently interpreted as the association of NC and TK miospore zones, corresponding to late Viséan-early Namurian (Bossowski and Jachowicz, 1987).

MATERIALS

The deposits of the Wałbrzych Formation in the vicinity of Wałbrzych were studied palynologically, with 13 samples, taken from mudstones, siltstones and bituminous coal, from outcrops at the villages of Szczawno Zdrój, Konradów and Biały Kamień (Fig. 3). The deposits sampled belong to the lower and middle parts of the upper member of the Wałbrzych Formation. The monotonous lithology of this unit and the lack of any guide horizon cause some problems with stratigraphical correlation and the determination of the age relationships between deposits from different localities. During the field work, intersection indicators supported the opinion that the oldest part of the Wałbrzych Formation was sampled at Szczawno Zdrój, a slightly younger part at Konradów and the youngest at Biały Kamień.

There is an abandoned quarry at Szczawno Zdrój, located near "Zacisze" sanatorium. Grey and brownish-grey mudstones were taken from the quarry for palynological studies (samples 6A and 6B). The part of the section, which is available for sampling is about 10 m thick, consists of fine-grained conglomerates with intercalations of sandstones and mudstones (Fig. 4).

At Konradów, in two small quarries situated in the forest, parts of the Wałbrzych Formation (about 5 m thick) are visible. In each of the quarries, mudstones and fine-grained sandstones, which occurred between conglomerates and sandstones, were sampled (samples 4A, 4B, 5A and 5B) (Fig. 4).

In Biały Kamień samples were taken from part of the Wałbrzych Formation outcropping in the southwestern scarp of the railway-track, near an abandoned station. Sandy deposits with thin intercalations of conglomerates, mudstones and coal dominate this part of the sequence. From this locality samples were taken from the basal part of the coal bed, probably seam number 678. The upper part of the seam is not available, because the scarp at this locality is lined with brickwork. Samples 3A, 3B, 1A and 1B represent barren rocks — mudstones and siltstones underlying the coal. The lower part of the seam was sampled bed by bed. Samples were taken from each lithological type of coal, i.e. matt coal (sample 2A), bright coal (sample 2B) and semibright banded coal (sample 2C). The thickness of the sampled part of the seam is 22 cm (Fig. 4).

SAMPLE PREPARATION

The standard method of sample processing for palynostratigraphical studies was used. All the samples, including bituminous coals, appeared to contain some mineral matter, so the processing method was similar for all of them. Rock fragments were processed in 40% hydrofluoric acid (for about 24 hours) to separate insoluble organic components. The next step was oxidation of the samples in 96% nitric acid overnight, followed by rinsing in water to clean. Finally, the residue was sieved through a 16 mm sieve in an ultrawave bath and the material concentrated to make microscopic slides in the glycerine jelly. During the microscopic analysis a *PZO Biolar* microscope and a *Nikon Optiphot* microscope were used. Microphotographs (Figs. 5–8) were taken on the *Optiphot* microscope using the magnification x 40.

PALYNOSTRATIGRAPHY

Rich and diverse palynological assemblages were obtained. One hundred twenty five miospore taxa were identified, many of which were recorded from this area for the first time. A complete list of the taxa found and their distribution in the samples studied is presented in Table 1. Most of the samples were rich in miospores, with only the deposits from Konradów containing smaller quantities. The miospores were usually well preserved. Only in the siltstones underlying the coal seam studied from Biały Kamień (samples 3A and 3B) miospores were poorly preserved and thus more difficult to identify. The siltstones, which are lying above the samples and just under the coal seam (samples 1A and 1B) contain excellently preserved and strongly diversified palynological material. The majority of the palynomorph components were trilete spores, pollen grains and monolete spores occur very rarely.

The palynological material obtained is dominated by miospore genera which are characteristic for the whole Carboniferous: *Calamospora*, *Punctatisporites*, *Granulatisporites*, *Verrucosisporites*, *Anaplanisporites*, *Reticulatisporites*, *Lycospora* and *Densosporites*. The genera *Bellispores*, *Savitrisporites*, *Microreticulatisporites*, *Neoraistrickia*, *Rotaspora*, *Stenozonotriletes*, *Simozonotriletes*, *Orbisporites*, *Corbulispora*, *Knoxisporites*, *Triquitrites*, *Tripartites*, *Discer-*

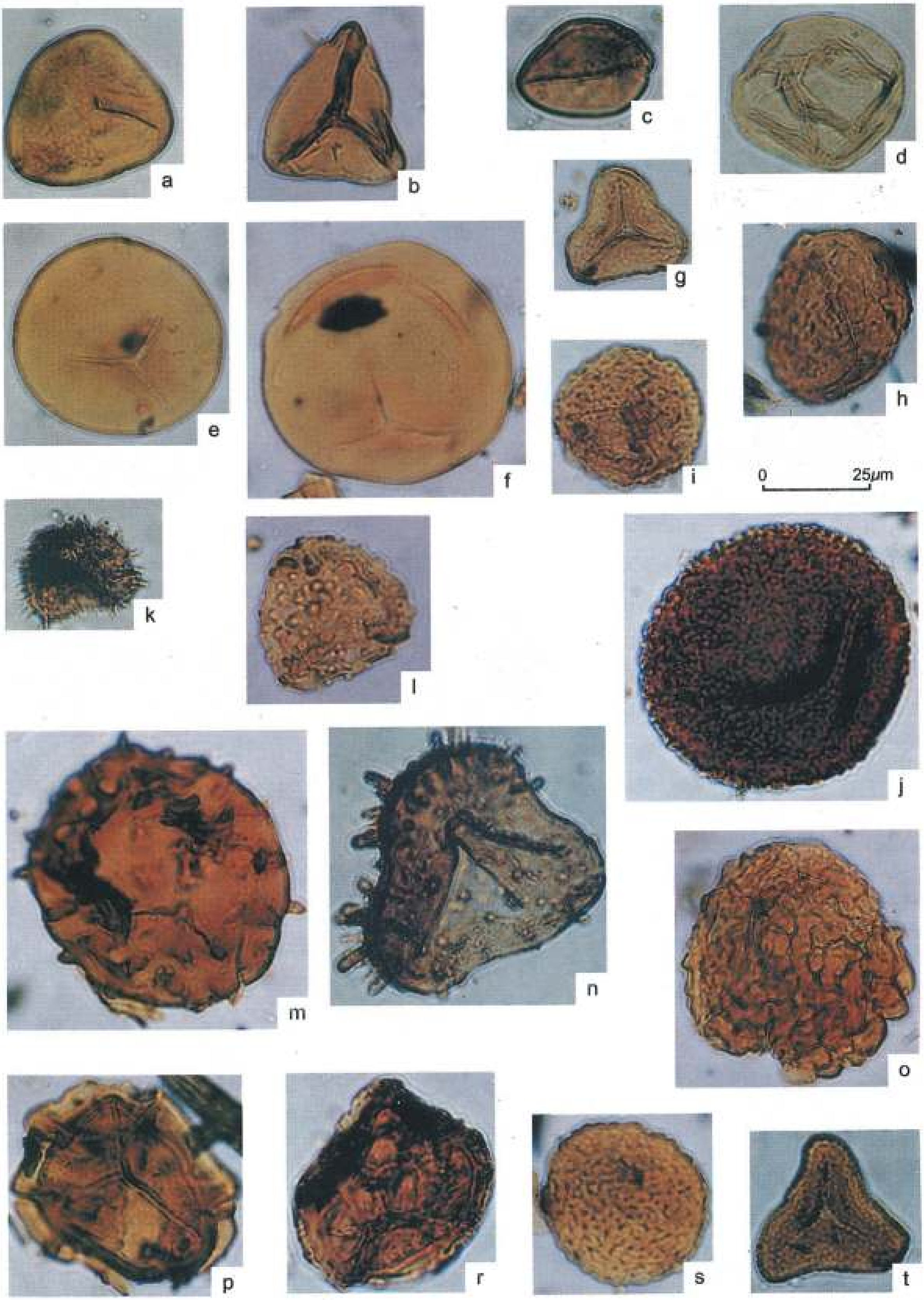

Fig. 5. **a** — *Leiotriletes inermis* (Waltz) Ishchenko, 1952; Biały Kamień; sample 2A; E44/4, F44/2. **b** — *Leiotriletes tumidus* Butterworth et Williams, 1958; Szczawno Zdrój; sample 6B; J11/3, K11/1. **c** — *Calamospora pedata* Kosanke, 1950; Biały Kamień; sample 2B; U55/2. **d** — *Calamospora parva* Guennel, 1958; Biały Kamień; sample 1A; V20/3, W20/1. **e** — *Punctatisporites aerarius* Butterworth et Williams, 1958; Biały Kamień; sample 2A; G41/3/4, H41/1/2. **f** — *Punctatisporites platirugosus* (Waltz) Sullivan, 1964; Biały Kamień; sample 2A; W26/4. **g** — *Granulatisporites piroformis* Loose, 1934; Szczawno Zdrój; sample 6B; K39/4, K40/3. **h, i** — *Verrucosisporites cerosus* (Hoffmeister, Staplin et Malloy) Butterworth et Williams, 1958; Szczawno Zdrój; sample 6B: **h** — G39/2; **i** — W56/3/4, X55/1/2. **j** — *Verrucosisporites verrucosus* (Ibrahim) Ibrahim, 1933; Biały Kamień; sample 1B; P2. **k** — *Acanthotriletes castanea* Butterworth et Williams, 1958; Biały Kamień; sample 3A; R45; **l** — *Anaplanisporites globulus* (Butterworth et Williams) Smith et Butterworth, 1967; Szczawno Zdrój; sample 6B; W47/1/3. **m** — *Raistrickia* aff. *fulva* Artüz, 1957; Biały Kamień; sample 3B; T24/4, T25/3, U24/2, U25/1. **n** — *Neoraistrickia inconstans* Neves, 1961; Biały Kamień; sample 1A; V21. **o** — *Convolutispora mellita* Hoffmeister, Staplin et Malloy, 1955; Szczawno Zdrój; sample 6A; T17/2, S17/4. **p** — *Dictyotriletes vitilis* Sullivan et Marshall, 1966; Szczawno Zdrój; sample 6A; G21/3, H21/1. **r** — *Dictyotriletes insculptus* Sullivan et Marshall, 1966; Biały Kamień; sample 1A; Q52/3. **s** — *Microreticulatisporites punctatus* Knox, 1950; Biały Kamień; sample 2A; X21/2. **t** — *Microreticulatisporites concavus* Butterworth et Williams, 1958; Biały Kamień; sample 1B; Y9; magn. x 750

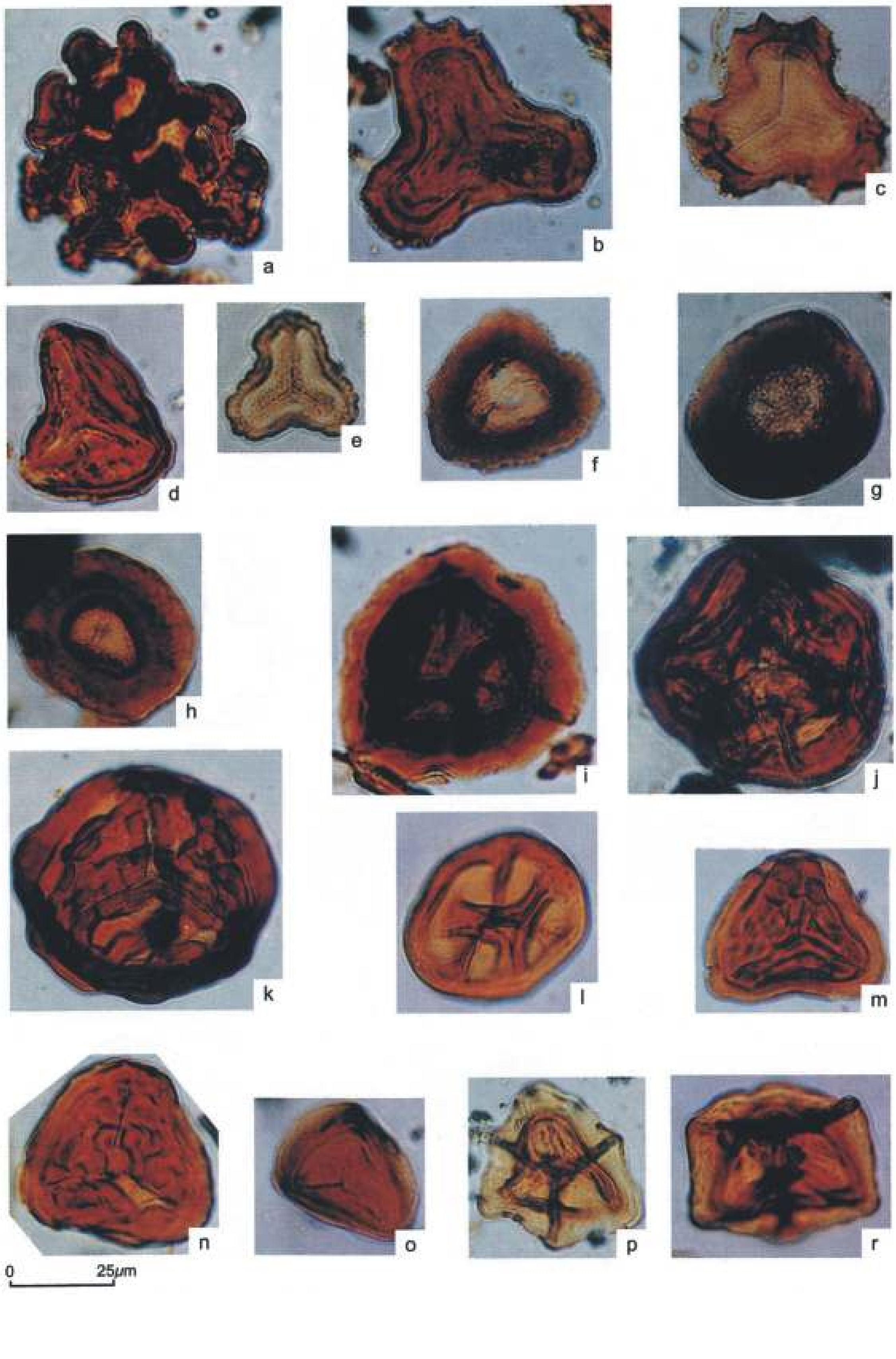

Fig. 6. **a** — *Secarisporites lobatus* Neves, 1961; Biały Kamień; sample 1A; B56/3/4. **b** — *Tripartites* sp.; Biały Kamień; sample 1B; Z12. **c** — *Tripartites vetustus* Schemel, 1950; Szczawno Zdrój; sample 6B; R55/3. **d** — *Triquitrites marginatus* Hofmeister, Staplin et Malloy, 1955; Biały Kamień; sample 1A; V55/2. **e** — *Bellispores nitidus* (Horst) Sullivan, 1964; Szczawno Zdrój; sample 6B; P11/2, P12/1; **f** — *Densosporites intermedius* Butterworth et Williams, 1958; Biały Kamień; sample 1A; L50/3/4. **g** — *Densosporites triangularis* Kosanke, 1950; Biały Kamień; sample 1A; Q16/2, Q17/1. **h** — *Densosporites pseudoannulatus* Butterworth et Williams, 1958; Biały Kamień; sample 2A; K47/3/4, L47/1/2. **i** — *Knoxisporites dissidius* Neves, 1961; Biały Kamień; sample 1A; A18. **j** — *Reticulatisporites* sp.; Szczawno Zdrój; sample 6A; U59. **k** — *Corbulispora* sp.; Biały Kamień; sample 1A; L48/4, M48/2. **l** — *Knoxisporites seniradiatus* Neves, 1961; Szczawno Zdrój; sample 6B; E19/3/4, F19/1/2. **m, n** — *Savitrisporites nux* (Butterworth et Williams) Smith et Butterworth, 1967; Biały Kamień: **m** — sample 1A, Z17/2, Z18/1; **n** — sample 2A, L21/3, M21/1. **o** — *Rotaspora knoxi* Butterworth et Williams, 1958; Biały Kamień; sample 3B; S6/3, T6/1. **p, r** — *Simozonotriletes siblyana* Sullivan, 1964; Szczawno Zdrój: **p** — sample 6A, B37/1/3; **r** — sample 6B, P15/1/2; magn. x 750

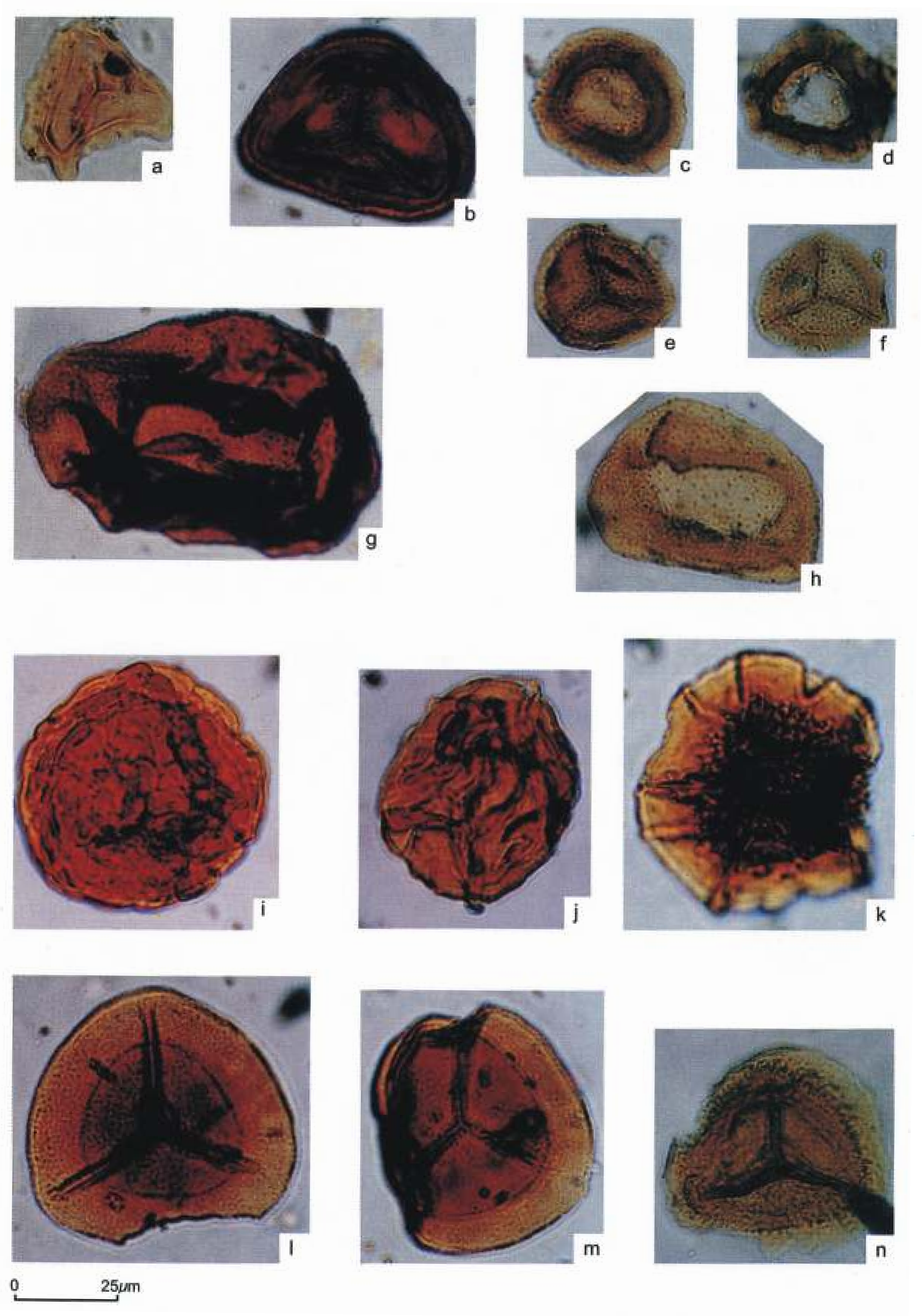

Fig. 7. **a** — *Murospora kosankei* Somers, 1952; Szczawno Zdrój; sample 6A; T49/1/3. **b** — *Stenozonotriletes triangulus* Neves, 1961; Szczawno Zdrój; sample 6A; N22/1. **c, d** — *Cingulizonates bialatus* (Waltz) Smith et Butterworth, 1967: **c** — Biały Kamień, sample 1B, N12; **d** — Szczawno Zdrój, sample 6B, V51/4, V52/3, W51/2, W52/1. **e, f** — *Lycospora pusilla* (Ibrahim) Schopf, Wilson et Bentall, 1944; Biały Kamień; sample 1B: **e** — L21/3, M21/1; **f** — R16/3/4; **g** — *Crassispora maculosa* (Knox) Sullivan, 1964; Biały Kamień; sample 1B; Q54/3/4. **h** — *Crassispora kosankei* (Potonié et Kremp) Bharadwaj, 1957; Biały Kamień; sample 2A; N41/3, O41/1. **i** — *Hymenospora palliolata* Neves, 1961; Szczawno Zdrój; sample 6B; M21/4, N21/2. **j** — *Proprisporites* cf. *laevigatus* Neves, 1961; Szczawno Zdrój; sample 6A; F8/3/4, G8/1/2. **k** — *Discernisporites* cf. *irregularis* Neves, 1958; Biały Kamień; sample 1A; E54. **l, m** — *Discernisporites micromanifestus* (Haquebard) Sarby et Neves, 1971; Biały Kamień: **l** — sample 1A, T33/4; **m** — sample 1B, Z12/3. **n** — *Kraeuselisporites ornatus* (Neves) Owens, Mishell et Marshall, 1976; Szczawno Zdrój; sample 6B; K18/3/4, L18/1/2; magn. x 750

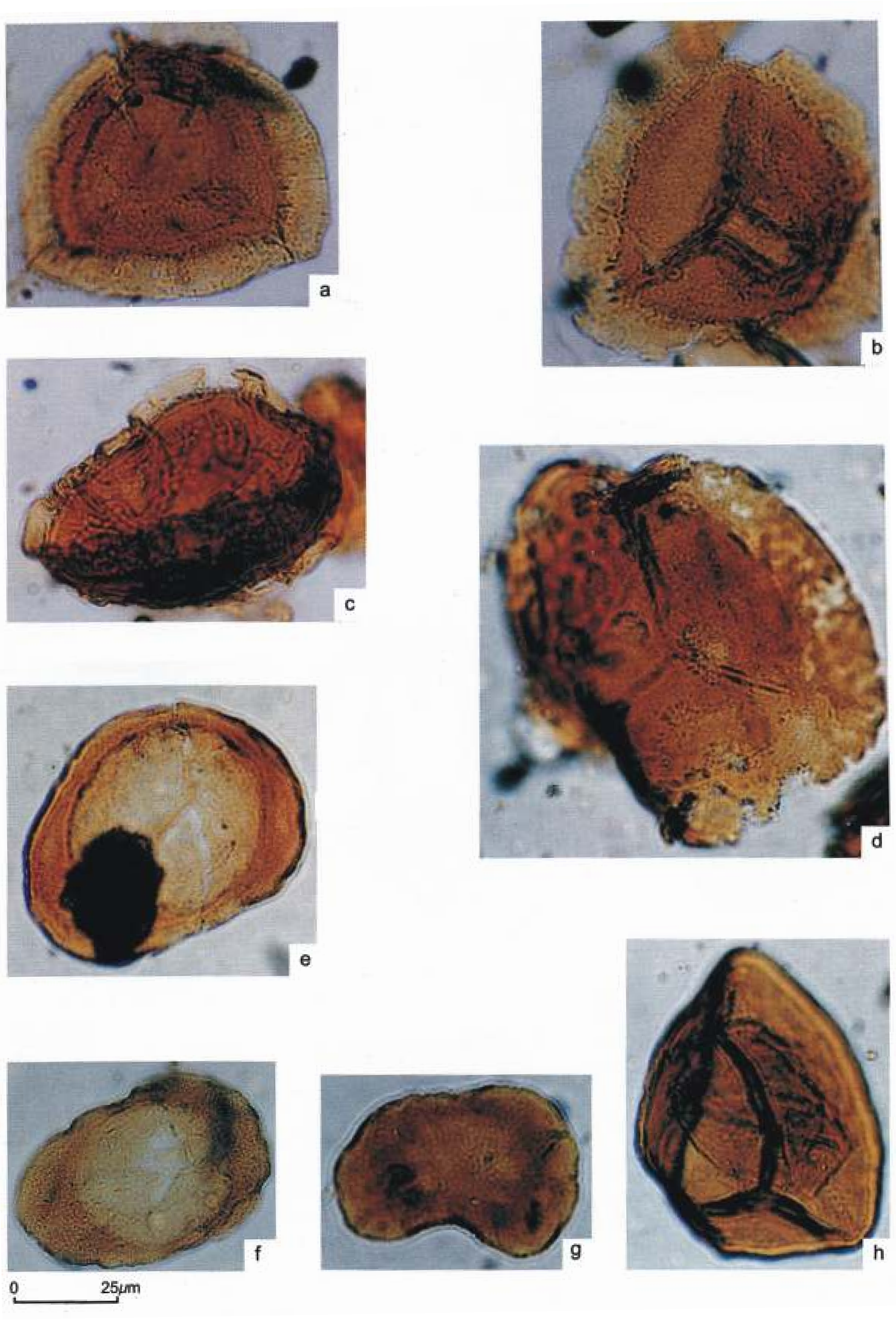

Fig. 8. **a, b** — *Kraeuselisporites ornatus* (Neves) Owens, Mishell et Marshall, 1976; Szczawno Zdrój; sample 6B: **a** — S12/3/4, T12/1/2; **b** — Y22/1/3. **c** — *Perotrilites perinatus* Hughes et Playford, 1961; Szczawno Zdrój; sample 6B; Y16/2/4, Y17/1/3. **d** — *Endosporites* sp.; Biały Kamień; sample 1A; E55/2; **e**, **f** — *Schulzospora ocellata* (Horst) Potonié et Kremp, 1956: **e** — Biały Kamień, sample 1A, Z42/3; **f** — Szczawno Zdrój, sample 6B, R48/2/4, R49/1/3. **g** — *Schulzospora elongata* Hoffmeister, Staplin et Malloy, 1955; Biały Kamień; sample 1A; M7/3/4. **h** — *Remysporites* sp.; Biały Kamień; sample 1B; K17/2/2; magn. x 750

Table 1

Distribution of the miospore taxa in the studied samples

Miospore taxa	Konradów				Biały Kamień								Szcza-wno	
	TK Zone												SO Zone	
	Sample													
	5A	5B	4A	4B	3A	3B	1A	1B	2A	2B	2C	5A	6A	6B
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Punctatisporites nitidus Hoffmeister, Staplin et Malloy, 1955	+		+			+	+	+	+	+	+	+		
Savitrisporites asperatus Sullivan, 1964	+						+	+				+		
Savitrisporites nux (Butterworth et Williams) Smith et Butterworth, 1967	+	+			+		+	+	+	+	+	+		
Wilsonites sp.	+											+		
Calamospora pedata Kosanke, 1950	+				+	+	+	+	+	+		+	+	
Leiotriletes inermis (Waltz) Ishchenko, 1952	+						+	+	+		+	+	+	
Leiotriletes parvus Guennel, 1958		+	+		+			+					+	
Anaplanisporites globulus (Butterworth et Williams) Smith et Butterworth, 1967	+	+		+			+				+	+		+
Bellispores nitidus (Horst) Sullivan, 1964	+				+	+	+	+	+	+		+	+	+
Granulatisporites microgranifer Ibrahim, 1933	+	+			+							+	+	+
Granulatisporites piroformis Loose, 1934	+		+	+	+	+	+	+	+	+	+	+		+
Kuhlensisporites sphaerotriangulus Kruszewska, 1963	+	+	+		+	+	+	+	+	+	+	+	+	+
Lycospora pusilla (Ibrahim) Schopf, Wilson et Bentall, 1944	+	+	+	+	+		+	+	+	+	+	+	+	+
Schulzospora ocellata (Horst) Potonié et Kremp, 1956	+						+	+				+		+
Verrucosisporites cerosus (Hoffmeister, Staplin et Malloy) Butterworth et Williams, 1958	+	+	+	+	+		+	+	+	+	+	+	+	+
Grumosisporites rufus (Butterworth et Williams) Smith et Butterworth, 1967		+												
Punctatisporites sinuatus (Artüz) Neves, 1961		+												
Savitrisporites lubaviensis Górecka-Nowak, 1995		+					+							
Acanthotriletes falcatus (Knox) Potonié et Kremp, 1955		+						+	+					
Dictyotriletes falsus Potonié et Kremp, 1955		+					+	+		+				
Cyclogranisporites minutus (Bharadwaj) Ravn, 1986		+	+	+	+		+		+	+	+			
Kuhlensisporites verrucosus Kruszewska, 1963		+		+	+		+	+		+	+			
Calamospora parva Guennel, 1958			+	+	+	+	+	+	+	+	+		+	
Granulatisporites granulatus Ibrahim, 1933		+	+	+	+			+	+				+	
Stenozonotriletes bracteolus (Butterworth et Williams) Smith et Butterworth, 1967		+											+	
Calamospora cf. *microrugosa* (Ibrahim) Schopf, Wilson et Bentall, 1944		+												+
Convolutispora mellita Hoffmeister, Staplin et Malloy, 1955		+					+	+					+	+
Densosporites intermedius Butterworth et Williams, 1958		+					+			+	+		+	+
Punctatisporites aerarius Butterworth et Williams, 1958		+						+	+	+	+		+	+
Punctatisporites minutus Kosanke, 1950		+	+	+	+				+		+		+	+
Anaplanisporites baccatus (Hoffmeister, Staplin et Malloy) Smith et Butterworth, 1967			+						+		+			
Densosporites regalis (Bharadwaj et Venkatahala) Smith et Butterworth, 1967			+			+	+				+			
Dictyotriletes castanaeformis (Horst) Sullivan, 1964			+										+	
Tripartites vetustus Schemel, 1950			+						+	+	+			+
Acanthotriletes echinatus (Loose) Potonié et Kremp, 1955				+		+	+	+						
Leiotriletes priddyi (Berry) Potonié et Kremp, 1955				+			+	+	+					
Pustulatisporites papillosus (Knox) Potonié et Kremp, 1955				+	+		+						+	+
Acanthotriletes castanea Butterworth et Williams, 1958					+									
Acanthotriletes falcatus (Knox) Potonié et Kremp, 1955					+									
Lycospora noctuina Butterworth et Williams, 1958					+	+	+	+						

Table 1 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Schulzospora rara Kosanke, 1950					+	+	+	+						
Ahrensisporites guerickei (Horst) Potonié et Kremp, 1955					+			+	+					
Calamospora breviradiata Kosanke, 1950					+		+	+	+					
Calamospora pallida (Loose) Schopf, Wilson et Bentall, 1944					+		+	+	+					
Crassispora kosankei (Potonié et Kremp) Bharadwaj, 1957					+	+	+		+	+	+			
Densosporites spinifer Hoffmeister, Staplin et Malloy, 1955					+			+	+	+	+			
Lycospora orbicula (Potonié et Kremp) Smith et Butterworth, 1967					+				+	+	+			
Sculptatisporites angulatus Krawczyńska-Grocholska, 1966					+				+	+	+			
Calamospora microrugosa (Ibrahim) Schopf, Wilson et Bentall, 1944					+	+			+	+	+		+	
Neoraistrickia inconstans Neves, 1961					+		+	+	+				+	
Schulzospora elongata Hoffmeister, Staplin et Malloy, 1955					+		+	+					+	
Cingulizonates bialatus (Waltz) Smith et Butterworth, 1967					+			+	+				+	+
Raistrickia aff. *fulva* Artüz, 1957						+								
Dictyotriletes insculptus Sullivan et Marshall, 1966						+	+							
Lophotriletes commisuralis (Kosanke) Potonié et Kremp, 1955						+	+	+	+					
Rotaspora knoxi Butterworth et Williams, 1958						+				+	+			
Verrucosisporites baccatus Staplin, 1960						+	+				+			
Knoxisporites seniradiatus Neves, 1961						+							+	+
Calamospora laevigata (Ibrahim) Schopf, Wilson et Bentall, 1944							+							
Cincturasporites cf. *radialis* Bharadwaj et Venkatahala, 1962							+							
Convolutispora cf. *cerebra* Buttreworth et Williams, 1958							+							
Discernisporites cf. *irregularis* Neves, 1958							+							
Endosporites sp.							+							
Kuhlensisporites laevigatus Kruszewska, 1963							+							
Murospora sublobata (Waltz) Playford, 1962							+							
Orbisporis sp.							+							
Reticulatisporites peltatus Hughes et Playford, 1961							+							
Schulzospora plicata Butterworth et Williams, 1958							+							
Sculptatisporites trigonalis Krawczyńska-Grocholska, 1966							+							
Secarisporites lobatus Neves, 1961							+							
Stenozonotriletes clarus Ishchenko, 1958							+							
Tricidarisporites sp.							+							
Triquitrites marginatus Hofmeister, Staplin et Malloy, 1955							+							
Discernisporites micromanifestus (Haquebard) Sarby et Neves, 1971							+	+						
Knoxisporites dissidius Neves, 1961							+	+						
Savitrisporites cingulatus Marshall et Smith, 1965							+	+						
Camptotriletes retinocularis Krawczyńska-Grocholska, 1966							+		+	+				
Sculptatisporites irregularis Krawczyńska-Grocholska, 1966							+	+	+	+				
Densosporites triangularis Kosanke, 1950							+	+	+		+			
Microreticulatisporites concavus Butterworth et Williams, 1958							+	+			+			
Laevigatosporites vulgaris (Ibrahim) Alpern et Doubinger, 1973							+			+		+		
Endosporites pallidus Schemel, 1950							+						+	
Endosporites zonalis (Loose) Knox, 1950							+						+	
Stenozonotriletes triangulus Neves, 1961								+					+	
Corbulispora sp.							+	+						+
Grumosisporites inaequalis (Butterworth et Williams) Smith et Butterworth, 1967							+							+
Leiotriletes tumidus Butterworth et Williams, 1958							+	+	+					+
Remysporites sp.								+						
Stenozonotriletes lycosporoides (Butterworth et Williams) Smith et Butterworth, 1967								+						
Tripartites incisotrilobatus (Naumova) Potonié et Kremp, 1956								+						
Tripartites sp.								+						
Verrucosisporites verrucosus (Ibrahim) Ibrahim, 1933								+						
Tripartites trilinguis (Horst) Smith et Butterworth, 1967								+						
Camptotriletes bucculentus (Loose) Potonié et Kremp, 1955								+	+					
Microreticulatisporites punctatus Knox, 1950								+	+	+				
Crassispora maculosa (Knox) Sullivan, 1964								+			+			

Table 1 continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Stenozonotriletes stenozonalis (Waltz) Ishchenko, 1958								+			+			
Acanthotriletes baculatus Neves, 1961								+			+		+	
Simonozonotriletes intortus (Waltz) Potonié et Kremp, 1954								+	+				+	
Convolutispora usitata Playford, 1962									+					
Corbulispora subalveolaris (Luber) Sullivan, 1964									+					
Grumosisporites verrucosus (Butterworth et Williams) Smith et Butterworth, 1967									+					
Leiotriletes sphaerotriangulus (Loose) Potonié et Kremp, 1954									+					
Punctatisporites platirugosus (Waltz) Sullivan, 1964									+					
Raistrickia sp.									+					
Densosporites anulatus (Loose) Smith et Butterworth, 1967									+	+				
Densosporites pseudoannulatus Butterworth et Williams, 1958									+	+	+			
Calamospora perrugosa (Loose) Schopf, Wilson et Bentall, 1944										+				
Convolutispora planimuricata Butterworth et Spinner, 1967										+				
Grumosisporites varioreticulatus (Neves) Smith et Butterworth, 1967										+				
Armatisporites castanaeformis Dybova et Jachowicz, 1957											+			
Cristatisporites cf. *solaris*											+			
Granulatisporites adnatoides (Potonié et Kremp) Smith et Butterworth, 1967											+			
Murospora kosankei Somers, 1952													+	
Stenozonotriletes ocultus Ravn, 1986													+	
Reticulatisporites sp.													+	
Proprisporites cf. *laevigatus* Neves, 1961													+	
Simozonotriletes siblyana Sullivan, 1964													+	+
Vallatisporites sp.													+	+
Dictyotriletes vitilis Sullivan et Marshall, 1966													+	+
Apiculatisporis variocorneus Sullivan, 1964														+
Kraeuselisporites ornatus (Neves) Owens, Mishell et Marshall, 1976														+
Hymenospora palliolata Neves, 1961														+
Perotrilites perinatus Hughes et Playford, 1961														+
Stenozonotriletes conspersus Naumova, 1953														+

nisporites and *Schulzospora* are common, although not so abundant. The genus *Sculptatisporites*, described from the deposits of the Wałbrzych Formation from the Nowa Ruda region by Krawczyńska-Grocholska (1966), was also recorded. Species belonging to the genera *Kraeuselisporites*, *Vallatisporites*, *Secarisporites*, *Perotrilites*, *Proprisporites* and *Hymenospora* were encountered, but they are not numerous. The percentage of the genera identified in the miospore assemblages varies, but this is probably due to changes in the palaeoecological factors and has no stratigraphical value.

Analysis of the taxonomic composition of the miospore assemblages gives the basis for stratigraphic interpretation. For such an analysis it is important to look at the occurrence of taxa known from other regions and recognised as important for age determination, and establishing a palynostratigraphical division. Because many such taxa were recorded from the deposits of the Wałbrzych Formation, it was possible to use the same criteria as for the miospore zonation of the Carboniferous deposits of Western Europe (Fig. 4) (Clayton *et al*., 1977). The biostratigraphical units distinguished have the same names as in the Western European division, and they are defined by very similar miospore assemblages. It helps in the stratigraphical correlation of the rocks studied with deposits of the same age from different regions.

Some of the miospore taxa important for age determination occur in the samples from all three localities: Szczawno Zdrój, Konradów and Biały Kamień. The most important of them are *Bellispores nitidus*, *Crassispora kosankei* and representatives of the genus *Schulzospora*. Their concurrence indicates without any doubts that the deposits studied not older than Namurian. *Bellispores nitidus* and *Schulzospora* appear for the first time in Viséan (*Schulzospora* in the early Viséan TC Zone and *Bellispores nitidus* in the late Viséan) and their stratigraphical ranges extend to the early Westphalian. *Crassispora kosankei*, which is a typical Late Carboniferous taxon, appears for the first time at the base of the Namurian, in the assemblage of the NC Zone (Clayton *et al*., 1977).

The distribution of other stratigraphically important taxa allows for the division of the obtained palynological material into two assemblages, corresponding to miospore zones.

STENOZONOTRILETES TRIANGULUS-ROTASPORA KNOXI (TK) ZONE

Very diverse miospore assemblage was determined in the deposits of the Wałbrzych Formation from Konradów and Biały Kamień. Beside the miospore taxa mentioned above, several characteristic species occur there: *Leiotriletes tumidus*, *Punctatisporites sinuatus*, *Microreticulatisporites concavus*, *M. punctatus*, *Stenozonotriletes triangulus*, *Tripartites vetustus*, *T. trilinguis*, *Triquitrites marginatus*, *Rotaspora knoxi*, *Crassispora maculosa*, and *Savitrisporites nux*. Other, less important taxa, but typical for the Namurian, were also recorded for this assemblage: *Verrucosisporites cerosus*, *V. baccatus*, *Neoraistrickia incostans*, *Cingulizonates bialatus*, *Knoxisporites dissidius*, *K. seniradiatus*, *Discernisporites micromanifestus*, *D.* cf. *irregularis*, *Murospora sublobata*, *Secarisporites lobatus* and *Remysporites* sp. The composition of this association indicates that it represents the TK Zone, the upper limit of which is marked by the disappearance of the genera *Rotaspora* and the species *Triquitrites marginatus* (Clayton *et al*., 1977).

LYCOSPORA SUBTRIQUETRA-KRAEUSELISPORITES ORNATUS (SO) ZONE

In the samples studied from Szczawno Zdrój, an assemblage of miospores occurs which differs from the association described above. Some new taxa, not recorded from older zone, appear there: *Murospora kosankei*, *Simozonotriletes siblyana*, *Hymenospora palliolata*, *Perotrilites perinatus*, *Apiculatisporis variocorneus*, genera *Vallatisporites* and *Endosporites* with species *E. zonalis* and *E. pallidus* belong to them. The most important fact is the presence of several specimens of *Kraeuselisporites ornatus* from sample 6B. This species is one of the index taxa of the SO Zone. Its first appearance in the profile is treated as a marker of the lower limit of this zone (Clayton *et al*., 1977). In this study such a criterion was also used to distinguish this border.

Although both of the miospore zones distinguished are well documented, the occurrence of some taxa, the stratigraphical ranges of which slightly differ from those accepted by Clayton *et al.* (1977), should be pointed out.

In the deposits of the Wałbrzych Formation, in the TK miospore zone (middle Namurian A), representatives of the genus *Laevigatosporites* were recorded although infrequent in occurrence. In the miospore zonation of Western Europe (*op. cit.*) this taxon appears in the upper part of the SO Zone, corresponding to late Namurian A. *Laevigatosporites* was also recorded from the deposits of the Wałbrzych Formation from the vicinity of Nowa Ruda (Krawczyńska-Grocholska, 1966). Its occurrence in deposits older than late Namurian A seems to not be uncommon, because there are some records of its presence in earliest Namurian and even Viséan deposits from elsewhere in Europe and North America (Sullivan and Marshall, 1966; Neves and Belt, 1970; Marshall and Williams, 1970; Jachowicz, 1972).

The second discussed taxon is *Tripartites vetustus* found in the deposits from all three studied localities. It is typical component of the TK Zone, but according to the zonation scheme (Clayton *et al*., 1977) the disappearance of the genus *Tripartites* should mark the upper limit of this biozone. The presence of *Tripartites vetustus* in the miospore assemblage from Szczawno Zdrój, assigned to the SO Zone, indicate, that in the studied area genus *Tripartites* occurred for a longer time. Representatives of it (*T. cristatus*) were also recorded from the Westphalian deposits of the Žacler Formation from the Intrasudetic Basin (Górecka-Nowak, 1995) and the Westphalian deposits from the Upper Silesian Coal Basin (Jachowicz, 1972).

Presence of *Raistrickia* aff. *fulva* Artüz, 1957 (Fig. 5m) in the deposits of the Wałbrzych Formation from Biały Kamień (the middle Namurian A TK Zone) should be underlined too. The specimens found and assigned to this taxon are very similar to *Raistrickia fulva* Artüz, 1957 (*vide* Smith and Butterworth, 1967, p. 180-1, pl. 8, figs. 17–20, particularly figs. 17–18) although some processes on it are slightly narrower in their basal diameter. The first appearance of species *Raistrickia fulva* is treated as characteristic feature of the upper part of the KV Zone, corresponding to Namurian B (Clayton *et al*., 1977; Owens *et al*., 1977). In the Carboniferous succession of the Upper Silesia it appears for the first time even higher, in the Namurian C FR Zone (Oliwkiewicz-Miklasińska, 1995).

CONCLUSIONS

1. The deposits of the Wałbrzych Formation outcropping in Konradów and Biały Kamień belong to the *Stenozonotriletes triangulus-Rotaspora knoxi* (TK) Zone, corresponding to middle Namurian A (early-middle Arnsbergian).
2. The age of the Wałbrzych Formation from Szczawno Zdrój was determined as *Lycospora subtriquetra-Kraeuselisporites ornatus* (SO) Zone, correlated with late Namurian A (late Arnsbergian, Chokierian and Alportian).
3. The results of the palynological studies indicate that part of the Wałbrzych Formation sequence occurring in Szczawno Zdrój is younger than deposits from Konradów and Biały Kamień.

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