

Palynostratigraphy of the Culm deposits of the Moravian–Silesian zone (Poland) at Toszek Castle Hill

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The Early Carboniferous age of the flysch succession in the Moravian–Silesian zone has been based principally on lithological correlations with the stratotype goniatite-bearing section. Its uppermost part — the Kyjovice Formation in the region of Toszek (Poland) — has been studied palynologically for the first time. Miospore assemblages of the upper part of the Western European *nitidus–carnosus* (NC) miospore Zone of the early Serpukhovian have been distinguished. This agrees well with a general stratigraphic range of the Kyjovice Formation within the Goy–E1a goniatite zones.

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INTRODUCTION

The Early Carboniferous age of the Moravian–Silesian flysch succession in the territory of Poland, based principally on lithostratigraphical correlations with the stratotype section of the Moravia region (Unrug, 1964, 1971, 1974, 1977; Unrug and Dembowski, 1971; Kumpere, 1971a, b, c, 1977; Dvořák, 1973, 1994) has been confirmed locally, by records of rare goniatites, molluscs, orthocones and foraminifers (Żelichowski, 1962a, b; Geroch, 1971). Palynology was first used in the 1960's to recognise the stratigraphy of the uppermost part of this succession — the Kyjovice Formation in the region of Toszek — but did not bring any results (Żelichowski, 1962a). However, recently resumed miospore studies have yielded new data. In selected samples of the Horny Benešov Formation (Głubczyce region), scant traces of organic matter have been recorded. The best results have been obtained from the Kyjovice Formation at Toszek (Fig. 1). Its late Viséan age within the Goy — *Goniatites granosus* Zone determined by Żelichowski (1962a), was based principally on lithological correlations with the Goniatite “Series” of Bobrovník in the Nizky Jeseník Mts. (Knopp, 1929), containing an analogous fauna to that found at Toszek (Fig. 1). Preliminary palynological investigations supported Żelichowski's opinion (Trzepierczyńska, 2002), the results of further studies being presented in this paper.

STRATIGRAPHY OF THE CULM IN THE MORAVIAN–SILESIAN ZONE

The stratotype section of the Early Carboniferous flysch deposits (Culm) in the Moravian–Silesian zone is exposed in the Nizky Jeseník Mts., the Odra Mts. and the Drahaný Upland of the Moravia region, Czech Republic (Patteisky, 1929; Hokr, 1955; Havlena, 1964; Koverdynský, 1964; Kumpere, *op. cit.*; Dvořák, 1973). Natural exposures of the Culm in Poland occur in the Eastern Sudetes, east of Głuchołazy, and at the western margin of the Upper Silesia Coal Basin, in the vicinity of Toszek (Fig. 1).

Most exposures are located in the region of Głubczyce, and the deposits from that area correspond to the part of the flysch succession from the Horny Benešov to the Hradec Formations (Żelichowski, 1962b; Unrug, 1977). The graywacke sandstones and shales exposed in the region of Toszek, a longitudinal, narrow area of Culm outcrops in the northern part of the zone, correspond to the uppermost part of the flysch succession (the Kyjovice Formation). They represent the northernmost and probably the youngest part of the flysch deposits cropping out in the Moravian–Silesian zone (Żelichowski, 1962a; Paszkowski, 1995).

Although the Culm deposits in Poland have been much studied they are still poorly understood due to scarcity of natural exposures and to unsatisfactory biostratigraphic data.

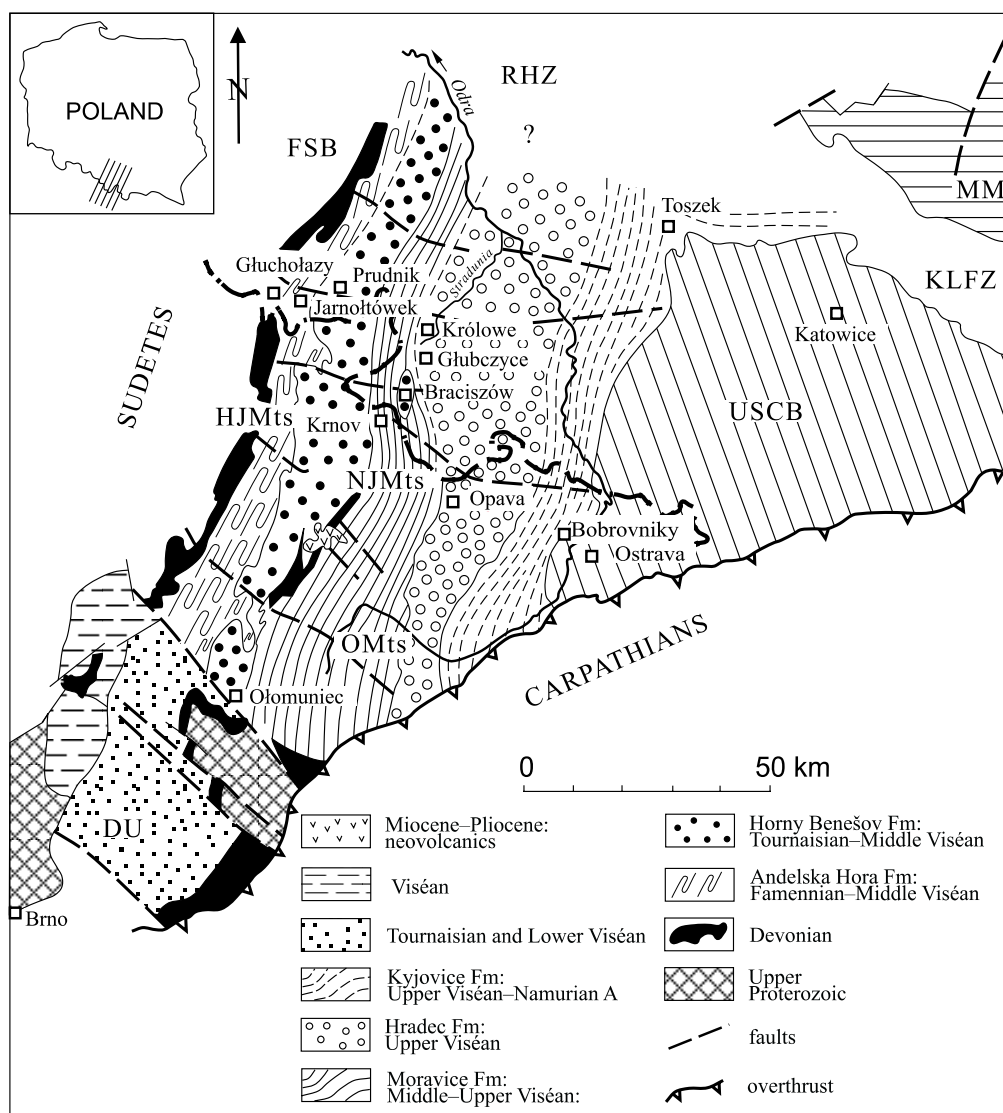


Fig. 1. Generalised geological map of the region studied (after Fusan *et al.*, 1967; Pożaryski and Dembowski, 1983; Dvořák, 1994; modified by the author)

HJMts — High Jeseník Mts.; NJMts — Nizky Jeseník Mts.; OMTs — Odra Mts.; RHZ — Rhenohercynian Zone; USCB — Upper Silesia Coal Basin; KLFZ — Kraków–Lubliniec Fold Zone; MM — Małopolska Massif; FSB — Fore-Sudetic Block; DU — Drahany Upland

Flysch sedimentation in the Moravian–Silesian zone started in the Famennian and finished in the early Serpukhovian (Grygar and Trzepierczyńska, 1995) (Fig. 2). The Andelska Hora Formation, an epimetamorphic rock succession of sandy shales with conglomerates and crinoidal limestones of Famennian–middle Viséan age, was distinguished in the lower part of the flysch succession (Kumpera and Martinec, 1995) (Fig. 2). In Poland, natural exposures of this formation occur south-east of Głuchołazy, in the vicinity of Jarnołtówek (Fig. 1).

The younger, Horny Benešov Formation is biostratigraphically documented only in Moravia. It is predominantly formed by unfossiliferous graywackes. Only plant fossils referred to *Asterocalamites scrobiculatus* (Schlotheim) indicate an Early Carboniferous age (Patteisky, 1929 *vide* Unrug, 1977), but more precise dating is based on micro- and macrofauna found at the base and top respectively (Fig. 2). In the sili-

ceous-radiolarite shales of the Ponikiev Beds (Drahany Upland), Tournaisian and early Viséan conodonts were found (Zikmundova, 1967), whereas in the overlying and most fossiliferous Moravice Formation, goniatites of the late Viséan — $Go\alpha$ and $Go\beta_4$ zones were recorded (Kumpera, 1971a, 1977) (Fig. 2). The occurrence of *Goniatites striatus striatus* (?) (Sow.) and *Nomismoceras germanicum* Schmidt determine the late Viséan age of the Moravice Formation between the $Go\alpha$ and $Go\beta_4$ zones (Żelichowski, 1962b), whereas in Moravia, the age of the formation is between the $Go\alpha_{2-3}$ and $Go\beta$ zones respectively (Kumpera, 1971a) (Fig. 2). In Poland, natural exposures of the Horny Benešov and Moravice Formations occur south-west of Głubczyce.

Lithologically different, but well biostratigraphically dated, the Hradec (Unrug, 1977) and Hradec-Kyjovice (Dvořák, 1973, 1994) Formations represent the uppermost part of the

flysch succession in the Moravian–Silesian zone. The Hradec Formation *s.s.* (south-east and north of Głubczyce), comprising thick-bedded sandstones with intercalations of conglomerates and thin-bedded mudstones, corresponds to the late Viséan between the $Go\beta_3$ and $Go\beta_7$ zones (Želichowski, 1962b), whereas in Moravia, the age of the Hradec-Kyjovice Formation is between the $Go\beta_{spi}$ –E1a zones (Kumpera, 1971c; Dvořák, 1994) (Fig. 2).

In Poland, natural exposures of graywacke sandstones and dark shales with abundant plant detritus, characteristic of the uppermost part of the flysch succession — the Kyjovice Formation — occur in the western margin of the Upper Silesia Coal Basin, in the region of Toszek and the Stradunia River Valley (north of Głubczyce) (Fig. 1). The stratigraphical position of these deposits was first estimated by Roemer (1870), who found *Asterocalamites scrobiculatus* (Schlotheim) and *Lepidodendron tetragonum* (?) Goeppert, which indicated an Early Carboniferous age, but this has not been confirmed by contemporary investigations. Only individual specimens of *Asterocalamites* sp. and *Lepidodendron* sp. have been described from the outcrop 3 (Toszek Castle Hill) here studied, but these have no stratigraphic significance (Želichowski, 1962a).

More precise dating has been based on macrofauna. Michael (1913) recorded *Posidonia becheri* Bronn, a taxon of late Viséan age. Knopp (1929), however, suggested that the studied deposits lithologically correspond to the “Series” of Bobrovník (the Nizky Jeseník Mts.), documented by goniatites. *Sudeticeras wilczeki-hoeferi* Patteisky, recorded in these beds, indicate a late Viséan age, the $Go\gamma_2$ Zone (Knopp, 1933 *vide* Želichowski, *op. cit.*). Ruzička (1956) showed that specimens found by Michael (1913) are similar to *Posidonia corrugata*, characteristic of the late Viséan–early Serpukhovian. *P. corrugata* was also found by Želichowski (1962a) in outcrop 3 together with *Posidoniella minor* Brown and *Orthoceras* sp.

MATERIAL AND METHODS

Palynological samples have been retrieved from the Horny Benešov (HBFm) and Kyjovice Formations (KFm). Fifty samples of graywacke sandstones and shales with plant detritus from the exposures at the Braciszów quarry (south-west of Głubczyce, HBFm) and Toszek Castle Hill (western margin of the USCB, KFm) were taken (Fig. 1).

The standard method of sample processing for Carboniferous palynomorphs was used.

Crushed 10 g samples were processed using 96% nitric acid and 40% hydrofluoric acid. One thousand and five hundred microscope slides were analysed, and useful palynological data were obtained. Though the organic matter was metamorphosed, miospores were preserved (Figs. 3 and 4). Their number in a single slide was estimated between several and several dozen specimens. Several hundred specimens have been identified and assigned to 26 genera and 46 species.

		LITHOSTRATIGRAPHY	
Chrono-stratigraphy		Eastern Sudetes and Toszek vicinity (after Želichowski, 1962a, b; Unrug, 1977)	Nizky Jeseník Mts. (after Kumpera, 1971a, b, c; Unrug, 1977; Dvořák, 1994)
	Serpukhovian	Kyjovice Fm $Go\gamma$ –E1a	Hradec-Kyjovice Fm $Go\beta_{spi}$ –E1a
Upper Viséan		Hradec Fm $Go\beta_5$ – $Go\beta_7$	Moravice Fm $Go\alpha_{2-3}$ – $Go\beta$
		Moravice Fm $Go\alpha$ – $Go\beta_4$	
		Horny Benešov Fm Lower Viséan– $Go\alpha_{1-2}$	
Middle Viséan		Andelska Hora Fm Famennian–Middle Viséan	
Lower Viséan			
Tournaisian			
Famennian			

Fig. 2. Stratigraphy of the Culm in the Moravian–Silesian zone

PALYNOSTRATIGRAPHY

In selected samples of the Horny Benešov Formation, miospores occur rarely. Individual specimens of the Carboniferous genera: *Densosporites* sp., *Granulatisporites* sp. ? (= *Waltzisporea* sp. ?) have been determined, but they have little stratigraphic significance.

The best results were obtained from the Kyjovice Formation. Twenty three rock samples were collected from the exposure at Stary Młyn 2, located at the eastern side of Toszek Castle Hill (Fig. 1). This is a two-metres thick succession of laminated dark shales with abundant plant detritus and with a layer of fine-grained, olive-gray graywacke sandstone at the base (see locality No 3, Želichowski, 1962a; locality No 5, Paszkowski, 1995; Biernat, 1964). Within the interval between 0.35 m and 1.30 m above the sandstone, seven miospore-bearing levels were recognised (Fig. 5). Abundant and taxonomically diverse miospore associations of stratigraphically important taxa were obtained (Table 1). The assemblages are dominated by representatives of the late Viséan genera *Tripartites* and *Schulzospora*.

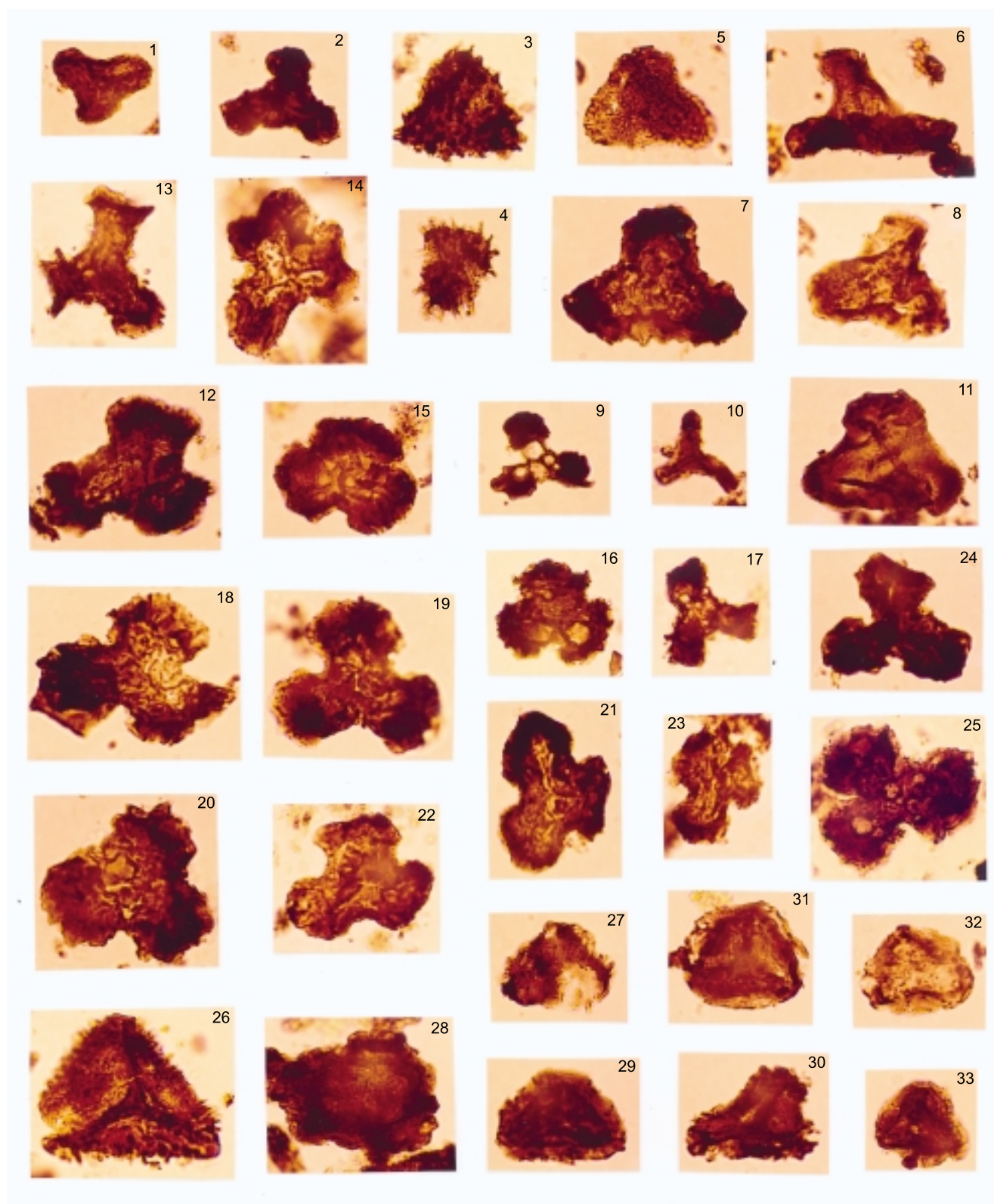


Fig. 3. Miospore assemblage of the early Serpukhovian from the Toszek Castle Hill section

1 — *Waltzisporea planiangulata* Sullivan, 1964, sampled level A; 2 — *Waltzisporea* cf. *sagittata* Playford, 1962, sampled level C; 3 — *Acanthotriletes falcatus* (Knox) Potonié et Kremp, 1955, sampled level A; 4 — *Acanthotriletes castanea* Butterworth et Williams, 1958, sampled level G; 5 — *Microreticulatisporites concavus* ? Butterworth et Williams, 1958, sampled level A; 6 — *Triquitrites trivalvis* (Waltz) Potonié et Kremp, 1956, sampled level A; 7 — *Triquitrites* sp., sampled level F; 8 — *Triquitrites marginatus* ? Hoffmeister, Staplin et Malloy, 1955, sampled level F; 9, 10 — *Triquitrites tripertitus* (Horst) Sullivan et Neves, 1964: 9 — sampled level B, 10 — sampled level D; 11 — *Triquitrites* cf. *tribullatus* (Ibrahim) Schopf, Wilson et Bentall, 1944, sampled level D; 12 — *Triquitrites comptus* ? Williams, 1973, sampled level G; 13, 14 — *Tripartites distinctus* Williams, 1973: 13 — sampled level B, 14 — sampled level A; 15, 16 — *Tripartites cristatus* Dybová et Jachowicz, 1957, sampled level A; 17 — *Tripartites complanatus* Staplin, 1960, sampled level A; 18, 19 — *Tripartites vetustus* Schemel, 1950, sampled level F; 20 — *Tripartites cristatiformis* Jachowicz, 1962, sampled level A; 21 — *Tripartites* cf. *insignitus* Jachowicz, 1962, sampled level A; 22, 23 — *Tripartites trilinguis* (Horst) Smith et Butterworth: 22 — sampled level B, 23 — sampled level A; 24, 25 — *Tripartites astricus* Jachowicz, 1962, sampled level A; 26 — *Diatomozonotriletes trilinearis* Playford, 1963, sampled level A; 27 — *Diatomozonotriletes ubertus* (Ischenko) Jachowicz, 1962, sampled level C; 28 — *Reticulatisporites carnosus* ? (Knox) Neves, 1964; sampled level F; 29 — *Savitrissporites nux* (Butterworth et Williams) Smith et Butterworth, 1967, sampled level A; 30 — *Bellisporites nitidus* ? (Horst) Sullivan, 1964, sampled level A; 31 — *Rotasporea knoxi* Butterworth et Williams, 1958, sampled level C; 32, 33 — *Rotasporea* cf. *fracta* (Schemel) Smith et Butterworth, 1967: 32 — sampled level B, 33 — sampled level A; Magn. $\times 500$

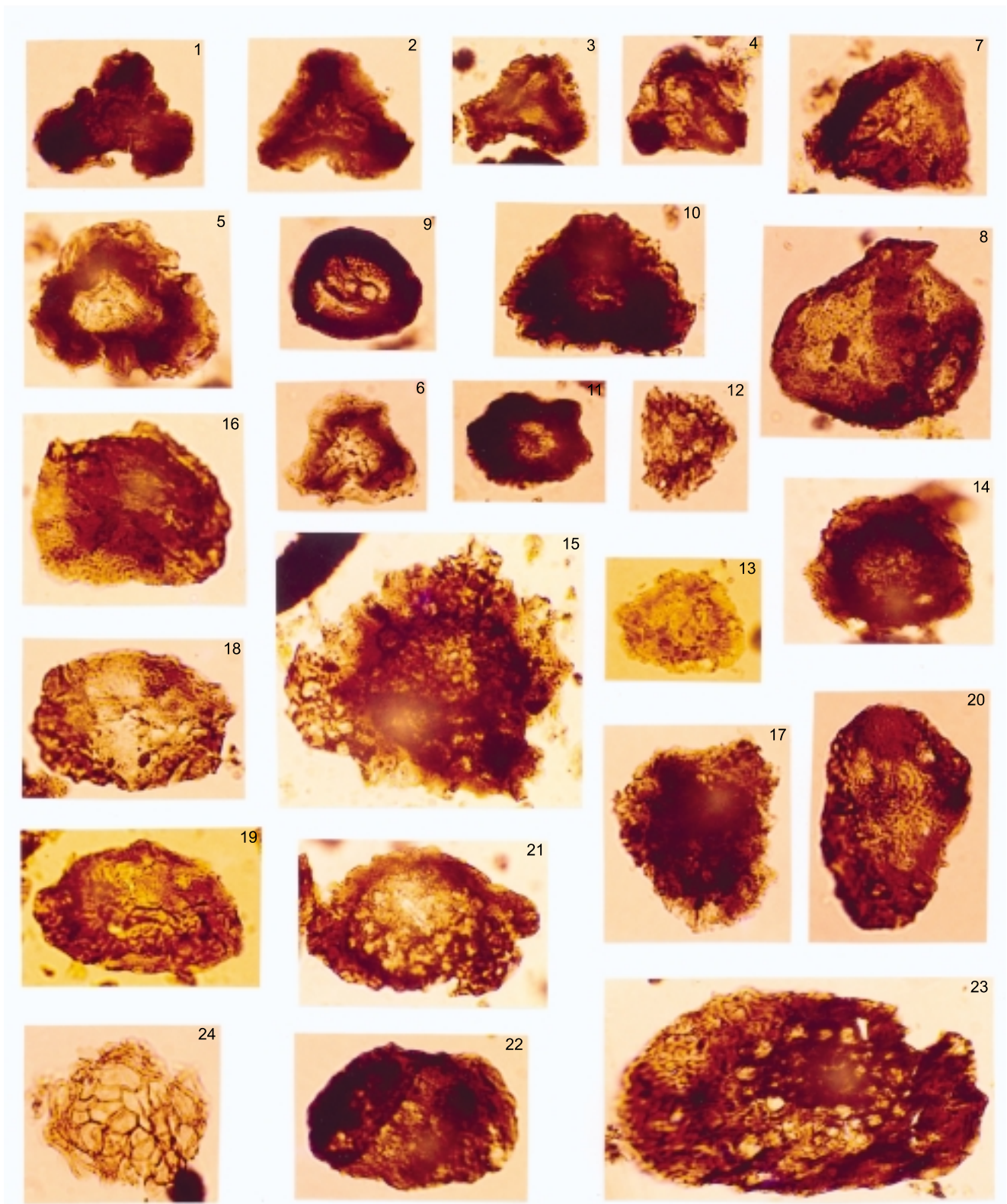


Fig. 4. Miospore assemblage of the early Serpukhovian from the Toszek Castle Hill section

1, 4 — *Murospora* cf. *parthenopia* Neves et Ioannides, 1974: 1 — sampled level G, 4 — sampled level D; 2 — *Murospora complicata* Ravn, 1991, sampled level F; 3 — *Murospora horrens* (Ischenko) Beju, 1970, sampled level A; 5 — *Potonespores delicatus sensu* Playford, 1963, sampled level A; 6 — *Potonespores* cf. *delicatus* Playford, 1963, sampled level D; 7, 8 — *Crassispora kosankei* (Potonié et Kremp) Bharadwaj, 1957: 7 — sampled level A, 8 — sampled level D; 9 — *Densosporites anulatus* (Loose) Smith et Butterworth, 1967, sampled level A; 10 — *Densosporites* sp., sampled level A; 11 — *Pseudoannulatisporites polonicus* ? Karczewska, 1967, sampled level A; 12 — *Lycospora* sp, sampled level B; 13, 14 — *Cingulizonates* sp., sampled level A; 15 — *Kraeuselisporites* sp.; sampled level A; 16 — *Discernisporites micromanifestus* (Hacquebard) Sabry et Neves, 1971, sampled level F; 17 — *Auroraspora* sp. ?, sampled level B; 18–20 — *Schulzospora primitiva* Dybová-Jachowiczowa, 1966, sampled level A; 21 — *Schulzospora vetusta* Dybová-Jachowiczowa, 1966, sampled level A; 22 — *Bugensipollenites ovatus* ? Dybová-Jachowiczowa, 1966; sampled level B; 23 — *Florinites* sp. ?, sampled level B; 24 — *Cymatiosphaera* sp., sampled level B; Magn. × 500

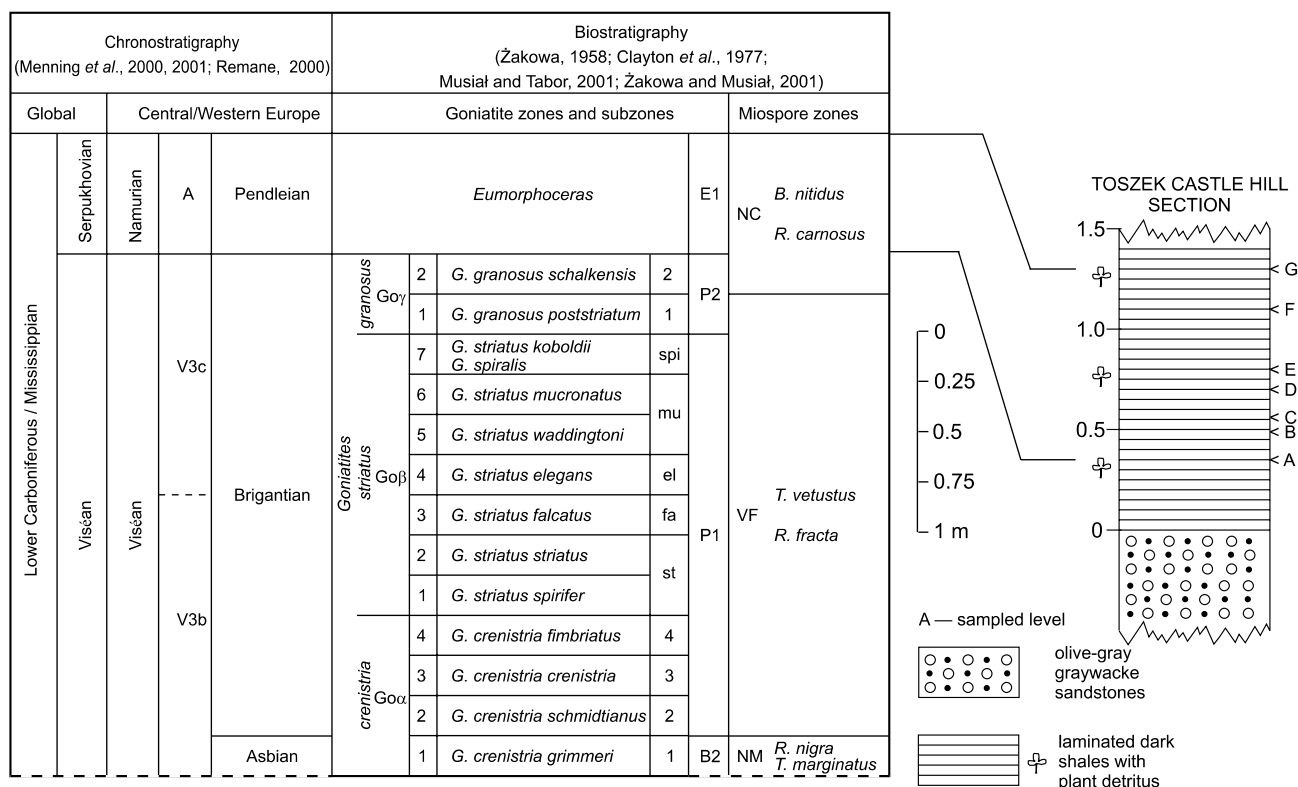


Fig. 5. Palynostratigraphical position of Culm deposits at the Toszek Castle Hill section

Specimens of *Rotaspora*, *Murospora*, *Diatomozonotriletes* and *Lycospora* are also common.

The assemblages include *Lycospora pusilla* and also some other species that appear in the late Viséan, such as: *Tripartites vetustus*, *Schulzospora primitiva*, *Sch. campyloptera*, *Savitrisporites nux*, *Rotaspora knoxi*, *R. cf. fracta*, *Murospora horrens*, *Diatomozonotriletes ubertus*, *Diatomozonotriletes trilinearis*, *Pseudoannulatisporites polonicus?*, *Acanthotriletes falcatus* and *Acanthotriletes castanea* (Figs. 3 and 4).

Some relic species characteristic of the Asbian–Brigantian *tessellatus–clavata* (TC) and *nigra–marginatus* (NM) miospore zones were also recorded: *Triquitrites triperitius*, *Triquitrites comptus?*, *Triquitrites marginatus?*, *Tripartites distinctus*, *Murospora cf. parthenopia*, *Potoniespores delicatus* and *Potoniespores interitorsus* (Figs. 3 and 4) (Neves *et al.*, 1973; Neves and Ioannides, 1974).

Within the interval between 0.35 m and 1.10 m above the sandstone (Fig. 5 and Table 1), individual specimens of *Crassispora kosankei*, *Reticulatisporites carnosus?*, *Florinites* sp.? and *Bellisporites nitidus?* have been recorded. These are the principal and/or index taxa of the *nitidus–carnosus* (NC) miospore Zone (Clayton *et al.*, 1977).

The abundance of *Schulzospora* and *Tripartites* and the presence of the index species *Tripartites vetustus* and *Rotaspora cf. fracta* indicate an age not older than the latest Viséan. But the occurrence of the index species *Reticulatisporites carnosus?* and *Bellisporites nitidus?* accompanied by *Crassispora kosankei* and *Florinites* sp.? suggests the upper part of the *nitidus–carnosus* (NC) miospore Zone.

CONCLUSIONS

The shales of the Kyjovice Formation exposed at Toszek Castle Hill belong to the *nitidus–carnosus* (NC) Zone of the Western European miospore zonation scheme (Clayton *et al.*, 1977) and indicates an early Serpukhovian — E1a age of the deposits. This agrees well with the dating based on the presence of *Posidonia corrugata* (Etheridge) indicative of the late Viséan Goγ–early Serpukhovian E1a age. The results reported here show the deposits, though, to be younger than previously thought. This agrees well with the general stratigraphic range of the Kyjovice Formation in the Nizky Jeseník Mts. in Moravia (Goγ₁–E1a; after Dvořák, 1994), as well as of its facies equivalent — the Malinovice Beds, the uppermost lithostratigraphic Culm unit distinguished in Silesia (Paszowski, 1995).

The success of these studies of the Kyjovice Formation at the Toszek Castle Hill section demonstrates that palynology is an efficient method of dating the uppermost part of the Culm exposed in the entire Moravian–Silesian zone.

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Table 1

Distribution of important miospore taxa in the Toszek Castle Hill section

Miospore taxa	Toszek Castle Hill section early Serpukhovian NC (<i>nitidus</i> – <i>carnosus</i>) spore zone sampled level						
	A	B	C	D	E	F	G
<i>Tripartites vetustus</i> Schemel, 1950	+	+	+	+	+	+	+
<i>Tripartites cristatus</i> Dybová et Jachowicz, 1957	+	+					
<i>Tripartites complanatus</i> Staplin, 1960	+				+		
<i>Tripartites cristatiformis</i> Jachowicz, 1962	+		+			+	
<i>Tripartites</i> cf. <i>insignitus</i> Jachowicz, 1962	+						
<i>Tripartites trilinguis</i> (Horst) Smith et Butterworth, 1967	+	+		+			
<i>Tripartites astricus</i> Jachowicz, 1962	+		+	+		+	
<i>Tripartites distinctus</i> Williams, 1973	+			+		+	+
<i>Rotaspora</i> cf. <i>fracta</i> (Schemel) Smith et Butterworth, 1967	+	+					
<i>Rotaspora knoxi</i> Butterworth et Williams, 1958			+				
<i>Schulzospora primitiva</i> Dybová–Jachowiczowa, 1966	+	+	+	+	+	+	+
<i>Schulzospora vetusta</i> Dybová–Jachowiczowa, 1966	+			+			+
<i>Schulzospora campyloptera</i> (Waltz) Hoffmeister, Staplin et Malloy, 1955	+	+					+
<i>Pseudoannulatisporites polonicus</i> ? Karczewska, 1967	+						
<i>Bugensipollenites ovatus</i> ? Dybová–Jachowiczowa, 1966		+					
<i>Waltzispora planiangulata</i> Sullivan, 1964	+	+	+				
<i>Waltzispora</i> cf. <i>sagittata</i> Playford, 1962			+				
<i>Murospora</i> cf. <i>parthenopia</i> Neves et Ioannides, 1974				+			+
<i>Murospora complicata</i> Ravn, 1991						+	
<i>Murospora horrens</i> (Ischenko) Beju, 1970	+						
<i>Potoniesporites delicatus</i> Playford, 1963	+			+		+	
<i>Reticulatisporites carnosus</i> ? (Knox) Neves, 1964						+	
<i>Cingulizonates</i> spp.	+	+	+	+	+	+	+
<i>Triquitrites comptus</i> ? Williams, 1973							+
<i>Triquitrites</i> cf. <i>tribullatus</i> (Ibrahim) Schopf, Wilson et Bentall, 1944				+			+
<i>Triquitrites triperitius</i> (Horst) Sullivan et Neves, 1964	+	+		+			
<i>Triquitrites trivalvis</i> (Waltz) Potonié et Kremp, 1956	+				+		
<i>Triquitrites marginatus</i> ? Hoffmeister, Staplin et Malloy, 1955						+	
<i>Discernisporites micromanifestus</i> (Hacquebard) Sabry et Neves, 1971						+	
<i>Savitrissporites nux</i> (Butterworth et Williams) Smith et Butterworth, 1967	+						
<i>Bellisporites nitidus</i> ? (Horst) Sullivan, 1964	+						
<i>Densosporites annulatus</i> (Loose) Smith et Butterworth, 1967	+						
<i>Diatomozonotriletes trilinearis</i> Playford, 1963	+						
<i>Diatomozonotriletes ubertus</i> (Ischenko) Jachowicz, 1962			+				
<i>Lycospora</i> spp.	+	+	+	+	+	+	+
<i>Crassispora kosankei</i> (Potonié et Kremp) Bharadwaj, 1957	+			+			
<i>Florinites</i> sp.?		+					

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