Geological Quarterly, 2003, **47** (4): 373–380

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

Aleksandra TRZEPIERCZYŃSKA

Trzepierczyńska A. (2003) — Palynostratigraphy of the Culm deposits of the Moravian–Silesian zone (Poland) at Toszek Castle Hill. Geol. Quart., **47** (4): 373–380. Warszawa.

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 Goγ–E1a goniatite zones.

Aleksandra Trzepierczyńska, Polish Geological Institute, ul. Kr. Jadwigi 1, PL-41-200 Sosnowiec, Poland *(received: March 26, 2003; accepted: July 9, 2003).*

Key words: Moravian–Silesian zone, Culm, flysch, palynostratigraphy, miospores, Serpukhovian.

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; Kumpera, 1971*a*, *b*, *c,* 1977; Dvořak, 1973, 1994) has been confirmed locally, by records of rare goniatites, molluscs, orthocones and foraminifers (Żelichowski, 1962*a*, *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, 1962*a*). 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 Goγ — *Goniatites granosus* Zone determined by Żelichowski (1962*a*), was based principally on lithological correlations with the Goniatite "Series" of Bobrovnik in the Nizky Jesenik 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 Jesenik Mts., the Odra Mts. and the Drahany Upland of the Moravia region, Czech Republic (Patteisky, 1929; Hokr, 1955; Havlena, 1964; Koverdynský, 1964; Kumpera, *op. cit.*; Dvořak, 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, 1962*b*; 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, 1962*a*; 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.

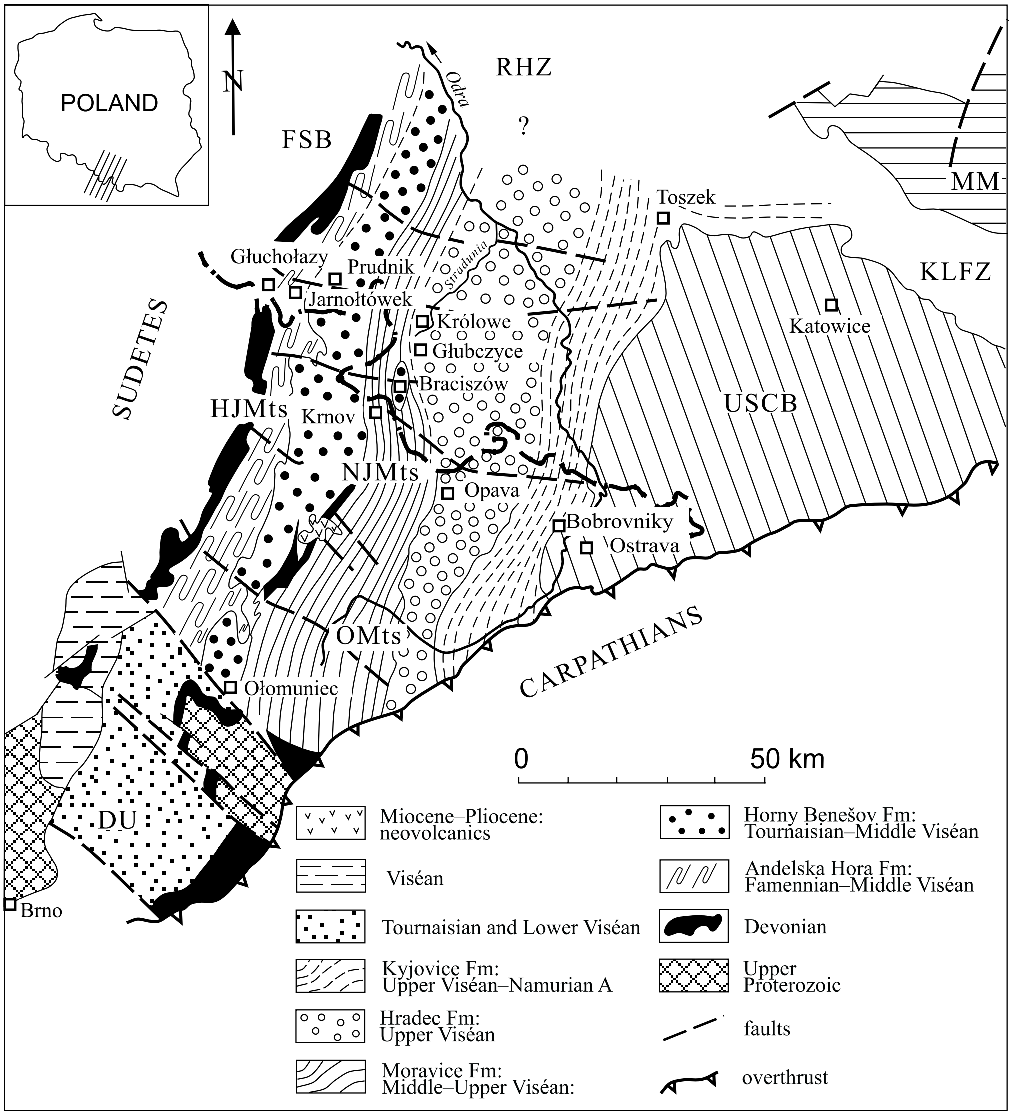

Fig. 1. Generalised geological map of the region studied (after Fusan *et al.*, 1967; Pożaryski and Dembowski, 1983; Dvořak, 1994; modified by the author)

HJMts — High Jesenik Mts.; NJMts — Nizky Jesenik Mts.; OMts — Odra Mts.; RHZ — Rheno-Hercynian 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 Trzepierczyński, 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 *fide* Unrug, 1977), but more precise dating is based on micro- and macrofauna found at the base and top respectively (Fig. 2). In the siliceous-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 — Goα and Goβ_4 zones were recorded (Kumpera, 1971*a*, 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 Goα and Goβ_4 zones (Żelichowski, 1962*b*), whereas in Moravia, the age of the formation is between the Goα_{2-3} and Goβ zones respectively (Kumpera, 1971*a*) (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 (Dvořak, 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 Goβ_5 and Goβ_7 zones (Żelichowski, 1962*b*), whereas in Moravia, the age of the Hradec-Kyjovice Formation is between the Goβ_{spi}–E1a zones (Kumpera, 1971*c*; Dvořak, 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 (Żelichowski, 1962*a*).

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 Bobrovnik (the Nizky Jesenik Mts.), documented by goniatites. *Sudeticeras wilczeki-hoeferi* Patteisky, recorded in these beds, indicate a late Viséan age, the Goγ_2 Zone (Knopp, 1933 *fide* Żelichowski, *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 Żelichowski (1962*a*) in outcrop 3 together with *Posidoniella minor* Brown and *Orthoceras* sp.

MATERIAL AND METHODS

Palynological samples have been retrived 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.

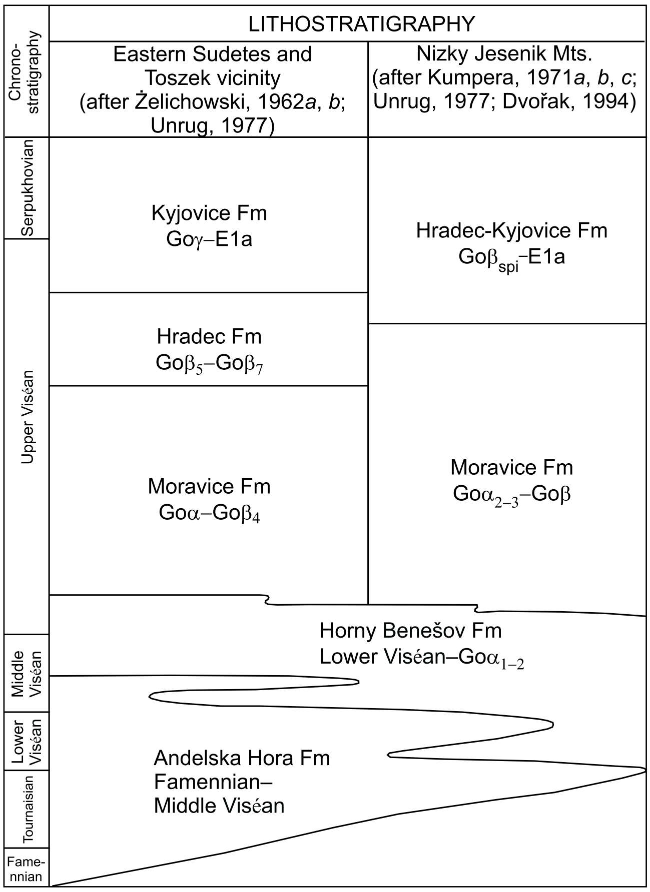

Fig. 2. Stratigraphy of the Culm in the Moravian–Silesian zone

PALYNOSTRATIGRAPHY

In selected samples of the Horny Benešov Formation, miospores occur rarely. Individual specimens of the Carboniferous genera: *Densosporites* sp., *Granulatisporites* sp. ? (=*Waltzispora* 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, Żelichowski, 1962*a*; 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*.

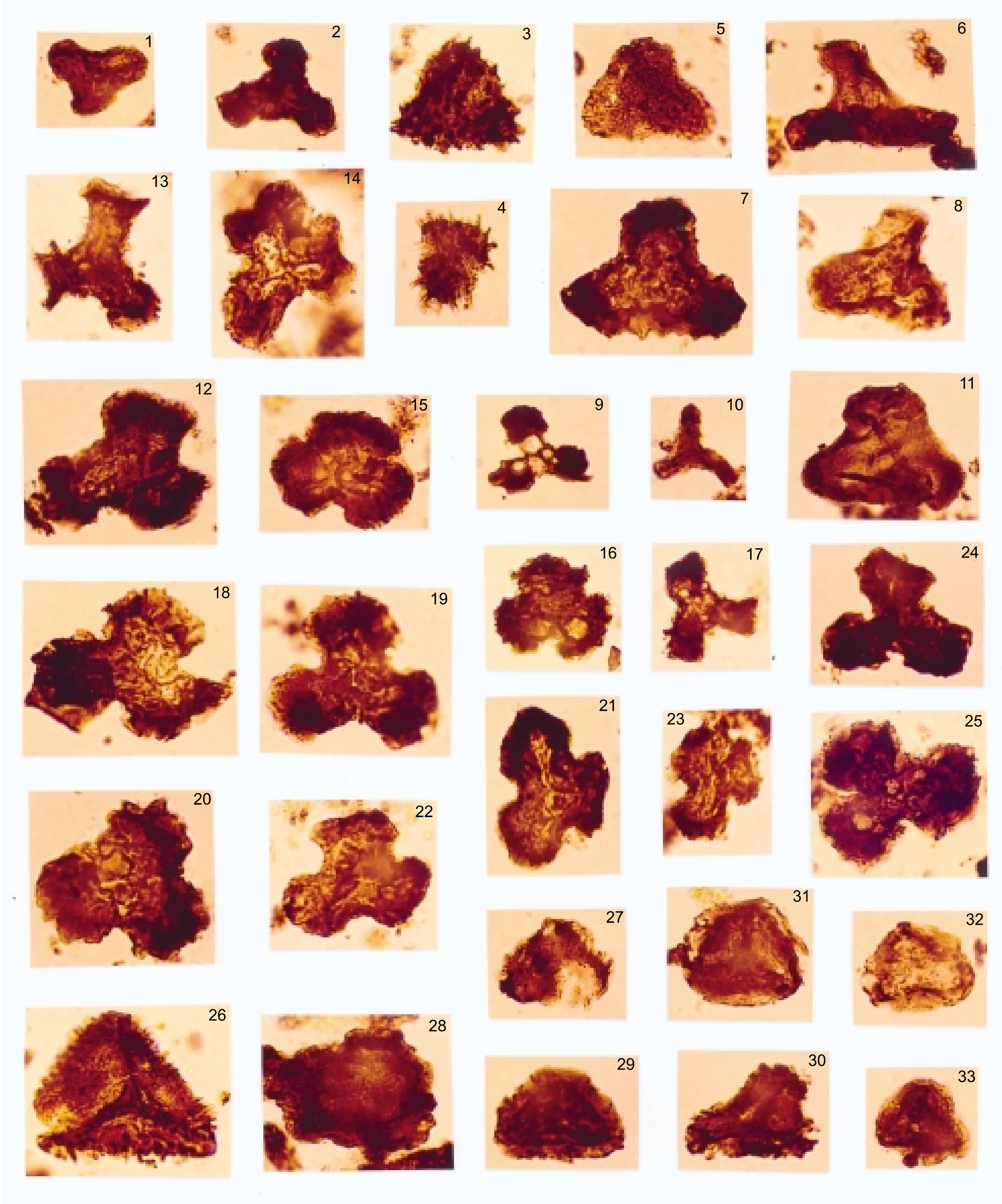

Fig. 3. Miospore assemblage of the early Serpukhovian from the Toszek Castle Hill section

1 — *Waltzispora planiangulata* Sullivan, 1964, sampled level A; **2** — *Waltzispora* cf. *sagittata* Playford, 1962, sampled level C; **3** — *Acanthotriletes falcatus* (Knox) Potonié et Kremp, 1955, sampled level A; **4** — *Acanthotriletes castanea* Butterworth et Willams, 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 and 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** — *Savitrisporites nux* (Butterworth et Williams) Smith et Butterworth, 1967, sampled level A; **30** — *Bellispores nitidus* ? (Horst) Sullivan, 1964, sampled level A; **31** — *Rotaspora knoxi* Butterworth et Williams, 1958, sampled level C; **32**, **33** — *Rotaspora* cf. *fracta* (Schemel) Smith et Butterworth, 1967: **32** — sampled level B, **33** — sampled level A; Magn. × 500

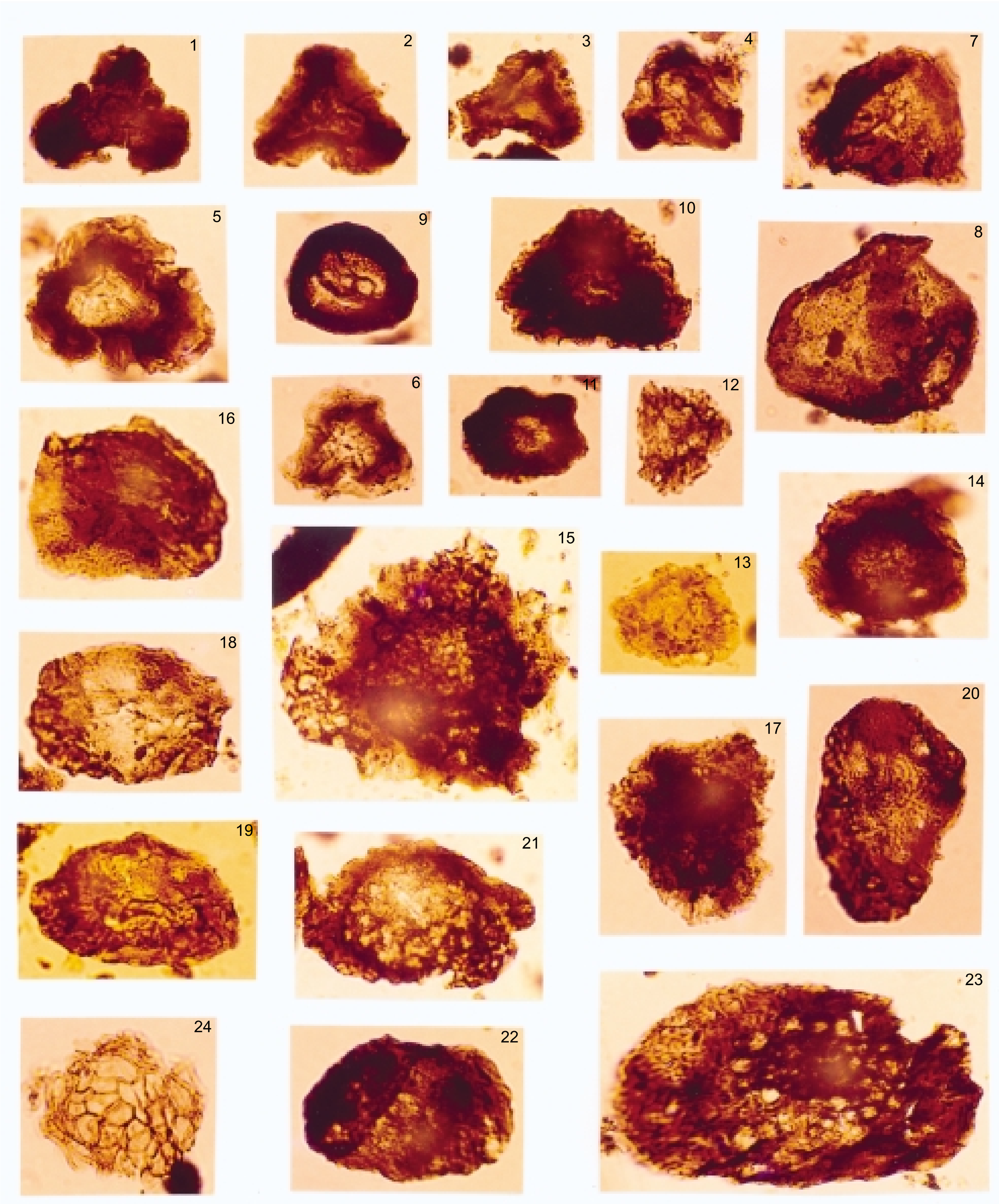

Fig. 4. Miospore assemblage of the early Serpukhovian from the Toszek Castle Hill section

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** — *Potoniespores delicatus sensu* Playford, 1963, sampled level A; **6** — *Potoniespores* 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

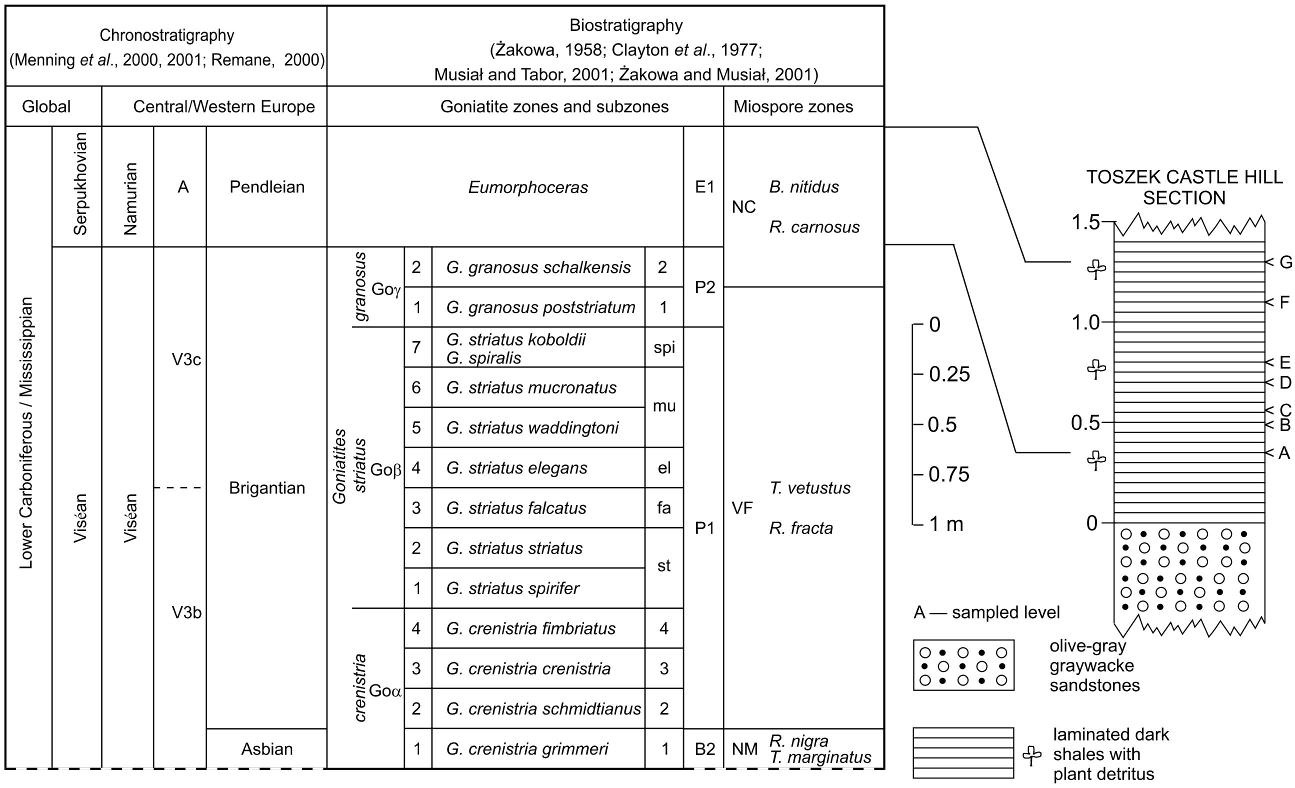

Fig. 5. Palynostratigraphical position of Culm deposits at the Toszek Castle Hill section

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 tripertitus*, *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 *Bellispores 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 *Bellispores 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 Goα–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 Jesenik Mts. in Moravia ($Go\gamma_1$–E1a; after Dvořak, 1994), as well as of its facies equivalent — the Malinovice Beds, the uppermost lithostratigraphic Culm unit distinguished in Silesia (Paszkowski, 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.

Acknowledgements. This comprises statutory research supported financially by the Committee of Research Science (No 6.20.1641.00.0). The author is indebted to Dr. A. Górecka-Nowak and an anonymous reviewer for their comments on the paper. I would like to express my gratitude to Prof. Dr. hab. E. Turnau for her critical remarks and valuable suggestions on an early draft of this paper. Thanks also go to Mrs. E. Kulesz and S. Wilk M. Sc. Ing. for computer editing of the text and the drawings.

T a b l e 1

Distribution of important miospore taxa in the Toszek Castle Hill section

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

REFERENCES

BIERNAT S. (1964) — Objaśnienia do szczegółowej mapy geologicznej Polski. Ark. Pyskowice 1:50 000. Inst. Geol.

CLAYTON G., COQUEL R., DOUBINGER J., GUEINN K. J., LOBOZIAK S., OWENS B. and STREEL M. (1977) — Carboniferous miospores of Western Europe: illustration and zonation. Meded. Rijks. Geol. Dienst., **29**: 1–72.

DVOŘAK J. (1973) — Synsedimentary tectonics of the Palaeozoic of the Drahany Upland (Sudeticum, Moravia, Czechoslovakia). Tectonophysics, **17**: 359–391.

DVOŘAK J. (1994) — Variský flýšový vývoj v Nizkém Jeseniku na Moravé a ve Slezsku. Pr. Českého Geol. Ústavu, **3**.

FUSAN O., KODYM O., MATÉJKA A. and URBANEK L. (1967) — Geological map of Czechoslovakia 1:500 000. Ústr. Ústav Geol. Praha.

GEROCH S. (1971) — Występowanie fauny otwornicowej w utworach kulmu rejonu Głubczyc. Przew. 43 Zjazdu Pol. Tow. Geol.: 168–170.

GRYGAR R. and TRZEPIERCZYŃSKI J. (1995) — Pozycja tektoniczna i rozwój formacji fliszowej strefy morawsko-śląskiej. Mater. międzynar. konf. nauk. sedyment. i tekton. kulmu w zach. obrzeż. GZW. Sosnowiec.

HAVLENA V. (1964) — Geologie uhelnych loaisek. Praha.

HOKR Z. (1955) — Hranice uhlonosti hornoslezské panve v okoli Ostravy na zaklade dosavadnich vysledku geologickeho vyzkumu. Prirodov. sbor. Ostrav., **16**: 480–505.

KNOPP L. (1929) — Zur kenntnis des Oberschlesischen Unterkarbons. Zs. Oberschles. Berg-u Hűttenm. Ver., **68**: 474–479.

KNOPP L. (1933) — Űber die Tektonik und Stratigraphie der Ostsudeten. Jb. Geol. Verein. Oberschles., **1**: 3–35.

KOVERDYNSKÝ B. (1964) — Domele vapencove vloaky v kulmu a vysledky noveho mapovani v širsim okoli Šternberka. Zpr. Vlast-Ust. Olomouc, **117**: 9–19.

KUMPERA O. (1971*a*) — Faunisticke lokality a prehled fauny moravickeho souvrstvi (svrchni vise). Sbor. Ved. Praci Vys. Skoly Banske v Ostrave, Rada Horn.-Geol., **17**: 107–124.

KUMPERA O. (1971*b*) — Contribution to the geology of Lower Carboniferous strata in the central and northern part of the Nizky Jesenik Hills. Sbor. Ved. Praci Vys. Skoly Banske v Ostrave, Rada Horn.-Geol., **17**: 125–135.

KUMPERA O. (1971*c*) — Faunisticke lokality a prehled fauny hradeckeho souvrstvi (svrchni vise moravskoslezskoho kulmu). Sbor. Ved. Praci Vys. Skoly Banske v Ostrave, Rada Horn.-Geol., **17** (2): 129–141.

KUMPERA O. (1977) — A review of the fauna of the Moravo-Silesian Kulm. Proc. Symp. Carbon. Strat. Ústř. Úst. Geol., **3**: 235–264.

KUMPERA O. and MARTINEC P. (1995) — The development of the Carboniferous accretionary wedge in the Moravian–Silesian Palaeozoic Basin. J. Czech. Geol. Soc.

MENNING M., WEYER D., DROZDZEWSKI G., VAN AMEROM HENK W. J. and WENDT I. (2000) — A Carboniferous time scale 2000. Discussion and use of geological parameters as time indicators from Central and Western Europe. Geol. Jb., **A 156**: 3–44.

MENNING M., BELKA Z., CHUVASOV B., ENGEL B. A., JONES P. J., KULLMANN J., UTTING J., WATNEY L. and WEYER D. (2001) — The optimal number of Carboniferous series and stages. Newsl. Stratigr., **38** (2/3): 201–207.

MICHAEL R. (1913) — Die Geologie des oberschlesischen Steinkohlenbezirkes. Abh. Preuss. Geol. L. -A., N. F., **71**.

MUSIAŁ Ł. and TABOR M. (2001) — Korelacja biostratygraficzna karbonu górnego Polski z innymi obszarami na podstawie makro- i mikrofauny. In: Budowa geologiczna Polski. Tom 3. Atlas skamieniałości przewodnich i charakterystycznych, **1c** (1). Warszawa.

NEVES R., GUEINN K. J., CLAYTON G., IOANNIDES N. S., NEVILLE R. S. W. and KRUSZEWSKA K. (1973) — Palynological correlations within the Lower Carboniferous of Scotland and Northern England. Trans. Royal Soc. Edinburgh, **69** (2): 23–70.

NEVES R. and IOANNIDES N. S. (1974) — Palynology of the Lower Carboniferous (Dinantian) of the Spilmersford borehole, East Lothian, Scotland. Bull. Geol. Surv. Britain, **45**: 73–97.

PASZKOWSKI M. (1995) — The Carboniferous in the Małopolska — Holy Cross Mts. basin. XIII Intern. Congr. on Carbon.-Perm. Kraków.Guide to Excur., **B2**: 16–23.

PATTEISKY K. (1929) — Die Geologie und fossilführung der Mährisch-Schlesischen Dachschiefer und Grauwacken formation. Troppau, **354**.

POŻARYSKI W. and DEMBOWSKI Z. (1983) — Geological Map of Poland and adjoining countries 1:1 000 000. Państw. Inst. Geol. Warszawa.

REMANE J. (2000) — Explanatory note to the International Stratigraphic Chart Courtesy of the Division of Earth Sciences. UNESCO.

ROEMER F. (1870) — Geologie von Oberschleschien. Breslau.

RUa IČKA B. (1956) — Nova paleontologicka lokalita v moravickich břidlicéch z Podhradi na Opavsku. Přiroved. Sbor. Ostravského Kráje, **17**: 76 (1).

TRZEPIERCZYŃSKA A. (2002) — Stratigraphy of the Culm deposits in the Toszek area — palynological evidences (in Polish with English summary). In: Mat. 25 Symp. "Geologia Formacji Węglonośnych w Polsce". 17–18 kwiecień, Kraków.

UNRUG R. (1964) — Turbidites and fluxoturbidites in the Moravia–Silesia Kulm Zone. Bull. Acad. Pol. Sc., Sér. Sc. Géol. Géogr., **13** (3): 187–194.

UNRUG R. (1971) — Dolny karbon w facji fliszowej (kulm) na południowy zachód od Głubczyc. Przew. 43 Zjazdu Pol. Tow. Geol.: 157–167; 170–177.

UNRUG R. (1974) — Dolny karbon w facji fliszowej (kulm) w południowej części Opolszczyzny. Przew. 46 Zjazdu Pol. Tow. Geol.: 12–17.

UNRUG R. (1977) — Lower Carboniferous flysch in the Głubczyce region (Lower Silesia). Ann. Soc. Geol. Pol., **47** (1): 73–92.

UNRUG R. and DEMBOWSKI Z. (1971) — Diastrophic and sedimentary evolution of the Moravia–Silesia Basin. Ann. Soc. Geol. Pol., **41** (1): 119–168.

ZIKMUNDOVA J. (1967) — Konodontova zona *Scaliognathus anchoralis* Branson et Mehl v ponikievskych břidlicich Nizkeho Jeseniku. Vest. Ústr. Úst. Geol., **42**: 449–541.

ŻAKOWA H. (1958) — Biostratigraphy of the Lower Carboniferous marine deposits of the area of Wałbrzych Miasto (Lower Silesia) (in Polish with English summary). Pr. Inst. Geol., **19**.

ŻAKOWA H. and MUSIAŁ Ł. (2001) — Korelacja biostratygraficzna karbonu dolnego Polski z innymi obszarami na podstawie makro- i mikrofauny. In: Budowa geologiczna Polski. Tom 3. Atlas skamieniałości przewodnich i charakterystycznych, **1c** (1).

ŻELICHOWSKI A. (1962*a*) — On the Culm from the region of Toszek (in Polish with English summary). Kwart. Geol., **6** (2): 267–280.

ŻELICHOWSKI A. (1962*b)* — Profiles of Culm from the vicinity of Głubczyce (East Sudeten) (in Polish with English summary). Pr. Inst. Geol., **4–5**: 196–200.